

# CAUSES OF DEATH AFTER EXTERNAL CARDIAC MASSAGE: ANALYSIS OF OBSERVATIONS ON FIFTY CONSECUTIVE AUTOPSIES

WILLIAM R. BYNUM, M.D.,\* ROBERT M. CONNELL, M.D.,†

and

WILLIAM A. HAWK, M.D.

*Division of Pathology*

EXTERNAL cardiac massage for the treatment of catastrophic cessation of heart action has been readily accepted as a means of sustaining peripheral circulation until adequate myocardial function can be restored. This technic has been recently described by Kouwenhoven, Jude, and Knickerbocker.<sup>1</sup> However, we are becoming fully aware that the inherent complications of this procedure may be a direct cause of death. A review of these complications has been reported by Baringer, Salzman, Jones, and Friedlich.<sup>2</sup> Any morphologic alterations can best be evaluated by thorough study both of the gross and of the microscopic changes present at autopsy. We have reviewed the observations on 50 consecutive autopsies of patients who died after external cardiac massage, have analyzed the conditions possibly precipitating cardiac arrest, and have studied the anatomic changes that developed as a result of external cardiac massage. The 50 patients, on medical or surgical services, received external cardiac massage in the Cleveland Clinic Hospital between May 1961, and March 1962. During this interval there were 14,527 admissions to the Cleveland Clinic Hospital.

## Material and Method

The series of 50 patients included 37 males and 13 females whose ages ranged from two and one-half months to 75 years; 11 patients were less than 50 years of age. In each case the clinical chart was analyzed to determine whether or not significant antecedent chronic disease had been present, such as arteriosclerotic heart disease, old or recent myocardial infarctions, congenital heart disease, and pulmonary disorders. It was adjudged beyond the scope of this paper to evaluate the relationship of the various surgical procedures to occurrence of cardiac arrest. The autopsy protocol and the histologic preparations were reviewed in each case. Fractures of the ribs as well as other bony parts, and lacerations and other traumatic alterations of solid or hollow viscera were noted. Particular attention was paid to significant resultant hemorrhage. Pulmonary bone marrow emboli were assessed by microscopic examination of lung sections, and an average of four sections per

\*Fellow in the Division of Pathology.

†Formerly Fellow in the Division of Pathology; present address: Department of Pathology, University of Oregon Medical School, Portland, Oregon.

case was screened. The sections were purposely taken from the peripheral lung regions. The usual histologic procedures were employed.

### Results

The most common postmassage finding was injury to the rib cage, usually in the vicinity of the costochondral junction. Of the 14 cases with these findings, in 13 there were multiple rib fractures. One of these cases was associated with a transverse fracture of the body of the sternum. Fractures of the left ribs occurred eight times.

Cardiac damage was grossly evident in eight cases; minimal subepicardial hemorrhage was noted in seven cases. In the eighth case, the patient had received Dicumarol\* in therapeutic dosage, and slight subendocardial hemorrhage was visible in the septal region of the left ventricle. The average duration of massage in the eight patients was 19 minutes.

Microscopic foci of intracardiac damage in the form of hemorrhage were present in four cases. The damaged areas were in the anterior and anterolateral regions of the left ventricle. The average duration of massage for these four patients was 15 minutes.

Direct trauma to the solid organs of the abdomen was rare, but was the most serious complication observed. There were three cases of hepatic contusion with laceration of Glisson's capsule. However, in one case there was antecedent severe hepatic parenchymal necrosis. In the two cases, the lacerations were located in the anterior and superior regions of the dome of the right hepatic lobe. One of the lacerations was associated with intraabdominal hemorrhage in the amount of 2,500 ml. None of the cases of hepatic damage was associated with fractures of the ribs. In one case a 2-cm. laceration of the spleen was associated with only slight hemorrhage; there were fractures of six of the left ribs in this case. *Table 1* summarizes the gross pathologic lesions.

**Table 1.**—*Incidence of gross damage after external cardiac massage (50 patients)*

Gross damage	No. of cases
Rib fractures	14
Cardiac injury	8
Subepicardial hemorrhage	7
Subendocardial hemorrhage	1
Hepatic injury	3
Sternal fracture	1
Splenic injury	1
Total	27

\*Abbott Laboratories.

Pulmonary bone marrow emboli were present in six cases. The emboli were demonstrable microscopically in sections taken from the peripheral regions of the lungs. In one case there was no demonstrable injury to the rib cage. However, in the other cases multiple rib fractures were present.

In regard to preexisting disease, the most outstanding finding from a review of the charts was the high incidence (72 percent) of known cardiac disorders, as follows (*Table 2*): myocardial infarction, 19 patients (10 recent; 6 both recent and remote; 3 remote only); coronary artery disease without infarction, 6 patients; rheumatic valvular disease, 5 patients (mitral and aortic valves involved separately or in combination); congenital heart disease, 3 patients; significant antecedent hypertension, 3 patients.

**Table 2.**—*Preexisting cardiac disease in 36 patients\* having cardiac arrest*

Cardiac disease	No. of patients
Coronary artery disease	25
Recent infarction	10
Recent and remote infarction	6
Remote infarction	3
(No infarction, 6)	
Rheumatic valvular disease	5
Congenital heart disease	3
Hypertensive heart disease	3
Total	36

\*Cardiac disease was absent in 14 patients.

Preexisting pulmonary disease was noted in 14 patients as follows: obstructive emphysema, greatly advanced, 6 patients; bronchopneumonia with severe debilitation, 4 patients; malignant disease (prior pneumonectomy), 2 patients; tracheo-bronchial obstruction resulting from inspissation of mucus, 1 patient; pulmonary edema, 1 patient.

Arteriosclerosis of the major arteries was advanced in 10 patients, 4 of whom had had recent grafts for arteriosclerotic abdominal aortic aneurysms.

## Discussion

The gross changes associated with external cardiac massage appear to be minimal in the cardiac musculature. Although within the myocardium slight hemorrhage was noted, in no case was it adjacent to the bundle of His where it could have interfered with the normal conduction mechanisms. One patient had been receiving therapeutic anticoagulants, but the myocardial damage was not apparently increased in severity, and certainly this should not be a contraindication to external massage. The subepicardial hemorrhages were adjudged to be without consequence.

No case of laceration of the myocardium or extensive pericardial hemorrhage was noted in spite of high incidence of rib fractures.

Additional cardiopulmonary embarrassment may result from the presence of pulmonary bone marrow emboli. With the restoration of the cardiac function there will be a limited cardiac reserve that may not be able to overcome this additional strain on the peripheral pulmonary circulation. It is of particular interest to reiterate that pulmonary bone marrow emboli were present in one case in which there was no damage to the rib cage.

The solid organs of the abdomen are always a possible source of injury. In one patient, an associated, massive, intraabdominal hemorrhage secondary to extensive laceration of the liver was believed to be the direct cause of death. A similar complication was present in the case reported by Morgan.<sup>3</sup> Preexisting hepatic parenchymal damage, such as severe, diffuse, parenchymal necrosis, may make that organ much more susceptible to injury. Splenic damage was not remarkable in this series.

The significance of rib fractures, especially when associated with sternal fractures, should not be underestimated. Extensive rib cage injuries are known to compromise pulmonary function severely, and this becomes of particular importance in a person with a depressed circulatory system.

The most outstanding finding of this study was the extremely high incidence (72 percent) of cardiac arrest associated with preexisting cardiac disorders. This correlation should alert the attending physician to the possibility of such an occurrence. The largest group is composed of those patients who have had myocardial infarctions, especially of recent origin. In fact, infarction frequently is the precipitating event. Rheumatic valvular disease with its associated conduction abnormalities is also a cause for cardiopulmonary embarrassment. In this group, there had been a history of long-standing congestive failure. The congenital abnormalities were of a severe nature with extreme valvular and outflow distortions. Hypertensive cardiac disease was of low incidence; however, there was generalized arteriosclerosis of great magnitude in 10 cases. In this group having generalized arteriosclerosis, the incidence of temporary restoration of cardiac function was high.

There was also a high incidence (28 percent) of antecedent pulmonary affections. All 14 cases were associated with increased resistance in the lesser circulation in the form of chronic obstructive emphysema, bronchopneumonia, pulmonary edema, tracheobronchial obstruction, or pneumonectomy. The significance of this increased resistance may be further augmented by the rather commonly associated cardiac disease and, or generalized arteriosclerosis.

### Conclusion

Cardiac arrest can occur in all age groups, but the occurrence in a general hospital population is rare. Patients sustaining cardiac arrest have a high incidence

of preexisting cardiac abnormalities. To a lesser extent this appears in patients who have chronic pulmonary disorders or generalized arteriosclerosis. In the treatment of cardiac arrest, serious complications may follow the use of external cardiac massage, the most serious of these being injury to the solid abdominal viscera. Fractures of the rib cage during external cardiac massage are important because of the possibility of interference with pulmonary ventilation. Any of these injuries may prevent recovery after an otherwise satisfactory restoration of myocardial function.

#### References

1. Kouwenhoven, W. B.; Jude, J. R., and Knickerbocker, G. G.: Closed-chest cardiac massage. *J.A.M.A.* 173: 1064-1067, 1960.
2. Baringer, J. R.; Salzman, E. W.; Jones, W. A., and Friedlich, A. L.: External cardiac massage. *New England J. Med.* 265: 62-65, 1961.
3. Morgan, R. R.: Laceration of liver from closed-chest cardiac massage. *New England J. Med.* 265: 82-84, 1961.