Abdominal Pumping

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ABSTRACT

This article reviews the author's experience with a form of interposed abdominal compression cardiopulmonary resuscitation (IAC-CPR) in the United Kingdom. The development of the technique based upon animal resuscitation, including the use of phasic compression (abdominal pumping) for the resuscitation of rats from 30 minutes of cardiac arrest due to hypothermia, is reviewed. A simple technique for clinical use is described. The technique uses a hard-covered book or bean-shaped board applied to the abdomen below the umbilicus and compressed alternately with cardiac massage while respiration is assisted. Anecdotal clinical results suggest that further controlled clinical investigation is warranted.

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My experience in the United Kingdom with a form of interposed abdominal compression cardiopulmonary resuscitation (IAC-CPR) has shown the technique to be effective in rats and of potential value for the treatment of cardiac arrest in human beings.

My investigations began with animal studies of cardiac arrest due to hypothermia. Early laboratory work on hypothermic cardiac arrest was based on two models. In the 1950s Niazi and Lewis anesthetized rats, cats, dogs, and a human being, and cooled them down until their hearts stopped, subsequently reviving them with assisted ventilation with oxygen and warming.[1–4] Andjus and Smith made rats rebreathe their own expired air until they became unconscious, then cooled the rats down until their hearts stopped, left them in cardiac arrest for up to one hour, and then revived them with artificial respirations and reheating.[5] My studies used a model similar to that of Niazi and Lewis,[1–4] except that during recovery the animals were given artificial ventilation with room air, not oxygen, since my colleagues and I wished to develop simple techniques of resuscitation that could be used by unskilled first-aid providers in situations where oxygen might not be rapidly available.

Rats were used in these experiments because of their physiologic similarity to human beings and because they were available cheaply in numbers sufficient for statistically significant biochemical studies. From the experience with rats and from findings in the literature about the effects of continuous abdominal compression for clinical trauma resuscitation, a procedure was designed for treating patients in low-cardiac-output states and cardiac arrest. Although a formal clinical trial has not been performed, I have used the procedure in a number of clinical cases. These laboratory and clinical experiences are summarized in this article.

REVIEW OF LABORATORY STUDIES

Adult rats were anesthetized with pentobarbital sodium (6 mg/100 mg body weight). They were then placed in iced water until first their respirations and then their hearts stopped; they were left there for 30 minutes after cardiac arrest, during which time their deep body temperatures fell to 3–8°C. They were ventilated with a Starling pump, using room air, and were warmed by radiant heat with a lamp. Usually 30–60 minutes elapsed between the beginning of resuscitation and return of spontaneous respiration; with this basic resuscitative care only three of 32 rats (9%) recovered.[6]

The study was designed with two goals. The first was to compare the neurologic and biochemical conditions of groups of rats at specific intervals[7–10]: 1) when anesthetized; 2) when their heart stopped; 3) 30 minutes later; 4) immediately after they started breathing spontaneously again; and 5) after about the same interval if they did not. The clinical and metabolic states of survivors were assessed during the subsequent days and weeks. The second goal was to determine whether we could increase the incidence of recovery from 30 minutes of hypothermic cardiac arrest.

It was soon found that when rats were artificially ventilated *during* the cooling as well as during resuscitation, 80–90% recovered.[6] This model is not useful, however, for the treatment of patients. If, for example, climbers were to fall on a mountainside in the cold, anyone nearby would immediately attempt to obtain help for them, rather than giving them ventilatory assistance while they were cooling.

We found that two other measures increased survival.[11] The first measure used centripetal intracarotid perfusion of about one-seventh of the blood volume of the rats, with either reduced blood, Krebs-Ringer solution, or normal saline; these infusions increased the incidence of recovery to about 50%. We presumed that saline acted by flushing the coronary arteries, in which the stagnant blood inhibited contraction of the myocardium. The second measure was given the name "abdominal pumping." After a hypothermic rat had been in cardiac arrest for 30 minutes, the researcher's thumbs were applied to the rat's abdomen and compressed approximately 240 times per minute for two minutes. The rats were then warmed and mechanically ventilated. The combined effects of intraarterial perfusion and abdominal pumping increased recovery to spontaneous respiration from 9% to 77–81%.[11] Intensive nursing of the rats that started to breathe again resulted in full recovery from blindness, lack of appetite, incontinence, and spinal-cord dysfunction.[7]

PREVIOUS CLINICAL USE OF ABDOMINAL COMPRESSION FOR RESUSCITATION

When reviewing the literature after we found that abdominal pumping enhanced resuscitation in our animal model, we found that compression of the abdomen already had a long history in the treatment of failing circulation. In the last century, midwives used to bind the abdomens of mothers after the delivery of babies. In 1903 Crile found that dogs that he had bled recovered more often if he bound their abdomens, and he applied these findings to patients who had suffered severe surgical hemorrhage.[12] The pneumatic antishock garment (PASG) was used to apply external pressure to the lower limbs and abdomen for acute hemorrhage therapy during transport of casualties in the Vietnam War[13] and civilian traffic casualties in Britain.[14] A table specially designed for external counterpulsation was used for the treatment of cardiogenic shock, but the apparatus was heavy and could be used only in hospitals.[15,16]

CLINICAL EXPERIENCE

My colleagues and I devised a simple procedure for the treatment of patients. A hard-covered book was applied to the lower half of the abdomen, and it was compressed by hand alternatively with cardiac massage (Fig. 1).[17,18] The technique was always car-

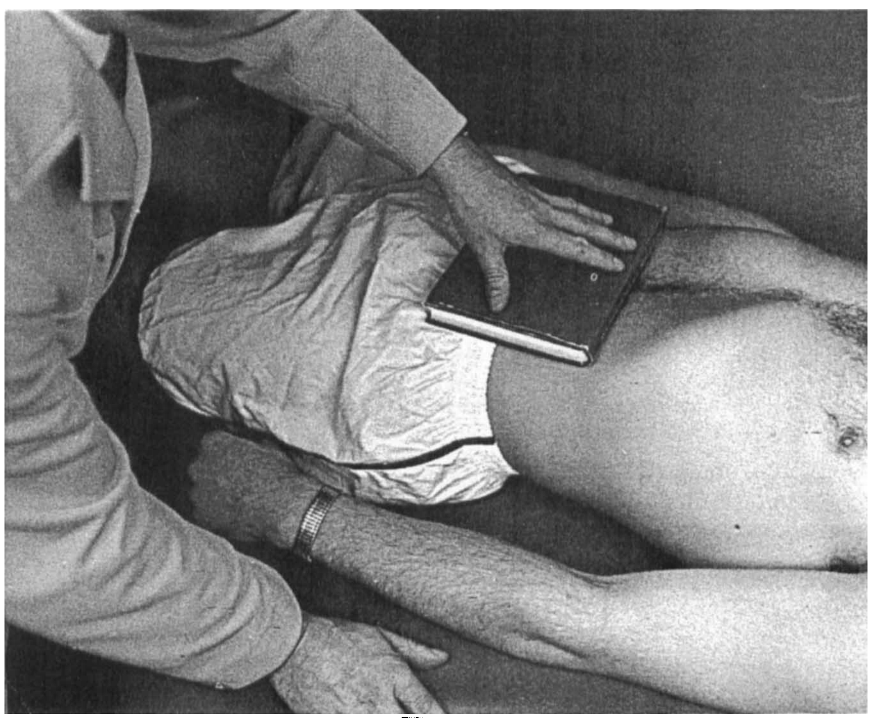

FIGURE 1. Simulated abdominal compression to show the position of the book (or bean-shaped board) below the umbilicus during interposed abdominal compression cardiopulmonary resuscitation (IAC-CPR). Cardiac massage and assisted ventilation are carried out on the patient at the same time, and intratracheal intubation is done if a doctor is present.

ried out *in addition to* cardiac massage and assisted ventilation, so a third person was needed to do it while two other rescuers were carrying out the other two maneuvers. However, this person needed no skill or previous training; instruction was simply to press on the abdomen when the chest was not being compressed. The pressure applied was measured using a sphygmomanometer cuff that was partially inflated so that any compression would record a rise in pressure. The cuff was sandwiched between the book (or board used by ambulance men) and the patient's abdomen below the umbilicus. The pressure was found to be less than 10 torr in 12 patients in whom I measured it, but higher pressures warrant investigation.

We initiated a clinical trial with ambulance personnel in a large service in Britain in 1974. At that time, these personnel were not trained as paramedics; their task was to carry out first aid on patients, doing cardiac massage and artificial ventilation if necessary. They were not permitted to intubate patients or to inject or infuse fluids intravenously.

The ambulance personnel picked up all patients found with cardiac arrest in the streets over a period of three months. Each control patient was given cardiac massage and artificial ventilation, and each experimental subject was given these two maneuvers plus abdominal pumping. The conditions for which abdominal pumping was done are listed in Table 1. Contraindications to abdominal pumping included a known or suspected abdominal lesion and obvious pregnancy (Table 2). While a theoretical risk of harm exists with these conditions, an abdominal pressure of 10 torr is less than that used to diagnose appendicitis or salpingitis during physical examination, or to decide the position of a fetus in pregnancy.

Two ambulance personnel gave cardiac massage and assisted ventilation, while a third carried out the abdominal pumping, with instructions to alternate with the compression phase of cardiac massage. The patients in the clinical trial were not intubated, because the ambulance personnel were not trained in this skill. At least 60 patients were treated with cardiac massage and artificial respiration and 70 with those plus abdominal pumping. The ambulance personnel filled out a short questionnaire about the state of each patient, the treatments given, and the outcome. Unfortunately, although all of the successful outcomes were reported, not all of the unsuccessful ones were. Therefore, the results must be considered anecdotal; nonetheless, the reported cases suggest an advantage to the inclusion of abdominal compression in standard cardiac resuscitations.

I have carried out the procedure myself on about 40 patients with the conditions listed in Table 1, mostly myocardial infarction and shock due to traffic injuries. While my anecdotal experience suggests limited benefit, the prognoses for the patients I treated were quite poor. So far as I know, there has been no other trial in the United Kingdom of interposed abdominal compression or abdominal pumping, either in the laboratory or in clinical situations, although we are now embarking on one.

TABLE 1 Conditions for Use of Abdominal Pumping during Interposed Abdominal Compression Cardiopulmonary Resuscitation

Cardiac arrest
Myocardial infarction
Shock
Slow recovery from cardiac arrest or shock
Hypothermia
Neonatal asphyxia
Slow recovery from epileptic fit*
Drowning
Stokes-Adams syndrome
Damage to thoracic cage, preventing cardiac massage
Failing circulation

*Since cyanosis and hypoxia may accompany epileptic fits, improvement of circulation may accelerate recovery.

TABLE 2 Contraindications to Abdominal Pumping during Interposed Abdominal Compression Cardiopulmonary Resuscitation*

Peritonitis
Pregnancy
Ectopic gestation
Open abdominal wound
Blood in the peritoneum
Gastroenteritis
Abdominal tumor
Peptic ulcer
Colitis

*When possible, the patient or family should be questioned and the patient examined to exclude these contraindications. However, in an emergency involving profound hypoperfusion or full cardiac arrest, observation or exacerbation of these findings would be unlikely.

INTERPOSED ABDOMINAL COMPRESSION AND ABDOMINAL PUMPING

There are several differences between our technique and that described by Ralston, Babbs, and Niebauer[19] and used by Berryman and Phillips.[20] First, these other investigators used pressures on the abdomen of 80–100 torr, and we used pressures of less than 10 torr. We used the lower pressure 1) because we did not know whether the patient was pregnant or had other conditions (e.g., peritonitis, ectopic gestation, or blood in the abdominal cavity) that would contraindicate abdominal pumping; 2) because the use of lower pressure did not seem alarming to patients or their relatives, and hence could be started much earlier during the patients' declines; and 3) because given our simple technique, no special skill was needed, and thus any bystander could be instructed to carry out the procedure without previous training. On reflection, and after discussion at the First Purdue IAC-CPR Conference, I believe that if one sees a patient whose blood pressure has not yet fallen considerably, one should use a low pressure for abdominal compression, which will appear neither too vigorous nor too violent to the patient or bystanders. However, when the patient has an extremely low blood pressure and cardiac output or is unconscious, and if there are no bystanders, the higher pressure may be better. A compression pressure of 80–100 torr should perfuse the coronary arteries to a much greater extent than the 10 torr we used.

Second, the other investigators compressed the abdomen with their hands, while we distributed the pressure with a hard-covered book or kidney-shaped board. Third, they considered interposed abdominal compression to be a procedure to be carried out mainly in the hospital, but we sought to develop it as a first-aid procedure, which could be used with minimal training.

FUTURE WORK

The optimal frequency and timing of the procedure, the method of application, and the pressure to be applied need to be determined in large mammals, and subsequently in patients. Physiologic parameters to be monitored include the coronary flow, minute volume, and incidence of recovery, since all of these affect the prognosis after treatment. Clinical trials will require large numbers of patients in several centers and assessments of the technique both in the hospital and outside the hospital. If clinical trials are successful, the means by which the technique should be taught as a first aid measure and its effect upon CPR-related injury must be considered.

In addition to clinical trials, the use of abdominal pumping for reviving perinatal and neonatal lambs warrants further investigation in the veterinary sciences.[21]

CONCLUSION

Animal experiments and anecdotal clinical use suggest that the abdominal pumping form of IAC-CPR using light abdominal pressure (10 torr) may play a role in resuscitation of hypotensive patients with poor cardiac output. Animal experiments suggest that this technique holds promise for enhancing the circulation and, hence, for resuscitation of the hypothermic patient in cardiac arrest or near-arrest.

While our anecdotal clinical results and other studies have yielded variable results,[20,22–24] the time is ripe for a standardized, multicenter clinical trial of the use of interposed abdominal compression to resuscitate patients who are low-cardiac-output states or cardiac arrest.

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