

## Heart Injuries - Still a Challenge for Cardiac Surgery

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**Abstract:** *Background:* Heart injuries can be penetrating or non-penetrating (blunt). Penetrating injuries are most often caused by stab wounds made by stabbing weapons or tools as well as firearms. It is usually the right ventricle that is injured, since it is located most frontally and closest to the chest wall. Mortality in stab wounds is 20-30%, and as high as 30-60% in all penetrating wounds.

Non-penetrating injuries most often occur during traffic accidents. High pressure on the front side of the thorax towards spine, followed by sudden increase of intracardiac pressure, may lead to rupture of the free wall of the heart, intraventricular septum or valvular insufficiency, caused by ruptured leaflets, chords or papillary muscles.

*Methods:* Clinical outcome of 17 consecutive patients with heart injuries, treated surgically and nonsurgically, were retrospectively analyzed.

*Results:* Over the period from 1982 to 2007, 17 patients with heart injuries were treated at The Institute for Cardiovascular Diseases, Clinical Center of Serbia (Belgrade, Serbia). There were 14 penetrating injuries (4 inflicted by firearms, 10 by stabbing weapons).

Fifteen patients were treated surgically, and two were not operated. Within the operated group, 1 patient died postoperatively.

*Conclusion:* Prompt and accurate diagnosis of heart injury, fast transport and urgent surgical intervention are important factors in reducing death rate in these highly lethal condition.

**Keywords:** Heart injuries, penetrating and non penetrating heart injuries, heart trauma.

### INTRODUCTION

Heart trauma was described for the first time by Egyptian authors, some 5000 years ago. It is a grave and often fatal condition in cardiac surgery. Rapid development of traffic and industry, use of fire weapons in civil and war conditions on one hand, and extensive application of invasive cardiology procedures on the other, have led to the growing number of heart injuries. Over the last decades, in the USA, injuries take the third place as the cause of overall mortality, after malignant and cardiovascular diseases. About 150.000 people died of injuries every year in the USA, 25.000 – 30.000 of which due to injuries of the heart and large blood vessels, which represents 25% of all deadly injuries [1]. Ten percent of these deaths are the result of penetrating heart injuries [2].

Heart injuries have always presented a great challenge for surgeons and a team of various researchers and practitioners, which took part in upgrading the knowledge for their successful treatment. In the 16<sup>th</sup> century Pare was the first to describe cardiac tamponade. In the year 1889, Larrey, Napoleon's surgeon, performed the first successful

pericardial drainage and Williams successfully dealt with stab wound suturing. The first successful suture of a stab wound of the heart was performed by Hill in 1902, in the USA [3, 4].

### THE OBJECTIVE

Retrospective analysis of clinical outcome of 17 patients with heart injuries, penetrating and nonpenetrating, treated surgically and nonsurgically, at the Institute for Cardiovascular Diseases, Clinical Center of Serbia, Belgrade, during the 25 years period, was performed.

### MATERIAL AND METHODS

Over the period from 1982 to 2007, 17 patients with heart injuries were treated in our institution. Patients with large blood vessels injuries were not included in this study. They were predominantly male subjects (12 patients, 70,5%), and 5 female patients (29,5%), with age ranging from 19 to 60 years. Average age was 36 years. Out of all injuries, 14 were penetrating (82,3%) and 3 were non-penetrating (17,7%). Ten out of fourteen penetrating injuries were caused by sharp weapons (71,4%), while 4 were caused by fire weapons (28,5%). In penetrating injuries the right ventricle was damaged in 11 pts (78,6 %), left ventricle in 2 (14,3%), both ventricles in 1 pt (7,1%). All three non-penetrating injuries occurred in traffic accident.

All patients with penetrating heart injuries were admitted at the hospital and treated as urgent surgical patients,

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operated immediately after hospital admission. Initial resuscitation treatment started with arterial and central venous line conduction, crystalloid and colloid solution infusion, ECG, hemodynamic and biochemistry monitoring, intubation and artificial lung ventilation and general anesthesia. Diagnostic algorithm depended on the patients hemodynamic condition. If general status and hemodynamic situations allow diagnostic procedures, chest X ray and transthoracic or transoesophageal echocardiography was performed. In unstable patients immediate medial sternotomy was done with intraoperative transoesophageal echo monitoring. Pericardiocentesis as diagnostic tool was not performed. Preoperative drainage of the left hemithorax was performed in one patient with concomitant lung injury.

In patients with blunt heart injuries due to traffic accident, chest X ray sign of thorax trauma, EKG abnormalities (arrhythmias, ST and Q changes), elevation of serum CPK, echocardiography sign of myocardial contusion and abnormal heart wall kinetics indicated patients admission at the hospital. One week ECG, hemodynamic and biochemistry monitoring was performed as well as medicamentous treatment. One patient with blunt heart injury was operated due to pericardial rupture, heart herniation and hemodynamic instability. Heart herniation was diagnosed preoperatively on chest X ray examination.

## RESULTS

All patients with penetrating injuries were urgently operated as well as one patient with pericardial rupture and consecutive heart herniation due to blunt trauma. Rest of 2 patients with blunt trauma were treated medicamentously.

Surgical procedure in penetrating injuries implied medial sternotomy and suture of damaged right or left ventricle. All operations were performed without ECC. In one patient concomitant suture of the upper left lung lobe was performed concomitantly. There were no death in this patient group.

One operated patient with pericardial rupture and heart herniation due to blunt trauma died because of postoperative complications.

## DISCUSSION

Over the last thirty years, the incidence of heart trauma has increased eight times. In most cases of penetrating heart injuries, the cause was stab wound in civilian conditions, but during the last couple of years, the number of heart lesions by fire arms (Fig. 1) have increased in our country, as well as worldwide [3-7].

Most of heart penetrating injuries are caused by stabbing wounds, usually representing 60-70% of cases, while firearms wounds takes 30-40% [1, 2]. In our material there were 71,4 % of stabbing heart injuries.

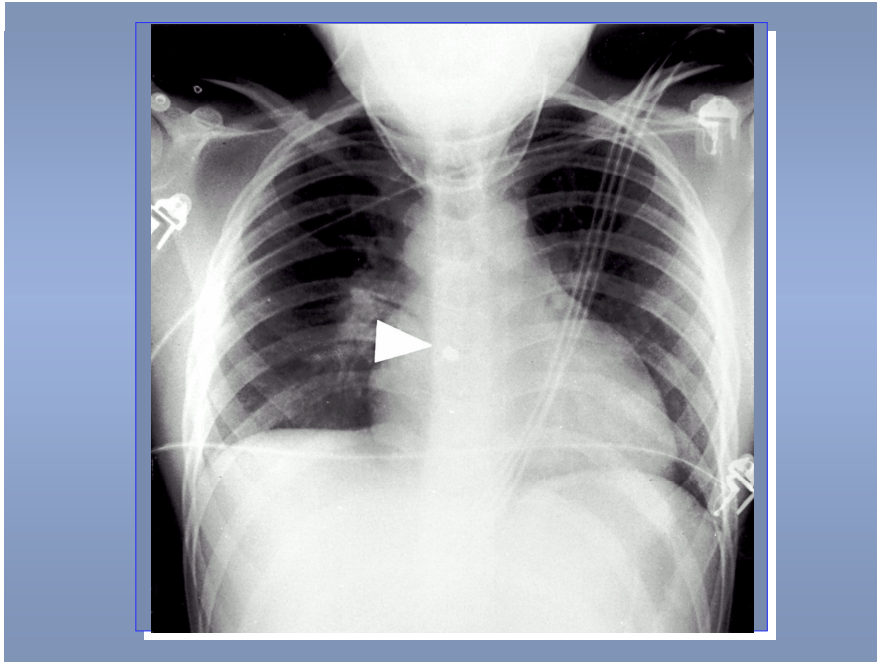
With these heart injuries, the death rate is 25% [8,9]. It is reasonable to expect that the number of penetrating heart injuries should be much higher than 14 cases, founded in our material, and it is probably due to the fact that those fatally injured patients died before hospital admission. Only about 11% of heart injuries caused by firearms and 40% of heart injuries caused by stabbing tools come to hospital alive [8,9].

“The Death Quadrangle” represents part of the chest in which penetrating injuries happened most often. It spreads under the middle of clavicle, medial from the nipple and above diaphragm. In penetrating wounds of the heart, usually one heart chamber is damaged, and that makes 70% of all the cases, while simultaneous injury to more than one chamber occurs in 30% of cases [8,9]. In our patient group, only one patient had two heart chambers injured, which makes 7,1% of penetrating wounds.

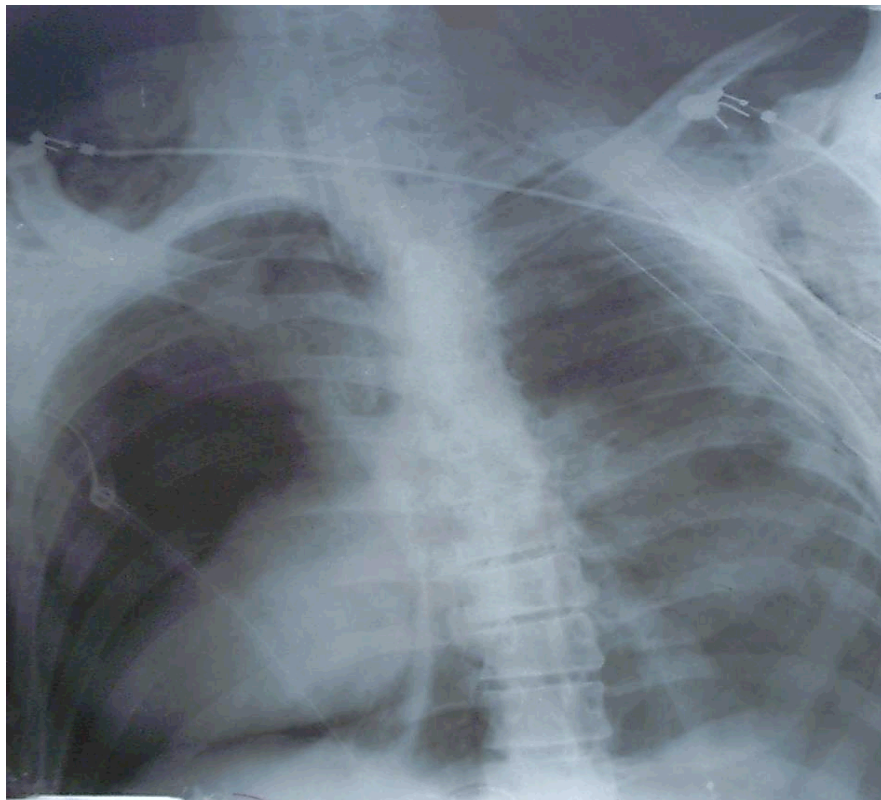
Penetrating injuries, according to heart anatomy localization, occurs with the following frequency: Right ventricle in 40-45% of cases, left ventricle in 30-35%, right atrium in 15% and left atrium in 5% [2]. In our patient group, right ventricle constituted 78,6% of cases, left ventricle 14,3%, while in one patient (7.1%) both ventricles were injured.

Clinical presentation in most penetrating heart injuries is dominated by at least one of the symptoms of Beck's trinity (hypotension, elevated central venous pressure and dull heart sounds). A chest injury that may imitate cardiac tamponade is tension pneumothorax, which can have all the elements of Beck's trinity, but with absent breathing sound on the side of the lesion. In a number of cases of penetrating injuries, patients do not have symptoms that point to cardiac involvement [10], therefore, adequate diagnostics and prompt surgical intervention are essential. Adequate preoperative diagnostics can be conducted only in hemodynamically stable patients. In unstable patients, with signs of bleeding, heart tamponade, parasternal wound, growing haemothorax, early thoracotomy or medial sternotomy are indicated, without complex diagnostics. Pericardiocentesis is a diagnostic procedure yields false positive or false negative results in 50% of cases [11], while electrocardiography gives false negative results in 89% of cases [10]. Heart catheterization, a valuable but time consuming diagnostic procedure, is not necessary in the initial phase of heart injury diagnostics. However, it should be conducted in all patients after the surgery has been performed, to exclude secondary complications. In penetrating heart injuries secondary complications can be expected in up to 6-10% cases [2], including damage to coronary arteries and mitral valve, VSD, pseudoaneurysm, aorto-caval and aorto-pulmonary fistula etc. In suspected heart injury, opening of the subxyphoid pericardial window can be performed as a golden standard diagnostic procedure [10]. Echocardiography is also, if the urgency allows it, an excellent diagnostic tool, as it proves to be 90% sensitive and 97% specific in penetrating heart injury diagnosis [10].

Non-penetrating heart injuries are much more rare than penetrating ones, which was proved in our material as well, with 17,7% of all heart injuries. Causes are most often traffic and industrial trauma. Non-penetrating heart injuries can lead to free wall or septum rupture (ventricular septal defect usually occurs in muscular part of septum, close to heart apex), valvular defect, contusion and coronary thrombosis, intramyocardial bleeding, heart herniation, due to pericardial fissure. Causes of blunt heart trauma which results in pericardial fissure are: Direct kick, high intra-abdominal pressure and fractured ribs. The most likely spot of pericardial fissure is on the left side, parallel to phrenic nerve and is seen in about 64% of the cases. Due to serious heart



**Fig. (1).** Chest X ray with bullet in the heart shadow fire-arm heart injury.



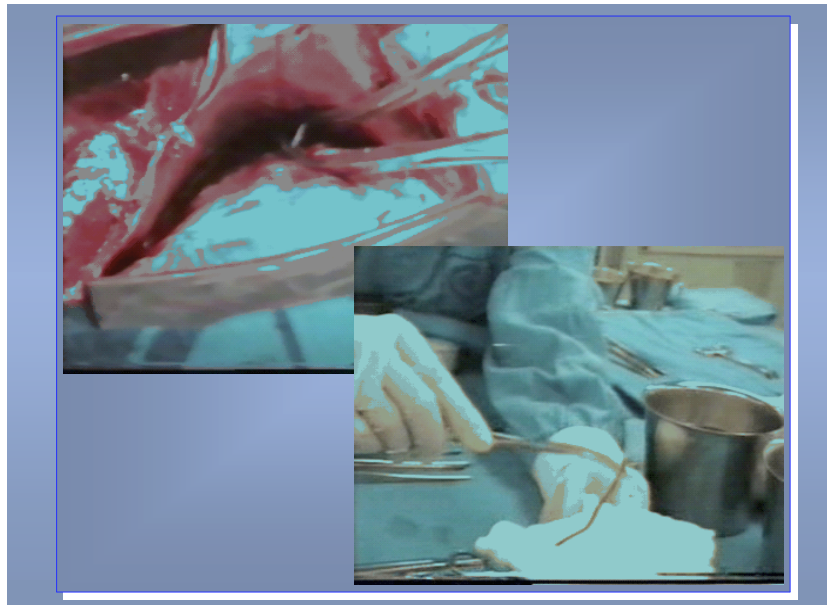
**Fig. (2).** Chest X ray with the sign of heart herniation blunt heart injury.

defect, death rate of heart herniation is about 50% [12]. In our series of three blunt heart traumas, one was a case of pericardial rupture and heart herniation (Fig. 2), which was operated, but was nevertheless fatal.

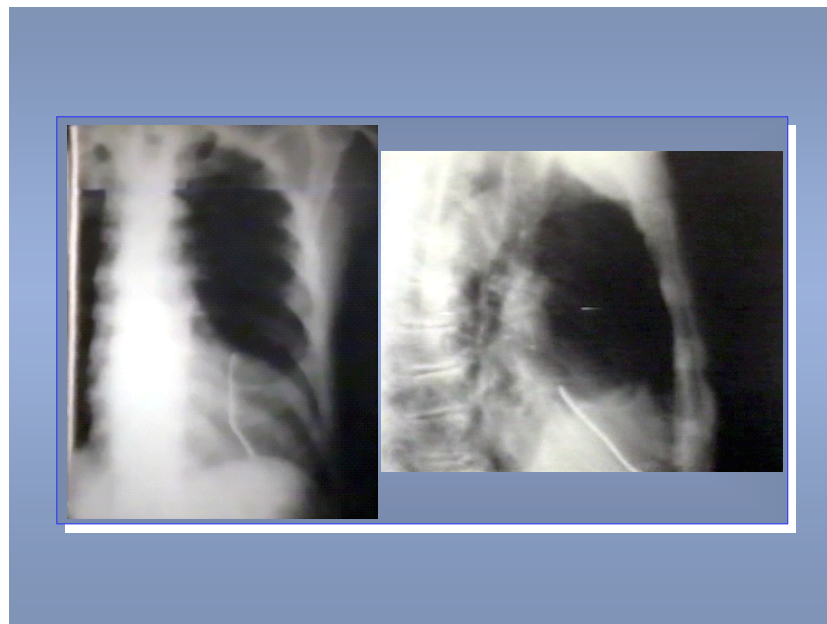
In non-penetrating (blunt) heart trauma, where there is no real defect in the heart wall or coronary arteries, the following clinical signs can be expected: Elevated creatine phosphokinase (CPK) and isoenzymes, abnormal heart wall

kinetics, abnormal ECG. Level of heart isoenzymes is increased initially after a blunt heart trauma, and is back to normal several hours after the injury, as opposed to myocardial infarction where isoenzymes' level rises over 48-72 hours. About 10% of patients with blunt heart trauma can have a permanently reduced ventricular function [12].

Whenever there is a suspected blunt heart trauma, following screening examinations should be conducted: Chest X-ray and



**Fig. (3).** Extracted broken wire from the right ventricle.



**Fig. (4).** Chest X ray with broken wire entering the right ventricle.

ECG, transthoracic, and if possible transoesophageal echosonographic examination. Continuous hemodynamic monitoring is also necessary, as there is a risk of hypotension when pharmacological treatment is necessary.

In our group, alcoholism was the main risk factor for 50% of cases with penetrating and non-penetrating heart injuries. A Swedish group of authors [5] had similar results in their patient group. Time from injury to arrival at our institution showed ranged from 62 minutes to 3 days. The patient who admitted at the clinic, three days after the injury, was completely hemodynamically stable, and had hurt himself by falling onto wire which had penetrated thorax, entered the right ventricle and broken off (Figs. 3, 4).

If patient presents with a penetrating object sticking out, the object must not be removed until adequate surgical access and control are provided, as there is great risk of cardiac tamponade.

In highly developed countries, with better health care organization, the time from injuring to hospital admission is significantly shorter [6], which is of great impact on patient survival.

#### CONCLUSION

Prompt and accurate diagnostics of heart injury, immediate reanimation, fast transport and urgent surgical intervention by well coordinated team of experts, are

relevant parameters for successful treatment of these highly lethal condition.

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