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ACTION OF CHLOROFORM ON THE BLOOD—PROBABLE CAUSES OF  
ITS FATAL EFFECTS WHEN INHALED AS AN ANÆSTHETIC.

BY CHARLES T. JACKSON, M.D.

[Communicated for the Boston Medical and Surgical Journal.]

Six years ago, I published in this JOURNAL a case in which sudden death was produced in a healthy young woman by inhalation of pure chloroform, given preparatory to extracting a tooth. The case was investigated by a coroner's jury, a *post-mortem* examination being made by Dr. Stedman, Dr. F. S. Ainsworth and myself. The blood taken from the right side of the heart was analyzed, and was found to contain formic acid in considerable quantities, but no chloroform in an undecomposed state. Microscopic examination of the blood, by Dr. J. Bacon, showed that the blood-globules were withered up in a very remarkable manner. Chlorine was also found to be a component of the blood. It was also observed that this blood did not coagulate, nor did the blood-globules subside, but the whole remained a solution, the blood having a cranberry-red color, like red ink.

I have now a phial of this blood before me, it having been kept in my office, exposed to temperatures from the freezing point to above 80° for more than six years, and yet it has not decomposed, nor has a single blood-globule settled to the bottom of the phial, nor has the color changed in the least.

Attention is now called to these remarkable phenomena, which appear to throw some light on the chemical action which chloroform exerts on the blood. As I view the matter, I consider the chemical action on the blood by inhaled chloroform to be this:—Chloroform consists of one equivalent of formyle and three of chlorine. Formic acid consists of one equivalent of formyle and three of oxygen. When chloroform is inhaled into the lungs, the oxygen is abstracted from the blood, and combining with the formyle makes formic acid, while chlorine combines with the blood as a substitute for oxygen. Thus a portion of the blood becomes chemically

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changed, disorganized and rendered unfit for its vital functions. Then, if that portion of the blood contained in the heart, and large vessels, which we may style the immediate working blood of those organs, is vitiated, so as no longer to be an appropriate stimulus to the most vital organs, sudden death is most likely to take place through cessation of their action. Our only surprise should be that death does not more frequently follow from inhalation of this dangerous anæsthetic agent, for the decomposition I have described undoubtedly always takes place to a certain extent, and to a sufficient degree to deoxidize a considerable portion of the blood, and to charge it with chlorine and formic acid.

It is well known, that deaths more frequently take place in cases where chloroform is administered in minor surgical operations, or in cases where there is no loss of blood, than in larger and bloody operations.

This I think admits of an explanation in the fact, that where there is large hæmorrhage the vitiated blood, or a portion of it, is removed and is replaced in the vital organs by blood coming from other parts of the body, where it has been but little acted upon by the chlorine—a new working blood being drawn into the large circulating organs, which are thus enabled to continue their proper action, and to supply the brain with its appropriate stimulus. This hypothesis appears to me to cover the cases thus far reported, and I offer it for the consideration of physiologists.

The great disadvantage under which chloroformization labors is the introduction of chlorine, as such, into the composition of the blood. This we know to be destructive of the blood-globules, and an actual poison in the system.

We naturally inquire how this vitiated blood is got rid of, for it evidently never can be re-organized in the circulation. It is undoubtedly thrown off as so much effete matter, by the secernent and excretory organs, and chiefly by the kidneys. Hence, in a large majority of cases, the patients recover with but little damage to their health, though there is always a degree of prostration in most if not all cases of chloroformization.

It is obvious that we may much diminish the danger in employing this agent, by mixing with it a large proportion of pure ether, say at least three fourths of its bulk. By this means we not only dilute the dangerous with a perfectly safe anæsthetic agent, but add the stimulus of ether to overcome the deadly, depressing effects of chloroform. The object in allowing any addition of chloroform to ether, was to obtain a less bulky and more powerful agent than pure ether alone, and to afford greater facility in carrying an anæsthetic agent into the field of battle. It was therefore recommended by me, and was used in the French and Sardinian armies of the Crimea, with great success and safety, while chloroform, which was employed by the English surgeons, produced many fatal accidents. Still, in cities and at home, or in

hospitals, I should always prefer pure washed ether, as it is known to be a safe and sure anæsthetic agent, though it is somewhat bulky. However, from my own experience and observation, I must say I never have known any fatal or even inconvenient effect to result from the employment of the mixture of chloroform and ether in the proportions I have named.

In Austria, by orders of the Government, one ninth of the bulk of chloroform is added to ether, and this is employed in the Austrian hospitals and armies. Its introduction was effected by Dr. Weiger, of Vienna, and it is stated that no fatal accidents have thus far arisen from its use. It is obvious that the dangers from chloroform are diminished in the direct proportion to its dilution with ether. The surgeon is more able to guard his patient from an over-dose, and the comparative lightness of ether, when compared with chloroform, together with the stimulating nature of ether, allows the more ready exhalation of the vapor, and prevents nervous depression from going too far.

As to the impurities of chloroform of commerce, I am aware that it is liable to contain fusel oil and the products arising from decomposition of that poisonous fluid, also free chlorhydric acid, and sometimes sulphurous acid, are present in badly-prepared chloroform. Such chloroform we should at once reject, as being wholly unfit for inhalation, either alone or in any mixture.

Some chloroform, from causes not yet fully known, readily undergoes spontaneous decomposition, with the disengagement of pungent fumes of chlorhydric acid gas. I have two samples now on hand which have thus undergone decomposition. This chloroform was made according to directions contained in the United States Dispensatory, by one of our most skilful pharmacutists. When freshly prepared, it appeared to be of good quality, but in a few months underwent decomposition, as above stated, and without having been exposed to direct sunlight.

Chloric ether, so called formerly, is nothing but an uncertain mixture of chloroform and alcohol. When administered on a wet sponge, the alcohol is retained by the water, and only the chloroform is inhaled by the patient. The first samples introduced here were merely the unwashed first runnings of the chloroform still. Subsequently, the article was made more uniform in strength, by dissolving one measure of chloroform in three measures of 95 per cent. alcohol. This preparation is now but little used as an anæsthetic, several deaths having resulted from its inhalation—one at Lynn and another at the Chelsea Marine Hospital will be remembered by physicians in this vicinity.

It is well known that there have been a large number of deaths caused by the inhalation of chloroform, while it is believed here that there are no well-ascertained deaths resulting from the use of ether. That deaths occur in grave surgical operations many hours or days after an operation effected under etherization, is no

evidence that the ether caused the death or had anything to do with it, and yet we see such cases tabulated and presented to the public as proofs of death from etherization. Such reports should not be adopted without careful analysis and discrimination of the real facts concerned.

Lest some persons may suppose that the discoverer of etherization is jealous of any substitute for ether, let me say that I was the first person in this country who adopted Waldie and Simpson's substitute for ether, and that I not only made the first pure chloroform, and distributed it gratuitously to physicians, but also induced a manufacturer to procure one of the largest stills, and instructed him in the processes of the manufacture and purification of chloroform. I also made public trials of the effects of this preparation, administered it to our late chief surgeon, Dr. J. C. Warren, and aided in every way the introduction and use of this new agent. Experience has at length satisfactorily proved that chloroform is a dangerous substitute for ether. I feel bound, therefore, to aid in calling upon the medical public to return to their original anæsthetic agent, pure washed ether.

*Tests for Chloroform.*—The following are the approved tests for chloroform:—

1st. For *Alcohol*.—Take its specific gravity at 60° Fah.; if it is lower than 1.496, alcohol or ether may be present. To test for alcohol, take a graduated glass test-tube, put in a given measure of the chloroform, and add water. Then shake up quickly, stop the tube, and set it in a cold place until the chloroform has entirely subsided; observe how many divisions the chloroform has contracted to, and thus measure the proportion of alcohol that has been dissolved by the water.

2d. For *Aldehyde*.—Hydrated oxide of silver is reduced by it to the metallic state, without heating. A solution of caustic potash turns the aldehydic chloroform brown.

3d. *Formic acid* reduces nitrate of silver to the metallic state, when chloroform containing it is mingled with a solution of the nitrate of silver and is heated.

4th. *Chlorhydric or muriatic acid* is detected, first, by the acrid and pungent fumes of the gas; secondly, by the formation of a dense white cloud, when a feather dipped in aqua ammonia is brought over the impure chloroform; thirdly, by the formation of a white precipitate of chloride of silver, when nitrate of silver solution is added. Litmus paper, wet with pure water, is instantly reddened when held over the mouth of a bottle containing chloroform, giving out chlorohydric acid gas.

5th. *Hypochlorous acid* may be detected by its odor, and by its first reddening litmus paper and then partially bleaching it.

6th. No ready and satisfactory tests for the presence of *methyle* are yet known, but its effects on inhalation are known to be, a peculiar throbbing headache, and rapid prostration of the vital pow-

ers. Dr. Letheby states that these effects may be observed, on merely smelling of a chloroform containing these compounds, the headache coming on in a short time.

7th.—*Sulphurous acid* may be detected by its odor, being the same as that of a burning sulphur match, and by its bleaching litmus paper.

8th. *Hydrochloric ether* may be washed out from chloroform by water, and be obtained by distillation of the aqueous mixture.

Dr. Letheby states that, chloroform should be perfectly colorless and free from opacity; that its specific gravity should be near 1.496. It should neither redden nor bleach litmus paper. It should not become opaque when dropped into water. It should not become cloudy and white when nitrate of silver solution is added to it. It should not coagulate white of egg; and, we may add, it should not turn brown when concentrated sulphuric acid is mingled with it, nor should it be made brown by the action of a strong solution of hydrate of potassa. It should leave no odor in a sheet of blotting-paper from which it is evaporated.

By these tests the physician and surgeon who employ chloroform as an anæsthetic, may know whether he has a pure or an impure article to operate with.

*Boston, March, 1861.*

## TRIAL FOR MURDER BY POISONING.

(Continued from page 136.)

### TESTIMONY FOR THE DEFENCE.

*Frederick S. Ainsworth.*—Reside in Boston. Am a practising physician and surgeon. In practice sixteen years. Have had a good deal of experience in post-mortem examinations—some hundreds of cases. I held the position of teacher and demonstrator of anatomy at Boston. Pursued my studies in foreign countries. Have paid attention to strychnia. It produces death in five to six hours. If given in solution, action much more rapid. In case of several grains of strychnia taken during the night, the person would not be likely to live till ten or eleven o'clock the next day. The spasms are intermittent—come on suddenly; the person is usually conscious that they are coming. They come like lightning; the limbs are drawn up forcibly, back bent, sense of suffocation, difficulty of breathing, fixing of jaws. The patient is usually conscious; he may be unconscious at the very last paroxysms, from exhaustion. Sometimes the spasms are so severe as to throw a person off the bed, but there is no throwing out of the arms. I cannot say it is impossible to throw out the limbs, but it is not done. The patients swallow with exceeding difficulty during the spasms; sometimes call for water or something to drink when the spasms are coming on, and after they are over. I don't know of