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ON
CHLOROFORM

AND

OTHER ANÆSTHETICS:

THEIR

ACTION AND ADMINISTRATION.

BY

JOHN SNOW, M.D.

LICENTIATE OF THE ROYAL COLLEGE OF PHYSICIANS.

EDITED,

WITH A MEMOIR OF THE AUTHOR,

BY

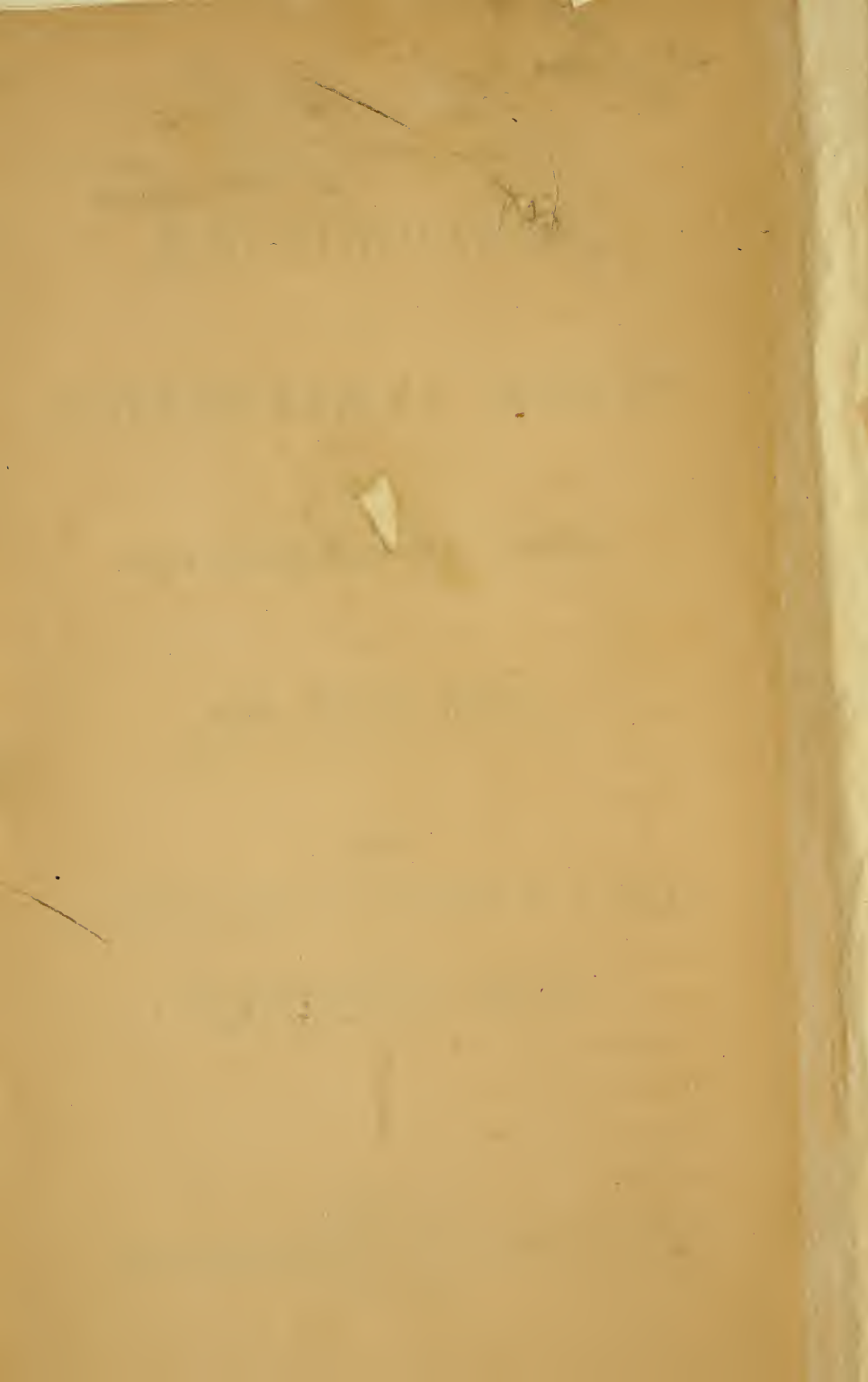
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P R E F A C E.

THE book here presented to the reader is the legacy to science of Dr. JOHN SNOW. The completion of the work was his last act and deed. In editing the book, therefore, all that remained to be done consisted in the construction of the index, and in this a plan suggested by the author himself has been followed.

In contributing the memoir, I have performed a painful and unexpected duty : the fulfilment of a promise given at a moment when two friends who often enjoyed close companionship met at one of their happiest meetings. The promise was given with the idea of fulfilment far distant, or improbable altogether, and, as connected with a more extended biographical survey, reserved for the work of years long in the future ; it is called for now hastily and in deep sorrow.

Writing with the fact of my late friend's death not as yet fully realized ; with the sensation still on me at intervals (like one who has lost a part of his own body, and yet at times conceives the lost present), that he cannot possibly be so far away ; I may perchance be pardoned for any deficiencies in style or matter. I have done my best, and leave it so.

B. W. RICHARDSON.

12, *Hinde Street, Manchester Square.*

August 6th, 1858.

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THE
LIFE OF JOHN SNOW, M.D.

THERE is not much credit in the mere acts of living and dying ; in being driven by unavoidable fate through the common journey, with shoulders uncovered and the whip over them ; in doing nothing save the drudgery of existence ; in enjoying, in an approach to the recognition of enjoyment, the brief dreams of childhood ; in struggling into manhood ; in battling through the after-strife obedient to the castigator behind ; and in dying at last, as though life had never been ; dead to-day, wept for to-morrow, and forgotten by the morrow's succeeding sun. There is not much credit in this surely, for credit must be earned by something done beyond that which all must perforce do. But, in the face of all the struggles incidental to the existence, so to have managed as to have stolen out of time hours which other men knew not in their calendar—so to have defied the inexorable taskmaster as to perform more than is included in his demands ; so to have willed and acted as to live on when death has done his worst ; to assist all coming wayfarers in their conflict wherever they may meet it ; to prove that there is something more in life than labour lost, and nothing more in death than an idea—*Hoc opus hic labor est*—in this there is achieved the grand attainment ; the perpetual life.

He whom I, with poor biographer's pencil, put forward now in brief sketch, is one amongst the few

who have thus realized the ideality of death. It were but little matter, therefore, though no biography should appear at all ; it is of but little count that such biography, as the recollections of friends and intimates shall call forth, be scanty in its details ; it is of but little count that the life of him who is to be shadowed forth is destitute of incident fitted for the taste of wonder-loving, passion-courting, romance-devouring, readers. Biographies for these are common. Good men are scarce.

JOHN SNOW, the subject of the present memoir, was born at York, on the fifteenth day of June, 1813. He was the eldest son of his parents. His father was a farmer. His mother, who is living, resides still at York. As a child, he showed his love of industry ; and increasing years added only to the intensity with which he applied himself to any work that was before him. He occasionally assisted his father in agricultural pursuits, and often in later life spoke with great *naïveté* of the recollections of those early winter mornings when his boy's fingers were too intimately to be pleasantly acquainted with the effects of benumbing cold. He was first sent to a private school at York, where he learned all that he could learn there. He was fond of the study of mathematics, and in arithmetic became very proficient. At the age of fourteen, he went to Newcastle-on-Tyne, as an apprentice to Mr. William Hardcastle, surgeon, of that place. He had also the opportunities of studying at the Newcastle Infirmary. During the third year of his apprenticeship, viz., when he was seventeen years old, he formed an idea that the vegetarian body-feeding faith was the true and the old ; and with that consistency which throughout life attended him, tried the system rigidly for more than eight years. He was a noted swimmer at this time, and could make head against the tide longer than any of his omnivorous friends. I have

heard him tell that so long as he continued to qualify his vegetables with milk and butter, the vegetarian plan supported him fairly. But on one unfortunate morning, when taking his milk breakfast, some quiz-zical friend, learned in botany, cross-examined him as to the vegetable on which he was then feeding. The joke went home ; and the use of milk, as food for a pure vegetarian, became too absurd for consistency. The milk, therefore, must be put aside, and the butter and the eggs. The experiment did not answer ; the health of our pure vegetarian gave way under the ordeal, and although in after life he maintained that an approach to the vegetarian practice was commendable, in that it kept the body in better tone for the exercise of the mind, he admitted that in his own case his health paid the forfeit of his extreme adherence to an hypothesis. Amongst his earlier scientific readings was a book in defence of the vegetable regimen by John Frank Newton. This book is annotated by himself, 1833. It is an useful book, full of curious arguments, facts and suggestions, many of which, as his own after writings indicate, he had carefully studied and applied.

At or about the same time that he adopted his vegetarian views, he also took the extremity of view and of action, in reference to the temperance cause. He not only joined the ranks of the total abstinence reformers, but became a powerful advocate of their principles for many succeeding years. In the latter part of his life, he occasionally and by necessity took a little wine, but his views on the subject remained to the end unchanged ; he had strong faith in the temperance cause, and a belief that it must ultimately become an universal system.

In 1831-32, cholera visited Newcastle and its neighbourhood, and proved terribly fatal. In the emergency, Mr. Snow was sent by Mr. Hardcastle to the Killingworth Colliery, to attend the sufferers from

the disease there. In this labour he was indefatigable, and his exertions were crowned with great success. He made also on this occasion many observations relating to this disease, which proved to him of immense account in after years.

He left Newcastle in 1833, and engaged himself as assistant to Mr. Watson of Burnop Field, near Newcastle. Here he resided for twelve months, fulfilling the assistant duties; regarding which it can only be said, and that from analogy, that they were neither without their anxiety nor their reward. Leaving Burnop Field in 1834-5, he revisited his native place, York; made a short stay, and thence to a certain half-inaccessible village called Pately Bridge, in Yorkshire, to assist it with Mr. Warburton, surgeon there. Some few years ago a friend of mine went to the same village, by the recommendation of Dr. Snow, as assistant to the present Mr. Warburton of that place, a son of Dr. Snow's "old master". The circumstance of this recommendation often led Dr. Snow to refer to his life at Pately Bridge in our conversations. He invariably, on such occasions, spoke of Mr. Warburton, his "old master", in terms of sincere respect, and depicted his own life there with great liveliness. He was a vegetarian then, and his habits puzzled the housewives, shocked the cooks, and astonished the children. His culinary peculiarities were, however, attended to with great kindness. Eighteen months at Pately Bridge, with many rough rides, a fair share of night work, a good gleanings of experience, and this sojourn was over. Now back again went our student to York, to stay this time a few months, and—not to be idle—to take an active share in the formation of temperance societies. In leisure days during this period it was his grand amusement to make long walking explorations into the country. In these peregrinations he collected all kinds of information, geological, social, sanitary, and architectural.

At last York must be again left; the London student life was in view. In the summer of the year at which we have arrived, 1836, he set off from York to Liverpool, and, trudging it afoot from Liverpool through the whole of North and South Wales, turned London-ward, calling at Bath by the way, on a visit to his uncle, Mr. Empson, to whom, to the end of his life, he was devotedly attached. October 1836—eventful October—brought him to the “great city”, and placed him on the benches of the Hunterian School of Medicine in Windmill-street: a school long since closed, and now almost a myth; like the mill which gave the name to the locality.

I am indebted to the courtesy of Mr. Joshua Parsons of Beckington, near Bath, for an insight into the life and manners of my beloved friend during his student career. Mr. Parsons had the happiness to be the special fellow-student of Snow. Their friendship, cemented early in life, never declined, but had added to it, “on my part,” says Mr. Parsons, “respect and admiration for the solid talents and industry of my old colleague.” Speaking of their common labours, Mr. Parsons writes as follows:

“Our acquaintance commenced in 1836, at the Hunterian School of Medicine in Windmill-street, where we were both dissecting at that time. It happened that we usually overstayed our fellows, and often worked far on into the evening. The acquaintance thus grew into intimacy, which ended by our lodging and reading together. We were constant companions from that time till I left town, in October 1837. During that period Dr. Snow was, as a student, characterized by the same mental qualities which have marked him ever since. Not particularly quick of apprehension, or ready in invention, he yet always kept in the foreground by his indomitable perseverance and determination in following up whatever line of investigation was open to him. The

object of this steady pursuit with him was always *truth*: the naked truth, for its own sake, was what he sought and loved. No consideration of honour or profit seemed to have power to bias his opinions on any subject. At the period of our co-residence he was a strict vegetarian, and many and great were the controversies held between us on the subject. These led to trials of our comparative strength and endurance, in one of which, on Easter Monday 1837, we walked to St. Alban's, and back to town through Harrow,—a distance, I believe, of rather more than fifty miles. On reaching the Edgware Road, my companion was fairly beaten, and obliged to reach home in an omnibus. But though this, you will say, shows a fair amount of strength, yet it was my impression that my friend's constitutional powers were impaired by his mode of living, for I observed that he suffered from an amount of physical excitability not to be looked for in a man of his bodily powers and placid mental organization. I remember, on two or three occasions, so slight an injury as a cut of the finger with a dinner knife, or a graze of the skin, producing such an amount of fever, attended by so rapid a pulse, and so intense a flush upon the cheeks, that I once asked the opinion of an experienced medical friend about him, and was by that opinion alone restrained from summoning his uncle to his bedside. He also was subject to great drowsiness, so that he was obliged often to close his books, and retire to bed long before his inclination would have led him to do so."

In October 1837, Mr. Snow took out his hospital practice at the Westminster Hospital. On May 2nd, 1838, he passed his examination, and was entered duly as a member of the Royal College of Surgeons of England. He lived at this time at 11, Bateman's Buildings, Soho-square.

In July 1838, Mr. Thurnham having resigned his

post of apothecary to the Westminster Hospital, Mr. Snow, with much promise of support from the medical staff, competed for the vacant post. He presented excellent testimonials from Mr. Hardcastle, Mr. James Allen of York, Dr. Conquest, Mr. W. B. Lynn, Surgeon to the Westminster Hospital, Mr. Anthony White, Sir Anthony Carlisle, Mr. Warburton, and Dr. Hunter Lane. His canvass was very satisfactory; but he was compelled to resign his claims from a cause which he did not expect. By the laws of the hospital, the office of apothecary could only be held by a member of the Apothecaries' Company. In those days the worshipful Company were sometimes lenient in admitting students to examination. The leniency, however, clearly extended to those only who had friends at court. To render himself eligible, Mr. Snow addressed a very simple, earnest, and gentlemanly request to the Court of Examiners of the Apothecaries' Company, begging to be allowed to go up to his examination at the second court in July instead of the first in October, at which he was legally admissible. The request, under the circumstances, was not very great; but for some reason it met with refusal. After the refusal he addressed a second note to the Court, equal in tone with the first. In this note he urged the simple character of the request; he reminded the sapient body that they had allowed a similar extension of privilege to that asked by himself to others, and even for less important reasons. He explained that he had attended the practice of the Newcastle Infirmary; and promised that if he could be admitted, he would fulfil the required term of hospital curriculum rigidly. Lastly, he stated the expenses into which the canvass had led him, and once more prayed for leniency of the examiners, from "confidence in their kindness". The confidence was misplaced. The Blackfriars Shylocks demanded the pound of flesh;

and our disappointed student, on the very eve of success, was compelled to relate his discomfiture in the following address :

"To the Governors of Westminster Hospital.

"MY LORDS, LADIES, AND GENTLEMEN,

"I became a candidate for the vacant office of Apothecary to the Hospital a little before my term of study was completed, expecting that the Court of Examiners of the Apothecaries' Company would admit me for examination in time for the election, knowing that they had granted a similar boon to my fellow-students on less important occasions. I have asked the favour of that Court with all due respect and ceremony, showing them that my course of study had already been twice as long as they require ; and they have refused to examine me till my last item of study was completed according to their own peculiar curriculum, without stating any reason for their refusal. I must therefore necessarily resign, which I beg most respectfully to do, and to offer my sincere thanks to all those who have taken trouble in my behalf,"

On the first Court of October 1838, held on October 4th of that year, Mr. Snow met the Blackfriars Shylocks by legal right. They had not forgotten him, and gave him good proof of their remembrances. He passed, however, safe and sound ; and, having the double qualification, laid himself out for the duties of a general practitioner in medicine in the great city.

At this time there existed in London a society (now sunken into the "Medical Society of London") called the "Westminster Medical Society." It was a society which had long given encouragement to those junior members of the medical profession who might wish for a hearing at its meetings and debates. Mr. Snow was not the man to lose an opportunity such as this. I have often heard him say, both privately and publicly, that, upon this early connexion with the "Westminster Medical," his continuance in London

depended, and all his succeeding scientific success. When he first attended the meetings of the "Westminster Medical," he was very timid; and although he always spoke to the point, found it difficult to obtain a favourable notice. At first, as he told me, nobody ever replied to what he said. After a long time some grave counsellor condescended to refer to him as the "last speaker". "In reference to an observation made by the last speaker, Mr. President, I could bring forward many practical objections; but I prefer to observe on the admirable, and, I have no hesitation in saying profound, remarks which Dr. Goldstick" (a very great gun, of course) "has done us the favour to lay before the society." A little later and somebody ventured to name the "last speaker" even by his name. Then some one, bolder still, concurred with Mr. Snow; and ultimately Mr. Snow became recognized more and more, until, as we shall see in the sequel, the presidential honours were his own.

Frith-street, Soho-square, No. 54, was the house at which Mr. Snow, to use his own words, first "nailed up his colours". He removed from Bateman's Buildings in the beginning of September 1838, and became, in Frith-street, the tenant of Mrs. Williamson, widow of Captain Williamson, known as the author of several works on India. He bought no practice, nor exhibited any pretence. Like mighty Columbus, his caravel was very insignificant when compared with the voyage on which he embarked, and through which he sailed so successfully. He did not find the voyage very smooth either at first. How could he? A man cast at large in the modern Babylon, with few introductions, no plethora of purse, and great purposes in hand, need never ignore the necessities from the idea of rising to the crest of the wave by three cheers and a long pull. Snow was too foreseeing to be ignorant of this, and he prepared accordingly. A more thoroughly girded man for the world's en-

counter could hardly be conceived than he at this time. He took no wine nor strong drink; he lived simply of the simple, on anchorite's fare, with more than anchorite resolution, with the temptations of the world always before him; he clothed plainly, and made the best of everything; he kept no company, and found every amusement in his science books, his experiments, in his business, and in simple exercise.

To fill up time till the money patients should come, he became one of the visitors of the out-patients of Charing Cross Hospital; and to many a poor representative of the great half-starved, extended a skill which would have been a blessing to a duke. The Librarian of the College of Surgeons' Library knew him as a quiet man, who read closely, and was not too proud to ask for a translation when an original bothered him. All who knew him said he was a quiet man, very reserved and peculiar—a clever man at bottom perchance, but not easy to be understood and very peculiar.

The connection with the "Westminster Medical" led to Mr. Snow's first attempts at authorship. On October the 16th, 1841, he read at the Society a paper on "Asphyxia and on the Resuscitation of new-born Children." The paper in full will be found in the *London Medical Gazette* for November the 5th of the same year. The paper is remarkable for the soundness of its reasonings, and the advanced knowledge which it displays. The object of the paper was to introduce to the Society a double air-pump, for supporting artificial respiration, invented by a Mr. Read, of Regent Circus. The instrument was so devised that by one action of the piston, the air in the lungs could be drawn into one of the cylinders, and by the reverse action, the said air could be driven away, and the lungs supplied with a stream of pure air from the second cylinder. There was also advanced, in the concluding part of the

communication, a sentence or two on the cause of the first inspiration, which is well worthy of note. The cause of the first inspiration, he explained, is probably the same as the second or the last, viz., a sensation or impression arising from a want of oxygen in the system. So long as the placenta performs its functions, the foetus is perfectly at ease, and feels no need of respiration ; but whenever this communication between the child and its mother is interrupted, at least in the later months of pregnancy, the child makes convulsive efforts at respiration similar to those made by a drowning animal.

On December the 18th, 1841, Mr. Snow was again before the "Westminster Medical" with a very ingenious instrument which he had invented for performing the operation of paracentesis of the thorax. The description of the instrument will be found in the *Medical Gazette* of January 28th, 1842.

In the *Medical Gazette* for November 11th, 1842, Mr. Snow published a note on a new mode for securing the removal of the placenta in cases of retention with hæmorrhage ; and in the same journal for March 3rd, 1843, he communicated an essay on the circulation in the capillary vessels. The essay was selected and rearranged from papers read before the "Westminster Medical" on January 21 and February the 4th. We have in this essay an admirable sketch of the capillary circulation. He advanced, on this occasion, the idea that the force of the heart is not alone sufficient to carry on the circulation, but that there is a force generated in the capillary system which assists the motion. He explained also the great importance of the cutaneous exhalation, and reasoned that in febrile states, accompanied with hot skin, the transpiration from the skin is in reality greater than is normal, and that the good effect of poultices and similar applications to inflamed skin is due to their influence in checking the transpiration from the affected part.

But what of practice during all this work at the purer science of medicine? The story to be told is an old one. Practice did not come, at least not from the wealthy. He had plenty of practice in so far as seeing patients was concerned certainly, for he was encumbered with four sick clubs; and his club practice, together with the out-patient work at the Charing Cross Hospital, kept the bell ringing all day, and not unfrequently enlivened the night with the clamorous music. But the patients with the fees in their hands kept at a respectful distance. Why? The answer gives another old story—because the practitioner at 54, Frith Street, Soho, was an earnest man, with not the least element of quackery in all his composition, with a retiring manner and a solid scepticism in relation to that routine malpractice which the people love. I have heard many reasons alleged for the want of success which attended Mr. Snow's first labours as a claimant on the public confidence. These reasons have all had one reading, in that they refer to every cause but the true one. The true cause was, that a young man having no personal introduction to the bedsides of dowagers of the pill-mania dynasty, sought to establish his fame on the basis of a sound and rational medicine—because impressed with the knowledge of the external origin of disease, he went in for the removal of external causes, and studied nature in preference to the Pharmacopœia.

Pushing on in the higher branches of his profession, and aiming always at the best, the degree of the University of London became a temptation, and *Mr.* became *Dr.* Snow on the 23rd of November, 1843, by passing the M.B. examination. He was enrolled in the second division on this occasion. On the 20th of December in the following year, he passed the M.D. examination, and came out in the first division of candidates.

The harass of London life by this time commenced

to tell on Dr. Snow. He had suffered a few years previously from threatened symptoms of phthisis pulmonalis, but took plenty of fresh air, and recovered. He again became slowly unhinged for work, and in the summer of 1845, was attacked with acute and alarming symptoms of renal disorder. His friend and neighbour, Mr. Peter Marshall, then of Greek Street, now of Bedford Square, gave him his able assistance, and the advice of Dr. Prout, and, I believe, of Dr. Bright, was obtained. He was induced by their general opinion to change his mode of living, and even to take wine in small quantities. In the autumn of 1845, he paid a visit to his friend and old colleague, Mr. Joshua Parsons, at Beckington, with whom he stayed a fortnight, enjoying himself very much. The friends resumed their old controversies, and the Doctor admitted that he had been obliged to relinquish his vegetable diet in favour of a mixed regimen. He improved greatly, says Mr. Parsons, during his stay ; but it was obvious that London life and hard study had hold of him. From Beckington he went to the Isle of Wight, but soon returned to London and to his work. A little after this, he was elected Lecturer on Forensic Medicine at the Aldersgate School of Medicine, and held the appointment till the establishment dissolved in 1849. I have often heard from him, in his quiet droll way, many laughable stories in relation to his duties in the forensic chair. When he left off teaching, he found that, in addition to the labour implied and the cost of experiments, he had to pay, with the rest of his colleagues, a ransom for his release.

There is no night without its morning. The eventful medical year of 1846 proved the turn of tide season with our struggling Esculapian. In this year, the news came over from America that operations could be performed without pain under the influence of sulphuric ether.

The fact was just such an one as would at once attract the earnest attention of Dr. Snow. It was a physiological, as well as a practical fact. It was rational in its meaning, and marvellously humane in its application. The question once before him, was in a scientific sense his own. His previous experimental studies on respiration and asphyxia had prepared him for this new inquiry. He lost no time, therefore, in investigating the new fact; he took it up for its own sake, however, not from any thought, at the time, of a harvest of gold.

The first inhalations of ether in this country were not so successful as to astonish all the surgeons, or to recommend etherization as a common practice. The distrust arose from the manner in which the agent was administered. Dr. Snow at once detected this circumstance; and, as he explains in the pages of the work now in the hands of the reader, remedied the mistake by making an improved inhaler. He next carried out many experiments on animals and on himself, and brought the administration to great perfection. One day, on coming out of one of the hospitals (I am giving the narrative as he gave it to me), he met Mr. — (a druggist whom he knew) bustling along with a large ether apparatus under his arm. "Good morning!" said Dr. Snow. "Good morning to you, doctor!" said the friend; "but, don't detain me, I am giving ether here and there and everywhere, and am getting quite into an ether practice. Good morning, doctor!" "Good morning to you!" Rather peculiar! said the doctor to himself; rather peculiar, certainly! for the man has not the remotest chemical or physiological idea on the subject. An "ether practice! If he can get an ether practice, perchance some scraps of the same thing might fall to a scientific unfortunate." Consequently, with his improved inhaler, Dr. Snow lost no time in asking to be allowed to give ether at St. George's Hospital. He got per-

mission to give it there to the out-patients, in cases of tooth-drawing. Dr. Fuller, of Manchester-square, standing by, was surprised to see with what happy effects ether was administered when administered properly. A day or two afterwards, an operation having to be performed, and the surgeon (I believe, Mr. Cutler) not approving of the ether in the way in which it had previously acted, Dr. Fuller remarked on the superiority of Dr. Snow's mode of administering it; and the result was, that he was asked to give it on operating days. He did so with great success. He administered it at University College with the same success. Liston, then the leading operator, struck with the new man who came before him in such an able and unaffected way, took him by the hand; and from that time the ether practice in London came almost exclusively to him. Science for once put assumption in its right place.

The new field once open, it were impossible but that he should cultivate it diligently. The Westminster Medical Society was often favoured with his communications and experiments on etherization; and in the September of 1847, he embodied, in his first work, the whole of his experience up to that time. The work was remarkable for the care with which it was written, the science which it displayed, and the complete mastery of the subject which it everywhere conveyed.

What had been a mere accidental discovery, I had almost said a lucky adventure, was turned by the touch of the master into a veritable science. The book was readily appreciated by the profession, and was just beginning to sell, when the discovery of the application of chloroform threw ether into the shade and the book with it.

Dr. Snow, though a man of great firmness when once his mind was made up, was always ready for new inquiry. Chloroform, therefore, was no

sooner brought before the profession by Dr. Simpson, than he began to institute a series of independent researches, and having satisfied himself personally as to the effects and greater practicability of chloroform, he at once commenced its use, and forgot sooner almost than others all predilections for ether. In 1848, he commenced a series of experimental papers on narcotic vapours in the *Medical Gazette*, and continued them until 1851, when the *Medical Gazette* virtually ceased to exist. The papers on narcotics, in accordance with his other and earlier productions, were stamped with the evidences of profound and careful research, and still more careful deduction. I infer that they have been more talked about than read, for few people seem to be aware of the enlarged and positive physiological arguments which they contain. Chloroform and ether are not alone discussed, but all narcotics. Narcotics are not alone considered, but various of the great functions of life. The records of a vast number and variety of experiments are here related, and an amount of information, original in kind, collected, which will always remain as a memorable record in the history of medical literature. But the great points in these papers are those in which the author enters on the physiological action of narcotics. Here appear the generalizations and insights into the relations of allied phenomena which mark the man of true power. His greatest deduction on these matters, and the proofs on which it is based, are to be found in his observations, where he explains that the action of the volatile narcotics is that of arresting or limiting those combinations between the oxygen of the arterial blood and the tissues of the body, which are essential to sensation, volition, and all the animal functions. He demonstrated that these substances modify and, in large quantities, arrest the animal functions in the

same way, and by the same power as that by which they modify and arrest combustion, the slow oxidation of phosphorus and other kinds of oxidation unconnected with the living body when they (the narcotics) are mixed with the atmospheric air.

In his modest way, he often spoke to me, with honest pride, on this observation. He himself thought it the best observation he had ever made, and believed that it would not be lost as an historical truth. Placing a taper, during one of our experiments, in a bottle through which chloroform vapour was diffused, and watching the declining flame, he once said, "There, now, is all that occurs in narcotism ; but to submit the candle to the action of the narcotic without extinguishing it altogether, you must neither expose it to much vapour at once, nor subject it to the vapour too long ; and this is all you can provide against in subjecting a man to the same influence. I could illustrate all the meaning of this great practical discovery of narcotism on a farthing candle, but I fear the experiment would be thought rather too commonplace."

The year of the world's fair in London, 1851, may be considered a fortunate one for Dr. Snow. His affairs had taken a new turn, and the tide was fairly in his favour. He had a positive holiday, physical and mental. The harass of the professional struggle was over, the world was opening its eyes to his intrinsic merits ; old friends flocked around him, brought to the grand show in town, and all was well. He did but little this year, except to write a characteristic letter to Lord Campbell, who was pushing on a bill in the House of Lords, called the "Prevention of Offences Bill," in which a clause was introduced to prevent, by severe punishment, any attempt that might be made by any person to administer chloroform or other stupifying drug for unlawful purposes. Dr. Snow, believing that Lord Campbell was actu-

ated in introducing this clause by the fact of certain trials having recently occurred for the offence of using chloroform unlawfully, and being himself convinced that, in two of the cases (the one the case of a robbery in Thrale-street; the other, of a robbery attempted on London Bridge), the evidence against the prisoners, of attempting to produce insensibility by chloroform, was without any reason or possibility, he opposed the afore named clause in the bill on the ground that if it became law numerous frivolous and false charges would be constantly brought up against innocent people, or against guilty persons, but persons not guilty of the special charge laid against them, that, namely, of administering a volatile narcotic by inhalation. Knowing that weakness of human nature which leads a man, in the presence of all evidence, never to admit intoxication as possible in his own proper person, Dr. Snow felt that, in any case where an intoxicated person had been robbed, such person might allege that he had been made insensible by narcotic vapour. The two cases specially noticed in his letter admitted readily of such interpretation, and were clearly not cases in which chloroform had been administered. Lord Campbell, on the receipt of Dr. Snow's letter, referred to it in very complimentary terms in the Lords', but intimated that the reasoning of the letter did not alter his determination. The editor of the *Medical Gazette*, Dr. Alfred Taylor, opened fire on Dr. Snow; and for two or three weeks a sharp contest occurred between the two doctors; but the matter soon rested, each author retaining his own opinions, and both agreeing to differ.

Dr. Snow's amiable but firm nature led him often to this ultimatum. Freedom of expression was a right he always claimed; but for this reason he extended the same privilege to others. He was never stirred into provocation by any difference of opinion.

It was enough for him to form carefully his own opinions, and then to hold to what he had said, so long as he felt, from his internal convictions, that he was right.

In the year 1848, Dr. Snow, in the midst of his other occupations, turned his thoughts to the questions of the cause and propagation of cholera. He argued in his own mind that the poison of cholera must be a poison acting on the alimentary canal by being brought into direct contact with the alimentary mucous surface, and not by the inhalation of any effluvium. In all known diseases, so he reasoned, in which the blood is poisoned in the first instance, there are developed certain general symptoms, such as rigors, headache, and quickened pulse; and these symptoms all precede any local demonstration of disease. But in cholera this rule is broken; the symptoms are primarily seated in the alimentary canal, and all the after symptoms of a general kind are the results of the flux from the canal. His inference from this was, that the poison of cholera is taken direct into the canal by the mouth. This view led him to consider the mediums through which the poison is conveyed, and the nature of the poison itself. Several circumstances lent their aid in referring him to water as the chief, though not the only, medium, and to the excreted matters from the patient already stricken with cholera, as the poison. He first broached these ideas to Drs. Garrod and Parkes, early in 1848; but feeling that his data were not sufficiently clear, he waited for several months, and having in 1849 obtained more reliable data, he published his views *in extenso* in a pamphlet entitled "The Mode of Communication of Cholera". During subsequent years, but specially during the great epidemic outbreak of the disease in London in 1854, intent to follow out his grand idea, he went systematically to his work. He laboured

personally with untiring zeal. No one but those who knew him intimately can conceive how he laboured, at what cost, and at what risk. Wherever cholera was visitant, there was he in the midst. For the time, he laid aside as much as possible the emoluments of practice ; and when even, by early rising and late taking rest, he found that all that might be learned was not, from the physical labour implied, within the grasp of one man, he paid for qualified labour. The result of his endeavours, in so far as scientific satisfaction is a realization, was truly realized, in the discovery of the statistical fact, that of 286 fatal attacks of cholera, in 1854, occurring in the south districts of the metropolis, where one water company, the Southwark and Vauxhall, supplied water charged with the London fæcal impurities, and another company, the Lambeth, supplied a pure water, the proportion of fatal cases to each 10,000 houses supplied by these waters, was to the Southwark and Vauxhall Company's water 71, to the Lambeth 5.

There was, however, another fact during this epidemic, which more than the rest drew attention to Dr. Snow's labours and deductions. In the latter part of August 1854, a terrific outbreak of cholera commenced in and about the neighbourhood of Broad-street, Golden-square. Within two hundred and fifty yards of the spot where Cambridge-street joins Broad-street, there were upwards of five hundred fatal attacks of cholera in ten days. To investigate this fearful epidemic was at once the self-imposed task of Dr. Snow. On the evening of Thursday, the 7th of September, the vestrymen of St. James's were sitting in solemn consultation on the causes of the visitation. They might well be solemn, for such a panic possibly never existed in London since the days of the great plague. People fled from their homes as from instant death, leaving behind

them, in their haste, all the mere matter which before they valued most. While, then, the vestrymen were in solemn deliberation, they were called to consider a new suggestion. A stranger had asked, in modest speech, for a brief hearing. Dr. Snow, the stranger in question, was admitted, and in few words explained his view of the "head and front of the offending". He had fixed his attention on the Broad-street pump as the source and centre of the calamity. He advised the removal of the pump-handle as the grand prescription. The vestry was incredulous, but had the good sense to carry out the advice. The pump-handle was removed, and the plague was stayed. There arose hereupon much discussion amongst the learned, much sneering and jeering even; for the pump-handle removal was a fact too great for the abstruse science men who wanted to discover the cause of a great natural phenomenon in some overwhelming scientific problem. But it matters little. Men with great thoughts in their heads, think of little things which little men cover with their wide-spread feet. It matters little, for the plague was stayed; and whoever will now read dispassionately the report of a committee, afterwards published by the vestry, and the demonstrative evidence of the Rev. Mr. Whitehead, will find that the labours and suggestion of Dr. Snow, in reference to the Broad-street epidemic of cholera, must become each day better and better appreciated, as time, which never yet told a lie, tells the tale and points the moral of the event which is here so imperfectly described. Some who, at first, were amongst those who held up the labours of our friend to ridicule, or passed them over in contemptuous silence, have, indeed, since modified their opinions, and have either tacitly accepted his facts, or have done far worse by attempting to put them forward as though they were the work of no single man, or of some one unknown, or as though their connection

with a theory destroyed the originality of the facts themselves. It was my privilege, during the life of Dr. Snow, to stand on his side. It is now my duty, in his death, as a biographer who feels that his work will not be lost, to claim for him not only the entire originality of the theory of the communication of cholera by the direct introduction of the excreted cholera poison into the alimentary system ; but, independently of that theory, the entire originality of the discovery of a connection between impure water supply and choleraic disease. The whole of his inquiries in regard to cholera were published in 1855, in the second edition of his work on the "Mode of Communication of Cholera"—a work in the preparation and publication of which he spent more than £200 in hard cash, and realized in return scarcely so many shillings.

In 1856, he made a visit to Paris in company with his uncle, Mr. Empson, who having personally known the present Emperor many years, had on this occasion special imperial favours shown to him, in which the nephew participated. During the visit, Dr. Snow lodged a copy of his work on Cholera at the "Institute", in competition for the prize of £1,200 offered for the discovery of a means for preventing or curing the disease. The decision of the judges has since been published, but no note seems to have been made of Dr. Snow's researches.

The Medical Society of London, reformed under that name in 1849-50, by amalgamation with the Westminster Medical, was at this time the principal scene of Dr. Snow's scientific exertions. In 1852, the Society elected him as Orator for the ensuing year ; and at the eightieth anniversary of the Society, held on March the 8th, at the Thatched House Tavern, he delivered an admirable oration on "Continuous Molecular Changes, more particularly in their Relation to Epidemic Diseases." He made no claim to the ora-

tor's gown; but the address was too forcible and first class not to call forth the enthusiasm of the audience. It was admirably received; and few of us who were present on that interesting occasion will forget the simple and genuine earnestness of our beloved associate, as in the twinkling twilight he carried us along with the smooth current of his thoughts. He spent nearly twelve months in the preparation of this oration. It was intended to convey, in the most pleasing manner at his command, a broad view of his observations on the communication of certain spreading diseases. He advanced, on this occasion, the idea that intermittent fever, and perhaps yellow fever, are, like cholera, carried by their poisons direct into the alimentary system.

Two years after this event, having, meantime, passed the office of vice-president, the Society elected him to the highest honour it can confer,—to the presidential chair. He took his place as President, in his unassuming manner, on March 10th, 1855, delivering a short but pleasing address. Throughout the year he carried out the duties of his office with great success. One of his presidential acts was peculiarly graceful. One evening, while presiding, Dr. Clutterbuck (then the father, or oldest member of the Society) came into the meeting. The venerable and distinguished old man, then long past his eightieth year, had lately been a stranger to the assembly, and was known but to few of the members. The President, as Dr. Clutterbuck entered the room, himself rose, and in a way that was irresistible in its simple courtesy resigned his chair to the veteran Esculapian. "It is near fifty years," said Dr. Clutterbuck with emotion, as he took the proffered seat, "since I last occupied this honourable position." At the next anniversary meeting, held on March the 8th, 1856, Dr. Clutterbuck came to his last meeting, and to see (so the fates willed it) his friend the President play also

his last part in presidential duties. At the anniversary dinner on that same day, the President reviewed, in feeling terms, his own career in the professional strife, and expressed that his success in life had originated in his acquaintance with the Society over which he then governed by the general will.

In addition to the fellowship of the Medical Society, Dr. Snow belonged to the Royal Medical and Chirurgical, Pathological, and Epidemiological societies. He was also a member of the British Medical Association. The Medical Society, from its old associations, was, however, that in which he took the most active part. Next to this, the Epidemiological Society claimed his regard. When Mr. Tucker first contemplated the formation of the Epidemiological Society, Dr. Snow was one of the first with whom he held consultation, and from whom he received that able support which enabled him to found that excellent institution. From the first of the Society, Dr. Snow was an active member. He was on many of its committees; he was a member of council, and a frequent contributor to its *Transactions*. He used often to meet with opponents to his peculiar opinions at the meetings of this Society, but he always retained friendships.

The position which he took as an epidemiologist was original, and in opposition to the views of many eminent men who had in the matters relating to public health considerable influence, scientific and political. He could not consequently, and did not, expect to go on his way unopposed. But he did sometimes expect a more deliberate and considerate attention to his hard wrought labours than he received or deserved. He used constantly, though no great professor of Shakespearian lore, to deplore the long admitted fact, that nothing so inevitably tends to transform an earnest inquiring and enthusiastic man, into a supercilious, superficial, and cold-hearted egotist, as translation from the stool of self-reliance

and independence, into the gilded chair of office and brief authority.

It must be admitted that Dr. Snow's views on the spread of epidemics were extreme in character ; but from the slight which they too hastily received, they were not, I believe, properly understood. It has often been said that he encouraged by his arguments the perpetuation of certain offensive arts and occupations which are injurious to the public health ; and in 1855, several journalists commented on him severely for this supposed error. But the fact is, he never presumed that any man could breathe with impunity other gaseous mixture than oxygen and nitrogen in atmospheric proportion. He knew too well the effect of inhaling chemical substances to allow of such supposition to enter his mind. But he contended, in regard to pure epidemic disorders, distinguished by specific symptoms, that these have a specific poison, which is propagated by certain fixed laws, which attains its progression and increase in and through animal bodies ; which is communicated from one animal body to another, and which is the same in its essence from first to last. This was his position, and he adhered to it. No mere emanation arising from evolution of foul smelling gas can, *per se*, according to his views, originate a specific disease, such as small-pox or scarlet-fever ; as well expect that the evolution of such gas should plant a plain with oaks or a garden with crocuses. True, small-pox may occur over a cesspool as an oak may spring up from a manure heap ; but the small-pox would never appear over the cesspool in the absence of its specific poison ; nor the oak rise from the manure heap in the absence of the acorn which seeded it.

In 1855, Dr. Snow gave evidence before the select committee on the "Public Health and Nuisances Removal Bill," in which evidence he strove to convey the impressions which are condensed above. Feel-

ing that he had not been correctly understood, he afterwards wrote a letter to Sir Benjamin Hall, in which he set forth the whole of his argument very distinctly and sensibly. He indicated in this letter that he was no defender of nuisances, but that whereas a bad smell cannot simply because it is a bad smell give rise to specific disease, so an offensive business conducted in a place where it ought not be should be proceeded against by ordinary law as a nuisance, without using in regard to it the word pestiferous, or otherwise dragging in and distorting the science of medicine. As time rolls on, it will probably be elicited that the groundwork of Dr. Snow's theory is sound. That if he committed error, it was in adhering too closely to the abstract fact, and in not allowing sufficient importance to the favouring influence of impure conditions in the propagation and distribution of the specific poisons of the specific diseases.

At all events, the view he had maintained originally, he maintained to the end, and throughout conscientiously ; and the aspersions that the object of his argument was to support his special theory regarding the communication of cholera, are utterly unfounded. In the present year, 1858, he read at the Epidemiological Society, and published in the *Medical Times and Gazette*, a repetition of his previous opinions, strengthening them by a statistical record, showing that the mortality of persons working at so-called offensive occupations is at certain ages lower, and at certain ages slightly higher, than in the general population. When the paper was read at the Epidemiological Society, Mr. Edwin Chadwick made a long series of objections to the paper, and complained that the argument was illogical. It was so, doubtless, on Mr. Chadwick's premises ; but on the premises advanced by Dr. Snow, as to the specific propagation of specific diseases by specific poisons, phy-

siological problems on which, from his experimental researches and knowledge, he was far the best authority, his arguments were perfectly logical, and perfectly consistent.

In relation to public health, Dr. Snow contributed many other observations. In the first number of the *Sanitary Review*, he communicated a valuable paper, previously read at the Epidemiological Society, on the "Comparative Mortality of Town and Rural Districts"; and, previous to his decease, he was busily occupied in investigating the question of adulteration of bread with alum. He made several analyses of different specimens of bread, but his papers merely leave a brief record of the fact, without any comments or results.

We return for a few moments to some further points connected with his researches on inhalation. In addition to his experiments with volatile narcotics, he carried out for a long time a series of inquiries with other medicinal substances, and administered many remedies by inhalation at the Brompton Hospital, during a period of twenty months. In 1851, he recorded the result of this experience at the Medical Society of London, and explained the modes of administering various agents. Some, as morphia and stramonium, were inhaled with the aid of heat; others, as hydrocyanic acid and conia, were inhaled at the ordinary temperature. The particulars of these experiments will be found in a short paper in the *London Journal of Medicine* for January 1851.

He continued steadily to investigate the effects of various volatile agents for the production of insensibility, and arrived by frequent experiment to such a degree of positive knowledge regarding agents of this class, that the composition and boiling point of any new chemical body having been supplied, he could predict whether or not its vapour would pro-

duce narcotism by inhalation. Other than the volatile narcotics referred to in his present essay, he performed a variety of experiments with carbonic acid, carbonic oxide, cyanogen, hydrocyanic acid, Dutch liquid, ammonia, nitrogen, amylovinic ether, puff-ball smoke, allyle, cyanide of ethyle, chloride of amyle, a carbo-hydrogen from Rangoon tar, a carbo-hydrogen coming over with amylene, and various combinations of these. His grand search was for a narcotic vapour which, having the physical properties and practicability of chloroform, should, in its physiological effects, resemble ether in not producing, by any accident of administration, paralysis of the heart. The fact that in almost every fatal case from chloroform the result had occurred from the action of the narcotic on the central organ of the circulation, was never absent from his thoughts. An agent having this effect, however intrinsically valuable, was not to be put in the hands of every person for administration. "There would be a great uproar," he remarked on one occasion, "if a student were to undertake on the operating table to tie the femoral artery, and were to open the femoral vein. Yet at some of our hospitals, the administration of chloroform has been entrusted to the porter, who would only grin in ignorance, if informed that each time his services were required, he performed the grand act of suspending for a time the oxidation of the whole body, and of inducing a temporary death; and who would tell you, if you asked him the composition of chloroform, that it was smelling stuff." He spoke this from no selfish feeling, but with that kind of regret which an educated engineer would feel, on referring to the fact of a railway porter who, knowing nothing of steam, how to put it on, when to take it off, or why it propelled, had mounted an engine and driven a host of confiding passengers to their destruction. This is the way in which he ex-

pressed himself, and it would be difficult to show that he was not correct.

Intent on the discovery of some new anæsthetic, which might be more safely entrusted to general use, Dr. Snow began, in 1856, to experiment with amylen. As usual, he went to work cautiously and with precision. First he ascertained the boiling point of the specimen supplied to him; then the point of saturation of air with the vapour at different temperatures; then the effects of inhalation of the vapour by inferior animals, and the quantity required to be inspired, with the air breathed, to produce insensibility. These were the usual steps in all his inquiries of this kind. When he had obtained any substance which would produce insensibility favourably on animals, he pushed it, in one or two experiments, to its extreme in animals of different kinds; and having produced death by the inhalation, both by giving rapidly a large dose, and by giving a small dose for a long period, he observed the mode of death, whether it occurred by cessation of the heart, or by cessation of the respiration primarily. If the agent seemed to promise favourably from these inquiries, he commenced to try it on man; and the first man was invariably his own self. His friends, knowing his unflinching courage in the ardour of his inquiries, often expostulated with him in regard to the risks he ran. It was of no avail. He felt the personal trial a duty, and he did it. I do not believe, as some have supposed, that these personal experiments had any effect in producing his early death; but it is certain that he underwent many risks in the performance of his investigations, and that he held his own life of least consideration when the lives or well-being of others were under consideration.

There is yet another trait in his character which I cannot but notice, and which I would respectfully commend to all physiological inquirers. While he

held it as a necessity to use inferior animals for the purpose of experiment, he never touched living thing with the physiologist's finger without having before him some definite object; and never performed experiment on any animal without providing with scrupulous care against the infliction of all unnecessary suffering. The interests of humanity were, according to his rule, best advanced by the practice of a humanity that was universal.

He paid considerable attention to the subject of local anæsthesia, and tried numerous methods for attaining to a knowledge of a perfect local anæsthetic. He performed experiments with freezing mixtures, with chloroform; and for the production of rapid and efficient benumbing by cold, he tried, in 1854, the effects of applying solid carbonic acid to the skin. At one of the meetings of the Medical Society, he reported at length the results he had arrived at; but he was never satisfied with them, and soon relinquished the inquiry, in order to concentrate his energies on the discovery of what he felt sure must be discovered ultimately,—an anæsthetic which might be inhaled with absolute safety, and which would destroy common sensation without destroying consciousness.

To some extent he succeeded in this latter direction, in his discovery of the physiological effects of amylene; and for some time he was sanguine as to the great safety of the new agent. But the deaths which he has so faithfully recorded as occurring in his own hands from amylene, removed his expectations, and he discontinued its use as soon as he learned the risks which might follow its administration.

By his earnest labours Dr. Snow soon acquired a professional reputation, in relation to his knowledge of the action of anæsthetics, which spread far and wide; and the people, through the profession, looked up to him from all ranks, as the guide to whom to en-

trust themselves in "Lethe's walk". On April the 7th, 1853, he administered chloroform to Her Majesty at the birth of the Prince Leopold. A note in his diary records the event. The inhalation lasted fifty-three minutes. The chloroform was given on a handkerchief, in fifteen minim doses; and the Queen expressed herself as greatly relieved by the administration. He had previously been consulted on the occasion of the birth of Prince Arthur, in 1850, but had not been called in to render his services. Previous to the birth of Prince Leopold, he had been honoured with an interview with His Royal Highness the Prince Albert, and returned much overjoyed with the Prince's kindness and great intelligence on the scientific points which had formed the subject of their conversation. On April 14th, 1857, another note in the diary records the fact of the second administration of chloroform to Her Majesty, at the birth of the Princess Beatrice. The chloroform again exerted its beneficent influence; and Her Majesty once more expressed herself as much satisfied with the result.

Inquisitive folk often overburthened Snow, after these events, with a multitude of questions of an unmeaning kind. He answered them all with good-natured reserve. "Her Majesty is a model patient," was his usual reply: a reply which, he once told me, seemed to answer every purpose, and was very true. One lady of an inquiring mind, to whom he was administering chloroform, got very loquacious during the period of excitement, and declared she would inhale no more of the vapour unless she were told what the Queen said, word for word, when she was taking it. Her Majesty, replied the dry doctor, asked no questions until she had breathed very much longer than you have; and if you will only go on in loyal imitation, I will tell you everything. The patient could not but follow the example held out to her. In

a few seconds she forget all about Queen, Lords, and Commons; and when the time came for a renewal of hostilities, found that her clever witness had gone home to his dinner, leaving her with the thirst for knowledge still on her tongue.

From the literary and general history of Dr. Snow, let us turn for a few pages to his history personal. I will take the mean of the last eight years of his life,—the period in which I knew him,—as the period from which to draw particulars. He was of middle size, and, some years since, slender; but of late he had become of slightly fuller build. His long life in comparative student loneliness had made him reserved in manner to strangers; but with private friends he was always open, and of sweet companionship. With his increased popularity he became less reserved to strangers; and within the last few years he so far threw off restraint as to visit the opera occasionally. But he moderated every enjoyment, and let nothing personal stand in the way of his scientific pursuits. He was the impersonation of order. He had his time and place for everything; he kept a diary, in which he recorded the particulars of every case in which he administered chloroform or other anæsthetic, with comments on the results of the administration, and hints as to dangers avoided or chanced. He kept a record of all his experiments, and short notes of observations made by his friends. He rose early, and retired early to rest,—at eleven o'clock. He seemed, whenever he was waited on, as though he had nothing in hand, and were always open to an engagement.

Anything and everything of scientific interest arrested his attention, and his kindness of heart was at all times in the foreground. When I was living at Mortlake, he would run down, on request, after his day's duties were over, to a *post-mortem*, to see a

poor patient, or to take part in an experiment, returning as cheerily as though he had been to receive the heaviest fee. I name this as but one example of his kindly nature ; there are many who could corroborate the example in like personal manner.

He laid no claim to eloquence, nor had he that gift. A peculiar huskiness of voice, indeed, rendered first hearings from him painful ; but this was soon felt less on acquaintance, and the ear once accustomed to the peculiarity, the mind was quickly interested in the matter of his discourse, for he always spoke earnestly, clearly, and to the point. In the societies he spoke very often, and gave expression to views, on which he had spent great thought, with a generous freedom which, in so far as the fame of his originality was concerned, had been better held in reserve. It had been better, that is to say, for him to have carefully elaborated some of his views in the closet, and published them fully, than to have sent them forth in the hurry of debate. Had he lived, he would possibly have collected many stray labours thus put forward, and have given to them the matured consideration which they deserved. One of his views, on which he would have bestowed great attention, refers to the origin of various morbid growths, as cancer. He believed that these morbid formations are all of local origin ; that they arise in the parts of the body where they are found, from some perversion of nutrition ; and that the constitutional effects are secondary to and dependent on the local disorder. He had made many observations on this important subject, notices of which are to be found scattered, here and there, in the proceedings of the Medical Society of London, but no connected record was ever completed.

His private conversation was both instructive and amusing ; he was full of humorous anecdotes, which he told in a quiet, and irresistibly droll style ;

and when he laughed, his goodnatured face laughed in every feature.* His anecdotes were never given in set form, but were elicited by some circumstance or other which might happen to suggest them. Once, when a friend of ours related at dinner some of the economical measures of an odd old doctor who was known to some of the company, he gave us an anecdote, showing how a man may work too hard for his money. "When I was a very young man," he said, "I went for a brief period to assist a gentleman who had a large parochial practice. I found his surgery in a very disorderly state, and thinking on my first day with him that I would enhance myself in his opinion by my industry, I set to work, as soon as his back was turned, to cleanse the Augean stable. I took off my coat, cleared out every drawer, relieved the counter of its unnecessary covering, relabelled the bottles, and got everything as clean as a new pin. When the doctor returned, he was quite taken by storm with the change, and commenced to prescribe in his day book. There was a patient who required a blister, and the worthy doctor, to make dispensing short, put his hand into a drawer to produce one. To his horror, the drawer was cleansed. Goodness! cried he, why where are all the blisters? The blisters, I replied, the blisters in that drawer? I burnt them all; they were old ones. Nay, my good fellow, was the answer, that is, the most extravagant act I ever heard of; such proceedings would ruin a parish doctor. Why, I make all my parochial people return their blisters when they have done with them. One good blister is enough for at least half a dozen patients. You must never do such a thing again, indeed you must not. I did not, for he and I soon found a good many miles of ground between us,

* Messrs. Maule and Polyblank have an excellent photographic portrait of Dr. Snow in their "Scientific Portrait Gallery" series. Mr. Empson has also a bust, which has been greatly admired for its correctness and for its superiority as an artistic work.

though we never had any more serious misunderstanding."

His replies, when under the fire of cross-question, were ready and commonsense. Once, he observed that in his opinion sulphuric ether was a safer narcotic than chloroform. Why, then, said a listener, do you not use ether? I use chloroform, he resumed, for the same reason that you use phosphorus matches instead of the tinder box. An occasional risk never stands in the way of ready applicability. On another occasion, after one of the meetings of the "Medical Society," when the subject of a specific cholera cell had been under debate, some one asked him, as a poser and rather ironically, where he thought the first cholera cell came from? "Exactly," he replied, with a droll face. "But to begin, do you tell *me* where the first tiger or the first upas tree came from; nay, tell me where you came from yourself, and I will then tell you the origin of the first cholera cell, and give you the full history of the first case; but I want a model before I venture on the description of ultimate facts."

As an author, his style was plain, clear, and smoothly elegant. His argument was always carefully studied and as carefully rendered. He sent manuscript to the printer which required scarcely a letter of correction. Both in writing and speaking, he made the expression of truth his first business. Neither provocation nor temptation could ever lead him aside from that principle. His readings were select. He chiefly read scientific works, old and new. He had great relish for some of the old medical writers—the masters in physic. He had read Bacon, but agreed with Harvey's criticism that Bacon wrote science like a lord chancellor. He had a notion that there had been a history long previous to any we know of from existing records, in which the sciences generally had risen to a greater perfection than they are at this present. His conversance

with Sprengel's *History of Medicine* had possibly led him to this opinion. He was fond of general history also, but studied it little. He never read novels, because the hours devoted to them were, he felt, hours thrown away. At the same time, he enjoyed as much as any man ridiculous life-pictures naturally cast. When he came to see me, and leisure was with us, I used often to read to him some of the more amusing passages from Dickens and Thackeray, or from one of the older writers, as Swift. It was a new world to him, and provoked great fun. He would ask to have passages read over again, that he might better realize the conception. He enjoyed vastly any anecdotes about the old men in physic, the Cullens and Meads and Arbuthnotts and Harveys. Any such anecdotes he took into his memory and never forgot them.

On such occasions I would, in ridiculous mood, sing him absurd songs to any tune, two or three tunes, or to no tune at all, and without any pretence at voice. At first he would listen with his hands flat together and with a perfect melancholy on his face, as if he could hear it no longer. Bit by bit he would relax, and at last get into a continued laughter. Then I would stop, and he would begin to open out his list of anecdotes, professional and general, upon which the laughter came over to me with compound interest, for of men enriched with stores of droll stories, few could equal him. Nor was he inventive in these narrations; he had simply observed character shrewdly, and described it in its humorous phases. If he had written as he related, he would have ranked as one of the humorists of the age of no second order.

He thought severely of the reviewer's art, and would never of late review any book critically. If a book were good, it carried the review of its own merits. If it were bad, it were better left untouched. He, at all events, with so much original work before

him, could not stop to criticize his compeers or their transactions. Let the dead bury their dead ; he must march with the living while life gave power.

Notwithstanding, he was fond of controversy and courted it. I expressed to him once some surprise that he with such an even temper should write so often in controversial style ; and that surely it were better to follow Harvey's and old Sam Johnson's plan, to do the best oneself, and leave the controversy altogether to others less personally influenced. He agreed that this was by far the best system, but did not think it practicable generally, and feared that silence might often be misinterpreted.

Men who have something in them take different courses in the way of accepting the world's recognition of their labours. The beginning, in most cases, is after a given pattern ; the end is modified and turned about variously, according to the stamp of the man. All start with an exaggerated appreciation of their own doings, and with exaggerated feelings respecting the critics who first notice them. The critic is Jove the all wise, or Pluto the all black. There was never middleman critic yet. Some men stop at the first, either too elated with the pleasure of the first reception to venture more, or too cast down from the pain of a sharp reception to tempt fortune further. Cowards these both, in one word. Others enter into violent controversies ; in the heat of the same, drop one or two contradictions, and, wishing every month that Cadmus had been still born, go on always at controversy, boring everybody, and especially those who would believe if not bored. Others, again, soon find their own level, and not only their own, but the level of their critics. Surfeited with commendation, or hardened by attacks, these care little for either, and make no retorts save such as are by ambuscade and go right home. A fourth class, of immovable temper and self-reliant, fall into what seems, superficially, indifference, but which

means, deeply, the soul of earnestness. These do always the best thing at the time, and, when it is done to their own satisfaction, put it forward, with no anxiety whatever as to what may be said of it, with no intention of entering into any defence of it, and with no intention of doing anything less than themselves correct all such errors in it as after knowledge may indicate, or commit it to the flames, if destruction be its best fate. Fatalists in letters, men of this class, if it be pleasure to call them so ; but great fatalists too—honest reviewers of their own works, who fear their own criticisms, and none other ; who offer immense labours, and die to them as they offer. Dr. Snow, as we have seen, was the representative rather of the controversial class of workers. But he had his own way of doing the controversy business, which saved friendships, and exhibited a firm principle and an exact knowledge. It is not to be denied, however, that, had he put his labours before the world, and trusted in them and on the world's justice, never replying a syllable, he would have avoided an extremity of argument which was often not merely unnecessary in relation to his propositions, but injurious to them, as reasonings overstrained.

He admired art, and felt real pleasure in advancing it. He enjoyed innocent recreations, and was ever at home in the family circle. He had his regrets that he had never married, the fates had been against him permanently on that score. He loved the prattle of children. When he went to court during last season, and had arrayed himself in his court suit, nothing connected with the event amused him so much as the saying of the child of a friend, who, on seeing him start, with his sword and flattened hat, held up her hands, and exclaimed : “ Oh ! isn't Dr. Snow *pretty*, mamma.” The idea of being considered pretty roused in him quite a new and droll sensation, which he could not help telling about as

a rare incident in a courtier's career. The anecdote is simple, but it gives a good idea of the simple and genial nature of the man.

It has been shown that the tendency of Dr. Snow's mind for philosophical pursuits led him away in some measure from the practical drudgery of professional life. From this fact, it has been too hastily inferred that he was therefore, in the common parlance, "not a practitioner." Those who knew him as a practitioner, who had had the advantage of his assistance in cases of doubt or difficulty, have a very different opinion. These speak of him, with one accord, as having been, without any ostentation, one of the soundest and most acute of our modern physicians. He had great tact in diagnosis; an observant eye, a ready ear, a sound judgment, a memory admirably stored with the recollection of cases bearing on the one in point, and a faculty of grouping together symptoms and foreshadowing results, which very few men possess. Mr. Peter Marshall, of Bedford Square, who often called in Dr. Snow in consultation, has remarked to me in nearly the same terms as I have expressed, his independent appreciation of Dr. Snow's practical knowledge. For my part, I never had the good fortune to put many fees into his pocket; but as I had often the pleasure of meeting him on pure scientific grounds in cases of interest, I can bear truthful testimony to his eminent qualities as a practitioner, and to the fact that his philosophical labours only served to render him more intelligent and profound in matters relating to diseases and their treatment. He did not become the idol of the people in common practice, far from it: but the failure arose not from deficiency of knowledge, but from a more perfect knowledge with assumption whipped out of it. It is no discredit to his memory that he was not the idol of the people in common practice, though it cost him much suffering to feel himself kept down, by that wisdom which is the oil

to the water of popular ignorance concerning life and its laws. For, to be the idol of the people in physic, is too often to be the Juggernaut of physic, —an idol of wood or of stone in showy gold and tinsel. This idol has neither sense nor force ; if it had, it were not an idol ; it would walk off, or tell the worshippers no longer to shake hands constantly with themselves in its presence.

But, when the opportunity offered for obtaining remunerative practice by the exercise of his scientific skill, Snow showed himself, both in act and industry, competent for success. He soon overcame all difficulties, and managed by his frugality to lay in store for a rainy day for himself, and to help such friends as needed. Many rumours as to the extent of his gains abound which it is right to correct. His income of late years was near £1,000 a year, but it never exceeded that sum. For this, he exhibited chloroform or one or other anæsthetic about four hundred and fifty times annually, taking an average of the ten years preceding his death. In a large number of these cases, however, his services were gratuitously supplied.

In his private relations, Dr. Snow was a man of the strictest integrity and purest honour. The experiences of life, instead of entwining about him the vices of the world, had weaned him from the world. Without any pretence, maintaining no connection with sect or party, living by the rules of the eternal laws which, according to the best of his abilities, he could read from the universe, he carried out a practical religion, independently of any hypothesis or abstruse profession, which few professors could approach. A child of nature, he knew no way of recognizing the Divine influences so purely as in silent and inexpressible admiration of those grand external phenomena which pharisees see not, but which each moment convey to men of his character,

the direct impression of a Power all present and revealing itself for ever.

We approach the end. In the midst of his success, when medicine most needed him and his hand was most powerful, he stood one day in his mental strength, and the next day fell. Death found him at his work, and the stern enemy came on him suddenly, though not without forewarnings.*

His health had long been indifferent; he had suffered from hæmatemesis several times in the last few years, for which Dr. Budd had attended him, and he had his own forebodings that his life was not of the longest. In the month of December 1857 he was suddenly seized one evening with vertigo and sickness, which compelled him to keep the recumbent position for more than twenty-four hours. At the end of this time he felt better, and went about his usual avocations. He had no convulsions at this time, nor did he lose his consciousness. After this attack, he complained on many different occasions, both to his housekeeper and to several of his medical friends, of numbness in his extremities. Some of these to whom he mentioned this circumstance, do not recollect whether this symptom was greater on one side of the body than on the other; while others distinctly state that it was referred to the left side only. His housekeeper was certain that he never complained of this numbness before the attack in December; and even afterwards, it would appear to have been only an occasional symptom. For six weeks before his final seizure he had made no mention of it. About three weeks before his last attack, he had complained, for some days, of a severe pain in the back of his head, which he himself considered

* Dr. Murchison, who with Dr. Budd rendered Dr. Snow all that able assistance which the best of medicine can offer, has kindly given me several particulars in regard to the fatal illness, which I embody in the text, with many thanks.

neuralgic, and for which he treated himself. This pain quite left him, and for about a fortnight he had been enjoying excellent health.

On the evening of Tuesday, June the 8th, 1858, he attended a meeting of the Royal Medical and Chirurgical Society. On the following evening there was a meeting of a private society for the study of chest diseases, held at Dr. Quain's. The subject discussed was the cause of the first sound of the heart. On this, the last occasion of the kind at which he was present, he was in unusual spirits, and looked exceedingly well. He entered into the debate with great earnestness, agreed to form one of a committee to inquire into the cause of the first sound by experiment, and left his friends with enthusiastic expression as to the success of the proposed undertaking. We exchanged our last farewells that night.

He went to bed at half-past eleven o'clock on June 9th, and on the following morning he came down stairs at 8 A.M. When he came down, he complained to his housekeeper of slight giddiness, and she thought he did not walk very steadily. He reclined on the sofa, and said that he should be well again in a few minutes, but that he did not think he could eat any breakfast. Soon after, however, he got up, said he felt very hungry, and ate a very hearty breakfast. When this was done, he proceeded to write a portion of the manuscript of the work on anæsthetics now published. He had written to the last printed sentence, when his housekeeper, who had scarcely left him, heard a great noise, as if some one had fallen. She ran up again and found her master on the floor, making vain endeavours to regain his chair. He does not appear to have had any convulsions, and his consciousness was unimpaired, for he remarked when his housekeeper came into the room, that though he did not quite understand the nature of his

complaint, he was very sure he never had had any such symptoms before. His housekeeper observed that he had quite lost all power over his left arm and leg, and that his mouth appeared drawn to the right side. She had him lifted on the sofa; and here he remained for twenty-four hours before any medical assistance was sent for. This was his own wish, as he said he should soon be better, and that he did not wish to trouble any one. During this period he complained much of pain over the lower end of the sternum, which he endeavoured to relieve by frequent inhalations of sulphuric ether, but he neither ate nor slept the whole time. At 6 A.M. on the morning of Friday, June 11th, retching came on, and he vomited a considerable quantity of blood. Upon this his housekeeper sent for Dr. Budd, who, along with Dr. Murchison, continued to attend him to the last. His symptoms, when seen by these gentlemen, were briefly as follows:—Complete paralysis of motion over the whole of the left side of the body, but without loss of sensibility; the left angle of the mouth falling down, and the apex of the tongue deviating to the left; memory and consciousness were unimpaired; there was pain and great tenderness in the epigastrium, with urgent hiccup and hæmatemesis; there were slight indications of albuminuria, but there were no dropsical symptoms.

The hæmatemesis ceased after about twenty-four hours, but the vomiting and hiccup continued. By Monday, the 14th, these symptoms also had subsided, but others of a more alarming nature began to show themselves. The pulse and respiration became accelerated, the countenance and extremities became livid, and there was occasional wandering delirium. These symptoms gradually increased in severity; but he retained his consciousness until 11 A.M. of Wednesday, June 16th, when the breathing became stertorous, and deglutition impossible.

Throughout his illness, he had been sanguine of recovery, and expressed his belief frequently that he should soon be at his professional work again. On this, the last morning of his life, the fact of the danger in which he was placed was explained. He met the intelligence with calmness, but felt a wish to see Dr. Todd. Soon he sank into a somnolent state approaching to dissolution, and at 3 P.M. death took him.*

On the Monday following, Dr. Snow was buried at the Brompton Cemetery. It was the wish of many of his medical friends to follow him to his last home. But his relations, recalling his own unostentatious feelings, laid him in the grave in simple ceremony; and there, ingenuous friend, in the sleep that knows no waking, he sleeps on and takes his rest; the rest he has earned. The old changes of the world live after him, women mourning for their children; youths exulting on the marriage day; the inanimate returning to the elements; the animate returning to the infinite. But in the gaping time shall it chance rarely, for another science-man to come and go, who, taking him all in all, may call him "brother"!

* Dr. Murchison has also given me an outline of the *post mortem* appearances, which is subjoined. "The *post mortem* examination revealed slight white softening, only detectable by the microscope, in the right corpus striatum and optic thalamus, and fatty degeneration of the minute cerebral vessels. The heart was slightly fatty, but there was no valvular disease, nor atheromatous disease of aorta. The lungs were congested, and showed marked evidence of old disease at the apices. Both the kidneys were much contracted and granular, with numerous cysts, the right organ being almost entirely converted into cysts; with the uriniferous tubes either denuded, or containing granular disintegrating epithelium. There was distinct cicatrix of an old ulcer in duodenum, and the stomach was much congested, with numerous hæmorrhagic spots."

HISTORICAL INTRODUCTION.

THE most important discovery that has been made in the practice of medicine since the introduction of vaccination, is, undoubtedly, the power of making persons perfectly insensible to the most painful surgical operations, by the inhalation of the vapours of ether, chloroform, and other agents of the same kind.

In giving a brief outline of this discovery, it is necessary to inquire into the attempts of every kind which had previously been made to prevent severe pain; and also to notice the history of medicinal inhalations, whether undertaken with the view of preventing pain, or of relieving or curing disease.

The practice of taking opium and other vegetable narcotics, to relieve pain or procure sleep, was common in the most remote periods to which history extends; but the earliest notices which remain of any attempts to prevent the pain of surgical operations were written at the period of the Roman Empire. They were alluded to by Dr. Simpson at the Medico-Chirurgical Society of Edinburgh in November, 1847.* Dioscorides,† speaking of mandragora, says, "Some persons boil the root in wine down to a third part, and preserve the decoction, of which they administer a cyathus (rather more than an ounce and a half) in want of sleep and severe pains of any part, and also before operations with the

* See Monthly Journal of Med. Sc., vol. viii, p. 452.

† Liber iv, cap. 76.?

† *vid.*, Matthioli. *Opera Medica*. (*Commentarii Matthioli medici in liber quantum Dioscoridi*) Cap. LXXI. (pg. 759.)

knife or the actual cautery, that they may not be felt." (Ante sectiones ustionesve, ut ne sentiantur.) Further on he says: "A wine is prepared from the bark of the root without boiling, and three pounds of it are put into a *cadus* (about eighteen gallons) of sweet wine, and three cyathi of this are given to those who require to be cut or cauterized: when being thrown into a deep sleep they do not feel any pain."

The same author also adds,* in speaking of a kind of mandragora called morion, "They relate that a drachm of it being taken as a draught, or eaten in a cake or other food, causes infatuation, and takes away the use of the reason. The person sleeps without sense, in the attitude in which he ate it, for three or four hours afterwards. Medical men also use it when they have to resort to cutting or burning."

In treating of mandragora, Pliny† remarks that the juice of the leaves is more powerful than the preparations made from the root. He says, "Some persons even die from a considerable draught. It has the power of causing sleep in those who take it. The dose is half a cyathus (six drachms). It is taken against serpents, and before cuttings and puncturings, lest they be felt. For these purposes it is sufficient for some persons to have sought sleep from the smell (of the medicine)."

Apuleius,‡ under the head mandragora, says, "If any one eat it he will immediately die, unless he be treated with butter and honey, and vomit quickly. Further, if any one is to have a limb mutilated, burnt, or sawn, he may drink half an ounce with wine, and whilst he sleeps the member may be cut off without any pain or sense."

After reading the above passages from such well-known authors, it may be asked how it was that the practice of

* Loc. cit.

+ Natural. Hist., lib. xxv, cap. 13.

‡ De Herbarum Virtutibus, cap. 131.

preventing the pain of surgical operations was entirely unknown just prior to 1846.

The reason, no doubt, was that the statement these passages contain was looked upon as a vulgar error of the period, which had imposed on the credulity of the authors. Dr. Woodville,* speaking of the use of mandragora by the ancients, says, "They employed it principally in continued watchings, and in those more painful and obstinate affections which were found to resist less powerful medicines." He gives, in a foot note, a reference to the place in Dioscorides from which the passages above quoted are taken, and had he believed in the performance of operations without pain, we may conclude he would not have passed over so important a fact in silence.

With the knowledge we at present possess, however, a different view must be taken of the subject; and it must at least be allowed that the statements of the ancients had some foundation in truth. This is rendered more certain by the circumstance that *atropa mandragora* belongs to the same genus as *belladonna*, which has a greater power in annulling the common sensibility than any plant in present use, unless it be *aconite*. The loss of reason, described by Dioscorides as caused by mandragora, is a striking symptom of poisoning by the class of plants (the *solanaceæ*) to which it belongs. It appears from some remarks of Aretæus† and Cælius Aurelianus‡ that people were in the habit of taking mandragora as an inebriating agent in the time of the ancients, as an allied plant, the *datura*, is used at present by the natives of India. This practice would lead to a correct knowledge of the quantity which might be taken with impunity.

The mandrake is scarcely used in medicine at present, but

* Medical Botany, p. 236. † De Causis Morb. Diut., lib. i, cap. 6.

‡ De Morbis Acutis, lib. i, cap. 4.

its narcotic properties are well established. Hoffberg* administered the root in doses of three grains in some cases of gout, with the effect of relieving the pain.

Cases of poisoning by belladonna end, with very few exceptions, in recovery, however large the dose, and however alarming the symptoms may be ; and, taking all the above circumstances into account, it is probable, that after ascertaining the right quantity to be administered for the purpose, this medicine or mandragora might be used, with considerable success, and no great danger, to prevent the pain of operations, if chemistry had not supplied us with agents much more convenient.

Not many ages after the Greek and Roman authors above quoted were describing the effects of mandrake in preventing the pain of operations, another plant, the Indian hemp, was employed for the same purpose in a more remote part of the world. M. Stanislas Julien, in an article on Chinese Medicine,† gives a notice of a work entitled “Koukin-i-tong, or a General Collection of Ancient and Modern Medicine,” in fifty volumes, 4to., and makes an extract from it respecting Hoa-tho, a practitioner, who flourished under the dynasty of Wei, between 220 and 230 of our era. Respecting Hoa-tho, it is stated that—“When he found that it was necessary to employ acupuncture, he applied it in two or three places ; he did the same with the moxa, if it was indicated by the nature of the affection which he had to treat. But if the malady was situated in parts on which the needle, the moxa, or liquid medicines could not act—for example, in the bones, in the medulla of the bones, in the stomach, or the intestines, he gave to the patient a preparation of hemp (Ma-yo), and, at the end of some instants, he became as insensible as if he had been drunk, or deprived of life. Then,

* Vet. Acad. Handl., 1763, vol. xxiv, p. 229.

† Comptes Rendus de l'Acad. de Sc., t. xxviii, 1849, p. 195.

according to the case, he made openings and incisions, performed amputations, and removed the cause of mischief; he then brought together the tissues with points of suture, and applied liniments. After a certain number of days (at the end of a month, according to the annals of the later Hân) the patient found himself re-established, without having experienced the slightest pain during the operation."

We are not informed of the way in which the hemp was administered. If insensibility was caused so quickly, as is stated, it must have been by inhaling the fumes of the hemp when exposed to heat, and not by taking it into the stomach. This view of the matter is rendered more probable by the circumstance that the ancient Scythians were in the habit of inhaling the fumes of hemp,* several centuries before the time of Hoa-tho, and also by the practice of the Hindoos at present, who inhale the fumes of hemp from a pipe. The remark that the patient became re-established at the end of a certain number of days, must refer to his recovery from the wound caused by the operation, and we are not informed how long the state of insensibility continued.

The next notice of any attempt to prevent the pain of operations, that I am aware of, occurs in the work on Surgery of Theodoric, an author who lived in Italy in the latter half of the thirteenth century. He writes as follows:† "The making of a flavour for performing surgical operations according to Dominus Hugo. It is thus made:—take of opium, of the juice of the unripe mulberry, of hyoscyamus, of the juice of hemlock, of the juice of the leaves of mandragora, of the juice of the woody ivy, of the juice of the forest mulberry, of the seeds of lettuce, of the seeds of the dock, which has large round apples, and of the water hemlock [cicuta]—each an ounce; mix all these in a brazen vessel,

* See Herodotus, book iv, 73-5.

† Lib. iv, cap. 8.

and then place in it a new sponge ; let the whole boil, as long as the sun lasts on the dog days, until the sponge consumes it all, and it is boiled away in it (the sponge). As oft as there shall be need of it, place this sponge in hot water for an hour, and let it be applied to the nostrils of him who is to be operated on, until he has fallen asleep ; and so let the surgery be performed. This being finished, in order to awaken him, apply another sponge, dipped in vinegar, frequently to the nose, or throw the juice of the root of fenugreek into the nostrils ; shortly he awakes."

I altogether disbelieve that a sponge, prepared as above, would, after being placed in hot water, give off any odour or vapour which would cause insensibility. The active ingredients, as they exist in the various plants, are not sufficiently volatile to be given off at a heat below that of boiling water. Hemlock, indeed, contains a volatile principle, which can be liberated by an alkali ; but, even if it were set free by any chance during the preparation of the sponge, it would all be dissipated by the long boiling.

If sleep were really caused in this way, it must have been by some of the moisture from the sponge reaching the mouth or throat, and being swallowed ; and it may be remarked that the author speaks of the preparation of a taste or flavour (*confectio saporis*), rather than an odour, although the sponge is certainly directed to be applied to the nostrils. It must be remarked, also, that if the patient were made so insensible, as not to feel the surgeon's knife, he would be little affected by vinegar, or the juice of fenugreek, in his nostrils.

Immediately after the prescription quoted above, and in the same paragraph with it, Theodoric gives another recipe from Master Hugo, directing antimony, quicksilver, soap, quick lime, and a little arsenic, to be sublimed together. A portion of the resulting compound, the size of a nut, is

directed to be placed over a hernia, or whatever else is to be operated on. Then follows a rather lengthy direction for subliming arsenic, also from Dominus Hugo. The arsenic so sublimed is described as rendering surgical operations extremely pleasant. The words are—"hæc acus fiat mitis et suavis: sicut sudor beatæ virginis quum peperit Christum."

I have applied arsenic to the skin for twenty-four hours, with no other effect than irritation, and an eruption of pimples, the sensibility of the part being increased; and in my opinion, arsenic would not cause insensibility, unless it were applied so long that the inflammation caused by it should end in gangrene. I consider that the statement of Theodoric, respecting arsenic, strengthens the doubts I have expressed concerning his *spongia somnifera*. There is another reason for disputing the efficiency of the above mentioned recipes. Theodoric directs the patients about to undergo operations to be tied, or held by strong men. In the operation for hernia, for instance, he directs the patient to be tied to the bench, or table, with three bands, one round the ankles, another round the thighs, and a third across the chest, holding the arms and hands. This circumstance is the more significant, since Theodoric had lived some time with Hugo, and seen his practice, as he states in the dedication to his work.

It is reasonable also to conclude that if any successful plan of preventing the pain of surgical operations had been introduced after the revival of literature, it would not have fallen into disuse and been forgotten.

In an interesting paper by Dr. Silvester,* an anecdote is quoted, with an intention to show that anæsthetics were commonly had recourse to in severe operations as late as the end of the seventeenth century. The quotation is from

* Med. Gaz., vol. xli, p. 515.

a German work by A. G. Meissner, called *Skizzen*, or Sketches, and published at Carlsruhe in 1782. It is as follows :—

“Augustus, King of Poland and Elector of Saxony, suffered from a wound in his foot, which threatened to mortify. The court medical men were opposed to the operation of amputation; but during sleep, induced by a certain potion surreptitiously administered, his favourite surgeon, Weiss, a pupil of Petit, of Paris, cut off the decaying parts. The royal patient was disturbed by the proceeding, and inquired what was being done, but on receiving a soothing answer he again fell asleep, and did not discover till the following morning, after his usual examination, that the operation of amputation had really been performed.”

It is most probable that the potion surreptitiously administered in this case, was an ordinary sleeping draught, and that only the “decaying parts” were cut off, as in fact is stated. The decaying parts of course would be without feeling.

The mind of surgeons seems now and then to have turned spontaneously towards preventing or alleviating the pain of operations, and certain attempts and suggestions were made with this object during the later part of the last century, in apparent ignorance of what had been done by the ancients in this direction.

Ambroise Tranquille Sassard, principal surgeon of the Hospital la Charité at Paris, recommended the employment of a narcotic previous to serious and painful operations, the dose to be proportioned to the age and strength of the patient.* He does not state whether the plan was actually tried.

Mr. James Moore, surgeon,† recommended compression

* Observations sur la Physique, tome xvi (1780), p. 256.

† Method of preventing or diminishing Pain in several Operations of Surgery. Lond. 1784.

of the large nerves, and tried it on a patient in St. George's Hospital, whose leg Mr. John Hunter amputated below the knee. The crural and sciatic nerves were compressed for nearly an hour by an instrument contrived for the purpose, and Mr. Moore considered that the greater part of the pain was prevented. The patient complained more of the sawing of the bone than of the cutting part of the operation. I am not aware whether this plan was tried in other instances, but it is certain that it did not come into general use.

M. le docteur Liégard (de Caen) has stated,* that the peasants in his part of France are in the habit of tying a band very tightly round the arm or leg before operations on the extremities. He had himself removed a toe nail in two cases, without pain, after a handkerchief had been tied very tightly round the lower part of the leg. By this measure both the nerves and blood vessels are, of course, more or less compressed.

The persons who believe in the existence of a force or power, which they call Mesmerism, or animal magnetism, made many and persevering efforts in recent times to cause insensibility to the surgeon's knife. In some cases they were imposed on by dishonest and designing patients, who afterwards confessed they had suffered the pain to which they had pretended to be insensible, but in other cases I have no doubt of the operations having really been performed without pain. Absence of consciousness and sensation is a common symptom in many cases of hysteria and catalepsy, and in certain susceptible persons, hysteria and catalepsy, or conditions nearly resembling them, can be induced by acting on the imagination, or by exhausting the attention by means of the fixed stare and monotonous "passes" of the so called Mesmerisers.

* Gazette des Hôpitaux, 1st April, 1854.

Dr. Esdaile was more successful in putting Hindoos to sleep, and operating on them in the hypnotized* state, than any one has been with Europeans: yet it was only in a portion of the cases in which it was tried that the alleged agent took effect. In many instances, efforts continued for two or three months had no effect on the patient; and in many of the operations, which were reported as successful, "there was much convulsive movement of the limbs, corrugation of the brows, and even loud cries and sobs," although the patients afterwards denied all knowledge of what had passed.†

The discovery of the means of preventing pain, which will occupy the greater number of the following pages, did not arise out of any of the attempts either in ancient or modern times above enumerated. It sprung directly from the practice of inhaling chemical and medicinal substances.

The custom of inhaling the fumes of narcotic plants existed at the very commencement of the historic period, as appears by the following passages from Herodotus. Speaking of the people who inhabited some small islands on the river Araxes, which flows into the Caspian Sea, he says,‡ "They add that they have discovered other trees that produce fruit of a peculiar kind, which the inhabitants, when they meet together in companies, and have lit a fire, throw on the fire as they sit round in a circle; and that by inhaling the fumes of the burning fruit that has been thrown on, they become intoxicated by the odour, just as the Greeks do by wine; and that the more fruit is thrown on, the more intoxicated they become, until they rise up to dance and betake themselves to singing."

* Hypnotism is the term employed by Mr. Braid of Manchester for the peculiar sleep produced by the Mesmerists.

† Record of Cases treated in the Mesmeric Hospital. Calcutta, 1848.

‡ Cary's Herodotus, book i, 202.

Again, when treating of the funeral ceremonies of the Scythians, he says,* “When they have set up three pieces of wood, leaning against each other, they extend round them woollen cloths; and having joined them together as closely as possible, they throw red-hot stones into a vessel placed in the middle of the pieces of wood and the cloths. They have a sort of hemp growing in this country very like flax, except in thickness and height; in this respect the hemp is far superior: it grows both spontaneously and from cultivation; and from it the Thracians make garments very like linen, nor would any one who is not well skilled in such matters distinguish whether they are made of flax or hemp, but a person who has never seen this hemp would think the garment was made of flax. When, therefore, the Scythians have taken some seed of this hemp, they creep under the cloths, and then put the seed on the red-hot stones; but this, being put on, smokes, and produces such a steam, that no Grecian vapour-bath would surpass it. The Scythians, transported with the vapour, shout aloud; and this serves them instead of washing, for they never bathe the body in water.”

Mental illusions of all kinds have frequently been looked on as divine revelations, not only by savages, but even by nations having a considerable amount of civilization. The priestess at Delphos became intoxicated with the fumes of narcotic plants before delivering her oracular responses, and it is a curious circumstance that when America was discovered by Columbus, it was the custom of the Indians to throw tobacco on the fire during their religious ceremonies, when the piaches, or priests, who officiated, were thrown into a state of ecstatic inebriation by the smoke they inhaled.

I have already stated my belief that the Indian hemp ad-

* Book iv, 73-5.

ministered, previous to surgical operations, in China, by Hoa Tho, in the beginning of the third century of our era, was exhibited by inhalation.

The fumes of various narcotic plants are inhaled by eastern nations at present, for smoking in the east is an entirely different process from smoking in the west of Europe, where the fumes of tobacco are merely drawn into the mouth and then puffed out again. In Asia and some of the eastern parts of Europe, the fumes of opium, tobacco, datura, Indian hemp, or whatever else is smoked, are always inhaled into the lungs.

John Baptista Porta of Naples makes the following statement in his work on Natural Magic,* published in 1597:—

“At last shall be related a wonderful method by which any sleeping person may inhale a soporific medicine. From what we have said, any one will easily know that he is liable to suffer severely after sleep caused by medicine, and to have his suspicions aroused.

“But the quintessence is extracted from a number of the above named medicines by somniferous menstrua. This is put into leaden vessels perfectly closed, lest the least aura should escape, for the medicine would vanish away. When it is used, the cover being removed, it is applied to the nostrils of the sleeping person, he draws in the most subtile power of the vapour by smellings, and so blocks up the fortress of the senses that he is plunged into the most profound sleep, and cannot be roused without the greatest effort. After the sleep, no heaviness of the head remains, nor any suspicion of trick or fraud. These things are plain to the skilful physician, but unintelligible to the wicked.”

The author does not make known what the “somniferis menstruis” were, with which the “quinta essentia” were extracted. As sulphuric ether had been described more than fifty

* Liber viii, cap. 1.

years before he published his work, it is not improbable that this was the evanescent substance which required to be so carefully closed up, and that the profound sleep was simply caused by this, as the narcotic principles dissolved in it would remain in the bottle in the form of extracts. The benefit of inhalation has been frequently attributed to medicines which were supposed to be inhaled, when it was really due to the menstruum in which the medicines were dissolved. This often happens at present when the menstruum is merely water. Baptista Porta does not say that operations were performed under the influence of the inhalation, or, in fact, that it was applied to any useful purpose whatever.

The Persian Pharmacopœia* contains some recipes for fumigation, called bouc-houri, that were inhaled, for the medicines are directed to be made up into balls or cubes which are to be placed on the live coals, and the head is to be held over them. Some of the prescriptions contain myrrh, camphor, mace, and storax, and are for the cure of coryza and catarrh; one containing musk, camphor, guaiacum, etc., is said to comfort the brain and intellect, and to be useful in palpitation of the heart, faintness, and debility of the senses. This Pharmacopœia also contains† a “remedium odorativum somniferum”, which consists of opium and camphor, besides the seeds of roses and the root of mandragora. The ingredients are to be powdered and put in a box, for the purpose of being smelt at. There is also‡ a stupifying remedy prepared with five drachms of opium and ten drachms of black poppy, which are directed to be boiled to dryness in water with a pound of wheat, and then powdered. It is added that whoever shall take a drachm and a half of this wheat will be alienated from his senses. With regard

* Translated into Latin by Father Angelus, Paris, 1681, p. 21.

+ P. 287.

‡ P. 98.

to the last but one of the above prescriptions—that to be put in a box for smelling, it may be observed that, as heat was not applied, the only ingredient which would produce any effect is the camphor.

The discoveries of Cavendish, Priestley, Lavoisier, and others respecting the nature of atmospheric air and the more important gases, gave an impetus to medicinal inhalations, at the latter part of the last century. Dr. Beddoes, in particular, distinguished himself by the administration of oxygen, hydrogen, carbonic acid, and other gases, in consumption and various diseases. Dr. Richard Pearson exhibited the vapour of ether in consumption with some advantage in the year 1795.* Three years afterwards, a medical pneumatic institution was established at Bristol, by the exertions of Dr. Beddoes and others. The celebrated Humphrey Davy was the superintendent. This establishment was not very successful in the immediate objects for which it was instituted, but Davy made at this place his masterly researches concerning nitrous oxide gas. In the course of his experiments, he found that severe pain arising from inflammation of his gums was relieved by breathing this gas, and he published the following opinion:—

“As nitrous oxide in its extensive operation seems capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place.”†

This suggestion of Sir Humphrey Davy was not acted on either by himself or any other person for nearly half a century, when the late Mr. Horace Wells, Surgeon Dentist of Hartford, Connecticut, having witnessed the exhibition of nitrous oxide gas by a public lecturer, named G. Q. Colston, was induced, in consequence of what he saw of its effects, to

* See Medicinal Use of Different Kinds of Airs, by Dr. Pearson. Birmingham, 1795.

+ Researches concerning Nitrous Oxide, p. 556.

request Mr. Colston to accompany him to his office and exhibit the gas to him, whilst another dentist, named Dr. Riggs, extracted a tooth for him which was troublesome. The tooth was extracted without pain, and Mr. Wells, after the effect of the gas had subsided, exclaimed, "A new era in tooth pulling." This took place on December 11th, 1844.* Mr. Wells administered the nitrous oxide in thirteen or fourteen cases of tooth drawing in Hartford with a success more or less complete, and before the end of the year he repaired to Boston to introduce his discovery to the professors at the Massachusetts General Hospital. He called on Drs. Warren and Hayward, who invited him to exhibit the gas to one of the patients, who was expecting to have a limb amputated. He remained two or three days in Boston, but the patient decided not to have the operation performed at that time. The nitrous oxide was consequently tried on an individual who required to have a tooth extracted. This patient felt some pain, and the application was considered to be a failure. It is worthy of remark that Drs. Charles T. Jackson, and W. T. G. Morton, were present on this occasion. Mr. Wells returned to Hartford in disappointment. He expressed his opinion to his friends that the nitrous oxide gas was uncertain in its action, and not to be relied on; and he altogether abandoned the use of it until some time after Dr. Morton's discovery of the effects of sulphuric ether in preventing pain.

As long ago as 1818 an article, which is believed to have been written by Mr. Faraday, appeared in the *Quarterly Journal of Science and Arts*,† describing the great resemblance between the effects of the vapour of ether and nitrous oxide gas. This circumstance has since been published in all the standard works on chemistry; and it was the annual

* See 32nd Congress, 2nd Session [Senate] Rep. Com. No. 421, p. 17.

† Vol. iv, p. 158.

custom of the late Professor Turner, of University College, London, to pour a little ether into a bladder of air, and allow some of the students to inhale the vapour. The same practice prevailed, more or less, in other colleges, both in Europe and America, when the lecture on ether was delivered. The resemblance between the action of nitrous oxide and that of vapour of ether was therefore extensively known.

Dr. Morton, surgeon dentist of Boston, in America, administered sulphuric ether, by inhalation, to a man in his office, on the 30th of September, 1846, and extracted a tooth without causing any pain. He applied the ether in several cases of a similar kind during the next few days. Having obtained the permission of Dr. J. C. Warren, he administered it to a patient in the Massachusetts General Hospital, on whom that surgeon performed an operation on the neck. On the following day, Dr. Morton exhibited ether to a woman in the same hospital, whilst Dr. Hayward removed a large fatty tumour from the arm, and after this date it was frequently administered.

Dr. Morton was well acquainted with Mr. Horace Wells, before alluded to, and had been in partnership with him. Before administering the ether to his patient in September 30th, Dr. Morton had a conversation with Dr. Charles J. Jackson, Professor of Chemistry, respecting the safety and propriety of the application, and the names of these gentlemen were associated in a patent which they took out for the discovery. Dr. Jackson asserts that Dr. Morton knew nothing of the effects of the vapour of ether till he gave him the information; whilst the latter says it was his intention to use the ether before he went into Dr. Jackson's laboratory. It seems impossible to arrive at the exact truth on this point, but it is admitted on all hands, that Morton was the first who administered ether to prevent

the pain of an operation. Dr. Jackson* has indeed claimed the whole merit of the discovery, on the ground of the alleged information he gave to Dr. Morton; but, if every word Dr. Jackson says be admitted, it only appears that he suggested the use of ether to Dr. Morton, just as Sir Humphry Davy had suggested the use of nitrous oxide to all the world in the year 1800. Dr. Jackson had inhaled ether as hundreds of others had done, and being aware of Davy's suggestion of nitrous oxide for preventing the pain of operations, he concluded that ether might also have that effect.

It will be shown further on that Mr. Waldie, of Liverpool, had a greater share in the introduction of chloroform than Dr. Jackson had in the introduction of ether—even supposing that Dr. Morton was previously quite ignorant of that medicine; for when he informed Dr. Simpson of the existence and nature of chloroform, he was able to give him, not merely an opinion, but an almost certain knowledge of its effects; yet Dr. Simpson is justly considered to be the person who discovered and introduced the use of undiluted chloroform as a substitute for ether.

The practice of the ancients in giving mandragora and Indian hemp has no connection with the recent discovery for preventing the pain of operations, which may be briefly related as follows:—Sir Humphry Davy made the suggestion that nitrous oxide gas might be employed for this purpose, and, at the end of forty-four years, Mr. Horace Wells carried this suggestion into practice, but failed to bring the nitrous oxide into general use, and gave the matter up. Two years later, Dr. Morton, who was well acquainted with the efforts of Mr. Wells, applied the vapour of ether, which was already known to resemble nitrous oxide in its action. He succeeded completely in preventing the pain of operations, and

* A Defence of Dr. Charles T. Jackson's Claims to the Discovery of Etherization. Boston, 1848.

in bringing his discovery into general use throughout the civilized world. In a short time the inhalation of ether was found to be so safe and certain in its action, and to prevent the pain of operations so entirely, that the most ardent imagination could scarcely conceive that anything further could be desired in this direction.

Dr. Morton withheld at first the name of the agent he was employing, but its strong and peculiar odour revealed it so plainly that concealment was impossible. Dr. Bigelow, of Boston, having tried sulphuric ether, and found it to produce all the effects of the so-called letheon, he made the subject known, not only to his own countrymen, but also by letter to Dr. Boot of London. The first operation under the influence of ether on this side of the Atlantic, was the extraction of a tooth, at the house of Dr. Boot, on Dec. 19th, 1846. Mr. Robinson, of Gower Street, administered the ether and performed the operation. The patient was a lady, named Miss Lonsdale. The ether was quite successful in preventing the pain in this case, as well as in two operations performed at University College two days afterwards, by the late Mr. Liston. These operations were amputation of the thigh, and evulsion on both sides of the great toe nail. The ether was given by Mr. Squire, of Oxford Street, with an apparatus which he contrived for the occasion.

Considerable opposition was made to the inhalation of ether in America, soon after its introduction, and it seemed likely to fall into disuse, when the news of its successful employment in the operations of Mr. Liston, and others in London, caused the practice of etherization to revive. Mr. Robinson, dentist, gave much time and attention to the exhibition of ether in London on its first introduction, and was on the whole very successful. This was not generally the case, however, with other operators during the first six weeks of the new practice. Owing to imperfections in the

inhalers employed and in the method of using them, the ether often either failed altogether or only made the patient partly insensible ; and Mr. Liston, and some other surgeons, were inclined to discountenance the use of it, in consequence of the struggles and cries of patients to whom it had been administered.

It soon became apparent, however, that the vapour of ether was capable of inducing a state of perfect quietude, with entire absence of pain, during all kinds of surgical operations. From the 28th of January the ether produced the desired effect in every operation that was performed in St. George's Hospital, until the time when chloroform was introduced as a substitute for this agent.*

Ether was employed in Paris a few days after its first application in London, and in a short time it was in use nearly all over the world.

On the 19th of January 1847, just a month after the first application of ether for the prevention of pain on this side of the Atlantic, Dr. Simpson of Edinburgh administered the vapour in a case of labour, and ascertained that it was capable of removing the sufferings of the patient without interfering with the process of parturition. Etherization was soon afterwards employed in the reduction of strangulated hernia and dislocations of the femur and humerus, some of them of long standing. It was also used with advantage in neuralgia, tetanus, and the convulsions of infants, and it became more and more general in surgical operations.

No great improvement in the practice of medicine was probably ever established so readily as the inhalation of ether for the prevention of pain. Yet it met with stout opposition in certain quarters, and when a serious operation

* The Inhalation of the Vapour of Ether in Surgical Operations. By John Snow, M.D. 1847.

in which ether had been used terminated unfavourably, there were those who attributed the patient's death to the new practice, although numerous other patients had sunk in exactly the same manner long before ether was used. In one of these cases a coroner's inquest was held, and the jury returned a verdict that the death of the deceased was caused by the inhalation of ether, although the patient had not even been made insensible by it, had felt all the pain of the operation, which was retarded by her struggles, and did not die till the third day. Notwithstanding a certain amount of opposition and mistrust, the inhalation of ether was becoming more general in the course of the year 1847, and there is every reason to conclude that it would very soon have obtained the complete confidence of the medical profession and the public, had it not been for circumstances which must next be considered.

A medicine called chloric ether has been in use since 1831. It consists of a solution of chloroform in spirits of wine. It is somewhat variable in strength, but usually contains about twelve per cent. of its volume of chloroform. Dr. Henry Jacob Bigelow of Boston tried this by inhalation, as well as other substances, when Dr. Morton first used sulphuric ether, but he did not succeed with it in causing insensibility to pain. Mr. Jacob Bell of London tried the chloric ether in the beginning of 1847, and succeeded in causing insensibility with it in some cases.* After this time the chloric ether was exhibited occasionally in St. Bartholomew's and the Middlesex hospitals, and in the private practice of Mr. Lawrence, but it did not come into general use, owing to its expense, and its frequently failing to cause insensibility.

The relation of chloroform to chloric ether is exactly the

* *Pharmaceutical Journal*, Feb. 1847, p. 357; and *Med. Gaz.*, 1847, vol. xi, p. 939.

same as that of opium to laudanum, and no one acquainted with this circumstance could doubt for a moment that chloroform inhaled alone would produce the effects which it did when inhaled from its solution in spirit; the only uncertainty about the matter that could possibly exist would be whether it might not be too strong for use in its undiluted state.

The true nature of the so called chloric ether was, however, known to very few persons. It did not enter into the pharmacopœias, and it was mentioned in very few of the works on materia medica. I examined a specimen of it, and found that its properties when inhaled were due to a volatile body containing chlorine, which evaporated first, leaving a great quantity of spirits of wine behind. I concluded that the volatile body was hydrochloric ether, and as this article is so volatile that it exists in the form of gas except in comparatively cold weather, and consequently could not be conveniently used for inhalation, I did not consider the matter any further. M. Flourens had indeed experimented on animals with undiluted chloroform, but was so struck with its great and dangerous power, that he was far from recommending its use in surgical practice.

It was left for Dr. Simpson of Edinburgh, who had already the merit of having discovered the use of inhalation in midwifery, to be the first to administer chloroform in an undiluted state, and to recommend it successfully for general use. Mr. Waldie, of the Apothecaries' Hall of Liverpool, first mentioned chloroform to Dr. Simpson, as the latter states in a foot-note to his first pamphlet on the subject. Mr. Waldie has given the following account of the circumstance in a pamphlet on chloroform.*

“When in Scotland, in October last, Dr. Simpson introduced the subject to me, inquiring if I knew anything likely

* Quoted in Med. Gaz., 1847, vol. xl, p. 1153.

to answer. Chloric ether was mentioned during the conversation; and, being well acquainted with its composition, and with the volatility, agreeable flavour, and medicinal properties of the chloroform, I recommended him to try *it*, promising to prepare some after my return to Liverpool, and to send it to him. Other engagements and various impediments prevented me from doing this so soon as I should have wished; and in the meantime Dr. Simpson, having procured some in Edinburgh, obtained the results which he communicated to the Medico-Chirurgical Society of Edinburgh on the 10th of November, and which he published in a pamphlet entitled—‘Notice of a New Anaesthetic Agent as a Substitute for Sulphuric Ether in Surgery and Midwifery.’”

Dr. Simpson’s first experiments with chloroform were made in the early part of November 1847, and his pamphlet on the subject, which was published on the 15th of that month, had a wide circulation, and created great interest. Chloroform was immediately used everywhere to a greater extent than ether had been. An impression became very prevalent that chloroform was safer than ether. This impression arose rather from the general tenour of Dr. Simpson’s essay than from any direct statement, for he had not treated on this point.

The great strength of chloroform as compared with ether, and the extreme care required in its use, were indeed soon pointed out;* these precautions, however, attracted but little attention till the first death from chloroform occurred near Newcastle on the 28th January, 1848. Ether was exhibited by inhalation during eleven months in Europe, and about sixteen months in America, before chloroform was introduced. During all this time no death was occasioned by its use, if we except one at Auxerre in France,

* *Lancet*, Nov. 27, 1847, p. 575; and *Med. Gaz.*, 1847, vol. xl, p. 1031.

which appeared to be occasioned by want of air, owing to an imperfect inhaler, and not to the effect of ether. Chloroform had only been employed between two and three months when the above mentioned death occurred, and this was soon followed by others in nearly all parts of the world. These accidents have prevented many persons from inhaling chloroform, and they have prevented a still greater number from enjoying that freedom from anxiety and apprehension before an operation, which ought to be one of the greatest advantages of any plan for preventing pain. As chloroform possesses advantages over ether, in being more convenient and less disagreeable, it continues to be used, to the exclusion of the latter agent, in most parts of the world. In the Massachusetts General Hospital, however, where sulphuric ether was first employed, it was resumed three or four years ago, and the use of chloroform was prohibited by the governors, on account of two accidents from it. Ether is also employed out of the hospital, both in surgical and obstetric practice, in Boston and the neighbourhood; and I have been informed that this is also the case in Philadelphia, whilst in the state of New York both chloroform and ether are employed. I learned last year that ether was the agent employed for causing insensibility at Naples and at Lyons.

Several volatile substances have been tried in a few cases with the effect of causing insensibility, since the introduction of chloroform, but none of them came into use except amylene, which was first employed by me in King's College Hospital in November 1856, after I had made several experiments on animals with it, and inhaled small quantities of it myself. I have administered it in a great number of operations already, and find it to possess certain advantages over chloroform in the greater number of cases. Although it has not yet been generally employed in this country, it

has been used extensively in Paris, Strasbourg, Lyons, and other places on the continent, with very favourable results.

It is not improbable that, amongst the multitudes of new bodies which chemistry makes known every year, some agent may be found superior to those hitherto used ; and besides the great practical advantages which are directly derived from the discovery of inhalation for the prevention of pain, the method of breathing medicinal substances in the gaseous state offers great facilities for the investigation of their effects, and cannot fail to hasten the time when the mode of action of medicines will be a branch of exact knowledge.

INHALATION OF CHLOROFORM, ETC.

GENERAL REMARKS ON INHALATION.

INHALATION is simply the act of breathing, or at least so much of it as consists of inspiring, or drawing the air into the lungs. The term is usually applied when any medicinal substance is added to the air which the patient breathes, and the process is altogether different from that called "smoking," as practised by the nations of western Europe and of America, where the fumes of tobacco are merely drawn into the mouth and puffed out again. The eastern nations, however, always inhale when they smoke, as was stated before (page 12). This process of inhaling smoke, as I first witnessed it in a gentleman connected with one of the eastern embassies to this metropolis, is very instructive, as showing that the lungs become emptied of their contents by three rather full expirations and inspirations. When this gentleman took the cigar from his mouth to speak, the smoke could be seen issuing thickly with each word till there was a momentary pause as he took a fresh inspiration, then the smoke could be seen issuing with each word as before, only not so thick, and after another inspiration, the smoke could be still perceived in the expired air, but in a very diluted state; but after a third inspiration, it could no longer be seen till he had resumed the cigar.

The following are the chief reasons for resorting to inhalation.

1. Certain agents, as nitrous oxide and oxygen, being permanently in the gaseous form, cannot be administered in any other way.

2. By taking advantage of the immense surface of the air cells of the lungs for absorption, a more sudden and profound effect may be produced by medicine than it would be safe, or, in some cases, even possible to produce in any other way. It is to this circumstance, and to the rapidity with which certain volatile medicines exhale in the breath, and leave the patient free from their effects, that the power of preventing the pain of surgical operations is due.

3. Many medicines which have a disagreeable taste—as turpentine, creasote, and camphor—are not unpleasant when inhaled in the form of vapour; and the process of digestion is less interfered with than by taking them into the stomach.

4. Medicines, such as benzoic acid, and some of the gum-resins, which are believed to exert a local action on the mucous membrane of the air-passages, may be expected to have a greater effect when inhaled, than when they are taken into the stomach in the same doses, and reach the lungs only through the circulation.

5. Some agents, as chlorine and ammonia, have a local action when inhaled, which they could not exert if exhibited in any other way.

In every kind of inhalation, the breathing should be allowed to go on freely, and in the natural way.

Medicines may be inhaled either at the ordinary temperature, or with the aid of artificial heat; and in the latter case they may be breathed with the addition of vapour of water, or with only so much of it as is naturally present in the atmosphere. The medicines in use for the prevention of severe pain, are always inhaled at the ordinary temperature.

CHLOROFORM.

History and Composition. Chloroform was first made in 1831 by two chemists who operated independently of each other. The liquid, which is formed by the union of equal volumes of chlorine and olefiant gas, and which is usually called Dutch liquid, was named chloric ether by Dr. Thos. Thomson (*System of Chemistry*, 6th ed., 1820). In consequence of a statement in Silliman's *Elements of Chemistry*, that the alcoholic solution of this chloric ether was useful in medicine as a diffusible stimulant, Mr. Guthrie, an American chemist, attempted an easy method of obtaining it.* He distilled together chloride of lime and alcohol, and he considered that the product he had obtained was an alcoholic solution of the chloric ether of Dr. Thomson,† and it is still used in medicine under that name. About the same time, M. Soubeiran distilled together the above ingredients in France, and analysed the chloroform which he obtained. His analysis, which was incorrect, led him to name the liquid bichloric ether.‡ In 1832, Liebig examined the liquid which has been since named chloroform, but as he failed to detect the hydrogen which it contains, he called the liquid chloride of carbon,§ a name which its alcoholic solution occasionally bore afterwards when used as a medicine. In 1834, Dumas examined this liquid. He proved that Soubeiran and Liebig had not obtained it pure, or had been incorrect in their analysis.|| He showed that it consists of two atoms carbon, one atom hydrogen, and three atoms chlorine.

Dumas gave the name of chloroform to the liquid, on

* Dr. Pereira in *Pharmaceutical Journal*, March 1846, vol. v, No. 9.

+ Silliman's *American Journal of Science and Art*, vol. xxi, p. 64, Jan. 1832.

‡ *Ann. de Chim. et de Physique*, t. xlviii, p. 131.

§ *Ibid.*, t. xlix, p. 146.

|| *Ibid.*, t. lvi, p. 134.

account of the relation it bears in composition to formic acid, which consists of two atoms carbon, one hydrogen, and three oxygen.* Liebig, who, in common with other chemists, admits the accuracy of Dumas' analysis, has proposed the name of perchloride of formyle.† He supposes that the carbon and hydrogen which enter, in the same definite proportion, into numerous compounds, form a base which he calls formyle; and although this base has never been obtained in a separate form, its existence is well supported by analogy, and the term formyle is useful in assisting the memory to retain the composition of a number of substances. For all practical purposes, however, the medicine we are considering is likely to go by the name of chloroform. In the last edition of the London Pharmacopœia, the article has received a name intermediate between the other two. It is called chloroformyl, a name which departs from the brevity of the word chloroform, without having the merit of expressing the chemical constitution of the substance. I believe that no one uses the word chloroformyl; not even the Fellows of the College of Physicians in their individual capacity.

Mode of Preparation. Chloroform can be obtained in various ways, but the most convenient process, and the one which yields it in greatest purity, is that alluded to above, by which it was first procured. The following are the directions in the London Pharmacopœia for making it.

“Take of chlorinated lime, lb. iv; rectified spirit, Oss; water, Ox; chloride of calcium, broken in pieces, 3j. Put the lime first mixed with the water into a retort, and add the spirit to them, so that the mixture may fill only the third part of the retort. Then heat them in a sand-bath,

* Formic acid is so named because it was originally obtained from the red ant (*Formica rufa*). It is now made from starch.

† Turner's Chemistry, 8th ed., p. 1009.

and as soon as ebullition begins, withdraw the heat as quickly as possible, lest the retort should be broken by the sudden increase of heat. Let the liquid distil into the receiver so long that there may be nothing which subsides, the heat being reapplied if necessary. To the distilled liquid add a quarter of the water, and shake them all well together. Carefully separate the heavier portion which subsides, and add the chloride to it, and frequently shake them for an hour. Lastly, let the liquid distil again from a glass retort into a glass receiver.”*

Some manufacturers of chloroform prefer to rectify it from dry carbonate of potassa, since they consider that it is liable to get an acid reaction from decomposition of the chloride of calcium, when it is distilled from that substance. The truth is, however, that there is very little occasion to use either of these substances; for the small quantity of water which chloroform can hold in solution is of no consequence.

Chemical and Physical Properties. Chloroform is a clear colourless liquid, having a hot and intensely sweet taste. It is not inflammable, but when paper moistened with it is introduced into the flame of a candle, it is destroyed with the evolution of smoke and chlorine gas. It is just half as heavy again as distilled water. Its specific gravity was formerly stated to be 1.483, but the liquid used for inhalation of late years has been heavier than this. I find that pure chloroform, when saturated with water, has a specific gravity of 1.500 at 60° Fah.; and after agitating it with sulphuric acid, to deprive it of the water, the specific gravity is 1.503. The amount of water that chloroform can hold in solution is only one part in from 200 to

* Nearly all the chloroform used in Great Britain and her colonies is made in Edinburgh, where the spirit duty is lower than in England. The London druggists have almost ceased to make it, as they find it cheaper to get it from the trade in Edinburgh.

300 ; and when this is separated by oil of vitriol, the chloroform is liable to undergo spontaneous decomposition.*

Chloroform is soluble in alcohol and ether in all proportions, but it is very sparingly soluble in water. It has been said to require 2000 parts of water for its solution, but this is an error. As the solubility of this and similar medicines in watery fluids has a very important connexion with their physiological action, I took great pains to ascertain the solubility of chloroform correctly. By admitting small quantities of water into graduated jars containing chloroform vapour, I was able to ascertain that chloroform is soluble in about 288 times its volume of water. Chloroform is itself an active solvent of many bodies ; dissolving camphor, caoutchouc, gutta percha, wax, resin, iodine, and some other substances very readily. It is a very mobile liquid, and when dropped from the lip of a small phial, the drops are very small. There are three drops to a grain of the liquid, and as a minim of it weighs a grain and a half, there are nine drops in two minims. Consequently persons should not speak indiscriminately of drops and minims, as they sometimes do, when talking of chloroform.

Adulterations. The odour of chloroform is by no means disagreeable. The only liquids that resemble it in smell are Dutch liquid and the chlorinated products of hydrochloric ether, but as they are much more difficult to prepare than chloroform, they are not likely to be substituted for it, or used for its adulteration. The smell of chloroform is therefore a good criterion of its purity and identity. When dropped on the hand, it should quickly evaporate, leaving not the least moisture or smell behind. If a disagreeable odour remains on the hand after the evaporation of the chloroform, it has

* The Edinburgh druggists suffered a great loss in 1850 from purifying their chloroform in this way on the recommendation of Dr. Gregory, who was not aware of the consequences, although they had been stated by Dumas (*Ann. de Chim. et de Physique*, t. lvi, p. 117).

probably been made from impure spirit, or even from wood spirit or acetone, and is unfit for medicinal use.* When chloroform becomes decomposed from any cause, it acquires a greenish-yellow colour, and gives off chlorine and hydrochloric acid, so that the alteration is at once apparent. When chloroform is pure it has no reaction on test-paper, but is quite neutral. The best way to detect a small quantity of hydrochloric acid in it, is to moisten a slip of blue litmus paper with distilled water, and hold it just within the neck of the bottle exposed to the vapour. If sulphuric acid should be present, it may be discovered by agitating the chloroform with distilled water, and adding nitrate of baryta.

The only article that can be mixed with chloroform without altering its appearance and smell is alcohol. This can be detected by the reduction it occasions in the specific gravity of the chloroform; or, if it be present in any considerable quantity, it may be discovered by adding water to a little of the chloroform in a graduated tube or measure, when a diminution of its volume takes place, owing to the water abstracting the alcohol. The chloroform also acquires a milky opacity under these circumstances. M. Miahle† speaks of the milky opacity of the chloroform on the addition of water as a very delicate test of the presence of alcohol; but I find that it requires upwards of two per cent. of alcohol to cause this appearance on the addition of water.

It has been asserted, and often repeated, that the presence of alcohol in chloroform causes it to have caustic properties, and makes its vapour unusually irritating. I have never seen any evidence of this, although I have had hundreds of

* I have seen some specimens of chloroform that left a white, limy-looking stain on the hand, which I believe was a minute quantity of crystalline chloride of carbon. These specimens were unobjectionable for all practical purposes, and had the merit of keeping remarkably well.

† See Med. Gaz., vol. xl, p. 1092.

opportunities of witnessing the action of chloroform mixed with spirit. Under certain circumstances, it is advisable to dilute chloroform with alcohol previous to its administration, as will be explained hereafter.

The chloroform I have met with in London has always been sufficiently pure for inhalation, except in a few cases where a small quantity had become decomposed, probably from having been left a long time exposed to strong daylight. In these instances, its altered appearance generally prevented its being used. I am not aware of serious consequences having arisen anywhere from the impurity or adulteration of chloroform. A case occurred in the London Hospital, where cough and a feeling of suffocation were caused by hydrochloric acid with which the chloroform was contaminated, but the inhalation was discontinued, and no ill consequences resulted.*

Chloroform should be kept in well-stoppered bottles, and protected from the light. It boils at 140 Fah. under the ordinary pressure of the atmosphere. It is consequently one of the most volatile liquids employed in medicine, with the exception of sulphuric ether and amylene.

The Vapour of Chloroform is more than four times as heavy as atmospheric air. It has a specific gravity of 4.2 at 60° Fah. Under ordinary circumstances, the vapour of chloroform has of course no separate existence, but is always mixed with air. It can exist in a pure state only when the temperature is raised to 140° or upwards; or when the pressure of the atmosphere is in a great measure removed by the air-pump. The quantity of vapour of chloroform that the air will hold in solution at different temperatures, under the ordinary pressure of the atmosphere, depends on the elastic force of the vapour at these temperatures. It is governed by a law precisely analogous to that which

* Dr. Letheby in Med. Gaz., vol. xlv, p. 1037.

determines the amount of watery vapour which air will hold in solution.

The following table shows the result of experiments I made to determine the quantity of vapour of chloroform that 100 cubic inches of air will take up, and retain in solution, at various temperatures.

Temp. Fah.					Cubic inches.
40°	-	-	-	-	- 7
45	-	-	-	-	- 8
50	-	-	-	-	- 9
55	-	-	-	-	- 11
60	-	-	-	-	- 14
65	-	-	-	-	- 19
70	-	-	-	-	- 24
75	-	-	-	-	- 29
80	-	-	-	-	- 36
85	-	-	-	-	- 44
90	-	-	-	-	- 55

In the above table, the air is a constant quantity of 100 cubic inches which becomes expanded to 107, and so on; but it may be convenient to be able to view at a glance the quantity of vapour in 100 cubic inches of the saturated mixture of vapour and air, at different temperatures, and in the table which follows the figures are so arranged as to show this.

Temp. Fah.		Air.			Vapour.
40°	-	94	-	-	6
45	-	93	-	-	7
50	-	92	-	-	8
55	-	90	-	-	10
60	-	88	-	-	12
65	-	85	-	-	15
70	-	81	-	-	19
75	-	78	-	-	22
80	-	74	-	-	26
85	-	70	-	-	30
90	-	65	-	-	35

As the effects of chloroform when inhaled depend en-

tirely on the quantity of vapour present in the air which the patient breathes, the effect of temperature on its volatility is of great practical importance. The air, it is true, does not become fully saturated with vapour during the process of inhalation, but the effects of temperature are relatively as great. If, for instance, a person inhales chloroform from a handkerchief or an inhaler, in such a way that the air he breathes shall be half-saturated with the vapour, then supposing the temperature of the apartment, the handkerchief, etc., to be 50° , the air he breathes will contain 4 per cent. ; but if the temperature be 70° , the air will contain 9.5 per cent. of the vapour.

A considerable amount of caloric becomes latent during the evaporation of chloroform, and the temperature of the vapour and air which the patient breathes are generally reduced a good deal, but not to the same extent as during the inhalation of ether. In giving chloroform from a small sponge which had been squeezed out of water, I have sometimes observed, after laying it down, that it became covered with a kind of hoar frost ; the minute particles of frozen water having a slight taste of chloroform. The cold produced by the evaporation of a liquid like chloroform is often the means of checking the evaporation to a certain extent, and limiting the amount of vapour which is taken up by the air.

PHYSIOLOGICAL EFFECTS OF CHLOROFORM.

Chloroform belongs to the large class of medicines known as narcotico-irritants. This and some other agents which have been inhaled for the prevention of pain are often called anæsthetics ; a name to which there is no objection, so long as it does not lead to the idea that they have a different action from other narcotics, or more precisely speaking, narcotico-irritants ; there being no such medicines as pure

narcotics. The term anæsthesia has been frequently employed to designate the insensibility and suspension of consciousness caused by chloroform and ether ; but, in describing the effects of these agents, I shall confine this term to its original meaning, privation of feeling, and I shall employ the term narcotism to designate the entire effects of these agents on the nervous system. This is the sense in which the term narcotism has always been employed. It has been the custom, however, to restrict the use of the word very much to cases in which stupor existed, but I shall apply it to designate the slighter, as well as the more profound effects of a narcotic, as I am entitled to do by strict etymology.

In order to facilitate the description of the effects of chloroform, I have been in the habit of dividing them into degrees. I use the term degree in preference to stage, as, in administering chloroform, the slighter degrees of narcotism occur in the later stages of the process, during the recovery of the patient, as well as in the beginning. The division into degrees is made according to symptoms, which, I believe, depend entirely on the state of the nervous centres, and not according to the amount of anæsthesia, which there is good reason to conclude, depends, in a great measure, on the local action of the chloroform on the nerves. The different degrees of narcotism glide insensibly into each other.

In the first degree, I include all the effects of chloroform that exist while the patient retains a perfect consciousness of where he is, and what is occurring around him. This degree constitutes all that a person remembers of the effects of the vapour, except when he happens to dream, and recollect it afterwards. The sensations caused by inhaling chloroform are usually agreeable, when it is taken merely for curiosity ; and individuals who have inhaled nitrous oxide

at some previous time of their lives, often describe their feelings as being very much the same from both agents. Patients who are about to undergo a surgical operation are, however, not always in a state for receiving agreeable impressions, and they sometimes complain of palpitation of the heart, and a feeling of fulness in the head. There is generally a sense of dizziness, with singing in the ears and tingling in the limbs. Many persons have a feeling like that of rapid travelling, and as an appearance of darkness sometimes comes on from the failure of the sight, whilst there is also a loud noise in the ears, it not unfrequently happens that a person feels as if he were entering a railway tunnel, just when he is becoming unconscious.

Those persons whose mental faculties are most cultivated appear usually to retain their consciousness longest whilst inhaling chloroform; and, on the other hand, certain navigators and other labourers, whom one occasionally meets with in the hospital, having the smallest possible amount of intelligence, often lose their consciousness, and get into a riotous drunken condition, almost as soon as they have begun to inhale. There is a widely different class of persons who also yield up their consciousness very readily, and get very soon into a dreaming condition when inhaling chloroform. I allude to hysterical females.

There is often a considerable diminution of the common sensibility during the first degree of narcotism by chloroform, more especially when it is inhaled very slowly, so that the patient is kept some minutes partially under its influence. In this way neuralgia can often be relieved, without removing the consciousness, when it is not extremely severe, and the suffering of labour may often be removed in the same manner, when the pains are not very sharp. In a few cases, the extraction of a tooth and other minor operations have been performed without pain, whilst

consciousness has been retained ; but as a general rule, it is better not to operate under these circumstances, for failure is more likely than success ; and this plan does not succeed in any case without inhaling longer, and consuming more chloroform, than would be necessary in the usual way. The complete recovery of the patient from the effects of the vapour, after a protracted inhalation of this kind, is also more tardy.

The first degree of narcotism recurs when consciousness returns as the effect of the chloroform is subsiding. At this time, there is generally a greater amount of anæsthesia than at the commencement of inhalation, just before consciousness is removed. I have many times known the introduction of sutures, and such like measures, performed at the concluding part of an operation, after the patient had recovered his consciousness, without his feeling what was being done. As a general rule also, the smarting of the wound does not commence till some time after consciousness has returned.

In the second degree of narcotism, there is no longer correct consciousness. The mental functions are impaired, but not necessarily suspended. When a patient inhales chloroform quietly for a medical or surgical purpose, he usually appears as if asleep in this degree ; but if his eyelid be raised, he will move his eyes in a voluntary manner. There are occasionally voluntary movements of the limbs ; and although the patient is generally silent, he may nevertheless laugh, talk, or sing. Persons sometimes remember what occurs whilst they are in this state, but generally they do not. Any dreams that the patient has, occur whilst he is in this degree, or just going into, or emerging from it, as I have satisfied myself by comparing the expressions of patients with what they have related afterwards. There is sometimes a little trouble with the patient in this degree of

narcotism. He feels the inconvenience of the vapour he is breathing, and having become unconscious of the object for which it is inhaled, he endeavours to push away the inhaler. As a person in this condition can generally hear and partly understand what is said, a few kind words will often render him tractable. This is generally true of all those who have been brought up with care and kindness, more especially patients of the female sex; but the man who has been roughly treated from the time of his birth, can often be made insensible only by means of a little restraint.

There is generally a considerable amount of anæsthesia connected with this degree of narcotism, and I believe that it is scarcely ever necessary to proceed beyond it in obstetric practice, not even in artificial delivery, unless for the purpose of arresting powerful uterine action, in order to facilitate turning the foetus. The loss of sensation is indeed sometimes so complete in this degree, especially in children, that the surgeon's knife may be used without pain; I have indeed seen a child unconsciously handling its toys all the time that the operation of lithotomy was performed on it. Commonly, however, the use of the knife, when the narcotism has not proceeded further than this degree, occasions expressions indicative of pain, which are either not remembered, or are recollected as having occurred in a dream. The patient is generally in this degree during the greater part of the time occupied in protracted operations; for although, in most cases, it is necessary to induce a further amount of narcotism before the operation is commenced, it is not usually necessary to maintain it at a point beyond this.

In the third degree of narcotism, there are no longer any voluntary motions. The eyes, for instance, are not directed towards any object; and although the limbs may move, they are not directed to any purpose. The pupils are ge-

nerally inclined upwards in this degree, and are at the same time usually somewhat contracted. The bloodvessels of the conjunctiva are generally somewhat enlarged in this degree in all persons who are well nourished and not deficient in blood. It is in this degree of narcotism that rigidity and spasms of the muscles occur in certain cases. These phenomena occur most frequently in cases where the muscles have been much exercised, and are consequently well nourished. They are never met with in infancy, and rarely before puberty. They are much more common in the male than the female sex. The rigidity and spasm are greatest and most constant in labourers and persons accustomed to athletic exercises, and they are usually absent in patients who have been long confined to the room, or are much reduced in strength from any cause. They are less marked in old age than in the middle period of life, and they are not by any means so frequent or strong in fat, as in thin, muscular persons. I have seen the spasms take an epileptiform character in a few cases; but by gently continuing the chloroform, they have always been subdued. In a great number of cases, the patient mutters in an almost inarticulate and a perfectly unintelligible manner, just as the muscular rigidity and spasm are subdued. Under these circumstances, I have never heard a single word pronounced so that it could be understood. If articulate language is uttered just after the muscular rigidity, it is evidence that the effects of the chloroform are being allowed to diminish, and that the patient is going back into the second degree of narcotism.

In the third degree of narcotism, a person is quite incapable of having any perception or consciousness of pain, but anæsthesia is not a necessary part of this amount of narcotism when it is first induced, and in some cases a patient may flinch, and put on an expression of countenance which seems indicative of pain. He may also cry out, but not in

an articulate manner. By continuing the chloroform gently for a minute or so, a state of complete anæsthesia can be induced in nearly every case, without carrying the narcotism of the nervous centres further than this degree. The loss of sensibility of the conjunctiva, as shown by the absence of winking when the edges of the eyelids are gently touched, is the best criterion that the patient will bear the knife without flinching or crying.

The circumstance of the anæsthesia, or loss of common sensibility, not keeping pace with the degree of narcotism of the brain, as shown by the presence or absence of consciousness and volition, appears to depend on the chloroform acting on the peripheral distribution of the nerves, as well as on the nervous centres.* The following considerations support this view. 1. Chloroform has the effect of diminishing the sensibility of a part to which it is applied locally, even to the sound cuticle. When the cuticle is removed, the local anæsthesia of the surface is complete; and in frogs, which have a thin permeable skin, and a languid circulation, one limb can be rendered insensible, by the local application of this agent, before the remainder of the animal is much affected. 2. Chloroform when inhaled immediately circulates throughout the body, in all parts of which it can be detected by chemical means. 3. Chloroform and other narcotics suspend the function of the nerves, when locally applied to them. 4. When inhaled, the local effect of chloroform must be greatest when it has had time to exude through the coats of the vessels, into the extra vascular liquor sanguinis, and come into immediate contact with the nervous fibrillæ; and it must take some little time after the chief part of the chloroform has escaped from the blood during its passage through the lungs, before that which is in the lymph external to the vessels can pass back

* Lancet, Feb. 12, 1848.

again into them, by endosmosis. The brain, on the other hand, is without lymph and lymphatics. The blood in this organ is all contained within the vessels, in which, moreover, it circulates with more velocity than in the external parts of the body. It can be easily understood, therefore, how the brain may escape from the effects of the vapour whilst the nerves of sensation throughout the body still remain partially under its influence. 5. It is in young subjects, in whom, connected with the more active process of nutrition, the quantity of lymph external to the vessels is greatest, that the general insensibility most frequently remains, whilst the cerebral hemispheres are resuming their functions; whilst in persons of spare habit, approaching the middle or later periods of life, there is little anæsthesia except in the unconscious state.

The co-operation of the brain with the nerves is, of course, necessary to sensation; and it is possible by a large dose of chloroform to produce complete anæsthesia very suddenly, before there is time for the nerves to be acted on locally to any extent; and if the chloroform is not continued, the anæsthesia may subside as quickly as it was induced. The large ganglia of sensation, the optic thalami, seem to require a greater quantity of chloroform to suspend their function than is necessary to suspend that of the cerebral hemispheres, but, by occupying three or four minutes in giving chloroform, one is enabled to add its local action on the nerves to its influence on the brain, and thus to induce anæsthesia with less narcotism of the nervous centres than would otherwise be required.

It must not be supposed that the difference of the action of chloroform on the cerebral hemispheres, and on the optic thalami, will of itself explain the want of uniformity between the loss of consciousness and loss of feeling. If it were a mere difference of degree, it might be so explained; but the

absence of all regular relation between these phenomena can only be satisfactorily accounted for when the circumstances connected with the circulation and the liquor sanguinis, that I have endeavoured to explain above, are taken into account.

In the fourth degree of narcotism, the breathing is stertorous, the pupils are dilated, and the muscles completely relaxed. The patient is always perfectly insensible. It is very seldom necessary to carry the effects of chloroform as far as this degree. It is, however, sometimes requisite to do so, in attempting to reduce dislocations of long standing in muscular persons, and whilst the surgeon is dissecting in the neighbourhood of important vessels and nerves, in certain robust subjects and others who seem to have acquired an excess of sensibility by hard drinking, and who can hardly be kept quiet under the knife, except when the breathing is stertorous.

There are some further effects of chloroform with which one becomes acquainted in experiments on the lower animals. If the inhalation is continued after the symptoms just described are produced, the breathing is rendered difficult, feeble, or irregular, and is sometimes performed only by the diaphragm, whilst the intercostal muscles are paralysed. If the dose of chloroform is gradually increased after these effects are produced, the breathing entirely ceases, but the heart continues to pulsate very distinctly, till its action becomes arrested by the absence of respiration, as in asphyxia. This interval, including the embarrassment and cessation of the breathing, I call the fifth degree of narcotism.

Although the respiration may be suspended by an amount of chloroform that has very little direct effect in the motion of the heart, it is quite possible to stop the heart's action by the immediate effect of this agent. When frogs are exposed

to the action of the vapour, they go on absorbing it by the skin, after the respiratory movements have ceased ; and in this way the pulsations of the heart are arrested, when a certain amount of chloroform has been absorbed into the blood. And when animals of warm blood are made to breathe air containing as much as eight or ten per cent. of the vapour of chloroform, the blood which is passing through the lungs becomes so charged with it as to stop the action of the heart, when it reaches that organ through the coronary arteries. It is in this way that accidents from chloroform have happened. The power of this agent to arrest the pulsations of the heart can also be shewn, by blowing a stream of the vapour on its surface, when the chest is opened immediately after the breathing has ceased, and whilst it is still beating.

The ultimate and greatest effect that chloroform is capable of producing on the animal body is to destroy the irritability of the muscles, and produce the post mortem rigidity. Either the whole body or a single limb can be rendered instantly rigid by injecting the arteries with a little chloroform shaken up with water. The rigidity remains for weeks in the dead body, and would probably be permanent if the chloroform were prevented from evaporating. Whilst it lasts, putrefaction is of course prevented.

Effect of Chloroform on the Pulse. I have not mentioned the state of the pulse in the above description of the effects of chloroform, for it affords no criterion of the amount of narcotism, and it was better therefore to reserve it for a separate notice. It is nearly always increased both in force and frequency, more especially at the early part of the inhalation. After the patient has become quite insensible, the pulse indeed generally settles down nearly to the natural standard, and in the middle of the most formidable operations, it is often beating with natural volume and force, not

more than sixty or seventy times a minute. The pulse rarely becomes weaker or slower than natural under the influence of chloroform, except from considerable loss of blood, or where the patient is about to be sick. I have twice found the pulse as slow as 44 in the minute at the conclusion of an operation attended with great loss of blood. One of the cases was the removal of a large tumour of the labium pudendi, in a woman, aged forty-five, on the 28th of April, 1849, at King's College Hospital, by Mr. Fergusson. The pulse was, however, not small or weak, and there was no faintness. In a few minutes, the patient vomited, and the pulse immediately resumed its natural frequency.*

There is occasionally a feeble state of pulse with a feeling of faintness as the effects of the chloroform subside, and in two or three cases in which the patient was in a sitting posture, positive syncope occurred, which, however, was promptly removed by the horizontal position. The persons most liable to a feeling of faintness after chloroform, are those who are subject to syncope from slight causes.

Action of Chloroform on the Nervous System. Chloroform, when inhaled, immediately reaches every part of the nervous system through the circulation, and it acts on every part of that system from the first, as a careful observation of the symptoms proves. It does not, however, act equally on all parts of the nervous system, according to the quantity which is absorbed; some parts of that system have their functions entirely, or almost, suspended, whilst others are but little under the influence of the vapour, and

* Since the above was written, I have met with an instance in which the pulse was only 40 in the minute, as the effects of the chloroform were subsiding. There was neither sickness nor loss of blood. The case was that of a gentleman in good general health, who inhaled chloroform whilst Mr. Brodhurst endeavoured to make forcible flexion of the femur on the pelvis. He woke without any unpleasant symptoms, and the pulse resumed its natural frequency.

it is owing to this fact that the most severe pain may be prevented without danger. M. Flourens made the following remarks respecting the action of sulphuric ether, and they apply equally well to the effects of chloroform, when it is inhaled gradually: "Under the action of ether, the nervous centres lose their powers in regular succession — first, the cerebral lobes lose theirs, viz., the intellect; next, the cerebellum loses its, viz., the power of regulating locomotion; thirdly, the spinal marrow loses the principle of sensitiveness and of motion; the medulla oblongata still retains its functions, and the animal continues to live: with loss of power in the medulla oblongata, life is lost."* I may add, that after the breathing has ceased, from the loss of power of the medulla oblongata, the ganglionic nerves still perform their functions, and the heart and intestines continue to move for a time, often with vigour.

Owing to the unequal effects of a given quantity of chloroform on different parts of the nervous centres, and owing to its acting also on the nerves, a variety of states may be met with during a surgical operation, some of which have often been thought curious, or anomalous. The most usual state of the patient during an operation, when chloroform is successfully administered, is one of perfect quietude, without any sign of consciousness or sensation. The patient under chloroform may, however, moan, or cry, or flinch, or show other symptoms which are usually thought indicative of pain, but without using any articulate language, or remembering anything of the operation afterwards. If his flinching or crying out has neither interfered with the surgeon, nor distressed the friends who may be present, a case of this kind may be considered satisfactory. A third condition of the patient under the influence of chloroform is that in which he talks, or laughs, or sings during the opera-

* Gazette des Hôpitaux, 20 Mars, 1847.

tion, his words having no reference to what is being done. If he is sufficiently quiet for the proceedings of the surgeon, the application of the chloroform must be considered successful, and this condition proves the absence of pain even more completely than that in which there is neither sign nor sound, except the breathing and pulsation of the heart and blood vessels. A fourth condition of the patient is that in which he is conscious, and can look on whilst the surgeon is performing some small operation, or the minor part of a large one, without feeling it, or whilst feeling it in a manner which is not painful. This condition, when it occurs, is the most satisfactory proof of the power of chloroform to prevent pain. It happens but rarely, however, and cannot be induced at will, and it is usually at the concluding part of an operation, during which the patient has been unconscious, that this condition is met with. He wakes whilst there is still a vessel to tie, or a suture to be introduced, and does not feel it, owing, as was stated before, to some of the chloroform being detained in the extra vascular liquor sanguinis, whilst the brain has become almost free from the medicine. When the knife, or the needle, is felt without being painful, it is because the common sensibility, without being entirely abolished, is so much reduced, that what would otherwise cause acute pain only occasions an ordinary sensation.

A fifth state of the patient is met with when an insufficient quantity of chloroform has been administered, or when its effects have been allowed to subside too soon. The patient may call out or complain in articulate words, such as "Oh, you are hurting me," and yet may assert afterwards that he had no pain, and knew nothing whatever of the operation. His own language at the time must, however, be held to decide that there was some pain, which made so slight an impression on the disordered mind as not

to remain in the memory. Pain which is not remembered is of very little consequence, and probably is but slight in degree. It should not be judged of by the expressions of the patient when he is but partially conscious, and using no self-control. Chloroform may, lastly, be administered so badly, that the patient simply falls asleep under the soothing influence of a very gentle dose, as he might sleep from an ordinary dose of opium, without being insensible, and, when the operation is commenced he wakes to full consciousness, and both feels pain and remembers it.

Patients, when insensible, sometimes moan or groan from the effects of the chloroform, and quite independently of the operation. The groaning or moaning comes on sometimes and even leaves off again, before the operation is commenced. When symptoms like those of pain are present during an operation, one may generally know whether they are the consequences of it, by observing whether or not they are connected with each cut of the knife. But even when a flinch or a groan follows each manipulation of the surgeon, it does not necessarily follow, provided the patient does not speak, that he is suffering pain. Some amount of consciousness is essential to the presence of pain, but many of the lower animals execute movements like those caused by pain, after the head is cut off, and when, of course, there can be no consciousness. Although the mind, under ordinary circumstances, is conscious of the attitude, gestures, and cries, which accompany pain, neither the intellect nor the will have any share in their production. On the contrary, they usually take place in spite of the efforts of the will to prevent them, and one may understand that, when consciousness and volition are suspended, the actions usually indicative of pain may, for want of control, be excited by slighter causes, and to a greater degree, than in the waking state.

It is certain that chloroform may prevent pain in two ways, either by rendering the mind unconscious of external impressions, or by removing the sensibility to these impressions, that is, by a true anæsthetic action, but usually, and always when breathed in a full dose, it acts in both ways at once.

The patient sometimes supposes that he remembers all the particulars of the operation, although he did not feel the pain, but on questioning him it is usually found that it is a dream which he remembers, and not the actual facts. It is extremely rare for a patient to assert that he has felt pain from the operation, when he has not felt it, but I have known this to happen once or twice, and a circumstance which was related to me by Mr. Robinson proves the possibility of it. He administered chloroform, or ether, to a lady, with the intention of extracting some teeth, but could not succeed in getting the mouth open, and the lady woke before anything had been done, and asserted that she had felt the operation. She inhaled again, and awoke, and repeated the same statement once or twice before the teeth were actually extracted.

I have heard it stated that patients have felt the pain of the operation, but have been unable to make any sign of feeling it. Such an occurrence may possibly take place when the chloroform is inhaled too slowly, or not in sufficient quantity; but I have not witnessed it, and it evidently cannot happen with a sufficient dose.

CIRCUMSTANCES WHICH INFLUENCE OR MODIFY THE EFFECTS OF CHLOROFORM.

I arrived at the conclusion, after much careful observation, that chloroform might be given with safety and advantage in every case in which the patient requires, and is in a condition to undergo, a surgical operation; and having

acted on this conclusion for several years, I have found no reason to change it. It is desirable, however, to pay attention to every circumstance connected with the health and constitution of the patient before exhibiting chloroform, as many of these circumstances influence its effects.

Age. The age of the patient has considerable influence in modifying the effects of chloroform. It acts very favourably on children: they sometimes oppose the inhalation of it as long as they are conscious, but it does not occasion the rigidity and struggling after loss of consciousness, which are sometimes met with in the adult. Anæsthesia is generally induced with a less amount of narcotism of the nervous centres in children than in grown up persons. The effects of chloroform are more quickly produced and also subside more quickly in children than in adults, owing no doubt to the quicker breathing and circulation. It often happens, however, that when the insensibility has been kept up for some time, say twenty minutes or half an hour, in a child, it is followed by a natural sleep of a few hours duration, provided there is no painful wound, or other cause, to prevent the sleep. I have given chloroform in a few cases as early as the ages of eight and ten days, and in a considerable number before the age of two months; and I have at this time, June 30th, 1857, memoranda of the cases of 186 infants under a year old to whom I have administered this agent. There have been no ill effects from it either in these cases, or in those of children more advanced in life; and it is worthy of remark that none of the accidents from chloroform which have been recorded, have occurred to young children.

There is nothing peculiar in the effects of chloroform on people advanced in years, except that its influence subsides rather slowly, on account of the slower breathing and circulation. I have given chloroform to many patients over

seventy-five years of age, and to one as old as ninety years.

Strength or Debility. The comparative strength or debility of the patient has considerable influence on the way in which chloroform acts. Usually the more feeble the patient is, whether from illness, or any other cause, the more quietly does he become insensible; whilst if he is strong and robust, there is very likely to be mental excitement in the second degree, and rigidity of the muscles, and probably struggling in the third degree of narcotism. Patients in a state of debility resemble children, not only in coming quietly and easily under the influence of chloroform, but also in the circumstance, that the common sensibility is suspended with less narcotism of the nervous centres than is generally required in robust persons. Children and persons in a state of debility have usually an acute sensibility which causes them to suffer pain from very slight injuries, but this sensibility is more easily suspended by chloroform than the less acute sensibility of robust persons. It is in strong men, accustomed to hard work or athletic sports, that the rigidity and struggling previously alluded to in describing the effects of chloroform, most frequently occur after the loss of consciousness. Some of the patients in whom the struggling and rigidity have been greatest were gentlemen belonging to boating clubs; but I think the patient, in whom these symptoms were most violent, was a celebrated harlequin of one of the London theatres, on whom Mr. Fergusson operated a few years ago.

The persons in whom the rigidity and struggling are well marked are often lean and wiry, and these symptoms rarely occur in fat people. The rigidity and struggling are less marked when the chloroform is given slowly than when quickly given.

Hysteria. Patients who are subject to hysteria sometimes have symptoms of the complaint, such as sobbing, crying,

or laughing, as soon as consciousness is suspended, or even impaired, by the chloroform; but these symptoms can always be subdued by proceeding with the inhalation. In a very few instances the hysterical state returns, and becomes troublesome as the effect of the vapour subsides. In two or three cases that I have met with, it continued for three or four hours, but it usually subsides in a much shorter time. The inhalation should not be suspended on account of the hysteria, but should be continued till it is subdued before an operation is performed.

I have rarely seen a decided fit of hysteria from the effects of chloroform, but in the case of a young married lady, to whom I gave this agent to prevent the pain of an operation on the rectum, a somewhat violent paroxysm of hysteria came on directly after the inhalation was commenced. The surgeon would not permit me to continue the chloroform, and expressed his intention of operating without it. After waiting for about half an hour, however, for the hysteria to subside, and finding that it continued the same as at first, the inhalation was resumed. The patient was soon rendered insensible, and lay perfectly still whilst the operation was performed. There was a little hysteria as the effects of the chloroform subsided, but not so severe as before.

I have several times seen hysterical symptoms in the male, either during the administration of chloroform, or whilst the patient was recovering from its effects. But in all these cases, the patients informed me afterwards that they were subject to hysterics when under the influence of mental emotion.

In some persons who are subject to hysteria, the breathing becomes excessively deep and rapid whilst inhaling chloroform. This usually occurs just as the patient is becoming unconscious, but in a few cases even earlier, and the

patient is aware of the impulse to breathe in this manner. After this kind of hysterical breathing has lasted a minute, the patient generally rests nearly a minute without breathing at all, after which the respiration generally becomes nearly natural. I give the chloroform very sparingly during this violent breathing, or else withdraw it altogether for a minute or two.

I do not consider that the hysterical diathesis forms any objection to the use of chloroform in operations, as the patients would be generally quite as liable to suffer an attack of hysteria from the pain, if chloroform were not used.

Epilepsy. Chloroform occasionally brings on a fit of epilepsy in persons who are subject to this disease. It was stated in one of the foreign medical journals, in 1848, that this agent was so certain to cause a fit in epileptic persons, that it might be used to detect impostors pretending to be subject to this disease; but if this assertion has been acted on, it must have led to great injustice, for I have many times administered chloroform to the extent of causing complete insensibility in epileptic patients who required to undergo operations, without its inducing the least approach to a fit.

In the few cases in which epileptic convulsions are occasioned by chloroform, they do not appear till the third degree of narcotism is induced, in this respect differing from hysteria, which comes on in the second degree, or even earlier, as was stated above. The course to pursue, when epileptic convulsions appear, is to continue the chloroform steadily and gently, till they subside. I have never seen the chloroform fail to subdue the convulsions in a very few minutes, and I have never seen them recur after the operation, as the effects of the vapour subsided. In medical and obstetric practice, and for slight operations, it is not requisite to carry the effects of chloroform so far as that stage in

which an epileptic fit would occur, so that under these circumstances the fact of a patient being subject to epilepsy hardly requires to be taken into account.

Pregnancy. I have repeatedly given chloroform at all periods of pregnancy, both for tooth drawing and more important operations, and I have not met with any ill effects from it in any of the cases.

The Menstrual Period. It is customary to avoid the menstrual period in fixing the time for a surgical operation, when it can be so arranged. There are, however, often reasons for not waiting over this period, and under such circumstances, I do not know any objection to the inhalation of chloroform. I have administered it frequently during the menstrual period, and have seen no ill effects from it. I have observed that there is a little more tendency to slight hysterical symptoms, during its inhalation at this period, than when the same patients inhale it at other times, which is what we might expect.

Diseases of the Lungs. Affections of the lungs sometimes cause a little difficulty and delay in the administration of chloroform, as the vapour is liable to excite coughing when the mucous membrane of the air passages is irritable. The inconvenience is, however, confined to the time of inhalation, for the cough is generally relieved afterwards.

I have given chloroform for surgical operations in many cases where phthisis was present, and in several patients who had suffered from hæmoptysis, and have not seen any ill effects from its use in these cases. Chloroform has indeed often been inhaled with advantage to relieve the cough in consumption. The cases of chronic bronchitis in which chloroform is administered for surgical operations are still more numerous. The effects I have observed have been coughing at the time of inhalation, and very often a relief of the cough afterwards. Some of the patients had emphy-

sema of the lungs. It is scarcely necessary to allude, in this place, to acute diseases of the lungs, as surgical operations are not performed during their continuance, but from the fact of chloroform being inhaled occasionally in the treatment of these affections, it is evident that they would cause no obstacle to its employment.

Disease of the Heart. There is a very general impression that the use of chloroform is unsafe when disease of the heart exists, more particularly, fatty degeneration of that organ. This belief has been encouraged by the circumstance that this affection has been present in a few of both the real and alleged deaths from chloroform; and also by the fact that, in the accidents that have been really due to chloroform, the heart has been the organ on which it has exerted its fatal influence. When we come to investigate these cases, however, we shall find reason to conclude that the heart has probably been diseased in quite as great a proportion of the patients who have taken chloroform without ill effects, as in those who have succumbed under its influence. As regards my own practice, indeed, the only case in which death could in any degree be attributed to the chloroform, was one in which there was extreme fatty degeneration of the heart; but, on the other hand, I have given chloroform in numerous cases without ill effects where the symptoms of this, as well as other affections of the heart, were present in a very marked degree. Indeed, I have never declined to give chloroform to a patient requiring a surgical operation, whatever might be his condition, as I early arrived at the conclusion that this agent, when carefully administered, causes less disturbance of the heart and circulation than does severe pain. Whenever I have had an opportunity of seeing an operation performed without chloroform, I have carefully observed the pulse, and although none of these operations have been of a very severe nature,

I have found the circulation to be much more disturbed than it would have been by chloroform carefully administered. The pulse in most of these cases has been excessively frequent during the operation, and in some instances it has intermitted to an unusual extent.

In one instance, I had an opportunity of witnessing a similar operation on the same patient, first without chloroform, and afterwards under the influence of this agent. On January the 6th, 1855, Mr. Fergusson performed lithotritry, in King's College Hospital, on a man, aged fifty-one. He generally directs chloroform to be administered in lithotritry, but in this instance he omitted to do so, as he thought that the bladder was not very irritable, and that the patient would not suffer much. I began to feel the pulse just when the patient saw the lithotrite about to be introduced. It was 120 in the minute. As soon as the instrument was introduced, the pulse increased to 144, and immediately afterwards it became uneven, irregular, and intermitting. I could not count more than three or four beats at a time; and, occasionally, when the pain seemed greatest, and the man was straining and holding his breath, the pulse was altogether absent for four or five seconds. In order to ascertain whether the absence of pulse at the wrist might not depend on the pressure of the muscles of the arms, caused by grasping the table, I applied my ear to the chest, and found that there was no sound whatever to be heard during the intervals when the pulse was imperceptible. It was evident that the patient held his breath till the right cavities of the heart became so distended as to stop the action of that organ till the respiration returned. The man did not complain or cry out during the operation. A week afterwards the lithotritry was repeated, but on this occasion I administered chloroform. The pulse was about 120 in the minute when the patient began to inhale the chloroform,

but it became slower as he was made unconscious, and it was regular and natural during the operation. It was only towards the end of the operation, when the effect of the chloroform was allowed to diminish, and when the man began to strain a little, though not yet conscious, that the pulse intermitted slightly, passing over a single beat occasionally. There were none of the long intermissions of the pulse observed on the former occasion.

It is very evident that if the above-mentioned patient had been the subject of any affection of the heart which weakened or embarrassed its action, he would have run a much greater risk from the pain of the first operation, than from the inhalation of chloroform in the second one.

In a few of the patients having the arcus senilis of the cornea, a weak, intermitting, or irregular pulse, and other signs of fatty degeneration of the heart, there have been a feeling of faintness and a tendency to syncope, as the effects of the chloroform were subsiding, especially when the operation had been performed in the sitting posture; but these symptoms have soon subsided, in all the cases I have met with, on placing the patient horizontally, with or without the help of a little ammonia to the nostrils.

Cerebral Disease. Affections of the head offer no obstacle to the administration of chloroform. I have given it to several patients who had suffered previously from an attack of apoplexy. Some of them still retained the paralysis resulting from their attack, but the chloroform has not been attended or followed by ill effects in any of these cases. The following case, in which alarming head symptoms had existed a few hours before the inhalation of chloroform, cannot fail to be interesting.

The 31st of October, 1854, was appointed by Mr. Fer-
gusson to perform lithotrity on a gentleman, seventy-eight years of age, who had a phosphatic calculus in his bladder.

He was a patient of Mr. Propert, and Mr. Fergusson had removed a similar calculus by lithotrity, and I had given him chloroform at each of the operations, and it was arranged that he should have chloroform on the present occasion. Mr. Propert informed Mr. Fergusson and me, on our arrival, that his patient had had an attack the night before resembling apoplexy; he had been insensible, the breathing had been stertorous, the pupils dilated, and the face very red and congested. Mr. Propert had caused him to be cupped to fourteen ounces, and had given him twenty grains of calomel in the course of the night, and in the morning he was as well as usual, and remained so at the time of our visit. We considered the case with Mr. Propert, and as there were reasons for not postponing the operation, it was determined that he should inhale the chloroform rather than be subjected to the pain. The vapour acted very favourably; he recovered his consciousness a few minutes after the operation, and expressed himself as feeling quite well.

Mr. Fergusson crushed another calculus in this patient in March 1855, when I again administered chloroform, and in 1856 I understood that he was free from the complaint.

Insanity. Chloroform acts on insane patients just as it does on others, that is to say, they are made insensible by it, and, when its effects completely subside, it leaves them in the same state of mind as before. Insane people are, however, often so suspicious that they cannot be persuaded to inhale chloroform, and it can only be given to them by force. When once under its influence, however, I have seen teeth extracted, and other operations performed, which it would have been impossible to accomplish in the same individuals without resorting to inhalation. The use of chloroform in the treatment of mania will be alluded to in another part of this work.

Hard Drinkers. It was at one time alleged that hard

drinkers of spirituous liquors were not susceptible of the influence of ether or chloroform, and for a long time there remained an impression that these persons were difficult to render insensible. I have always found that hard drinkers were rendered unconscious, and even comatose, by the same amount of ether or chloroform as other persons; but they sometimes have a morbid excess of sensibility in the nerves of common sensation, and do not lie still under the surgeon's knife except when the nervous centres are deeply narcotised, and the breathing almost stertorous. On this account, they sometimes inhale much more chloroform during a protracted operation than other persons.

AMOUNT OF VAPOUR OF CHLOROFORM ABSORBED TO CAUSE
THE VARIOUS DEGREES OF NARCOTISM.

Before proceeding to describe the mode of administering chloroform, it is desirable to treat of the quantity of it which produces its different effects. Without alluding to the facts and experiments which prove that all narcotics produce their effects by being absorbed into the circulating fluid, and so reaching the nervous system on which they act, it is only necessary to mention the following circumstances to show that this is the case as regards chloroform. In some experiments in which I assisted Dr. Sibson, we found that the vapour of chloroform produced its effects after both the pneumogastric nerves had been divided, exactly the same as before. Chloroform can be detected by means of chemical tests exhaling in the breath of those who have just previously inhaled it. It can also be detected in the urine after inhalation, and very readily in all the tissues of animals that have been killed by it, for several days after death.

The quantity of chloroform in the blood in the different degrees of narcotism might be estimated approximatively

from the amount used in inhalation, but I devised some experiments in 1848 for ascertaining the quantity with accuracy.* The experiments were based on the following circumstances.

When air containing vapour is brought in contact with a liquid, as water or serum of blood, absorption of the vapour takes place, and continues till an equilibrium is established; when the quantity of vapour in both the liquid and air, bears the same relative proportion to the quantity which would be required to saturate them at the temperature and pressure to which they are exposed.

This is only what would be expected to occur; but I verified it by numerous experiments in graduated jars over mercury. The intervention of a thin animal membrane may alter the rapidity of absorption, but cannot cause more vapour to be transmitted than the liquid with which it is imbued can dissolve. The temperature of the air in the cells of the lungs and that of the blood circulating over their parietes is the same; and, therefore, when the vapour is too dilute to cause death, and is breathed till no increased effect is produced, the following formula will express the quantity of any substance absorbed:—As the proportion of vapour in the air breathed is to the proportion that the air, or the space occupied by it, would contain if saturated at the temperature of the blood, so is the proportion of vapour absorbed into the blood to the proportion the blood would dissolve.

The manner in which the experiments were performed, was to place a small animal in a glass jar, so large that it formed a capacious apartment for it, and held much more air than it could require in the course of the experiment. The jar was covered with a closely fitting lid, and a carefully weighed portion of chloroform was allowed to diffuse itself through the air of the jar. The experiments were continued

* Medical Gazette, vol. xli-ii.

till the chloroform produced no further effect. I shall pass over a number of tentative experiments, and adduce only a few of those which were made after I had ascertained the quantities requisite to produce the desired effect. The results obtained in these experiments were entirely due to the degree of dilution of the vapour ; for the quantity of chloroform employed was, in every instance, more than would have killed the animal in a much shorter time than the experiment lasted, if it had been conducted in a smaller jar. It is assumed that the proportions of vapour and air remain unaltered during the experiment ; for the quantity absorbed must be limited to what the animal can breathe in the time, which is so small a part of the whole that it may be disregarded.

Experiment 1. A guineapig and a white mouse were placed in a jar holding 3,000 cubic inches, and fifteen grains of chloroform were introduced by a tube in the lid of the jar, which was closed immediately by a screw. The chloroform fell on some blotting paper suspended in the jar, and in a minute or two was converted into vapour and diffused through the air in the jar. The animals were allowed to remain half an hour, and were unaffected by the chloroform, except that they appeared to be a little less brisk than usual, during the first two or three minutes after their removal.

Experiment 2. A guineapig was placed in the same jar, and twenty-two and a half grains of chloroform were introduced in the same manner as before, being three-quarters of a grain to each hundred cubic inches of air. In two or three minutes the chloroform was converted into vapour and diffused through the air in the jar. Six minutes afterwards the guineapig began to stagger, and soon afterwards was unable to keep on its legs. It was kept for half an hour in the jar, but did not become further affected. It was occasionally quiet, but always tried to walk when disturbed by

moving the jar. When taken out, it flinched on being pricked, and it tried to walk, although unable to support itself on its legs. It recovered from the effects of the chloroform in three or four minutes.

Experiment 3. Another guineapig was placed in the same jar, and thirty grains of chloroform were introduced. In three or four minutes the chloroform had evaporated and diffused itself through the air in the jar. In two minutes afterwards the guineapig lay down, but stirred when the jar was moved. It was allowed to remain in the jar for half an hour, being asleep except when disturbed. When taken out it awoke and endeavoured to walk, but was unable to support itself at first. It flinched on being pricked. Recovered in three or four minutes.

Experiment 4. A cat was placed in the same jar, and the same quantity of chloroform was introduced. In three minutes it had evaporated, and, when ten minutes had elapsed, the cat began to stagger. Soon afterwards it was unable to support itself on its legs; and, when a quarter of an hour had elapsed, it seemed asleep, but raised its head when the jar was inclined. It remained apparently sleeping till the end of an hour, when it was taken out. It was unable to stand, but was sensible to the slightest pinch. It recovered gradually in the course of twenty minutes.

Experiment 5. Sixteen grains of chloroform were put into a jar holding 1,600 cubic inches, being one grain to each 100 cubic inches of air, as in the two last experiments. When it was converted into vapour, a white mouse was introduced, by moving the lid a little to one side for a moment. After running about for a minute and a half, it began to stagger and to lose power, but it continued to run with little intermission till three minutes had expired. After this it lay still, except when the jar was inclined, when it always endeavoured to maintain its balance and to walk. It

also moved its limbs now and then, when not disturbed. It was removed at the end of ten minutes, when it tried to walk, but was unable. It did not flinch when its tail was pinched, but flinched, half a minute after its removal, on one of its toes being pinched. It recovered in two or three minutes.

Experiment 6. A guineapig was placed in the jar holding 3,000 cubic inches, and 37·5 grains of chloroform were introduced in the same manner as in the former experiments, being a grain and a quarter to each 100 cubic inches of air. The chloroform took three or four minutes to evaporate and diffuse itself in the jar; and by the end of this time the guineapig, which had been excited and running about, began to stagger, and in two minutes longer it was unable to walk, but endeavoured to keep its balance when the jar was inclined. At the end of a quarter of an hour it was lying still, but moved its limbs when it was rolled over by inclining the jar; but it made no voluntary effort. It was taken out when thirty-three minutes had elapsed. It moved its limbs as it was removed, though apparently not in a voluntary manner. Its limbs were not relaxed. It was quite insensible to pricking. It recovered in about ten minutes. The temperature in the axilla before it was put into the jar was 100° Fah., and immediately after its removal 96°.

Experiment 7. A guineapig was placed in the same jar, and forty-five grains of chloroform were introduced, being a grain and a half to each 100 cubic inches of air. In four minutes after the chloroform had evaporated, the guineapig was unable to walk. In half a minute more it seemed asleep, but there was a tremulous motion of the hind legs, which continued till ten minutes had elapsed. Afterwards it lay still, but winked now and then spontaneously. When rolled over by moving the jar, it made no voluntary effort. It was taken out twenty minutes after the chloroform had evapo-

rated. It winked spontaneously, and also when the eyes were touched. It did not flinch when the ear was pricked, but flinched when the paw was pricked. The temperature in the axilla before the experiment was 100° , and immediately afterwards it was 96° . The guineapig recovered from the effects of the chloroform in ten minutes.

Experiment 8. A guineapig was put into the same jar, and 52.5 grains of chloroform were introduced, being a grain and three quarters to each 100 cubic inches of air. The chloroform evaporated in the course of four minutes, at the end of which time the guineapig was altered in its manner, as if partially inebriated. In two minutes more it was becoming drowsy. A little while afterwards it was lying down. Six minutes after the evaporation of the chloroform was complete, the guineapig made no effort when turned over by inclining the jar, but only moved its feet, as it were automatically. At the end of nine minutes, it was lying quietly and breathing naturally. When fifteen minutes had elapsed it was in the same condition, and was removed from the jar. It cried and flinched on the foot being pricked. The temperature in the axilla was 97° . In five minutes after its removal it was fast recovering, and in ten minutes was quite recovered.

Experiment 9. A guineapig was placed in the jar used in the last three experiments, and sixty grains of chloroform were introduced in the same manner, being two grains to each 100 cubic inches of air. In four minutes it was all converted into vapour, and the guineapig was beginning to be affected by it. In two minutes more it was unable to stand or walk. In five minutes from the time when the evaporation was complete, the guineapig showed no sign of sensibility when turned over by inclining the jar; the breathing was natural. At the end of ten minutes it was lying still, breathing gently forty times in the minute. At

the end of fifteen minutes it was in the same condition. From seventeen to twenty minutes, it stretched out one of its hind legs several times, and was doing so when taken out, at the end of twenty minutes. It showed no sign of sensibility when pricked. The temperature in the axilla was 96° . It began to recover gradually in a minute or two, and recovered completely in from ten to fifteen minutes.

Experiment 10. A cat was placed in the same jar, and the same quantity of chloroform was introduced in the same manner. It became quite insensible in a few minutes after the chloroform was introduced; and it was allowed to remain for twenty-five minutes, when it was taken out. It was perfectly insensible to pricking, and its muscles were quite relaxed; it was breathing gently, and the pulsations of the heart were between sixty and seventy in the minute. It was immediately made the subject of another experiment of drowning whilst insensible, which need not be related in this place.

Experiment 11. Four grains of chloroform were put into a glass jar holding 200 cubic inches, and when it had evaporated and was diffused through the air in the jar, a white mouse was introduced, by momentarily removing the cover a little to one side. A minute after its introduction the mouse was lying, but it moved its legs for a quarter of a minute longer. When four minutes had elapsed, the breathing became slow, and it was taken out. It was totally insensible for the first three minutes after its removal, and recovered during the two following minutes.

Experiment 12. Thirty-two grains of chloroform were diffused through the air of a jar holding 1,600 cubic inches, being two grains to each 100 cubic inches, as in the last three experiments. A white mouse was introduced by moving the cover a little to one side for a moment. In one minute it was insensible, and did not make any effort on

being rolled about by inclining the jar, but it moved its paws for half a minute longer. It remained insensible, breathing 160 times in the minute, till it was taken out at the end of five minutes. It was quite insensible to pinching. It began to walk in a minute or two. Its temperature before the experiment was 98° , and immediately afterwards was 92° . The temperature of the room was 68° .

Experiment 13. A guineapig was put into a jar holding 3,000 cubic inches, and 67.5 grains of chloroform were introduced on blotting paper suspended within the jar, being $2\frac{1}{4}$ grains to each 100 cubic inches. In four minutes, the chloroform had all evaporated, and the guineapig was becoming affected. In two minutes more, it was quite insensible. Eight minutes after the chloroform had evaporated, it was lying still, breathing forty times in the minute. During the next three or four minutes, it moved one or other of its legs occasionally. At the end of seventeen minutes, it was lying still, and the breathing was twenty-six in the minute. It was taken out at the end of twenty minutes quite insensible; in three or four minutes it began to try to walk, and in ten minutes, was quite recovered.

Experiment 14. Two white mice, one being full grown, and the other about three-quarters grown, were placed in the jar holding 1,600 cubic inches, and forty grains of chloroform were introduced on blotting paper, being two grains and a half to each hundred cubic inches. In two minutes, the chloroform had evaporated, and the mice were much excited. In another minute, they were unsteady in walking; and in a minute more, the old mouse was lying insensible, and breathing deeply and laboriously. In four minutes more, *i. e.*, six minutes after the chloroform had evaporated, the young mouse was insensible also, but was moving one of its hind legs. In other four minutes, the young mouse was breathing by slow gasps, whilst the old one continued

to breathe deeply as before. Three minutes later, *i. e.*, thirteen minutes after the chloroform had evaporated, the old mouse had begun to gasp, and the young one was gasping only at intervals. They were removed, and recovered completely in ten minutes. The young one recovered most quickly. Their temperature, on being removed, was about 90°.

Experiment 15. A cat was put into the jar holding 3,000 cubic inches, and 82.5 grains of chloroform were introduced, being two grains and three-quarters to each hundred cubic inches. In five minutes, it had evaporated, and the cat began to stagger in its walk. In two minutes more, it was unable to stand. Five minutes after the chloroform had evaporated, the cat was breathing deeply, seventy-five times in the minute. At eight minutes, it was breathing less deeply, one hundred and seventeen times in the minute. Ten minutes after the chloroform had evaporated, the cat was quite insensible, and breathing one hundred and twenty-six times in the minute. It was now taken out. The temperature in the axilla was 98°. In half an hour after its removal from the jar, it had recovered its consciousness, but was still drowsy.

It was now put into the jar again, and the same quantity of chloroform was introduced in the same manner as before. In five minutes, it had evaporated, and the cat was again insensible. In other five minutes, it was breathing rather deeply, forty-eight times in the minute. Twelve minutes after the chloroform had evaporated, the cat was breathing in the same manner, but sixty-eight times in the minute. The breathing afterwards became shallow and feeble, and half an hour after the chloroform had evaporated, it was eighty-eight in the minute. In five minutes more, the breathing ceased. The cat was taken out of the jar, and the stethoscope was applied to the chest. The heart could not be heard to beat at first, but in a short time, the cat

gave a gasp, and the heart's action returned, and the breathing became re-established.

Experiment 16. Forty-eight grains of chloroform were put into a jar holding 1,600 cubic inches, being three grains to each hundred cubic inches, and when it was converted into vapour and diffused through the air in the jar, a white mouse was introduced. It ran about for a minute and a half, and then it was unable to move any longer. In nine minutes and a half, the breathing was getting very slow, and the mouse was immediately removed. Before it could be got out, it appeared to have entirely ceased to breathe, but it immediately began to gasp at intervals. In a minute, the breathing improved, and soon became natural. Three minutes after its removal, the mouse began to walk in a ring, and in seven minutes, it had quite recovered.

Experiment 17. A guineapig was placed in a jar holding 1,600 cubic inches, and fifty-four grains of chloroform were introduced on blotting paper, in the manner previously explained; being three grains and three-eighths to each hundred cubic inches of air. In four minutes, the chloroform had evaporated, and become diffused through the air in the jar, and the guineapig was drowsy. In three minutes more, it was lying apparently insensible, and breathing feebly, thirty times in the minute. After this, it kicked occasionally for a few minutes. When six minutes had elapsed from the time when the chloroform had evaporated, the breathing was very feeble, and apparently performed only by the diaphragm. From fifteen to eighteen minutes, I could hardly see whether the animal was breathing or not, and it was taken out of the glass at eighteen minutes, when the breathing appeared to have ceased. The stethoscope was applied to the chest, and the sounds of the heart could scarcely be heard at first, but the breathing returned in a few seconds; and the action of the heart im-

proved. The guineapig gradually recovered, but it was not able to walk for twenty-five minutes.

Experiment 18. Sixty grains of chloroform were introduced into the jar employed in the last experiment, being three grains and three-quarters to each hundred cubic inches of air contained in the jar. When it had evaporated, and was diffused through the air, a white mouse was introduced, whilst the lid of the jar was moved a little to one side for a moment. It ran about at first, but suddenly ceased to run, and became insensible, at the end of three-quarters of a minute. It lay breathing deeply and rapidly till two minutes had elapsed, when the respiration became slow, and it ceased at two minutes and three-quarters after the mouse was introduced. It was removed at this time, and it gasped a few seconds afterwards; this gasp was soon followed by another; the gaspings became more frequent, and in a short time, the natural breathing was resumed. In five minutes, the mouse was able to walk.

The third, fourth, and fifth of the above experiments show that one grain of chloroform to each hundred cubic inches of air suffices to induce the second degree of narcotism, or that state in which consciousness and voluntary motion are disturbed, but not entirely abolished. Now one grain of chloroform produces 0.767 of a cubic inch of vapour at 60°, when its specific gravity is 4.2; and, when the vapour is inhaled, it expands somewhat, as it is warmed to the temperature of the lungs; but it expands only to the same extent as the air with which it is mixed, and therefore the proportions remain unaltered. But air, when saturated with vapour of chloroform at 100°, contains 43.3 cubic inches in 100; and

$$\text{As } 0.767 : 43.3 :: 0.0177 : 1.$$

So that if the point of complete saturation be considered as unity, 0.0177 or 1-56th, will express the degree of satu-

ration of the air from which the vapour is immediately absorbed into the blood; and, consequently, also the degree of saturation of the blood itself.

I find that serum of blood at 100° , and at the ordinary pressure of the atmosphere, will dissolve about its own volume of vapour of chloroform; and since chloroform of specific gravity 1.483 is 288 times as heavy as its own vapour, $0.0177 \div 288$ gives 0.0000614, or one part in 16,285, as the average proportion of chloroform by measure in the blood, in the second degree of narcotism.

It is evident, from the experiments numbered 9 to 12 inclusive, that two grains of chloroform to each hundred cubic inches of the inspired air cause a state of very complete insensibility, corresponding with what I have designated the fourth degree of narcotism; and by the method of calculation employed above we get 0.0354, or 1-28th, as representing the degree of saturation of the blood, and 0.0001228 the proportion by measure in the blood.

In experiments 6, 7, and 8, in which quantities of chloroform were employed intermediate between one and two grains to each hundred cubic inches of air, a moderate amount of insensibility was induced, corresponding very much with the state of patients during operations under chloroform.

The experiments from 13 to 18 show that quantities of chloroform, exceeding two grains to 100 cubic inches of air, have a tendency to embarrass and arrest the function of respiration, if the inhalation is continued. I have not yet been able to determine satisfactorily the exact proportion of chloroform which requires to be absorbed to arrest the respiration of animals of warm blood. I believe there is a definite proportion which has this effect, but there are two reasons why it is not so easy to ascertain it, as to ascertain the proportion which causes the minor degrees of narcotism.

In the first place, the breathing often becomes very feeble before it ceases, so that the animal inhales and absorbs but very little chloroform, and remains on the brink of dying for some time. In the next place, the temperature of the body falls in a deep state of narcotism, especially in small animals; and, as the temperature falls, the amount of chloroform which the blood can dissolve from any given mixture of air and vapour increases.

Judging from the experiments numbered 14 to 18, three grains of chloroform to each hundred cubic inches of air must be very nearly the quantity which has the power of arresting the breathing when the temperature of the body is 100° ; and as three grains of chloroform produce 2.3 cubic inches of vapour, and air at 100° is capable of taking up 43.3 per cent. of its volume, it follows that the blood must contain between 1-18th and 1-19th as much chloroform as it is capable of dissolving, at the time when the respiration is arrested. In the 14th experiment, the breathing of the two mice was on the point of being stopped by two and a half grains of chloroform in each hundred cubic inches of air, but during the thirteen minutes which the mice breathed the vapour, their temperature fell to about 90° . Air, when saturated with the vapour of chloroform at this temperature, contains 35 per cent., and two grains and a half of chloroform yield 1.917 cubic inches of vapour; so by a calculation similar to that made at page 68, the mice at the time when the breathing was about to cease must have absorbed 1-18th part as much chloroform as their circulating fluids were capable of dissolving.

The reader will have observed that, in the experiments related above, the mice became much more quickly affected than the guineapigs and cats. The reason of this is their quicker respiration and circulation, and much more diminutive size. Little birds, such as linnets and sparrows, are

also very quickly affected by chloroform. Frogs are more slowly affected, owing to their languid respiration, unless the vapour to which they are exposed is very strong.

They can, however, owing to their low temperature, be rendered insensible by proportions of vapour too small to affect animals of warm blood; and as they have no proper temperature of their own, the amount of vapour (in proportion to the air in which they are placed) that will affect them, depends entirely on the temperature of that air.

The following experiment was several times performed on frogs with the same result, the temperature of the room being about 55° , as it was in winter.

Experiment 19. 4·6 grains of chloroform were diffused through the air of a jar of the capacity of 920 cubic inches, and a frog was introduced. In a few minutes, it became affected, and at the end of ten minutes, was quite motionless and flaccid; but the respiration was still going on. Being now taken out, it was found to be insensible to pricking: it recovered in a quarter of an hour.

In a repetition of this experiment, in which the frog continued a few minutes longer in the vapour, the respiration ceased, and the recovery was more tardy. On one occasion, the frog was left in the jar for an hour, but when taken out, and turned on its back, the pulsations of the heart could be seen. In an hour after its removal, it was found to be completely recovered.

The first of the experiments related above (page 60), showed that an atmosphere containing half a grain of chloroform to each hundred cubic inches, produced scarcely any appreciable effect on animals of warm blood; but the following calculation explains why this quantity acts so energetically on the frog, and proves that this creature is affected by chloroform according to the same law as animals of warm blood. The vapour is absorbed into the blood and

lymph of the frog at the temperature of the external air, whose point of relative saturation therefore remains unaltered, both in the lungs and in contact with the skin of the animal; and as half a grain of chloroform produces 0.383 cubic inches of vapour, and air at 55° contains, when saturated, 10 per cent. of vapour; 0.0383, or 1-26th, expresses the degree of saturation of the air, and also of the blood of the frog. And this is a very little more than the quantity (0.0354 or 1-28th) which was calculated above to be the greatest amount which could be absorbed with safety into the blood of the mammalia. It must be observed, however, that the pulmonary respiration of the frog was arrested by this proportion of 1-26th as much chloroform as the blood would dissolve, whilst we calculated that it required about as much as 1-18th to arrest the breathing of animals of warm blood. It must be remembered, however, that the pulmonary respiration of frogs is a process of swallowing air, which only goes on when the creature is comparatively active. In the torpid state, the respiration takes place only by the skin, and the frog never breathes with the aid of the same muscles and nerves as mammalia and birds.

By warming a frog, together with the air in which it is placed, it is, in accordance with the law explained above, rendered comparatively proof against an amount of chloroform which would otherwise render it insensible.

Experiment 20. A frog, which had been a few days previously subjected to the experiment just narrated, was put into the same jar, which was placed near the fire, till a thermometer inside marked 75° Fah.; 4.6 grains of chloroform were then introduced, and diffused through the air in the jar. The jar was kept for twenty minutes, with the thermometer indicating the same temperature within one degree. For the first seventeen minutes, the frog was unaffected; and only was dull and sluggish, but not insensible,

when taken out. Air at 75° , when saturated with vapour of chloroform, contains 22 per cent., and therefore the 0.383 per cent. of vapour, which at 55° was capable of saturating the fluids of the frog to the extent of 1-26th of what they would dissolve, was, at 75° , capable of saturating them only to the extent of 1-57th.

At one of Dr. Wilson's Lumleian Lectures, at the College of Physicians, on March 29th, 1848, I had the honour of performing some experiments, and making some remarks, on chloroform, and I combined together two experiments on frogs and small birds, in a way which shows how entirely the effects of a narcotic vapour depend on the quantity of air with which it is mixed, and on other physical conditions.

Experiment 21. I introduced a chaffinch, in a very small cage, into a glass jar holding nearly 1,000 cubic inches, and put a frog into the same jar, covered it with a plate of glass, and dropped five grains of chloroform on a piece of blotting paper suspended within. In less than ten minutes, the frog was insensible, but the bird was not affected.

Experiment 22. I then placed another frog and another small bird in a jar containing but 200 cubic inches, with exactly the same quantity of chloroform. In about a minute and a half, they were both taken out,—the bird totally insensible, but the frog not appreciably affected, as from its less active respiration it had not had time to absorb much of the vapour.

The blood in the human adult is estimated by M. Valentin to average about thirty pounds. M. Valentin's experiments were so conducted that this quantity must include the extra vascular liquor sanguinis, as well as the blood actually contained within the vessels. On this account, his estimate is all the better fitted for calculating the amount of chloroform absorbed, since this medicine, when inhaled gradually, passes by exosmosis through the coats of the blood-

vessels into the fluid in which the tissues are immediately bathed. The above quantity of blood would contain 26 pounds 5 ounces of serum, which, allowing for its specific gravity, would measure 410 fluid ounces. This being reduced to minims, and multiplied by 0·0000614, the proportion of chloroform in the blood required to produce narcotism to the second degree (see page 68), gives 12 minims as the whole quantity in the blood. More than this is used in practice, because a considerable portion is not absorbed, being thrown out again when it has proceeded no further than the trachea, the mouth and nostrils, or even the face-piece. But I find that if I put twelve minims into a bladder containing a little air, and breathe it over and over again, in the manner of taking nitrous oxide, it suffices to remove consciousness, producing the second degree of its effects.

To induce the third degree of narcotism, or the condition in which surgical operations are usually commenced, would require that about 18 minims should be absorbed by an adult of average size and health, according to the above method of calculation; and to induce the deep state of insensibility, which I have termed the fourth degree of narcotism, would require 24 minims; whilst to arrest the function of respiration would require that about 36 minims should be absorbed.

PREPARATIONS FOR INHALING CHLOROFORM.

The only direction which it is usually requisite to give beforehand, to the patient who is to inhale chloroform, is to avoid taking a meal previous to the inhalation; for chloroform is very apt to cause vomiting, if inhaled whilst there is a quantity of food in the stomach. The sickness is not attended with any danger, but it constitutes an unpleasantness and inconvenience which it is desirable to avoid. The best time of all for an operation under chloroform is before

breakfast, but the customs and arrangements of this country do not often admit of that time being chosen, and it is unadvisable to make the patient fast beyond his usual hour. It answers very well to perform an operation about the time when the patient would be ready for another meal, or, if the time of operation fall two or three hours after the usual time of eating, to request the patient to make only a slender repast at that time, so as just to prevent the feeling of hunger. It is impossible to prevent vomiting in some cases with the best precautions, for the stomach occasionally will not digest when the patient is expecting a surgical operation, and the breakfast may be rejected in an unaltered state hours after it has been taken. In other cases the patient does not vomit, even when he inhales chloroform shortly after a full meal.

The most convenient position in which the patient can be placed whilst taking chloroform is lying on the back, or side, as he is then duly supported in the state of insensibility, and can be more easily restrained if he struggle whilst becoming insensible. The semi-recumbent posture on a sofa does very well, and there is no objection to the sitting posture, when that is most convenient to the operator. In that case, however, the patient should be placed in a large easy chair with a high back, so that the head as well as the trunk may be supported without any effort, otherwise he would have a tendency to slide or fall when insensible. It has been said that it is unsafe to give chloroform in the sitting posture, on the supposition that it would in some cases so weaken the power of the heart, as to render it unable to send the blood to the brain. Observation has proved, however, that chloroform usually increases the force of the circulation; and although the horizontal position is certainly the best for the patient under an operation in all circumstances, I consider that the sitting posture is by no

means a source of danger, when chloroform is given, if the ordinary precaution be used, which would be used without chloroform—that of placing the patient horizontally if symptoms of faintness come on. I have preserved notes of nine hundred and forty-nine cases in which I have given chloroform to patients in the sitting posture, and no ill effects have arisen in any of these cases.

The person who is about to inhale chloroform is occasionally in a state of alarm, either about that agent itself or the operation which calls for its use. It is desirable to allay the patient's fears, if possible, before he begins to inhale, as he will then be able to breathe in a more regular and tranquil manner. In a few cases, however, the apprehensions of the patient cannot be removed, and they subside only as he becomes unconscious from the inhalation. It has been said that chloroform ought not to be administered if the patient is very much afraid, on the supposition that fear makes the chloroform dangerous. This is, however, a mistake; the danger, if any, lies in the fear itself. Two cases will be related hereafter in which the patients died suddenly from fear, whilst they were beginning to inhale chloroform, and before they were affected by it; but the probability is that, if they had lived till the chloroform took effect, they would have been as safe as other patients who inhaled it. If chloroform were denied to the patients who are much afraid, the nervous and feeble, who most require it, would often be deprived of its benefits. Moreover, the patients would either be prevented altogether from having the advantage of surgery, or they would be subjected to the still greater fear of the pain, as well as the pain itself; for whatever undefined and unreasoning fears a patient may have when the moment comes for inhaling chloroform, he has only chosen to inhale it on account of a still greater fear of pain.

Fear and chloroform are each of them capable of causing death, just as infancy and old age both predispose to bronchitis, but it seems impossible that fear should combine with the effects of chloroform to cause danger, when that agent is administered with the usual precautions. Fear is an affection of the mind, and can no longer exist when the patient is unconscious; but the action of that amount of chloroform which is consistent even with disordered consciousness is stimulating, and increases the force and frequency of the pulse, in the same way as alcohol. I believe that no one would assert that a person would die the sooner of fright for having taken a few glasses of wine, or a small amount of distilled spirits, whatever might be the state of his health. When chloroform has been absorbed in sufficient quantity to cause unconsciousness, fear subsides, and with the fear its effects on the circulation. It is a subject of almost daily observation with me that the pulse, which is extremely rapid from some ill defined apprehension, when certain patients begin to inhale chloroform, settles down to its natural frequency after they become unconscious.

The practice I have always followed has been to try to calm the patient, by the assurance that there was nothing to apprehend from the chloroform, and that it would be sure to prevent all pain; but where it has been impossible to remove the fears of the patient in this way, I have always proceeded to remove them by causing a state of unconsciousness. It would of course be wrong to choose a moment for beginning the inhalation, when fear was producing a very marked depression of the circulation. On feeling the pulse of a gentleman, about twenty-one years of age, in March 1855, who had just seated himself in the chair to take chloroform, previous to having some teeth extracted, by Mr. Thos. A. Rogers, I found it to be small, weak, and intermitting, and it became more feeble as I was feeling it.

I told the patient that he would feel no pain, and that he had nothing whatever to apprehend. His pulse immediately improved. He inhaled the chloroform, had his teeth extracted, woke up, and recovered without any feeling of depression. Now if the inhalation had been commenced in this case, without inquiry or explanation, the syncope which seemed approaching would probably have taken place, and it would have had the appearance of being caused by the chloroform, although not so in reality.

MODE OF ADMINISTERING CHLOROFORM.

The experiments previously related show that air containing rather less than two grains of chloroform, in one hundred cubic inches, is capable of causing a state of insensibility, sufficiently deep for surgical operations; but in a creature the size of the human being, an inconvenient length of time would be occupied in causing insensibility with vapour so much diluted. About four cubic inches of vapour, or rather more than five grains of chloroform to each hundred cubic inches of air, is the proportion which I have found most suitable in practice for causing insensibility to surgical operations. In medical and obstetric cases, it should be inhaled in a more diluted form.

Dr. Simpson recommended chloroform to be administered on a handkerchief—the method in which sulphuric ether was administered by Dr. Morton, in the first case in which he exhibited that medicine. The objection to giving chloroform on a handkerchief, especially in surgical operations, where it is necessary to cause insensibility, is that the proportions of vapour and of air which the patient breathes cannot be properly regulated. Indeed, the advocates of this plan proceed on the supposition that there is no occasion to regulate these proportions, and that it is only requisite that the patient should have sufficient air for the purposes of

respiration, and sufficient chloroform to induce insensibility, and all will be right.* The truth is, however, that if there be too much vapour of chloroform in the air the patient breathes, it may cause sudden death, even without previous insensibility, and whilst the blood in the lungs is of a florid colour. Chloroform may indeed be inhaled freely from a handkerchief without danger, when it is diluted with one or two parts by measure of spirits of wine, but the chloroform evaporates in largest quantity at first, and less afterwards, until a portion of the spirit is left behind by itself. The process, however, of inhaling chloroform from a handkerchief is always uncertain and irregular, and is apt to confirm the belief in peculiarities of constitution, idiosyncrasies and predispositions, which have no existence in the patient.†

* According to Professor Miller, chloroform was given, at one time, in the Royal Infirmary of Edinburgh, in a somewhat slovenly, and not very cleanly manner; he describes the means of applying it as, "anything that will admit of chloroform in vapour being brought fully in contact with the mouth and nostrils; a handkerchief, a towel, a piece of lint, a *worsted glove*, a *nightcap*, a sponge." He says, "In the winter season, the *glove* of a clerk, *dresser*, or onlooker, has been not unfrequently pressed into the service. . . . The object is to produce insensibility as completely and as soon as we can; and there is no saying, *à priori*, whether this is to be accomplished by *fifty drops* or *five hundred*. We begin with generally two or three drachms *spilt* on the handkerchief or lint; and we refresh that, or not, from time to time, as circumstances require." *Surgical Experience of Chloroform*, Edin., 1848, pp. 16 and 17. The italics are not in the original.

† Curious arguments are sometimes used in support of the idea of peculiarities and idiosyncrasies. A medical man informed me, one day, that he had seen a patient inhale an ounce of chloroform without any effect. I expressed my opinion that if she had taken the vapour of one drachm into her lungs within four minutes, or the vapour of a little more than half a drachm within two minutes, she would have been insensible; and that the chloroform had mostly evaporated into the room, without entering the patient's lungs. Then, he said, it would have made all of us insensible. Now to charge the air of a moderate sized room of twenty feet square and ten feet high, uniformly with only a grain and a half of chloroform to each hundred cubic inches, so that, if all the crevices were closed, a person inside might, in course of time, absorb about eighteen minims of the medicine, and be rendered insensible, would require nearly fifteen pounds of chloroform.

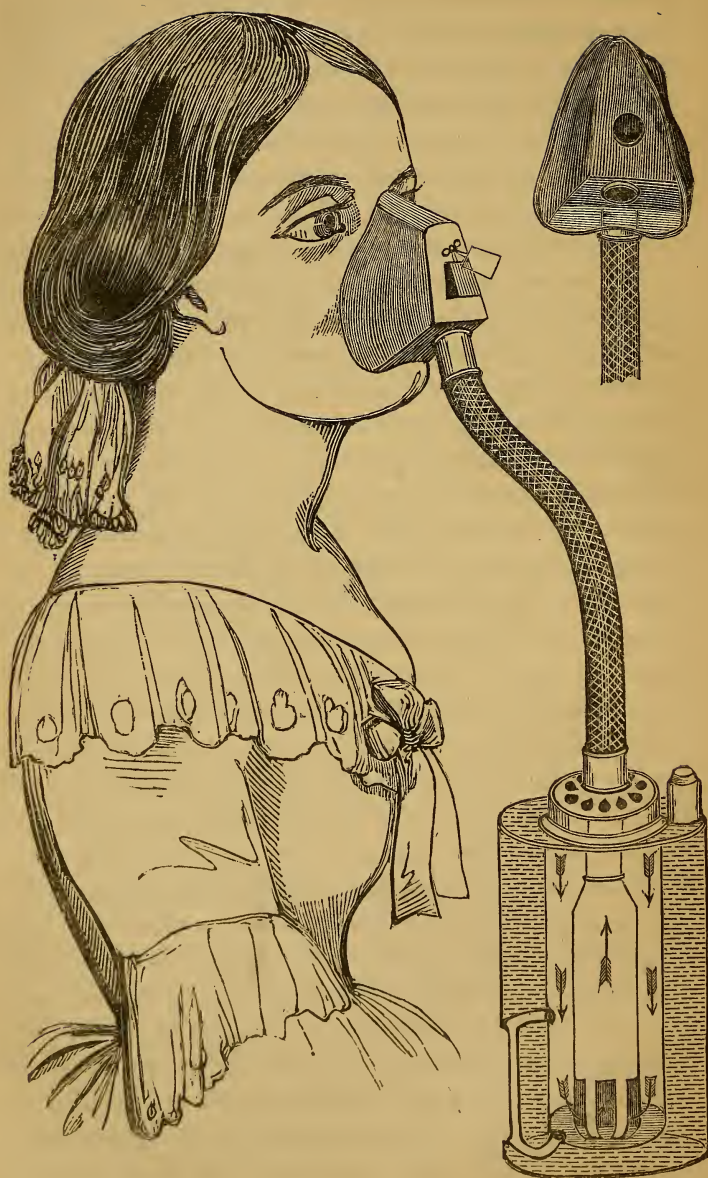
The most exact way in which it is practicable to exhibit chloroform to a patient about to undergo an operation, is to introduce a measured quantity into a bag or balloon of known size, then to fill it up by means of the bellows, and allow the patient to inhale from it; the expired air being prevented from returning into the balloon, by one of the valves of the face-piece to which it is attached. I tried this plan in a few cases, in 1849, with so much chloroform in the balloon as produced four per cent. of vapour in proportion to the air. The effects were extremely uniform, the patients becoming insensible in three or four minutes, according to the greater or less freedom of respiration; and the vapour was easily breathed, owing to its being so equally mixed with the air. I did not try, however, to introduce this plan into general use, as the balloon would sometimes have been in the way of the surgeon, and filling it with the bellows would have occasioned a little trouble. It seemed necessary to sacrifice a little of absolute perfection to convenience, and I therefore continued the plan which I had already followed.

The great point to be observed in causing insensibility by any narcotic vapour, is to present to the patient such a mixture of vapour and air as will produce its effects gradually, and enable the medical man to stop at the right moment. Insensibility is not caused so much by giving a dose as by performing a process. Nature supplies but one mixture of diluted oxygen, from which each creature draws as much as it requires, and so, in causing narcotism by inhalation, if a proper mixture of air and vapour is supplied, each patient will gradually inhale the requisite quantity of the latter to cause insensibility, according to his size and strength. It is indeed desirable to vary the proportions of vapour and air, but rather according to the purpose one has in view, whether medicinal, obstetric, or surgical, than on

account of the age or strength of the patient ; for the respiratory process bears such a relation to the latter circumstances, as to cause each person to draw his own proper dose from a similar atmosphere in a suitable time.

The inhaler represented in the adjoining engraving is, with some slight alterations, the same that I have employed since the latter part of 1847. It is made of metal, and consists of a double cylinder, the outer space of which contains cold water, and the inner serves for the evaporation of the chloroform which the patient is to breathe. Into the inner part of the cylinder there is screwed a frame, having numerous openings for the admission of air, and four stout wires which descend nearly to the bottom of the space, and are intended to support two coils of stout bibulous paper, which are tied round them, and reach to the bottom of the inhaler. In the lower part of this paper four notches are cut, to allow the air to pass in the direction indicated by the arrows. As the quantity of chloroform which is put in should never fill the apertures or notches, the air which passes through the inhaler meets with no obstruction whatever. There is a glass tube communicating with the interior of the inhaler, and passing to the outside, to enable the operator to see when the chloroform requires to be renewed. The elastic tube which connects the inhaler to the face-piece is three-quarters of an inch in internal diameter, to allow of the passage of as much air as the patient can possibly breathe. On the introduction of the practice of inhaling sulphuric ether there was no tubing in this country fit to be breathed through ; that in ordinary use was only about one-third, or three-eighths of an inch in diameter,—not more than a quarter of the proper calibre.

The face-piece, to include both the mouth and nostrils, of which that shown in the engraving is one of the modifications, is one of the greatest mechanical aids to the process



of inhalation which has been contrived in modern times. Dr. Francis Sibson is its inventor. Dr. Hawkesley did indeed contrive a very similar one about the same time as Dr. Sibson,—early in 1847,—but he did not make it known. Dr. Ingen Housz made patients inhale oxygen through the nostrils by means of a bottle of India rubber with the bottom cut off; and Mr. Waugh, of Regent Street, had more recently contrived a mouth-piece to be adapted outside the lips, but the usual practice of inhalation previous to 1847, was for the patient to draw in the medicated air by means of a tube placed in the mouth. This led generally to great awkwardness at first, as the patient usually began to puff as if he were smoking a pipe; and it had the further inconvenience, in the administration of ether, that the tube dropped from the mouth, and the patient began to breathe by the nostrils, just as he was getting unconscious. The sides of the face-piece delineated in the engraving are made of thin sheet lead, which is pliable, and enables it to be adapted exactly to the inequalities of the face, and the patient can breathe either by the nostrils or mouth, just as his will, or instinct, or other nervous functions, determine.

I have introduced two valves into this face-piece, one which rises on inspiration, to admit the air and vapour from the inhaler, and closes again on expiration, and the other which rises to allow the expired air to escape. I contrived the latter valve to turn more or less to one side, as indicated by the additional line in the engraving, and thus admit more or less of the external air to dilute still further that which has passed through the inhaler, and become charged with vapour. By this means the patient can begin by breathing air containing very little vapour, and more and more of the air which has passed over the moistened bibulous paper can be admitted, as the air passages become blunted to the pungency of the vapour.

The object of the water bath is to supply the caloric which is rendered latent, and carried off, as the chloroform is converted into vapour, and thus to render the process of inhalation steady and uniform. Without the water bath, the evaporation of the chloroform would soon reduce the temperature of the inhaler below the freezing point of water, and limit very much the amount of vapour the patient would inhale; and if the apparatus were warmed by the hand, the temperature would be too high, and the amount of vapour too great. A medical author of great reputation in Paris sent to inquire at what temperature I used the water bath, and being informed, at the ordinary temperature, published his opinion that it had no effect, and might as well be left off. He appeared not to have considered the relations of heat, either to liquids or vapours.

In arranging the bibulous paper in the inhaler, it is my object to contrive that the air passing through, in the ordinary process of inhalation, and at the ordinary temperature of about 60°, shall take up about five per cent. of vapour. This quantity can be diminished, as much as is desired, by turning the expiratory valve of the face-piece a little to one side; and in winter I usually place a short coil of bibulous paper against the outer circumference of the inside of the inhaler, in addition to the central coils which are delineated.

I commonly put two, or two and a half, fluid drachms of chloroform into the inhaler at first. About a drachm of this is absorbed by the filtering paper, and the rest remains at the bottom of the inhaler; and in a protracted operation, when it is seen, by means of the glass tube, that the latter part of the chloroform has disappeared, more is added, by a drachm or so at a time, to prevent the paper ever becoming dry. Mr. Matthews, 8, Portugal Street, Lincoln's Inn Fields, makes the inhaler. There are smaller face-pieces for

Warm my
inhaler by
hand because
amount of Eth-
er cannot be
too great -
opinion.

children. The patient never inhales in so upright a posture as the artist has represented.

There are several other kinds of apparatus in use for the inhalation of chloroform. The most usual consist of Dr. Sibson's face-piece more or less altered, and with a small piece of sponge placed inside. The apparatus which is in most reputation on the continent is that of M. Charrière; it consists of a glass vase with suitable valves, and a fabric for exposing a surface wetted with chloroform to the air which passes through it.

M. Duroy, of Paris, has contrived an ingenious, but very complicated, apparatus, which he calls an anæsthesimeter. The object of it is to regulate the amount of chloroform which is inhaled in a given time, and this can be varied from four to sixty drops in the minute; but the experiments which I have related show that the quantity of chloroform employed is not so important as the proportion of it in the inspired air; and although each of these circumstances has considerable influence over the other, in many cases there are conditions in which no regular relation exists between them. For instance, if the inhaler were supplied with sixty drops of chloroform per minute, these sixty drops weigh twenty grains, and produce 15·3 cubic inches of vapour; and if an adult patient were breathing the average quantity of four hundred cubic inches per minute, the air he would breathe would contain nearly four per cent. of vapour, which would answer extremely well; but if the breathing were slow or feeble, or if he should hold his breath for an interval and commence again, he might breathe air much more highly charged with vapour. Indeed it would depend on the amount of surface moistened with chloroform, the temperature of the air, and other physical conditions, whether or not the air he inhaled might not be charged with chloroform to a dangerous degree; whilst, on the other hand, if

the breathing were deep and rapid, as often happens whilst the patient is getting slightly under the influence of the chloroform ;—if, for instance, the patient were to breathe at the rate of 1,600 cubic inches, instead of 400, the air he would inhale would contain less than one per cent. of vapour, and he would not become insensible with the utmost supply of the anæsthesimeter, till his breathing should be moderated. M. Duroy also follows the rude and objectionable plan of using a nose clasp, and thus compelling the patient to breathe by the mouth alone.

It is advisable to request the patient to breathe gently and quietly, when he commences to inhale chloroform ; in other words, to do nothing but conduct himself as if he were about to fall asleep naturally ; for, if he breathes deeply, the vapour feels much more pungent than it otherwise would do, and is apt to excite coughing, or a feeling of suffocation.

In using the inhaler described above, the patient should commence to inhale with the expiratory valve of the face-piece turned on one side, and it should be gradually advanced to the required extent, over the opening it is intended to cover, as the sensibility of the lungs becomes diminished. Not only patients with phthisis or bronchitis, but many sensitive and irritable persons with sound lungs, have a great intolerance of the vapour of chloroform at first, on account of its pungency ; and it is necessary to occupy two or three minutes in gradually commencing the inhalation, before the patient makes any appreciable progress towards insensibility. In administering chloroform to children also, it is desirable to begin very gently ; by this means, and with a little persuasion, one generally succeeds in getting them to inhale voluntarily ; although, occasionally, it is necessary to use a little force to accomplish one's purpose.

In certain cases of the medicinal application of chloroform, and also in obstetric cases, where the pains are not severe, it is unnecessary to render the patient unconscious, but for surgical operations this is nearly always requisite. No force should ever be employed so long as the patient is conscious, unless it be to children or lunatics; but some patients become excited, as soon as they are unconscious, and attempt to leave the couch, or push away the chloroform; under such circumstances, if they cannot be calmed by what is said to them, they should be held, and the vapour should be steadily and gently continued, for a minute or two, till a state of quietude is produced. By far the greater number of patients remain quiet as they become unconscious, but there is no difficulty in ascertaining whether a patient is unconscious or not. If the eyelids remain open, the countenance shows whether the patient is conscious or not; and, if they are closed, it is only necessary to touch them gently, to ascertain this circumstance. If he is still conscious, he will look at his medical man, and probably speak, or, at all events, show intelligence in his countenance.

Signs of Insensibility. The absence of consciousness, and a state of quietude, are both requisite before the commencement of a surgical operation, and they go a good way towards the preparation of a patient for it, but these symptoms may be present and the patient not be ready for an operation. The surgeon wishes to know whether he will lie still under the knife, or whether he will make a resistance and outcry which he would probably not make in his waking state. Some surgeons have recommended that the patient should be pricked with the point of a knife or some other instrument. This is not a good or satisfactory plan, however, for a person will often show no sign of feeling a slight prick, when a severe incision would rouse him to resistance. A more elegant and successful plan is to

raise the eyelid gently, by placing one finger just below the eyebrow, and then to touch its ciliary border very lightly with another finger. This should not be done roughly nor too frequently, for fear of exhausting the sensibility when it is slight. Just after unconsciousness is induced, the eyelids are often closed very strongly when their margins are touched, especially in females, and there seems to be a positive hyperæsthesia; this, however, is only apparent, and arises from the control of the will being removed, whilst sensibility remains. By continuing the chloroform, the sensibility of the edges of the eyelids diminishes until, at last, they may be touched without causing winking. Under these circumstances, the most severe operation may, in almost every case, be commenced without sign of pain. I have employed this test of the sensibility or insensibility of the patient ever since chloroform has been in use, and also in the employment of ether in 1847, and I am satisfied that it affords more reliable information on this point than any other single symptom. It even indicates the amount of sensibility where a little remains; when, for instance, touching the margin of the eyelids causes very slight and languid winking, the patient will commonly flinch a little if the knife is used, but only in a manner that can be easily restrained, and will not interfere with the majority of operations. The cases, in which the indication afforded by the eyelids is not always to be depended on, are those of hysterical patients, in whom there is sometimes no winking on touching the eyelids, even when unconsciousness is scarcely induced. In such cases, one must judge by the other symptoms, and also by the length of time the patient has inhaled, the strength of the vapour, and depth and activity of the breathing. Indeed, these conditions should be observed and taken into account in every case; and all the symptoms exhibited by the patient should be watched, such

as the expression of the face, the state of the breathing, and the condition of the limbs with regard to their tension or relaxation. The last is indeed sometimes relied on as the chief or sole sign whether the operation may be commenced, but it is of itself very insufficient, and even fallacious. The patient may allow his limbs to lie relaxed when he is scarcely unconscious, and not at all insensible, merely because he is not exerting his will upon them ; if the arm is lifted, it may fall listlessly down again, at a time when the knife of the surgeon would rouse the patient to active resistance. Indeed, the limbs, which have been lying relaxed, may become tense as the effect of the chloroform increases, and may remain so during a short operation, in which there is no sign of pain.

Although the pulse of itself gives no indication as to how far a patient is under the influence of chloroform, it is proper to pay attention to it, not only during the first administration of the chloroform, but also throughout the operation, especially if it be attended with much bleeding. The pulse sometimes becomes intermittent or irregular during the administration of chloroform, more especially in elderly persons. This more commonly happens in the first exhibition of it, than when it is repeated during the course of an operation. I have not seen any harm from either of these conditions, but it is well to intermit the chloroform for ten or fifteen seconds, and let the patient have a few inspirations without it, if the pulse is not in a satisfactory condition. If the precaution be taken to ensure that the air the patient breathes shall never contain more than five per cent. of vapour, the pulse can never be seriously affected by the direct action of the chloroform, and the state of the breathing affords the best warning against continuing the inhalation too long at a time.

The breathing is fortunately also a sign that cannot be

overlooked. It is by the breath that the chloroform enters, and it is extremely improbable that any one would go on giving the vapour after the breathing became stertorous and laboured.

The patient sometimes holds his breath after he is unconscious, and before he is insensible; this occurs under two conditions: first, after deep and rapid breathing, during which the patient seems to absorb more oxygen than is immediately required, under the circumstances; and in this condition, I have known him hold his breath for a whole minute, whilst the pulse was unaffected. The other condition in which the breathing is suspended, is when there is rigidity in the third degree of narcotism, and the respiratory muscles seem to partake of the general rigidity; the holding of the breath in these cases seldom continues so long as under the former circumstances. I do not consider that there is any danger from either of these kinds of suspension of breathing. I believe it always returns as soon as there is a want of oxygen in the system. Of course the inhaler need not be applied to the face when the patient is not breathing, and he may as well have an inspiration or two without chloroform when the breathing is renewed. It is seldom requisite to carry the effects of chloroform so far that the breathing becomes stertorous, and whenever stertor is observed, the inhalation should be suspended; under these circumstances, the patient is always insensible. In some cases, in which a little more chloroform has been inhaled than is necessary, the patient breathes for half a minute or so by the diaphragm only, and breathes in fact hardly at all. The abdomen rises and falls freely, but, from the muscles of the chest not fixing the ribs, hardly any air enters the lungs, and the face becomes rather livid; meanwhile the pulse goes on very well, and at last the patient draws a deep, sonorous inspiration, the face resumes its

proper colour, and all is right again. I have not heard of any accident from chloroform commencing in this manner. This state of breathing, when it does occur, usually takes place a few seconds after the inhalation has been left off, and arises from the accumulation of the effects of the chloroform, owing to the absorption into the system of the vapour which was contained in the lungs at the time when the inhalation was discontinued.* This accumulation or increase of the effects of chloroform lasts for about twenty seconds; it is not dangerous unless the vapour is inhaled of too great strength, but it should be borne in mind in all cases. It may be prevented altogether, by reducing the strength of the vapour, just as the patient is getting insensible, or by giving it with intermissions of a few seconds, at this time.

The rigidity and struggling previously mentioned (pages 39 and 50) as occurring occasionally in the third degree of narcotism, more particularly in robust persons, often form a very prominent feature in the effects of chloroform; and have sometimes caused the medical man to discontinue the exhibition of chloroform, under the belief that it did not agree with the constitution of the patient, and that its further exhibition would be unsafe. The proper course to pursue is to continue the inhalation gently, till the struggling and rigidity are subdued. The patient is often insensible before these symptoms are subdued, but it is necessary to have him quiet, in order to enable the surgeon to operate with convenience and safety. I have always succeeded in subduing the involuntary struggling and rigidity, but have

* The increase of effects of chloroform after the inhalation is discontinued, was pointed out by Prof. Sédillot of Strasbourg and myself almost simultaneously. I explained the circumstance in a paper read to the Westminster Medical Society, on January 8th, 1848, and M. Sédillot announced it to the Academy of Sciences of Paris, on January 10th. My remarks were published in the *Medical Gazette* of January 14th, and those of M. Sédillot in the *Gazette Médicale* of January 15th.

occasionally occupied five or six minutes in doing so. It is desirable to proceed slowly and cautiously, because, when these symptoms occur, the patient has already absorbed nearly the usual quantity of chloroform, and he often holds his breath, and then takes a sudden and deep inspiration, when he might inhale an overdose of vapour, unless it were presented to him in a well diluted state.

When the rigidity and struggling are subdued, the breathing, in some cases, becomes stertorous, and relaxation of the muscles takes place, the limbs appearing quite flaccid; but by proceeding gently, these effects may generally be avoided, and the patient becomes quiet, whilst the breathing is natural, and the muscles are in a moderate state of tension. If the operator should be afraid to proceed with the exhibition of chloroform, on account of the violence of the muscular spasm and rigidity, it will be satisfactory to him to know that, if the inhalation is resumed in a few minutes, these symptoms will be less violent than at first.

Struggling and rigidity are less likely to occur, when chloroform is administered slowly, than under opposite circumstances; but it is impossible to prevent these phenomena altogether in certain patients. After they are once subdued, they but very rarely recur during the operation; the patient, in most cases, seems to take on, when he is subdued by the chloroform, the same relation to it that women, children, and persons in a state of debility have from the first. M. Chassaignac has called this condition one of tolerance of the chloroform. It is a condition in which the patient bears both the chloroform and the operation very comfortably; but tolerance of a medicine is generally meant to imply that the patient can take it in larger quantity than before. But this is the reverse of what occurs when the patient is in a tranquil state from chloroform; he has already absorbed a considerable quantity, which has most likely penetrated

deeply into the tissues, and he certainly does not require, and could not bear, so much as in the earlier stage of inhalation, where he is restless and breathing more quickly, and thus exhaling and getting rid of the chloroform at a greater rate.

It might be a question whether the absence of muscular excitement, in a number of cases, does not arise from the circumstance that anæsthesia, or absence of common sensibility, is obtained, and the operation performed, at a stage of narcotism anterior to that in which the muscular rigidity and spasm occur. This is true in a few cases, but I am satisfied by careful observation that, in the greater number of instances in which muscular excitement is absent, it would not occur at all, though the inhalation should be pushed to the most extreme degree. Many animals also are killed by chloroform without the least excitement of the muscular system occurring at any part of the process.

The pupils of the eyes are dilated in the deep state of insensibility which I have called the fourth degree of narcotism, but it is desirable to avoid carrying the effects of chloroform to this extent. They are occasionally dilated, however, under the slighter effects of chloroform, and even as the patient is recovering from its effects. In the third degree of narcotism, when the eyes are turned upwards, the pupils are usually, if not always, contracted; there seems to be a consentaneous action in the iris and the muscles which turn up the eye. The pupils seem also to be less sensitive to light, when the patient is insensible from chloroform, than at other times. This is all the information I am able to give about the pupils. Some writers have entered into a good deal of detail about the pupils, but their statements are very conflicting. The pupils are acted on by other causes, both external and internal, as well as the chloroform. The amount of light has great effect on them; and I have

seen them remain dilated for some time after the chloroform was discontinued, and then suddenly contract, as the patient began to use his eyes. Even if definite laws could be ascertained with regard to the action of chloroform on the pupils, in different doses, and under different conditions, there would be some difficulty in applying them during the administration of the vapour, as the patient cannot be made to direct his eyes to or from the light. There is also some difficulty in making correct observations on the pupils. Very often, when I am exhibiting chloroform, one of the bystanders lifts the patient's eyelid and makes a remark on the state of the pupil, and, on my looking in the face of the speaker, I often have occasion to tell him that his own pupils are quite as much dilated, or contracted, as the case may be.

With regard to the position of the eyes, they are usually turned upwards in the third degree of narcotism, as I have already said, but in a considerable number of instances they retain their usual position all through the inhalation. In a few cases, they are turned downwards, the pupils being almost hid under the lower eyelids, and causing a curious expression. I have noticed this most frequently in children of ten to fourteen years of age. I have scarcely ever seen temporary strabismus under the influence of chloroform.

The length of time which it is most desirable to occupy in the administration of chloroform, before the commencement of an operation, is about two minutes in infants, three minutes in children, and four or five minutes in adults. Circumstances occasionally occur, however, to lengthen these periods. The time during which the adult patient usually remains conscious whilst inhaling, is about two and a half minutes, but this period is sometimes prolonged from the nervousness of the patient, or his intolerance of the pungency of the vapour. Again, when unconsciousness is

induced, there is, in many cases, an increased flow of saliva ; and although this usually causes no impediment, the patient sometimes keeps making efforts of deglutition which very much retard the inhalation ; and, at other times, he holds his breath, with his mouth full of saliva, as if he had some obscure idea of disposing of it in a suitable manner.* The delay which often arises from the struggling and rigidity has been already mentioned ; but notwithstanding all these circumstances, it hardly ever takes more than seven or eight minutes to make a patient sufficiently insensible.

I have indeed met with a few cases in which a longer time has been occupied, but there has always been a physical reason for it. I have never had occasion to attribute the delay to any idiosyncrasy, or great peculiarity in the patient, but only to the circumstance that the vapour did not enter the lungs in sufficient quantity within a given time. I have had under my care several patients who, it was supposed, were not susceptible of the effects of chloroform, or were, at least, very difficult to bring under its influence, as previous attempts had failed. It so happens, however, that I have had no difficulty whatever with any of these cases.

Two or three female patients who were about to undergo some trifling operation, preferred to leave off before they were unconscious, on account of unpleasant sensations in the head or chest, and to have the operation performed without the full effects of the chloroform ; but there is no doubt the agent would have acted well enough if it had been continued.

The following case will show that chloroform may be in-

* I have reason to conclude that the increased secretion of saliva is caused, not so much by the action of the chloroform on the mucous membrane of the month, and the extremities of the gland ducts, as by its action on the capillary circulation of the glands themselves ; for on inhaling the vapour carefully by the nostrils, so that none enters the mouth, I still find that there is an increased secretion of saliva.

haled with advantage in cases which at first seem very unfavourable. I received a note in 1849 from a medical man in the country, in which he says:—"I have now a young lady under my charge, from whom I am about to remove a tumour attached to the ear. She is anxious to take chloroform, and by the desire of herself and mother, I yesterday administered it by way of trial, but only to what would be termed the second, and perhaps you would say, the first degree. She lost some sensation, but was quite conscious, and spoke. She felt giddy; there was tumultuous beating of the heart, and a much accelerated pulse, with a dilated pupil; a perfect coldness over the whole skin, with an equally cold perspiration; and, during recovery from this slight effect, severe tremors of the whole body, so much so as to shake the couch on which she was lying. From this state she did not recover for nearly an hour. She complained of great giddiness and oppression at her chest. She is a healthy looking, florid girl, but not strong, and has had, from time to time, severe spasm affecting her chest, so much so as to take away her breath. I have thus endeavoured to give you an outline of the constitution of my patient, how she had suffered, and what were the effects of the small dose of chloroform given by an inhaler. I never witnessed such extreme cold, tremor, or such tumultuous action of the heart; and am therefore anxious for the opinion of one who has administered chloroform under a greater variety of circumstances than myself, and to learn whether the symptoms I have described are sufficient to deter one from giving a sufficient dose to cause entire suspension of consciousness. My own impression is that they are sufficient to deter, but the patient and her friends being both anxious it should be inhaled if possible, I shall only be too glad to hear that you have witnessed like symptoms, and that you do not consider them sufficient indications of danger to deter me from its careful administration in the case."

I advised that the chloroform should be administered again, and continued steadily till the patient should become insensible ; expressing my belief that the unpleasant symptoms would subside as unconsciousness was induced. I received a reply to the effect that the operation had been performed very successfully under the influence of chloroform, although the vapour had an exciting effect for some time.

Repetition of Chloroform during an Operation. The first application of chloroform often suffices for an operation, if it be of short duration, without repeating the inhalation. In a few cases the patient remains insensible to the knife for three minutes after the inhalation is left off, but this is an exception ; and one cannot, at all events, make sure of this prolonged effect of chloroform, without producing a deeper state of narcotism than is desirable. More usually, if the operation lasts more than a minute or two, it is necessary to repeat the inhalation ; it is, indeed, generally desirable to let the patient have a few inspirations of air charged with chloroform vapour every half minute or so, whilst the operation continues, in order to keep up the insensibility. When the surgeon is cutting in the neighbourhood of important parts, it is desirable to prevent any sign of sensibility, and to keep repeating the chloroform so as to keep up the coma, without, however, causing embarrassment of the breathing, or wide dilatation of the pupil. In the greater number of operations, however, it is better to wait till there is some sign of sensibility, such as a slight cry or tendency to flinch, before the inhalation is resumed ; and then a few inspirations of well diluted vapour make the patient quiet again.

RECOVERY FROM THE EFFECTS OF CHLOROFORM.

As soon as a patient has ceased to inhale, the chloroform

begins to exhale in the form of vapour from the blood as it passes through the lungs. It cannot be detected by the sense of smell, after the lungs have been emptied, by two or three expirations, of the vapour they contained at the moment when the inhalation was discontinued; but I have detected it by chemical means, after consciousness had returned. The chloroform exhales in greatest quantity at first, and the patient usually recovers his sensibility and consciousness in the time which it ought to take for the chief part of the chloroform to be exhaled, according to mechanical principles; as will be explained in treating of the *modus operandi* of this agent. The last traces of the chloroform of course exhale more slowly, and a very minute and insignificant quantity may remain for a considerable period in the system, not only of the patient, but of anyone who was standing by whilst he inhaled.

It is probable that a small portion of chloroform passes out by other channels than that of the expired air: the latter, however, offers such a ready and expeditious outlet, that the quantity excreted in any other way is, most likely, very minute. I have on four occasions examined urine passed after the inhalation of chloroform, by boiling it in a flask, and passing the vapour, first through a red-hot tube, and afterwards through a tube moistened inside with solution of nitrate of silver, and I only on one occasion obtained a very slight precipitate of chloride of silver.

The patient usually becomes conscious within five minutes after the inhalation has been discontinued. After a short inhalation, for a very brief operation, consciousness sometimes returns immediately, and after a prolonged inhalation the recovery of consciousness is sometimes retarded till ten minutes have elapsed. Old people are often longer than others in awaking from the effects of chloroform, owing, no doubt, to their slower breathing and circulation. Chil-

dren, on the other hand, usually recover very quickly from its direct effects ; but they often lapse into a natural sleep which lasts a considerable time—even for hours if they are not disturbed, and if the operation has left no painful wound or other cause of uneasiness.

It is desirable not to talk to the patient as he is recovering from the effects of chloroform, but to leave him to collect his ideas, and not speak to him till he is quite conscious, or makes some remark or inquiry himself. If not prevented by the medical attendant, the friends of the patient often address him the moment he opens his eyes ; and the words they generally use are of a very equivocal meaning to one who cannot understand their application. They usually say “It’s all over”, which very often has the effect of raising an indefinite feeling of alarm in the patient ; for, until he has had time to recover his memory, the operation he was to undergo is generally the farthest thing from his mind. When left to himself the patient usually recovers from the insensibility in a very tranquil manner. If he has not been moved whilst insensible, and awakes in the position in which he fell asleep, he supposes, very commonly, that he has not been asleep at all ; and in a great number of instances will contend this point very stoutly, even after a protracted operation, and assert that the chloroform has not taken effect. It is as well to let him remain in this conceit for a while, or even till he finds out the mistake himself ; for, if reminded of the pain they have been spared, just on waking after an operation, persons are liable to be excited by emotions of pleasure and gratitude ; but a few minutes later, when the effects of the chloroform have more completely subsided, they are better able to control their emotions. A few persons wake with a full recollection of the preceding circumstances, and inquire if the operation is done ; whilst others, on first

awaking, are still entirely occupied with the subject of their dreams.

The greater number of patients who inhale chloroform have to remain in bed on account of the operation which has been performed, but after minor operations, the patient is sometimes able to walk away within five minutes; although more frequently there is a little languor or feeling of fatigue for half an hour or so; and it is desirable in all cases for the patient to sit or lie quietly for this space of time, if not longer, before he makes any mental or bodily exertion, even if he feels quite well.

OCCASIONAL SEQUELÆ OF THE INHALATION OF CHLOROFORM.

Sickness. The chief drawback to the benefits conferred by chloroform is the sickness which in many cases follows its use. It is most frequent when the inhalation takes place soon after a meal, and some of the precautions which are requisite in order to avoid this symptom, or render it as rare as possible, have already been described (p. 74); but it occurs in certain cases, notwithstanding the best measures which may be used for its prevention. Moving the patient as the effects of the chloroform are subsiding is very apt to excite vomiting when it might not otherwise occur; it is therefore desirable, when convenient, to allow the patient to lie for half an hour or so, without moving his head from the pillow. By this means, even when a feeling of nausea is present, it often subsides without the occurrence of vomiting. It is advisable also not to give the patient anything to eat or drink till about an hour after the inhalation, and, as a general rule, not even then, unless there is some inclination for it; for if anything is taken into the stomach before the effects of the chloroform have entirely subsided, it is apt to excite vomiting. Even medicine, such as an opiate, is better delayed for an hour or upwards,

unless there is an urgent necessity for giving it sooner. Severe faintness from loss of blood during an operation of course forms an exception to this rule; in such a case brandy and water should be given, and repeated if it should be vomited.

These rules respecting food are, moreover, meant to apply only to the use of chloroform in surgical operations, and not to its employment during labour. Under the latter circumstances, one allows the patient all the nourishment that is desirable, intermitting the inhalation now and then for the purpose. And chloroform, given in the moderate way in which it is employed in labour, hardly ever causes sickness, but often alleviates it when present from physiological causes.

The sickness induced by chloroform usually subsides of itself in the course of an hour, or even less; I, therefore, think it advisable not to do anything for it during this space of time. When it has continued beyond this period, I have found a little cold brandy and water to remove it in most cases; and when the tendency to vomit still remained after a few hours, I have seen it removed by a dose of opium. Effervescing draughts have not appeared to be of service in the sickness from chloroform, and sal volatile and draughts of warm water seem injurious. It is desirable for the patient to make no effort, but only to vomit if obliged to do so.

Several cases have come within my knowledge, in which the sickness has continued for two or three days after every thing that was taken into the stomach. These cases have not been under my care, but under that of the surgeon. I have been informed, however, that all the usual remedies for sickness were applied for the time mentioned above without success. The cases in which the sickness lasts so long form but a very small portion of the whole number in

which chloroform is administered, and they chiefly occur in persons who are subject to attacks of vomiting from slight causes, or, as they say, to bilious attacks.

The most usual time for the vomiting to commence is when the inhalation has been discontinued, and the effects of the chloroform are passing off. In many cases, it occurs before the patient has become quite conscious, and he does not know that it has occurred unless he is told. In a few cases, especially where there is a good deal of food in the stomach, the vomiting comes on before the operation is finished, or even before it is commenced. When vomiting comes on during an operation, it is apt to interfere with the inhalation, and it is sometimes difficult to prevent the patient from waking; but this can be accomplished by wiping the patient's mouth, and reapplying the chloroform, the moment the act of vomiting ceases. In many cases, however, the sickness does not come on till the patient is quite awake, and perhaps, even then, not until he moves. I believe that the sickness which is due to chloroform always commences within an hour or two, or at the farthest, just after the first food which is taken. I have known vomiting attributed to the chloroform which did not occur till the following day, but I ascertained that a dose of opium had been taken at night, and it was to this that the sickness was probably owing. In those cases where the chloroform does cause sickness in the first instance, it is not always the cause of all the vomiting which the patient may suffer. If the patient becomes infected or is inoculated with the poison of erysipelas or hospital gangrene at the time of the operation, he will probably be attacked with vomiting a day or two afterwards; and if sickness has already been caused by the chloroform, that which is due to disease may appear to be a continuation of it.

Soon after the introduction of chloroform, I administered

it to a gentleman, aged about 55, whilst a fatty tumour was removed from the nape of the neck. It did not turn out as fatty tumours usually do, but required to be dissected out. The patient had taken a meal before the operation, and vomited freely afterwards. On his visit the next morning, the surgeon thought his patient going on well. Vomiting returned, however, and the patient became affected with partial stupor and delirium, which his friends attributed to the chloroform. He became covered with an eruption of erysipelas over a great part of the body, had a very rapid pulse with great depression, and died on the fifth day. An examination after death showed that there had been diffuse cellular inflammation around the seat of the operation. A surgeon who assisted at the operation on the above patient, and also at the post mortem examination, removed an encysted tumour from the scalp of an old lady the day following the latter event. This operation was performed without chloroform, but the patient was attacked with erysipelas and diffuse cellular inflammation, and died in three or four days.

Faintness and Depression. Although chloroform acts as a stimulant to the circulation, increasing the force and frequency of the pulse whilst it is being inhaled, it is occasionally followed by a feeling of faintness, especially if the patient remains in the sitting posture. At one period in the history of medical opinion, it would have been said that the depression was a consequence of the previous excitement. The facts, however, would not agree with such a doctrine. The subjects who are most stimulated by chloroform are the strong and robust, and they do not suffer from depression afterwards; whilst the feeble and debilitated, who are most liable to subsequent depression, are but little stimulated by it at the time of inhaling. Some amount of faintness and depression usually accompanies the sickness

caused by chloroform, and is in fact a consequence of it, being, like the sickness, most frequent after a full meal. This depression is usually relieved by vomiting. I have met with a few cases in which there has been more decided faintness, and once or twice absolute syncope after chloroform, which was not attributable to loss of blood. In these cases, however, the patients were in the sitting posture, and they recovered from the syncope immediately, on being placed horizontally. The patients most subject to faintness after chloroform are those who are subject to this affection at other times, being often persons in a state of anæmia, or having the symptoms of fatty degeneration of the heart. Faintness is, however, very much more rare after operations with chloroform than without it. The only cases in which I have seen it follow the use of chloroform in the horizontal position, and where there was no considerable loss of blood, have been two or three of operations on the rectum, performed before breakfast, and after a brisk purgative had been taken the previous night. It might be advisable, where persons in a state of debility have taken a purgative, to make an exception to the usual rule of prohibiting the breakfast, and to risk the inconvenience of vomiting rather than the more formidable symptoms of faintness from inanition.

The faintness which now and then follows an operation under chloroform should be treated on ordinary principles, as the horizontal posture, the application of the vapour of ammonia to the nostrils, and the exhibition of brandy or wine, if the other measures do not suffice. I never give ammonia internally where a patient is sick or faint, but the spirit of sal volatile, when at hand, serves very well to pour on the corner of a towel and apply to the nostrils.

Hysteria. I have already stated (p. 51) that chloroform occasionally excites hysteria in those who are subject to

that complaint; and that, in a few cases, the hysteria, which has been subdued by the chloroform, reappears as the effects of the vapour subside. It is nearly always in the female sex that one meets with these phenomena, although I have two or three times seen hysterical symptoms in the male for half an hour or so after the inhalation. The hysteria commonly takes the form of laughing or crying, but the patient sometimes remains quiet, and simply in an unconscious state. The hysterical symptoms usually pass off spontaneously, in half an hour or less, without any remedies; if they last longer, the ordinary remedies for hysteria may be applied. I am not aware that the hysteria has lasted longer than three or four hours in any of the cases in which I have administered chloroform, but it may have done so without my being informed of the circumstance. I was informed of the case of a young woman in King's College Hospital, who remained unconscious, or at least apparently so, for three days after chloroform had been administered for an operation, the nature of which I have forgotten. She recovered without ill effects. When the patient does not wake spontaneously, and cannot be roused to the waking state, within twenty minutes or half an hour after the inhalation of chloroform has been left off, we may rest assured that the patient is affected with hysteria—at least this has been the case in every instance with which I have become acquainted. The physical properties of this agent do not permit it to remain long in the system, if the circulation and respiration are going on properly, and this circumstance ought to prevent unnecessary alarm, in the absence of other symptoms except the state of unconsciousness. I have, however, known great alarm to exist where the properties of chloroform were not well understood. Soon after its introduction, a medical man administered it to a young woman in domestic service, for the extraction of

a tooth. He became alarmed, in the first instance, from the impression that he had given an overdose. In a few minutes, however, the patient burst out in a loud fit of laughter, but again became unconscious, and various measures were used to restore her, including even artificial respiration, in the idea that she was still under the influence of chloroform. I was sent for thirty-six hours after the inhalation, and found the patient apparently in a profound state of insensibility, and breathing very feebly. Guided by the considerations mentioned above, I concluded that she was only labouring under hysteria, and that the anxiety of those about her tended very much to keep up the complaint. The anxious attendance on her was discontinued, she took some medicine containing valerian, and became quite conscious in few hours. I was told, however, that she did not seem quite well for some time.

I am not aware of any permanent ill effects having been produced by chloroform, although, amongst the multitudes of persons who have inhaled it, some have not failed to blame it for symptoms that have occurred afterwards.

A clergyman from the country called on me, in 1852, and the following are some notes I made when he left my room. He is 63 years of age. He said that he had inhaled chloroform about a year ago to have four teeth extracted. He felt very well for about a week afterwards, but on his pupils returning, and his beginning to apply himself to teaching, he became affected with flushings of the face and a rushing noise in his head, which lasted occasionally for a day or two, and have troubled him ever since. An eminent physician, whom he named, prescribed quinine, under the use of which he became worse. An eminent surgeon prescribed infusion of hops, etc., and he has tried other medicines without good effect. He had been recommended to travel, and had been to Switzerland; but the complaint troubled him when at leisure, as well as when ap-

plying himself mentally. He could not sleep at night, when affected with the attacks. He is rather deaf, and has been so for three or four years ; he was also occasionally troubled with a rushing sound behind the ears before he inhaled the chloroform. He is rather short and rather stout, and has a florid complexion. The pulse was rather feeble. The second sound of the heart was rather louder than the first. In other respects its sounds were natural, but its impulse was not strong. In every respect, except the symptoms above named, the health of the patient was good, and he felt quite well between the attacks.

It was my opinion that the complaint of this gentleman was coming on long before he inhaled the chloroform, and that it depended on a much less transient cause. I have not heard from him since.

CAUSE AND PREVENTION OF DEATH FROM CHLOROFORM.

All narcotics are capable of causing death, and the discovery of preventing pain by inhalation consists essentially in carrying the effects of a narcotic much further than had previously been the custom ; there was, therefore, every reason to apprehend that accidents might occur in the new practice, unless the effects of the medicines employed could be very effectually controlled. There are certain circumstances connected with the physiological properties of chloroform, as ascertained in the experiments previously related, which indicate how accidents may very easily happen with this agent, if not carefully and systematically managed. It was calculated (p. 74) that 18 minims of chloroform is the average quantity in the system of an adult, when sufficiently insensible for a surgical operation, and that this amount might be absorbed by the use of 36 minims, allowing one half of the quantity breathed to be exhaled again, without being absorbed ; but 36 minims of chloroform make only 37·5 cubic inches of vapour, which, at the tem-

perature of 60° Fah., may exist in combination with 257 cubic inches of air, making it expand to not quite 300 cubic inches ; the whole of which might be breathed in twelve ordinary inspirations of 25 cubic inches each. If the inhalation of vapour of this strength were continued till insensibility was induced, the lungs would still contain a great quantity of unabsorbed vapour. The amount of air usually present in the lungs is about 250 cubic inches, and if saturated with chloroform at the temperature of 60° it would contain the vapour of 30 minims. About half of this might be absorbed, the remaining half passing off in the expired air ; but the addition of 15 minims to the 18 minims already absorbed would almost double the quantity of chloroform in the system, and bring the patient necessarily to the brink of death. It is true that, in the ordinary methods of inhalation, the air seldom becomes quite saturated with vapour, and usually is not more than half saturated, or accidents might be of much more frequent occurrence ; but the above considerations are sufficient to show that the amount of vapour contained in the air breathed by the patient should not be left to mere accident, such as the varying temperature of the handkerchief from which the chloroform is breathed, or the greater or less extent of wetted surface over which the air passes. It should be recollected also that the patient sometimes draws a deep and sudden inspiration by which he may inspire 100 cubic inches of air, which would contain, if strongly charged with vapour, ten or twelve minims of chloroform—a large quantity to be suddenly added to that already in the circulation, when the patient is insensible, or nearly so.

It is, however, only by a knowledge of the different modes in which chloroform is capable of causing death, that the exact nature of the accidents from this agent can be understood, together with the means of preventing them, and

the reason why they are usually irremediable when they happen. If animals are kept for a very long time under the deep influence of chloroform, they become ultimately exhausted, the circulation and respiration are gradually weakened, and cease nearly together. Such a mode of death from this agent is never likely to occur to the human subject, and therefore need not engage our further attention. The following experiments illustrate the different modes of dying, when death is caused more suddenly by this agent.*

Experiment 23. A young but full-grown cat was placed in a glass jar, of the capacity of 1,600 cubic inches, and a fluid drachm of chloroform was introduced, by a portion at a time, through a tube in the cover of the jar. As twenty-five minims of chloroform produce twenty-six cubic inches of vapour, the atmosphere which the cat had to breathe contained nearly four per cent. of vapour, and the jar was moved about, to ensure the uniform mixture of the vapour with the air. In five minutes, the cat became insensible, and lay breathing naturally. In about ten minutes more, the breathing became very feeble, and it ceased altogether in about another minute, or sixteen minutes after the cat commenced to breathe the chloroform. It was immediately taken out and laid on a table, and the stethoscope was applied to the chest. The heart could be heard beating distinctly at first, but the pulsations became slower and

* London Journal of Medicine, April 1852.

In one of the latest communications of Dr. Marshall Hall to the *Lancet*, he did me the honour to quote the account of the three following experiments, together with some accompanying remarks from the *London Journal of Medicine*, and to make the following observation respecting the pages from which he quoted.

"I have no hesitation in affirming that the first three pages of this paper are amongst the most able and valuable in physiology, and I beg to be allowed to reproduce them in the pages of the *Lancet*." (*Lancet*, April 18th, 1857, p. 397.)

feebler, and in about a minute they could be no longer heard. Just at this time, however, the cat took a gasping inspiration, and immediately the heart was heard to beat in a most rapid manner. The gasps were repeated, and the action of the heart became less rapid, but stronger. In a little time, both the breathing and the action of the heart became natural, the cat remaining, however, insensible for some minutes.

Experiment 24. A cat, about the same size as the last, was put into the same jar, and the same quantity of chloroform was introduced. It was removed at the end of four minutes, when it was so far insensible as to offer no resistance. Being laid on the table, it was made to breathe air charged with ten per cent. of vapour of chloroform from a bladder. Twenty-five minims of chloroform were put into the bladder, which held 250 cubic inches, and it was filled up with the bellows. A portion of another bladder, which was attached to the stop-cock, was made to surround the head of the cat, which consequently breathed to and from the bladder. In half a minute it was quite insensible : in about half a minute more the breathing became difficult, and the sounds of the heart less distinct. The breathing became gradually slower, and ceased altogether between three and four minutes after the respiration from the bladder commenced. The sounds of the heart were, rather frequent, and scarcely audible, just before the breathing ceased, and they could not be heard afterwards. The chest was opened three-quarters of an hour after death. The lungs were of a pale red colour, everywhere permeated with air ; and a small quantity of fluid blood flowed from them on making an incision. The right cavities of the heart were quite full of blood, and the left cavities contained a small quantity.

Experiment 25. A cat was made insensible in the same manner as the two previous ones. As it made strong efforts

to get out of the jar, and consequently breathed more deeply, the chloroform took effect sooner; and it was removed and laid on the table, in a passive state, at the end of two minutes and a half. The respiration and sounds of the heart were quite natural. The nose of the animal was placed in the mouth of a metal vessel, lined with bibulous paper, and used as a chloroform inhaler. The inhaler contained chloroform, and was surrounded with water of the temperature of 110° Fahr. The stethoscope was kept applied to the chest whilst the chloroform was exhibited. After four or five inspirations from the inhaler, the heart suddenly ceased to beat, the breathing still going on. The inhaler was removed as soon as I was satisfied that the action of the heart had ceased, and there were two or three rather convulsive respirations afterwards, and then the breathing stopped; but, between one and two minutes later, there were two or three feeble inspirations, accompanied with motion of the nostrils, but no returning action of the heart could be heard. The chest was opened ten minutes after death. The lungs were quite pale throughout. There was a little clear serum in the pericardium. The heart appeared quite motionless when first observed; but, after exposure to the air for a short time, there were some slight contractions of a few fibres of the right ventricle. The right auricle and ventricle were filled with blood.

The air which this cat breathed must have contained much more than ten per cent. of vapour.

In experiment 23 the breathing was arrested by the influence of the chloroform on the nervous centres, but the action of the heart continued, until it was stopped, or very nearly so, for want of respiration, as in asphyxia from privation of air. In experiments 24 and 25 the action of the heart was arrested by the direct effect of the chloroform; in one instance at the same moment as the respiration, and in the other instance, even before it.

The paralysing effect on the heart of large doses of chloroform was shown in the first experiments which were made with this substance, viz., those by Dr. R. M. Glover in 1842.* In animals which were killed by injecting it into the jugular vein, the irritability of the heart was found to be destroyed, whilst this organ retained its irritability in those that were killed by the injection of chloroform into the arteries, stomach, or peritoneum. I have frequently arrested the action of the heart remaining in animals which were opened immediately after death, by blowing the vapour of chloroform on it; and I ascertained by some experiments on frogs, that the motion of the heart can be arrested by an amount of chloroform somewhat greater than suffices to suspend the respiration. As absorption of chloroform vapour is continued by the skin of these animals after the respiratory movements have ceased, they can be exposed to the vapour till the action of the heart is suspended by its direct influence.

Experiment 26. Four and a half grains of chloroform were introduced into a jar containing 600 cubic inches, being three-quarters of a grain to each 100 cubic inches, and, the vapour having been equally diffused, two frogs were put in. They tried to climb up the side of the jar, as if wishing to make their escape, and one or the other occasionally ceased to breathe for a minute or two, probably from disliking the vapour, but commenced to breathe again. In about five minutes the efforts to escape ceased, and they only moved to adjust their equilibrium when the jar was disturbed. They were now breathing regularly, and continued to do so till about ten minutes after their introduction, when all voluntary power ceased, and the breathing began to be performed only at intervals. They were allowed to remain till half an hour had elapsed, during the

* Edin. Med. and Surg. Journal, vol. lviii.

last ten minutes of which time no respiratory movement was observed in either of them. On taking them out, and laying them on their backs, the pulsations of the heart were observed on each side of the sternum. These pulsations were the more distinct, from the lungs being apparently empty. I continued the experiment on these frogs, placing one of them back again, in the course of two or three minutes, in the same jar, with three grains of chloroform, and the other in a jar of 400 cubic inches capacity, with five grains. They were laid on their backs, and the heart of the former one, in air containing half a grain of chloroform to each 100 cubic inches, continued to beat distinctly and regularly, 45 times in the minute, for four hours that it remained in the jar, and it was not observed to breathe during the whole time, although it was watched almost constantly. The respiration commenced again within half an hour after its removal. In about an hour, it recovered its power of voluntary motion, and it was not injured by the long narcotism.

The pulsations of the heart of the other frog, in air containing a grain and a quarter of chloroform to each 100 cubic inches of air, became slower and more feeble, and in a quarter of an hour could not be observed. The frog was left in the jar a quarter of an hour longer, and removed when it had been in half an hour. The under part of the thorax was immediately opened sufficiently to expose the heart. It was moderately full of blood, but not contracting at all, and it did not evince the least irritability on being pricked, either at first or after exposure to the air for some time. It is evident that the heart of this last frog became paralysed by the absorption into the blood of more vapour, in addition to the quantity that was sufficient to arrest the respiration. The temperature of the room during this experiment was 65° Fah.

The effect of chloroform on the heart of the frog is further shewn by the next experiment.

Experiment 27. A frog was placed in the jar containing 600 cubic inches, with six grains of chloroform. In twenty minutes the respiration had ceased, but the heart continued to pulsate strongly. At the end of three-quarters of an hour, the pulsations were more feeble, and had diminished from 40 to 30 in the minute. An hour and five minutes from the commencement of the experiment, no movement of the heart could be observed. The frog was taken out of the vapour, and a portion of the sternum and integuments removed, so as partly to expose the heart, when it was found to be still contracting, with a very feeble undulatory motion. This motion increased in force, and, in a quarter of an hour after its removal, the heart was pulsating regularly and strongly, the ventricle apparently emptying itself perfectly. When the frog had been out twenty minutes, it was placed again in the same jar, with the same quantity of chloroform. In about ten minutes, the heart's action began to fail again; and in about twenty minutes, the slightest movement could no longer be perceived in it. The frog was immediately taken out, and the ventricle of the heart was pricked with a needle. In a few seconds, a slight quivering was observed,—whether the result of the prick is not certain,—and the action of the heart became gradually re-established as before. It was arrested a third time by exposure to the vapour; and although, in its third removal, the anterior extremities of the frog had become rigid, the heart resumed its action partially, and continued to contract feebly for three or four hours after the rigidity of death had invaded the body and limbs of the animal. The temperature of the room was 62° during this experiment.*

In the human being and all other creatures of warm

* Lond. Med. Gaz., vol. xlii, p. 414.

blood, any vapour which is inhaled and absorbed in the lungs passes at once to the left side of the heart, and as the coronary arteries are the first branches given off from the aorta, the heart must, during the process of inhalation, be always a very little in advance of the rest of the body, as regards the amount of vapour to which it is subjected. This, however, is no source of danger, as regards chloroform, if the inhalation takes place in a gradual and uniform manner; for the heart being able, as shown by the above experiments on frogs, to bear a greater amount of this narcotic than the brain, its action continues even after respiration has ceased, if the vapour is added only by a little at once to the blood, as it passes through the lungs. But if the air which the patient breathes be too highly charged with vapour, it is easy to understand how the sensibility of the nerves of the heart may be paralysed, notwithstanding their power to bear somewhat more of this agent than the brain and nerves of respiration. I calculated (p. 74) the quantity of chloroform which would suffice to arrest respiration in the adult of average size to be thirty-six minims, provided it were equally diffused through the circulation; but supposing a patient breathes, at any time, air containing ten per cent. of vapour of chloroform, a considerable part of this might enter the lungs at a very few inspirations, for thirty-six minims of chloroform occupy only 37.5 cubic inches, and would be contained in 375 cubic inches of air, and might be breathed in less than a minute; but for the whole of the blood to pass through the lungs occupies a considerable time—I believe about four minutes in the adult—and therefore the portion of blood which is passing through the lungs, at the time when vapour of the above strength is inhaled, must become much overcharged with chloroform, making every allowance for the portion of vapour which is expired again, without being absorbed.

I have observed the manner in which the breathing and circulation ceased in a great number of instances, with the stethoscope applied to the chest of the animal, when the quantity of chloroform contained in the air it breathed was known, and have notes of the result. The animals were chiefly cats, which would otherwise have been killed by prussic acid, or in some other way. In every instance in which the quantity of vapour in the air breathed by the animals was from three to six per cent., the respiration ceased whilst the sounds of the heart were still very distinct, as in Experiment 23, related above; in many instances the heart continued to beat from two to three minutes after the breathing had ceased, and, in a great number of instances, there were one or more gasping inspirations just at the moment when the sounds of the heart ceased. In many cases these gasping inspirations caused the action of the heart to return, as in Experiment 23, if the animal had been withdrawn from the chloroform; but this was not always the case; and if the chloroform was still breathed during these gasping efforts, all signs of life immediately ceased in every instance.

When, on the other hand, the air breathed by the animals contained eight or ten per cent., or upwards, of vapour of chloroform, the action of the heart was always seriously affected and rendered extremely feeble, if it did not actually cease, at the time the breathing was arrested. In several instances, indeed, the sounds of the heart entirely ceased before the breathing, as in Experiment 25; and although the chloroform was withdrawn, in this and many other experiments, the moment the heart ceased to beat, and fresh air was drawn in by inspiratory efforts, it very rarely had the effect of restoring the heart's action, although this happened so frequently when that organ had gradually ceased to act on account of suspension of the breathing, by the effect of more diluted vapour.

It would they not recover in this

In order to see more precisely the action of the vapour of chloroform on the heart, when not sufficiently diluted, the chest and pericardium were opened on four occasions, in cats and a rabbit, and chloroform was exhibited by artificial respiration. I was assisted by Mr. Peter Marshall in these experiments, and the following is the account of one of them.*

Experiment 28. A young rabbit, rather more than half-grown, was made insensible by breathing air charged with four per cent. of vapour of chloroform in a large jar. The trachea was then opened, and a tube was introduced and tied. The lungs and heart were then exposed, by making an incision and removing the lower half of the sternum, with the adjoining part of the cartilages of the ribs on each side. The front of the pericardium was also cut away, to expose the heart. Whilst these operations were performed, artificial respiration was kept up by means of a bladder of air attached to the tube in the trachea. The heart contracted vigorously and quickly, and the lungs were of a light red colour. The rabbit was beginning to show signs of returning sensibility, when the bladder of air was changed for one containing ten per cent. of vapour of chloroform. The bladder contained 125 cubic inches, and twelve minims of chloroform were put in before it was filled with the bellows. Three or four inflations of the lungs only were made, when I perceived that the heart was beginning to be affected, and I changed the chloroform for a bladder containing only air. These three or four inflations of the lungs with chloroform, had the effect of causing the right cavities of the heart to become distended with blood, and its pulsations to become much slower. In two or three minutes, however, the action of the heart was quite reestablished by the artificial respiration, the pulsations being vigorous and

* London Journal of Medicine, April, 1852.

frequent, and the ventricles being apparently emptied at each contraction. The bladder charged with ten per cent. of chloroform was again attached, and artificial respiration was made with it. The right ventricle began almost immediately to become distended; and, by the time that eight or ten inflations of the lungs had been made, the contractions of the heart were very slow and feeble. Artificial respiration with air was resumed, but without the effect of restoring the action of the heart. The lungs were observed at the time when the right ventricle was becoming distended, and it was noticed that their colour was unchanged. They afterwards became paler, as the artificial respiration was continued after the ventricle had ceased to empty itself. No contractions of the diaphragm were observed after the first inflation of the lungs with chloroform, and the rabbit did not gasp at any time; whilst the cats were observed to make a few gasping efforts at the time when the heart's action was ceasing.

The circumstance of the lungs not changing in colour at the moment when the right ventricle was becoming distended, which was observed in the cats as well as in the rabbit, shows that the distension arose from the failure of the contractile power of the heart, and not from impediment to the pulmonary circulation; for, in the latter case, the lungs would have become congested, and of a deeper colour. In one of the cats, it appeared to me that the left, as well as the right ventricle, was distended with blood; but this distension of the left ventricle did not continue.

In the Experiments 24 and 25, related above, the animals were first made insensible by vapour of moderate strength, in order to keep them quiet for the application of the stethoscope whilst the stronger vapour was inhaled, but when animals are made to breathe air containing ten per cent. or so of vapour of chloroform from the first, death takes place

in the same manner, *i. e.* by the direct action of the chloroform on the heart. Under these circumstances the creatures die suddenly, after a brief interval of agitation and excitement, without previous insensibility. This is what has happened in some of the accidents from chloroform, to be related further on; whilst in many cases death has happened after a longer or shorter period of insensibility.

In many of the fatal cases of inhalation of chloroform the alarming symptoms commenced whilst the patient was still inhaling, but in a considerable number there was no sign of danger until after the inhalation had been left off; and this is a result which may be imitated on animals. The two following experiments, which were made at Dr. Sibson's on December 27th, 1849, illustrate this point. *See this*

Experiment 29. The subject of this experiment was a young guineapig, about half grown. Ten or twelve drops of chloroform were put into a short bent metal tube, lined with bibulous paper, which formed part of an inhaler, and one end of the tube was applied to the animal's nose, which closed it. The guineapig consequently breathed backwards and forwards through the tube, which was, moreover, warm from being held in the hand. It struggled at first, endeavouring to get away from Dr. Sibson, who held it; but in twenty or thirty seconds it became quiet; and observing that the conjunctiva was insensible, I withdrew the chloroform, and the guineapig was laid on the table. We remarked that the breathing was very slow; and scarcely had this remark been made, when it ceased altogether, three or four inspirations only having been made since the inhalation was left off. Dr. Sibson proceeded immediately to open the body; but as soon as he had divided the integuments of the chest the animal began to make some convulsive gasping inspirations, during which the mouth was widely opened, and we observed that the diaphragm acted alone, the ribs

being pressed inwards by the atmosphere. The heart was not contracting at all when the pericardium was first opened; but in a few moments the auricles began to contract rhythmically. The lungs were of a light red colour.

Experiment 30. Another guineapig of the same age was treated in the same manner, except that I removed the tube from the nose for a short time between every two or three inspirations, in order to see if I could not make it insensible in this way without a fatal result. In half a minute or so the animal no longer required to be held, but lay on the table without making any resistance, the conjunctiva being still sensible, and some motion of the limbs, apparently voluntary, remaining. It only inhaled once after Dr. Sibson ceased to hold it, and whilst in the state just described, and then only for two or three inspirations. After this it appeared quite insensible, and no more chloroform was given. It breathed at first naturally, except more slowly and gently than before the inhalation; but the breathing became slower, and ceased altogether about a quarter of a minute after the inhalation had been left off. The body was opened immediately. When the pericardium was opened, the auricles were observed to contract slightly, and the contractions increased after their exposure to the air.

The amount of vapour in the air breathed by these two guineapigs is not known, but there is no doubt that it was upwards of eight per cent.

FATAL CASES OF INHALATION OF CHLOROFORM.

If it were possible for a medical man to mistake or disregard the symptoms of approaching danger, and to go on exhibiting vapour of chloroform, diluted to a proper strength, till the death of the patient, this event would take place slowly and gradually, as in Experiment 23, related above,

and every other experiment in which the air did not contain more than five per cent. of vapour. The action of the heart would survive the respiration; there would be a great tendency to spontaneous recovery, and the patient would be easily restored by artificial respiration, if it were performed whilst the heart was still acting; as I have always found it to be successful in animals under these circumstances.

In examining the recorded cases of fatal inhalation of chloroform, we shall find, however, that they have none of them taken place in this gradual manner; but that in all cases the fatal symptoms, if not the actual death, have come on very suddenly. Dr. Sibson was, I believe, the first to point out that, in the fatal cases of inhalation of chloroform, death was caused by its paralysing the heart; but he was not at that time aware of the physical conditions under which this agent may act directly on the heart. In commenting on the first four deaths from chloroform, he says: * "In all the four cases it is manifest that the immediate cause of the instantaneous death lay in the heart. The heart, influenced by the poison, ceased to contract, not from the cessation of respiration, for the heart in asphyxia will beat from one to three minutes after respiration has ceased, but from immediate death of the heart. There is no doubt a combination of causes operating to destroy the heart's contractile power: the mental influence, the congestion in the systemic, and that in the pulmonary capillaries, will all have a material influence." And further on he says: "We are obliged, then, from the experience of these cases, to conclude, that in man the death is usually instantaneous, and due, as every instantaneous death is, to paralysis of the heart. In animals the death is usually due to paralysis of the muscles of respiration. It is chiefly owing to the

* London Medical Gazette, vol. xlii, 1848, p. 109.

superior control of the mind over the body in man, that in him the poison acts on the heart more than in dogs."

I had been long aware that chloroform was capable of paralysing the heart in animals ; and, indeed, that sulphuric ether would do so when it could reach the heart in sufficient quantity ;* and soon after Dr. Sibson's remarks I was able to ascertain and point out the strength of the vapour which will produce this effect, and how one may avoid the risk of it, by having the vapour sufficiently diluted.† The greater number of experimenters who have killed animals with chloroform have found that the action of the heart continued after the breathing ceased ; but they did not either control or ascertain the proportion which the vapours of chloroform bore to the inspired air. In Mr. Thomas Wakley's experiments the action of the heart continued after the breathing had ceased ; and this was the case in a great number of experiments performed by a Commission which reported to the Society of Emulation of Paris, in 1855.‡

This Commission came to the conclusion that, in all instances in which animals are killed by chloroform, the action of the heart survives the respiration ; but they might have administered chloroform to an equal number of human patients without any one of them being cut off by sudden paralysis of the heart. If animals were usually to die suddenly of paralysis of the heart, when the chloroform is given in a manner similar to what may be called its ordinary administration to patients, we should be at a loss to know how this agent could be used at all. It is only reasonable to suppose that, in experiments so conducted, that mode of death should usually be met with which would occur to the

* On the Inhalation of the Vapour of Ether, p. 82.

† Medical Gazette, vol. xlii, p. 415.

‡ See l'Union Médicale, 1855, No. 13.

human subject, if the chloroform were continued, in the disregard of dangerous symptoms, till death should ensue. I have, indeed, been informed of several instances in which animals died in a sudden, and what was thought an unaccountable manner, whilst chloroform was given to prevent the pain and struggles which would be occasioned by physiological experiments. In these cases there is no doubt the heart was paralysed; but the experimenters were often too intent on other matters to observe the circumstance. By a proper arrangement of circumstances, however, one may produce at will the event in animals which occurs, in fact, so very rarely to a patient, although it may at any time happen if great caution, guided also by right principle, is not used.

Air, when saturated only at 60° Fah., contains 12 per cent. of vapour of chloroform, and at 70° 19 per cent. (p. 33); and 8 or 10 per cent. in the inspired air is capable, as we have seen, of causing sudden death by paralysing the heart; but in practice the air is usually far from being saturated, in passing over a handkerchief or similar material, even at the temperature at which it is inhaled; and this is generally lowered considerably by the absorption of caloric by the chloroform, as it changes its condition from a liquid to a vapour. Moreover, air strongly charged with vapour of chloroform is not easy to breathe, owing to its pungency; and the physiological knowledge and close attention of every medical man who administers this medicine causes him to withdraw it immediately on the least appearance of danger.

See

Case 1. The first death from chloroform was that of Hannah Greener, which occurred at Winlaton, near Newcastle, on the 28th of January, 1848.¹ The patient was a girl of 15, who required to have the nail of the great toe

removed. A similar operation had been performed on the other foot, in the previous November, in the Newcastle Infirmary, when ether was administered with a satisfactory result. The following is the account of the accident by Dr. Meggison, who administered the chloroform: "She appeared to dread the operation, and fretted a good deal: in fact, she commenced sobbing on our entering the house, and continued so until seated in the operating chair, and commencing the inhalation, which was done from a handkerchief on which a teaspoonful of chloroform had been poured. After drawing her breath twice, she pulled my hand from her mouth. I told her to put her hands on her knees, and breathe quietly, which she did. In about half a minute, seeing no change in breathing, or alteration of pulse, I lifted her arm, which I found rigid. I looked at the pupil and pinched her cheek, and, finding her insensible, requested Mr. Lloyd to begin the operation. At the termination of the semilunar incision she gave a kick or twitch, which caused me to think the chloroform had not sufficient effect. I was proceeding to apply more to the handkerchief, when her lips, which had been previously of a good colour, became suddenly blanched, and she spluttered at the mouth, as if in epilepsy. I threw down the handkerchief, dashed cold water in her face, and gave her some internally, followed by brandy, without, however, the least effect, not the slightest attempt at a rally being made. We laid her on the floor, opened a vein in her arm, and the jugular vein, but no blood flowed. The whole process of inhalation, operation, venesection, and death, could not, I should say, have occupied more than two minutes."*

An examination of the body was made the day after death by Sir John Fife and Dr. Glover, who reported as follows:—"The body was that of a well-grown female of

* London Medical Gazette, vol. xli, p. 255.

about fifteen years of age. . . . On opening the chest, the lungs were not collapsed. One or two very slight adhesions were encountered on separating them from the walls of the chest. The external appearance of both lungs, over the whole surface, but especially in the inferior portions, was that of organs in a very high state of congestion. They were mottled with patches of a deep purple, blueish, or scarlet hue. They were everywhere crepitant. Along the outer and interior border of both lungs, particularly of the upper lobe of the left lung, were several emphysematous bubbles of small size. . . . The pulmonary tissue was filled with bloody froth, which was also found in the interior of the bronchi, mixed with mucus. There was no appearance of hepatization. On examining the larynx and trachea, the epiglottis was found reddened at the summit, of a vermilion hue. The mucous membrane of the larynx was redder than natural—mottled with vascular patches. The sinuses of the larynx contained a good deal of dark mucus. The œsophagus was healthy. The stomach was distended with food. Some of the veins were more distinct than usual. The heart contained dark fluid blood in both its cavities: very little in the left. Its structure, and that of the great vessels near it, quite healthy. The brain, externally and internally, was more congested than usual; and the ventricles contained rather more than the usual quantity of serum.”*

Sir John Fife and Dr. Glover expressed the opinion that chloroform caused death by producing congestion of the lungs. After the further experience which has been gained respecting chloroform, this opinion of the mode in which it caused death, in the above case, would probably not now be offered. Indeed, in similar cases which have since occurred, the same opinion has not been advanced;

* *Opus cit.*, p. 253.

and as the lungs were crepitant throughout, in the above case, it is probable that the congestion was not greater than is commonly met with in cases of sudden death without hæmorrhage. Dr. Simpson published his opinion, immediately after this case occurred, that it was not caused by the chloroform, but by the brandy which was given when the alarming symptoms came on ; but Dr. Meggison replied that only a teaspoonful of brandy was given ; that it was swallowed, though with difficulty ; that there were no symptoms of choking from it ; and that the girl was without pulse when it was given.*

From the lips becoming suddenly blanched in the above case, there is every reason to conclude that the heart was suddenly paralysed. The patient breathed for a little time after this, and was able to swallow, though with difficulty. The process of inhalation occupied only a little more than half a minute in Dr. Meggison's estimation ; yet he appeared to think that the fluid drachm of chloroform which he had put on the handkerchief had evaporated ; for he was about to apply more when the alarming symptoms appeared. But supposing only one-third of the drachm was actually inhaled into the lungs in the half minute, the vapour would necessarily be in a highly concentrated state—probably twenty cubic inches of vapour in 200 cubic inches of air, which would be adequate to occasion the result which happened. In the short space of about half a minute, the blood could not be uniformly impregnated with the vapour ; only a portion of it could pass through the lungs in the time ; yet, as the patient was rendered insensible, this portion must necessarily have been highly charged with vapour.

It was often the practice to render the patient insensible in as short a time as half a minute, when chloroform was first introduced, but I believe never without danger ; and I

* *Opus cit.*, p. 341.

had expressed the opinion before any accident happened, that, for reasons such as I have stated above, a patient should on no account be rendered insensible in less than two minutes.*

Case 2. The next recorded case in which the inhalation of chloroform was fatal, occurred at Cincinnati, on the 23rd of February, 1848. The subject of it, Mrs. Martha G. Simons, was thirty-five years of age, and enjoyed good general health; she was the mother of six children, and her last confinement occurred eight weeks before her death. The patient exhibited no alarm on account of inhaling the chloroform, which was administered by two dentists, who were not members of the medical profession. It was breathed from an inhaler which Dr. Morton of Boston contrived for sulphuric ether. This inhaler consisted of a glass globe four inches and a half in diameter, and contained a sponge about one-third filling the globe, and saturated with chloroform.

Two female friends of the patient reported the following as the events which occurred. "The respiratory movements appeared to be free; chest heaving. While inhaling, the face became pale. At the expiration of about one minute, the instruments were applied, and four roots of teeth extracted. The patient groaned and manifested what they regarded as evidences of pain, while the teeth were being extracted, although she did not speak or exhibit any other sign of consciousness. As the last root came out, which was about two minutes from the beginning of the inhalation, the patient's head turned to one side, the arms became slightly rigid, and the body drawn somewhat backwards, with a tendency to slide out of the operating chair. At this instant, Mrs. Pearson states that she placed her finger

* London Medical Gazette, vol. xli, p. 75.

upon the patient's pulse; observed that it was feeble, and immediately ceased to beat; respiration also ceased about the same time. The face, which was previously pale, now became livid, as did also the finger nails; and the lower jaw dropped, and the tongue projected a little at one corner of the mouth, and the arms were perfectly relaxed. The females regarded her as being then quite dead.”*

The dentists gave nearly the same account, saying that the breathing was at first slow, and that the patient inhaled twelve or fifteen times, occupying from a minute to seventy-five seconds. They committed the great error of not placing the patient at once in the horizontal position, when the alarming symptoms came on, but kept her sitting in the chair, from five to ten minutes, whilst they sent out for restoratives. They thought the patient was living during this time, but her female friends thought not. The patient was placed on a sofa, and sometime afterwards artificial respiration and galvanism were applied without effect.

An examination of the body was made twenty-six hours after death by Drs. Mussey, Lawson, Baker and Mulford. The following are the chief particulars of the appearances met with. A larger quantity of blood than usual flowed from the sinuses of the dura mater. General aspect, colour, and consistence of the brain, normal. Lungs considerably but not intensely congested; crepitated freely at all points; no extravasation. Lining membrane of bronchia slightly congested, apparently the result of recent catarrh; deeply stained by the blood. Pleura at all points highly injected; six drachms of bloody serum in the right, and two ounces in the left chest. Pericardium contained six drachms of bloody serum. Heart flaccid, and all its cavities entirely empty; inner surface of both ventricles and auricles deeply

* London Medical Gazette, vol. xlii, p. 80, from Western Lancet, and Phil. Med. Exam. April 1848.

stained. Abdomen—one ounce and a half of bloody serum in the right hypochondrium. Stomach and intestines distended with gas. Partially digested aliment, amounting to about three gills in the stomach. Blood fluid as water in every part of the body; not a coagulum was seen in any vessel. Lining membrane of all the bloodvessels deeply stained. The colour in every part of the system was that of dark venous blood.

It was estimated, in the inquiry which took place respecting this case, that one-fourth part by measure of what the patient inhaled might be vapour of chloroform; but this is evidently an over-calculation, for there could not be this quantity unless the interior of the glass globe were maintained at the temperature of 80° Fah. and the air were quite saturated with vapour in passing through it; however, less than half the amount of vapour here assumed would have the effect of causing sudden death, in the way it happened. The period of the inhalation, a minute or seventy-five seconds, during which the patient took twelve or fifteen inspirations, did not admit of the blood in the body being regularly and uniformly charged with the chloroform; and the increase of its effects, owing, no doubt, to the absorption and circulation of the vapour contained in the lungs at the moment when the inhalation was discontinued, was well marked. The patient became pale during the inhalation, but the alarming symptoms suddenly came on during the extraction of the fourth stump, probably within half a minute after the inhalation ceased. The patient seemed, in fact, to die with the slight struggle that took place at this moment. In the case of Hannah Greener, related above, the spasm at the moment of dying was even more marked. This is a symptom I have often seen during the death of animals killed suddenly with vapour of chloroform in a concentrated state, before they were made thoroughly insensi-

ble. Although the heart was empty, the stained condition of its cavities showed that they had contained blood at the time of death and afterwards. Owing to its fluid state, it probably escaped from the heart during the moving of the body; especially during the examination of the head, which was made first.

Case 3. The next recorded case of death from chloroform is reported by Dr. John C. Warren, of Boston, U.S., in the *London Medical Gazette*.* His report, apparently extracted from some other report, is as follows.

“Name—Patrick Coyle. [Age—not stated.] Date—March 1848. Disease—fistula. Previous use of chloroform—once. Time of inhalation—about one minute. Quantity consumed—about thirty drops. [Query minims.] Posture—upon the side. Lapse of time till death—about one minute. Symptoms—showed signs of pain, by putting his hand to the part; in a moment his pulse, which was full and natural, sank: death. Morbid appearances—brain, with membranes, natural and healthy. Heart enlarged, pale, and soft; two or three ounces of serum in pericardium; bloodvessels with dark fluid blood. Lungs, studded with tubercles; abscess in each; lower parts congested; pleura extensively adherent; stomach—mucous membrane softened, its veins turgid.”

Nothing is said about the apparatus used in this case, but from the summing-up of Dr. Warren's paper, it must have been either a towel or a handkerchief. The quantity of chloroform employed appears to have been much less than in the two previous cases. In speaking of drops, the writer probably means minims, or what is the same, a quantity equal to as many drops of water. Thirty drops of chloroform from a small phial are only equal to between six and

* Vol. xliii, p. 682.

seven minims, and if they were dropped on a handkerchief, so that they might be counted, they would evaporate entirely during the process. Supposing the quantity used to have been what is probably meant—half a fluid drachm—it would be quite adequate, according to calculations previously made in these pages, to cause the accident which happened. The period of inhalation was again very short—one minute; and the evidence of paralysis of the heart is distinct:—"In a moment his pulse, which was full and natural, sank: death."

Case 4 was that of Madlle. Stock, aged thirty, and occurred at Boulogne, in May 1848. The operation was that of opening a sinus in the thigh, between two and three inches in length, at the bottom of which a small splinter of wood was found. M. Gorré, the surgeon who attended the patient, says: "I placed over the nostrils of the patient a handkerchief moistened with fifteen to twenty drops of chloroform at most." It is necessary to remark, however, that a judicial examination of the bottle from which it had been taken, proved that from five to eight grammes had been used, a quantity equal to from 77 to 123 grains, and there are three drops of chloroform to a grain. M. Gorré proceeds to say: "Scarcely had she taken several inspirations, when she put her hand on the handkerchief to withdraw it, and cried with a plaintive voice, 'I choke.' Immediately the face became pale; the countenance changed; the breathing embarrassed; and she foamed at the mouth. At the same instant (and certainly less than a minute after the beginning of the inhalation), the handkerchief moistened with chloroform was withdrawn." M. Gorré performed the operation, but he expressed the opinion afterwards that death had already taken place when he made the incision. Amongst the means used, with a view to resuscitate the

patient, was inflation of the lungs, which was performed with such force as to produce permanent dilatation of the air-cells. The lungs, besides being distended from this cause, were found after death to be visibly engorged in their lower lobes. When cut into, a large quantity of black blood escaped. The cavities of the heart were empty, but the internal membrane, especially of the right cavities, was red. The tissue of the heart was pale, and was easily torn. Air was found in the pulmonary veins, and in most of the systemic veins throughout the body. The blood was very dark-coloured and fluid.*

M. Gorré reported the above case to the Academy of Medicine of Paris, and a commission was appointed to inquire and report on it, who came to the following conclusions.

“ 1. In the medico-legal fact submitted to our notice, we found no indication of the poisonous action of chloroform; and consequently we reply to the minister, that the patient of M. Gorré did not die from the effect of inhalation of that agent.

“ 2. There have occurred a great number of analogous cases of sudden and unforeseen death, during operations, without any administration of chloroform, in which the most minute examinations have failed in detecting any assignable cause of death.

“ 3. In the case in question, the most probable cause, under all circumstances, seems to have been the mixture of a considerable quantity of gas with the blood.”†

The report on this case gave rise to frequent discussions in the Academy, extending over several months, and the Academy ultimately confirmed the above conclusions, but

* *Gazette Médicale*, 8 Juillet, 1848; and *London Medical Gazette*, vol. xlii, p. 211.

† *Proceedings of Academy* on Feb. 6th, 1849. See *London Journal of Med.*, 1849, p. 307.

not without considerable opposition from M. Blandin, M. Jules Guérin, and other members.

M. Malgaigne, the reporter to the commission, and others, who strongly supported the first of the above propositions, founded their argument chiefly on the assertion that chloroform always produces intoxication and insensibility before death; but this is incorrect, as I have explained above; and I took occasion to make the following remarks on this point about the time when the discussion in the Academy of Medicine took place. I said: "I have several times made animals—small birds, mice and rabbits—breathe air saturated with vapour of chloroform at the temperature of the atmosphere, and the consequence has always been that, after attempting for a few seconds to escape from the capacious jar in which they were enclosed, they suddenly exhibited signs of distress, and died without any interval of intoxication or insensibility, in periods varying from less than half a minute to a minute after their first exposure to the vapour."*

The power of chloroform to cause sudden death without previous insensibility is now, I believe, generally admitted. The French call this kind of fatal action *sideration*.

With regard to the second conclusion of the commission, if it had been really true that the surgeon put only fifteen to twenty *drops* at the most of chloroform on the handkerchief, one would have been inclined to admit it; but with the quantity actually employed, and the strong sensation of choking it occasioned just before death, one must, in connection with other cases, and with what is known of the action of chloroform, attribute the fatal event to this agent, rather than to the surgical operation, which was not of a serious nature.

With regard to the third of the above conclusions, it is

* London Journal of Medicine, 1849, p. 324.

not a little remarkable that most even of those speakers who opposed the conclusions of the commission, agreed that death was caused by a sudden development of air in the veins; and differed from them only in this, that they considered the chloroform as the cause of the evolution of air or gas, and that it proved fatal in this way. That the air was not caused by putrefaction, and that it did not enter by the wound in the thigh, may be readily admitted, but there remains the artificial respiration, which was performed with such force as to produce permanent dilatation of the air-cells. It was argued in the Academy that, as the air was in the systemic, as well as in the pulmonary veins, it could not have been introduced by the artificial respiration, since the left ventricle had previously ceased to act; but the action of the left ventricle is not necessary for the passage of the contents of the arteries through the capillaries into the veins, since this commonly goes on after death, the arteries being usually found entirely empty of the blood they must have contained at the moment of death. With regard to the passage of the air out of the heart into the arteries, supposing that the pulmonary veins were ruptured during the inflation of the lungs, there is an observation of Dr. Sibson's which will explain both this circumstance and the fact of the heart itself being found empty of blood. He found that the heart was often emptied of blood by distending the lungs with air after death in preparing the body for his diagrams of the position of the viscera.*

With the conclusions above quoted, some additional ones were adopted from the second part of the report of the commissioners; in these it was admitted that chloroform is capable of causing death, if administered too long, or in too large doses. One of these additional conclusions, however, is as erroneous as the previous ones. It is, "there is risk of

* Lond. Med. Gaz., vol. xliii, p. 694.

asphyxia when the anæsthetic vapour is not sufficiently diluted with air." When the vapour is not sufficiently diluted with air, the risk is one of sudden death, by paralysis of the heart. Chloroform does not yield enough vapour, at the natural temperature and pressure of the atmosphere, to exclude the air to the extent which would cause asphyxia. When chloroform vapour largely diluted with air is long continued, it may cause, not real asphyxia, but a mode of death resembling it, owing to the medulla oblongata and nerves of respiration becoming over narcotised.

Case 5 is that of a young woman at Hyderabad, who inhaled chloroform to undergo amputation of the middle finger. A drachm was sprinkled on a handkerchief and inhaled. The operator described what occurred as follows: "She coughed a little, and then gave a few convulsive movements. When these subsided, I performed the necessary incisions, which of course did not occupy more than a few seconds. Scarcely a drop of blood escaped." The absence of bleeding seemed to be the circumstance which called the attention of the operator to the state of his patient; and after describing the means which were used without avail to bring about recovery, he continues, "I am inclined to think that death was almost instantaneous; for, after the convulsive movements above described, she never moved or exhibited the smallest sign of life."*

In this case, it is probable that the breathing and the action of the heart were both arrested at the same time, by the action of the chloroform.

Case 6. Charles Desnoyers, aged twenty-two, a patient in the Hôtel-Dieu at Lyons, affected with scrofulous disease of the left wrist, having to undergo transcurent cauterisa-

* London Med. Gaz., vol. xlii, p. 84.

tion of the joint, inhaled chloroform from an apparatus for five minutes, and died at the beginning of the operation.* Further particulars are not given.

Case 7. A young gentleman, who had returned from Australia to visit his relatives in the neighbourhood of Govan, inhaled chloroform for an intended operation on the great toe, in December 1848. It is stated that the patient, after inhaling it, almost instantly expired. This account appeared in the *Glasgow Herald*, and was copied into the medical journals.† I believe that no further account of the case was ever published.

Case 8 occurred on January 19th, 1849. It is related by Dr. John C. Warren.‡ John Griffith, an Irishman, aged thirty-one, a seaman in the American navy, was admitted into the New York Hospital early in December 1848, on his return from Mexico. He was suffering with diarrhoea, chancres, and hæmorrhoids. The following is the account of this accident.

“Gurdon Buck, jun., attending surgeon to the New York Hospital, being sworn, says, that ‘on or about the 26th of December, I advised that chloroform should be administered to the deceased, for the purpose of examining the condition of the rectum, the parts being in such a state of excessive irritation as scarcely to admit of a separation of the nates. The patient recovered from the effects of the chloroform, and remained in all respects in the same condition, except the local ailments spoken of; and he having never complained of either his head or his chest, and not having suffered from the first administration of chloroform, I directed it to be administered to him for the purpose of performing

* Bouisson, *Traité de la Méthode Anesthésique*, p. 398.

† London Med. Gaz., vol. xliii, p. 41.

‡ *Ibid.*, p. 712.

an operation upon the rectum, and the operation of circumcision to remove a phymosis caused by the chancres: the patient soon became excited by the chloroform, as is usually the case, but not beyond a degree that I have often observed. Shortly after, he became more tranquil: the deceased was placed upon his side, and the operation performed, which consisted in the removal of two external tumours, and the tying of one internal tumour.

“At this moment my attention was arrested by my assistant's calling for a wet cloth: on examining the patient, I found his face and neck of a livid leaden hue or colour, the eyes turned upward, the pulse imperceptible at the wrist, and the whole body relaxed; after two or three gasps, he ceased to breathe. Every means was promptly used to restore the deceased, but without effect. The chloroform was obtained from Kent's, 91, John Street, and not exceeding three drachms was administered on a napkin. A portion of chloroform from the same phial had been administered the day before to a patient without any unfavourable effects. About ten minutes elapsed from the commencement of its administration before death took place. On making a post-mortem examination, twenty-four hours after death, I found the face less livid than before death; on examining the head, the brain and its membranes presented no other appearances than are seen in persons dying when in full health; the lungs were a good deal congested, and discharged, when cut, a large quantity of bloody serum; the heart was large, its ventricles and auricles were empty, its condition flabby, the substance of the left ventricle rather softer than natural; about half an ounce of watery fluid was found in the pericardium; the viscera of the abdomen were healthy.’”

This case differs from those previously related in respect to the time at which the fatal occurrence took place. It was not till ten minutes from the commencement of inhala-

tion, and when an operation which probably occupied two or three minutes had been performed, that the patient suddenly expired. The evidence of paralysis of the heart is, however, distinct enough in the absence of pulse at the wrist, and the livid hue of the countenance. In several of the previous cases, there was sudden pallor at the moment when the heart ceased to inject blood into the capillaries, but in a patient well supplied with blood, the sudden arrest of the action of the heart would cause turgescence of the veins and venous capillaries, which would be evident in the face in a few seconds. The syncope occasioned by paralysis of the heart differs from that kind of syncope which is caused by loss of blood, inasmuch as the right cavities of the heart are full in the former instance, and empty in the latter.

The circumstance of the patient having inhaled chloroform to insensibility three weeks previously, without accident or ill effects, is worthy of notice, as showing that the fatal event did not depend on any peculiarity of constitution.

Although the heart was found to be empty, its flabby condition and the watery fluid in the pericardium indicate that it must have contained blood at the time of death.

Case 9 occurred on January 24th, 1849, at the Hôtel-Dieu, Lyons, where case 6 previously happened. The patient was a youth, aged seventeen, named J. Verrier, who had been employed as a miner. He was of good constitution, and was about to undergo amputation of the middle finger for necrosis of the first phalanx. The following is the account of the accident.

“As the patient’s health was good, he was at once, and by his free consent, placed under the influence of chloroform. As usual, a piece of fine gauze was employed; it was spread over the face, leaving a free passage for atmospheric air; the chloroform was dropped from time to time upon that

portion of the gauze which was over the nostrils. It was administered by two assistants who were accustomed to its use, and who at the time attended to the pulse. The operator superintended the assistants. At the end of four or five minutes, the patient still felt and spoke; and at the end of another minute, he still spoke and was somewhat restless. Up to this time, from a drachm to a drachm and a half of chloroform had been employed. The pulse was regular, and of the normal strength. All at once the patient raised his body, and struggled so that the limbs escaped from the hold of the assistants, who however seized them quickly, and replaced the patient in his position. Within a quarter of a minute, one of the assistants stated that the pulse at the wrist had ceased to beat. The handkerchief was removed. The countenance was completely altered. The action of the heart had altogether ceased; the pulse could not be felt anywhere; and the sounds over the region of the heart could no longer be heard. Respiration still continued, but it became irregular, weak, and slow; and at length ceased completely in the space of about half a minute.

“ The extreme danger of the patient was manifest, and immediate and energetic means were employed to rouse him. Ammonia was held to the nostrils, and rubbed in large quantity over the surface of the chest and abdomen. It was also applied to the most delicate parts of the skin, *e. g.*, the lips and the extremity of the penis, with a view to excite irritation. Mustard was used; the head was inclined over the bed; and, finally, an attempt was made to restore respiration by means of alternate pressure on the abdomen and chest. After two or three minutes, respiration reappeared, and even acquired a certain fulness, but the pulse nowhere returned. Frictions were continued. Respiration became again slower, and at length ceased. Artificial inflation was practised, at first through the mouth, and after-

wards through the larynx, by passing a tube through the glottis, as it was perceived that air had passed from the mouth into the stomach. The precordial, epigastric, and laryngeal regions were energetically cauterised with a hot iron. The pulse did not return. For the space of half an hour every effort was made to resuscitate the patient; but in vain.

“ The autopsy could not be made until seventy-two hours after death. The temperature being low, the body showed no signs of decomposition; there was still rigidity of the limbs. The features were not altered. The examination of all the organs was made with care.

“ The stomach contained about one ounce and a half of a thick fluid, of the colour of the lees of wine, in no respect resembling an alimentary fluid. The organ was distended with gas, as was also the rest of the alimentary canal, which was otherwise sound. The liver and spleen were somewhat congested.

“ The heart, which was normal in volume, was flaccid and empty, contained neither blood nor air. The ventricular parietes were moistened by a fine, very red foam, as if from the presence of a little blood, which had been, as it were, whipped by the fleshy columns of the heart. The venæ cavæ and the portal veins were distended by black fluid blood in great quantity. On the Eustachian valve there was a fibrinous clot, moderately firm, and weighing from sixty to seventy grains. It was the only clot met with in the cavities of the heart and great vessels. These cavities, which were carefully opened, did not contain any appreciable quantity of air.

“ The lungs retracted on opening the chest. They presented both in their surface and in their substance a very black colour; otherwise their tissue was healthy. The larynx and trachea presented no lesion. The brain was

normal. The sinuses of the dura mater contained a considerable quantity of black uncoagulated blood.”*

In this case every precaution appears to have been taken, except that which is the most essential, of regulating the amount of vapour in the respired air. Arrangement was made that there should be amply sufficient air for the purpose of respiration; the patient was carefully watched by three persons at least, one of whom was constantly attending to the pulse, but with no other result than to be able to announce the exact moment when it suddenly stopped. The arrest of the action of the heart in this case took place at a time when the patient was not yet rendered insensible by the chloroform, although he had been inhaling it for five minutes. We must conclude that during these five minutes the vapour he inhaled was largely diluted with air, and that he then inhaled vapour in a much less diluted form. It is not improbable that he took a deep inspiration of strong vapour, just at the moment when he struggled violently, and within a quarter of a minute of the time when his pulse suddenly ceased.

The breathing continued a little time after the heart ceased to beat, and it is therefore very probable that, if this organ had not been irrecoverably paralysed, the natural breathing would have restored its action after a short pause, that would have attracted but a momentary attention. As the spontaneous breathing of the patient did not restore the heart's action, there is no ground for surprise that the measures adopted did not succeed.

Case 10 was that of a labourer, named Samuel Bennett. It occurred on February 20th, 1849, at a dispensary in Westminster. The patient inhaled chloroform for amputation of one of the toes. Half an ounce of chloroform was

* *Ibid.*, p. 747, from l'Union Médicale.

“sprinkled on a handkerchief, and held over the mouth and nose. . . This quantity of the agent failed, however, to produce anæsthesia, having caused only the ordinary excitement and struggling.” After a delay of two hours, more chloroform was procured, and half an ounce was again applied on a handkerchief, “care being taken to allow the entrance of air at short intervals.” Insensibility was induced, and the toe was amputated; the chloroform being applied, as I was told, during part of the time of the operation. At the close of the operation, no blood escaped when the pressure was removed from the arteries; the patient was in fact dying, and in a short time expired. “A few inspirations were noticed after the pulse had ceased at the wrist.”*

The lungs were of a dark venous hue throughout, a large quantity of blood escaping from them when cut into. Mucous membrane of trachea and bronchi congested. Heart rather large but flabby; auricles empty; each ventricle contained about an ounce of semi-fluid blood (the lungs had been inflated). Head: sinuses and veins contained blood, but not to any remarkable amount. But few bloody points occurred in cutting into the cerebral mass. Kidneys congested.

The failure of the first attempt to cause insensibility in this case, when so large a quantity of chloroform was used, illustrates very forcibly the uncertainty and irregularity of the way in which it was administered. On the first occasion only excitement and struggling were produced, and on the next the patient died suddenly.

Case 11 occurred on August 23rd, 1849, at Langres, France. The subject of it, Madame Labrune, was reported to be a healthy married woman. She inhaled chloroform with the intention of having a tooth extracted. “Complete

* *Lancet*, 1849, vol. i, p. 205.

insensibility was not produced at the first trial : more chloroform was placed on the handkerchief, and she drew a full inspiration. Her countenance immediately became pallid ; her features were visibly altered ; there was dilatation of the pupils, with a convulsive rolling of the eyes ; and no pulse could be felt. Every attempt was made to restore life, but without success. She died as if struck by lightning.* The instantaneous arrest of the circulation, on a full inspiration being taken, immediately after more chloroform had been placed on the handkerchief, is particularly worthy of notice. The heart was paralysed, in this instance, as quickly as in experiment No. 25, above related.

No inspection of the body is reported in this case.

Case 12 is the first which occurred in any of the hospitals in this metropolis. The following is the account of it.

“ John Shorter, aged forty-eight, a porter, known to Mr. Solly for some time as a very active messenger, habits intemperate, but apparently in perfect health, was admitted into George’s ward, under Mr. Solly, on the 9th October, 1849, suffering from onychia of the left great toe, which had existed some time. It was determined to remove the nail, the man having decided before entering the hospital on taking chloroform.

“ On Wednesday, October 10th, at a quarter to two P.M., he began to inhale the chloroform with one drachm in the inhaler. It had no visible effect for about two minutes ; it then excited him, and the instrument was removed from the mouth, and about ten drops more were added ; he then almost immediately became insensible ; the chloroform was taken away, and the nail removed. He continued insensible ; and, his face becoming dark, the pulse small, quick, but regular, respiration laborious, his neckerchief was removed,

* *L'Union Médicale*, Sept. 8th, 1849 ; and *Med. Gaz.*, vol. xlv, p. 478.

and the chest exposed to fresh air from a window near to the bed; cold water was dashed in his face, the chest rubbed, and ammonia applied to the nose. After struggling for about a minute, he became still, the skin cold, pulse scarcely perceptible, and soon ceased to be felt at the wrist; respiration became slow and at intervals, but continued a few seconds after the cessation of the pulse. Immediately on the appearance of these symptoms, artificial respiration was commenced by depressing the ribs with the hands and then allowing them to rise again until the proper apparatus was brought, when respiration was kept up by means of the trachea tube and bellows, and oxygen gas introduced into the lungs by the same means. Galvanism was also applied through the heart and diaphragm, but all signs of life ceased about six or seven minutes after the commencement of inhalation. These means were persisted in until a quarter past three, but to no purpose. On removing the inhaler, the sponge, which only contains one drachm, fell upon the floor, and the chloroform splashed about,—thus showing that a considerable part of the chloroform remained unused; so that the patient could not have inhaled more than a drachm. Every endeavour was made to procure a post-mortem examination, but in vain.”*

The above account is published in the *Medical Gazette* as communicated by Mr. Solly, but it is clearly not written by him, and it presents a very confused narrative of what occurred. If we are to understand the events in the sequence in which they are related, we must conclude that the patient became insensible and had the operation performed, that he then exhibited alarming symptoms for which cold water was dashed in his face and other measures were employed, and yet that after this he struggled for about a minute. This would be a state of things incon-

* Lond. Med. Gaz., vol. xlv, p. 757.

sistent, in my opinion, with death from chloroform ; but possibly the proper sequence is not observed in detailing what occurred. There is some obscurity also about the amount of chloroform used in connection with what remained on removing the inhaler. If the sponge was adapted to hold a drachm in the proper manner, the chloroform could not splash about on its falling, unless there was a good deal more than a drachm in it. But whatever was the quantity of chloroform remaining in the sponge, as it was in a condition to splash about, it is difficult to perceive what prevented the liquid chloroform from dropping into the patient's throat, as he lay on his back in bed. Chloroform is as pungent as the essential oils. I have been informed of a case in which a patient was nearly suffocated by one drop falling into the throat ; and the narrative of what occurred to Mr. Solly's patient is not at all inconsistent with death from spasm of the glottis arising from this cause. If, however, the patient died from the vapour of chloroform, we must conclude that he inhaled it at one moment not sufficiently diluted with air.

The chloroform in this case was administered by a non-medical person—a sort of surgery-man. After this accident, however, the chloroform in St. Thomas's Hospital was always entrusted to some one belonging to the profession.

Case 13 occurred at Shrewsbury, to a Mrs. Jones, a patient of Mr. Clement, surgeon, who had partly performed the operation of excision of the eyeball, when his patient suddenly died. Mr. Clement has, I believe, not published any account of the case, but the evidence which he gave at the inquest was reported in various local newspapers, and copied into the medical journals. The death was very characteristic of the effects of chloroform vapour not sufficiently diluted. Mr. Clement is reported to have said :

"He gave her but a small dose to commence with, imbibed from a sponge, and then commenced the operation. Finding that did not make her insensible, about a drachm more was poured on the sponge, which she inhaled again for a few seconds. He then went on with the operation, and shortly afterwards heard a peculiar sound, which he could not describe, and she died in a moment; all the attempts to rouse her proved ineffectual. She spoke in Welsh before she died, but so quickly that he did not know what she said; he had no doubt that she died from the effects of the chloroform."*

Case 14 occurred at Berlin. The subject of it was a young lady twenty years of age, of good health, well made, and of a good constitution. The chloroform was inhaled for the extraction of a tooth. It was administered on a sponge, covered with a napkin. The dentist who administered it was not a medical man. He made five unsuccessful attempts to extract the tooth under chloroform. Three of these attempts were at nine in the morning, and two about noon, just before the accident. His patient suddenly died almost at the commencement of the last attempt to administer chloroform, stretching herself out, and frothing at the mouth at the moment of death; the countenance at the same time becoming livid.

An examination of the body took place fifty hours after death, when putrefaction had set in.

"The lungs presented nothing morbid; the bronchi contained a little bloody froth. The blood was of the colour and consistence of cherry juice. The heart was soft, flabby and collapsed. Its coronary vessels and cavities were empty, and presented the bluish-red discoloration of decomposition."† The other organs were healthy.

* Journal of Prov. Med. and Surg. Assoc., 1849, p. 698.

† Casper's Wochenschrift, Jan. 12, 1850; and Lond. Med. Gaz., vol. xlv, p. 483.

Case 15 occurred in the public hospital of Kingston, Jamaica, on January 29, 1850. The name of the patient was William Bryan, his age is not stated, nor the nature of the operation he was about to undergo. He had previously, however, undergone the operation of amputation of the penis, on account of cancer of that organ, but it was performed without chloroform. Mr. Maygarth, the surgeon who administered the chloroform, stated as follows: "I had about a drachm poured on the sponge, and applied it over his mouth and nostrils, but at first not in close contact—at no period was the atmospheric air totally excluded. He bore it badly, and I was frequently obliged to withdraw it, to facilitate his breathing. The stage of excitement which is usual came on, and he struggled and kept away the sponge for some seconds; it was again reapplied, when, after a few more seconds, observing that he made one stertorous inspiration, I removed it altogether. He ceased to breathe; but after some seconds had elapsed, made another inspiration, and this occurred several times, until at length respiration ceased entirely." The measures which were employed were of the usual kind, but were of no avail.

The brain and its membranes were found to be congested. The lungs were congested, especially posteriorly. The right side of the heart contained dark fluid blood, and the inner surface of its left cavities, and of the aorta, were stained with blood. There was some disease of the aortic valves, and the heart had undergone some amount of fatty degeneration.*

Case 16. In February 1850, a death from chloroform occurred on board ship at the Mauritius. A report of the case was sent to the Board of Ordnance, and also to the Admiralty. The secretary of Sir William Burnett first in-

* Edin. Monthly Journal, April 1850, p. 377.

formed me of the case, and a day or two afterwards I had an opportunity, through the kindness of the late Marquis of Anglesey, of reading the report which was sent to him as Master of the Ordnance, and I made a note of the chief particulars as soon as I got home. As the report was a very able one, it is to be regretted it has not been published. The accident occurred to an artilleryman, aged 24, who required to have the last phalanx of the middle finger removed. In other respects, he was considered to be in good health. Two scruples of chloroform were first poured on the handkerchief with which it was administered, and then one scruple more. It was observed that the face turned pale, and the pulse and breathing ceased, soon after the chloroform was discontinued. The measures which were employed to restore him were of no service. The lungs after death were found to be emphysematous; and, upon inquiry, it was ascertained that he had been short of breath on exertion. The right cavities of the heart were filled with fluid blood. The sinuses of the dura mater contained less blood than usual, and the brain was pale. The medical man reporting the case considered that the emphysema was the cause of death, by interfering with expiration, and thus detaining the vapour; and it must be admitted that, if the vapour were not sufficiently diluted with air, the emphysema might increase the danger. I have, however, administered chloroform in several cases in which emphysema existed to an extreme degree, without any ill effects; consequently, when the vapour is properly diluted with air, this affection appears to be no source of danger.

Case 17 was that of a patient of Professor Carl Santesson, in the Seraphim Hospital at Stockholm. I was indebted to Mr. Paget for my first information about this case, and to Dr. W. D. Moore, of Dublin, for some further particulars respecting it.

The patient, a man thirty years of age, was affected with hydrocele, and there was some suspicion of disease of the testicle. It was consequently intended to operate on the hydrocele by incision, in order that the testicle, if diseased, might be removed. The chloroform was administered in the same way that Professor Santesson had seen it exhibited by Dr. Simpson, except that it was poured on a little cotton, which was placed at the small end of the cone, into which the folded towel he made use of was rolled. About a drachm and a half was first poured on the cotton, and the patient was told to inhale in long and deep inspirations. This quantity being nearly evaporated in two or three minutes, a drachm more was added. After a few inspirations rigidity and struggling came on: these subsided, but in a little time returned more strongly than before, and the towel was removed from the face until the struggling ceased. The patient, however, not being sufficiently insensible to undergo the operation with the necessary quietness, the towel was reapplied, when, after a few inspirations, the pulse suddenly ceased. The face and the whole surface of the body turned pale, the eyes rolled upwards and inwards, and the breathing became very slow, but full and deep, the intervals between the inspirations becoming longer, until the respiration ceased altogether. The patient died before the operation was begun, and within five minutes from the commencement of inhalation. During the application of various means of resuscitation, including the dropping of cold water *guttatim* on the epigastrium, the breathing returned, and continued for the space of three or four minutes; but the pulse and sounds of the heart did not return.

At the examination, thirty-two hours after death, the dura mater was found to be congested, and there was considerable serous effusion between the membranes of

the brain. There were also some bony deposits under the dura mater, and some adhesions of the arachnoid, indicating long standing disease of the membranes.

The heart was of normal size, and flaccid ; the vessels on its surface strongly distended with blood. The left ventricle was empty ; the left auricle, on the contrary, and the entire of the right side of the heart, with the great veins, were filled with thin uncoagulated blood. In the right ventricle only was a little loose coagulum found. The lungs, posteriorly, were highly congested, exhibiting here and there infiltrations of blood from the size of a pea to that of a small hazel-nut. The pulmonary tissue was otherwise sound ; giving, however, when cut into, the odour of chloroform, but more feebly than the brain did. The mucous membrane of the larynx and bronchial tubes were slightly reddened from sanguineous congestion. The blood was everywhere of the same thin juice-like nature.*

Case 18. I am indebted for my information respecting this case to Dr. James Adams, of Glasgow, who was good enough to send me a copy of the notes respecting it, from the case book of his colleague, Mr. Lyon, in whose practice, in the Glasgow Infirmary, the case occurred, in March 1850. The patient was a boy seven or eight years old, from the Highlands, whose health was considerably impaired by years of suffering from calculus. Mr. Lyon says, "being laid in bed, I placed a piece of lint, moistened with chloroform, near to his face, when, in a few minutes, he ceased crying. I now told my clerk to take charge of the chloroform, and introduced the sound. I thought I detected a calculus, but could not hear the click distinctly, in consequence of the patient moaning. One of the bystanders held his hand between my ears and the patient's face, when the click was

* Hygiea, October 1850, p. 602.

at once heard. I withdrew the instrument, and was horror-struck with the livid countenance and vacant eye of the patient; the cardiac and radial pulses were gone, and, making one deep gasp, he was to all appearance dead." Artificial respiration and other measures were employed without effect. "The external jugulars being remarkably turgid, and the face still very livid, the right jugular was opened, when several ounces of dark blood flowed rapidly." This measure, and galvanism, which was applied afterwards, were of no avail.

Case 19. The subject of this case was Alexander Scott, aged thirty-four, a police constable, who died in Guy's Hospital in June 1850, whilst undergoing an operation for the removal of a portion of the right hand. Mr. Cock, the operator, said that he was certain there was no disease about the patient. He described the accident as follows:—"The ordinary machine was used, and, as it had not the effect, witness directed that a napkin should be folded into the shape of a cone, which was applied with chloroform. The occupation of removing a portion of the bone occupied one minute and a half, but before it was completed, the blood which was gushing out, suddenly stopped, when witness directed Mr. Lacy to feel the pulse of deceased, and they found that deceased had expired."*

The sudden stopping of the hæmorrhage shews that, in this case, as in the others, the action of the heart was suddenly arrested. The first attempt to cause insensibility failed in this as in some other cases.

Mr. Cock tried to dissuade his patient from having chloroform, severe as the operation would have been without it. In Guy's Hospital and St. Thomas's the medical officers had a strong objection to narcotism by inhalation

* Lond. Med. Gaz., vol. xlv, p. 39.

for the first two or three years after the practice was introduced, and chloroform was used much less generally in these institutions than in any other of the hospitals of London; yet it was precisely in these two hospitals that two deaths from chloroform occurred, before any such accident had happened in any other hospital in this metropolis. This circumstance is worthy of the consideration of those who propose to limit the accidents from chloroform by restricting its use to a few great operations.

In this case the lungs were reported to be extremely congested. Heart flabby, not particularly distended; about two ounces of fluid blood on the right side; not more than half an ounce on the left. Head.—Much congestion of the dura mater; the grey matter of the brain was dark and congested; fluid was found in the subarachnoid space; and a considerable quantity of it in both ventricles. Kidneys congested.*

Case 20 occurred on September 20th, 1850, at the Cavan Infirmary, Ireland. The case occurred in the practice of Dr. Roe, and I am indebted to Dr. Robert Adams, of Dublin, for a manuscript account of it. The name of the patient was James Jones, and his age twenty-four years. Chloroform was exhibited with the intention of performing amputation below the knee, on account of scrofulous disease of the ankle, with ulceration of the cartilages. The patient was reduced to a state of great debility by the disease, and was suffering from hectic fever, but had no cough. The following is Dr. Roe's account of the accident:—

“When placed on the operating table the heart's action was very quick and weak, but he did not appear more faint or pale than usual. I then saw Mr. Nalty, the apothecary, measure one drachm of the chloroform in the small minim

* *Lancet*, 1850, vol. ii, p. 21.

glass measure, and pour it upon a little folded lint, which was placed in an oval hollow sponge, held in the hand with a small towel. Recollecting I had used this chloroform in another case, and finding some delay in producing the anæsthetic effects, I directed Mr. Nalty to add thirty drops more to that already put on the lint. I then applied the sponge to the patient's nose, directing him to keep his mouth shut, and gave the towel into the care of Dr. Halpin, who was on the opposite side of the table, while I went to prepare myself for the operation. Mr. Bird had scarcely screwed up the tourniquette, which had been previously placed on the thigh, while I was examining the state of the circulation in the tibial arteries, and which could not have occupied one minute,—certainly the patient could not have taken fifteen inspirations,—when Dr. Halpin told me the anæsthetic effects were produced. This struck me as being unusually quick and sudden, and on removing the towel from the face, we saw a slight convulsive action of the left eyelid (the eyelids were partially open), and a small quantity of frothy saliva at the mouth. I felt rather uneasy, but not much alarmed, as Dr. Halpin said he had often seen such symptoms from the effects of chloroform, although I had not met with them. On a more minute examination of the heart, the eyes, muscles of the limbs, &c. we found him dead."

Energetic means were used with a view to restore the patient, but without effect. No inspection of the body took place.

Case 21. The next case of recorded death from chloroform occurred in the Stepney Workhouse. The patient, named John Holden, age not stated, was about to undergo an operation on the penis. It was stated at the inquest that half a drachm of chloroform was administered without

effect, and then half a drachm more was applied, when the patient suddenly expired. This death occurred in April 1851.

Case 22 is important, as having given rise to a prosecution. The medical man, an officier de santé, named Kobelt, was accused of homicide, by imprudence, want of precautions, &c. The chloroform was administered on a handkerchief, and the accident occurred as suddenly as any of the others. The husband of the patient stated that the whole process did not last a minute. "I observed attentively," he said, "during this time, and the character that her countenance took all at once made me apprehensive. I spoke of it to the operator, who tranquillized me, and continued to extract the teeth. After the third tooth, however, he partook of my apprehension, suspended the operation, and proceeded to adopt measures indicated by the circumstances." Professor Sédillot, who had to pronounce an opinion on the case, after hearing all the evidence, said, "I do not think that M. Kobelt is guilty of imprudence or of rashness, because that officier de santé has followed a practice very habitually employed, and even recommended, by eminent practitioners, whose example and authority were sufficient to inspire him with security, and shade him from reproach." The accused practitioner was acquitted. The above remark of Sédillot applied to the plan of causing insensibility very rapidly, as first recommended by Dr. Simpson; and he added some observations, to the effect that, when used in a different manner, chloroform is free from danger.

The above case occurred at Strasbourg, on June 10th, 1851. The name of the patient was Madame Simon, and her age thirty-six. After death the lungs were found to be somewhat congested, and emphysematous. Heart flaccid, of

middle size; right cavities filled with liquid dark-coloured blood, mixed with some fibrinous clots. The left cavities contained similar blood in much smaller quantity.*

Case 23 occurred on July 8th, 1851, at the Seaman's Hospital, Greenwich. The patient was a light-coloured mulatto, aged forty-five, native of New York. He died during the operation of removing the left testicle, which was disorganized by suppuration. "The chest had been carefully examined a few days previously, both by percussion and auscultation. No physical signs of disease were detected. His pulse was regular and feeble, about seventy. He was rather nervous, and fearful of the operation. No *arcus senilis*. After taking a glass of wine he commenced the inhalation, twenty minims of chloroform having been poured on a linen cloth. At the expiration of a few minutes, this had been dissipated, producing only very trifling excitement; a second dose, of the same quantity, was then administered in the same way; the man began to sing and shout, his expressions relating to the firing of guns. The second quantity having been exhausted, and the effects of the chloroform becoming more apparent, but sensibility being still perfect, and even intelligence almost unaffected, a third quantity, of ten minims, was poured out, and, afterwards, twenty minims more. Having passed through the usual convulsive stage, and insensibility being established, the further administration of chloroform was desisted from at the end of about seven minutes, though this time is merely guessed at; it might have been more, but was certainly not less. At this time the respiration was unembarrassed, and the pulse regular, and about seventy, with as much volume as before the inhalation. The lips were florid; in fact, the chloroform appeared to have acted

* *L'Union Médicale*, January 29, 1852.

in the most benign way. Mr. Busk commenced the operation by an incision through the scrotum, which divided a small arterial branch, and some enlarged veins, from which the blood flowed pretty freely. The flow, however, almost instantaneously ceased, and Dr. Rooke, who kept his finger on the man's pulse, found that cease at the same moment. Respiration appeared to cease almost instantaneously with the heart's action. Regular respiration at least did; for, while we were looking at the man's face, he fetched one or two sigh-like inspirations. The ribs and abdomen were compressed, so as to induce inspiration and expiration; the lungs were inflated by blowing through the nostrils, the larynx being compressed against the spine, and, for three or four minutes, upon our efforts being suspended, the man occasionally took an inspiration; on one occasion three or four in succession, so as to make us flatter ourselves that he would come round. It is worthy of remark that, for a long time after spontaneous respiration had ceased, the lips retained a florid colour. The muscles were all relaxed, and the veins on the side of the neck turgid."*

At the inspection of the body next day, the vessels of the dura mater, and those on the surface of the brain, were gorged with fluid blood. The lateral sinuses also afforded a flow of dark-coloured blood. There was a considerable quantity of serous fluid in the cavity of the arachnoid and in the spinal sheath. The substance of the brain was very soft. (The weather was warm.) The lungs were of a dark purple colour posteriorly, and much loaded with fluid blood and serum, but were everywhere crepitant and healthy. The external surface of the heart was covered almost entirely with fat; in some parts to a considerable thickness. There were two fibrinous spots on its surface. No fluid in

* Medical Times, 1851, vol. ii, p. 98.

the pericardium. The venæ cavæ were full of fluid blood. On removing the heart, a white fibrous coagulum, about as big as a walnut, was found in the commencement of the pulmonary artery. The heart was uncontracted, and the cavities contained a very small quantity of dark fluid blood. The walls of the right ventricle, and of the left auricle, were thinner than natural. Some portions of the substance of the heart were paler than natural:—"In these paler portions of the muscular substance, the fibres had, for the most part, lost their striated aspect, and had become converted into a fine granular material contained in the sarcolemma. Here and there a minute oil-globule could be observed in the muscular fibrillæ, but nowhere did this amount to fatty degeneration."

In this case all the precautions appear to have been taken which are possible in making a patient insensible with undiluted chloroform, administered on a handkerchief; and the case, therefore, strongly confirms the proposition that chloroform cannot be administered in this way with perfect safety.

The patient was apparently in the most satisfactory condition at the conclusion of the inhalation, and yet, a few seconds afterwards, the heart suddenly ceased to beat, from the effect, as we must conclude, of that portion of vapour which was in the lungs at the moment when the inhalation was discontinued.

Case 24 occurred in October, 1851, at Chipping Norton, Somerset, to a patient of Mr. Farwell, named Elizabeth Hollis, and aged 37. No one observed the manner in which the breathing and circulation ceased, and, as the patient was in a state of extreme debility, it is not quite certain that the chloroform was the sole cause of death. It was administered to prevent the pain of removing the fæces, which

became impacted in the rectum on account of extensive cancerous disease of the uterus and vagina. The surgeon reports that "the time occupied in the inhalation was about eight or nine minutes; quantity inhaled $10\frac{1}{2}$ drachms, half a drachm at a time, allowing her frequently to breathe the atmospheric air. She spoke to me during this period. When I found that her arm fell after being raised, I proceeded to and accomplished the operation. At this time she was not inhaling. I then, as I always do, wetted the face with a sponge, with the view of washing off any remaining chloroform from the nose and lips, when, to my surprise, I found that she had ceased to breathe, and all attempts to restore her were in vain. . . . When I commenced the operation, the pupil was contracted, and the conjunctiva slightly red. After death, the pupil was very dilated, and the countenance extremely pallid."* There was no inspection of the body. This patient had inhaled chloroform on two previous occasions for a similar operation.

Case 25 occurred in St. Bartholomew's Hospital, on March 17, 1852. Thomas Hayward, aged 23, was suffering from aneurism by anastomosis, occupying the right ear and its neighbourhood. He had inhaled chloroform on the 14th of the previous month, whilst Mr. Lloyd placed ligatures on the temporal artery and some other arteries supplying the tumour; and it was with a view to tie an additional artery, situated between the mastoid process and the ramus of the jaw, that chloroform was again administered.

"The chloroform was some of the same, and the apparatus employed for its administration precisely similar [alluding to the former occasion.] It was administered by one of Mr. Lloyd's dressers, who well understood, and had great experience in its use. A gentleman of great experience, who

* Medical Times, 1851, vol. ii, p. 620.

had been for years at the hospital, and two years house-surgeon, was watching its effects, and marking the state of the pulse. Other gentlemen were assisting, and also on the look out.

"In from five to ten minutes the usual effect was produced, the patient having previously struggled much. The operation was then commenced ; but no sooner had Mr. Lloyd cut the skin, than it was stated that the pulse had suddenly ceased. The chloroform was at once removed ; but in a few seconds, the patient had ceased to breathe, and no pulsation could be felt at any of the arteries or the heart.

"Artificial respiration, as well as percussion and compression of the different parts of the body, were immediately employed with energy ; and, after continuing the means for a short time, the circulation was observed to be returning, and the act of respiration was several times performed. The state of inanimation, however, speedily returned ; but, by the employment of the same means as before, with the use also of galvanism, the circulation and respiration were again restored. Quickly, however, the patient fell into the same state as at first, but was again restored by the same means.

"In a few minutes the state of inanimation again returned, when the external jugular vein, which on the right side was very turgid, was opened, and tracheotomy was performed, and the lungs inflated. The patient was also placed in a warm bath, at the temperature of 104° , artificial respiration being kept up all the time. All, however, was of no avail."*

At the examination of the body, the following are amongst the appearances noted. "The *venæ innominatæ* and *vena cava superior* were full of blood, and probably would have been distended, but that two or three ounces of blood had flowed into the coffin from the opening made into

* Medical Times and Gazette, vol. i. p. 293.

the external jugular vein. The right auricle and ventricle were distended with blood, and would probably have been more so but for the escape of blood mentioned above. The left auricle and ventricle contained very little blood; the left ventricle was perfectly contracted in the rigor mortis. The heart was of full size. It appeared in every part natural in its texture, and as if it had possessed full power. Its valves also were all healthy; neither could any disease be found in any of the chief blood-vessels within the chest. All the blood, however, was fluid, and it remained without coagulation after its escape from the heart and vessels. It had also a brownish purple hue, much like that which is commonly observed in the spleen: none of it, when thinly spread out, presented the ordinary dark, black, or crimson hue of venous blood. Both lungs were attached by old adhesions about their apices and posterior surfaces, but these were of small extent. Their texture was healthy, but they appeared more than usually collapsed and dry. Their blood-vessels were not over filled.”*

In this case, every precaution seems to have been taken, except that one which is most essential of all, of regulating the proportion of vapour in the inspired air. It had always been made a great point in St. Bartholomew's Hospital to attend to the pulse very carefully, † and on this occasion it was closely examined, but only, as in some other cases, with the result of being able to note the moment when it suddenly ceased.

With regard to the return of the circulation, which is mentioned in the report as having occurred on three occasions, together with the breathing, during the efforts at resuscitation, I understood from inquiries I made of a gentleman present, that this was judged of from the red

* Medical Times and Gazette, p. 318.

† See a clinical lecture by Mr. Stanley, Med. Times, Nov. 22, 1851.

colour returning to the face and lips, but that the pulse and sounds of the heart were never distinctly perceived after they first ceased. The respiration may cause the colour to return to the face without a true circulation, as I have seen whilst inflating the lungs of still-born children ; for if a portion of red blood be mechanically displaced from the lungs by the motion of the chest, it will be propelled by the contractility of the arteries, which continues for some time after death.

Case 26 is related by Dr. Majer, of Ulm.* It occurred on June 27th, 1852. The patient, Madame W., was 32 years of age, and of good constitution. She was in very good spirits, and was only waiting the operation of having a tooth extracted, before going to dinner. It was stated that only twenty or twenty-five drops of chloroform were put on a sponge, which was surrounded by a handkerchief. After four or five inspirations, the operator inquired if his patient did not feel a singing in the ears. She replied with a trembling and thick voice. At the same time she stretched out her limbs, the face became bluish, the eyes haggard, the head and the arms fell—she was dead. The patient's husband said, that the time between the inhalation and death was so short that one could scarcely have said Yes or No.

An examination of the body was made twenty-five hours after death. Putrefaction had commenced, and the body was not rigid. The vessels of the membranes of the brain were gorged with blood containing many bubbles of air. The heart was soft and flaccid ; the coronary vessels were engorged with blood and air ; the cavities of the heart contained air, but little blood. The lungs were congested at the inferior parts.

* Gaz. Médicale, 1852, p. 630, from Medicinisches Correspondenz Blatt.

Case 27 took place at Melbourne, Australia. The name of the patient was Mr. John Atkinson, but his age is not stated. Dr. Thomas, who was about to operate for fistula *in ano*, said: "Before administering the chloroform, I asked the deceased particularly if he had ever suffered from any serious illness, to which he replied in the negative. I also inquired whether he had been subject to cough or palpitation, and he answered that, some time ago, he had suffered slightly from cough. The pulse was good, and Mr. Barker proceeded in the usual manner to administer the chloroform, which shortly produced convulsive twitchings of the muscles. I then went to the door to request the nurse to send up some person to assist in holding the patient in a proper position for the operation, and I returned to the bed, and poured a little more chloroform on the handkerchief; when it was applied to the face, I heard him splutter at the mouth; the chloroform was instantly discontinued, but the patient suddenly expired. We tried all the means usually resorted to in other cases of suspended animation, but without effect. I had frequently used the same chloroform in other cases. It was not more than a minute after the first application of chloroform that death occurred. About a drachm had been poured on the handkerchief."

At the examination after death, "there was considerable serous effusion into the pericardium, and the heart itself was larger and more flabby than usual. It was hypertrophied, and there was dilatation of the cavities; the lungs were healthy, and there was a slight appearance of disease about the liver, such as is observed in persons addicted to intemperance."*

Case 28. On August 10th, 1852, a Mr. Martin, a cattle

* Medical Times and Gazette, 1852, vol. ii, p. 531.

dealer died near Melrose, in Scotland, after inhaling chloroform for the application of potassa fusa to some ulcers of the leg. Dr. W. M. Brown, who relates the case, says:—"Before proceeding to apply the caustic I gave him chloroform. He was not easily affected by it, and struggled a good deal. After beginning to apply the caustic I found he was not sufficiently insensible to pain, and gave him a little more chloroform, which had the desired effect. I then proceeded with the application of the caustic, and was just finishing, when I observed a sort of catch in his breathing. I immediately stopped, and, on looking at him, I saw the mouth and eyes open, the breathing irregular, the face pale, the eyes slightly turned upwards, and the pupils dilated." Dr. Brown tried artificial respiration and other means to resuscitate the patient, but without effect. He says, "in a few minutes the man died." The pulse is not mentioned, nor the age of the patient.*

Case 29 took place in the Manchester Royal Infirmary, on December 24th, 1852, during the removal of a malignant tumour of the thigh, by Mr. Jordan. The patient was Henry Hollingsworth, a factory operative. His age is not stated. "The man was very much excited, struggled and talked fast. The chloroform was administered slowly, and every precaution was taken to prevent any danger, and the medical men remarked two or three times how very long it was in taking effect. He at last became insensible, in about seven minutes at least. Mr. Jordan commenced the operation by an incision into the skin covering the tumour. I was assisting the surgeon when Mr. Heath directed my attention to the patient's face. This was about five minutes after the operation had commenced. I then observed congestion about the face, but there was no stertorous breath-

* Monthly Journal of Med., vol. xv, 1852, p. 377.

ing. His pupils appeared almost to have ceased to act. His breathing was becoming exceedingly slow, and he seemed to be sinking fast. I directed the attention of the operator and the other medical men to these symptoms. The operation was then suspended, and means were resorted to for restoring animation, but the pupils had ceased to act, and had become fixed almost immediately. He gave one strong gasp, and then to all appearance was dead. In administering the chloroform, successive doses were given until it took effect. Every dose consisted of a drachm, taken, at intervals, in an inhaler.”*

The following remark is made respecting the autopsy. “The post-mortem examination shewed that asphyxia, caused by chloroform, produced the death. There was a congestion both of the brain and lungs.” The appearances met with after death from chloroform do not indicate the way in which death has taken place. In animals that are killed by it, the right cavities of the heart are always found filled with blood, whether they die suddenly by its direct action on the heart, or more slowly by its effects on the brain, and the breathing ceases before the circulation. The lungs are seldom much congested in animals, whichever be the mode of dying, and the appearances in the head are not unusual. The state of the pulse is not mentioned in the above account of the case ; but congestion about the face was first observed, and then it was noticed that the breathing was getting slow. It is sufficiently probable that the breathing ceased on account of the action of the heart being first arrested ; but even if the respiration was embarrassed by the action of the chloroform on the brain, it is pretty certain that that agent also acted directly on the heart ; for it cannot be supposed that the means used for restoring animation would have failed, if the heart had been acting properly when the breathing ceased.

* *Lancet*, 1853, vol. i, p. 21.

Case 30 took place on March 19th, 1853, in University College Hospital, London. The subject of it was an unmarried woman, named Caroline Baker, aged twenty-eight. The chloroform was administered with the intention of applying nitric acid to a sloughing ulceration of the labia and vagina. "The chloroform, supposed in the first instance to be about a drachm, was poured on lint about five inches square, and folded four or five times over. After a short time the patient became restless, talked loudly, and threw about her arms. Soon afterwards a partial relaxation of the limbs took place, and she became insensible and pulseless."*

Further symptoms are not given, but it is stated that she sank and died. The breathing is not mentioned, but Mr. Erichsen, who, although not present at the accident to his patient, would be made aware of all that occurred, stated at the inquest, that death was produced by a paralysis of the heart from the influence of the chloroform. Dr. Quain examined the structure of the heart with the microscope, and he "found that organ, particularly on the right side, in a state of fatty degeneration."

Case 31 was communicated to the Society of Surgery of Paris by M. De Vallet, Surgeon-in-chief to the Hôtel-Dieu, d'Orléans. "A soldier of the line, aged twenty-five, apparently in good health, and of strong frame, consulted M. Vallet for a small tumour situated behind the right labial commissure. Before operating, he proceeded to direct the inhalation of chloroform. The patient, fasting, being placed in the horizontal posture, the chloroform (about one gramme) was poured upon a hollow sponge, and applied to the nose, the mouth being left free. At the expiration of a minute, no effect having been produced, four grammes

* *Lancet*, 1853, vol. i, p. 307.

were poured on the sponge, and at the expiration of four minutes, the patient, without having experienced any irritation of the larynx, without having manifested any resistance, without redness of the countenance, and after only a slight period of agitation, fell into a state of insensibility fit for the operation. Scarcely had the incision been made, necessary to expose the cyst, when the patient became pale, respiration was suspended, and he sank into a state of complete collapse. All the usual remedies were tried, and without avail. M. Vallet opened the trachea, and performed artificial respiration with an elastic tube; then an electric current was sent by needles through the region of the heart. The patient died without any sign of reaction.

“Examination of the body.—The vessels of the brain were empty; the lungs were congested with blood, which in some situations was extravasated; the heart was excessively flaccid; there were some soft clots in the right cavities; the left were empty. The stomach was full of gas; the liver, spleen, and kidneys were gorged with black blood.”*

Case 32 occurred in the Royal Infirmary of Edinburgh to a man aged forty-three, on whom Dr. Dunsmure was about to operate for stricture of the urethra by perineal section. The chloroform was administered by Dr. Struthers. About an ounce of chloroform was used, and the patient had been put under the influence of this agent on two former occasions, when a similar quantity was employed without ill effect. The following is Dr. Dunsmure's account of the case:—

“While the patient was inhaling the drug, he struggled considerably, and became a good deal congested in the face and head. He seemed to take a slight convulsion, like an epileptic fit, and such as I have seen on several occasions

* Med. Times and Gaz., 1853, vol. ii, p. 47.

in people who have led an intemperate life. During the convulsion, the handkerchief containing the chloroform was removed to some distance from the face. In a short time the inhalation took effect, and he began to snore, and although still violent, the chloroform was removed from the face entirely, and the handkerchief placed under the pillow. As soon as the patient became more quiet, he was pulled down on the table, and placed in the proper position for the operation. I then shaved the perineum, and was just going to make my first incision, when one of the assistants said that his pulse was becoming weak. The posterior tibial, Mr. Spence then remarked, was good, but in a second or two after, both gentlemen exclaimed that the pulse was gone. I rushed from my seat to the patient's head, and found that his breathing had ceased. Those present who had an opportunity of observing the respiration, which I had not, owing to the stool on which I sat being low, positively assert that the breathing did not cease before the pulse. The face was much congested, the jaws were firmly closed, and the pupils were dilated. I immediately forced open the lower jaw by means of the handle of a staff, and with catch forceps pulled out the tongue. Artificial respiration was had recourse to, and in a few minutes he made a long inspiration. This was soon followed by a second, by a third at a longer interval, by a fourth at a still longer period, and then by a fifth, when all attempts at natural breathing ceased. No pulsation could be felt in the radial arteries. The chest was noticed to be much contracted, to have apparently lost its elasticity, and not to expand when the ribs were forcibly compressed during the artificial respiration. I had previously sent for a galvanic apparatus, which was in the flat below, and it arrived almost immediately after the patient had made the fifth inspiration. When the tongue was pulled out, and before

the first breath was taken, I was on the point of opening the trachea, but this proceeding was then abandoned; it was now, however, had recourse to, in order to carry on artificial respiration more certainly: the external jugular was also opened, and about a couple of ounces of blood flowed. By the time the tracheotomy tube was inserted, the galvanic apparatus was in working condition, and it was applied on each side of the diaphragm. It acted remarkably well; at each application of the sponges, the muscle descended as if the patient was in life; air passed through the tube in the trachea, and for some time I was in great hopes that the man was to be saved; but the muscle gradually lost its contractility, and although the galvanism was kept up for an hour, it was evident that all our efforts were in vain—that life was extinct. The post-mortem examination was made the following day at one o'clock, rather more than twenty-four hours after the patient's death, and I give the report of it as drawn up by Dr. Gairdner, the pathologist to the Infirmary:—

“John Mitchell, aged forty-three, died 28th September. A very robust man; height five feet eight inches; diameter (lateral) of base of thorax, ten and a half inches.

“External appearances.—Considerable lividity of face and neck, and more than usual congestion of depending parts. Considerable amount of fat, but more in omentum and around viscera of abdomen than in external parietes.

“Chest.—Right pleura presents a few slight adhesions near the middle; left pleura free. No fluid in either pleural cavity. Pericardium contained about half an ounce of serum, and presented a few opaque patches on its surface. Both sides of heart contained blood, the right side rather more than the left. Blood more than usually fluid. External fat of heart considerable, about three lines on some parts of right ventricle. Muscular tissue of heart

generally flabby, and rather pale, but not distinctly disorganized to the naked eye. Valves perfectly healthy. Aorta presented very faint traces of atheroma. A few traces of atrophy of right lung towards its apex and anterior edge, but very limited. In all other respects lungs free from disease, but somewhat congested.

“Spleen soft, but not diffuent.

“Liver congested, but otherwise normal.

“Kidneys congested, but otherwise healthy.

“Brain.—The subarachnoid fluid presents considerable milky opacity, and is of moderate quantity. Moderate congestion of the meninges generally. About half an ounce of fluid in the ventricles. Substance of brain healthy. Arteries at base perfectly free from atheroma. Air passages.—Glottis perfectly patent. Mucous membrane of larynx and trachea slightly congested.

“Microscopic examination shewed the fibres of the heart to be nearly normal, though scarcely so distinctly striated as in some cases. The minute vessels of the brain and pia mater presented at some points a few clustering granules, but to no great extent.”*

Dr. Dunsmure expressed the opinion that four or five minutes elapsed from the time the chloroform was left off before the pulse failed. But it is pretty certain that he has much over-estimated the time. Indeed, if the shaving of the perineum were likely to occupy even half of this time, the operator would have done it, or had it done, before the chloroform was administered. Dr. Dunsmure makes the following remark in his comments on the case: “In several instances where I have seen chloroform very nearly prove fatal, the respiration became gradually restored after an inspiration had once been made; in this case, however, no such fortunate occurrence took place.” In the other cases

* Monthly Journal, Nov. 1853 p. 427.

to which allusion is here made, the heart has not been paralysed, or at least not completely, but they show that the method of administering chloroform in Edinburgh had been far from satisfactory in its results, although no patient had before that time been actually lost.*

Case 33 occurred in University College Hospital, London, and the following account of it was given by Dr. Hillier :

"E. R., aged 40, a woman of moderate height, rather thin. The general health has been pretty good ; she had not been liable to palpitation or dyspnoea. Had been in the habit of drinking pretty freely. Admitted on October 5th, at 11 p.m. She was suffering from the symptoms of strangulated hernia, which had existed two days and a half. Efforts were made to reduce the hernia, both without and with a warm bath, in which she was for upwards of half an hour without getting very faint. These efforts being unsuccessful, an operation was at once determined on. Her pulse was at this time regular, and of tolerable strength.

"Chloroform was administered in the usual way, on a piece of lint, which was held three or four inches from the patient's face, and then brought to within an inch and a half of her nose and mouth, leaving space around for the admission of air.

"For three or four minutes nothing unusual presented itself ; the pulse and respiration proceeded normally. There was put on the lint, at first, one fluid drachm of chloroform ; and, at the end of three or four minutes, forty minims more were added. This was the whole quantity of chloroform employed. Within a minute after the second quantity of chloroform was added, the patient struggled violently both with her arms and legs. During these struggles I was

* Since writing the above, I have noted by the watch the time which a surgeon occupied in shaving the perinæum before the operation of lithotomy ; it was twelve seconds.

holding her right hand, and was unable to feel the pulse in consequence of her constant motions. The struggling lasted about a minute, and on its ceasing, the patient commenced to breathe with loud, rough stertor. I at once removed the lint from before the face, and felt for the pulse, which I could not find. Immediately cold water was dashed on her face. She breathed with this stertor for two or three short inspirations, and then two or three long ones, and then the breathing ceased. Immediately artificial respiration was resorted to, and within a minute galvanism was applied to the back of her neck and the diaphragm. Under the influence of these agencies, the patient gasped about three times at intervals ; after this, no further signs of life were exhibited.

“ At the time when the stertor commenced and the pulse failed, the pupils were dilated, and the face of the patient was only slightly altered. The tongue was not retracted, for one of the bystanders at once put his fingers into her mouth to ascertain this.”

At the autopsy made by Dr. Garrod thirteen hours after death, the rigor mortis was well marked ; the blood was very fluid in all parts of the body. There was about an ounce of colourless fluid in the pericardium. The heart was quite collapsed and empty, but, as Dr. Garrod observes, this may have been due to the fluidity of the blood. The weight of the heart was seven ounces and three quarters ; valves healthy. Walls of the right ventricle flabby and pale ; mean thickness one eighth of an inch. At some parts the muscular substance was in a very thin layer, being much encroached on by fat. In several places there was scarcely any muscular fibre visible. This was chiefly the case near the apex. Examined by the microscope, much fatty degeneration of the muscular fibres of the right ventricle generally was discovered. The walls of the left ventricle were flabby, dry in appearance, pale,

and very friable. Both lungs were crepitant throughout, not much engorged. Brain not congested. The intestines above the strangulation were much distended with flatus, and inflamed.*

Case 34 occurred on October 20th, 1853, a few days after the last. The patient was a young woman named Ann Smith, aged 22 years, under the care of Mr. Paget in St. Bartholomew's Hospital, who was about to apply the actual cautery to a sore of canceroid nature in the vagina. She was a stout, florid young woman, formerly of dissolute habits, but apparently in perfect health, with the exception of the local ailment. She had been put under the full and prolonged influence of chloroform a fortnight previously for the application of the cautery, without the occurrence of any untoward symptoms whatever. The chloroform was administered by Dr. Black, one of the assistant physicians.

"The usual form of inhaler was employed,—a padded metal cup, fitting over the nose and mouth, and supplied with valves. A drachm, by measure, was first poured on the sponge, but as the administration did not immediately commence, a considerable part of this was no doubt wasted; after a short inhalation, a second drachm was supplied, and subsequently the further quantity of half a drachm. The patient had gone through the usual stages of excitement, etc., and the last dose was scarcely used, as she sank off, almost immediately after its application, into a state of complete insensibility, unattended by any alarming symptoms. About five minutes had been occupied by the inhalation, and probably not more than a drachm and a half of the fluid really inhaled. The apparatus was now removed from the face, and the patient having been drawn into the proper position, Mr. Paget was about to commence the

operation, when Dr. Black, who throughout had kept his finger on the pulse, noticed it to have become extremely weak and fluttering. Almost immediately afterwards, the patient's countenance was observed to be dusky, turgid, and congested, and the respiratory movements began to be performed at long intervals, and by slight catching efforts. No time was lost; cold water was at once dashed on the thighs, face, and breast; and, the failure of the respiration becoming shortly complete, Mr. Paget immediately began artificial insufflation of the lungs, by alternately blowing into the nostrils, and compressing the chest. Just before commencing this process, Mr. Paget had ascertained, by drawing the tongue forwards and examining the glottis with the finger, that the epiglottis was not pressed down."

Other means were employed, but no further signs of life appeared. It is further recorded that, "immediately after the first alarming symptoms, the pupils were of the medium size, neither contracted nor dilated. All efforts at respiration ceased about two minutes after the first indications of failure; the pulse, however, as a very feeble flutter, was felt occasionally for at least two minutes later."*

At the autopsy, performed by Mr. Paget, twenty-two hours after death, "the thorax was first examined, and nothing whatever abnormal could be detected in any of the viscera; the lungs were healthy and crepitant in every part; their posterior lobes were not more congested than is seen in almost every examination; the heart, collapsed, but not contracted, and containing a small quantity of fluid blood in each cavity, was of normal size and proportions, in every respect, and its muscular structure, examined by the microscope, showed no degeneration. . . . The brain, its sinuses, ventricles, etc., were all carefully examined, and neither in texture nor quantity of blood was anything abnormal detected."†

* Medical Times and Gaz., 1853, vol. ii, p. 449.

+ Ibid., p. 450.

Although the failure of the pulse was the first symptom of danger in this case, it continued to be felt as a very feeble flutter for about four minutes, so that the heart was not so completely paralysed as in most of the fatal cases. It must, however, have been so far paralysed as to be past recovery.

Case 35. Professor Dumreicher related a case of death from chloroform at the meeting of the Vienna Society of Physicians, held on November 16, 1853. The patient was a young man, aged nineteen, in somewhat feeble health, who inhaled chloroform in the recumbent position, in order to have his anchylosed knee-joint forcibly extended. It was inhaled from a vessel resembling a snuff-box, which was held to the nostrils. "The inhalation was continued for fifty seconds, and the patient had spoken a few seconds previously, when Professor D. observed that the pulse had become frequent and undulating. He immediately suspended the administration of the anæsthetic. Trismus occurred; the respirations became irregular; the face turned livid, and he foamed at the mouth." The measures which were employed included the abstraction of eight ounces of blood from the jugular vein, but they were of no avail. He only once made a feeble attempt at inspiration.*

Case 36 occurred in the practice of Dr. Wüstefeldt of Neustedt. "A young girl, thirteen years of age, had on the dorsal region a voluminous lipoma, which extended from the last dorsal vertebra to the crest of the ilium. . . . One drachm of chloroform was employed. As soon as insensibility was manifested, the operation was commenced, but scarcely had the surgeon divided the skin, when the girl, yielding to the laws of gravity, fell suddenly forwards

* Edin. Monthly Jour., vol. xix, 1854, p. 372.

on her chest. Dr. Wüstefeldt, struck by the phenomenon, which he had witnessed before under similar circumstances, immediately desisted from operating, and strove to restore the patient to life ; but every effort was useless, and, in the course of a few minutes, it became evident that she was dead.”*

Further particulars are not given ; but as the patient died suddenly, when the surgeon had scarcely divided the skin, it must be admitted that he was, in all probability, correct in attributing the event to the chloroform. The patient usually yields to the laws of gravity when only partially under the influence of chloroform, and it seems surprising that the operation should have been undertaken without placing the patient in the horizontal posture. The proper position of the patient, when a large tumour of the back is to be removed, is to be lying almost flat on the abdomen, the head being a little turned on one side, so that it rests with one ear on the pillow.

Case 37. Jane Morgan, aged fifty-nine, died whilst inhaling chloroform in the Bristol Infirmary, on January 21st, 1854. She was moderately stout, pale, but not otherwise of unhealthy appearance. “The stethoscopic indications were favourable, the beat of the heart was natural, and the air passed freely throughout both lungs ; but the chest movements on the right side were not quite so free as on the left.” Chloroform was ordered by Mr. Harrison, the senior surgeon of the Infirmary, with the intention of attempting to reduce a dislocation of the humerus of eight weeks standing. “Having taken no food since her breakfast, she commenced the inhalation of one drachm of chloroform, at 2 P.M., in bed in her ward, under the superin-

+ Med. Times and Gaz., 1854, vol. i, p. 19, from Med. Zeitung von den Vercine für Heilkunde in Preussen, No. 44, Berlin, Nov. 2, 1853.

tendence of Mr. Hore, the house-surgeon. Nothing unusual occurring in the patient's general condition during inhalation, a second drachm, in about five minutes from the first, was poured upon the sponge, and the inhalation was continued. Almost immediately after the addition of the second drachm, the chloroform was withdrawn, as the patient's breathing became stertorous; and immediately afterwards her pulse, which had hitherto continued pretty firm, was suddenly imperceptible, the respiration ceasing at the same time. The pupils were not dilated." Various measures were promptly resorted to with the hope of restoring the patient; but there were no further signs of life, unless "some convulsive efforts of the respiratory muscles," under the application of galvanism, be so regarded.

At the examination of the body on the following day, the right pleura was found to be adherent. The lungs were healthy in structure, but gorged with dark fluid blood. There was about an ounce of fluid in the pericardium. There was a small quantity of fluid blood in each of the cavities of the heart. For the length of an inch from their commencement, both coronary arteries were much dilated, and studded with atheromatous and bony deposits. The muscular structure of the heart was examined under the microscope by Dr. William Budd, and a considerable proportion of the fibres were found in a state of incipient fatty degeneration. It was learned, after her death, that she had been subject to occasional attacks of fainting.*

Case 38. A death from chloroform occurred in the Hôpital St. Antoine, at Paris, in the spring of 1854. The subject of this was a woman aged forty, on whom M. Richard was operating for the removal of a uterine polypus. The surgeon placed the patient in the horizontal posture,

* Association Med. Jour., 1854, p. 109.

and administered the chloroform on a compress of lint. She became insensible in two minutes, having first been excited so that it was necessary to hold her. M. Richard moved the patient to the edge of the bed, gave the compress containing the chloroform into the hands of an assistant, and commenced the operation, which was likely to be of short duration. He had almost completed it, when he was apprised by an assistant, who had been set to feel the pulse, that it had ceased to beat. He sought for it himself, but found that it did not beat. The face was extremely pale; a slow respiration still continued, but soon ceased; and the measures which were used with the hope of restoring the patient were of no avail.*

At the examination of the body all the organs were found in a healthy state. The right cavities of the heart and the great veins contained a considerable quantity of blood, and the left cavities of the heart a small quantity. The blood was everywhere fluid.†

Case 39. A patient, named Mrs. Harrup, died at Sheffield from the effects of chloroform administered with the intention of removing a cancerous tumour of the left breast. The age of the patient was forty-five, and she was stated to be in good health, excepting the local affection.

“The chloroform was administered with more than the usual precautions. After the inhalation had gone on without any effect for twenty minutes, it was thought that possibly different chloroform might succeed, and one ounce was accordingly procured from the public dispensary. After the inhalation had been conducted with the fresh chloroform about twenty minutes, the usual effects of the vapour began to manifest themselves. The pulse, which was 136 before any chloroform had been given, and had

* L'Union Médicale, 1854, p. 171.

† Ibid., p. 187.

been very gradually decreasing in frequency while it improved in strength, was now about 104. At this moment muttering—half articulate delirium—came on, but ceased in a few moments, and was immediately followed by conclusive signs of the satisfactory action of the chloroform. Dr. Law now desired Mr. Wright to begin the operation; but before he could do so, Dr. Law, seeing an alarming change in the countenance of the deceased, cried, ‘Stop, Mr. Lewis, how is the pulse?’ I replied, ‘It is gone.’” After stating the means which were used with a view to resuscitate the patient, it is added that the heart had ceased to beat, and that, after a few short and laboured inspirations, life became extinct.

At the examination of the body, the cartilages of the ribs were found to be ossified. The heart and lungs were perfectly healthy, but the lungs were in a congested condition. There was an extravasation of blood in the spinal muscles, and a little blood in the spinal canal, in what part or between what structures is not stated.*

Case 40 occurred in the Lock Hospital, London, in May 1854. Walter Hollis, a tailor, aged eighteen, had been under treatment for sores within the prepuce, and these having healed, he was about to undergo the operation for congenital phymosis. He had been of dissolute habits, and exhibited a pale cachectic appearance.

“The inhaler used was a simple mouth-piece by which the nostrils are left uncovered. About two drachms of the fluid were poured into the instrument. After about six minutes inhalation, insensibility seemed to be coming on, and at this moment the pulse was ascertained to be of good volume. Nothing whatever had occurred to indicate the impending danger, when, after a few more inhalations,

* Association Medical Journal, 1854, p. 315.

the pulse suddenly failed, became quite imperceptible, and the countenance assumed a pale and leaden hue. The inhalation was immediately stopped, and attempts to resuscitate, by means of striking the chest sharply with a wet towel, applying ammonia to the nostrils, and by artificial respiration, were at once commenced. These were employed for three or four minutes before any signs of life were perceived ; but, subsequently, the pulse was again to be felt, and spontaneous respiration was renewed. Artificial respiration was desisted from on the occurrence of these signs of returning life, and for upwards of ten minutes the chest continued to fill regularly, and the pulse beat at a rate of from 40 to 50 in the minute ; the countenance of the patient also much improved, and even assumed a slight flush. After the expiration of, perhaps, a little more than ten minutes, however, these indications of returning vitality again disappeared, the pulse and respiratory efforts simultaneously ceased, and the countenance became deathlike. Artificial respiration and the other means were again adopted, but this time without the slightest success. . . . Post-mortem examination on the next day shewed great venous congestion within the cranium ; the lungs were also somewhat congested. The heart was slightly enlarged, and the ventricular parietes were thinned ; in the muscular fibres the microscope detected decided fatty degeneration. The blood was universally fluid.”*

The partial recovery of the patient is a remarkable feature in this case, and it is difficult to explain why he did not recover completely. The number of the pulsations during this partial recovery is mentioned, but not their quality, and I cannot help supposing that the pulse must have been extremely weak, as well as slow, at this period. The ten

* Medical Times, 1854, vol. i, p. 572.

minutes during which the pulse and breathing returned is mentioned with the qualifying term of "perhaps", which leads to the supposition that it was not noted by the watch or clock, and under such circumstances of anxiety and suspense, the time might be very much over-rated. The slight fatty degeneration of the heart might probably interfere with the complete recovery of the patient, after this organ had once been paralysed by the chloroform.

Case 41 took place on July 13th, 1854, in the Middlesex Hospital. The patient was a stout, muscular, and florid man, 65 years of age, on whom Mr. De Morgan was about to perform amputation at the upper part of the thigh, on account of a large malignant tumour growing from the inner side of the femur.

"Chloroform was administered by Mr. Sibley, the registrar to the hospital. Snow's inhaler was employed. The quantity at first placed in the inhaler was rather less than two drachms, and another drachm was added eight minutes afterwards. The patient inhaled the chloroform without difficulty, and went through the usual stages; at the end of about ten minutes violent spasm was induced; this continued about three minutes, and then somewhat abated. The pulse, which had risen to about 120, descended to 70, having a full, steady, and deliberate beat. The pupils, which had been much dilated, became less so. The respiration continued free and deep, but not stertorous. The colour of the face remained good.

"At this moment, which was between thirteen and fourteen minutes from the commencement of the inhalation of the chloroform, the pulse gave a few rapid and irregular beats, and then ceased. Respiration, which, as has been stated, had been going on freely, ceased simultaneously. The face became suddenly pallid and deathlike. The inhaler

was removed instantaneously, and cold water dashed on the face. Mr. Sibley immediately commenced to carry on artificial respiration, by applying his mouth to that of the patient, and inflating the lungs. The period that elapsed between the sudden cessation of the pulse and the inflation of the lungs was only a few seconds. After a few inflations, there appeared to be a slight effort at inspiration, but this was the only sign of life discovered after the syncopal attack. Galvanism was in operation within two minutes after the cessation of the pulse."

"An examination of the body was made by Dr. Corfe forty-eight hours after death. In the head nothing particular was discovered; the brain was firm, and rather more vascular than natural; the blood in the sinus was partly coagulated; the heart was rather larger than natural, and was extremely loaded with fat, especially on the right side, where fat formed three-fourths of the thickness of the wall of the ventricle; the muscular tissue was extremely pale and soft, and exhibited both to the naked eye, and the eye assisted by the microscope, an extreme degree of fatty degeneration; the blood in the cavities of the heart was firmly coagulated; on both sides it was almost purely fibrinous; the clot on the right side was larger than on the left; a fibrinous clot extended down the aorta."*

I do not know how the bibulous paper was arranged in the inhaler in this instance, nor whether the inhaler was used with a view to regulating the amount of vapour in the inspired air. The proportion of vapour must have been small during the first ten minutes, as the patient became so slowly insensible; and judging from the result, we must conclude that the proportion was large just before the accident. The firm coagulation of the blood and separation of the fibrin were probably owing to the galvanism which

* Medical Times and Gazette, 1854, vol. ii, p. 86.

was so promptly applied. I found the fibrin separated from the colouring matter of the blood in the cavities of the heart of a cat, in which shocks of electro-magnetism had been sent through the chest just after it had been killed with chloroform.

Case 42. A man died whilst inhaling chloroform in University College Hospital on October 11th, 1854. The patient was a shoemaker named George Sands, aged 39, and of rather bloated aspect. He inhaled chloroform whilst Mr. Erichsen was endeavouring to introduce a catheter, and had the intention of puncturing the bladder if not successful. The patient was made insensible, and the chloroform was left off, but was reapplied on account of the patient making some expression of pain. "Probably about two minutes of the second inhalation had elapsed, when the man became profoundly insensible, and began to snore with a peculiar and very profound stertor. His face at this time was suffused and flushed, and the inspirations were drawn at rather prolonged intervals. Mr. Erichsen's attention was at once excited by these symptoms, and, desisting from the use of the catheter, he immediately commenced dashing the patient's face and chest with water. The chloroform had, of course, been removed. In the course of about a minute, the noise with the breathing gradually lessened, and it became apparent that the respiration was ceasing altogether. Mr. Erichsen now put his finger into the patient's pharynx, and dragged forwards the root of the tongue; at the same time attempting artificial inflation of the lungs, by applying his own mouth to that of the man. The latter plan did not appear to succeed well, and was almost immediately substituted by the more usual mode of artificial respiration, by compression of the chest, which was kept up most vigorously. The man's pulse had been felt by the adminis-

trator [Mr. Carnell] to be still beating some little time after the commencement of the alarming symptoms and the cessation of respiration. Artificial respiration had been employed for about four minutes, when the man, whose countenance had meanwhile retained its colour and an expression of yet remaining life, began to breathe again. A very short intermission of artificial assistance having been made, he drew spontaneously three or four inspirations; but, as each successive one was more feeble, the artificial aid was at once recommenced. About five minutes from the commencement, the galvanic apparatus was got in readiness and applied. It produced, however, no benefit; and from this time the patient lost colour in the face, and was evidently dead. The form of inhaler which had been employed was the one in ordinary use at this hospital, viz. a folded piece of lint. The administrator's hands and the patient's face had been covered during the inhalation by a towel."*

At the examination of the body seventy hours after death, extensive fatty degeneration of the heart was met with. The cavities of the heart were empty, owing, no doubt, to the artificial respiration.†

The above case differs to a certain extent from those previously quoted, inasmuch as the first symptoms of danger were those of profound coma, and of threatened death by apnoea, as a consequence of the action of the chloroform on the medulla oblongata and nerves of respiration. In addition to this cause of danger, however, the chloroform present in the lungs at the moment when the inhalation was discontinued must have acted directly on the heart, or the prompt assistance of so able an authority on asphyxia as Mr. Erichsen, the moment the breathing was suspended, would surely have restored the patient.

* Med. Times and Gaz., 1854, vol. ii, p. 390.

+ Ibid., p. 442.

The mode of death, although not exactly the same as that in Experiment 24 (page 110), differs from that in the previous experiment, where the heart's action was good and distinct after the breathing ceased; it resembles the mode of dying in many animals that I have killed with chloroform; being, in fact, a combination of death by apnoea and cardiac syncope, which generally occurs when the quantity of vapour in the respired air is intermediate between that in Experiments 23 and 24, or somewhere between 5 and 10 per cent.

A great peculiarity in the way in which chloroform was administered in the case we are considering was that the head and face of the patient were covered by a towel, under which the lint wetted with chloroform was held. The countenance and state of respiration could not be observed in this mode of giving the chloroform; the person administering it had to depend almost entirely on the pulse; and, except for this cause, there is every reason to conclude that the chloroform would have been withdrawn in this instance in time to save the patient. It was not apparently till a peculiar and very loud stertor attracted the attention of the operating surgeon himself, that the inhalation was discontinued, and the face was already suffused.

This plan of administering chloroform with the head and shoulders of the patient covered with a towel, was introduced by Mr. Clover, who was for several years a resident officer of the institution; and it is but right to state that it led to no accident in his hands; in those of his successors it was, however, less successful; three accidents having occurred in a little more than a year and a half. I much regret to find that Mr. Erichsen recommends this method of giving chloroform in the edition of his work on surgery recently published.

Case 43 occurred in Guy's Hospital, on December 5th, 1854. The patient was a woman whose leg Mr. Birkett was about to amputate on account of malignant ulceration. She gave her age as fifty-six, but appeared ten years older. "In each eye was a fairly marked arcus senilis, but the woman was not known to have suffered any symptoms referable to thoracic disease. . . . The administration of the anæsthetic was conducted by Mr. Bryant, the inhaler used consisting of a fold of lint, rather larger than an out-spread hand, and protected on its back by a piece of oiled silk to prevent wasteful evaporation. . . . In the first instance, about a drachm of the fluid was poured upon the lint. The patient inhaled it kindly; and, after about two minutes, another drachm was added. A stage of excitement now followed, during which the limbs required to be held. Insensibility was just fully established, and Mr. Birkett was on the point of commencing the operation, when Mr. Callaway, who was compressing the femoral artery, exclaimed that the pulse had suddenly ceased entirely. The wrist was examined, and the same found to be the case. Almost immediately afterwards, a long-drawn inspiration, attended with a deep sighing noise, was observed. For two or three breaths the cheeks puffed out during expiration; the respiration next fluttered, and then ceased. Mr. Birkett at once put his finger into the patient's mouth, and drew forward the tongue, artificial respiration being meanwhile commenced by assistants by means of compression of the chest. A few slight inspirations were attempted by the patient subsequent to the commencement of the artificial assistance; but they did not continue, and no sign of vitality was ever afterwards shown. . . . It must be noted, that the woman had been very pale both before and throughout the exhibition, and that no change in her appearance was perceived when the alarming symptoms occurred, excepting that the superficial veins of

the neck and temple became distended with blood. The cessation of the pulse was most sudden. Mr. Callaway stated that it was not preceded by the least premonitory fluttering, the stroke having been good one beat, and entirely wanting the next. This order of symptoms was of course suggestive of death beginning at the heart (cardiac syncope), the cessation of the functions of the nervous system having been markedly subsequent to that of the circulation. . . .

“Autopsy, twenty-four hours after death (conducted by Dr. Wilks). The corpse was much emaciated, and the rigor mortis imperfect. The lungs were much congested with fluid blood, which ran out after incision of their substance. The heart was of normal size, but soft and flabby; its left side was nearly empty, the right being distended with fluid blood. The left ventricle was of good thickness; its muscle of a deep colour, not encroached on by fat, or in the least mottled, the only observable departure from a healthy state being its flabbiness. The right ventricular wall was very thin, the subserous fat having in some parts almost taken the place of the muscular tissue. The layer of the latter, however, although much thinned, had still a good colour, and did not appear to the naked eye as degenerated, an observation which may apply also to the *carneæ columnæ*. The liver was in an early stage of cirrhosis, and the kidneys were both of them mottled, and contained numerous small cysts in the external part. The brain was rather paler than usual, its convolutions appeared shrunken and atrophied, and there was a quantity of serous fluid in the arachnoid sac and in the ventricles. There was general atheromatous disease of the arterial system, both in the head and other parts of the body. The blood was universally fluid, and of a dark colour.”*

* Med. Times and Gaz., 1854, vol. ii, p. 501.

As far as could be estimated, the time occupied by inhalation was about three minutes in this case.

Case 44 occurred at the Royal Ophthalmic Hospital, on April 10th, 1855, in a man on whom Mr. Bowman was about to perform excision of the left eyeball. The patient, named John Cannon, was forty years old, and was moderately stout, florid, and healthy-looking. He had generally led a temperate life. The disorganisation of the eye was the result of injury.

“The inhaler used was the one devised and recommended by Dr. Snow. . . . The administration was intrusted to Dr. Playne, of King’s College Hospital. In the commencement of the inhalation, the valve of the mouthpiece was so turned as to admit an abundant supply of air, a point to which Mr. Bowman directed personal attention. During the first four minutes (more or less) nothing unusual occurred. Dr. Playne, who had his finger on the pulse, had noticed that it had rather increased in fulness, and was of good volume. Rather suddenly, however, just as the anæsthetic appeared to be producing its effect, symptoms of excitement occurred. The eyes became fixed and staring, the arms outstretched and rigid, and the face contorted. It was now impracticable to feel the pulse, on account of the tossing about of the arms; but, as is usual in such conditions, the respiration was noticed to be all but, if not quite, suspended by the spasmodic fixtured of the chest. The inhaler was at once removed, and the face and chest of the patient dashed with cold water. Almost immediately after, as the respirations had become extremely feeble and sighing, Mr. Bowman commenced practising artificial breathing, by the application of his own mouth to that of the patient. By this means, the chest was made to fill very completely, and the process was kept up almost without intermission for from five to

eight minutes. During the first three or four minutes after the alarm began, the patient continued at times to make slight sighing efforts at voluntary inspiration, and the case was not thought, by those looking on, to be by any means hopeless. At length, however, these finally ceased, and from that time it was apparent that the man was dead. At the first opportunity which occurred for examining it after the spasmodic struggling had commenced, the pulse was found to be extinct, and it remained so ever after, although there were, as stated, feeble efforts at inspiration. The patient's countenance changed somewhat during the treatment, but was mostly suffused and congested."

At the examination of the body forty-eight hours after death, "the sinuses, and the veins of the brain generally, were much congested, and there was some cedema of the brain substance. The heart, excepting some slight deposits on the curtains of the mitral valve, was healthy. Its muscular substance was easily lacerable. The right ventricle contained a considerable quantity of fluid blood, the left was nearly empty. There were some pleuritic adhesions, and the lungs generally were congested, being also in some parts full of air. The blood in every organ examined was fluid, and without trace of coagulation."*

It does not seem that the inhaler used in this case was employed with the object for which it was contrived—that of regulating the amount of vapour in the inspired air; and I do not know whether the bibulous paper was arranged properly in the interior.

Case 45. On September 8th, 1855, a lady, aged twenty-nine, the wife of a physician, died suddenly whilst inhaling chloroform for the relief of facial neuralgia. I was sent for

* Medical Times and Gazette, 1855, vol. i, p. 363.

when the accident happened, and arrived twenty minutes afterwards. I found the deceased lady without any sign of life. The face and lips were very pallid. The husband was performing artificial respiration by mouth to mouth inflation of the lungs, and alternate pressure on the chest, and I assisted him in this for a long time, though with no hope that any thing could be of service. Dr. Barker, of Grosvenor Street, arrived soon after me, and assisted in the same measures. An inhaler was employed in this case consisting of a face-piece, like the one above delineated in this work, and a bent metal tube lined with bibulous paper. Two quantities of ten minims each had been inhaled, with some relief to the pain, and without causing unconsciousness when the inhaler and the chloroform were put away in a closet; but the patient begged to have more chloroform, in order to be completely relieved of the pain, as she had been on a previous day. Ten minims more chloroform, as I was informed, were put into the inhaler, and the patient, being seated on a sofa, began to inhale very eagerly, but had no sooner commenced than she gave a sudden start, as if taken in some kind of fit. Her husband laid her on the floor, but she evinced no further signs of life.

There was no inspection of the body.

The only explanation which the case admits of is that, in her eagerness to get relief, the patient took one or more inspirations of air very highly charged with vapour. The symptoms were those of death by cardiac syncope.

Case 46 occurred in the practice of Dr. Roberts, a surgeon-dentist of Edinburgh. The patient was a lady, thirty-six years of age, to whom Dr. Roberts had administered chloroform on four previous occasions within a twelve-month. Dr. Roberts says the chloroform was administered in the usual way, by which he means on a handkerchief.

He says: "Mrs. H. had only taken about nine or ten inspirations, obtaining but a partial influence of a quantity short of 3iss poured out from the bottle, and inhaling it for a space of time certainly less than a minute, when she said, 'You must not operate until I am quite insensible;' and again, 'I am not over yet;' and immediately, even while speaking, she gave a convulsive start, and with a stertorous inspiration, and with the eyes and mouth open, sunk to the floor." Dr. Simpson was sent for, and arrived within five minutes. Artificial respiration was resorted to, and after it had been applied for a time, there were a few spontaneous inspirations, and the pulse, it is said, could be perceived at the wrist; but these symptoms of reviving animation disappeared.

At the examination of the body, the right cavities of the heart were found gorged with blood. The walls of the right ventricle were thinner than natural, and affected to a certain extent with fatty degeneration.*

A paragraph was inserted in some of the Edinburgh newspapers, and forwarded by Dr. Roberts to the *Lancet*,† in which it was implied that death in this case was not caused by the chloroform. It is, however, like the preceding case, a well marked instance of the sudden and fatal action of this agent.

Case 47. A sailor, aged thirty, died whilst inhaling chloroform in St. Thomas' Hospital, in October 1856, preparatory to having some necrosed bone removed from one of his fingers. "He did not appear to be in robust health; still there was no obvious reason against his having the chloroform, which was accordingly administered as follows. One drachm was poured on a sponge folded between two thicknesses of lint, and this held at a little distance from

* Edin. Med. Jour., 1855, p. 524.

+ 1855, vol. ii, p. 479.

his mouth, while he was sitting in a chair. He appeared to be going off very comfortably, when the chloroform was left off for from half a minute to a minute, and then resumed. He now began to raise his hands and tremble, and kept spitting in the lint, and appeared as if about to vomit. Suddenly he was violently convulsed through his whole frame, as if in an epileptic fit. The chloroform was at once discontinued, and he was laid in a semi-horizontal posture. The convulsion only lasted for a few seconds, and when it had ceased he began to breathe with effort and puffing of the lips, and almost immediately to gasp irregularly. His pulse was almost imperceptible and intermittent. Artificial respiration was at once performed by alternate compression and relaxation of the walls of the chest, the tongue being held out of the mouth by the forceps. Ammonia was applied to the nostrils, and cold water dashed in the face, and in about a minute he rallied so as to breathe without assistance, but in a few seconds he relapsed, and could not be recovered.

“At the post-mortem examination there was found to be fatty degeneration of the heart, liver, and spleen, and the membranes of the brain were thickened. The lining of the ventricles presented a peculiar pitted appearance, apparently from inflammatory deposit. The brain itself was pale.”*

It was ascertained after the man's death that he had been of intemperate habits, and had had an attack of delirium tremens three weeks previously. In the report of this case in the *Association Medical Journal*, the following is the account of the appearances met with after death. In the autopsy in the present case, which we observed with particular care, the brain was in a state of oedema and bloodlessness, very like the brain in a patient who died from chloroform in the Ophthalmic Hospital. The liver was

* Medical Times and Gazette, 1856, vol. ii, p. 442.

fatty; but the heart seemed the very model or type of the healthiest kind of heart. All the other organs were also healthy.”*

Case 48 is related by Mr. Paget as follows. “I am anxious to place before the profession, at the earliest opportunity, a narrative of a case in which chloroform proved fatal in my private practice.

“The patient was a boy, nine years old, of delicate constitution, and of nervous, timid disposition; but with no indication of any organic disease, except that for which the operation was to be performed: namely, a tumour of the scapula; for which it was proposed to remove the greater part of that bone.

“At half-past eight A.M., on February 28th, after the patient had passed a night of sound sleep, the chloroform was first administered in a room adjoining that in which the operation was to be performed. He was alarmed at the thought of being put to sleep, and of what would then be done, and was very averse from taking chloroform, but he was persuaded to inhale it; and, though not without resistance, yet with less than is commonly made by patients of the same age, he was brought under its full influence in about three minutes. He sat in bed during the first few inspirations, and after these, was recumbent. It was observed that two or three deep inhalations were quickly followed by complete insensibility; and the next few inspirations were stertorous. He was at once carried, in the horizontal posture, into the room, and laid on the table, arranged for the operation.

“Three or four minutes passed while we were arranging his position and his dress, and while I was pointing out to those who were to assist me the proposed plan of operation.

* Association Med. Jour., 1856, p. 903.

During this time the influence of the chloroform so far passed off, that he became sensible, displaced his coverings and pillows, said something expressive of discomfort, and vomited a small quantity of frothy fluid. (He had taken no food since the previous night, when he had had a good supper.) A very small quantity more of chloroform was slowly inhaled, and he became again nearly quiet, and was again placed on his side. I was on the point of commencing the operation, but as he again, by movements, indicated some degree of sensibility, and changed his posture, about forty drops more of chloroform were poured on cotton wool, inclosed in a fold of lint,—an inhaler, with the chloroform on sponge, having been previously used. The lint was held, about half an inch from the face, by Mr. Thomas Smith, my usual assistant in operations. The patient inhaled lightly for a few times, then made one long inspiration, and appeared to pass at once into deep sleep. Except that he thus appeared to come suddenly under the full influence of chloroform, no external change was visible; but, a few seconds later, his pulse, which had been carefully watched, and had been to this time normal, suddenly began to beat very quickly; then it ceased for two or three seconds; then beat rapidly several times, with a kind of flickering movement; and then ceased to be perceptible.

“Just before this change of the pulse was observed, the chloroform had been withdrawn. The one deep inspiration was followed by a few stertorous breathings, but after these he breathed naturally, his complexion and features showed no change, he seemed only calmly asleep, and in this state he continued breathing naturally, and with no change in his appearance, but pulseless, for at least a minute. Then his breathing became less frequent, and seemed as if it might soon cease; his face grew pale, and his lips very slightly livid.

“With the help of cold water sprinkled on his chest and

face, and cold air blown on his face and throat, he was raised from this state of defective breathing in about two minutes, and again breathed deeply and freely, though slowly, (probably about twelve times in the minute.) He thus breathed for two or three minutes, and during this time the lips, and the pale or slightly livid parts of the face, became pink again, and though no pulse could be felt at the wrists, the heart was heard acting. During this time, also, some wine and brandy were poured into the mouth, and passed down the oesophagus, but without any evident movements of swallowing. His breathing again became gradually infrequent and feeble. Cold air and sprinkling with water, frictions and percussions of the chest, scarcely increased the breathing, and in less than two minutes it ceased. Artificial respiration, by the method of Dr. Marshall Hall, was immediately employed, and many times during the first five minutes of its employment the artificial inspiration obtained, when turning the body over to its side, was followed by a distinct, and sometimes even a full muscular inspiration. But at the end of about five minutes, these signs of life ceased, fæces escaped, and no more indications of life appeared, though the artificial breathing, the friction of the limbs, and other means for resuscitation, were continued for twenty or more minutes.

“I refrain, at present, from all comments on this case. Only, I wish to call particular attention to the fact that good breathing was maintained, and, after a suspension, was renewed, long after the heart had ceased to act with sufficient force to produce a pulse at the wrist. And I would add, that this narration is sanctioned and considered to be exact, by the four gentlemen who were to have assisted in the operation, and to whom I am greatly indebted for their counsel and assistance in the greater difficulty that we had to cope with.”*

* Medical Times and Gaz., 1856, vol. i, p. 236.

Case 49. This case occurred in the Liverpool Infirmary on April 5, 1857, and is related by Mr. Allan, the resident officer who administered the chloroform. The subject of the case was a labourer, aged 35, on whom Mr. Bickersteth was about to perform amputation of the thigh on account of gangrene following the ligature of the femoral artery. He had inhaled the chloroform six days previously without ill effects, when the femoral artery was tied for popliteal aneurism. On the day of the accident, he was first rendered insensible in the ward by chloroform poured on a piece of lint which was held a short distance from the nose and mouth. Having partially recovered during his removal into the operating theatre, the chloroform was reapplied, and Mr. Allan relates what occurred as follows: "About half a drachm of chloroform was now poured on some lint, which was held to the nostrils, and he then became *fully* under the influence; respirations *good*; pulse frequent, feeble. The operation was about to be commenced, and I was pouring about twenty minims more chloroform on the lint, (having pronounced the patient to be in a fit state,) so as to be ready to give him some more as occasion required, but had not applied it, when, turning round, I noticed something peculiar in his general appearance, and, on lifting up the eyelid, found the pupil dilated, and the lid did not close over on the removal of the finger; the eyes were slightly turned up. I at once felt for the temporal artery, but there was no pulsation, and none detected at the left wrist; the respirations had almost ceased. The head was lowered, cold water was dashed on the face, and the abdomen struck with the palm of the hand; the finger thrust into the mouth (there was no action of the heart felt); the legs were elevated, and a wet towel was dabbed over the epigastrium. After one or two blows, the respirations became better, and seemed good, and in about two minutes a pulse was

felt at the wrist. This continued between two and three minutes, the respiration being good. His pulse then began to fail, and in about a minute more the respirations were less. The tongue was seized with a pair of forceps, and drawn forwards, and artificial respiration tried, and ammonia held to the nostrils; but he was becoming livid in the face, so the Ready Method was at once adopted, and this produced apparently a few *natural* respirations. But the pulse had gone, and in about two minutes more there was no breathing save artificial. About the time that the pulse stopped, there was a convulsive movement of the muscles of the leg, and a slight clamminess of the skin succeeded. The Ready Method was continued for half an hour, and galvanism tried, but without avail. From the time he was placed on the table to his death, or the cessation of natural respiration, about ten minutes elapsed."

The writer adds: "He apparently sank from syncope, or cessation of the heart's action, for his respiration had been good just before he changed, and it continued for a second or two, though faint, when the pulse had stopped; and after the respiration had been restored, and was very good, the pulse was very feeble, and ceased two minutes before the respiration."

At the autopsy on the following day, the brain was found to be healthy, tolerably firm, and pale; the lungs were healthy; the right cavities of the heart contained some fluid blood, which afterwards coagulated on exposure, and a small clot. The left cavities also contained some blood. The muscular tissue of the heart had an unhealthy look, and very readily tore, but no oil globules were discovered with the aid of the microscope.*

Case 50 occurred in King's College Hospital, August 7th,

* *Lancet*, 1857, vol. i, p. 429.

1857. The following is the account of the case furnished by Mr. C. Heath, the House-surgeon :—

“The patient [Ann Stoner] was a female, aged seventeen, under Mr. Partridge’s care, with syphilitic warts and mucous tubercles. She was admitted July 8th, and had had chloroform administered twice, in order that the sores might be touched with nitric acid, and, on both occasions, not the slightest ill effect was produced. On Friday evening last, chloroform was again administered for the same purpose; only a drachm was put into the inhaler (Snow’s), and as soon as she became unconscious the inhaler was removed, and the acid applied. I and my assistant (who administered the chloroform), then went to see another patient in the same ward, and then washed our hands, during which time the patient was moving her legs about much as they do when recovering, and in addition she made water over the bed. I gave directions to the nurse to apply a poultice as usual, and left the ward, having been up to the bed first without noticing anything unusual about the patient. In a few minutes the nurse came down for some medicine for another patient, and mentioned that this one was looking very pale: I sent up Mr. Liddon to see her at once; he found her pale and senseless, dashed some water over her, and called me, and I went up immediately. I found her pulseless and cold, and immediately commenced artificial respiration (Marshall Hall), and sent for the galvanic battery; this was brought and applied without effect, and the artificial respiration was continued for twenty-five minutes without the slightest effect being produced.”*

I was present at the examination of the body on the following day. The mouth was sore and swollen from the effects of the inunction of mercury. There were a few drachms of clear serum in the pericardium. The heart was

* Med. Times and Gaz., 1857, vol. ii, p. 171.

large for the size of the patient. There was a patch of organised lymph on the pericardium, covering the left ventricle. The right cavities of the heart were full of dark fluid blood, and the left cavities contained a little. The mitral valve was much thickened, but the other valves were healthy. The lungs were healthy, and not much congested. The brain was healthy. The patient had suffered from acute rheumatism before entering the hospital.

It will be observed that the pulse is not mentioned in the above case, until its absence is alluded to, when the patient was already cold, and the breathing is not alluded to throughout the account; indeed, it is not known when the patient died. She was alive after the application of the nitric acid, as she was observed to move her legs, but further than this there is no clear evidence.

It is perhaps an open question whether this patient died at once from the direct effects of the chloroform, or whether she died after partially recovering and going on favourably for a time. The account would, at first view, seem to favour the latter opinion, but it is not corroborated by any other case. Patients have been partially recovered from the effects of an overdose, without being entirely restored, and others have sunk after great operations, attended with hæmorrhage, when the effects of the chloroform had more or less subsided, but there is no instance of a patient going on favourably, and partially recovering from the influence of the vapour, and then dying suddenly without any other known cause. Patients have occasionally become faint whilst recovering from chloroform, more especially if they remain in the sitting posture, but in those cases the right side of the heart is probably insufficiently supplied with blood; whilst, in the case under consideration, the patient was lying, and the right cavities of the heart were found full after death, the serum in the pericardium showing that

they had probably been distended when death took place. If Mr. Heath had made any observation which enabled him to say that the patient was really alive, when he went up to the foot of the bed, before leaving the ward, it would decide the question, and show that death did not take place at once from the direct effects of the chloroform, but he only makes the negative remark that he did not notice anything unusual about the patient.

I had an opportunity of examining the particular inhaler employed, and found that it was so arranged that the vapour might be breathed from it in much greater proportion than would be safe, if precautions were not taken to leave the expiratory valve a considerable way open, especially when the high temperature of the weather at the time is taken into account.

The foregoing cases comprise all the instances I have seen recorded in which death appears to have been occasioned by the administration of chloroform, and not by other causes in operation about the same time. A few additional cases have indeed been referred to by different authors where death was probably caused by chloroform, but as I do not find that the details have been published, I cannot make them available in an inquiry respecting the cause and prevention of these accidents.

In June 1852, Dr. Simpson alluded in the following terms to an accident from chloroform which had occurred near Glasgow:—"In this instance, chloroform was given by the practitioner for tooth extraction; but, I am sorry to add, none of the parties present were at the time in a condition to give any satisfactory evidence."*

A person, named Breton, a dealer in porcelain, died in Paris, in the early part of 1853, immediately after a few

* Med. Times and Gaz., 1852, vol. i, p. 627.

inspirations of chloroform, which was administered with the intention of removing a tumour of the cheek. An action was brought against Dr. Triquet and M. Masson for causing death by imprudence in this case; and at the trial which ensued, various interesting opinions were given, and the accused practitioners were ultimately exonerated.* I have not, however, met with any record of the symptoms which occurred in the case.

In relating the case of death from chloroform, which occurred in his practice, to the Medical and Chirurgical Society of Edinburgh, Dr. Roberts referred to another death from chloroform in tooth-drawing which took place in the neighbourhood from which his own patient came, just previously to October 1855; but I have not met with any account of the case so alluded to. Dr. Mackenzie of Kelso also alluded in the same Society, in the following year, to a death from chloroform which had occurred at Coldstream, and I do not know whether this was the case to which Dr. Roberts had alluded, or a fresh one.

One of the surgeons to the hospital at St. Louis, who was lately visiting the medical institutions of London, informed me that there had been three deaths from chloroform at his hospital out of between six and seven hundred operations in which it had been administered. I did not learn the particulars of those fatal cases.

There have been several cases in which persons have been found dead after inhaling chloroform when no one else was present, either for toothache or some other affection, but I have not included such cases in the above list, as they throw no light on the way in which death is occasioned. The simple way to avoid such accidents as those just alluded to, is for persons to abstain from inhaling chloroform, when no one is by to watch its effects.

* *Gaz. Médicale*, 1853, p. 304.

ALLEGED FATAL CASES OF INHALATION OF CHLOROFORM.

Several deaths have been attributed to chloroform which were due to other causes, or where the cause of death is a subject of great doubt. A gentleman, named Walter Badger, twenty-two years of age, the son of one of the coroners for the county of York, died instantly at Mr. Robinson's, the dentist's, in Gower Street, on June 30th, 1848, whilst commencing to inhale chloroform with the intention of having some teeth extracted. The inhaler employed consisted of a face-piece to enclose the mouth and nostrils, and containing a sponge on which the chloroform (3iss) was placed. This, according to the evidence of Mr. Robinson and his female servant, who was present in the room, was held not nearer than an inch and a half from the face for less than a minute, and the patient made the remark that the chloroform was not strong enough; Mr. Robinson requested him, as he had done before, to have the operation performed without chloroform, but he again declined; and Mr. Robinson then took away the face-piece and asked his servant to reach the bottle, intending to put more chloroform on the sponge, to replace that which he believed had been lost by evaporation. Just after removing the face-piece, and before any fresh chloroform was poured out, the head and hand of the patient dropped, and he did not show any further sign of life.

I found, on making trial of the kind of inhaler which Mr. Robinson employed, that it is impossible to inhale enough of the vapour to produce any appreciable effect, unless it is applied so as to touch the face. At the distance of an inch no effect is produced, even in five or ten minutes; and therefore I expressed my opinion, soon after this accident, that it was not caused by the chloroform, which properly speaking the patient did not inhale.

A consideration of the symptoms in this case confirms the view that the death was not caused by chloroform. In six of the fatal cases related above, death took place instantaneously, without insensibility or any of the usual effects of chloroform having been produced; but the mode of dying was not the same as in Mr. Robinson's patient. In Case 4, that of Madlle. Stock, the patient said "I choke", and tried to push away the handkerchief; then there was embarrassed breathing and foaming at the mouth. In Case 11, that of Madame Labrune, the fatal attack followed immediately on a full inspiration of chloroform, and there was an immediate alteration of the features, and a convulsive rolling of the eyes, amongst other symptoms. In Case 14, the young lady stretched herself out, and frothed at the mouth, at the moment of the fatal attack, and the face became livid. In Case 26, that of Madame W., who died at Ulm, the voice, when answering the question about singing in her ears, was trembling and thick; she stretched out her limbs, and the face became bluish. In Case 45, that of the wife of a medical man, and in 46, that of Dr. Roberts's patient in Edinburgh, there was a convulsive start at the moment of the sudden death. It thus appears that whe then heart is suddenly paralysed by an overdose of chloroform, before the patient is rendered insensible, there are usually some symptoms as if of a violent shock or injury. After complete insensibility is induced, the heart may be suddenly paralysed by chloroform, as is shown by numerous cases, without this spasmodic action; and it would perhaps be premature to deny that a patient might die thus quietly without being first made insensible; and the nature of the death in this particular case must be chiefly decided by the physical fact that the patient could not have inhaled enough chloroform to produce an appreciable effect of any kind, much less to cause sudden death.

At the inspection of the body, the liver was found so much enlarged that it weighed eight pounds, and it encroached very much on the chest. The walls of the left ventricle of the heart were found thinner than natural, and the muscular tissue was interspersed with fatty degeneration. There was blood in the right auricle and in both ventricles. In the ventricles it was partly coagulated. The brain presented nothing abnormal.*

It is probable that the immediate cause of death in this instance was fear. The patient had been told in the country that it would be unsafe for him to take chloroform, and yet he could not summon resolution to undergo the operation without it. Mr. Robinson unfortunately allowed his patient to remain seated in the operating chair; and it was only when Dr. Waters had been sent for and arrived from a neighbouring street that he was laid on the floor.

I was present on one occasion with Mr. Peter Marshall at the examination of the body of a woman who died suddenly of fright in consequence of a fire in the next house to that in which she lived, and it is worthy of remark that we found exactly the same diseased conditions as those which were found in Mr. Robinson's patient; viz., great enlargement of the liver, displacing the viscera of the chest, and fatty degeneration of the heart.

A young man, aged twenty-four, died suddenly of syncope, on June 25th, 1848, at the Hospital Beaujon, at Paris, whilst M. Robert was performing amputation at the hip joint, the thigh bone having been broken into splinters by a bullet during the conflict in the streets of Paris. The patient was in a state of great depression, both physical and moral, before the operation; and it is most likely that he sank under the combined effects of the injury and the operation.

* *Lancet*, 1848, vol. ii, p. 47.

Another patient had the neck of the humerus broken by a ball in the same conflict ; he was much reduced by hæmorrhage and gangrene of the wound ; M. Malgaigne performed disarticulation at the shoulder joint ; a fresh inhalation took place to enable him to search for the ball, and the patient sank and died during the last incisions. This patient also most probably died from the effects of the operation added to those of the previous injury and loss of blood.

A woman died in Paris, 1848, after removal of the breast. The operation was finished, and the chloroform had been left off some time, and the patient had become conscious, when on raising her into a sitting posture, in order to apply a bandage, she suddenly expired. Although the chloroform was blamed in this instance, death evidently took place by the ordinary kind of syncope, which arises from the heart not being supplied with blood, and which may be called anæmic syncope, in contradistinction to cardiac syncope, which begins at the heart itself, when properly supplied, or even when distended with blood.

A child, aged twelve years, died in the hospital at Madrid in 1849, during amputation of the leg after violent tetanic rigidity.* Death was attributed to the chloroform which had been inhaled, but no further particulars are given, and it is not stated whether or not there was any unusual hæmorrhage, or other cause, which would explain the fatal event.

Dr. Aschendorf has attributed the death of a child a year old to chloroform.† The child had a nævus on the face and neck, which extended from the zygoma to the os hyoides, and from the external auditory meatus to the

* Bouisson, *Méthode Anesthésique*, p. 398.

† Casper's *Wochenschrift*, September 6, 1850 ; and *London Med. Gaz.* vol. xlvii, p. 261.

maxillary fossa. No one had been willing to undertake its removal. Dr. Aschendorf operated on the nævus at three different times, by means of seton threads. These operations were performed under the influence of chloroform. The tumour was reduced one-third part in size by these means, and eleven weeks afterwards Dr. Aschendorf determined to extirpate it. The chloroform was administered as on the former occasions, by placing six drops on some tow in a cup. In about ten minutes, as the child cried a little, three drops more of chloroform were used for inhalation, and in about eight minutes more the operation was concluded. "On raising the child it laid its head on one side, convulsive twitches of the face were observed, with distortion of the eyeballs and dilatation of the pupils. For one moment the arms were stretched out stiff, then again they were relaxed, and fell as supple as the rest of the body. Death quickly followed—only one pulsation of the heart and a single râle with the expiration being perceived."

There can be no doubt of this being a case of death from hæmorrhage, after the direct effects of the chloroform had subsided. Dr. Aschendorf says the quantity of blood lost was about two tablespoonfuls; but it would be necessarily removed by sponges during the operation, and there would be no means of estimating the quantity. The child was probably in a state of syncope during the latter part of the operation, as it would not remain insensible to the knife for eight minutes from a single application of chloroform.

On September 15th, 1852, a patient died to whom I was administering chloroform whilst Mr. Cæsar Hawkins was performing lithotritry. He was a gentleman from the country, aged seventy-three; he was tall and stout, he had a weak intermitting pulse, and a well marked arcus senilis in each cornea. He had inhaled chloroform five or six

times, between May 1850 and May 1851, for the same operation, when under the treatment of another surgeon, and it always acted favourably. In the first week of December 1851, Mr. Hawkins performed the operation of lithotrity twice, when the chloroform was administered by Mr. Geo. D. Pollock. On the second of these occasions he became faint during the operation whilst under the influence of the chloroform, but recovered from the faintness before its conclusion. He again fell into a very alarming state of syncope a few minutes after the conclusion of the operation, but rallied, and vomited the breakfast which he had taken a little time before. I first administered the chloroform to this patient on December 15th, 1851, eleven days after the above occurrence. Mr. Hawkins and I were inclined to think that the alarming syncope on the previous occasion might have been connected with the sickness which occurred. It was my firm belief that the patient had fatty disease of the heart; but I did not see any great objection to the chloroform on that account, as I had frequently given it in similar cases, and always with a favourable result. On this occasion (December 15th) he inhaled the chloroform before breakfast. Its effects were quite satisfactory, and it was not accompanied or followed by any unpleasant symptoms whatever. The operation was repeated four days afterwards, when I again exhibited the chloroform with like favourable results. After this the patient went back to the country relieved from his stone. He came back, however, in the autumn of 1852, with a return of his complaint, and I was again requested by Mr. Hawkins to assist him by giving the chloroform on September 15th.

The patient became insensible, without any excitement or struggling, in the course of three or four minutes, and the operation was commenced. A little more chloroform was

administered two or three times during the operation, in order to keep up the insensibility. After a few minutes had elapsed, I observed that the face and lips of the patient became pale. At this time he had not inhaled any chloroform for about two minutes. Immediately afterwards, however, his face became red, and he made straining efforts with the muscles of respiration, as if he were beginning to feel the operation. To prevent his becoming altogether sensible, therefore, I commenced to give him a little more chloroform, with the valve of the inhaler about one third open, as on the former occasions. He had only taken two or three inspirations, however, when the breathing ceased. He appeared to be merely holding his breath, as sometimes happens during the exhibition of chloroform, and I expected that he would begin to breathe again in about a quarter of a minute. In the meantime, I endeavoured to feel the pulse in the temporal artery, but did not perceive any. Instead of the breathing recommencing at the time I expected, the countenance became suddenly pale, and a little afterwards rather livid. I applied my ear over the region of the heart, but could not hear any sound. After a few seconds, however, the patient took a rather deep inspiration, and immediately after this I was pretty sure that I heard the heart beating very feebly and rather frequently, but only for a few seconds, after which no sound could be heard. There were one or two more very feeble inspirations at intervals of about a quarter of a minute, after which there were no further signs of life. As soon as the patient had entirely ceased to breathe, artificial respiration was performed, but no sign of returning animation appeared.

At the examination of the body fifty-two hours after death, the heart was found to be larger than natural, and there was a good deal of fat on its surface. Its right cavities contained air or gas, probably resulting from the

partial decomposition of the blood. The right ventricle was dilated, and its walls were very thin. At one place, near the apex, they were extremely thin. The left ventricle was also dilated, but its walls were of the proper thickness. They were, however, like those of the other ventricle, very soft and friable. There was a calcareous incrustation on one of the aortic valves. There was scarcely any blood in the heart, but its lining membrane was stained in places, showing that blood had been present after death.

Mr. Pollock and the late Mr. W. F. Barlow examined the structure of the heart under the microscope, and the latter gentleman furnished me with the following account of the examination :—

“Many of the fibres have been converted into fat completely ; in others, fatty degeneration was beginning. The degeneration, which was in various stages, appeared very general. The fasciculi were broken up, here and there, into masses of small irregular fragments, as they may be found frequently in hearts of this kind. Some large fat globules lay between and upon the fibres. A few fibres showed their transverse striæ plainly, and made the changes in the others look the clearer. On the whole, it may be said that the structure of the organ was greatly damaged, and that its action, consequently, was liable to cease suddenly from slight causes.”

I am of opinion that this patient did not die from the direct effects of the chloroform. The air he was breathing just before he died did not contain more than three or four per cent. of vapour of chloroform at the utmost, and he had previously breathed quite as much, both during the same operation and on previous occasions. The patient seemed to be holding his breath at the moment when his heart ceased to beat ; and it is whilst holding the breath, and making a straining effort, that patients labouring

under disease of the heart not unfrequently expire. Mr. Pollock, who was present when the patient died, expressed to me his belief that he died of his heart disease, and not of the chloroform.

After reflecting on this case, I see no reason to regret the course which was pursued. It was the opinion of Mr. Hawkins that the patient could not have borne the operations without the chloroform; consequently, if we had decided not to permit its use any more, in consequence of the alarming syncope which occurred after the operation under its influence on December 4th, 1851, he would probably have died in great suffering from the calculus, instead of having seven or eight months freedom from the complaint. And, on the other hand, if it had been decided to operate without chloroform, it by no means follows that the patient would have been in less danger, judging from what I have observed of the effect of pain on the circulation, as compared with the effect of the chloroform carefully administered, in numerous other cases of disease of the heart.

On May 11th, 1854, a patient died suddenly in St. George's Hospital as she was beginning to inhale chloroform. She was a pale and delicate looking woman, aged thirty-seven, from whose left breast Mr. Cæsar Hawkins was about to remove a mammary glandular tumour. "On entering the operating theatre she appeared nervous. Having been placed on the table on her back, in a half reclining position, the administration of chloroform was commenced. Dr. Snow's inhaler was used. The quantity of chloroform placed in the receiver was a little more than a drachm; and the valve for the admission of air was left wide open. Apparently, from excitement, she did not inhale well, but drew her breath by deep catches, and irregularly. Mr. Potter, noticing this, spoke to her, begging her

to compose herself, and try to breathe more quietly. The valve was then slightly turned on, in order that she might inhale but a very small quantity of chloroform. The same spasmodic efforts at inspiration still continued ; very shortly afterwards, at most not more than a minute and a half from the commencement of the inhalation, Mr. Potter noticed her breathing to suddenly cease, and that she had become deathly pale. The inhaler was at once removed. On placing the finger on the wrist, no pulse could be found. Endeavours to arouse her by dashing the face and chest with water were immediately adopted ; but, proving ineffectual, artificial respiration was commenced within a minute of the first symptoms. During the interval, two sighing attempts at inspiration had been observed ; but there had been no pulse whatever ; the mouth lay a little open, and the countenance was still extremely pale.”* Other attempts at resuscitation were made without effect.

“At the post-mortem examination, on the following day, no very noticeable lesions of the viscera were discovered. There was congestion of the whole venous system, and the blood, in every organ, was of a deep purple colour, and quite fluid. The brain-substance itself was perhaps a little more vascular than usual, and the veins of its meninges were loaded with blood. The heart was small and fat, the right ventricle being especially loaded with adipose material, and its muscular layer much thinned. Under the microscope there was found to be slight, yet decided, fatty degeneration of the muscular structure. Both chambers, but more particularly the right, were distended with blood in which no coagula could be found. The posterior lobes of the lungs were somewhat congested, but not more than the position in which the corpse had lain might account for. There was no disease of the abdominal viscera.”†

* Medical Times and Gazette, 1854, vol. i, p. 516.

† Ibid., p. 517.

I made a chemical examination of some blood obtained from the heart and large vessels, and also of portions of the lungs and liver, but I failed to detect any trace of chloroform, although the process I employed is one by which I have very easily detected it in the bodies of small animals killed by it, and also in portions of limbs and tumours removed whilst the patients were under its influence to the usual extent.

It was impossible that this patient could have breathed air strongly charged with vapour. Every one in the operating theatre was a witness that the expiratory valve of the face-piece was not, at any time, more than one-third closed, being two-thirds open. In this way no great effect of any kind can be produced, as very little of the air which the patient breathes passes through the inhaler. Mr. Potter informed me, moreover, that the patient breathed very little even of air, her breathing was so much embarrassed by her frightened condition. He was trying to calm her apprehensions at the moment when she died.

The mental emotion under which the patient was labouring was, no doubt, the cause of the sudden death in this instance, as in that above referred to, which occurred at Mr. Robinson's. The mode of dying, in the present instance, was evidently by cardiac syncope; the same mode of death, in fact, as that which is occasioned by vapour of chloroform, when not sufficiently diluted; and it is only the absolute knowledge, that any small quantity of vapour which this patient inhaled was very largely diluted with air, that enables one to decide, with confidence, that the chloroform was not the cause of death. It may be observed, however, that there was an absence of the convulsive start or spasm which occurred in all those deaths from chloroform, which took place at the beginning of the inhalation, without loss of consciousness having been first induced.

The right cavities of the heart were found full of blood in this case, and it is probable that they became so much distended, as the patient was in a state of alarm, and scarcely breathing, that, in the thin and diseased state of the walls of the right ventricle, the action of the heart was arrested. Sudden death not unfrequently takes place during mental emotion, and, in many of the cases, the mode of dying is probably that just mentioned.

SYMPTOMS IN THE FATAL CASES OF INHALATION OF
CHLOROFORM.

Out of the fifty cases of death from chloroform, related above, there are five in which the symptoms at the time of death are not detailed, viz., Cases 6, 7, 21, 24, and 50 ; in the two first cases it is merely related that the patient suddenly expired, and, in the two last cases, no one was watching the patient at the time when death took place. In considering the remaining cases they may be conveniently divided into groups, according to the period of the inhalation at which the accident occurred. In six of the cases the fatal symptoms came on suddenly, at the beginning of the inhalation, before the patient had been rendered unconscious ; in each of these cases there was the most unequivocal evidence of the sudden arrest of the action of the heart. In cases No. 4 and No. 11 there was sudden pallor of the face at the moment when the circulation ceased. In Nos. 14 and 26 the face became livid at the time of the fatal attack, and, in Nos. 45 and 46, the colour of the face is not mentioned. In all these cases there were also symptoms as if of a sudden shock to the system, such as stretching out of the limbs, foaming at the mouth, rolling of the eyes, or a sudden convulsive start. In Case 4, the patient at Boulogne had just complained of a choking feeling, one sign that the vapour she was breathing was not