CLINICOPATHOLOGIC CORRELATIONS

Rupture of Right Ventricle Complicating Closed Chest Cardiac Massage

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SUMMARY Two cases of rupture of the right ventricle following closed chest cardiac massage are presented. This is believed to result from trapping of blood in the right ventricle at levels of systemic arterial pressure. In one case there was massive pulmonary embolism which interfered with egress of blood from the right ventricle. In the other case, application of pressure during a closed chest resuscitative attempt might have closed the right ventricular outflow tract.

SINCE ITS INTRODUCTION, closed chest cardiac massage has been the method of choice for resuscitation over the older method of direct cardiac massage. Quite apart from the greater convenience and broad availability of the newer method, it is probably safer for the treatment of acute cardiovascular insufficiency. Yet even this method is attended by certain mechanical complications among which the most common and probably innocuous is pulmonary bone marrow embolism from the frequently occurring fracture of ribs. More serious cardiovascular complications have been reported sporadically. These include rupture of the right atrium, of a coronary artery and of the aorta. Hemopericardium without definition as to its source has been reported by a number of workers. Noncardiovascular traumatic lesions reported include hemothorax, pneumothorax, mediastinal emphysema, laceration of the abdominal organs (stomach, bowel, liver and/or spleen). With regard to traumatic cardiovascular lesions, we have observed two cases of rupture of the right ventricle following closed chest massage. This communication describes these cases and discusses the possible pathophysiology involved in the development of this complication. In neither case was there fracture of ribs or sternum. We have not been able to find, in the literature, other reports describing rupture of the right ventricle as a complication of closed chest cardiac massage.

Observations

Case 1

An 85-year-old woman, who one month previously had undergone successful segmental resection of the small bowel for gangrene, was admitted for evaluation of abdominal pain. A few days after admission, cardiac arrest developed and closed chest cardiac massage was unsuccessful.

At autopsy, massive bilateral acute pulmonary embolism was found. The pericardial sac was distended with blood (estimated 250 cc). The heart weighed 400 grams. The right ventricle, which was of normal thickness, showed a rent about 1 cm in length at its apex (fig. 1). This was considered to be the source of the observed hemopericardium. There was also a laceration of the right atrial wall measuring about 2.0 cm in length. This had not ruptured through the full thickness of the atrium. A mural thrombus was present in the right atrial appendage. There was no significant degree of coronary atherosclerosis. Histologic examination of the myocardium, including the edges of the right ventricular rent, showed no underlying disease.

Case 2

A 61-year-old man was admitted to the hospital in a state of cardiogenic shock with a pulse rate of 140. Electrocardiograms did not reveal evidence of acute myocardial infarction. Pulmonary edema developed rapidly and shortly thereafter cardiac arrest occurred. Standard closed chest resuscitative attempts were unsuccessful. Pertinent findings at autopsy were a laceration of the apex of the right ventricle measuring 2.0 cm and hemopericardium (estimated 300 cc). The right ventricular thickness was normal. The heart weighed 520 grams. Histologically, an occasional focus of chronic myocarditis was seen in the left ventricle but no lesions were observed in the right ventricle. The coronary arteries showed multiple foci of obstructive atherosclerosis.

Comment

In closed chest cardiac massage, compression of the chest wall causes propulsion of blood into the arterial system. By this method, it is possible to develop systemic levels of blood pressure equivalent to normal.

We assume that the right ventricular rupture observed in our cases was the result of trapping of blood in this chamber at levels of systemic systolic pressure. This might be accomplished by pressure to the chest applied while the outflow tract from the right ventricle was obstructed and at the same time the tricuspid valve was closed by the pressure applied.

In case 1, massive acute bilateral pulmonary embolism compromised the situation by reducing the caliber of the pulmonary artery and thereby interfering with the flow of blood from the right ventricle.

In case 2, wherein there was no intrinsic basis for obstruc-
RV RUPTURE FOLLOWING CARDIAC MASSAGE/Baldwin, Edwards

FIGURE 1. Case 1. a. External view of the heart. There is a laceration (between arrows) at the apex of the right ventricle. b. Interior of the right atrium (R.A.) and right ventricle (R.V.). The laceration of the right ventricular apex lies between the arrows. The laceration which did not involve the entire thickness of the right atrial wall appears above the tricuspid valve.

FIGURE 2. Two examples of right ventricular rupture following blunt trauma resulting from automobile accidents. a. External view of heart and partially opened right ventricle (R.V.). At the apex of the unopened portion of the right ventricle is a perforation (between arrows). b. Perforation (between arrows) of the anterior wall of the right ventricle at the lower portion of the infundibulum.

...tion to right ventricular outflow, we postulate that the pressure applied to the chest was at a higher position than ideal which closed the right ventricular outflow tract and, at the same time, the tricuspid valve.

While rupture of the right ventricle is an uncommon occurrence in closed chest cardiac massage, it must be numbered among the serious complications of direct cardiac massage. In cases which one of us (J.E.E.) observed, the rupture characteristically occurred in the wall of the right ventricular outflow tract and probably was caused by undue pressure by the thumb of the operator.19

Adelson13 reported on autopsy findings in 60 cases in which direct cardiac massage had been done. Six of these showed a gross laceration of a cardiac structure distributed as follows: left ventricle, four cases and left atrium and a cardiac vein, one case each.

Rupture of the right ventricle may result from a variety of situations other than attempts at cardiovascular resuscitation. These include myocarditis,14 penetration of an indwelling catheter15, 16 and blunt trauma to the chest (fig. 2). Penetration of the right ventricle by a catheter need not be followed by massive hemopericardium although this complication may occur (fig. 3).

Among the major cardiac complications of blunt trauma to the chest, rupture of a cardiac chamber was found to be
the most common type in the study of Parmley and associates.\textsuperscript{17} Rupture of a ventricle was more common than rupture of an atrium. These authors found that rupture of the right ventricle was as common as a rupture of the left ventricle.

The force of the blunt trauma that may rupture a right ventricle need not be great. Stein and Revitch\textsuperscript{18} reported rupture of the right ventricle in a 12-year-old boy who, while sledding in a face down prone position, was playfully fallen upon by a companion.

However interesting is the phenomenon of rupture of the right ventricle following external cardiac massage, rupture of the left ventricle is observed at autopsy much more frequently following application of this resuscitative procedure. In this setting, the question is raised as to whether this procedure caused the left ventricular rupture. In each case of this type that we have observed and in those reported by Yamada and Fukunaga,\textsuperscript{9} there was acute transmural myocardial infarction. In such cases it is probable that left ventricular rupture is spontaneous and the ensuing cardiovascular collapse causes the doctor to give external cardiac massage. It is doubtful that the massage causes the left ventricular rupture.

References


Figure 3. Penetration of the right ventricular wall by an indwelling catheter, which resulted in hemopericardium. External view of heart viewed from in front. The probe is in the laceration of the apical portion of the right ventricle. The related epicardium shows hemorrhage.
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