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Case Report

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Heart Firearm Wound Treated with Extracorporeal Circulation at the Emergency Service

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Abreviations: AB: Anal Border; AIS: Abbreviated Injury Scale; AP: Anatomic Profile; ASCOT: A Severity Characterization of Trauma; ATLS: Advanced Trauma Life Support; BP: Blood Pressure; ECC: Extracorporeal Circulation; FA: Firearms; HB: Hemoglobin; HR: Heart Rate; HW: Heart Wounds; ICU: Intensive Care Unit; ISS: Injury Severity Score; IU: International Units; ND: No Data; PTFE: Polytetrafluoroethylene; RR: Respiratory Rate; RTS: Revised Trauma Score; RV: Right Ventricle; SBP: Systolic Blood Pressure; TRISS: Trauma Injury And Severity Score; WBC: White Blood Cells

Abstract

It is known that almost 50% of heart injury victims die at the trauma site or in transportation. This study presents a case of firearm wound with intra-cardiac injury treated with extracorporeal circulation at the emergency service. A 19 year-old male patient with two gunshot wounds: one in the right thoracic-abdominal transition without exit orifice and the other in the right gluteus with right thigh exit. After angiotomography, with evidence of projectile inside the cardiac chamber and a lesion in the extraperitoneal rectum, a surgical procedure was indicated. Firstly, an access to the thoracic cavity was made by performing a longitudinal anterior sternotomy. Then, after opening the pericardial cavity, an entry orifice of the projectile in the anterior wall of the Right Ventricle and a large clot buffering the wound could be observed. The extracorporeal circulation was installed. The right atrial cavity without lesions was visualized after performing wide right atriotomy. A small incision was performed in the atrial septum for decompression. The Tricuspid cusps were exposed by the retractor showing the ventricular septum. The projectile was located between the posterior papillary muscle and the chordae tendineae. The exploratory laparotomy showed two extraperitoneal rectum lesions. Protective colostomy (sigmoidostomy in a loop), pre-sacral drainage, and distal stump washout were performed. The outcome was highly satisfactory.

Introduction

Until the late nineteenth century, thoracic surgery was behind the advances of other surgical areas, such as abdominal surgery. In 1883, Billroth stated that "The surgeon who would attempt to suture a wound of the heart should lose the respect of his colleagues."Cappelan recorded the first attempt of suturing a heart wound in 1895. His patient died two days later. The first surgeon to succeed in a cardiac suture was Rehn in 1897. Ten years later, he was able to record 124 cases of cardiac suture with a 40% recovery rate [1]. Heart Wounds (HW) caused by Firearms (FA) are related to high morbidity and mortality [2]. As a life threatening trauma, it usually requires immediate surgical intervention as the basis of treatment. Almost 50% of victims die before arriving at

the hospital [3]. Victims who arrive at the hospital alive have a 30% death risk [4], usually requiring resuscitation measures and immediate thoracotomy [3]. Heart wounds caused by stabbing are 1.5-4.5 times more frequent than lesions caused by FAs. However, the lethality is 13 times higher when wounds are caused by FAs [5,6]. The incidence of this type of wound has been increasing due to a progressive elevation in interpersonal violence in large urban areas and a greater access of the population to firearms [6].

Despite the increase in the number of victims, the absolute and relative rates of cardiac trauma still evidence the rarity of this condition. Among HWs caused by FAs, wounds in which projectiles are loose within the cardiac cavity, and therefore require Extracorporeal Circulation (ECC) for treatment, are rare [7]. We report the case of a patient who had been shot and had a projectile inside the heart chamber, by penetrating the Right Ventricle (RV), remained loose within the cardiac chamber. The patient was submitted to an emergency surgical procedure using ECC, with good results.

Clinical Case

The Mobile Emergency Service (SAMU) brought a 19-year-old caucasian male patient to our emergency service who was victim of two gunshot wounds in an exchange of gunfire with the police after a robbery. At the scene, he was hemodynamically unstable, with a Blood Pressure (BP) of 90/60 mmHg and a Heart Rate (HR) of 130 bpm. The transportation to the emergency room took 40 minutes and the pre hospital staff provided 1.000 ml of crystalloid solution.

At admission, he remained hemodynamically unstable, with a BP of 110x70 mmHg and a HR of 100 bpm. His extremities were cold and pale. He was treated according to the protocol recommended by the ATLS (Advanced Trauma Life Support). The pulmonary auscultation evidenced a decreased vesicular murmur and hypertympanic sound on percussion (keeping a saturation of 96% in ambient air) on the right hemitorax. There was an entrance wound at the sixth right intercostal space between the anterior axillary line and the right hemiclavicular line, without an exit wound and other entrance wound in the right gluteus with the exit wound in the right thigh (Figures 1,2).

Figure 1: Exit hole on the 1/3 upper right side of the patient's thigh.

Figure 2: Entrance hole at the sixth right intercostal space, with abrasion ring, between the anterior axillary line and the right hemiclavicular line.

After offering an oxygen mask (10 liters/minute), the patient was monitored. Two peripheral large venous accesses were installed, and he received 500 milliliters of physiological solution (SF 0.9%). The laboratory tests (blood typing, hemoglobin, and blood reserve) were performed. At the secondary survey, a rectal examination revealed a lesion 5 cm from the Anal Border (AB) at 6 o'clock and another lesion 7 cm from the AB at 3 o'clock.

A 38 French intercostal drain was inserted on fifth intercostal space in the right thorax, with no immediate complications, connected to an underwater seal bottle that immediately began to bubble. Four hundred milliliters of blood poured into the bottle, causing a subsequent stabilization of BP and HR. A chest X-ray, performed in the trauma room, showed a good location of the chest drain.

After hemodynamic stabilization, the surgery team accompanied him to perform a thoracic and abdominal angiotomography that showed a projectile inside the cardiac chamber and a lesion in the extraperitoneal rectum. The emergency surgery team indicated sternotomy and exploratory laparotomy and therefore contacted the cardiac surgery team of our institution.

The procedure began by providing an access to the thoracic cavity by performing a longitudinal anterior sternotomy. Then, after opening the pericardial sac, an entrance orifice of the projectile in the anterior wall of the RV and a large clot buffering the wound could be observed. The ECC was installed after complete heparinization using a cannula number 20 in the aorta and two venous cannulae, one (number 30) in the superior vena cava and the other (number 32) in the inferior vena cava. A total aortic clamping and cardioplegia were performed with Custodiol in the aortic root. Then a wide right atriotomy was performed and the right atrial cavity without lesions was visualized and a small incision was performed in the atrial septum for decompression. The cusps of the tricuspid valve were exposed by the retractor, showing the ventricular septum. The projectile was located between the posterior papillary muscle and the chordae tendineae. The projectile was then removed. The interventricular septum was free of lesion (Figures 3-5). Before the closure of the right atrial wall, the tricuspid valve was tested with

saline solution. The valve was competent. The right ventricular wall injury was repaired by separate anchored points buttressing with PTFE (polytetrafluoroethylene) and atriotomy closure was performed with a single layer continuos suture of Prolene 4-0 (polypropylene). Protamine sulfate was applied to the aortic root, and a temporary pacemaker was placed in the RV. The drainage of the pericardium was performed using tubular drainage and partial closure of the pericardium, in addition to drainage of the mediastinal cavity and sternum closure.

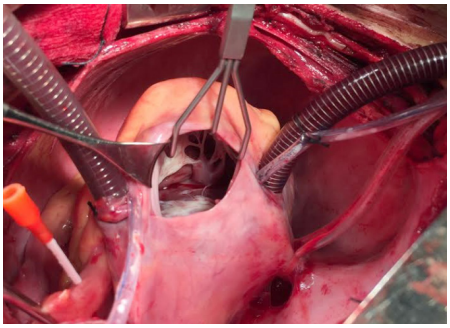

Figure 3: Identification of the projectile between the posterior papillary muscle and the chordae tendineae.

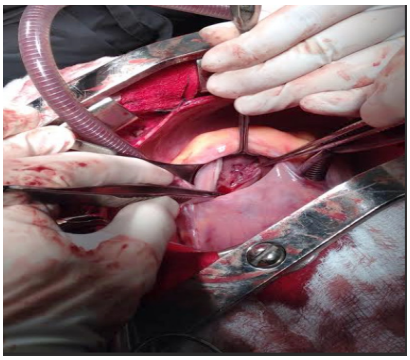

Figure 4: The cusps of the tricuspid valve were retracted and the interventricular septum was visualized intact, identifying the projectile between the posterior papillary muscle and the chordae tendineae

Figure 5: Projectile withdrawn from the cardiac cavity on a surgical compress.

Then, an exploratory laparotomy was performed with evidence of two extra-peritoneal rectum lesions (one lesion 5 cm from the AB at 6 o'clock and other lesion 7 cm from the AB at 3 o'clock). There were no other alterations. Protective colostomy (sigmoidostomy in a loop), pre-sacral drainage, and distal stump washout were performed.

The surgical procedure lasted seven hours. The ECC time was 30 minutes. The anesthetic time was seven hours and forty minutes. The patient received four Units (IU) of red blood cell concentrate, five IU of fresh frozen plasma, six IU of platelets, and 6.000 milliliters (ml) of crystalloid. He was then referred to the Intensive Care Unit (ICU) in a stable clinical condition, with a hemoglobin count of 7.7 (Table 1).

	Nov. 7	Nov. 8	Nov. 9	Nov. 10
HB	7.7	7.8	8.8	8.2

Table 1: Hematimetry in the first four postoperative days.

The thorax drain flow rate was 1.300 ml in the first ten hours after surgery. The contents of the draining were sanguinolent. The patient remained in the ICU for three days. He received antibiotic therapy (Ceftriaxone 1 g/12 h, and Metronidazole 500 mg/8 h) for seven days. The drains were removed on the eighth day and, ten days after the surgery, he was transferred to the penitentiary hospital. After 15 days, he returned in outpatient clinic with the cardiac surgery team in good conditions, without complains. The rest of the follow up was made at the penitentiary hospital; therefore, we do not have information about the intestinal transit reconstruction.

Discussion

The incidence of cardiac traumas by firearm projectiles has been increasing in urban areas. They are often fatal. A favorable prognosis depends on the immediate medical care, a precise diagnosis and a fast surgical intervention6, requiring greater attention and improvement of pre-hospital and hospital procedures. The position of the heart in the rib cage exposes the RV. It comprises most of the anterior face (sternum-costal) of the heart. This cardiac chamber is therefore more susceptible to penetrating lesions. The left atrium -as it is smaller than the other chambers and it has a posterior location- is the least affected chamber.4,6 Based on anatomy and casuistry, the most affected chambers are the RV (43%), left ventricle (34%), right atrium (18%), and left atrium (5%), in descending order [7].

Penetrating lesions in the "Cardiac box," or Ziedler Area, and its surroundings suggest the occurrence of cardiac involvement. However, injuries caused by FAs may reach the heart by penetrating other sites [8]. The ability of projectiles to deviate from planes of tissues and rigid surfaces is well known. Therefore, a cardiac injury may not be easily diagnosed by the site of the projectile

entry [4]. Lesions to multiple cardiac chambers result in a worse outcome than lesions affecting only a single chamber, such as the case presented here. In a retrospective study conducted by Lone et al., of forty patients with heart injuries caused by FA or shrapnel, 35 (87.5%) patients had lesions in a single cardiac chamber. The survival rate was 62.8%, while five (12.5%) patients had lesions in more than one chamber and the mortality was 100% [9]. In a retrospective study carried out in Brazil by Almeida Costa et al. on patients with cardiac wounds caused by blades and by firearms, the mortality rate was 37.5% for lesions in associated chambers. Among patients with this type of lesion, the mortality was 20% for RV associated with right atrium, and 100% for lesions in both ventricles [10].

Intra-cardiac projectiles may lodge partially or totally in the myocardium. They may also be retained in the trabeculae of the surface of the endocardium, stay loose in cardiac chambers and pericardial sac, or near large vessels.3 They are the result of a direct penetrating wound, as in the case presented here, or of a peripheral venous structure with embolization to the heart. When the foreign body is small and loose in the right compartment, greater caution is required as there is a possibility of embolization to the lung [11].

The choice for a surgical approach in asymptomatic patients depends on where the projectile is lodged. However, symptomatic patients should be immediately referred for removal surgery. Projectiles of FAs partially or completely intracavitary, as is the case here, should be removed due to the threat of embolization or infection. The access route chosen in the case reported here was median sternotomy. According to the literature, it is a safe approach due to low morbidity and short hospitalization time when compared to thoracotomy [12,13].

Some tools help to establish the patient's prognosis as they rate the severity of the lesion: the trauma indexes. They are scoring systems that aim to evaluate physiological changes, quantify anatomical lesions, calculate survival probability, refer trauma patients to trauma centers, conduct clinical research, evaluate institutional results, control quality of care, provide epidemiological data, help in violence prevention campaigns, and estimate medical and hospital costs [14].

The knowledge of the severity of a polytraumatized patient is fundamental to define the hospital team's behavior, which directly interferes with the probability of survival of the patient. The scores can be anatomical, physiological or combined. In this study, some of the main scores will be discussed. The Abbreviated Injury Scale (AIS) is an internationally accepted system that ranks the overall relative severity of a single lesion based on anatomy. It is the basis for the calculation of the Injury Severity Score (ISS), which is also anatomical. This score is intended for patients with multiple lesions. It is the simplest and most widely used method. It comprises a 6-point scale: One is the minimum and six is the maximum score [15]. All lesions are classified according to severity and grouped according to the body section where they are located. The Revised Trauma Score (RTS) is a physiological assessment system composed of three categories: assessment of neurological status (Glasgow Coma Scale), Systolic Blood Pressure (SBP), and Respiratory Rate (RR). The RTS, in association with the ISS, is the Trauma Injury and Severity Score (TRISS), a combined classification that determines the probability of patient survival and quality of service [14]. The TRISS takes into account the age of the patient (two age groups) and the mechanism of the injury (if blunt or penetrating) in order to evaluate the probability of comorbidities and estimate the probability of survival, respectively. However, this method has a low predictive capacity.

There is also the A Severity Characterization of Trauma (ASCOT), which was developed to overcome some limitations of TRISS. The ISS is no longer used in this scale, and the Anatomic Profile (AP) method has replaced it. The AP is an anatomical score that describes the capacity of the global influence of multiple lesions better than the ISS. This scale discriminates subtypes of penetrating poly trauma mechanisms into stab or gunshot, and considers the age of the patient with a greater specificity (five age groups), contributing to a better predictive [16]. Comparatively, the ASCOT has a better discrimination capacity, and is a more reliable index for the evaluation of survival, although its calculation is more complex. Due to great tissue destruction of lacerations by firearms, this type of injury presents more difficulties of repair when compared to injuries caused by blunt objects, for example. Lesions caused by FA projectiles, after suturing and controlling, often enlarge due to temporary cavitation and to the energy of the projectile over the myocardium, making it more friable. Thus, these lesions may require more than one suture to control bleeding. Biocompatible materials, such as PTFE, are needed to buttressing the initial suture, which is generally performed using a 4-0 or thinner propylene wire depending on the availability and the preference of the surgeon [17].

ECC in cardiac traumas is used in special situations: extensive ventricular injuries, large vessel and coronary artery lesions, valve lesions, intracardiac shunts, coronary-cavitary fistulas, and, as in our case report, foreign bodies or intracardiac projectiles [7,8]. Mari-Liis Kaljusto, et al. observed in their cohort study that, over a ten-year period, of 31 patients admitted with a penetrating cardiac trauma at the Oslo University Hospital, only one was submitted to extracorporeal circulation due to trauma caused by a knife, which affected the left atrium and the left ventricle [18]. Based on the great importance of ECC, the American College of Surgeons Committee on Trauma requires technology availability in level I trauma centers. This procedure is generally performed only by cardiovascular surgeons [6].

Conclusion

Although HW by FA are rare, such wounds lead to a high morbidity and mortality. The use of ECC in the emergency for the treatment of such lesions is rare. However, its use is imperative in some cases, and the synergy between the emergency and cardiac surgery staff in trauma centers is highly necessary. The experience of the surgeon in the emergency room also influences the survival of patients, since recognition and immediate intervention are decisive factors.

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