the minimum quantity sufficient to bring the patient speedily and safely to a state of insensibility is apparent. Mr. Clover has shown this to be in the proportion of 4 to 5 per cent. of chloroform vapour. It has been found that in animals killed by the inhalation of this proportion of chloroform, the heart continued to beat long after respiration had stopped.

With this percentage, insensibility can be produced in about five minutes, with the minimum danger of incurring the serious evils of an over-dose.

At the beginning of the chloroformization, Mr. Clover administers about 2 per cent. vapour, and as the patient becomes accustomed to its action he increases the quantity till 5 per cent. is reached.

The way in which chloroform destroys life is not yet well worked out, and much uncertainty still remains concerning its action on the heart. The sequence of events in animals killed by chloroform, when the percentage of its vapour is not sufficiently great to destroy life at once, is as follows:—The breathing grows gradually more and more shallow and infrequent, while the pulse becomes weaker and even ceases; soon after, breathing stops; but still, for a short time, the heart continues to beat languidly. This is the order of the toxic phenomena in animals, and that most frequently met with in the human subject. Here it is difficult to say whether the poison acts directly on the heart, and whether the enfeeblement of the heart-beats and the cessation of the pulse is due to the direct attack upon the heart, or whether it is simply connected, and depends on the gradual cessation of the breathing. It seems probable that the heart may be directly poisoned and paralysed by chloroform; for when a very large percentage of the vapour is breathed, the heart's movements cease immediately; and further, Dr. Harley has shown that a frog's heart suspended in chloroform vapour, ceases to beat much sooner than one suspended in watery vapour.*

* Dr. Richardson describes four modes of death by chloroform.—1. By syncopal apnœa. 2. By epileptiform syncope. 3. By paralysis of the heart. 4. By depression from chloroform and surgical shock. Of the first kind he says, "Death by this mode is very rapid, occurring within the minute after the commencement of inhalation. The action of the vapour in this mode of death is by the immediate influence exerted by it on the peripheral nervous system. By this action respiration is for an interval suspended, there is accumulation of carbonic acid in the blood, irritation of the vagus, and arrest—from the irritation—of the action of the heart." Dr. Sansom rejects this explanation, and adduces experiments by Scheinesson, showing "that chloroform has equally the power of slowing the heart's action in animals whose vagi have been previously divided. Even when the spinal cord was divided in the cervical region, as well as the vagi and sympathetic, the heart's action was enfeebled by chloroform;" an experiment showing that chloroform may affect the heart otherwise than through these nervous channels, but by no means proving that it cannot arrest the heart through the vagi, chord, or sympathetic.

Of the second mode of death, by epileptiform syncope, Richardson says, "it occurs during the second stage of narcotism—the rigid stage, as it has been designated. In this stage the chloroform is acting as an excitant to the whole muscular system through the blood, which conveys it over the organism, and in this excitement the involuntary as well as the voluntary muscular fibres share." There is an intense arterial contraction, which drives the blood from the left side of the heart and arteries into the venous system, and death from syncope ensues.

"The third mode of death is one in which, from the slow and continued action of the narcotic, there is paralysis of the heart, with apparent paralysis of the muscular system generally." Death gives warning of its approach by intermittence of the pulse.

"The fourth mode of death is a compound death. There are in it two factors—depression from chloroform, and surgical shock. The combination may be in two or three ways. In a few instances hæmorrhage has brought to a fatal degree a depression which had commenced during and from the administration of chloroform. In other cases the patient has not been fully narcotised, and in a half-unconscious state, feeling the pain of the operation, has become faint, and died from syncope. Finally, under very deep narcotism, death may take place from severity of shock, incident to operative procedure."

Dr. Richardson thus summarises his views of death by chloroform.—"In the first stage of administration, the effect of the vapour is upon the peripheral nervous surface and the cerebral centres. In both there is excitation, and very early the cerebral centres lose their natural condition,

The direct action of chloroform on the heart is probably displayed in those cases in the human subject when, without warning, the patient becomes pulseless, breathless, and dies.

When any serious symptoms arise, and danger is apprehended, the chloroform administration should, of course, be discontinued, and artificial respiration, after Sylvester's method, practised instantly and assiduously, whether the breathing has ceased or is growing slower and shallower. Where the breathing has been extinguished in a gradual manner, in a few seconds after the employment of artificial respiration, provided it is instantly adopted, the patient, in most instances, fetches a deep gasp, which is soon repeated, and presently the breathing grows more frequent, till it becomes natural, and he is saved. Even when the chest has ceased to move, the pulse to beat, and when the patient presents all the appearances of death, life may yet generally be restored. Little is to be hoped, however, from artificial respiration in those cases where the breathing and pulse both cease immediately, and without any warning. Besides the use of artificial respiration, cold water should be dashed over the face and chest, air should be freely admitted, and all hindrance to breathing removed; indeed, everything hampering to the breathing, as stays or a tight dress, should be

becoming suspended in function. Following immediately upon this, the chord, the sympathetic system, and the true nervous system of the heart, become excited. Thirdly, the nervous excitation generally ceases, and there follows calmness or even depression of action; and if the administration be continued, the medulla fails, the sympathetic fails, the cardiac nervous centres fail. This then is the natural order of death of each part—brain, chord, sympathetic centres, cardiac centres.

"In all the modes of death from chloroform we see a fatal disturbance of the balance between the inhibitory action of the vagus and the motor nervous system of the heart.

"In the first mode—by syncopal apnœa—we see the direct action (inhibitory it is called) of the pneumogastric upon the heart. In the second mode—by epileptiform syncope—we see the direct effect of excitation of the centres, which supply the outer contractile elements of the vascular system. In the third mode—by failure of muscular motion—we see the effect of the poisonous agent upon the motor system carried to paralysis; and in the fourth, when surgical shock combines with depression from chloroform, we see direct paralysing action, both on the sympathetic and pneumogastric."

removed before the administration of chloroform is begun. The most serious impediment to the breathing, sufficient to endanger life, may be caused by the patient lying prone for the convenience of the operator. The author has several times witnessed cases of imminent danger from this cause. When this position must be assumed, the most anxious care must be paid to the state of the breathing; for this prone posture is itself quite adequate to arrest feeble breathing, which without this impediment would go on safely.

It is a question of importance whether galvanism should be used in danger from chloroform. The committee appointed by the Medical and Chirurgical Society are of opinion that this agent is useful, but that it is far inferior to artificial respiration; but some authorities are wholly opposed to its use, on the score of its influence to arrest a very feebly acting heart, and so diminishing any slight remaining hope of recovery. It is advised to apply it to the phrenic nerve, to stimulate the diaphragm to action, and thus maintain breathing till the chloroform shall have had time to evaporate from the blood, and the system become freed from its effects. But breathing can be much better maintained by artificial respiration.

It has been proved that a certain per-centage of chloroform, amply sufficient to produce, in a short time, complete unconsciousness, can be inhaled with safety for an almost indefinite time. It is therefore obvious that the method required should enable us to give with certainty as much chloroform as we may wish, so that the quantity compatible with safety shall never be exceeded. The contrivance which best fulfils this condition is the ingenious apparatus of Mr. Clover. Its advantages are so great as to outbalance fully the slight inconvenience connected with its use. If this apparatus is not at hand, the use of a simple piece of lint and a towel, or Dr. Simpson's method, may be adopted.

Are there any conditions of age or health which forbid the use of chloroform as an anæsthetic? Provided due care is observed, the author thinks it may be given to all persons,

irrespective of their condition. He has given it in serious heart disease, in every stage of phthisis, in Bright's disease, cancer, chronic bronchitis, etc., to patients almost dead of exhaustion from loss of blood, to children of a few weeks, and to persons close upon an hundred years old, without any threatening symptoms. No doubt a dilated or a fatty heart adds to the patient's risk, and enforces on the operator more care and anxiety. The two extremes of age are conditions which exact close watching during its administration.

For minor operations ether spray is undoubtedly to be preferred to the inhalation of chloroform; but for the more formidable operations chloroform must be used. In addition to its more obvious and inestimable advantages in operations, chloroform has been found to reduce the mortality.

Chloroform inhalation is now frequently used with much advantage during delivery; it eases the uterine pains, without increasing the danger to mother or child. It is not necessary to obtain complete unconsciousness, but to give only sufficient chloroform to dull the pains; if this recommendation is disregarded, and the anæsthetic is pushed to the stage of complete unconsciousness, it weakens the contractions of the womb, and retards delivery. It is true that even if only slight unconsciousness is produced, the uterine contractions are probably somewhat weakened, but accoucheurs maintain that this disadvantage is more than compensated by the relaxation of the parts, and the abatement of spasm. Dr. Playfair who thinks chloroform inhalation is too indiscriminately used, says, he has often observed the pains alter and become less effectual after chloroformization, and when it is prolonged he thinks it favours *post-partum* hæmorrhage, (see Chloral).

In dental operations the patient incurs some additional risk of syncope, owing to his sitting posture. Chloroform should be forbidden in dentistry. Indeed, it is now superseded by nitrous oxide.

Chloroform may be used with signal benefit in renal and biliary colic. In the author's experience it is inferior only to

morphia injection, and is very far superior to opium, warm-baths, and the ordinary treatment in vogue. It removes the severe pain before unconsciousness is reached; indeed, it is never necessary to carry the administration of chloroform very far. The pain often speedily returns, but may be quelled again; and after two, at most three, administrations it is usually permanently removed.

Chloroform in the treatment of chorea is sometimes most valuable. It is applicable especially to those serious cases in which violent and constant movements prevent sleep, and even the swallowing of food, so that speedy exhaustion and death are to be apprehended. In such cases chloroform often induces a refreshing sleep; indeed, the sufferer passes from the insensibility of chloroform into that of natural sleep, and after, perhaps, some hours, wakes up soothed, refreshed, and with a marked abatement in the movements. So great sometimes is this improvement, that patients, who before the chloroform could scarcely be restrained in bed, after waking, sit up troubled with only slight involuntary movement, and eat and swallow with ease. Soon, however, the movements return, when the inhalation must be repeated. At first it should be administered three times a day; then, proportioned to the improvement, twice, and, after a time, once a day. It is stated that this treatment will cure the disease on an average of twenty-eight days. In delirium tremens, when the usual means of treatment fail to induce sleep it has been advised to produce unconsciousness by chloroform inhalation.

Chloroform will arrest convulsive fits, especially in children, sometimes permanently. Chloroform inhalation is of great service in puerperal convulsions. It is necessary in some cases to maintain unconsciousness for hours, or even days, allowing the patient to wake every three or four hours to take food.

In the reduction of hernia its use is obvious. It may be used to assist the diagnosis of abdominal tumours, when deep-seated, and when the walls of the belly are hard and rigid, It is useful also in determining the nature of phantom

tumours, which disappear entirely when the patient is made insensible by chloroform.

Chloroform inhalation gives relief in neuralgia, sciatica, colic of the intestines, if the pain is very severe, in distressing dyspnœa, whether this is due to asthma,* aneurisms, &c. In asthma the inhalation of a few whiffs without producing unconsciousness sometimes affords permanent relief; and if the paroxysm returns on the effect of the chloroform passing away then the inhalation may be repeated. A small quantity of chloroform given in this way often suffices to prevent an attack, though in most cases the effects are only transient, the paroxysm returning as the influence of the drug wears off.

It is said insomnia, tremulousness and inability to fix the attention are apt to follow the repeated use of chloroform inhalation.

ETHER.

The physiological action and therapeutic use of ether and chloroform are for the most part identical.

As a local anæsthetic in neuralgia, toothache, etc., ether is less frequently used than chloroform.

In the form of spray, after the method introduced by Dr. Richardson, ether is commonly employed to abolish temporarily sensation of the skin; the rapid evaporation of the ether and consequent great abstraction of heat, freeze the tissues and deprive them of sensation. Ether spray is frequently used in minor operations, as the opening of abscesses, the removal of small tumours, etc. It has been successfully em-

* Mr. Gaskoin reports a case of bronchitic asthma much benefited by rubbing the chest for an hour daily with liniment of chloroform. He attributes the success to the friction, and refers to a Widow Pau who has obtained a reputation in Paris and who uses friction in cases of asthma.

ployed in amputation of the leg and in ovariotomy, but it is not generally available in such serious and prolonged operations. The skin or mucous membrane, when sufficiently frozen to permit of an operation without pain, becomes pale, shrunken, tallowy-looking, and feels as if oppressed with a great weight. Whilst recovering the natural condition, the frozen tissues tingle and smart, sometimes so intensely as to exceed the pain of the operation. The obvious advantage of ether spray over chloroform inhalation is its perfect safety.

Ether for many years preceded chloroform as a general anæsthetic; and although at the present time chloroform has almost completely superseded ether, yet each has its respective advantages. Ether differs from chloroform in several particulars. Ether must be inhaled in larger quantities, and for a longer time; its effects pass off sooner, consciousness often returning almost immediately the inhalation is suspended; and it produces much more excitement than chloroform. The committee of the Medical and Chirurgical Society instituted to investigate the action of chloroform and ether, state that at first both strengthen the heart's contractions; soon, however, the heart grows weaker and weaker as the animal passes more deeply under the influence of chloroform; while the tonic effects of ether persist, and the heart's pulsations often continue strong till the moment of death, which in almost every instance depends on paralysis of the muscles of respiration. Thus ether and chloroform each destroy life by arresting respiration; but in regard to chloroform there is an additional danger from its depressing action on the heart.

In America ether is used in preference to chloroform. Mr. C. Tomes writing from America to the British Medical Journal, says, that ether is there considered so safe that the pulse is rarely watched and the patients when fully under the influence are put into any position without fear of danger. The ether is very freely used, sometimes half a pound is consumed for a single operation. He says "two or three ounces of pure anhydrous ether are poured upon a conical