

with cold water, or placing the patient in a cold draught of air, will suffice to restore sensibility.

Where there is complete unconsciousness, more urgent measures will be necessary. In all cases, the patient should be placed in the recumbent position, with the head lower than the shoulders. This is done in order that the blood flowing toward the cerebrum may have the assistance of gravitation, and also to accelerate the current travelling from the lower extremities toward the heart. All superfluous clothing should be removed from the chest and throat. Collars, neck-ties, and other articles which constrict the neck, hinder recovery. The stimulating inhalations of ammonia, etc., are of little avail in complete syncope, for there is scarcely any respiratory movement; the nostrils, however, may be moistened with the liquid. Cold water, thrown violently in the face, or sprinkled forcibly on the chest, striking the palms of the hands, and rubbing them rapidly, are efficacious in all cases. An efficient remedy is to dip a plate in hot water and place it over the epigastric or præcordial regions; either place will answer. All these methods may be combined in the treatment of individual cases. Should they fail, galvanism may be carefully tried. Too much is worse than too little. One pole of the battery may be placed at the upper part of the spinal column, and the other moved up and down over the sternum and præcordia. The poles may also be applied along the course of the spinal accessory nerve. The action of the heart has in some cases been renewed by exciting the spinal accessory and the four upper cervical nerves (*Valentin*).

The treatment of syncope resulting from excessive hæmorrhage has been discussed in a preceding chapter.

CHAPTER XII.

ASPHYXIA.

Respiratory Apparatus.—Effects of Non-aëration of Blood.—Strangulation.—Compression of Thorax.—Inhalation of Poisonous Gases.—Signs of Death.—Drowning.

THE pathological changes arising from defective aëration will be better understood if we glance briefly at the processes which regulate the supply of oxygen, and the elimination of carbonic acid. To describe in detail these important phenomena would lead us beyond the prescribed limit of this work. We must confine our attention to such as have a special bearing upon the morbid actions in question.

The respiratory apparatus comprises the larynx, trachea, bronchi, and lungs. The lungs, the heart, and great vessels, are contained within the cavity of the thorax or chest. A large, flat muscle, called the diaphragm, forms the floor of this cavity and separates it from the abdomen. Each lung is composed of bronchial tubes, air-cells, vessels, and nerves. The bronchial tubes commence at the termination of the trachea. They divide and subdivide, becoming smaller as they pass in, until they terminate with a diameter of $\frac{1}{10}$ of an inch in the intercellular passages or bronchioles. Around these passages and terminal bronchi, the air-cells are clustered in a manner similar to the arrangement of "leaves on a

tree-branch." These cells measure from $\frac{1}{70}$ to $\frac{1}{200}$ of an inch each in diameter. They are formed of a delicate layer of mucous membrane, closely attached to which are minute plexuses from the pulmonary artery and veins, and to unite the whole there is a quantity of yellow elastic tissue.

According to the calculation of M. Rocheaux, there are 17,790 air-cells connected with each terminal bronchus, and in the lungs, 600,000,000. Prof. Dalton, of this city, estimates the amount of surface thus exposed to the action of the air, at 1,400 square feet. The capillary vessels of the pulmonary artery and pulmonary veins distributed in delicate meshes on the walls of the air-cells are the channels through which the blood-changes are effected. The venous blood, loaded with carbonic acid, is carried by the pulmonary arteries from the right side of the heart to the lungs, where it gives up its load of impurity. The capillaries of the pulmonary veins, which originate in the walls of the air-cells, take up the renovated blood with its load of oxygen, and carry it to the left side of the heart, whence it is propelled to all parts of the body.

The interchange of gases and aëration of the blood are effected during the respiratory movements of inspiration and expiration. During inspiration, the diaphragm contracts and increases the vertical diameter of the chest, while the ribs are elevated and separated by the action of the other inspiratory muscles, thereby making the lateral diameters greater. A vacuum is thus formed, and the air rushes in. Following immediately is an expiratory movement, in which the air is forced out: 1. By the relaxation of the diaphragm, which is pushed upward by the abdominal organs resuming their original positions; 2. The ribs

are drawn together by the external intercostals; and 3. The lungs, which are extremely elastic, contract and force the air out of the cells. After the air enters the bronchial tubes, a diffusion of gases takes place, and the impure air below passes upward, while the oxygen continues on to the air-cells. After reaching the cells, the oxygen passes by endosmosis through to the blood, and is carried off by the corpuscular elements of the circulatory fluid which have previously given up their carbonic acid. Allowing that twenty respiratory movements take place in a minute, the air in the lungs will be necessarily changed 1,200 times in the course of an hour. About 17 cubic feet of oxygen are consumed in 24 hours, and during the same period from 300 to 400 cubic feet of atmospheric air are supplied to the lungs.

Oxygen gas is an essential requirement of a healthy organism. It exerts a remarkable influence upon both vegetable and animal life. Eight-ninths of the whole mass of water, one-third of the earth's substance, and one-fifth of the atmosphere, are composed of oxygen: no element is more abundant or more important.

Repair and decay are closely linked in the animal economy. Death is a necessary accompaniment of life. Molecular disorganization, elaboration, and growth of new material, proceed simultaneously. In health the growth keeps pace with loss, in disease waste preponderates. During the physiological interchange of material new substances of a poisonous nature are generated, and are removed by the different emunctories. Should the avenues of escape be closed, life is speedily terminated. For instance, the kidneys eliminate an excrementitious substance called *urea*, which is formed by the decay of nitrogenized tissue. When

these organs cease to abstract this material from the blood, it accumulates and produces convulsions, coma, and finally death. Carbonic acid, which is specially under consideration in this connection, is another product of retrograde metamorphosis. When through disease or accident it is retained, and the blood imperfectly aerated, all the nutritive processes are retarded, or entirely stopped. The vitality of the body necessarily fails to approximate to a healthy standard, and latent germs of disease are impelled to an inordinate and even fatal growth.

The large mortality in our tenement-houses is sufficient evidence of this truth. Human beings are crowded together in these dens, in a stifling atmosphere, unfit to supply the wants of the system. A family of six and seven will sometimes be cramped in one or two small rooms, scarcely large enough to accommodate a single person. But it is not alone the evil of a diminished quantity of oxygen that these people have to contend with; the surrounding atmosphere is rendered doubly poisonous by the animal exhalations which naturally accumulate and occasion cholera, typhus fever, and other pestilences. In these homes of the poor, these monuments to the grasping spirit of the nineteenth century, death reaps a rich and continuous harvest. And all this must endure until the strong arm of the law compels avaricious landlords to construct houses properly ventilated, and fit for human habitation.

As an example of the effects of imperfect ventilation, the suffocation of a large number of persons in the famous or rather infamous "Black Hole of Calcutta," will be remembered. One hundred and fifty persons were confined for a single night in a room eighteen feet square, having but one

small window. In the morning only seventeen were alive. As another example of the evils attending imperfect ventilation, we may mention the destruction of life which occurred on an Irish steamer some years ago while crossing the Channel. During a storm the captain compelled one hundred and fifty of the passengers to go below, and afterward closely fastened down the hatchways. Seventy persons perished before the hatchways were removed. The violent storm prevented their outcries from being heard, otherwise their horrible fate might have been averted.

Similar occurrences, but on a smaller scale, are frequently brought to our notice. They generally arise from design or neglect.

The condition resulting from a complete cessation of the respiratory movements is usually known as *asphyxia* or *apnea*. The word *asphyxia*, derived from two Greek words signifying pulselessness, does not define the condition. *Apnea* indicates the prominent features of the morbid process with greater accuracy; but, as *asphyxia* is the word in general use, it will be adhered to in the present chapter.

The first effect of obstructing the entrance of air is a retardation of the current of blood in the capillary vessels of the lungs and general system. The blood accumulates and moves slowly through them. Should the ingress of air be still further prevented, this state of congestion ends in complete stagnation or stoppage of the circulation. Unaerated blood cannot pass through the capillaries.

Prof. Austin Flint, Jr., considers the want of oxygen in the tissues, and the accompanying capillary congestion, as the starting-point of suffocation or *asphyxia*; and that the obstruction in the capillaries throws the blood

back on the heart, and overpowers it, so that it entirely ceases.

Some consider that the congestion of the lungs is alone the cause of death; others, that the blood going to the brain, loaded with carbonic acid, destroys the activity of the cerebrum, and through it acts upon the heart and the nerves supplying that organ.

Where so many phenomena exist, involving different vital parts, it is almost impossible to separate them, and definitely say which is the cause of death. To repeat, defective aëration causes the rapid increase of carbonic acid, and induces capillary congestion in every part of the system; this congestion demands more labor from the heart, and the congestion of the lungs increases the difficult respiration, and makes it more labored. The blood, which is loaded with carbonic acid, necessarily obtunds nervous sensibility, and, acting through the cardiac nerves upon the heart, combines with the other morbid influences in weakening the contractions of that organ, and bringing about a fatal termination.

The morbid appearances after death vary but little with the cause of the asphyxia. In the majority of cases there is a similarity in the changes. The face generally is of a dark, livid color; froth or foam, streaked with blood, surrounds the mouth. The eyes protrude. In suffocation from hanging, the tongue is swollen and pushed out between the lips. Rigor mortis appears soon after death. The lungs are heavy and dark, and contain a large quantity of black blood. The air-cells and smaller bronchial tubes are filled with a sanious, frothy fluid. Blood is absent from the left side of the heart and arteries. This latter peculiarity is due to the elasticity of the walls of the arteries forcing out the

blood. It is not confined especially to death from suffocation, but occurs in other forms.

The auricle and ventricle on the left side of the heart are distended with dark blood, and all the blood in the body is blacker than under ordinary circumstances. This is caused by the absence of oxygen, which gives the circulating fluid a red color. In the liver, kidneys, and spleen, there is generally more or less congestion. There are various opinions advanced respecting the conditions of the brain. Some modern investigators (*Ackerman, Dondus*) endeavored to show that anæmia of the brain is more common than congestion. This idea, however, is not sustained by facts, or accepted by many in the profession. The cerebral vessels, except in rare cases, are engorged with blood.

Having now dwelt on the physiology of respiration, and the pathological changes which depend upon the defective aëration of the blood and total cessation of the respiratory act, we now come to the various forms of asphyxia and their treatment.

STRANGULATION.—This term is generally applied to that variety of asphyxia caused by external compression; but any mechanical occlusion of the trachea or larynx, whether external or internal, belongs under the same head.

The strangulation produced by clasping the throat tightly with the arm or hands is the common method employed by garroters. In suicidal attempts, handkerchiefs or ropes are generally used, and the rope is resorted to in most civilized countries in judicial strangulation. All cases of hanging, however, do not terminate by asphyxia. The neck is usually broken by the fall, and death results from pressure

on the upper part of the spinal cord, and congestion of the brain.

The greatest number of strangulated patients who come under the care of the surgeon are those of attempted suicides, and every stage of asphyxia, from a slight suffocation to complete stoppage of respiration, may be found among them.

The symptoms arising from mechanical occlusion of the air-passages are common in a greater or less degree to all other varieties of asphyxia. They are usually so well marked as to preclude a possibility of mistake. At the same time, the history of the patient should always be inquired into. The patient's countenance presents an anxious expression, and is of a livid color, which, in extreme cases, is almost black. The lips are swollen and somewhat everted, the eyes bloodshot and prominent, the vessels of the head and neck are enlarged to double their ordinary size. There is an intolerable feeling of discomfort and oppression over the chest, and intense desire for air. The respiratory movements become rapid, but after a time they are slow and prolonged. There is a momentary increase in the pulsations of the heart. As the asphyxia progresses, the movements diminish in force, until they are totally lost. In the beginning, the patient suffers from giddiness, ringing in the ear (*tinnitus aurium*), and great general distress. The agony gives way where asphyxia results from immersion in water, and is succeeded by pleasant visions and dreams. In some recorded cases, these sensations are said to have been so entrancing as to cause the resuscitated patient to curse his attendants for bringing him back to renewed torture. These dreams are followed by insensibility; the pulse is usually

absent, but the action of the heart may still be made out with a stethoscope. So long as an impulse is detected, there is chance of recovery.

In asphyxia resulting from violence, there is often an accompanying condition of syncope. This may resemble death to such an extent as to prevent the continuance of treatment. However, if the points of difference between death and simple insensibility are appreciated, there will be little difficulty.

When life ceases, the pupils are dilated, the cornea is flattened, and the eyes fixed. There are congestion of the cutaneous capillaries, especially in the most dependent portions of the body, and blueness under the finger-nails. (In true asphyxia this congestion is not a sign of much importance.) All respiratory movements have ceased, and no moisture will appear on a looking-glass held over the mouth or nose. The pulsations of the heart cannot be made out with the ear or stethoscope.

Another test has been proposed lately by a French gentleman, who states that, if a bright steel needle be inserted into the dead body, it will become tarnished; if introduced into the living body, it will come out perfectly clean. If a preparation of Calabar bean is applied to the eye while life is present, the pupil will contract; if death has taken place, no effect will be produced.

A muscular rigidity (*rigor mortis*) ensues soon after death, and a peculiar, offensive odor is emitted.

Treatment.—The treatment of strangulation from foreign bodies in the air-passages has been considered in a previous chapter. When strangulation results from external compression of the throat, a careful examination should be instituted to ascertain the amount of local injury. Lacera-