ON CHLOROFORM AND OTHER ANÆSTHETICS
THEIR ACTION AND ADMINISTRATION

BY

JOHN SNOW, M.D.
Licentiate of the Royal College of Physicians

(Continued from page 342)

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 anaesthetics; 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 anaesthesia 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 anaesthesia, 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 infrequently 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 anaesthesia 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 anaesthesia 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 generally inclined upwards in this degree, and are at the same time usually somewhat contracted. The blood-vessels 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 anaesthesia 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 anaesthesia 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 anaesthesia, 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 anaesthesia 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 fibrillae; 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 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

---

*Lancet, Feb. 12, 1848.
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 anaesthesia 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 anaesthesia 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 anaesthesia 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 anaesthesia 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 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.

* 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.
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 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 operation, 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 a 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.

* Gazette des Hôpitaux, 20 Mars, 1847.
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 expression 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 anaesthetic 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.

(To be continued)