tion or fracture of the larynx or rings of the trachea may cause pieces of cartilage to protrude on the internal surface. Such obstructions must be removed, in order to render the treatment effectual. All superfluous clothing should be removed from the chest and neck, and the mouth and throat cleared of mucus. Artificial respiration, either by Marshall's, Hall's, or Sylvester's methods, must then be tried. The manner of employing these methods is hereafter fully explained. It is at times necessary to perform tracheotomy (*see* Tracheotomy), and to fill the lungs by forcing in air with a bellows, or with the mouth applied to the opening. In addition to artificial respiration, the surface of the body should be briskly rubbed to keep up the circulation, and stimulants administered through the rectum. As in cases of hanging there is congestion of the brain, a few ounces of blood can be taken from the arm with benefit.

Compression of the Thoracic Walls produces suffocation by preventing the expansion of the lungs and admission of air. It usually occurs from jamming, or by being crushed beneath embankments or masses of building material. In the former case the sufferer is usually very much frightened. The arms are thrown involuntarily above the head, leaving the chest exposed to the pressure of the crowd. Persons in large crowds can, with ordinary precautions, protect the chest by keeping the arms and elbows close to the side of the chest, flexing the forearm, and bringing it in front, thus making the hands meet in the median line. Unless extraordinary pressure is made, this method will allow of sufficient respiratory movement to sustain life.

The notorious resurrectionist and murderer, Burke, usually destroyed his victims by compressing the thoracic walls.

With this variety of asphyxia there may be more or less bruising and laceration of the chest-walls, but the general symptoms and treatment are the same as given above.

Suffocation from Inhalation of Gases.—The inhalation of nitrogen or hydrogen occasions the same changes and symptoms as are witnessed in other forms of asphyxia. Nitrogen exists in large quantities in atmospheric air. When inhaled in a pure state, it destroys life with greater rapidity than other gaseous bodies.

The inhalation of sulphuretted hydrogen, carbonic acid, carbonic oxide, carburetted hydrogen, etc., should be treated under the head of poisons. As death in these cases, however, is usually attributed to asphyxia, and as the treatment is the same, they will be considered in this section.

Sulphuretted hydrogen is a product of the decomposition of animal matter. It is found in sewers, old drains, and stagnant pools. The foul odor of "rotten eggs" is due to this gas. When inhaled, it proves rapidly fatal. According to Flenard, one part in a hundred and fifty of atmospheric air will kill a horse. Men can bear larger proportions.

Small quantities of sulphuretted hydrogen, inhaled in a diluted form, give rise to nausea, vomiting, pains in the abdomen and extremities, vertigo, and a semi-paralytic condition of the extremities. In large quantities, it produces rapid insensibility, convulsions, and death. The body exhales the characteristic odor of the gas. After death the mouth and fauces are coated with a dark-brown

mucus. The muscles and all the internal organs are dark-colored, and the blood is fluid.

Carbonic acid, or di-oxide of carbon, is found in large quantities in the bottom of wells, coal-mines, and in all dark, damp situations, where organic matter is in a state of decomposition. In coal-mines it is usually known as "choke-damp," and death is often caused by its inhalation. This substance also results from the physiological decay of living bodies.

An atmosphere containing one-tenth of carbonic acid will produce death. Its effect on the system is that of a narcotic poison, although, when death results from its inhalations, it is commonly said to cause suffocation, or asphyxia.

The symptoms attending its inhalation, with one or two exceptions, resemble those occurring in ordinary asphyxia. There is at first marked loss of muscular power, with tendency to sleep, and the countenance assumes a leaden hue. After death the eyes remain bright for some time, and several hours elapse before rigor mortis sets in.

Charcoal-vapor consists of carbonic acid, carburetted hydrogen, free nitrogen, and atmospheric air. This vapor is often used as a means of self-murder. In France it is frequently employed for this purpose. Suicides burn the charcoal on a brazier, in a close room, where all the crevices for the admission of air are shut off. The vapor at first creates a sensation of extreme languor and general weakness. This is soon followed by complete insensibility. In some of these cases the countenance is pale, and the jaws are usually fixed. After death the heart is empty, or a little black blood may occupy its right ventricle.

Coal-vapor.—The materials arising from the ordinary combustion of coal are sulphurous acid, carbonic acid, sulphuretted hydrogen, and carburetted hydrogen. It is impossible to inhale this vapor under ordinary circumstances. It possesses such irritating qualities that, unless a person is stupefied with alcohol or other narcotics, he will escape before a sufficient amount is taken in to destroy life. Occasionally, persons are suffocated in holds or cabins of vessels from this vapor. A sad instance occurred recently in New-York harbor. Five seamen shut themselves in the forecastle, where a brazier of coal was burning, and in the morning were found dead.

Coal-gas.—This substance is employed for illuminating purposes. It consists principally of light carburetted hydrogen, carbonic oxide, olefiant gas, hydrogen, nitrogen, etc. Its odorous principle is due to vapor of naphtha. *Carbonic oxide* is supposed to be its principal poisonous ingredient.

If the atmosphere of a room becomes impregnated with twelve per cent. of the gas, a lighted candle introduced will cause an explosion. Accidents arising from coal-gas are generally the result of carelessness or ignorance. Neglecting to turn the gas off, and leakage in the pipes, are the common causes. The effects produced by its inhalation differ from other varieties. There are more or less vertigo, nausea, and vomiting, a semi-paralytic condition of the muscles, and convulsions ending often in death. After death the blood is sometimes of a light-red color.

Treatment.—In all these varieties of suffocation, inhalation of oxygen gas will bring about speedy relief. Where respiration has ceased, it must be restored by artificial methods. If necessary, oxygen may be forced into the

lungs in the manner previously mentioned. Cold water, poured on the surface of the body, is likewise beneficial.

DROWNING.

The length of time that persons can remain under water, and afterward be resuscitated, varies according to the circumstances attending each individual case. When timid persons become accidentally submerged, they throw up the arms, open the mouth to shriek, and consequently fill the lungs with water and strangulate at once. If presence of mind is not lost, the arms kept under water, and the respiratory movements controlled until the head comes above the surface, life may be prolonged a considerable period. Again, should the submerged individual faint, the chances of resuscitation are good even when several minutes have been spent without air. The fit of syncope is attended with a stoppage of respiration and of the heart's action, and, the demand for oxygen being diminished, the system does not feel the loss as it would under other circumstances. Occasionally, life is destroyed after an immersion of one minute, while in other instances persons remain under water for two and even three minutes without receiving injury. Thus sponge and pearl divers, who spend a great part of their working-hours under water, remain deprived of air for two or three minutes with but little discomfort. Marac relates the case of a German woman who was tied up in a bag with a cock and cat, and thrown into the water as a punishment for child-murder. She was submerged fifteen minutes, and, when removed from the bag and exposed to the air, immediately recovered. Such a prolongation of life without air can only be accounted for on the supposition that the woman

fainted on being immersed, and that the state of syncope lasted until she was brought to the surface.

A committee of the Royal Chirurgical Society, London, instituted a series of experiments to ascertain the length of time animals could sustain life without a supply of oxygen. A brief statement of the principal results will be of interest. It was ascertained that, when the entrance of air was prevented by submersion, death was more rapid than when the trachea was thoroughly closed with a plug. When the trachea was simply plugged, the respiratory movements continued from three to four minutes and a half, and the action of the heart was perceptible from six to seven minutes and a half. As a rule, the heart's action continued two or three minutes after respiration ceased. When animals were kept under water one minute and thirty seconds, death followed, even when the animal was taken out alive. No efforts were made in any of these cases to restore life. If respiration had been artificially produced, they would have probably recovered. The striking difference in the period of death in the two classes is explained by the fact that, in simple plugging of the trachea, sufficient air remained in the lungs to maintain life for a short time, while in the other, water found its way into the lungs and displaced the air which might otherwise have been reserved for aëration. Some contend that water does not enter the lungs of the drowned, but the results of *post-mortem* examinations do not confirm this statement. Water, sea-weed, and other extraneous matter, have been found in the bronchial tubes in the majority of cases. It is true that at times there is not the slightest trace of water. This circumstance is, however, exceptional. The remarkable power of absorption possessed by

the lungs may account for the rapid disappearance of the liquid. As human beings, when drowning, alternately sink below, and rise again to the surface of the water, occasionally giving them opportunity to obtain a fresh supply of air, we cannot definitely determine the maximum of time they can remain under water and yet recover afterward. The experiments quoted are not proper criteria to judge by in the majority of drowning cases. When submersion is continuous, however, five minutes is the longest period after which life may be restored. There is a peculiar condition, known as secondary asphyxia, which occurs at times in persons who have been restored by artificial respiration. It shows itself generally within forty-eight hours after respiration has been fully established. When the symptoms seem favorable, and all anxiety removed, the patient is suddenly seized with urgent dyspnœa, the chest expands imperfectly and irregularly, the patient struggles for breath, and in a short time all the worst features of asphyxia return. Death soon supervenes, unless immediate relief is afforded by artificial respiration. The cause of this change is not well understood. It is probably due to congestion of the lungs, induced by some active movements on the part of the patient. The exercise sends more blood to these organs than they, in their weakened condition, can provide for. Excessive and laborious respiration immediately follows. The appearances presented in asphyxia resulting from immersion vary somewhat from other kinds. The livid discoloration of the face and fulness of the blood-vessels are not so distinctly marked. There are more general pallor and coldness of the surface. Rigor mortis or *post-mortem* contractions of the muscles appear very soon after death.

Treatment.—There are four special requisites in the treatment of drowned persons: 1. *Artificial respiration;* 2. *Warmth;* 3. *Friction;* 4. *Stimulation.* All these are employed together, but the first is generally relied on. Strip the patient of clothing, and envelop the body as far as possible in warm blankets. Then clear the mouth and throat of water, mucus, or other substance which might prevent the ingress of air.*

To do this perfectly, cover the index-finger closely with a handkerchief, and carry it in as far as possible, and sweep it around the pharynx and upper part of the larynx. The cloth takes up more of the moisture than the finger alone would. The tongue is now drawn out as far as possible. Unless the organ is pulled forward with considerable degree of force, the aryteno-epiglottidean folds at the upper border of the larynx will close the aperture sufficiently to interfere with the admission of air. This is a point of considerable importance in all cases where artificial respiration is resorted to, and cannot be too strongly insisted upon. A forceps attached to the extremity of the tongue, or a towel wrapped around its end, and grasped with the thumb and forefinger, will make traction easy. Having cleansed the air-passages, we try some of the methods of artificial respiration. When the immersion has been short, and the patient only partially asphyxiated, simple compression of the lower half of the thorax and upper part of the abdomen will answer. The hands are applied on each side of the chest-walls, the fingers reaching as high as the nipple, and firm

* Some advise suspension of the drowned person by the limbs, in order to facilitate the escape of water from the lungs; but this is an unnecessary procedure.

pressure made to diminish the cavity of the chest. The hands are then lifted for a few seconds, and the parts allowed to resume their natural position.

This is done rapidly and continuously until all danger has passed. Diminishing the thoracic cavity by pressure forces out some of the foul air from the lungs, and with the subsequent expansion a certain amount of fresh air passes in. This interchange gives more oxygen to the blood, and relieves it of carbonic acid, stimulates the circulation, and through it the nervo-muscular apparatus, and finally restores all the functions of life. In severe cases, either Marshall Hall's or Sylvester's method of artificial respiration is to be preferred. The latter is said to be superior, as it enables more air to pass out of and enter the chest. The preliminary steps, such as clearing the throat and drawing out the tongue, are the same. In Marshall Hall's method the patient is placed on the side, with the arm toward the posterior plane of the body. The body is then rolled slowly over on the face, while the hands of the surgeon at the same time are pressed firmly on the back and sides of the chest, diminishing its cavity. When this movement is completed the patient is turned on his back, and the chest-walls resume their original position; these movements are to be kept up until natural respiration is resumed. The principal effect to be produced in all cases is a renewal of the air in the lungs. In Sylvester's method the patient is placed in the recumbent position, with the head and chest somewhat raised. The operator stands at the head of the patient and grasps both arms midway between the elbow and wrist-joint, moving them gradually to a vertical position so as to make them nearly meet above the head. They are held in

this position for a moment, and then slowly returned to the sides. At the termination of the second movement, pressure is made with the arms on the sides of the thoracic walls. These movements are continued as long as the asphyxia remains. Raising the arms in this manner elevates the ribs, and allows comparatively a large quantity of air to enter, while relaxation causes them to resume their normal relations. Conjointly with all varieties of artificial respiration, the patient's limbs should be briskly rubbed by an assistant, and brandy and ammonia should be administered through the mouth or rectum. Hot bottles and blankets are to be applied to the extremities before and after the patient has recovered. Heat, by means of hot-air baths, is sometimes useful. Ammonia, in the form of vapor or in solution, may be applied to the nostrils. Should ordinary artificial respiration fail to revive the patient, pure oxygen may be forced into the lungs. This may be done by cutting a hole in the trachea, inserting a tube, and forcing the gas through it. The ordinary elastic bag employed for inhalation of oxygen, if pressed with moderate force, will send in enough gas to distend the lungs. If the gas is not at hand, the nozzle of a bellows may be attached to the trachea-tube, and the necessary expansion accomplished with atmospheric air.

Injuries to the Spinal Cord, above the origin of the phrenic and intercostal nerves, paralyze the muscles of respiration and produce death by asphyxia. Poisonous doses of nux-vomica or its alkaloids cause spasm of the same set of muscles, and terminate life in like manner.