

Cardiac Trauma. Management Strategies short panoramic View.

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Abstract

Introduction; Trauma is the leading cause of death in United States in the younger population. National Trauma Data Bank in 2017 reported that 140 000 Americans dies and 80 000 are permanently disabled as a result of trauma each year. Cardiac trauma is identified in less than 10% of all trauma admissions but is associated with a much higher mortality than other organ system injuries. Considering the lethality of this type of injury, better guidelines should exist to direct management. We have analyzed data from pub med, surgery books, reviews and original presentations from many institutions to present actuality in management strategies of cardiac injuries.

Cardiac injuries are classified penetrating and blunt. Penetrating trauma includes stab or guns wounds. All patients with a penetrating wound anywhere near the heart should be considered to have a cardiac injury. The penetrating cardiac traumas is a surgical emergency while the blunt injuries treatment consists mainly in observation.

With early aggressive management only 1/3 of patient that arrive at hospital can be saved and this number can arise to more than 70 % if the patient survives until operating room. The results of treatment depend from infrastructural health system to the clinical presentation of the patients. Penetrating cardiac wounds mortality varies 5 % to 76 %. Blunt cardiac injuries are encountered mostly during motor vehicle accidents. The incidence of cardiac injuries in blunt trauma is 2.3-4.6 %. Overall mortality varies 11.4-24.5 %. Myocardial contusion is the most frequent type of blunt cardiac injuries.

The diagnose of the cardiac trauma include: clinical assessment, physical examinations, chest radiographs, echocardiography, cardiac enzymes, ECG, CT scan and even chest drainage. Despite many diagnostic tools we have, it is very important the right management of these tools and the time.

Conclusion: The surgery teams should be familiar with the management of the cardiac injuries and continuing education about this topic is the success key to manage better these emergencies.

Keywords: cardiac trauma, emergency, thoracotomy, cardiac tamponade

Background

Cardiac trauma is damage done to the heart by penetrating or no penetrating injuries [1]. National Trauma Data Bank in 2017 reported that 140 000 Americans dies and 80 000 are permanently disabled as a result of trauma each year. Cardiac trauma is identified in less than 10% of all trauma admissions and is associated with a much higher mortality than other organ system injuries. The patients involved are mostly young [2].

Objectives; We tried to report the actuality about cardiac trauma from demography to the management.

Original article, no submission or publication in advance or in parallel

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Materials and methods; We analyzed data from original presentations, pub med, surgery books and reviews.

Cardiac trauma classification and demography

Cardiac traumas are classified in two main groups according to the mechanism of injury: penetrating and blunt cardiac injuries. The etiology of penetrating injuries is commonly a stab or gun shot while the mains causes of blunt injuries are motor vehicles accidents, struck of pedestrians from motor vehicles and falls from heights.

Penetrating cardiac injuries are mostly object of surgical treatment and that is why this group is going to be the main topic of our presentation.

The patients involved in cardiac trauma are mostly young. *Mattox and others* report thirty-year collection of cardiovascular injuries. They show that the most part of patients are 20-40 years old (fig 1) [3].

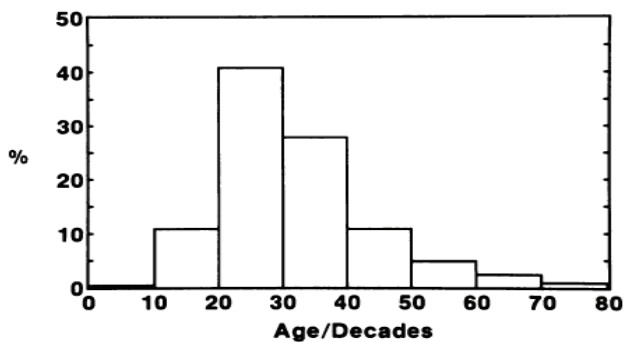


Figure 1 Patients Epidemiologic Evolution 1958 to 1987.

This trend remains the same for decades. The mean age varies from 25 to 45 years old and the patients are mostly of male gender (Table 1). In this table are involved original publications with different number of patients, from different countries and different times of presentations.

Anatomy

Every penetrating wound in the chest should be considered a high risk for cardiac injury.

J O'Connor et al [4] present the “cardiac box” that is localized from the clavicles to the costal margins between medial clavicular lines. When during the physical examination we see a wound is in this part of the thorax we should be more aware to have a cardiac injury (Fig 2)

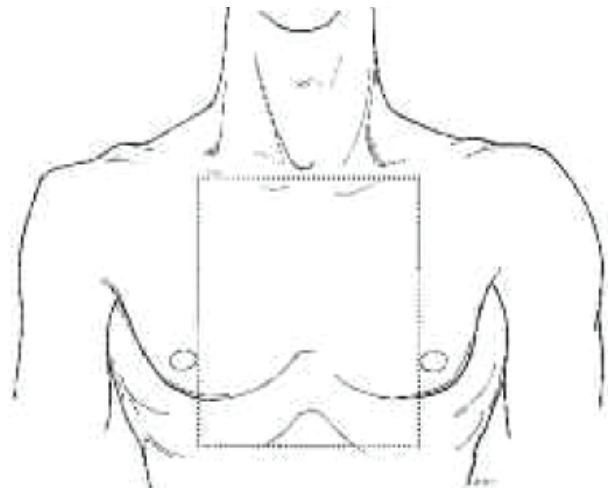


Figure 2. Cardiac Box. Penetrating Cardiac Injury

The most frequent part of the heart involved in the injury is the right ventricle followed by left ventricle, right atrium, left atrium and coronary arteries. This finding is conditioned by the anatomic position of the heart in the thorax (Table 2) [1, 5].

Author	No of Pat.	Mean Age	Male	Mortality	Survival	Journal
Bamous et al.	98	32	88%	60%		Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (2016) 24:6
<i>Clarke et al.</i>	282			76%		J Thorac Cardiovasc Surg 2011; 142: 563-8)
Bouassida et al.	19	25	90%	5%		Pan African Medical Journal. 2012; 11:54
<i>S.T.Yao et al</i>	80	30	88%	24		Annals of Surgery,july 1968
Molina et al.	94	28	95%		8%	ICTS 2008,845-849
<i>Gwely et al.</i>	73	28	95%	23%		Thorac Cardiovasc Surg. 2010 Jun;58(4):210-4
Christopher J et al.	129			8%		The annals of thoracic Surgery Vol 53, Issue 6, June 1992, 1006-1009
<i>Avaro JP et al.</i>	16	45	75 %	12%		J Chir (Paris). 2008 Jan-Feb;145(1):42-5
Mihalache et al.	20	34	85%	20	80	Chirurgia (Bucur). 2005 May-Jun;100(3):255-8
<i>Degiannis et al.</i>	117	35	93 %	25		World J Surg. 2006 Jul;30(7):1258-64
Mandal AK et al.	196			22%		World J Surg. 2001 Sep;25(9):1145-9.

Table 1 Original publications with different number of patients, from different countries and different journals

Anatomic Location	% of cases
Right Atrium	14
Right Ventricle	43
Coronary Arteries Involved	3.1-4.4
Left Atrium	5
Left Ventricle	33

Table 2. Anatomic Location of Penetrating Cardiac Injuries

Pathophysiology and clinical sings

Less than a quarter of patients with a penetrating cardiac injury reach the hospital alive [8]. The most part died at the scene or during hospital arrival [4]. Campbell at al refer that penetrating cardiac injuries are among the most lethal of injuries; typically, < 10% of patients with PCI arrive at hospital alive [7]. The usual physio pathological mechanisms are tamponade and haemorrhage that result in low cardiac output. Stab wounds commonly cause tamponade while shot guns go to haemorrhagic shock.

The patient may be presented from a good clinical condition to signs of cardiac arrest. Penetrating cardiac wounds are frequently accompanied by wounds involving lungs or abdominal viscera. Beck's triad may be diagnostic in patients with isolated normovolemic tamponade (1) distended neck veins (2) hypotension and (3) muffled heart tones. Cardiac tamponade may be also manifested with Kussmaul's sign (1) increased neck veins distension during inspiration and (2) pulsus paradoxus which show the increase of systolic blood pressure of 15 mmHg or more during spontaneous inspirations [16].

Evaluation

Rapid mandatory physical examination is done the moment the patient comes to emergency department. Location of wound and assessment of cardio respiratory status very important. The initial care of the trauma patient with cardiac injuries is practically the standard Advanced Trauma Life Support (ATLS) protocols. We should ensure the patency of the airways and establish adequate oxygenation and ventilation. There may be the necessity make tube thoracostomy for drainage of hemothorax from the pleural space to ameliorate the ventilation and in the same time the drainage may be helpful in diagnose too. Continuing with the evaluation of the circulatory system. Priority is given to establishing intravenous access for the administration of liquids, crystalloid and/or blood products. Insertion of central venous catheter helps a lot in treatment and diagnosis of tamponade.

When we discuss about the cardiac trauma we meet very often "the condition of patients" stable or unstable and "signs of life". The status stable or unstable is related with hemodynamic status. A patient with a systolic pressure

more than 90 mmHg is considered stable while when the systolic blood pressure is below these values the patient is considered unstable [5]. Signs of life were considered present with any of the following: pupillary response, spontaneous ventilation, presence of carotid pulse, measurable or palpable blood pressure, extremity movement, or cardiac electrical activity [9].

Depending on the patient's conditions the evaluation follow with a chest radiography and two-dimensional echocardiography. When we suspect the cardiac tamponade, this should be confirmed with sonographic confirmation. Diagnosis of cardiac injury and tamponade has been facilitated by portable ultrasound becoming the standard of care in the evaluation of trauma patients. Transesophageal echocardiography is nowadays technique of choice. The focused assessment with sonography for trauma (FAST) scan allows for simple, quick, and non-invasive assessment and recognition of cardiac trauma. When we miss the ultrasound examinations pericardiocentesis and subxiphoid exploratory can be very helpful. Both of them have diagnostic and intermediate treatment values. The drainage of the pericardial space even of 50 ml blood ameliorates clearly the hemodynamic conditions and gives us time in management. Subxiphoid window (fig 3) has been gold standard for the diagnosis at the times when the ultrasonography was unavailable [1, 5]. CT scan can be another diagnostic device that gives us information not only for the heart but also for the entire thoracic cavity [8, 11, 12, 13].

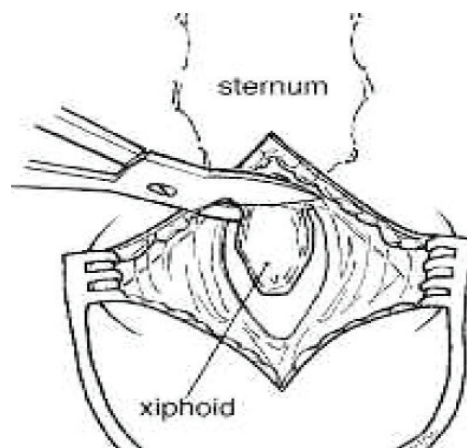
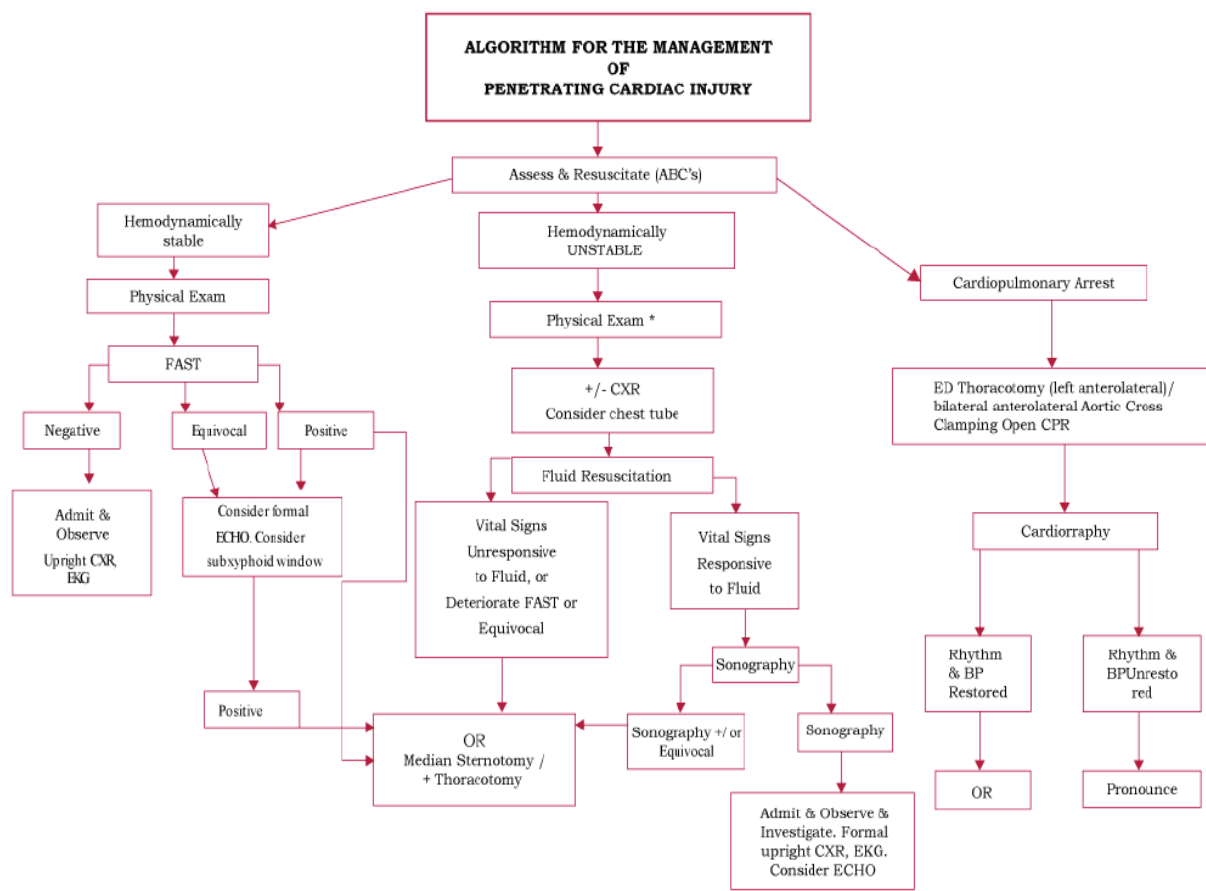


Fig 3. Schematic subxiphoid window

When patient has been under cardio pulmonary resuscitation (CPR), during arrival or in hospital the time from initiation of CPR is very important in making decisions of management. When this time greater than 15 minutes of CPR and no signs of life, the patients are pronounced [10].

Management and Treatment

Management and treatment depend on the clinical conditions of the patients. In all patients we start with restoring the circulating volume. In unstable patients' resuscitative



Source: Feliciano DV, Mattox KL, Moore EE: *Trauma*, 6th Edition:
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Graphic 1 Algorithm of management and treatment of penetrating cardiac injuries

measures, including endo tracheal intubation and insertion of chest tubes, are performed promptly on admission to the emergency department. In all cases the treatment is guided from the clinical situation of the patients and the evaluation goes parallel with the treatment. (Graphic. 1)

First of all, if the device is in *in situ* it should not be removed until the chest is opened. We should adapt the injured patient with the sections of the emergency department.

Surgically left antero-lateral thoracotomy is approach of choice for emergency room. It provides rapid access to the right and left ventricles and to the pulmonary artery. Technically the chest is opened through the fifth intercostals space just below the level of the male nipple (Fig 4).

If we need to have access to the right atrium and superior or inferior vena cava and proximal aorta we may continue with a 'clam-shell' incision (fig 5). This way allows cross-clamping of the descending thoracic aorta if we need it.

Median sternotomy is preferable in most stable patients. It gives access to the heart and great vessels, to other structures in the mediastinum and to both pleural cavities [14].



Figure 4. Left anterolateral thoracotomy

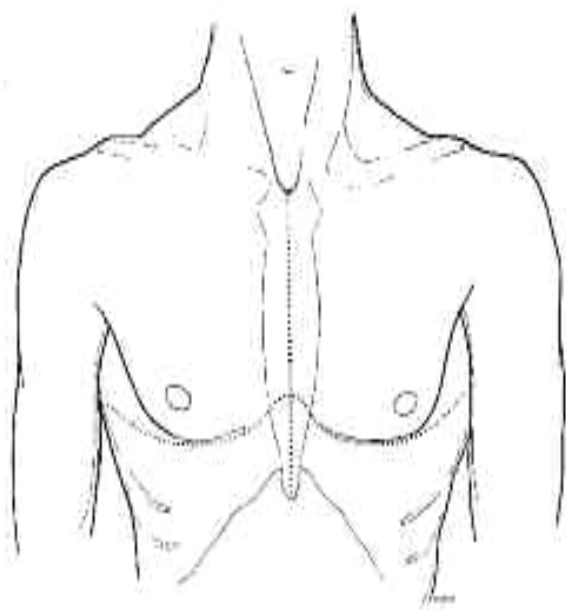


Figure 5 Median sternotomy and clamshell incisions.

Generally, when the patient arrives in the emergency department unconscious or semiconscious and without vital signs, when the data suggest a cardiac or great vessel wound as the cause, immediate emergency department thoracotomy is indicated. This procedure should be considered in patients who arrive within 10 minutes of having detectable signs of life.

When the patient is in shock but has vital signs, a pericardiocentesis is performed and he is transported rapidly to the operating room.

When the patient's condition is good and a cardiac wound is only suspected, investigation can be accomplished.

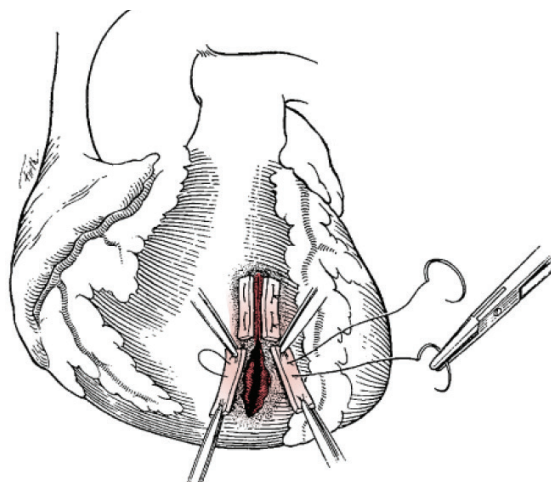
After the heart is exposed, cardiac wounds are repaired. The intervention usually does not need the cardiopulmonary by-pass. In case when it is necessary to accomplish full repair, we have control hemorrhage until CPB is feasible.

Atrial wounds are mostly repaired by direct suturing with polypropylene sutures while ventricle injuries are repaired generally with horizontal mattress sutures with pledgets (Fig 6, 7).

We can use digital pressure or Foley catheter to control the exsanguination until the repair can be feasible. In patients with severe hypotension or cardiac arrest we can clamp the descending aorta to improve the coronary and the cerebral perfusion. We should aim a systolic blood pressure approximately 90-100 mmHg [1, 6].

Results of emergency thoracotomy and risk factors

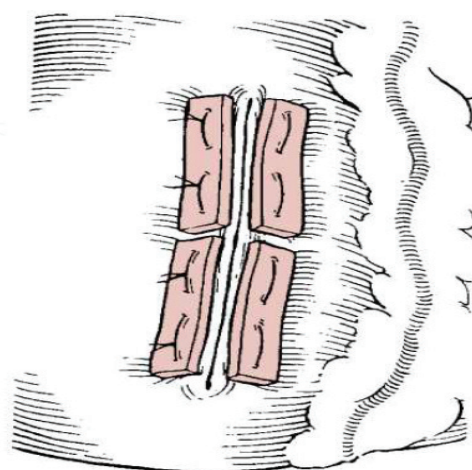
Overall survival of patients treated for stab wounds is 80 % while for patients with missile wounds have about 40 % survival [1]. In the patients arriving in the operating room with signs of life and recordable blood pressure the survival exceeds 85 % for stab wound and 75 % for gunshot wounds [6].



Source: Feliciano DV, Mattox KL, Moore EE: *Trauma*, 6th Edition: <http://www.accesssurgery.com>

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Figure 6. Schematic Repair of Right Ventricular



Source: Feliciano DV, Mattox KL, Moore EE: *Trauma*, 6th Edition: <http://www.accesssurgery.com>

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Figure 7. Pledgets are used to reinforce the suture line

Emergency thoracotomy is the most common intervention performed for the treatment of penetrating cardiac injuries. Eastern Association for the Surgery of Trauma report a guideline of surgical treatment of penetrating chest injuries. Answering the following PICO (Population, Intervention, Comparator, Outcomes) question: should patients who present pulseless after critical injuries (with and without signs of life after penetrating thoracic, extra thoracic, or blunt injuries) undergo emergency department thoracotomy vs. resuscitation without emergency department thoracotomy, to improve survival and neurologically intact survival, strongly recommend that patients who present pulseless with signs of life after penetrating thoracic injury undergo emergency room thoracotomy. In patients presenting pulseless to the emergency department without signs of life after penetrating thoracic injury, they conditionally recommend emergency

department thoracotomy depending of the time without signs of life [10].

The mortality reported in some publications varies from 5% to 76 % (Table 1).

Clarke *et al* have analyzed the data from hospital and from mortuary cohort for 1186 patients with penetrating thoracic wounds. Patients undergoing emergency thoracotomy were the patients with cardiac injuries. The mortality for the patients that underwent thoracotomy is 10 % while overall mortality from both hospital and mortuary cohort was 76 %. The patients that underwent the intervention have good chances for survival [8].

Yao *et al* in a series of 80 patients in 1968 report mortality 24 %. The gunshot wounds have higher mortality than stab wounds. Seven patients died the moment arrive at hospital. They recommend immediate thoracotomy because unpredictable progress of penetrating chest trauma [15]. Mechanism of injury is strongly related with survival. Cardiac tamponade from stab wounds, conferred a significant survival advantage versus gunshot [16, 19, 20].

Ninety-four of 237 patients presented with penetrating cardiac injuries, after emergency department thoracotomy, 8% survived their entire hospitalization. Survival rates were 5% for gunshot wounds and 33% for stab wounds. Prehospital transportation by police, sinus tachycardia, measurable vital signs were associated with improved survival [16].

Bamous *et al* report 60 % mortality and report that patients arriving without signs of life may benefit from aggressive resuscitative efforts depending on transport time. Cardiac tamponade, right ventricle lacerations and associated extra-cardiac injuries are independent risk factors of death [17, 21].

Clinical status as shock, cardio pulmonary resuscitation and emergency room thoracotomy were prognostic of a poor outcome and associated with high mortality rates [18].

The high rate of survival of the patients that arrive alive at hospital shows that a penetrating cardiac injury with a bad prognosis may change into a better prognosis. Patients with cardiac wounds should be transported to the nearest surgical hospital. Patients suspected of having penetrating cardiac trauma and cardiac tamponade are best managed by aggressive primary intervention and immediate operation [22, 23, 24]. Clinical status on the presentation, mechanism of injury, simultaneous associated injuries, transporting time to hospital, emergency room thoracotomy and tamponade, are the most important factors influencing the results of the progress of penetrating cardiac injuries. We are responsible about that it is in our hands and in this context rapid evaluation and intervention is very important.

Daniel Eiferman *et al.* present an algorithm for the management of penetrating cardiac trauma [5].

Conclusions

Cardiac injuries remain surgical and clinical challenge. Every surgical team should be familiar with the emergency surgical treatment. We think that continuous education is very important.

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