The small number of deaths between fifteen and twenty-five may be partly due to the circumstance that surgical operations are but seldom required at this period of life; but the decrease after the age of forty-five cannot be explained in this way; for persons become more liable to require surgical operations as they advance in years. Operations are often performed in infancy and old age, periods at which deaths from chloroform have not been recorded. The greatest proportion of deaths having occurred from thirty-five to forty-five, when the system is often more robust than at any other period, it cannot be supposed that an inability to bear the usual dose of chloroform, when carefully administered, is the ordinary cause of death from this agent.

Idiosyncrasy. The accidents from chloroform have frequently been attributed to idiosyncrasy in the patient. This, it may be observed, is not to give an explanation of them, but merely to state that they depend on something we do not understand; that something, however, being in the person to whom the accident happens. This view receives apparent support from the supposition that the chloroform has been inhaled in exactly the same manner in the fatal cases as in other instances; but this apparent support fails when it is pointed out that the supposed same manner is only an equally uncertain manner. The different effects that have been produced on the same patient at different times, and the great number of instances in which medical men have failed to make the patient insensible, show that most of the usual modes of exhibiting chloroform are extremely uncertain.

What most completely meets the question of idiosyncrasy, however, is the circumstance that in no fewer than eleven out of the fifty recorded cases of death from chloroform, the patient had previously inhaled this medicine without ill effects. In two other cases also, previous attempts had been made to make the patient insensible without success, on the day on which the accident occurred. In the above table of fatal cases, those are indicated in which previous inhalations had taken place. In twenty-nine cases, I have concluded that the patient had not previously inhaled, for the medical man, having given an account of the state of his patient, and his reasons for administering the chloroform, would certainly have mentioned such a material fact as a previous inhalation if it had occurred. There are ten cases of which only a meagre account is given, and where a previous administration of chloroform may possibly have taken place without being mentioned; but if only eleven, out of the fifty patients, who died from chloroform, had inhaled it
previously without ill effects, it is very clear that the fact of having inhaled it with a favourable result, gives no immunity from the possibility of accident. It would be impossible to say what proportion of the patients who have inhaled chloroform have inhaled it more than once, but it is not probable that they amount to more than 22 per cent., if so many.

**Alleged Impurity of the Chloroform.** At one time accidents from chloroform were loosely attributed to impurity in the medicine, but this was only a guess, and is opposed to the facts. No case of accident has been traced to this cause, and in nearly all the cases of which the details are given, it is distinctly recorded, either that the chloroform was examined and found to be of good quality, or else that chloroform out of the same bottle had been used in other cases without ill effects. I have not thought it necessary to state this in quoting the individual cases.

**Apparatus employed.** Accidents were at one time, and in one quarter, attributed to the use of inhalers; and it is curious that this allegation was made at a time when no death from chloroform had yet occurred in any cases in which an inhaler was used, except one in America, and one in France, the accounts of which had not reached this country. It is possible that death might be occasioned by want of air from the use of a faulty inhaler, and a case will be mentioned in which this apparently occurred in the administration of sulphuric ether, but there is no recorded case of accident from chloroform in which death was occasioned in this way. In the cases of death previously recorded, a handkerchief, a piece of folded lint, hollow sponge, or some such simple contrivance, was used in thirty-four instances; in twelve cases, an inhaler of some kind or other was used; and in four cases, it is uncertain what were the means employed.

**Alleged Exclusion of Air.** The assertion has often been made that death might be caused by the vapour of chloroform excluding the air, and so causing asphyxia; but it has already been pointed out in this work that the physical properties of chloroform do not allow it to yield a quantity of vapour which would have that effect, and in much smaller quantity than this the vapour kills by a quicker way than asphyxia, I believe that the only elastic fluids which can cause death simply by excluding the atmospheric air are nitrogen and hydrogen.

**Alleged Closure of the Glottis.** At the trial which took place in Paris respecting the death of a porcelain dealer previously mentioned, M. Devergie gave evidence, and after saying that chloroform might cause death as a poison, if given in undue proportion, he added: “Also it closes the glottis, and offers an obstacle to respiration. Employed by M. Demarquay on himself, in very small doses, closure of the glottis was occasioned. It was possible that Le Sieur Breton had experienced that accident, and in that case the most able surgeon could not prevent death.”

I have not met with M. Demarquay’s account of his experiment, but I am happy to know that he did not die of the closure of the glottis. It may fairly be denied that a person could commit suicide in this manner if he wished, for he would either have to give up the attempt, or receive the vapour into his lungs, and experience its
specific effects. When animals are placed in mixtures of vapour and air, they always breathe them, whatever the strength; and if the vapour amounts to eight or ten per cent., they die much more quickly than they would of mere closure of the glottis. Vapour of chloroform, when not largely diluted with air, is apt to cause cough and closure of the glottis, as soon as a little of it reaches the lungs; but this, so far from being a source of danger, is, as a general rule, a safeguard, by its preventing the patient from readily breathing air which is highly charged with vapour.

In commenting on the fatal case No. 12, which occurred in St. Thomas's Hospital, I have suggested that the accident might have happened from liquid chloroform being dropped into the throat; but liquid chloroform is very different from the vapour; it causes a lasting irritation if applied to a mucous membrane; when used for toothache, it often blisters the gums. The irritation caused by the vapour, on the contrary, is only momentary, and its local action ceases directly it ceases to be inhaled; for what is left in the air passages is immediately absorbed or expelled with the expired air. The glottis is not a vital organ of itself. Its closure only causes death by preventing the access of air to the lungs. The glottis does not remain permanently closed, I believe, from the contact of any elastic fluid, however irritating,* but it does from the contact of a liquid, and persons who die by drowning, die with the glottis closed, for

* Hydrochloric acid gas and ammonia are no exceptions to this rule, for they cease to exist as gases so soon as they come in contact with the moist lining membrane of the air passages. Carbonic acid gas will be treated of in another part of this work.

ey they do not fill their lungs with water. Therefore, if the vapour of chloroform did cause persistent closure of the glottis, and if a person were to hold it by force to the patient, the death it would occasion would be precisely like that in drowning. Death by asphyxia is a comparatively slow one. 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 guinea pigs, 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. The process of drowning in the human subject is well known to occupy some minutes; 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 breathing 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. If any patient, therefore, has died from closure of the glottis, it must have been one in whom there was a great tendency to sudden death from any slight interruption to respiration. I do not know the particulars of the case respecting which M. Devergie was giving his evidence, but in those fatal cases previously related, in which the symptoms are sufficiently described, it is not probable that death took place in any instance from closure of the glottis. In the sudden death
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at St. George's Hospital (page 95), it is possible that the slight pungency of the vapour might assist the fear under which the patient was labouring in impeding the breathing, and thus add to the distension of the right cavities of the heart, under which the patient apparently died.

In 1855, two years after M. Devergie had given the above opinion, Dr. Black, of St. Bartholomew's Hospital, who has had great experience in the administration of chloroform, advanced a similar theory in the pamphlet previously alluded to. He did not, however, confine the effects of the supposed closure of the glottis to possibly causing a death here and there, as M. Devergie had done, but he attributed all the accidents which had happened to this cause, and not to the effects of chloroform in the system. He says that "the chloroform has not been even inhaled: its pungency was felt at the glottis, and its inspiration was immediately arrested. The patient would have removed the apparatus, but in this he was restrained. The struggle forthwith commenced, but up to the moment of his death, not a single inspiration took place." These remarks were not applied to a single case, but generally to the accidents from chloroform. Dr. Black says: "Any concentration of the vapour of chloroform which can be breathed is safe; any condition of dilution which forces the patient to cough or hold his breath is dangerous, and if persevered in for even half a minute, may be fatal. . . . We have only to attend to the breathing; we may disregard all considerations affecting the relative proportion of the chloroform in the air which is breathed; . . . if the patient breathes easily he is in safety, whatever be the amount of chloroform which is passing into the lungs."

In Experiment 28, previously related, where the respiration was kept up by a tube in the trachea, there could be no error in respect to the vapour of chloroform entering the lungs, when a bladder of air charged with ten per cent. of the vapour was substituted for the bladder of simple air; and the immediate paralysis of the heart was evident. An examination of the fatal cases, of which the particulars have been recorded, shows that death did not occur in the manner Dr. Black suggests. In the majority of the cases, the patients were rendered quite insensible by the chloroform, and the operation had either been commenced, or was on the point of commencing, when the fatal symptoms set in. In several other cases, the patients were partially under the influence of the vapour before the symptoms of danger commenced; and in the six cases where death occurred at the beginning of the inhalation, without loss of consciousness having been induced, the patients were not restrained in any way, and it was observed that they did breathe the chloroform; three of them were speaking up to the moment when the pulse stopped, and one took a full inspiration the moment before the fatal symptoms set in. It is only in eighteen of the fatal cases that there is any reason to suppose that the patient required to be held, and then only from mental excitement or muscular spasm, arising from the physiological effects of the absorbed chloroform. It is hardly possible that the struggles of a conscious patient from inability to breathe, would be mis-
In a case, No. 34, which occurred at St. Bartholomew’s Hospital whilst Dr. Black was present, and long before his pamphlet was written, the patient inhaled for five minutes and sank off into a state of complete insensibility without alarming symptoms. The inhalation was discontinued, the patient moved into a proper position, and the operation just about to be commenced, when Dr. Black found the pulse to become extremely feeble and fluttering. Surely this patient breathed the chloroform, and died without any spasm of the glottis. In Case 48, so minutely related by Mr. Paget, the boy made one long inspiration, and became suddenly insensible. In a few seconds, the pulse suddenly failed, and then ceased to be perceptible, but the breathing continued for at least a minute afterwards. There was certainly no closure of the glottis in this instance.

**Alleged Exhaustion from Struggling.** In cases where the patients have struggled violently whilst getting under the influence of chloroform, the accidents have been attributed to a supposed exhaustion caused by the struggling.* This opinion is, however, contrary to experience; for the patients who struggle violently are precisely those who bear chloroform the best, provided they do not breathe it in an insufficient state of dilution. They are generally cheerful and exhilarated by it, and are less liable to be depressed by its prolonged use, than those who come quietly under its influence. Although the patients who struggle bear the chloroform well, when it is carefully and judiciously administered, it is not improbable that the struggling has been now and then an indirect cause of accident. The muscular spasm and rigidity do not occur till about three-quarters as much chloroform has been absorbed as can be present in the system with safety; and, as the patients often hold their breath whilst struggling, and take deep inspirations suddenly and at long intervals, the greatest care is required that the vapour be administered in a very diluted state. In Cases 9, 44, and 47, the fatal symptoms came on whilst the patients were struggling; and in some other cases, the sudden failure of pulse occurred just after the struggling had ceased, rendering it probable that the patient inhaled too much of the vapour whilst struggling, or just as the spasmodic condition of the muscles was subsiding.

The circumstances just mentioned, are probably the cause why so many of the fatal cases occurred at that period of life when the body is most robust. Very nearly two-thirds (twenty-seven out of forty-one) of those cases in which the ages are recorded, occurred in persons of twenty years and under forty-five years of age, although the proportion of persons living at this period of life, in England and Wales, is only a little more than one-third of the entire population. The majority of the accidents from chloroform occurred also in the stronger sex, in which muscular rigidity and spasm are most frequent: — twenty-nine of the fatal cases happened to males, and only twenty-one to females. According to my experience, the females who inhale chloroform for surgical operations are nearly twice as numerous as the

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males; and although this may not be the proportion in every one's practice, it is probable that females inhale this agent quite as frequently as the other sex, in every part of the world.

Sitting Posture. In some of the early cases of death from chloroform, the patients were inhaling it in the sitting posture, and it was surmised that this circumstance was the cause of death. An examination of the account of the fatal cases, however, does not bear out this supposition. In thirty-one instances the patients were lying, in nine instances sitting, and there are ten cases in which the position is not mentioned, and where from the nature of the operation it may have been either one or the other. In fully one-fourth of the cases of which I have kept notes of the administration of chloroform, the patients were seated in an easy chair; and as in forty fatal cases in which the position is known, only nine, or less than one-fourth, were seated, it does not appear that the position of the patient has had any share either in causing or preventing accidents.

Supposed Effect of the Surgeon's Knife on the Pulse. Mr. Bickersteth alluded to a peculiar circumstance,* which he thought would account for several of the deaths attributed to chloroform. He relates three instances in which the pulse suddenly ceased on the first incision by the surgeon, and commenced again in a few seconds, the breathing going on naturally all the time. All the three cases were amputation of the thigh, and occurred in the latter part of 1851. Mr. Bickersteth did not observe the circumstance again during the two following years, and I have never observed it, although I have very often examined the pulse at the moment when the operation began, especially after reading Mr. Bickersteth's remarks. He supposes that the action of the heart was arrested by the shock of the incision, notwithstanding the patient was insensible. I should attribute the temporary stoppage of the pulse in these instances to the direct influence of the chloroform on the heart. The moment when the operation is commenced, is usually a few seconds after the inhalation has been discontinued, and when the effect of the chloroform is at its height. A portion of that which was left in the lungs having been absorbed, in addition to that which was previously in the system. And if the vapour inhaled just at last was not sufficiently diluted, it might paralyse the heart, but not so completely as to prevent the natural respiration from restoring its action, in those cases where respiration continues. I found in experiments on animals that, when the action of the heart has been suspended by the effect of chloroform, it can very often be restored by artificial respiration instantly applied; and it is extremely probable that an accident of this kind not unfrequently occurs during the administration of chloroform, and is remedied by the breathing, without being noticed. The pulse recovered itself, in the cases mentioned by Mr. Bickersteth, just as it does in animals after the heart has been nearly overpowered by chloroform.

(To be continued)