EVALUATION OF METHODS OF RESUSCITATION*

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PATHOLOGICAL conditions which progress to a state involving impairment of respiratory function are so numerous and occur so frequently that knowledge of the appropriate methods of instituting artificial respiration is a necessity.

To apply methods of artificial respiration successfully not only necessitates a long period of serious practical training but also entails knowledge of pertinent physiology. By necessity, the anaesthetist applies almost routinely different methods of artificial respiration and therefore should be well qualified to teach all aspects of resuscitation. Indeed he should consider it his duty to diffuse his knowledge not only to other members of his profession, but also to non-medical groups.

To lower the appalling toll of drowning tragedies during the summer months, all doctors at this time of year should strive not only to teach methods of artificial respiration, but also to take active interest in the organization of rescue groups in their respective communities. Unless the victim is located in the shortest possible time, all attempts at resuscitation will fail.

Since partial or complete respiratory obstruction is often the precursor of cessation of respiratory function, prophylactic measures against this complication, which by themselves can be life-saving, will be considered briefly.

In all comatose or paralysed patients, where the cough reflex is obtunded, maintenance of a clear airway is realized by frequent aspiration of pharyngeal, tracheal, and bronchial secretions. The patient should be placed in the lateral decubitus to establish gravity drainage of secretions and to assist in keeping the tongue forward. An appropriate artificial airway, either oro-pharyngeal, naso-pharyngeal, or endotracheal should be introduced before it is too late. Even mild partial obstruction should never be tolerated. A snoring, comatose patient should always be considered as a partially obstructed patient. In the presence of a severe glottic or laryngeal respiratory obstruction requiring emergency tracheotomy, laryngeal atresia need not result. More ideal conditions can be secured for a low tracheotomy by the preliminary insertion of a fourteen gauge trocar through the crico-thyroid membrane before cessation of spontaneous respiratory activity (1). If necessary, the insufflation of oxygen through such a trocar, as suggested by Reed and associates (2), should maintain life until tracheotomy is performed. All patients in danger of becoming obstructed should have uninterrupted supervision.

Avoidance of delay in treating respiratory arrest must be insisted upon. Usually cardiac arrest occurs within five minutes after interruption of respiratory function (3). It must be realized that these same considerations also apply to drowning victims. They must be rescued without delay so that artificial respiration can be

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instituted within five minutes of the last resurfacing effort, which usually entails a breath of air. In other words cardiac arrest will generally occur after a total uninterrupted submersion period of five minutes' duration. However, we all know of rare incidents where this time limit did not apply, and for this reason efforts at resuscitation must be carried out on all vicitims who have been rescued within a reasonable period of time. The presence or absence of residual cardiac activity cannot be determined by the means at hand on a beach. It must always be assumed that the heart is potentially capable of recovering adequate function. Cardiac massage through a thoracotomy becomes a formidable undertaking outside the hospital and cannot be recommended for general adoption. However, we do insist that indirect cardiac massage over the left hypochondrium is occasionally successful (4) as are other easily performed manoeuvres such as thumping the precordial region and direct needle stimulation of the heart. Attempts at cardiac resuscitation when required should always accompany any emergency methods of artificial respiration.

All persons should be trained to apply emergency methods of resuscitation. There should be no delay in waiting for the doctor or for mechanical devices. At this point we renew our plea for widespread and often repeated training programmes in emergency methods of resuscitation in all our educational institutions.

Emergency methods of artificial respiration immediately available are the manual methods and mouth to mouth breathing requiring no equipment.

In 1951 co-ordinated studies in the different methods of manual artificial respiration were carried out in the following American institutions: University of Illinois (5), University of Pennsylvania (6), Harvard University (7), and Springfield College (8). Gordon, Sadove, and Raymon (9) analysed and integrated the results obtained. They evaluated the methods according to efficiency of ventilation and oxygenation and to the ease of administration.

They recommended for general adoption methods which, in addition to an active expiratory phase, also combined an active inspiratory phase. The University of Illinois group (5) demonstrated on normal anaesthetized and curarized subjects that the double active phase methods yielded a tidal ventilation at least twice as great as that produced by the prone-pressure method. The Holger-Nielsen or "arm-lift back-pressure" method was selected as the most practical.

With regard to resuscitation of the newborn, Whittenberger (10) believes that the active inspiratory manoeuvre of the manual methods in all probability develops insufficient force to start inflation of airless lungs.

Mouth to mouth, and mouth to nose breathing are other emergency methods immediately available for resuscitation. They may be applied either by direct contact with the victim or in certain instances be made more acceptable by the interposition of an anaesthetic mask if available. In newborn infants and children the method is most effective. The victim's lungs are filled with oxygenated dead space air from the operator's non-functional respiratory cavities. This volume of air is pushed down to the alveoli by subsequent portion of alveolar air from the operator which, however, mainly fills the victim's own dead space. In the

absence of mechanical devices, mouth to mouth breathing appears to be the most effective method of resuscitation in the newborn (11).

Mechanical means of resuscitation are used both for emergency purposes and for long-term maintenance of artificial respiration.

The various types of resuscitators are designed to administer air or oxygen, either alone or as a mixture via a mask or endotracheal tube. Pressure breathing apparatus of this type may deliver either intermittent positive pressure or intermittent positive and negative pressure.

The self-contained hand-operated devices usually incorporate a bellows (12). Other hand-operated resuscitators, such as those represented by the bag and mask arrangement and other types incorporating special valves (13), require a source of air or oxygen and thereby are not self-contained, evidently an undesirable disadvantage when this source of compressed air or oxygen is not available. Since the intermittent positive mask-pressure curve delivered by these devices is in the hands of the operator, optimum results are obtained only when used by trained persons (10).

Automatic resuscitators for emergency use are intended to relieve the operator who has initiated resuscitation by manual methods. Too often fatigue and exhaustion resulting from sustained efforts at maintenance of manual artificial respiration lead to discouragement and unwarranted premature abandonment of the victim. Herein lies the advantage of automatic mechanical devices when they are used for protracted periods of resuscitation.

Since automatic resuscitators have preset pressures varying between 15 and 20 mm. of mercury, which cannot be altered, in many instances they will be unable to meet ventilatory requirements introduced by the individual exigencies of lung compliance. Although it is undeniable that these fixed pressure settings are intended to safeguard the patients' lungs, we recommend the incorporation of a bag and mask principle which could be made to by-pass the automatic mechanism when necessary. Whittenberger, Affeldt, and Mead (14) have shown that compliance of the lungs can be temporarily increased by a single overinflation and recommendations for including a means of providing an occasional deep breath have already been made (10). Another reason why the bag and mask principle should be a useful addition to automatic resuscitators arises from the frequently observed glottic or vocal cord spasm, initiating failure of respiration and accounting for resistance in the air passages. The machine would acquire a wider range of usefulness by allowing the trained operator to increase the positive pressure sufficiently to break through the spasm. It is our opinion that many patients would thereby be saved from irreparable cerebral or cardiac damage.

The effects of positive and negative pressure breathing on respiration and circulation need further elucidation.

Appliances for long-term maintenance of artificial respiration are classified as respirators. In this regard the tank respirator is the most useful device in our country for maintaining respiration in paralytic diseases involving the respiratory system.

Radford, Ferris, and Kriete (15) have devised a Nomogram for predicting the

optimum tidal volume from the breathing frequency, body weight, and sex of the patient. The Nomogram is based on the fact that basal carbon dioxide production and respiratory dead space are related to body size and may be estimated from body weight. Thus this simple practical method, which replaces more elaborate determinations, entails observation and proper setting of spirometric readings and respiration frequency rather than tank pressures to avoid problems of hypo- and hyperventilation.

Cuirass type respirators which cover the anterior and lateral surfaces of the thorax and abdomen are not consistent in sustaining basal ventilatory requirements in apneic patients. For that reason they are classified as weaning devices for convalescent patients who have had a long sojourn in the tank respirator.

The rocking bed, an adaption of the Eve gravity method, is also established as a weaning device. It does not maintain adequate pulmonary exchange when lung or thoracic compliance are much reduced (10).

For the past few months in our hospital we have been working on a simple, self-contained infant resuscitator which can be instantaneously put into service and which is not a bulky addition to the doctor's emergency bag. The heart of the resuscitator is the Fink modification of the Stephen-Slater valve (16). This valve was fitted with a bulb having a low resistance wide bore intake valve. The bulb, as determined on a dry gas Bennett ventilation meter, dispenses an average volume of air ranging between 75 to 80 cc. when compressed fully by the hand. Pressures can be suitably adjusted to avoid overdistension of the lungs through a safety outlet incorporated in the Fink valve. However, since pressure is a function of gas velocity and diameter of the outlet, and whereas the outlet is a constant factor after being set, the velocity of air flow varies according to the energy applied by the hand to collapse the bulb. An ordinary blood pressure manometer acts as a constant check on the energy of the hand squeeze and helps to keep pressures within safe limits. The manometer connects directly to the mask or endotracheal tube adapter and is quickly fastened to the wrist for convenience by means of a malleable metal band covered with rubber tubing. Pressures, to be safe, are not allowed to go beyond 25 to 30 mm.Hg. (17).

Oxygen, if available, can be introduced by connecting a delivery tube to a nipple located in the air intake valve orifice of the bulb. When oxygen is being used the apparatus may carry on as a respirator when the baby has started to breathe spontaneously. This is made possible by wide bore openings throughout and low resistance valves.

Although our resuscitator may bear resemblance to the Goddard-Bennett-Lovelace or G.B.L. hand resuscitator (18, 19), the mechanism of which is not familiar to us, its indications are quite different. Our resuscitator is designed for routine resuscitation and to inflate easily distensible lungs, whereas the high mask-pressure hand resuscitator appears to be intended mainly for cases of severe atelectasis, where cohesive forces are beyond ordinary means of separation without danger of alveolar rupture. We hope that the G.B.L. hand resuscitator will soon be available to us to supplement our instrument in those occasional cases of tenacious atelectasis requiring time-limited, controlled high pressure impulses.

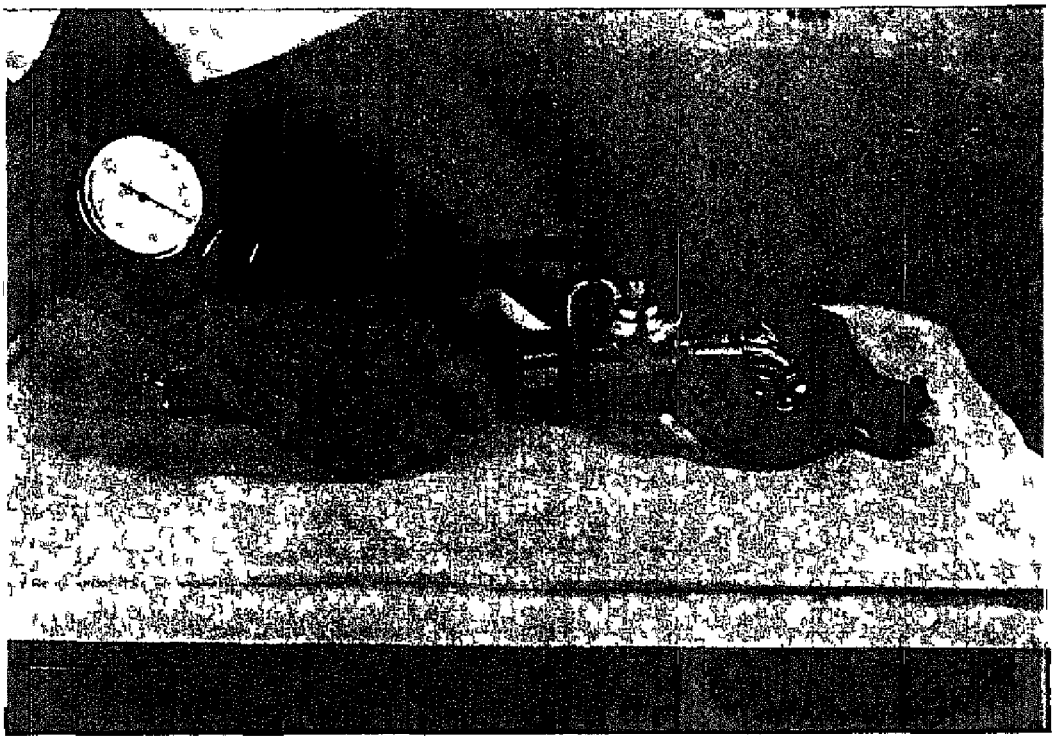

FIGURE 1 Self contained semi automatic infant resuscitator with mask showing manner of fixing blood pressure manometer to wrist for extemporaneous pressure control

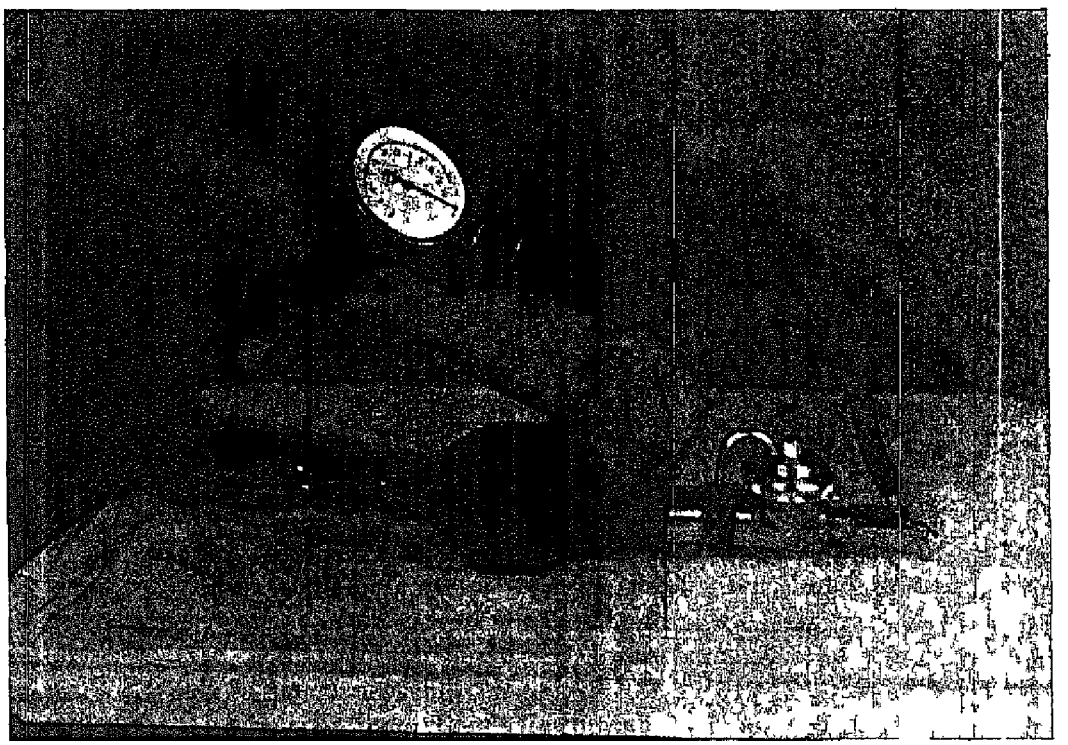

FIGURE 2 Semi automatic infant resuscitator fitted with endotracheal connector and oxygen delivery tube

From our preliminary clinical trials, we have reason to believe that this low cost resuscitator (fabricated by us from standard anaesthesia accessories) will be of value to the paediatrician, obstetrician, general practitioner, anaesthetist, and possibly untrained personnel in emergency situations. Further clinical evaluation is required before assessing the usefulness of the apparatus.

Figure 1 illustrates the resuscitator with mask ready for use as a self-contained unit and shows the manner of adjusting the blood pressure manometer.

Figure 2 shows the resuscitator fitted with endotracheal connector and delivery tube from an oxygen supply tank.

Summary

The anaesthetist is well qualified as a specialist to train other doctors and lay personnel in methods of resuscitation. A plea is set forth for a widespread training programme.

The prevention and treatment of respiratory obstruction can be a life-saving procedure in itself, and simple methods for maintaining a clear airway are described. Cases of severe respiratory obstruction in imminent danger of death can be saved by the introduction of a number fourteen trocar through the crico-thyroid membrane, thus providing more ideal conditions for a low tracheotomy.

The time factor is insisted upon in starting manual artificial resuscitation in drowning victims.

Should apparent cardiac arrest accompany cessation of respiration, simple methods of heart stimulation are recommended to be applied simultaneously with artificial respiration.

In an emergency, artificial respiration should be started with immediately available methods such as manual artificial respiration or mouth to mouth breathing.

It is explained that mechanical methods of artificial respiration are intended to replace the operator who has initiated resuscitation by manual methods.

Different types of mechanical devices are described and the advantages of self-contained units not requiring a source of compressed air or oxygen to become operative, are made evident.

It is suggested that a bag and mask device be incorporated in all types of automatic resuscitators to meet individual exigencies of lung compliance.

The use of a Nomogram for patients undergoing long-term maintenance of artificial respiration in a tank respirator is a simple practical means of avoiding consequences of overventilation or hypoventilation.

Cuirass type respirators and the rocking bed are considered as weaning devices and are not recommended for use in apneic patients with low lung or thoracic compliance.

A new type of infant resuscitator incorporating the Fink modification of the Stephen-Slater valve is presented and described. The resuscitator is a self-contained easily transportable unit which is simple in design and operation. It is intended for routine use and is operated at controlled pressures. It is not to be confused with the G.B.L. hand resuscitator which operates at high mask pressures and time limited impulses.

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