SCIENTIFIC PROCEEDINGS

ABSTRACTS OF COMMUNICATIONS.

One hundred twenty-fifth meeting.

New York Post-Graduate Medical College, October 18, 1922
President Wallace in the chair.

1 (1961)

An oxyhæmoglobinometer for the clinical measurement of cyanosis.

By P. J. FLAGG (by invitation)

[*From the Rockefeller Institute, New York City*]

Cyanosis occurs as a local or general manifestation of oxygen unsaturation. Localized cyanosis, such as is seen in the blue lips of bathers experiencing a temporary superficial vaso constriction for heat preservation, or, that which is seen as the result of gravity, (Trendelenburg posture) constriction by Tourniquet, etc., is quite a different matter from the generalized cyanosis observed in patients with warm perspiring skin free from all effects of gravity. A simple capillary stasis in a localized region usually accounts for the former condition; while the latter implies a systemic sub-oxygenation of far reaching significance. While cyanosis is seen in diseases of the heart and lungs, in ascent to high altitudes and in various forms of chemical poisoning, there is, perhaps, no condition in which the extremes may be so readily studied as during the administration of a general anæsthetic.

Some eight years ago, while teaching anæsthesia, the writer became impressed with the need of a clinical measure of cyanosis.

The general term, or, even its gradations spoken of as marked, moderate, or a mild degree of cyanosis, conveyed no accurate idea of the condition under observation. Furthermore, it was noted that when an observer had been with a patient for some time, his appreciation or registration of a color witnessed became less acute. It is a common occurrence for a spectator to enter an operating room and be struck by the patient's cyanosis, the condition having been imperceptibly increased under the color wearied gaze of the anæsthetist. A standard measure of cyanosis, therefore, serves two purposes. It provides data relative to the degree of cyanosis present and provides a criterion for the color wearied vision of the constant observer.

That there has been a general failure to meet the demand for a measure of cyanosis is possibly due to a rather unique and widely accepted impression that where there is cyanosis there must be an increased tension of carbon dioxide. This accidental association of carbon dioxide and cyanosis has so complicated the matter of measuring cyanosis that, to the average medical mind, the solution was quite out of the question. To brush away the cobwebs of carbon dioxide as an element affecting the color of the blood is to reduce the problem to its simplest terms.

The observations which follow are based upon the assumption that the color of the blood, where the hæmoglobin is approximately normal, is directly dependent upon the amount of oxygen present as oxyhæmoglobin. Complete oxygen saturation (0 no cyanosis) representing one extreme; complete oxygen unsaturation (100 per cent. or complete cyanosis) representing the other.

Through the courtesy of Dr. Van Slyke of the Rockefeller Institute, numerous specimens of venous blood taken from the distal portions of ligated veins, after 5, 10, 15, 20 minutes stagnation, were subjected to quantitative analysis. The longest exposure resulted in oxygen unsaturation (cyanosis) of not more than 30 per cent. An attempt to secure a completely unsaturated specimen from an amputated leg also proved a failure. It became evident that it would not be possible to secure a completely unsaturated specimen from the blood while in the blood vessels, the oxygen tension being probably upheld by a flow of oxygen from the tissues, and possibly from atmospheric absorption from the mucous membranes.

At the suggestion of Dr. Van Slyke a specimen of oxalated blood was artificially unsaturated by passing hydrogen gas over it. It was found that the lower percentages of oxygen were displaced with difficulty. Finally, a specimen exposed to hydrogen gas for an hour and 15 minutes was found by quantitative analysis to be completely unsaturated (100 per cent. cyanosis). Before submitting this specimen for examination, the mass color was carefully matched by a color expert and recorded in non-fading ink. Complete saturation (0 cyanosis) was easily arrived at by passing oxygen gas through a specimen of oxalated blood. The two extremes of the mass color of the blood thus secured formed the basis for the intermediate percentages. This scale based upon the mass color of the circulating blood provides a fixed and optically accurate means of determining the percentage of specimens collected from blood vessels under the usual airtight precautions. It also offers a measure for the degree of oxygenation of blood escaping from a fresh incision when the skin and mucous membranes are not available for estimation, as for example, in operations for brain tumors, glands of the neck, thyroidectomies, etc.

The basic extremes representing the actual mass color of the blood having been secured, the next problem was to so modify this scale that the resultant color would faithfully represent the actual color seen in the nails, skin and mucous membranes.

It soon became apparent that the skin color depended upon the volume of the capillary circulation as well as upon the quality, hue or oxygen percentage of this circulation, *i.e.,* the normal individual at rest shows a delicate skin color whose variations are read with difficulty. The same individual after physical exertion or under anæsthesia will fall into a totally different range of color whose variations are much more clearly defined. While convinced that the skin and mucous membrane colors were fundamentally dependent upon basic blood scale already arrived at, the writer, nevertheless, essayed a determination of actual skin color under anæsthesia by enlisting the assistance of a color expert. What was his chagrin to find that it was not possible to accurately match the colors under observation? For there appeared to be a constant undulation of color value due to the respiratory complications of anæsthesia. Had it not been the writer's good fortune to become acquainted with the Munsell system of color notation, it is quite likely that the end achieved could not have been accomplished. This system offers a conception of color in three dimensions and provides means of measuring accurately any color under observation.

Unknown colors are arrived at by spinning disks containing segments of colors of known hue, values and chroma. The optical mixtures resulting are unvarying and may be actually matched by fast colors. Employing the original blood scale as a base a color segment was added, which, on being rotated, yielded a result closely corresponding to fingernail and mucous membrane color. By varying the amount of this dilutant, various ranges were secured, representing the anaemic normal and plethoric types. The scales so made, while corresponding fairly well to the color of the skin, lacked brilliancy, and left much to be desired. While seeking a reason for this discrepancy, an interesting fact was noted:

It was observed that the color of completely oxygenated blood *en masse* was in accordance with previous findings of a brilliant claret hue. A drop presented the same color. If, however, this drop was spread out to represent a thin film, the color changed to a brick red, and, if further diluted, to a reddish yellow. The thin film of brick red representing the capillary circulation was then spun with the dilutant before used and the desired brilliancy was secured. The resulting scale offers gradations so close to the skin color that the line of demarkation can scarcely be seen.

The hæmoxometer (oxyhæmoglobinometer) consists of a series of scales representing the oxyhæmoglobin content of the blood as seen in the actual mass blood, mucous membrane and the finger nail, or skin of the normal plethoric and anæmic individual. Each step of the scale is arrived at by a separate process, mathematically and optically accurate. The skin is read at the lobe of the ear, the mucous membrane at the bucal aspect of the lips or the palpebral conjunctiva. The finger nails read, directly, represent about the same opacity as the skin.

By employing this device, one may determine not only the approximate oxyhæmoglobin content of the blood, but the volume as well. By observing into what range the color falls, the superficial circulation may be checked up and variations in blood pressure may be anticipated.

CONCLUSIONS.

The need of a simple clinical measure of cyanosis has long been felt, not only by surgeons and anæsthetists, but by physicians who have under their care pulmonary and cardiac cases.

It is contended that sub-oxydation or oxygen unsaturation of the total circulating blood is abnormal and imperils the life of the patient.

There appears to be a large unexplored field in the physiological limits of oxygen unsaturation. This field includes obstetrics.

By simple laboratory methods the two extremes of complete cyanosis and complete oxygenation have been secured.

The exact color value of these extremes has been permanently recorded by the help of the Munsell system of color notation.

Intermediate gradations of these extremes have been secured by mechanical means, so that a scale is available.

The resulting scale, the hæmoxometer (oxyhæmoglobinometer) is a positive basic measure of the oxyhæmoglobin content of the blood under observation. The opacity presented by the finger nail and mucous membrane has been studied and closely duplicated.

The hæmoxometer is offered as a simple clinical measure of oxygen unsaturation (cyanosis), *basically correct,* in practice, *approximate.*

In submitting this original device, the writer is convinced that it has a sphere of usefulness scarcely second to that of the hæmoglobinometer.

2 (1962)

Allergy to cow's milk in infants with severe malnutrition.

By OSCAR M. SCHLOSS and ARTHUR ANDERSON

[*From the Children's Hospital, Boston, Mass.*]

There is much evidence to indicate that under certain conditions the intestinal tract of infants is permeable to slightly altered or unaltered protein.