Secondary Lesions of Penetrating Cardiac Injuries

A Frequent Complication

MANUCHER FALLAHNEJAD, M.D., AHMED C. K. KUTTY, M.D., HERBERT W. WALLACE, M.D.

Between July 1962 and July 1978, 29 patients (23 male and 6 female) from 17 to 48 years of age were followed from two weeks to 15 years after penetrating cardiac injuries involving right ventricle (12), right atrium (6), left ventricle (8), left atrium (2), and pulmonary conus (1). Thoracotomies were performed on all patients either in the emergency room during resuscitation or in the operating room. Repair of the injuries were carried out. All patients were followed for presence of residual cardiac damage. To our surprise, secondary complications were noted in 15 of the 29 patients as follows: Coronary damage (3), pseudoaneurysm (2), bullet embolus (1), VSD (4), recurrent pericarditis (1), mitral valve injury (2), aorta caval (1), and aorto pulmonary fistula (1). Between July 1962 and July 1974, only symptomatic patients with subjective and objective findings had detailed cardiac evaluations. Eight of 20 patients were found to have secondary cardiac complications. Since July 1974, seven of nine patients underwent a posttraumatic cardiac evaluation. Six of the seven patients were found to have significant cardiac lesions which were unrecognized at the time of initial operation. The incidence of posttraumatic remediable cardiac lesions is probably higher than previously suspected. An aggressive, detailed postoperative evaluation is recommended for all patients with penetrating cardiac injuries.

ALTHOUGH THE CONSEQUENCES of cardiac injuries have been understood since antiquity, only during the last few decades has major progress been made in the surgical management of cardiac injuries. An aggressive surgical approach, advances in cardiac surgical technique, improvement in transportation, training of emergency services personnel, and the availability of circulatory support have resulted in greater survival of the trauma victim. With a better understanding of cardiac physiology and the availability of safe diagnostic techniques, a more detailed follow-up of these patients can be performed and a large number of secondary problems have become apparent. This report reviews our experiences regarding delayed sequelae of cardiac injuries.

From the Department of Surgery of the Graduate Hospital and the School of Medicine of the University of Pennsylvania, Philadelphia, Pennsylvania

Reprint requests: Manucher Fallahnejad, M.D., Department of Surgery, Graduate Hospital, 19th and Lombard Streets, Philadelphia, Pennsylvania 19146.

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Materials and Methods

Between July 1962 and July 1978, 29 patients, 23 males and 6 females ranging in age from 17 to 48 years, were evaluated for a period of a few days to several years after the initial trauma. The distribution of the primary injuries are to be found in Table 1. Emergency thoracotomies were performed in all patients either in the emergency room during resuscitation or in the operating room and appropriate repair was carried out. The following secondary lesions were diagnosed in 15 of the 29 patients as follows: Coronary damage (3), aneurysm and pseudoaneurysm (2), bullet embolus (1), VSD (4), mitral valvular injury (2), aorta caval (1), aorta pulmonary fistula (1), and pericarditis (1) (Table 2).

Between July 1962 and July 1974, only the symptomatic patients with subjective and objective findings were fully evaluated. Of the 20 patients followed during this period, eight were found to have secondary residual cardiac complications. Impressed by this high incidence of residual lesions, nine patients consented to a detailed follow-up which included serial EKG's, echo and phono cardiograms, and cardiac catheterizations. Seven of the nine had secondary lesions. Six of these seven lesions went unrecognized at the time of the initial operation. The following cases illustrate the most frequently encountered complications following cardiac trauma.

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TABLE 1. *Anatomical Location of Cardiac Injuries*

Location	Number of Patients
Right ventricle	12
Right atrium	6
Left ventricle	8
Left atrium	2
Pulmonary conus	1
Total	29

TABLE 2. *Secondary Lesions from Penetrating Cardiac Wounds*

Wound	Number of Patients
Coronary damage	3
Pseudoaneurysm	2
Bullet embolus	1
Ventricular septal defect	4
Recurrent pericarditis	1
Mitral valve injury	2
Aortocaval fistula	1
Aortopulmonary fistula	1
Total	15

Clinical Data

Coronary Artery Injury

A 31-year-old male was brought to the emergency room with a stab wound to the fourth left intercostal space, without obtainable blood pressure, dilated pupils, and bruises on his head and a laceration to the left brachial artery. Immediative resuscitation was performed in the emergency room with endotracheal intubation, rapid fluid infusion through the saphenous vein, and a resuscitative left thoracotomy with manual cardiac massage. Clotted blood was evacuated from the pericardial sac. A large penetrating wound of the anterior intraventricular zone was noted and was closed. He was moved to the operating room where a formal thoracotomy was completed. Further evaluation revealed complete transection of the left anterior descending coronary artery. The distal portion of LAD was not visible and a large area of bluish discoloration of the ventricle and poor kinetic motion was evident. He was severely hypotensive with a blood pressure of about 50–60 mmHg. despite large doses of vasopressor. He had several episodes of ventricular fibrillation and was anuric. Due to his poor general condition and questionable coronary and cerebral status, revascularization was felt to be inappropriate. Intra-aortic balloon pumping was instituted. Satisfactory hemodynamic response was achieved gradually. Cardiac output measured several hours later was 4.5 liters per minute. Twenty four hours later, the patient became conscious but confused and pulled out one of his chest tubes. Because of severe bleeding from the chest, re-exploration was necessary. Dramatic changes were noted in the appearance of the left ventricle by reduced area of bluish discoloration and improved contractility of the myocardium. Seventy two hours later, the intra-aortic balloon was discontinued and he made a gradual recovery. Four weeks later he underwent cardiac catheterization and coronary angiography showed the site of the coronary artery laceration. There was faint visualization of the distal left anterior descending vessel and a significant area of akinesia in the apex of the ventricle (Fig. 1). The patient remains asymptomatic one year post injury.

Comment

To our knowledge, the preceding case is one of the first reported cases to utilize IABP for traumatic injury to the heart although its use is well established for ischemic heart disease.[4]

Three patients in our series had traumatic injuries to their coronary arteries. One patient with a high velocity bullet injury to the left ventricle without apparent direct injury to the anterior descending artery developed cardiogenic shock on the second postoperative day from which he recovered. However, he was left with significant myocardial dysfunction. He probably developed secondary occlusion of his LAD because of intimal and elastic membrane disruption from the kinetic energy of the missile.[8,13] The third patient succumbed to severe shock and delayed cardiac tamponade secondary to a laceration of a marginal branch of the right coronary artery 12 hours after primary abdominal trauma. Coronary artery laceration is rather rare. In Rea's[12] report of 500 cases of cardiac trauma, only 22 patients (4.4%) were associated with coronary artery laceration. Initial and delayed complications of this injury are rather formidable. Ideally, direct myocardial revascularization is highly desirable[6] but, unfortunately, often due to operative circumstances and the patient's poor general condition, this procedure cannot be accomplished.[12]

Aneurysm and Pseudoaneurysm of the Ventricle

A 43-year-old woman with a stab wound of the left side of her chest was brought to the emergency room unconscious and in severe

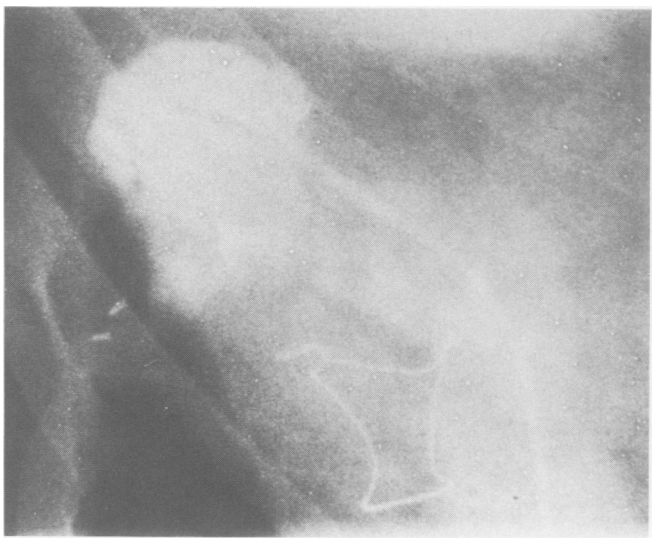

FIG. 1. Patient after coronary artery ligation. Left Ventriculogram eight weeks after shows akinesia of auteroapical segment of left ventricle.

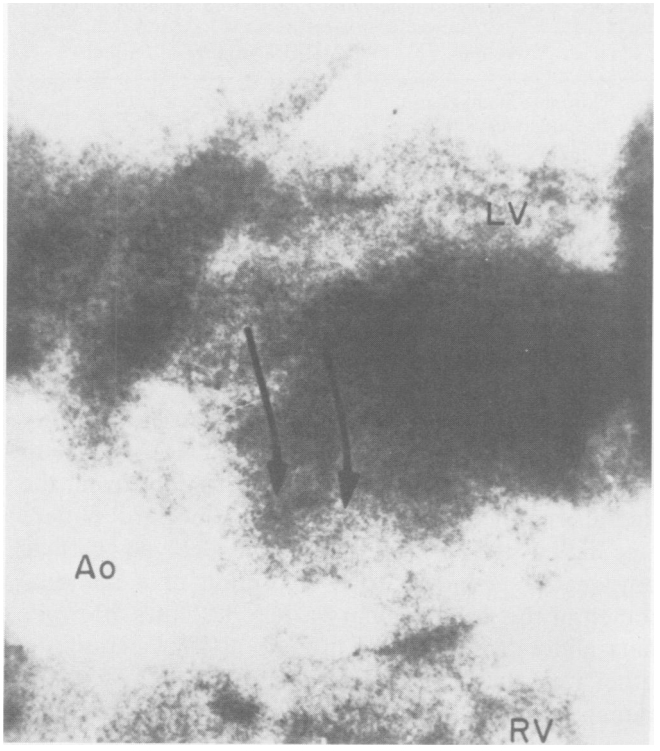

FIG. 2. Ventricular septal defect posttraumatic. Left Ventriculogram shows opacification of right ventricle.

shock. Pericardiocentesis yielded 190 cc of blood and promptly her condition improved. She was operated upon immediately and a large laceration of her left ventricle near the apex was repaired. She eventually gained consciousness and recovered. Eight weeks later there was presence of a round density near the apex. Pseudoaneurysm was diagnosed and was successfully treated one year later.

Comment

This complication is relatively rare.[16] We have only seen two instances which were detected eight weeks and one year after cardiac injury. Both patients had few symptoms and the diagnosis was primarily made by chest roentgenogram. Aneurysm and pseudoaneurysm may result after infection, infarction, or improper placement of suture.[7] In a true aneurysm, the wall is composed of altered myocardial fibrous tissue. The wall of a pseudoaneurysm contains no myocardial fibers, only fibrous tissue in adherent pericardium.[17] In the early stage of pseudoaneurysm development, the condition resembles a pulsating hematoma which develops as blood gradually leads from the perforation of the myocardium but is retained by the adjacent pericardium and surrounding clot. Subsequently, fibrous thickening and adhesions localized the hematoma area. In both our patients, the lesion was localized in the left ventricle; however, it is possible to have a right ventricular aneurysm. We have found high velocity Doppler signal corresponding with systolic filling of aneurysm very useful.[7] The diagnosis is confirmed by angiogram.

Bullet Embolus

Bullet embolus was seen in one instance in this series. A 42-year-old woman was brought to the emergency room unconscious with multiple gunshot wounds of the left chest and survived resuscitative thoracotomy. A single bullet wound of the left ventricle was repaired. A postoperative chest x-ray showed no evidence of a bullet. She developed severe ischemic symptoms of the left upper extremity and the bullet was detected in an x-ray of the arm. The bullet was extracted from the brachial artery. The patient made a complete recovery without complications.

Comment

There are numerous reports regarding cardiac foreign bodies.[13] However, embolization from a bullet to the upper extremity is relatively rare. The presence of an entrance wound without an exit wound or the sudden disappearance of a bullet from the chest x-ray should alert the physician to the possibility of a foreign body embolus.

Ventricle Septal Defect

A 19-year-old boy was brought to the emergency room unconscious, without blood pressure, and with stab wounds in the left posterior sternum and epigastrium. He did not respond to the initial resuscitative efforts, therefore, the chest was opened and blood and clots were evacuated from the pericardium. The ventricular wound was repaired. His subsequent postoperative recovery was uneventful. In follow-up, he complained of atypical chest pain, dyspnea, and inability to maintain normal activities. On examination, there was a grade IV/VI holosystolic precordial murmur heard best over the midsternum. Electrocardiogram showed left ventricular hypertrophy without any strain pattern. Echocardiogram was normal. Cardiac catheterization showed normal pressures. Ventriculogram showed interventricular septal defect (Fig. 2), competent mitral valve, and normal ventricular contractions. The patient remains asymptomatic 18 months after initial trauma.

Comment

Although interventricular septal defects of penetrating cardiac injuries are reported to be relatively infrequent,[1,14,16] we have found four cases in our series (14%). Apparently a small portion of patients with this injury require surgical management. However, the complications during long-term follow-up of this defect are not well documented. Recently, we observed another patient with posttraumatic interventricular septal defect who developed endocarditis extending into the aortic valve. In a rather large series of 12 cases reported by Asfaw, et al.[1] only four patients required surgical intervention. They also cited 40 additional cases from the literature of repair of traumatic septal defects of which only 17 were due to penetrat-

ing injuries. Only one of our patients had a pulmonary to systemic flow ratio greater than two to one. A repeat cardiac catheterization in 18 months showed it to be unchanged. Similar observations were previously reported by Pirzada.[11] In our experience, clinical symptoms alone are not satisfactory criteria for operative repair of the ventricular septal defect. Three of our four patients had ventricular septal defects limited to the muscular septum and none had multiple defects. Experimental data indicated that spontaneous closure of traumatic interventricular defects in dogs require several months.[19] Therefore, if clinical conditions permit, a prolonged period of observation is desirable. None of our patients had ventricular septal defect appreciated at the time of the initial surgery. Several days to several months lapsed before it was recognized. Cardiac catheterization is required for physiological anatomic delineation of these lesions.

Recurrent Pericarditis

A 26-year-old man who was initially admitted with cardiac and multiple visceral injuries subsequently had six hospitalizations over the next two years for recurrent pericarditis. Pericardiectomy was performed and pathological examination revealed a sclerotic pericarditis with abundant new blood vessels and a small number of inflammatory cells.

Comment

Posttraumatic pericarditis is a frequent complication of penetrating cardiac injuries. Tabatznik's series showed only 22%.[18] The pathogenesis of this syndrome is not clear. Inflammatory response to trauma, reaction to intrapericardial blood, hypersensitivity, and infection have been suggested as causative factors in the development of this syndrome. Although clinical symptoms and EKG findings of pericarditis have been seen in several of our patients, only one patient had serious enough symptoms to require pericardiectomy.

Mitral Valve Injury

An 18-year-old boy presented with a stab wound of the left anterior chest. There was a 3 cm parasternal laceration over the third intercostal space. Chest x-ray revealed a moderate hemopneumothorax which was treated with a chest tube. He had no evidence of severe hemodynamic abnormalities. Hemopneumothorax resolved, however, he developed pyrexia with bilateral pulmonary infiltrates. A chest x-ray on the fifth hospital day revealed some enlargement of the cardiac shadow. Echocardiogram revealed a small amount of pericardial effusion posteriorly. In the following ten days, he became more symptomatic. A repeat echocardiogram revealed an increase in the pericardial sac. Following the pericardiocentesis, a repeat echocardiogram showed complete disappearance of the effusion. Paradoxically, a short time after the pericardiocentesis, his condition deteriorated. He became diaphoretic, hypotensive, cold and clammy and he was urgently operated on. The pericardial sac was thick, appeared acutely inflamed and was very tense. Three hundred cubic centimeters of blood were evacuated. There was a defect in the pericardium extending from the stab wound tract with an obvious wound in the left atrium. An apical and symptomatic murmur was noted postoperatively. As part of his postoperative work-up, cardiac catheterization was performed and revealed a moderate degree of mitral insufficiency without any other intracardiac damage. He has remained asymptomatic for the last 11 months.

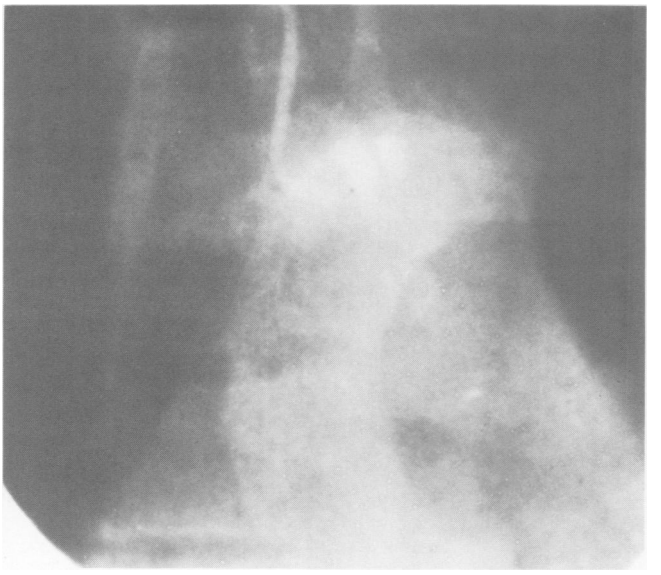

FIG. 3. Aortogram shows opacification of superior vena cava through a tract originating at the level of aortic arch.

Comment

It has been stated in the literature that often serious cardiac trauma will lead to secondary valvular damage and that these patients will not survive their initial trauma. This statement is perhaps valid in reference to the bullet wound, however, penetrating stab wounds may involve valve leaflets, chordae, or papillary muscles. The clinical course of these patients may be insidious and complicated as in the above case. The secondary finding of posttraumatic mitral valve insufficiency was rather surprising to us. The prognosis for this patient is yet to be determined. Another patient, with a known posttraumatic mitral valve injury, remained asymptomatic for 20 years before developing enough hemodynamic and clinical symptoms to require surgery.[8]

Aortic Fistula

A 38-year-old man was admitted to the emergency room in a state of profound shock following gunshot wounds of the chest and abdomen. At thoracotomy and laparotomy, a large laceration of the left ventricle was found and repaired as was the hepatic damage. His postoperative course was complicated by low cardiac output, hypoxemia, and severe respiratory distress but he gradually improved. On the eleventh postoperative day, a loud murmur was heard over the anterior chest in the intraclavicular area. Cardiac

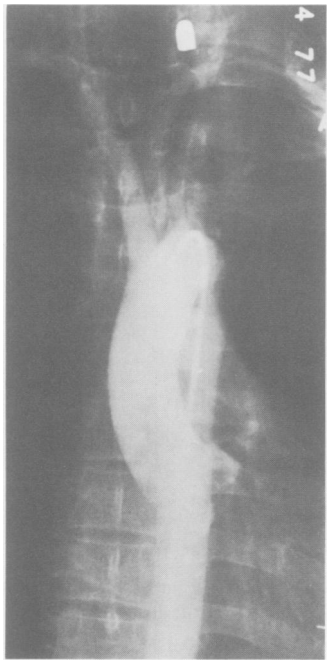

FIG. 4. This figure shows a small outpouching of aortic lumen on the left lateral aspect of ascending aorta. Fistula could not be demonstrated.

catheterization did not reveal any intracardiac lesion. However, an injection of contrast material into the aortic arch demonstrated an aortocaval fistula just distal to the takeoff of the brachiocephalic arteries (Fig. 3). During the next six months, the intensity of the murmur diminished and ultimately was inaudible. At re-evaluation, an aortic arch arteriogram did not reveal an arterial venous fistula. Small outpouching of the left lateral aspect of the descending aorta was noted (Fig. 4).

Comment

Penetrating wounds of the aorta are usually fatal. In 1958, Parmley, et al.[10] reviewed 456 autopsy reports and reported that only 18% of the patients survived for longer than one hour. We have seen two of these patients in our rather limited series of complicated sequelae of cardiac wounds. Secondary problems may become evident weeks after recovery from the initial injury and require thorough evaluation. Our second patient acquired an aortopulmonary fistula secondary to a stab wound and became severely symptomatic and it required surgical correction.

The most frequent fistula following penetrating cardiac injury is between the aorta and the right ventricle.[17] Other fistulae are relatively rare and often subjects of individual case reports.[2] Due to the wide pathologic spectrum, several methods of treatment and time intervals anywhere between two and twenty years have been recorded.

Discussion

After centuries of fear, inquiry, debate, and observation, the management of cardiac wounds have become part of routine surgical practice. New methods and new discoveries have overcome the natural difficulty that attend the heart wound despite Paget's pessimistic predictions in 1896[13] The education of emergency personnel, the rapid means of transportation, and the improved training of house officers have resulted in universally good surgical results.[1,3,16] The total death rate for 15–24-year-olds in the United States has risen during the 1960's[20] due to the doubling of suicides and homicides as well as a 30% increase in motor vehicle accidents. These factors have resulted in many more cardiac injuries. The nature of these injuries have also changed dramatically. The simple, small knife wounds have gradually been replaced by bullet wounds. Each year there are 25,000 gun deaths in the United States.[9] Cardiac injuries apparently make up 15% of the total fatalities from thoracic injuries. Unfortunately, the majority of heart wounds are still fatal. Survival depends on the velocity of the bullet, the anatomical location, and the extent of associated injuries. However, the majority of patients who reach the hospital alive usually recover.[3,13,15] This increasing group of survivors present with new problems of residual damage which was previously only a matter of interest to the forensic pathologist.[5,9] To our surprise, secondary complications were noted in 15 of our 29 patients. It is also significant that since undertaking routine posttraumatic cardiac evaluations, seven of our nine patients had residual cardiac damage. Six of the seven patients were found to have significant cardiac lesions which went unrecognized at the time of initial operation. Due to social status and migratory pattern of the life of this class of urban nomads, detailed long-term follow-up is very difficult and sketchy.

That these sequelae may manifest themselves after a very significant time interval is not generally realized. Perhaps, a simple method of national registry which will identify these patients' specific lesions might prevent some of the expensive repeated investigations of these patients and also may provide a guide to the natural history of these secondary cardiac lesions.

In conclusion, due to the increased rate of social violences and the improvements in quality of offensive weapons, the high success rate in the initial therapy results in a growing number of cardiac residual damages. We have shown that routine detailed posttraumatic work-up will uncover an even higher number of residual problems which will have important prognostic, therapeutic, and legal implications.

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