PROGRESS IN CARDIOVASCULAR SURGERY

Penetrating Wounds of the Heart*

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The treatment of patients with penetrating wounds of the heart is subject of continuing interest, stimulated by increasing urban crime extending even to cities not previously concerned with this problem.1

The treatment of penetrating wounds of the heart has followed two paths since the first advocacy of pericardiocentesis in 1649 by Riolanus2 and direct surgical intervention by Cappelen3 in 1895. Pericardiocentesis, although the earliest form of treatment, was temporarily supplanted by the operative treatment until its reintroduction by Blalock and Ravitch in 1943. Since that time, both methods have had many advocates. All are agreed on the necessity for operative treatment in the presence of recurrent pericardial tamponade, or continuous hemorrhage without tamponade.

In 1962, Smyth, Hughes, and Cornwell4 reviewed the experience of the George Washington University Surgical Service with stab wounds of the heart over a seven-year period at the District of Columbia General Hospital, a large municipal hospital. The present study is a review of the same problem in the Washington Hospital Center, an 800-bed community hospital in the District of Columbia with a very active emergency service. The review covers a seven-year period from the opening of the hospital in 1958 to July, 1965. During this time, 25 patients with penetrating wounds of the heart were seen at the Washington Hospital Center.

Diagnosis

An adequate history was rarely obtained, but it was possible in all cases to find out from the police the nature of the weapon. In our series, the weapon was a knife in 23 cases, an ice pick in one case and a .38 caliber revolver in another. Eighteen patients arrived at the hospital alive. The level of consciousness in these patients ranged from normal cerebral function to complete unconsciousness. All degrees of agitation, disorientation and fluctuating levels of consciousness were seen. Shock out of proportion to the external wound and external blood loss was noted in the majority of the cases.

Distended neck veins were noted in four patients, and in six patients venous pressures were recorded markedly above normal. Distant heart sounds were reported in three patients. Cyanosis confined to the face, neck, shoulders, and upper extremities were noted in two patients and flat cervical veins which became distended following infusion of fluids were noted in three patients.

Portable chest roentgenograms were obtained on admission in eleven of the patients. These were anteroposterior views taken in the upright position. The roentgenograms were useful in demonstrating two of three classic signs of tamponade in one patient (Fig. 1). In one patient, a bullet that had injured the left ventricle was located in the vertebral canal at the level of T8. The patient was paraplegic (Fig. 2). Other abnormalities such as pneumothorax, hemothorax and pneumopericardium were also demonstrated (Fig. 3).

Treatment

Of the 25 patients who arrived at the hospital, seven were dead on arrival. Details of their injuries (Fig. 4 and Table 1)
were obtained from both the District of Columbia police files and Coroner’s Office records.

Of the 18 patients who arrived at the hospital alive, one was treated by pericardiocentesis alone with survival. Seventeen were operated on, of whom 15 survived. There was one late death.

Preoperative pericardiocentesis was done in seven of these 17 patients. It was prob-

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**FIGURE 1A**

Preoperative roentgenogram showing increased transverse diameter of the cardiac silhouette and widening of the superior mediastinum to the right, caused by distension of the superior vena cava. The third sign of tamponade—straightening of the left cardiac border—is not present.

**FIGURE 1B**

Postoperative roentgenogram, showing reduction in size of superior mediastinum and the cardiac silhouette.

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**FIGURE 2A**

Preoperative roentgenogram, showing left hemopneumothorax, increased transverse diameter of the cardiac silhouette, and a bullet lying in the vertebral canal at the level of T.8.

**FIGURE 2B**

Postoperative roentgenogram, showing that the bullet has been removed; the cardiac silhouette has returned to normal and there is minimal pleural reaction at the left base.
Preoperative roentgenogram, showing pneumopericardium and right hemopneumothorax.

Postoperative roentgenogram following cardiorrhaphy and repair of laceration of right upper lobe.

ably lifesaving in one, although it did not completely relieve the tamponade in any patient. It was a complete failure in one patient. In one patient, a violently agitated 12-year-old girl, the procedure was abandoned as being too dangerous in a struggling patient.

Of 17 patients undergoing operation, the injury involved the left ventricle in five, the right ventricle in six, and the apex in one,

![Figure 3A: Preoperative roentgenogram, showing pneumopericardium and right hemopneumothorax.](image)

![Figure 3B: Postoperative roentgenogram following cardiorrhaphy and repair of laceration of right upper lobe.](image)

![Figure 4: Drawing showing the location of the penetrating injuries in the patients who were dead on arrival (a) and those that reached the hospital alive (b). Multiple injuries account for the discrepancy between number of patients and injuries.](image)
Table 1—Location of Injuries

<table>
<thead>
<tr>
<th>Location</th>
<th>Dead On Arrival</th>
<th>Treated Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left ventricle</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Left atrium</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Right atrium</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Apex</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Root of aorta</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Right ventricle, tricuspid valve and right atrium</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total number of injuries</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Total number of patients</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>

The discrepancy between the number of patients and the number of cardiac injuries is due to multiple cardiac injuries in some patients.

the right atrium in one and the left ventricle and root of the aorta in one. In one patient, the right ventricle, tricuspid valve, and right atrium were penetrated. Tricuspid insufficiency resulted, confirmed at operation by a coarse systolic thrill in the lateral wall of the right atrium.

Suture repair of the penetrating wound was carried out with interrupted non-absorbable sutures in all patients except the patient sustaining a gunshot wound of the heart. In this patient, bleeding stopped readily on application of pressure with a dry sponge to the deep furrow plowed by the bullet in the wall of the left ventricle. Any type of suturing in this case was impossible because of the proximity of the wound to the anterior descending coronary artery and the left circumflex coronary artery (Fig. 5).

Two of the patients died on the operating table of irreversible ventricular fibrillation, for an operative mortality of 12 per cent. One patient died of a massive pulmonary embolism ten days after successful repair of his cardiac wound. The hospital mortality was therefore 18 per cent.

One patient was paraplegic due to transection of the cord at the level of T10 by the same bullet that had injured the left ventricle. One patient was transferred to a psychiatric institution for further care because of hypoxic damage to the central nervous system. One patient was reoperated 12 hours after his initial operation for recurrent intrapleural bleeding. The hemothorax was evacuated. No individual bleeding point was found and no further bleeding occurred. One patient underwent...

Figure 5: Photograph showing bullet wound of the left ventricle in the angle between the anterior descending coronary artery and the left circumflex coronary artery.
splectomy for a lacerated spleen following definitive repair of his heart wound.

Three patients had knife wounds below the xiphoid. Shock in one case was thought to be due to abdominal injury and immediate laparotomy was carried out. Abdominal exploration was negative and the incision was converted to a thoraco-abdominal incision. Cardiac tamponade with laceration of the right atrium and ventricle was found and successfully repaired. This patient in whom the pericardium was partially closed at the end of the operation developed a pericardial effusion postoperatively for which pericardiocentesis was performed.

DISCUSSION

In many cases, the diagnosis of a penetrating wound of the heart is not difficult. The most striking signs are a degree of shock out of proportion to the severity of the wound or external blood loss, distended neck veins and elevated venous pressure in the presence of decreased systemic pressure. It is our current practice to place a saline manometer in one of the intravascular lines and monitor the venous pressure. On occasion, the venous pressure shows no rise until intravenous fluid therapy is started at which time a sharp rise will occur.

Fluoroscopy was not used in any case. It may be that with modern image intensification techniques, fluoroscopy will be of greater value, eliminating the old objection to the delay necessary for the examiner to become accommodated.

Chest roentgenograms were taken of 11 patients. Although such roentgenograms are taken by a portable machine, at varying distances, and are rarely good inspiratory films, when due allowance is made for these factors we have found the upright portable chest roentgenogram to be of value in detecting the presence of acute cardiac tamponade. The signs looked for are relative widening of the cardiac silhouette, straightening of the left cardiac border and widening of the superior mediastinum on the right side caused by distention of the superior vena cava. In addition to these changes a chest roentgenogram will document the presence of hemothorax, fractured ribs and other injuries (Fig. 1-3).

The correct diagnosis of injury to the heart was made in all our patients but one. This patient, as previously described, had a wound in the epigastrium which led to an erroneous initial diagnosis of abdominal injury.

In general, pericardiocentesis was not found to be of great value except in two patients in one of whom it was completely successful, and in the other a marked improvement was produced by the aspiration of 30 ml. of blood. In this patient, no further blood could be aspirated and signs of tamponade persisted so operation was performed with suture of a wound in the right ventricle. In three others some blood was obtained without complete relief of tamponade and in two no blood was obtained. All were successfully treated by operation.

Pericardiocentesis as a therapeutic measure has the great advantage that it is simple, and in selective cases very successful in achieving resuscitation without operation. The disadvantages have been described previously, and include failure because of clotting of the intrapericardial blood or loculation of the blood posteriorly in the pericardial sac, or failure because tamponade may recur. Damage to the myocardium or coronary vessels by the needle has also been described. Cardiac arrest or ventricular fibrillation may also be precipitated by this measure. Furthermore, patients treated by this method require observation for a prolonged period of time since there may be delayed hemorrhage, and finally there is a 5 per cent to 10 per cent instance of chronic pericardial effusion and constrictive pericarditis as a late complication.

The advantages of thoracotomy and cardiorrhaphy are that the cardiac wound or wounds are visualized and treated definitively. The pericardial sac is left wide open to prevent the possibility of development of
postoperative tamponade and late constrictive pericarditis. Any associated intrathoracic injury or abnormality can be dealt with definitively at the same time. The operation is concluded with water-seal drainage of the pleural cavity providing a safe, stable situation, should any further surgery for associated abdominal or other injuries be necessary, as was the case in one of our patients.6

In most series, mortality figures for treatment by pericardiocentesis tend to be low, because the patients treated by this modality are a select group, many of whom have cardiac wounds that have stopped bleeding and who have no other serious wounds.7,8 By contrast, all other patients, including those with multiple injuries, those in whom pericardiocentesis has failed, those in whom tamponade has recurred and those who developed cardiac arrest after admission, are included in an operative series.5,9,10 Inevitably, the mortality in this group tends to be higher. With improvements in surgical technique and modern anesthesia, the operative mortality has been greatly reduced and is now well below the 50 per cent reported 20 years ago.11 Figures from 8 per cent to 17 per cent are frequently reported in recent years.12,13,14

In our group, three patients died out of a total of 17 operated upon. Two of these were operative deaths, an operative mortality of 12 per cent. The third patient died ten days postoperatively from pulmonary embolism bringing the total hospital mortality to 18 per cent. The two deaths from irreversible ventricular fibrillation occurred early in the series and might now be avoidable with the use of the better drugs and defibrillating equipment currently available.

The ratio between patients dead on arrival and those reaching the emergency room alive was 7:18. This is a very favorable ratio, and reflects credit on the speed and efficiency of the District of Columbia Police Force and Fire Department Ambulance Service who handled all these cases.

The comparison of sites of injury seen at operation and those recorded by the Coroner’s Office at necropsy is of interest. The relative preponderance of left ventricular injuries in the latter group is significant. Exsanguinating hemorrhage and lethal tamponade evidently occur more frequently with penetrating injury of the high pressure ventricle.

CONCLUSIONS

Our experience with penetrating wounds of the heart at a busy community hospital has been similar to that previously reported from a municipal hospital in the same city, and confirms our belief that definitive surgery is much more effective than conservative treatment using pericardiocentesis.

We believe that pericardiocentesis should be attempted in all patients with cardiac tamponade. In our experience, it rarely results in a cure, but may improve the patient’s condition for subsequent definitive surgery.

REFERENCES


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Readers are invited to submit articles for Progress in Cardiovascular Surgery. Please submit material to David P. Boyd, M.D., 605 Commonwealth Avenue, Boston, Massachusetts.

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**INTRAPULMONARY NEUROGENIC TUMORS**

Primary intrapulmonary neurogenic neoplasms are exceedingly rare. They usually have a very long natural history, causing symptoms by either obstruction of a bronchus or only after they have attained a considerable size. The large majority of the cases reported have been neurofibromas and, of these, roughly 30 per cent were malignant. Only seven neurilemmomas have been reported previously. Two additional patients, one with a malignant schwannoma and another with a neurilemmoma are reported and the clinical, radiologic and pathologic findings in these neoplasms are briefly summarized by the authors.


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**ERRATUM**

Afin de faire correct ce que l'auteur veut dire, il faut effacer le mot "mals" que se trouve dans la premiere phase du resume en francais, page 488, l'issue de Novembre 1965.

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**ADRENAL FUNCTION IN CHRONIC RESPIRATORY INSUFFICIENCY**

The autopsy finding of hemorrhages in the adrenals of a patient who died of acute respiratory insufficiency prompted the authors to do adrenal function studies on 48 patients with chronic respiratory insufficiency. They found 24 patients or 54% had normal adrenal function, 11 patients or 23% had static adrenal insufficiency and 11 patients or 23% had dynamic adrenal insufficiency. It was noted that the patients with adrenal insufficiency showed more signs of progression in their respiratory insufficiency and the more severe cases were the ones which showed more and more constant adrenal insufficiency. The authors recommend that adrenal function studies be carried out on all patients with chronic or acute respiratory insufficiency, with therapy if indicated.


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**DEVELOPMENT OF AMYLOIDOSIS IN LESS THAN TWO MONTHS DURING PRIMARY PULMONARY TUBERCULOSIS**

The authors report the case of a North-African soldier serving with the French Army who developed amyloidosis in less than two months during the course of a primary active pulmonary tuberculosis. The diagnosis of amyloidosis was confirmed by hepatic and renal biopsy. The hepatic amyloidosis regressed during antituberculosis therapy. The renal amyloidosis also improved but a proteinuria persisted.