SOME STUDIES ON EXTERNAL CARDIAC MASSAGE

BY

W. J. PRYOR

Christchurch Hospital, Christchurch, New Zealand

SUMMARY

Water-filled balloons were placed inside the pericardium of cadavers from which the heart had been removed. The volume displaced with each compression was measured during external cardiac massage. Radiographs showed that lateral displacement of the "heart" did not occur. Brachial artery pressure measurements were made and the value of elevation of the legs was noted. Pressures were obtained which were as high as those following cardiac compression by the open method. Appreciable ventilation of the lungs occurred during the application of this technique in cadavers.

Since Kouwenhoven, Jude and Knickerbocker (1960) published their paper on external cardiac massage in 1960, there has been considerable interest in their technique, as it was realized that it could perhaps be lifesaving in circumstances where thoracotomy was impossible, as, for example, in electrocution in the field, or cardiac arrest outside the precincts of an operating theatre. Most of their experimental work was carried out on dogs and, though very convincing, the question arose as to its effectiveness in the human being.

The idea sounds reasonable anatomically, if it is assumed that a thoracic cage will allow sufficient antero-posterior compression of the heart, between the sternum in front and the vertebral bodies behind. The pericardium is thought to prevent lateral displacement of the heart, ensuring that the compression does actually take place.

With these ideas as a starting point it was decided to try to test whether the mechanics of the technique were sound. To this end a rubber balloon was constructed to the approximate shape and size of a human heart, and this was connected by a short piece of rubber tubing to a long piece of glass tubing. The whole system was then filled with coloured water.

The water-filled balloon was then inserted inside the pericardium of a cadaver whose heart had been removed, and the pericardium sewn up again. The rubber tubing was led out through the chest wall and the latter was sewn up. Coloured water was then added to reach an arbitrary mark on the glass. Compression was then applied to the sternum as recommended by Kouwenhoven, Jude and Knickerbocker (1960), and the new level to which the coloured water rose was noted. By this means it was possible to calculate the amount of water displaced with each stroke, which amounted to approximately 10 per cent of the total volume in the balloon. (Total volume 404 ml; displacement 44 ml.)

The next step was to fill the balloon with water but to add a quantity of radio-opaque dye. Antero-posterior and lateral radiographs were then taken of the cadaver, first in the neutral position, and then while the operator was applying compression to the sternum.

The antero-posterior views (figs. 1 and 2) show that there was certainly no lateral displacement of the "heart" during compression, and the pericardium appeared to anchor it satisfactorily in this position. The lateral views (figs. 3 and 4) showed a reduction in the antero-posterior diameter of the heart of almost a quarter. These radiographs were of the body of an 80-year-old patient with ossified costo-chondral junctions, so that a much better mechanical effect could be expected in the younger and more mobile thoracic cage.

It was next decided to try to obtain direct pressure readings from the brachial artery while carrying out external cardiac massage. By arrangement with the resuscitation ward, who notified the author immediately following the death of a patient, it has been possible to obtain pressure...
recordings from the warm cadaver within half an hour of death.

The brachial artery was cannulated and attached to a pressure recording device by means of rubber tubing filled with citrate solution, and external cardiac massage carried out under varying conditions. The following two experiments are representative of the findings.

Experiment I (fig. 5).

In the first tracing (1) standard external cardiac massage was carried out, then at (2) and (3) both legs were raised to 90° to promote venous drainage. An increased pressure reading was noted.

Experiment II (fig. 6).

In this case at (1) standard external cardiac massage was carried out. At (2) the legs were raised, and at (3) (with the legs still raised) the chest was opened and open cardiac massage performed. The pressure recorded was no higher than that obtained by external cardiac massage.

This is an important finding because it suggests that, although the recorded pressures are comparatively low, external cardiac massage would appear to be at least as efficient as the open method.

Cardio-respiratory movement.

In two cadavers a cuffed endotracheal tube was passed into the trachea and a Wright anemometer was connected to the end. Readings of 7½ to 8 l./min were obtained. Hence it is believed that a single-handed operator can produce some ventilation of the lungs by external cardiac massage alone.
FIG. 3
Lateral view of the "heart" at rest.

FIG. 4
Lateral view of the "heart" while sternal compression is being applied. Note the reduction in antero-posterior diameter.

FIG. 5
Brachial artery pressures obtained during external cardiac massage in the cadaver of a 38-year-old patient, 45 minutes after death.
1. Standard external cardiac massage.
2 and 3. As above but with legs raised.

FIG. 6
Brachial artery pressures obtained during cardiac massage in the cadaver of a 73-year-old patient; 10 minutes after death.
1. Standard external cardiac massage.
2. As above with legs raised.
3. Open chest cardiac massage. Note height of pressure tracing (disregard baseline shift).
METHOD OF PERFORMING EXTERNAL CARDIAC MASSAGE

Two operators are necessary, one at the head end to provide pulmonary ventilation, and the other to carry out external cardiac massage. The latter kneels at right angles to the patient and on his left side. The author modifies the technique of Kouwenhoven, Jude and Knickerbocker slightly by making a fist of the left hand and placing it over the xiphisternum with the right hand over it to reinforce the thrust. The sternum is then pressed firmly backwards 60-80 times per minute (this requires a fair degree of force in the adult). A firm base is necessary to press against, with the patient on the floor, or with fracture boards inserted if the patient is in bed. Both legs are raised 70 to 90°, to improve the venous drainage (fig. 7).

CASE HISTORIES

In the following two cases it is thought that external cardiac massage produced a dramatic result.

CASE 1. A lady of 72 years was admitted in status asthmaticus and had a 15-year history of “heart trouble.” On examination she was deeply cyanotic with marked dyspnoea and while undergoing examination she collapsed, respiration became gasping and then ceased, and she became pale, cold and clammy, and finally completely limp. Her carotid pulse was impalpable and the pupils partially dilated and unreactive to light.

External cardiac massage was commenced with the right hand behind the chest and the left hand pushing the sternum (the patient was propped up on pillows) at 50 to 60 compressions per minute. Two minutes later the pulse and feeble respirations returned. Nikethamide 6 ml and hydrocortisone 100 mg were given intravenously, and 45 minutes later the patient regained consciousness. She ultimately walked out of hospital with no demonstrable mental impairment or loss of memory.

CASE 2. A small boy of 7 years collapsed on return to the ward after tonsillectomy under halothane anaesthesia. The estimated time of cardiac arrest was some 3 to 4 minutes. External cardiac massage was started and this kept him a reasonable colour, but as the heart had not commenced to beat after a further minute it was decided to open the chest. As the skin was incised the heart started beating. A hypothermic regime was instituted for several days, during which time he showed marked signs of cerebral irritation, but finally made a good recovery. He was presented at a clinical meeting some months later when no signs of mental impairment were detected.

DISCUSSION

McKelvie and McKelvie (1961) reported on two cases in children in which external cardiac massage was successful, and they strongly recommend its use in the young in whom the thoracic cage is much more malleable. They doubt its
efficiency in the elderly, in whom the thoracic cage is more inelastic. The author agrees with Milstein (1961), who maintains that it is equally effective in the unconscious patient of any age.

The technique of external cardiac massage, especially in unskilled hands, it not without its morbidity and even mortality. Many complications have been reported, for example by Morgan (1961) and Baringer, Salzman and Friedlich (1961). These include haemopericardium, haemothorax, haemoperitoneum, ruptured spleen, laceration of the liver, and marrow emboli.

It seems clear that this method, which is now widely accepted, should be correctly taught so that the desired effect can be produced without undesirable complications.

It is suggested that teaching programmes should be instituted in hospitals. In addition it is recommended that a whistle and some form of appliance to facilitate expired air resuscitation should be placed in a plastic bag in each ward, together with a wall instruction sheet and a photograph of the procedure. The first person arriving on the scene after cardiac arrest has occurred will blow the whistle for help and commence external cardiac massage. The second person to arrive will commence expired air respiration. The author has shown that external cardiac massage itself is capable of effecting some ventilation of the patient’s lungs, and since there seems little point in first ventilating a patient whose blood is not circulating it is believed that the first essential is to attempt to restart the circulation. This manoeuvre is best carried out on the floor because it is necessary to have a firm surface behind the patient to enable external cardiac massage to be carried out efficiently.

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REFERENCES


SOMMAIRE

Des ballons remplis d’eau furent placés à l’intérieur de cadavres dans le péridicarde, dont le cœur avait été retiré. Le volume déplacé par chaque compression de massage cardial externe fut ensuite mesuré. Des radiographies montrèrent qu’il n’y eut pas de déplacement latéral du cœur. D’autre part l’auteur procéda à des mesures de la pression dans l’artère brachiale et il nota la valeur de l’élevation des jambes: Il obtint des pressions aussi fortes que celles survenant par la compression cardiaque par la méthode externe. L’application de cette technique à des cadavres eut pour résultat une ventilation appréciable des poumons.

ZUSAMMENFASSUNG