movement of the diaphragm may be more easily detected, or an inverse movement of the epigastrium—that is, a sucking in by that area during inspiration—may be noted. In cases of doubt I have found it of assistance to place the patient on his side, the abdominal wall being then in a neutral position, when it is easy to detect lesser degrees of excursion. Relative weaknesses of intercostal movement may be difficult to assess, but it should be recognized that there may be involvement of upper or of lower intercostals only or of all intercostal muscles.

Minor degrees of weakness may not require any accessory mechanical aid. When insufficient pulmonary ventilation occurs, however, respiratory treatment should be instituted, and the earlier the better if the involvement is of any degree. It is remarkable how promptly, if the respiratory treatment is going to do any good, the patient responds to it, falling asleep almost at once. A large number of respirators of the "Both" Nuffield cabinet type are distributed in the country, and this is the type of machine which is likely to be used for these cases. Patients with severe bulbar paralysis, having great respiratory difficulty, inconvenienced by collections of mucus in the pharynx, are extremely bad subjects for respirator treatment; their condition may even be worsened by putting them in respirators. But when paralysis is due to involvement of the phrenic or to a dorsal lesion, causing respectively diaphragmatic or intercostal weakness or paralysis, the respirator is of considerable value. Cases with extreme forms of respiratory paralysis of the spinal type may, of course, be kept alive for long periods in a respirator, but the end-result is often very disappointing. The intercostal muscles in particular seem prone to permanent weakness, and diaphragmatic recovery is often only partial.

The management of the patient in the respirator is a matter of careful detail into which the present space will not allow me to go. Much of it is a matter of highly skilled nursing. When there is complete respiratory failure owing to lesions in the cord the problem may arise, as it has in some of our cases, of keeping the patient alive and conscious during the brief periods when the cabinet is opened for change of bedclothes, skin treatment, catheterization, etc. Some form of accessory artificial respiration has to be provided, and for this the McKesson resuscitator is of value. It rhythmically inflates and deflates the lungs through a face mask closely applied, as in an anaesthetic apparatus, using pure oxygen or a mixture of CO₂ and O₂. The eventual weaning of the patient from the respirator may be a long and wearisome business, extending over months. When recovery is taking place he is allowed to breathe for gradually increasing periods without respirator aid, but sudden dyspnoea may occur and a rapid return to the machine may be necessary.

Statistical Summary

Of the 66 cases on which this article is based the age grouping is as follows:

Ages	Cases	Ages	Cases
0-5	22	26-30	5
6-10	15	31-35	4
11-15	11	36-40	0
16-20	6	41-45	1
21-25	2		

Cases showing disturbance of cranial nerves, 19; nuchal rigidity, 35; inability to sit up, 16; abortive attacks, 9.

Symptoms shown after onset and before paralysis (if any): vomiting, 37; headache, 46; sore throat, 11; catarrhal conditions, 11; rigor and shivering, 7; pain in limbs, 18; backache, 17; constipation, 6 cases.

Unusual manifestations: vertigo, 4; double vision, 3; nystagmus, 3; inequality of pupils, 2; facial paralysis, mostly unilateral, 5; diaphragm affected, 9; intercostal muscles affected, 7; masseter muscle weak or paralysed, 6; sternomastoid, one or both affected, 10; paralysis or paresis of pharynx, 9; retention of urine, 8 cases.

Of 42 cases with paralysis or paresis of limb or limbs: one upper extremity only affected, 9; one lower extremity only affected, 13; upper and lower extremities affected, 8; both upper extremities affected, 6; both lower extremities affected, 6 cases.

ARTIFICIAL CIRCULATION PRODUCED BY ROCKING

ITS USE IN DROWNING AND ANAESTHETIC EMERGENCIES

BY

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Valuable lessons can be learnt from the following case of drowning treated by manual rocking. In this method the victim, instead of being rocked on a stretcher resting on a trestle, is supported face downwards on the forearms of two operators, facing each other, who tilt the body 45 degrees each way alternately. This method I have fully described and illustrated in a booklet (Eve, 1946). There I had to admit that this new method was only on trial, because it had been tested in but one case—that of a drowned child, successfully revived but inadequately observed.

Case Report

The present case was treated by Mr. A. Akrill, a highly experienced first-aid and an acute observer who has been most useful to me in working out this manual method of rocking. He tells me that, in the Beverley shipyard where he is employed, a boy of 14 fell into the swollen River Hull (temperature 45° F. (7.2° C.)) on a cold November day in 1946. He soon sank, and his body was dragged out by grapnels 15 to 20 minutes later, 100 yards downstream. Mr. Akrill, with two trained helpers, arrived in two to three minutes and at once started manual rocking. The first head-down tilt drained out water freely, but during rocking the face soon became congested and blue. Schäfer's method was therefore tried—then and for brief periods later. It stopped congestion but proved less effective than rocking for ventilation and in expelling mucus. (A curious feature was that the lower jaw was propped slightly open by the tongue but was rigid till forced open.)

After about 30 minutes of mainly rocking the face changed from cyanosis to a natural pink colour, showing that an artificial circulation of oxygenated blood had been created. The boy seemed warmer too, necessitating further precautions against heat-loss. Great hopes of success were thereby raised, and after 65 to 70 minutes from the start Dr. W. H. James arrived. He tells me he found the face pale but not cyanosed, the heart inaudible, the pupils widely dilated and inactive, the eyeballs flaccid, and there was no current in the distended jugulars. Hence further efforts were abandoned. The long submersion in such cold water would make recovery highly improbable. Mr. Akrill found that he could be more useful at the head end instead of at the feet—as pictured in my booklet. For there a third man could, by his two thumbs, hold the rubber hot-water bottle to the neck, wipe mucus from the nose frequently, and help rocking with his fingers under the armpits. The boy in his wet clothes would weigh about 7 st. (45 kg.); above 10 st. (63.5 kg.) a rocking stretcher would be needed, and would always be preferable. The new Akrill thigh-grip proved efficient and labour-saving, and also kept the legs straight. These new achievements may mark a mile-

stone in resuscitation. For if rocking can create a circulation in the hopelessly dead it should revive the more newly dead.

I submit that this unexplored aspect of resuscitation may be interpreted in the light of the careful experiments on drowned dogs at Toronto (1939). There the post-mortem examinations showed that the right heart and great veins were invariably engorged with blood and the left ventricle was empty. From this I infer that the final stoppage of the circulation was due to the fatal inability of the right heart to overcome the resistance of the pulmonary capillaries, perhaps increased by their spasm induced by cold. As we shall see later, rocking an adult will produce intermittently a hydrostatic pressure in the pulmonary artery double the normal 35 mm. Hg. Thus during rocking the head-down tilts would force by gravity venous blood from the trunk and legs into the lungs, congesting them further as shown by the pink frothy mucus observed in this case. In the feet-down tilts the overflow blood from the lungs would fill the empty left ventricle and pass on oxygenated to the feet and trunk; the right heart would fill from the head and extended arms. Thus an artificial circulation, shown by pink cheeks, was in fact produced by rocking.

The Toronto investigators also found that in drowned dogs the heart ceased to beat expulsively 11 to 17 seconds after respirations stopped—with auricular-ventricular block. Then the ventricles either fibrillated (incurable), or continued to make little beats or twitches up to 20 minutes (an hour in one dog). Since the head-down tilts produce a strong pressure urging the blood through the coronary arteries it seems reasonable to hope that rocking may induce some of these limping hearts to start pumping again when their muscle is fed—besides overcoming the fatal traffic jam in the lungs. The heart may be restarted so long as it is not overdistended—beyond the limits of Starling's law. If rocking was impracticable a few brief suspensions by the heels should be very valuable. Alternatively, Dr. A. Tindal (1945) succeeded in restoring pink cheeks to a drowned boy by chest compressions combined with inversion, but it was too late for revival. Sir Leonard Hill showed in dogs that repeated total inversions could maintain circulation. It seems to me that this full range of rocking could be applied with advantage in asphyxia neonatorum. In the Toronto experiments amyl nitrite inhalations saved several dogs in late asphyxia; no other drugs were helpful. This is a valuable hint that spasm of plain muscle, in the coronaries and perhaps in the lungs, contributes to death and that blood must be forced through them by head-down tilts aided by amyl nitrite.

Hydrostatics of the Stopped Circulation

In an adult with a stationary circulation tilted head-down at an angle of 45 degrees the head of pressure in the pulmonary artery and the aorta for the first few moments will be

$$h \times \sin 45^\circ \times \frac{\text{specific gravity of blood}}{\text{specific gravity of Hg}} \times 25.4 \text{ mm. Hg.}$$

where h is the length of the column of blood—i.e., the distance between the heels and the lung root. In a subject of height 5 ft. 10 in. (1.78 m.) this distance is 56 in. (1.42 m.), which gives a head of pressure in the pulmonary artery under the above conditions of 78 mm. Hg. In life this pressure averages only 35 mm. Hg (Samson Wright).

Hence the head-down tilts of the rocking method, each lasting four seconds, should be adequate to force blood from the aorta through the coronary circulation, to force blood through the lungs into the left heart (oxygenated), and of course to fill the right heart. The head-up tilts of three seconds each pass on the newly acquired blood, oxygenated, along the aorta and refill the right heart from the reservoir of the extended arms and head. While all

blood currents are thus reversed, the valves in the heart and veins ensure that they all flow in the right direction.

If the patient is held up by the heels the above pressure is increased 43%, though this does not create a circulation. But unless quickly effective it should not be long sustained lest the congested devitalized capillaries in the lungs and head start to leak. And pressures soon diminish because the uppermost blood vessels empty.

Resuscitation in Anaesthetic Emergencies

Drowning may, I think, be regarded as a swift anaesthesia by anoxia combined with some asphyxia; treatment of emergencies is similar in both. If breathing stops, the anaesthetist can pump oxygen into the lungs by rhythmic pressure on his rubber bag. But if the pulse stops too the heart needs much more help than this, and we have already shown how rocking can aid the circulation or create one artificially. Dr. Gordh (1945), the great Swedish anaesthetist, revives very bad cases by a 30-degrees head-down tilt (to fill the heart) and by giving oxygen. This is excellent, but it is a half-measure. It cannot maintain a circulation, and if prolonged would produce congestions: it does not renew the blood in the brain (essential) nor does it utilize the head and arms to refill the heart.

If, on the evidence now available, anaesthetists wish to avail themselves of the rocking method, the promptest service would be obtained with the 1945 model of the Riley rocking stretcher, made by Messrs. Siebe Gorman, of London, which could hang on the wall of the anaesthetic room. When lifted, the legs of this model drop and lock themselves into a trestle for instant rocking. In a few seconds it could be placed in line with the operating table. Four persons could then lift the patient his 6-ft. (1.8-m.) journey without bending him. The surgeon would guard the wound manually. Rocking could start at once, face up or down. As in boat-drill, the staff would need occasional practice. Some operating tables are made to rock but would need anti-slipping devices for safety. Ventilation of the lungs by rocking is so ample that oxygen may prove redundant and CO_2 more toxic than useful in late asphyxia; but there is provision in the Riley rocking stretcher to give both if desired. For a stopped circulation rocking may replace the desperate remedy of cardiac massage. In operating theatres in which a technician is employed he would be in his element in adapting local resources to the practical problem of swift resuscitation by rocking—aided by hints from my booklet.

To sum up: resuscitation in severe cases demands artificial circulation as well as artificial respiration: ventilation of the lungs alone may fail even with oxygen. With a newly stopped circulation our conscious aims—though we cannot see them working—are, by prompt rocking, (1) to force the dammed-up venous blood right through the lungs; (2) to force blood through the coronary circulation; (3) to fill both sides of the heart. Thus the stopped heart may be coaxed to pump again and the oxygenated circulation—artificial or restored—may be in time to revive the respiratory centre.

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