Aortic Pressures during Closed-Chest Cardiac Massage

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RESUSCITATION by cardiac massage through the closed chest has been described recently by Kouwenhoven and associates. This technic consists of applying firm, rhythmic pressure to the lower sternum, thus compressing the heart between it and the spine. Based on exhaustive animal experiments, this method was instrumental in the effective cardiac resuscitation of 20 patients reported by the authors. Three of these cases were observed to be in ventricular fibrillation.

The present report concerns an episode of ventricular fibrillation during retrograde left heart catheterization that afforded an opportunity to obtain direct aortic pressure measurements while closed-chest cardiac compression was being performed.

Case Report

R. N., a 36-year-old white man, was admitted for evaluation of incapacitating episodes of squeezing anterior chest pain. No abnormalities were found on physical examination. The results of examination of the blood and urine were entirely within normal limits. Serial electrocardiograms, a 100-trip, two-step exercise tolerance test, and roentgenologic examination of the chest and gastrointestinal tract yielded normal findings.

Since the patient's symptoms suggested angina pectoris, it was decided to perform a coronary angiogram in order to clarify the puzzling clinical picture.

At 7:30 a.m. the patient received meperidine, 75 mg. intramuscularly, and secobarbital, 100 mg. by mouth. At 8:15 a.m. a loop-end, polyethylene catheter was introduced into the femoral artery and passed in retrograde direction up the aorta by the method described by Williams et al. The electrocardiogram and direct arterial pressures were monitored continuously with a multichannel recorder.* As the catheter was being passed into the ascending aorta to the region of the sinus of Valsalva, the patient experienced a brief episode of burning substernal pain unassociated with electrocardiographic changes. An injection of 5 ml. of 90 per cent diatrizoic acid (Hypaque) was then made into the end of the catheter to test sensitivity and for purposes of visualization. The catheter, which holds approximately 4 ml., was noted to be located just above the aortic valves. Another 1 ml. was introduced in order to define more clearly the loop-end.

At this time, 8:30 a.m., the patient complained of severe, substernal burning pain, almost immediately lost consciousness, and had a generalized convulsion. Ventricular fibrillation was observed on the monitor and the catheter was promptly withdrawn below the diaphragm. The patient remained cadaveric in appearance despite attempts at resuscitation that included immediate sternal pressure and repeated, ineffective attempts at transthoracic defibrillation with a 150-volt internal defibrillator followed by application of an external electric cardio pacemaker (fig. 1, no. 2). After an estimated 5 to 8 minutes had elapsed, closed-chest cardiac compression according to the method described by Kouwenhoven et al. was started.

Blood pressures of 80/40 mm. Hg (fig. 1, nos. 3 and 4) were immediately obtained from the catheter in the abdominal aorta and the patient's color appeared to improve. He had been ventilated continuously first by mouth-to-mouth respiration and within 10 minutes by intubation and intermittent positive pressure with oxygen. Procaine amide hydrochloride, 500 mg., was given intravenously while external massage was being carried on, but the arrhythmia persisted.

At 9:10 a.m., because of persistent fibrillation, after approximately 30 minutes of effective circulation, external massage was discontinued and a thoracotomy was performed by Dr. Martin Litwin. As the pericardium was being incised, the rhythm changed spontaneously to an ineonstant ventricular tachycardia. Direct manual massage of the exposed heart was begun; this produced arterial pressures of approximately 100/65 mm. Hg (fig. 1, no. 5) recorded from the catheter in the abdominal aorta. Adequate, spontaneous cardiac contractions developed after a few minutes of cardiac massage. At 9:20 a.m., the rhythm changed to a nodal tachycardia and the chest was closed. After a few short runs of ventricular tachycardia, a fairly stable sinus rhythm developed. An adequate blood pressure was maintained with the aid of small doses of metaraminol (Aramine).

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*Electronics for Medicine, Inc., White Plains, New York.

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2. 3. 4. 5

Figure 1

Representative segments of tracing showing the electrocardiogram above and intraluminal aortic pressure below. The vertical time-lines are at 0.1-second intervals. 1. Tracing prior to onset of ventricular fibrillation showing normal sinus rhythm and normal ventricular beats with corresponding pressures in the ascending aorta. 2. Following onset of ventricular fibrillation with baseline pressures before cardiac massage. 3 and 4. Arterial pressure recordings from the abdominal aorta during closed-chest cardiac massage at rates of 75 and 50 beats per minute. The electrocardiogram shows persistent ventricular fibrillation. 5. Pressure recording during open-chest manual massage.

Hypothermia was instituted in order to limit the anoxic brain damage, but despite all measures the patient never regained consciousness and died at 1:45 a.m. the following morning, following another bout of ventricular fibrillation.

Postmortem examination revealed scattered, focal hemorrhagic areas seen on cross-section of the myocardium, which were interpreted to be injuries sustained during direct, manual cardiac massage. No other abnormalities were found. There were no injuries of the thoracic cage, and there was no evidence of coronary artery disease. It is assumed, though there is no proof, that the cardiac arrhythmia resulted from a reaction to the contrast substance.

Discussion

Direct arterial pressure recordings in this case illustrate that rhythmic, manual compression of the lower sternum can produce a substantial blood pressure in the distal aorta during ventricular fibrillation. Coincident improvement in the patient's color suggested that this was associated with a significant peripheral flow of oxygenated blood. A pressure of 80/40 mm. Hg (fig. 1, nos. 3 and 4) was immediately obtained and maintained thereafter without difficulty throughout the period of closed-chest massage. This level compared favorably with the patient's pre-morbid, resting arterial pressure of 70/40 mm. Hg (fig. 1, no. 1), but was slightly less than the pressures obtained by open-chest, manual cardiac massage, which averaged around 100/70 mm. Hg (fig. 1, no. 5).

In all probability, the failure to revive this patient was due to the prolonged period of hypotension. External application of adequate countershock current may well have termi-
nated the fibrillation and restored normal sinus rhythm with or without the use of the external pacemaker.

It is noteworthy that no injuries to the thoracic cage were found at postmortem examination. One of the foreseeable complications of vigorous transthoracic massage is that of rib fractures with accompanying laceration of the underlying heart, great vessels, and other organs. In all likelihood, the elasticity of the thorax will have some influence on the safety and efficacy of this technic, although one of the successful resuscitations reported by Kouwenhoven et al. was in an 80-year-old woman.¹

The attractive features of closed-chest cardiac compression include its simplicity, ease of application, and general applicability regardless of place and regardless of whether the heart is in standstill or fibrillation. Valuable time may be gained through this method for obtaining other resuscitative equipment, such as an electric external pacemaker and defibrillator.

It is apparent from this case that substantial blood pressures, equal to the patient's own resting levels and slightly less than those produced by direct cardiac massage, can be obtained by this method. It appears likely that this is the procedure of choice in the treatment of cardiac arrest occurring outside the operating room or where an external pacemaker or defibrillator is not immediately available.

Summary

A case of ventricular fibrillation is presented which occurred during retrograde left heart catheterization and preparation for aortography. Direct arterial pressures were recorded from a catheter in the abdominal aorta during closed-chest cardiac massage. These indicated that substantial blood pressures can be readily produced by this simple and practical method.

References


Nothing will sustain you more potently than the power to recognize in your hum-drum routine, as perhaps it may be thought, the true poetry of life—the poetry of the commonplace, of the ordinary man, of the plain, toil-worn woman, with their love and their joys, their sorrows and their griefs.—Sir William Osler. Aphorisms From His Bedside Teachings and Writings. New York, Henry Schuman, Inc., 1950. p. 90.
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