RESUSCITATING DEVICES AVAILABLE TO THE LAYMAN¹

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WE HAVE FOUND it difficult to reduce resuscitation to plain terms beyond dispute. As anaesthesiologists, we may possibly think we have the last word on this subject, but take away our equipment and consternation might be the kindest word that could be applied to our state of mind. And, if the last word on this subject goes to us, then certainly the first word must go to first-aid personnel. However, their position is, perhaps, even more difficult than ours, for they are presented with the controversy of manual *versus* mechanical means, further confounded by the question of which manual or which mechanical means.

The Oxford Dictionary at least is straightforward. It says that resuscitation is the act of restoring to life. The first-aid manuals qualify this definition by stating that it is the prevention of death by artificial or mechanical respiration. They qualify still further: for successful resuscitation there must be an adequate supply of oxygen for the vital centres, the respiratory centres in the brain and the heart. Finally, two authorities on this subject, Ivy and Schwerma (1) of the Illinois School of Medicine, have laid down these absolute qualifications:

There must be:

- (1) An unobstructed airway.
- (2) An adequate functioning alveolar surface for the absorption of oxygen and the elimination of Carbon Dioxide.
- (3) Circulating blood to transport the absorbed oxygen to the heart and central nervous system.
- (4) A myocardium and central nervous system still capable of being resuscitated.

Once the airway is cleared, artificial respiration should be commenced at once with the most efficient method available. If no apparatus is immediately available, the manual method must be used. When a resuscitator arrives, it can always be substituted.

And so with this advice they leave us with vague notions of push and pull machines that seem efficiency itself, but about which we have our doubts.

MANUAL METHODS

Comparing the tidal air exchange of the various manual methods of resuscitation we find: Schafer, 340 cc.; Sylvester, 400 cc.; Eve, 560 cc.; Mouth-to-Mouth 970 cc. The Schafer method involves alternating push and release on the lower thoracic cage in the prone position to achieve tidal air exchange. The Sylvester method involves pull on the arms and release in the supine position. Both, we believe, rely too much on the elastic recoil of the chest wall which may not be adequate, and we cannot be absolutely certain of that all-important unobstructed

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airway. The Holger Neilsen method is a combination of these two and is called the push and pull method.

This subject of resuscitation is as old as time itself. In the Bible, in Kings I and II, it is revealed that Elisha revived the Shunamite child by mouth-to-mouth breathing; Hippocrates is said to have suggested that respiration might be restored by inserting a tube into the trachea and forcing air down it; in the Middle Ages, Paracelsus and Vesalius used the fireside bellows to inflate the lungs. The modern history of artificial respiration began about 1775 when John Hunter invented a double action non-rebreathing bellows which was adopted by the Royal Humane Society of London, while the Dutch Humane Society advocated mouth-to-mouth insufflation for victims of drowning. The Navy rolled them over a barrel. The nineteenth and early twentieth centuries produced many methods of manual respiration of which the best known are the Sylvester, the Schafer, and the Holger Nielsen.

This last method is now officially recommended by all life-saving organizations. The advantages are that the prone position of the patient with the head to one side should ensure a good airway. It is a push-pull method and not only is pressure applied to the upper chest to induce expiration, but the arms are lifted to induce inspiration. Therefore, there is increased efficiency of pulmonary ventilation and the lack of pressure on the abdomen reduces the risk of inhaling regurgitated water.

For the Eve Method, a rocking stretcher is necessary. The respiratory exchange is effected by changes in the position of the diaphragm as the patient is placed alternately in a head-downward and a head-upward position. The advantage of this method is that it affords a large respiratory exchange and increases cardiac output. It also promotes drainage of fluid from the chest. The ever water-conscious Navy changed from the roll over the barrel method to the rock of the Eve stretcher, firm in the belief that they were getting "the water out of the lungs," as well as inducing respiration. Since drownings are the most common accidents we are faced with, let us consider this "water in the lungs."

Dr. H. G. Swann reported on fresh water drowning in 1949 (2) that when an animal is totally immersed there is an initial period of struggling and apnoea. Within two minutes, an involuntary inspiration occurs and water is drawn into the lungs, usually in large quantities. There is an immediate, enormous absorption of this fluid into the circulation across the alveolar capillary membrane. An amount of water equal to 60 to 150 per cent of the blood volume can enter the circulation in a few minutes. The result is twofold.

(i) Haemolysis with potassium release and great increase in the K/Na ratio occurs. The coronary circulation receives this highly abnormal blood with serious biochemical insult to the myocardium, as well as anoxia.

(ii) There is great overloading of the circulation. The result is ventricular fibrillation in from three to seven minutes. The onset occurs almost simultaneously with cessation of effective respiratory excursions.

In 1951, data revealed that nineteen out of twenty victims of drowning have water in the lungs and haemodilution. Electrolyte studies showed changes capable of precipitating ventricular fibrillation in at least half.

In salt water drowning there is no change of the K/Na since there is no haemolysis. There is, however, haemoconcentration with movement of water from the blood into the lungs. The heart failure is due to anoxia and not to fibrillation. Water in the lungs can kill not only by causing anoxia and biotoxicity at the time of the accident, but also by inducing severe pulmonary oedema in both types later, the cause of death being ascribed to pneumonia or exposure. This pulmonary oedema is probably the reason why in many cases of successful resuscitation the victim succumbs hours, or even days later.

Time and tide are, therefore, decisive. Respiratory failure occurs some time before irreversible circulatory failure in one-third of cases, in one-third during failure, and in one-third after failure of circulation (on experimental evidence); so we must get busy immediately—and the Navy rule is right—we must try to “get the water out.” Manual methods employing the prone position would, therefore be best: Schafer and Holger Nielsen, when other equipment is lacking. Nevertheless, the skill of the rescuer is so very important in maintaining a rate of at least fifteen per minute and tidal exchange that we must look to simpler and better methods. The American Red Cross and the Council of Physical Therapy state that mouth-to-mouth resuscitation offers the greatest scope for general use and success (4). This method employs the basic physiological principle of using expired air as the ventilating gas. With normal respiration, expired air contains approximately 16 per cent oxygen. In resuscitating a drowning victim, the first 150 cc. of the rescuer's expired air which is dead space air and not involved in alveolar exchange is the first exhaled into the victim's lungs. So that the dead space air may have a nearly atmospheric composition, the rescuer should always take an inspiration just before each insufflation. The chief advantages of this method are: airway obstruction can be noted and dealt with quickly; less energy is expended; the procedure can be continued for hours; no equipment is needed. However, the effectiveness and facility of this method can be improved by the use of an ordinary anaesthesia face mask, airway, or endotracheal tube. The modification of two airways affixed end to end (Safar airway) is a useful adjunct. An infant and an adult size airway should be kept on hand.

The nose of the victim should be blocked when this technique is used on an adult and his head maintained in a well-extended position with the jaw pulled forward. In infants, one may insufflate through the nose and mouth after following the carefully prescribed steps to clear the airway. In tiny babies, Dr. Apgar recommends insufflation with small puffs of air from just the mouth and cheeks. The rate should be at least twenty per minute, whereas in adults twelve to fifteen per minute is adequate and, if correctly done, tidal volumes even over 1,500 cc. can be attained.

MECHANICAL METHODS

So far, we have been on safe ground since we all know that to do something intelligent during those first moments in an emergency is beyond reproach. However, when it comes to carrying on with mechanical devices, the thought searching begins. Even though a good mechanical resuscitator was brought out by Erickson

and Johnstone in 1927, it was not until 1950 that the Council on Physical Medicine and Rehabilitation of the American Medical Association published its tentative minimal requirements for inhalators and resuscitators. However, it had approved of the E & J in 1939 and the Emerson in 1942 (5) in principle. Let us consider these two types.

Several models of each are available, but all have the same type of head which allows them to be used as a resuscitator or inhalator or aspirator, according to the position of the control lever. The E & J inhalator is used when extra O_2 is needed by the breathing patient. It delivers 7 L. per minute with this advantage over the Emerson that the air/ O_2 ratio can be adjusted by the central control valve (7). The resuscitator has a positive phase of 13 mm. Hg and a negative of 9 mm. Hg regulated by the toggle diaphragm in the head. During the inspiratory phase, the flow of O_2 is directed into the lungs until a pressure of 13 mm. Hg is built up. At this time, the toggle diaphragm is tripped and the gas flow is re-directed by the Venturi chamber so that the natural expiratory flow is assisted by a suction effect which pulls the gases out of the lungs until a negative pressure of 9 mm. Hg is reached. The toggle now releases and returns to its original position and the cycle starts again.

Why the negative pressure phase? In 1953, Maloney, Elam, *et al.*, showed that in normal patients there may be a 12 per cent drop in cardiac output with intermittent positive pressure alone, and up to 42 per cent in those with respiratory paralysis or an inadequate circulation. Positive-negative pressure did not impair circulation in either type.

The positive pressures necessary to inflate the newborn baby's lungs is the same as for an adult. The only difference is that it takes a little longer in an adult. The difference in time, therefore, determines the respiratory rate and the volume of oxygen delivered. These pressures are considerably less than a premature infant can develop in its own lungs, and the control valve can be set at slow for very small infants or if there is partial obstruction of the child's airway.

It has never been known to cause lung damage. Though there is a danger of forcing regurgitated fluid into the lungs, we are trying to save a life and there is an aspirator attachment to deal with fluid in the airway.

Other resuscitators worthy of mention are: the McKesson, which operates on a volume adjustment which I believe adds slightly to its complexity; The G.L.B.—Goddard Bennet Lovelace (8) infant hand resuscitator consisting of hand bulb, positive pressure gauge with pressure control, use of which is restricted to medical personnel; last, and, I believe, foremost the A.M.B.U., or Rubens type, which adds to mechanical resuscitators what mouth-to-mouth adds to manual methods, offering a rare combination of simplicity and efficiency (9). The resuscitator is the equivalent of our bag and mask. It has a Ruben's non-rebreathing valve and the bag has a foam rubber lining to make it self-inflating. It can deliver a tidal volume of 400 to 1,000 cc. depending on compression and can be used on infants since on compressing the bag with one hand, a pressure of 60 mm. H_2O will not be exceeded. Oxygen can be vented into the bag. There is a suction pump operated by a foot or hand bellows connected to a suction bottle and can create a vacuum of from 190 to 300 mm. Hg.

CONCLUSION

In our final evaluation, we would reiterate the first-aid rule, "Don't wait—resuscitate," the best way one knows how, and mouth-to-mouth is probably the best. As soon as a mechanical resuscitator comes to hand, use it.

Clear the airway and try to clear the water out of the respiratory system.

Finally, let us hope we see more good hand resuscitators such as the Rubens available in all places where there is the possibility of drowning, or shock accidents, and that anaesthetists and first-aid personnel will be able to work together more closely in this service.

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