ILLUMINATING-GAS POISONING *

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I. THE EFFECT OF FORMALDEHYD ON TESTS FOR CARBON MONOXID IN THE BLOOD

In an examination of the blood from the body of a man in which post-mortem showed evidences of poisoning with illuminating gas (especially a brilliant red color of the muscles and blood), the question arose whether formaldehyd, used in embalming the body four days previously, would in any way modify or inhibit the various reactions ordinarily used to demonstrate the presence of carbon monoxid hemoglobin. A careful study of the literature failed to reveal any previous note on this subject, which may well be one of practical interest, especially in cases of a medicolegal nature.

The following preparations were studied by the spectroscope and by means of various chemical tests, which will be discussed individually: (1) the blood of the body examined post mortem after formaldehyd embalming; (2) normal blood; (3) normal blood containing formaldehyd solution; (4) normal blood through which illuminating gas had bubbled for fifteen minutes; (5) normal blood plus formaldehyd solution through which illuminating gas had bubbled for fifteen minutes, and (6) blood from several unembalmed bodies of persons whose deaths were suspected to be caused by poisoning with illuminating gas.

The test suggested by Hoppe-Seyler, namely, boiling the blood, which, if rich in carbon monoxid, yields a brick-red mass, while normal blood becomes brown-black in color, was found to be practicable in most instances. Not sufficient formaldehyd was present in the embalmed body to inhibit the test in any way. In the specimen of normal blood containing formaldehyd, and in that containing illuminating gas and formaldehyd, the blood did not coagulate readily, but boiled as a fluid. After cooling, the normal blood containing formaldehyd appeared as a brown-black fluid, and the normal blood with gas and formaldehyd appeared as a bright red fluid. After several days a thick coagulum settles out and the color distinctions are lost. If suspected specimens are quite old and appear dark and clotted, it is advisable before making the test to dilute them with water so as to make them compare more closely with specimens of normal blood.

In a test suggested by Rubner, four or five volumes of lead acetate solution are added to one volume of carbon monoxid blood and thoroughly shaken for about a minute. Such blood retains its red color; normal blood under similar conditions becomes dark red. This test for immediate use is not so good as the first mentioned. In twenty-four hours, however, the reaction is marked and it increases daily, being visible after several weeks. In the presence of formaldehyd a whitish coagulum forms in the blood in all cases, and the test is not valuable in the presence of much formaldehyd; but with small quantities the differences are more marked.

Blood diluted 1 part to 4 with water and shaken with three times its volume of a 1 per cent. tannic acid solution becomes in twenty-four hours gray when normal, but in the presence of carbon monoxid, carmin red (Wetzel). In this case a precipitate resulted in all specimens, those containing formaldehyd giving a

thicker coagulum. This, however, does not in any way interfere with the test. The reaction seems quite a good one in comparison with the others. The results are marked and the color distinctions very easy. The differences persist and become more marked with increasing time.

Another method suggested by Wetzel is as follows: When 10 c.c. of blood are mixed with 15 c.c. of 20 per cent. potassium ferrocyanid solution and 2 c.c. of moderately strong acetic acid (1 volume glacial acetic acid to 2 volumes of water) a solid coagulum gradually results, in normal blood black-brown, but when the blood contains carbon monoxid, bright red. With the quantities suggested, large amounts of material are required, and the tests must be made in large test-tubes or small beakers. The test may also be carried out with relatively smaller quantities. In several instances in which it was employed, however, the results compared very unfavorably with other tests. All formaldehyd-containing mixtures formed very thick coagulums as compared with those containing no formaldehyd. The color distinctions are difficult, and in the various cases which were examined very few bright red coagulums were observed. In most cases the coagulum was light green or purple-black, the color seeming to depend more than anything else on the age and viscosity of the specimen tested.

A modification of this test has been made by Schultz and used in many instances by Wachholz and Sieradzki.¹ In two flasks are placed 2 c.c. of the blood diluted with 8 c.c. of water. To these are added 20 drops of a freshly prepared solution of 10 per cent. potassium ferrocyanid. One tube is shaken once and set aside. The other is shaken repeatedly. After ten minutes from 3 to 5 drops of strong sulphuric acid are added, and following this, 10 c.c. of concentrated tannic acid. In the first tube there will be a red precipitate, in the second a brownish-green. By this method Otto was able to show carbon monoxid in a mummified body eighteen months after death. Here also I found the color distinctions very difficult. The fact that colored solutions are employed in making the test makes it difficult to distinguish variations in the shades of the sediments produced. As in other instances, specimens containing formaldehyd gave thicker, lighter coagulums.

The presence of formaldehyd affects most of all a test suggested by Salkowski which has heretofore received favorable comment as an aid to the recognition of illuminating-gas poisoning. When blood is added to dilute hydrogen sulphid water drop by drop, it produces a bright red precipitate when carbon monoxid is present, otherwise a bright green. It was found that the addition of formaldehyd to normal blood before carrying out the test caused a red precipitate on addition to hydrogen sulphid water which was but a little lighter than that produced by carbon monoxid blood. If no formaldehyd solution is present the test gives easily distinguishable color reactions. But the fact that the presence of formaldehyd causes a normal blood specimen to give a color reaction which is not distinguishable from that of blood containing illuminating gas makes the test of little value in embalmed bodies.

The following quotation from an article by Doremus² gives in brief the salient points regarding the examination of carbon monoxid blood by means of the spectroscope:

1. Kobert: *Lehrbuch der Intoxikationen*, 1906, p. 882.

2. Peterson and Haines: *Legal Medicine and Toxicology*, 1904, II, 658.

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Blood taken from persons or animals poisoned with carbon monoxid shows a characteristic absorption spectrum closely resembling that of oxyhemoglobin. The absorption occurs between the D and E lines chiefly, and is apparent through the appearance of two absorption bands of nearly equal intensity and width. The one near D coincides almost exactly with that of oxyhemoglobin of the same position; the space between it and the band toward F is considerably wider than that between the two bands of oxyhemoglobin spectrum. When more than 27 per cent. of the blood-coloring matter has been saturated by carbon monoxid, the addition to the blood of reducing agents, as a drop or two of a solution of crystallized ammonium sulphid, does not convert the spectrum into one of reduced hemoglobin. The character of this spectrum is that of a single band beginning on the D line and occupying a little more than half the space to the E line.

Dilution of the blood is advisable in order that a clear spectrum may be observed. Whenever carbon monoxid is present, the spectrum may be observed after a little practice, the presence of small amounts of formaldehyd having no inhibiting effect. Formaldehyd in larger quantities acts as a reducing substance, and when the quantity of carbon monoxid gas present is not larger than the percentage given above, the spectrum of reduced hemoglobin may be found. In the case of normal blood, various quantities of formaldehyd produce the various spectrums of oxyhemoglobin, some of which are distinguishable only with great difficulty from the spectrum of carbon monoxid gas blood, until sufficient formaldehyd is added, when the spectrum of reduced hemoglobin is produced. The addition of stronger reducing agents, such as mentioned by Doremus, produces the spectrum of reduced hemoglobin at once.

In view of the fact that formaldehyd was found to modify more or less completely all the chemical tests, and to act as a reducing agent when present in large amounts, so as to interfere also with spectroscopic examinations, it was thought best to make a brief report of these examinations. From my experience with the various tests under these conditions, it would seem that the first test suggested by Wetzel, namely, dilution of the blood 1 part to 4 with water and shaking with three times the volume of 1 per cent. tannic acid, whereby normal blood becomes gray and carbon monoxid blood remains red, is most reliable and trustworthy in the presence of formaldehyd. In case no formaldehyd is present, Rubner's test, the addition of 4 volumes of lead acetate, will be found to yield very satisfactory results. Spectroscopic observations are of little value unless preceded by many observations on the various forms of hemoglobin.

II. PERSISTENCE OF CARBON MONOXID IN THE BLOOD FOR FIVE DAYS

Of unusual interest are the conditions in the following instances of gas poisoning:

The patient, subjected for several hours after exposure to the action of the pulmotor, which has seemed to be of great efficiency in many cases, remained comatose. On admission to the Cook County Hospital, 12 ounces of blood were withdrawn and intravenous transfusion of saline solution was made. During four days normal saline solution by the drop method was given per rectum practically continuously. The patient remained unconscious throughout. The condition gradually grew worse and he died, nearly five days after the exposure to the gas. The following are the salient points in the post-mortem examination which was performed by Dr. E. R. LeCount:

This is the body of a colored adult 163 cm. (5 feet 4 1/8 inches) long and weighing approximately 125 pounds, about 22 years old. The skin in the axillary regions is white but else-

where it has a peculiar brown color as in Addison's disease. The skeletal muscles are very dark red. The blood in a glass pipet looked at through the sunlight has the color and appearance of turbid claret.

Anatomic Diagnosis.—Hemorrhage into the lungs and visceral pleura, subpleural emphysema of the right lung (following the use of pulmotor?), engorgement of the pial vessels, edema and petechial hemorrhages in the lining of the small bowel, petechial hemorrhages in the lining of the greater antrum of the stomach and into the lining of the duodenum distal to the ampulla of Vater, hyperemia of the kidneys, small hemorrhages and slight edema of the lining of the base of the bladder, slight fatty changes and cloudy swelling of the liver, marked cloudy swelling of the pancreas, hyperplasia of the mesenteric lymph-nodes, fatty changes in the intima of the aorta, absence of union of the two branches of the posterior coronary artery, slight fenestration of the pulmonary valves and of the thebesian valve, fibrous patches of thickening in the anterior mitral leaflet, fibrous adhesions between the hepatic flexure of the colon and the under surface of the right lobe of the liver and between the anterior surface of the right kidney and the same surface of the liver, distention of the seminal vesicles, scars on the chest over the sternum.

Carbon monoxid was demonstrable in the blood by the various tests, chemical and spectroscopic. This is of special interest in view of the fact that many authorities hold that carbon monoxid blood loses its characteristics when exposed to the air, whereas in this case it was found even though the person lived five days after removal from the gas. Ordinarily if the patient lives, the carbon monoxid is eliminated within a few hours. Kobert mentions the report by Wachholz of carbon monoxid in the blood seven days after the exposure to the gas. Few such cases are reported; probably a further study would show many instances of this nature.

I desire to acknowledge my appreciation of the valuable advice rendered me by Prof. Walter S. Haines in the study of these reactions and of the kindly interest shown by Coroner Hoffmann in this work.

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DISPENSARY ABUSE AND ITS ELIMINATION BY ORGANIZATION AND THE APPLICATION OF SOCIOLOGIC METHODS

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There is to-day to a greater or less extent in all of our larger cities discussion of the problem of dispensary abuse. This problem has many sides, and dispensary physicians, outside physicians, dispensary managers and the patients are each and all in turn the abused and the abusers of the others in many ways.

Beyond the individuals involved there are four fundamental factors: (1) the medical needs of our ambulatory poor; (2) the response to this by benevolence through free dispensaries; (3) the demand for material for the teaching clinics, and (4) the hereditary privileges of the family physician. It must be admitted that this need of the poor for medical aid, this zeal of benevolence to give, the attraction to the teacher combined with the absolute necessity for clinics, and the demands of the general practitioners for this same material have not been brought into a working harmony. We must admit also that in this strife some of these poor, whom all