Conclusion

A final word of warning with regard to purulent or faecal fistulae in the region of the terminal ileum is that there is a tendency for some of these patients to develop small-bowel obstruction after even slight abdominal operations. They would appear to be balanced on the threshold of obstruction, and are pushed over the edge by any manipulations in that region. It is possible that such catastrophes would be avoided by a preliminary short circuit between the ileum and the transverse colon.

COMPLACENCY IN RESUSCITATION OF THE DROWNED

BY

F. C. EVE, M.D., F.R.C.P.

The manuscript directions for resuscitation by the Schäfer method are in the hands (copyright) of the Royal Life Saving Society, who still regard the method as completely adequate. But knowledge of the very intricate subject of respiration has naturally advanced much since Schäfer's day, and an attitude of complacency will cause us to drift behind other countries. An excellent paper by Surg. Lieut. G. H. Gibbens (1942) has given us a useful jog. He had been bitterly disappointed with Schäfer's method when he used it in his ship on drowning cases—now so urgent a problem. Instead of the normal elastic inspiration on removing pressure to which he was accustomed in normal subjects, the victim's abdomen and thorax "felt like putty." Schäfer's method relies for inspiration on elastic recoil, and this was absent owing to lack of muscular tone. He therefore adapted to ships my rocking method (Eve, 1932), in which a dozen times a minute the patient (lashed to a stretcher) is rocked, face downwards, through a total angle of 60 to 90 degrees on a pivot—provided either by a trestle or by a rope from hammock hooks passed under the middle of the stretcher. On this see-saw the weight of the abdominal contents pushes and pulls the diaphragm alternately up and down by a piston action which is actuated by gravity and does not depend on elastic recoil for inspiration. The ventilation thus secured is quite adequate, and is equal to Schäfer's in the normal subject (Killick and Eve, 1933). The air can be felt, and heard, passing in and out freely; there is no need for voluntary breathing. A manual method is used till rocking has begun. On shore, a builder's two-wheel hand-cart would do well for rocking. Prof. Cordier of Belgium points out that in Scandinavia and Eastern Europe Silvester's method—in spite of its disadvantages—is considered more efficient, especially when tested on the warm cadaver which is toneless. They advance excellent reasons for this preference, which are too lengthy to quote here.

Schäfer's Method

On reading Schäfer's (1907-8) splendid Harvey lecture I see that he started experiments in the dead-house, but found rigor mortis an insuperable difficulty; warm cadavers are not mentioned, nor are drowning cases. Then he proceeded to anaesthetized dogs (drowned) and afterwards to normal humans. Speaking of his method, he says that you should "press gradually for three seconds with both hands close together flat on the back over the loins; the fingers extending over the lower ribs. . . . Of course, on relaxing the pressure the same volume of air must pass in again as the chest resumes its former shape and size."

Unfortunately, this perfectly natural assumption, justified by his experiments on normal people, does not hold good in the nearly drowned, in whom the elastic tone of the respiratory muscles fails progressively. Later, he modified his directions

so as to compress the diaphragm only; but with large hands and small loins the ribs cannot always be avoided—neither, in my opinion, can it be an important point when fighting to save a life.

Other Imperfections of Schäfer's Method

The fact is that Schäfer's method has many well-known advantages and may be the best manual method; but it is not a perfect method, and it is deplorable complacency—especially in these days of U boats—not to make every effort to find a better one. We must think not so much of the very numerous successes of Schäfer's method but rather of the distressingly greater number in which it fails, and try to diminish this. A drawback of Schäfer's method is that the weight of the shoulders and upper back opposes inspiration. This, in other countries, has been met by a second operator, who lifts the folded elbows (arms extended high over the head) upwards from the ground during inspiration—thereby greatly improving ventilation and circulation (Hederer). Radiographs have recently shown (Barclay) that in the prone position the diaphragm is pushed up into the full expiratory position, and this second drawback would be increased in the toneless body. This is partly countered (Henderson, 1937) by extending the arms above the head, but both of these methods rely on muscle tone.

The main defect in the nearly drowned is muscular tone, both for circulation and for respiration. It is therefore useless to judge any resuscitation method by its effects on normal persons: the best criterion is the toneless warm cadaver, and I have rocking stretchers at various hospitals to test this aspect.

Tone of the Diaphragm

The diaphragm is the chief and only indispensable muscle of respiration. It achieves inspiration by contracting its high dome into a low dome. In the warm cadaver, as it has lost all tone, the diaphragm is pulled fully up by the elastic contraction of the lungs, and by the pressure of the abdominal contents.

In the semi-final stages of incomplete death, of the three methods of resuscitation Schäfer's will be the first to become impotent with the loss of elasticity (due to tone of the diaphragm), on which he relies for inspiration; Silvester's method will still have some elastic recoil around the ribs to rely on: the piston action of my rocking method should work even more freely as the tone of the diaphragm declines. How swiftly this may happen was shown by H. W. Haggard (U.S.A.), who tried artificial respiration on a man who had just had a fatal heart attack. Ventilation of the lungs was normal at first, but after 10 to 15 minutes it failed completely. The asphyxiated nerve cells of the bulb and spinal cord which maintain the muscles in tone had died, so that the lungs collapsed in the toneless thorax. Henderson (1937) demonstrated another instructive point by measuring the total air respired in a quarter of an hour by various students. Then he tried artificial respiration on them and found the same figure, however hard the operator tried to increase the ventilation of the lungs. The respiratory centre—amazingly sensitive to CO₂—knew exactly how much ventilation was necessary, and by modifying the tone of the diaphragm set the stroke of its piston to give the correct ventilation both in natural and in artificial respiration.

Attempting Better Methods

The trouble with apparatus for the rocking method is that it may not be at hand when needed; but, in a ship, a stretcher which can be rocked could be instantly available, and if resuscitation drill is practised the interval between the victim's lying on the deck and rocking on the stretcher will already have been reduced—with my later gadgets—to 25 seconds. I find, from the officer responsible for first aid in one of the small ships (a mine-sweeper) which carry out many of the rescues from drowning in convoy, that there is no difficulty—as he showed me—in storing, suspending, and rocking a stretcher; he was enthusiastic about it. The short boat journey to the ship is the weak but vital stage. Thwarts and crowding may render the Schäfer method impossible in a boat. So our St. John men at Beverley are trying rocking each other on the four bent forearms of two men (opposite), with their two pairs of legs steadied by a thwart between them. Improvements

need working out; e.g., for the two operators to grasp mutually a pair of rings like deck quoits: suggestions are welcome—if tried out. When the method, even in its provisional form, was tried on me in a ship's lifeboat it seemed quite effective. Mr. Akrill, our local first-aid expert, whose help has been invaluable, has to his credit a resuscitation from drowning after 70 minutes of artificial respiration by alternate Schäfer and Silvester—aided by epigastric pushes in expiration, which would help both heart and diaphragm. This seems an excellent plan, for if the current of air at the mouth is not satisfactory by one method you should try another. A local unsuccessful case (by Schäfer only) was that of a short stout woman from whose lungs a pint and a half of water had first been emptied. Such people already have a high diaphragm, and in the prone position her heavy weight pressing on her prominent abdomen would force it higher still. Silvester's method might well have been better for her. Schäfer's method does not always drain away the water as alleged, for in a Hull child recently the water merely bubbled to and fro. Water in moderate amount is quickly absorbed from the lungs into the blood. Drowning cases always suffer from shock, so that in the U.S.A. they are resuscitated in the head-down posture—say 10 degrees—if sloping ground allows. Gibbens points out that this would impede inspiration, but it should help the heart—probably more important.

Other Respiratory Aids

In its very complete review of "breathing machines" the Medical Research Council (1939) states: "For short emergencies we would recommend insufflators of the Oxford or the McKesson type actuated by oxygen pressure and a tilting stretcher based on the Eve principle, which is almost fool-proof and needs little attention; its use is a simple extension of instruction in manual methods of artificial respiration. It is therefore particularly valuable in industrial establishments and places where respiratory accidents are frequent." Gibbens (1942) has shown its adaptability to ships. Messrs. Siebe Gorman are (presently) making to my design a simple latticed metal stretcher in which bandaging is nowhere impeded by canvas. If desired it can be rocked, and the rock is reinforced by a jerk—whereby the momentum of the moving viscera and blood columns is valuably enhanced.

The respiratory centre judges the need for deeper respiration by the minutest increase of CO_2 in its blood. Hence inhalation of CO_2 , preferably 5 to 8% in O_2 , is a potent respiratory stimulant, telling the centre to cause deeper breathing so as to wash out of the lungs the unnatural excess of CO_2 . The Novox apparatus is efficient for this purpose, its tube being led via the pivot of the stretcher.

Warmth.—The value of this in shock is well known, and every drowning case is shocked. Heat production is therefore minimal and heat loss very serious, especially in a cold wind and from the evaporation of wet clothes. Hence, besides blankets and hot-water bottles, impervious coverings such as waterproofs are very valuable. Heat loss can only be visualized by the imagination, and even nurses often fail to perceive it. Always we must bear in mind that in resuscitation it is the nerve cells of the respiratory (and spinal) centres which we have to revive with warm circulating blood, oxygenated by moving lungs. With circulation vastly enfeebled the neck and its vital nerve cells may rapidly be chilled. I (Eve, 1900-1) found that the sympathetic nerve cells of the rabbit were killed by a temperature of 50°C ., and were paralysed, till re-warmed, by cooling 20°C . below blood heat. High-grade nerve cells should be still more sensitive to cooling, and their blood vessels may be constricted by chill, so that it seems well worth while to apply a rubber hot-water bottle to the cervical spine as soon as Schäfer or rocking has started. A. T. Cholerton writes (March, 1943) from Moscow: "In this winter offensive, even a lightly wounded man, if left lying, dies of frost-shock in 10 to 30 minutes."

Another argument for warmth—to the chest—is that plain muscle, with which the lungs are well supplied, contracts with cold and relaxes with warmth. This is evident in many parts of the body, conspicuously in the scrotum and veins of the hands. Hence the lungs should shrink when chilled externally or internally by cold air and evaporation from redundant ventilation. Warmth should relax the lungs and assist inspiration.

It would be valuable to compare the statistics of successful resuscitation after drowning in cold seas and warm. In Australia there were for ten years no failures in resuscitation on bathing beaches patrolled by the Australian Surf Life-Saving Association. Rescues were prompt and a modified Schäfer's method was employed. But I have seen pictures of these fine young men carrying also a rocking stretcher.

Heart and Circulation

The very important needs of the heart and circulation are not studied enough here. In the U.S.A., Henderson (1937) considers that hypotonia is the essence of shock, and he finds that when, as in drowning, the tone of the muscles is lost the heart fails because it does not get enough blood from veins unsupported by muscle tone. Obviously an empty pump can't work. This theory rings true to me, and I see no inadequacy in it (as he does). For let us substitute—for the heart and artery, veins, and capillaries of the leg of a standing person—a rubber pump and a long vertical rubber U-tube with some cotton-wool in the bottom of it to imitate the capillary resistance. The model will work all right unless the venous return half is replaced by thin-walled tubing, which the blood will distend and in which it will stagnate without reaching the heart. Even if this model is laid horizontally in bed its arterial side will be ill filled (and thus low-pressured) until the "heart" is filled by raising the bed-foot. Similarly, the venous return to the actual heart will fail when the veins and capillaries are deprived of their external support by the muscles universally losing their tone as they do in drowning. Schäfer's method is helpful here because incidentally it squeezes venous blood from the abdomen to the heart. The well-intentioned efforts of first-aiders to stroke venous blood from the limbs appear to me rather fatuous. In this respect the rocking method should be pre-eminent, though the point should be proved by the physiologists; for while gravity will propel the venous blood alternately from the legs and the extended arms towards the heart, the valves in the veins and right heart will prevent the return current. Similarly, the alternating pressures in the chest fill and empty the pulmonary blood into the left heart. The accompanying diagram clarifies

Diagram analysing the effects of rocking on the two circulations

the various valuable effects of rocking on the two circulations and the coronaries. Smart but slow rocking (10 to 12 a minute) is probably best for the circulation. As you rock try to visualize the flow of blood in the long veins and arteries.

Anaesthetists find (personal letter from Mr. G. H. Colt) that the stopped respiratory centre seldom restarts working unless it is congested; in the rocking head-down posture one can see and feel congestion in the head. This may also restart a stopped heart.

Conclusions

Artificial respiration is a very misleading and therefore, maybe, a life-losing name. For resuscitation is not a simple

matter of ventilating the lungs; it is a trinity of *ventilation*, *circulation*, and *warmth*. Essentially it is an attempt to revive asphyxiated *nerve cells* in the medulla and spinal cord by a circulation of warm blood oxygenated by moving lungs.

Ventilation.—When asphyxiated by failure of respiration or circulation these nerve cells gradually die—usually in a few minutes, but they may remain viable for an hour, rarely more. When they are dead all hope is gone. As they die, the elastic *tone* of the muscles—which they maintain—progressively declines. When the diaphragm has in this way lost all its tone the lungs contract by their own elasticity; they pull the diaphragm right up and become deflated (as in the warm cadaver). At this stage (1) Schäfer's method has become impotent because the elastic recoil of the diaphragm (for inspiration) has gone; (2) Silvester's method will still produce some ventilation owing to elasticity in the thorax independent of its pectoral muscles; (3) the rocking method will effectively shift the flaccid diaphragm up and down independently of tone, and hence should save cases in which loss of tone had gone too far for the Schäfer method to revive.

Circulation.—The heart muscle itself does not die quickly, for after drowning it can be revived by perfusion with oxygenated saline solution—a baby's heart after several hours. The diagram shows how well the head-down tilt perfuses the coronaries. But in shock (hypotonia of muscles) the heart may also fail from mere emptiness because insufficient venous blood gets back to it through veins and capillaries unsupported by tone of muscles. Hence in drowning cases (always shocked) it is important to encourage venous return, as by the compression of abdominal veins which occurs in Schäfer's method or, far more potently, by the rocking method—as already explained. To fill the heart and respiratory centres with blood a head-down slope of about 10 degrees (1 in 6) should be chosen (as on a beach) for manual resuscitation when possible. To fill an empty heart is a quick way to restart it beating. When you tilt steeply to empty out water you incidentally fill the heart and change the coronary blood.

Warmth.—This is indispensable in shock treatment generally—e.g., by hot-water bottles and blankets; also by impervious coverings, to prevent heat loss from evaporation and cold winds. Nerve cells are paralysed by cooling but revive at once on re-warming. With a crippled circulation the indispensable nerve cells in the upper spinal cord will quickly cool and their blood vessels constrict. Hence it may prove very important to warm the back of the neck by a rubber bag early in the resuscitation.

Finally, transcending all else, it is essential to start Schäfer's method instantly: if ventilation (checked at the mouth) is satisfactory, persevere; if not, try Silvester plus expiratory pressure on the upper abdomen, or, better, proceed to rocking if available.

Confronted with so many lamentable failures of Schäfer's method our Naval medical officers seem entirely justified in advising for preference the rocking method, which is now included in BR 25/43, "First Aid in the Royal Navy."

Explanation of the Diagram

Since gravity in rocking affects only the longitudinal components of the blood vessels they may be represented as straight tubes. For clarity, the vessels of the arms (extended on the stretcher handles) and head are omitted: they are similar to the legs. Natural circulation is assumed to have stopped. The piston of this air-pump is formed by the weight of the abdominal viscera (capped by the flaccid diaphragm) sliding up and down. The patient is prone on the rocking stretcher.

When *head-down*, venous blood from the legs and abdomen falls past the right heart into the lung capillaries—reflux prevented by valves in the right heart and leg veins. Veins in the head and extended arms fill. The right heart fills (which may restart it). The aortic valves are banged shut by a pressure of 2 to 3 feet of blood: hence blood is forced into the coronary arteries and joins the stream flowing from the right heart into the lungs (course indicated by the dotted line C).

When *feet-down*, the venous blood which has just been oxygenated in the lungs cannot flow back into the right heart or into the legs (valves closed), but is free to flow past the open aortic valves into the leg capillaries. Blood from head and extended arms refills the right heart.

Thus analysed, slow rocking appears able to aid, or even to maintain unaided, both circulations in the drowned—including the all-important coronary circulation. Silvester's method—unless the epigastrium is compressed—seems to be ineffective on the circulation: Schäfer's method should push some abdominal blood into the lungs but perhaps no further.

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BLAST INJURY TO THE ABDOMEN BY DEPTH CHARGE

BY

D. DENHAM PINNOCK, M.B., F.R.C.S.

Lieut.-Col., R.A.M.C.

AND

PAUL WOOD, M.D., F.R.C.P.

Lieut.-Col., R.A.M.C.

As little information has been published concerning the effects of blast injury to the abdomen the following cases are recorded in order to supply additional data. Under conditions of active service it is not possible to do justice even to the very scanty literature. However, it can be mentioned that, in Zuckerman's (1940) experiments on animals exposed to air blast, haemorrhagic pulmonary lesions were the chief feature, and that according to Hamilton Bailey (1942) blast injury to the abdomen may be followed by melaena. That author also states that, although laparotomy has been performed with negative findings on several occasions, rupture to the colon has been revealed by timely operation. Breden, d'Abreu, and King (1942) record a number of cases of abdominal blast injury from depth charge, and they refer to papers by Atkins (1940) and by Gordon-Taylor (1940). These records show that persons swimming in the water close enough to an exploding depth charge may suffer blast injury to the abdominal viscera, characterized by shock, haematemesis, melaena, and pyrexia; recovery may take place without surgical intervention; perforation of the gut may sometimes be successfully treated by surgical repair; many of these patients have died before conditions were suitable for careful study or surgical help. Associated blast injury to the lungs is common.

In December a naval vessel was torpedoed and sank rapidly. The crew took to the water and were swimming away from the ship when two depth charges exploded in quick succession. Some who had managed to clamber on to rafts escaped all injury; others who had swum further afield felt the shock but suffered no ill effect; while about 15 felt as if kicked in the stomach or pelvis and were sufficiently injured to be taken to hospital. Of these 15, five were seriously ill and form the subject of this report. The other ten did not appear ill and had no symptoms suggesting serious trauma to internal organs; they recovered uneventfully.

The history given by four of the seriously ill patients was very similar (the fifth was more or less unconscious owing to a head injury received on the ship): they were all swimming in the water with their heads out and supported by life-jackets. Three felt as if kicked in the stomach, the other in the back of the pelvis. After receiving the injury they were still able to swim until they were picked up. They were all seen in hospital within four hours of the event.

Case I

This patient had most of his chest out of the water when the depth charge exploded, for he was trying to lift himself on to