

her nose, presented a purple tinge. The skin of the arms, face, throat, chest, and neck was hard and contracted, and of a dark olive colour.

When this patient appeared before me she was extremely emaciated, and her skin so much contracted as to appear too small for her body; her lower eyelids were drawn down, exposing more of the eye than usual; her features were lengthened, and the lower lip had fallen away from the mouth, exposing the teeth and gums. Her fingers were bent and contracted, and there were several sore places upon them, occasioned by ulceration; the sensibility of the skin was deadened, and her movements were effected with difficulty.

This patient died the year following, of acute bronchitis, "no change having taken place in the appearance or functions of the skin."

(To be continued.)

FURTHER REMARKS
ON THE
CAUSE AND PREVENTION OF DEATH
FROM CHLOROFORM.

BY JOHN SNOW, M. D.

I READ two papers before the members of the Medical Society of London a few years ago,* on the Cause and Prevention of Death from Chloroform, in which I pointed out that when animals, such as cats, rabbits, and guineapigs, are made to breathe air containing four or five per cent. of vapour of chloroform till they die, the breathing ceases a minute or two before the circulation of the blood; and that during this interval, in which the heart can be heard and felt to be still beating, the animal could be easily restored by artificial respiration; and, moreover, that at the moment when the heart's action was ceasing, the creature often gave one or more gasping inspirations, which, in many cases, had the effect of causing its recovery, if it had been removed from the chloroform. I showed that this mode of dying did not depend on a want of power in chloroform to arrest the functions of the heart by its direct effects, but on the circumstance that it requires rather more of this agent to stop the action of the heart than to arrest the respiratory movements. I had ascertained the power of chloroform to act directly on the heart by blowing the vapour on that organ when exposed, and by injecting a solution of it in water into the coronary arteries, as well as by giving it by inhalation. In some experiments on frogs, which go on absorbing vapour by the skin, after the respiratory movements have ceased, I was able also to ascertain the amount of chloroform which suffices to paralyse the heart, and I found it to be one-eighteenth part as much as the serum of the blood is capable of dissolving; whilst about one part in twenty-two of what the blood will dissolve has the effect of arresting the action of the muscles of respiration.

I pointed out also what I consider to be of the utmost importance in relation to the accidents from chloroform—viz., that this agent has the effect of arresting the action of the heart, by its direct influence, in animals of warm blood, when they breathe air containing not less than eight or ten per cent. of the vapour. I had ascertained the circumstance in numerous experiments in which the stethoscope was applied to the chest of the animals whilst they were inhaling the chloroform, and also in two experiments, in which I was assisted by Mr. Peter Marshall, where, the animals being kept alive by artificial respiration after the heart was exposed, the chloroform was administered by a tube inserted in the trachea, and its instant effect on the heart could be seen.

The reason why the chloroform is thus able to act directly on the heart, under certain circumstances, is as follows:—When the vapour is breathed till such an effect is produced on the brain and nerves of respiration, that the action of the respiratory muscles is suspended, there is still vapour in the lungs, which has been inhaled during the last inspirations, and this continues to be absorbed into the blood which is passing through the lungs at the moment, increasing the quantity of chloroform which the blood already contains. Whether this additional quantity of chloroform, which is absorbed into the blood during the first few seconds after the breathing has ceased, shall be sufficient

to remove the remaining sensibility of the cardiac nerves, and so paralyse the heart, depends on the quantity of vapour in the air last taken into the lungs. I find that when this quantity has not much exceeded five per cent., the action of the heart is not arrested by its direct influence, but when it reaches to about ten per cent., the action of the heart is at once arrested. I might explain the reason of this by arithmetical calculation, but shall content myself at present by stating the simple fact. In a few experiments, the action of the heart ceased a little before the breathing, and I shall allude to them afterwards.

In the paper which I read in 1852, I expressed my conviction that no accident, of which the particulars had been related, had arisen from the medical man mistaking the symptoms, and continuing to exhibit too long the vapour of chloroform sufficiently diluted with air; but that in all the recorded cases the action of the heart, as well as the respiration, had been suddenly arrested by vapour not sufficiently diluted with air. An examination of the accidents from chloroform which have since been recorded, has satisfied me that they have also been occasioned in a similar manner.

Dr. Black, of St. Bartholomew's Hospital, who has had great experience in the administration of chloroform, has lately advanced the opinion, that in the accidents from chloroform the patients did not die from the pathological effects of this agent, but died simply of asphyxia before they were brought under the influence of the chloroform, owing to the respiratory movements having been arrested, or impeded, by the pungency of the vapour, which has been administered in too concentrated a form, at the beginning of the inhalation.

This view is, in my opinion, altogether untenable, as an explanation of the accidents from chloroform, for various reasons. I find that when the access of air to the lungs is entirely cut off, death does not take place in less than three minutes and a half in guineapigs, and four minutes in cats. In dogs, the process of asphyxia is still slower. Mr. Erichsen states, that on taking the average of nearly twenty experiments, the contractions of the ventricles continued for nine minutes and a quarter after the trachea had been closed, and that the pulsations of the femoral artery also were perceptible for an average period of seven minutes and a half after all access of air to the lungs had been prevented. The duration of life under privation of air, in the human subject, resembles its duration in dogs more nearly than in still smaller animals; and even if the pungency of the vapour of chloroform should entirely prevent the patient from breathing, and the medical man could overlook the fact that respiration was not going on, it cannot be supposed that he would use the force, and have the perseverance, to cause his patient to die slowly by asphyxia. With the breathing merely impeded, the process of dying would be still slower; but there has been no accident, during the exhibition of chloroform, in which death took place so slowly as to resemble that caused either by the complete or incomplete exclusion of air. If, therefore, any patient has died from the mere impediment to breathing, caused by the pungency of the vapour, it must have been in a case where there was a great tendency to sudden death.

An examination of the recorded cases of death from chloroform shows, indeed, that the patients did not die by impeded or interrupted respiration. To take, for example, the fatal case which occurred in the Royal Infirmary of Edinburgh. The patient breathed the chloroform from a handkerchief, which was held a little distance from the face, to allow the air to enter freely. An ounce of chloroform was expended in the process of inhalation. The man struggled considerably, from the effects of chloroform, as a certain class of patients do. The exhibition of the vapour was left off when the man began to snore, although he was still violent. He soon became quiet, however, and Dr. Dunsmore says, "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 remarked, was good, but in a second or two after, both gentlemen exclaimed the pulse was gone." Dr. Dunsmore adds, "Those present who had an opportunity of observing the respiration positively assert that the breathing did not cease before the pulse." This patient certainly inhaled the chloroform, and became insensible from it, after which he died suddenly by cardiac syncope.

I may allude to another case which happened in St. Bartholomew's Hospital, whilst Dr. Black was present.

"A drachm of chloroform, 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

* See Edinburgh Medical and Surgical Journal, 1849, No. 180, and London Journal of Medicine, 1852.

patient had gone through the usual stages of excitement, &c., and the last dose was scarcely used as she sank off, almost immediately after its application, into a state of complete insensibility, unattended with alarming symptoms. About five minutes had been occupied in 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 feeble 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. 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."

In this case, also, the patient breathed the chloroform, and became quite insensible from it, when the heart became suddenly paralysed, so far as to be unable to keep up the circulation.

Out of forty-four deaths from chloroform which are recorded, seven took place after the patient was quite insensible, and when the surgeon was just about to begin the operation; twelve occurred during the performance of the operation, which was already commenced; in eight cases the operation, being of short duration, was completed before it was discovered that the patient had expired. In two or three of these latter cases, it was thought that the patient was probably dead when the operation was begun. In the remaining seventeen cases, the inhalation was discontinued at some period of its progress, owing to the sudden occurrence of alarming symptoms. In some of these cases, death took place quite early in the inhalation, before the patient had evinced any of the usual signs of the influence of chloroform, and it is extremely worthy of remark that, in every accident, the particulars of which are related, the symptoms of real danger set in suddenly, whether they appeared during the inhalation or after it was discontinued.

A commission appointed by the Academy of Medicine of Paris, in 1849, to report on the fatal case which occurred at Boulogne, denied that the death in question was caused by chloroform, on the ground that this agent always produces intoxication and insensibility before death. M. L. Lallemand also expressed a similar opinion last year, as the reporter of an experimental enquiry undertaken by the Society of Emulation of Paris. He stated that the phenomena produced by chloroform are "always manifested in the same order, and with the same characteristics," and that the respiratory movements always cease before the action of the heart.* These commissions are, however, in error as to a simple matter of fact; what they say is only true of chloroform when the vapour is diluted with air to a considerable extent; with a less amount of dilution, chloroform may cause sudden death by paralysing the heart, without its usual effects being apparent; and I can kill animals suddenly with it, as with vapour of prussic acid, without inducing previous intoxication or insensibility.

In all the cases of death from chloroform, in which the state of the pulse at the time of the accident is described, it was found to cease suddenly and abruptly, and in only two of the cases was there the slightest indication of returning pulsation, for a brief interval. In several cases, indeed, it was observed that the very last pulsation was equal in strength to the ordinary ones. This is entirely different from what takes place in asphyxia. Under a total privation of air, the pulse retains its usual strength for a minute or two, and then gradually diminishes in frequency and force during two or three minutes, till it finally ceases.

In twelve of the recorded cases of accident, the face was observed to become suddenly pale at the moment when symptoms of danger set in. This symptom probably occurred in many of the other cases, but was either not observed, or if so, not recorded. I need hardly say that sudden pallor of the countenance is indicative of death beginning at the heart, and is irreconcilable with asphyxia.

In four of the instances in which death occurred during the performance of an operation, the attention of the surgeon and his assistants was first called to the patient's danger by the sudden cessation of the bleeding—a phenomenon which proves the occurrence of sudden syncope even more strongly, if possible, than the circumstances previously mentioned.

A fact which also shows clearly, that in the accidents from chloroform, death has not taken place by asphyxia, is, that

when animals are killed by it very suddenly, so that death occurs in the same manner as in the accidents to the human subject, the blood is found to be of a florid colour in the lungs, if the body is opened immediately after death.

Except in the case of children and lunatics, who cannot always be persuaded to inhale chloroform, the patient breathes it voluntarily, but it would be manifestly impossible that a patient should willingly go on suffering from a want of breath, owing to the pungency of the vapour, without making any complaint, until he should die from this cause, or even become unconscious. As regards children and lunatics, no accident from chloroform is known to have happened to them. Persons do indeed complain sometimes of a choking feeling, and want of air, but the practice is to humour them at first, and restraint is never applied, except in the excitement and struggling that sometimes occur from the genuine effects of chloroform, after unconsciousness has been induced.

The vapour of sulphuric ether is as pungent and irritating as that of chloroform, if not more so, and, therefore, if the accidents were occasioned by the pungency of the vapour preventing the access of air to the lungs, they would be quite as liable to occur under the exhibition of ether as that of chloroform. But accidents during the inhalation of ether were extremely rare; only two are known to have occurred, and these, I believe, not from the effects of the vapour. In one of these cases, which occurred at the Hôtel Dieu d'Auxerre, the patient seemed to die by asphyxia, not occasioned, however, by the pungency of the vapour, but, more probably, the narrowness of the tubes of the inhaler. Symptoms of distress commenced when the man had been inhaling three minutes, and continued till the time of his death, at the end of ten minutes, the apparatus being kept applied the whole time. I need hardly say that no case resembling this has occurred during the exhibition of chloroform. In the other case which happened at the Hôtel Dieu de Lyons, the patient died of sudden syncope, caused, in my opinion, by loss of blood during the removal of the superior maxillary bone—an operation which the surgeon had been reluctant to undertake, on account of the weakness and general bad state of the patient.

In a few cases of death from chloroform the countenance has been observed to become turgid and dusky just after the circulation ceased. This circumstance has been thought to indicate death by asphyxia, which is an error. Although not of itself proving the kind of death, the turgid and dusky state of the face is what must take place from sudden arrest of the action of the heart in patients who are not deficient of blood. The moment the heart ceases to beat, its right cavities become distended, and no more blood can enter them from the veins; but the arteries are emptied by their contractility, aided by the molecular forces connected with the circulation through the capillaries, and consequently the veins become distended, even to their radicles.

In several of the fatal cases of exhibition of chloroform there was considerable struggling, either before the real symptoms of danger set in, or just as the circulation ceased, and Dr. Black considers that these efforts indicate asphyxia. In many of the cases the struggling arose, no doubt, from the ordinary effect of the vapour on a certain class of patients, whilst in a few patients who died suddenly, without first being rendered insensible, there was a spasm at the time the heart ceased to beat, analogous to what one often sees when animals are bled to death. In asphyxia the convulsions cease before the action of the muscles of respiration, and the heart continues to beat distinctly for two or three minutes longer, but it has not done so in any fatal case of the exhibition of chloroform.

If it were possible for a medical man to overlook or misunderstand the symptoms induced by vapour of chloroform when sufficiently diluted with air, and to go on administering it till the patient should die, the death would very much resemble one by asphyxia; for the respiratory muscles would first cease to act, and the circulation would be gradually brought to a stand by the failure of the respiration; of this I am satisfied from very numerous experiments upon animals. There has been no cases recorded, however, of death occurring in this manner during the exhibition of chloroform. In the few cases where persons have lost their lives by imprudently inhaling the vapour when no one was present, death has most likely taken place in this way, but this cannot be known for a certainty. In this mode of dying from chloroform, as well as in asphyxia, there are often two or three gasping efforts at inspiration directly after the heart has ceased to beat; and if fresh air is allowed to enter the lungs during these efforts, the circulation is in many cases restored, both in asphyxia and narcotism from chloroform.

* See L'Union Médicale, 1855, No. 13.

Dr. Sibson made the remark, in 1848, that during the inhalation of chloroform the blood which circulates in the coronary arteries must be more highly charged with vapour than that in any other part of the body except the lungs. When the chloroform is exhibited in a gradual and uniform manner, this circumstance is of no consequence, as the heart is capable of bearing a greater proportion of chloroform than the brain; but when the vapour is not sufficiently diluted the case is different, and the suggestion of Dr. Sibson affords the best explanation of those fatal cases, and of some experiments I have performed on animals, in which the action of the heart has ceased before the breathing. In a few of the fatal cases the period of inhalation was so short that it is impossible that the chloroform could have been equally diffused throughout the system, and the quantity of chloroform used was so small that no harm could have resulted if it had been thus diffused. In a case which occurred at Ulm, a lady, in good health and spirits, took but five inspirations of chloroform, when she expired; but it is impossible that, in a quarter of a minute, even a tenth part of the blood in the body could pass through the lungs and become charged with chloroform. A portion only of the blood was thus charged, and the mode of dying showed that it acted fatally on the heart.

There is a very common mistake with regard to the action of carbonic-acid gas, which has led to an erroneous opinion of the effects of chloroform in more than one quarter. Undiluted carbonic-acid gas is known to cause death very quickly, and it is generally believed to do so by causing spasm of the glottis; but spasm of the glottis would not cause death more quickly than tying the windpipe, or immersing the head in water, and the mode of dying would be the comparatively slow one of asphyxia. When an animal is placed in a jar of this gas, over water, the gas is seen to diminish considerably in volume, as it is absorbed into the blood with each inspiration. Moreover, I have never myself had any difficulty in inhaling pure carbonic-acid gas by small quantities—fifteen or twenty cubic inches—at a time, since I first tried nearly twenty years ago.* The gas causes no particular sensation till it reaches the lungs, when there is a tendency to cough and a feeling of tickling in the throat. It is advisable not to attempt to fill the lungs with this gas, for it has an unpleasant way of upsetting the dogma that narcotism is necessarily gradual and progressive.

As we have seen that all the accidents during the exhibition of chloroform have been caused by the air breathed by the patient being, at some moment, too highly charged with the vapour, it follows, that to prevent such accidents it is only necessary to insure that the vapour shall at all times be sufficiently diluted with air. The most fatal error with regard to chloroform has been to suppose that the patient was safe so long as he was supplied with sufficient air for the purposes of respiration; for the truth is, that the more air the patient breathes the greater is his danger, if the air be over highly charged with the vapour. Sudden death from this cause may happen at any period of the exhibition of chloroform, and a few accidents have occurred almost at the beginning of the inhalation. It is, however, a mistake to suppose that the danger from vapour not sufficiently diluted is greatest at the beginning of its administration. The danger from this cause increases as the patient comes under the influence of the chloroform, and as the blood absorbs more and more of it, the greater number of deaths having occurred after the patients were first rendered quite insensible. In the beginning of the inhalation, it is, indeed, necessary to give the vapour in a state of greater dilution than afterwards, in order that it may not be needlessly disagreeable to the patient; but there would be no danger in commencing at once with vapour diluted only with 95 per cent. of air, as I know by very numerous experiments on animals.

The means which I employ to regulate the amount of vapour in the air breathed by the patient is an inhaler, which has been described on a previous occasion, and which enables me to effect that object near enough for practical purposes. In using a handkerchief or sponge, the danger of the vapour being breathed in a too concentrated state may be prevented by diluting the chloroform with an equal measure of rectified spirit. Air at 60° Fah. is capable of taking up 14 per cent. of vapour from pure chloroform, and although it never gets fully saturated in the ordinary process of inhalation, the result shows that it has on many occasions taken up, at some moment, a great deal too much. When diluted with an equal measure of spirit, chloroform will only yield 8 per cent. of vapour at

60° Fah., even if the air were quite saturated with the mixed vapours. In practice, it yields enough to induce insensibility, without any risk of causing a sudden accident.

Artificial respiration, very promptly and efficiently performed, is almost the only measure which promises a prospect of relief in cases of accident from chloroform. It is the only thing which I have ever found to restore animals, when it was clear that they would not recover spontaneously from the chloroform. Electricity seems to be injurious, by exhausting the remaining sensibility; but opening the jugular vein is advisable, in cases where the veins are turgid, in order to relieve the distension of the right cavities of the heart.

Sackville-street, January, 1856.

ON SOME POINTS IN THE SURGERY OF HERNIA ;

WITH ILLUSTRATIVE CASES.

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(Continued from page 70.)

THE three cases recorded in the first portion of this paper are sufficient for the object I have in view, which is, to show how fatal and pernicious it is to attempt to accomplish, by a rough and barbarous manipulation, (which belies the very meaning of the word taxis,) that which could be done easily by a dexterous and delicate operation, and without any great chance of compromising life. I can here hardly resist relating the plan adopted by a student of the London Hospital some years back, in order to return a somewhat large hernia into the abdomen. The anecdote is related by Mr. Headington, formerly a surgeon of the hospital. He was sent for one evening to see a case of strangulated hernia; he arrived at the hospital with all due speed, and on entering the ward was much struck by the attention of the patients being riveted on an object walking rapidly up and down the ward. This object was no other than a tall, muscular pupil from the North, who had slung the female over his back and shoulders, and was rapidly strutting up and down the room, evidently proud and conscious of his own ingenuity, and of the probability of relieving his patient. Even, however, such an inverted down-hill position, and such a jumbling movement, though no doubt astounding and uncomfortable to the patient, was nothing in point of injury compared with the coarse handling too frequently resorted to, even in the present day. Chloroform, as an adjuvant to the taxis, is of great value, and in several cases of this series, a reduction was effected, in consequence of its employment, in which cases the taxis had been previously used without it. Chloroform appears to act by the temporary palsy that it induces of the abdominal muscles, whereby the struggles of the patient, and the compressing action of these muscles on the abdominal cavity are for a time suspended, the capacity of the cavity becomes enlarged, and less resistance therefore is offered, by the pressure of the viscera, to the return of a fluid in a hernia, and of the tumour itself. The following is an illustration of the efficacy of this agent:—A Jew child, aged ten months, was admitted with a strangulated non-congenital right oblique inguinal hernia. It was of three days' duration, and came down after coughing and crying. The symptoms of strangulation had existed for fifty-eight hours. There was no impulse on coughing, and the seat of strangulation test showed the impediment to reduction to be about the level of the outer ring. The taxis was ineffectually applied, after a warm bath. When the child was fully under the influence of chloroform, the taxis was again had recourse to, and the swelling retired within the abdomen without any difficulty. The bowels acted fifteen hours after the reduction of the gut, and the usual symptoms subsided. A similar case to this came under my notice some short time after the occurrence of the above, in the practice of my friend, Mr. Hutchinson, of the Metropolitan Free Hospital. A child was admitted, suffering severely from a strangulated inguinal hernia. He was placed under chloroform, and the gut easily went back. Of the benefit of freezing mixtures and the topical application of ice, the London Hospital does not offer any extensive amount of evidence, inasmuch as the strong surgical conviction is, that in cases of unqualified strangulation, much precious time would be lost in trusting to the chance efficiency

* See Cyclopædia of Practical Surgery, article Asphyxia, by T. B. Lucas, . 440.