Penetrating cardiac injuries

Penetran kalp yaralanmaları

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BACKGROUND

This study was planned to evaluate patients with penetrating cardiac injury.

METHODS

Twenty-two patients had cardiac injury among twenty-five patients who had been referred to our hospital with a suspicion of this diagnosis. Data of the patients were retrospectively evaluated.

RESULTS

Echocardiography could be performed in 11 patients with stable haemodynamics and pericardial effusion was established in all of them with one false positive result. The patient with false positive result had left internal thoracic artery and venous injury. Cardiac tamponade was seen in 17 (77%) patients. Injury sites were right ventricle 10 (45.5%), left ventricle 7 (31.8%), left ventricle consisting left anterior descending artery 2 (9.1%), right atrium 1 (4.5%) and pericardial injuries and hematoma 2 (9.1%). The mean physiologic index (PI) of the patients was 10.68±5.63, penetrating cardiac trauma index was (PCTI) 14.09±6.3, penetrating thoracic trauma index (PTTI) was 17±8.84 and organ injury scale according to the American Association for the Surgery of Trauma (AAST/OIS) was 3.86±1.25. Mortality rate was 27.3% with 6 out of 22 patients. PI, PCTI, PTTI and AAST/OIS scores of the non-survivors were significantly higher than those of the survivors ($p<0.05$). While there was no difference between survivors and non-survivors regarding the presence of tamponade and the frequency of the associated abdominal injury, left ventricular and left anterior descending artery injuries and associated lung injuries were more common in non-survivors ($p<0.05$).

CONCLUSION

Non-survivors with penetrating cardiac injury have higher PI, PCTI, PTTI and AAST/OIS scores and they are more severely injured patients comparing to the survivors.

Key Words: Echocardiography; penetrating cardiac injuries; precardial stab wounds; traumatic cardiac tamponade.

AMAÇ

Bu çalışmada penetran kalp yaralanması olan hastalar değerlendirildi.

GEREÇ VE YÖNTEM

Mayıs 1994 ile Eylül 2005 tarihleri arasında kalp yaralanması şüpesiyle hastanemize gönderilen 25 hastanın 22'sinde kardiyak yaralanma vardı. Hastaların tetkikleri ile fiziksel ve cerrahi bulguları retrospektif olarak değerlendirildi.

BULGULAR

Ekokardiyografi, hemodinamisi stabil olan 11 hastaya yapılabilmiş ve bir yanlış pozitif hariç tümünde perikardiyal efüzyon gösterilmiştir. Bir hastada sol internal torasik arter ve ven yaralanması vardı. 17 hastada (%77) kalp tamponadı vardı. Hastalarda sağ ventrikül (n=10, %45,5), sol ventrikül (n=7, %31,8), sol ön inen arteri içeren sol ventrikül (n=2, %9,1), sağ atriyum (n=1, %4,5) perikardiyal hematom (n=2, %9,1) yaralanması vardı. Hastaların ortalama fizyolojik indeksi (PI) 10,68±5,63, penetran kardiyak travma indeksi 14,09±6,3, penetran torasik travma indeksi (PTTI) 17±8,84 ve Amerikan Travma Cerrahisi Birliğinin sınıflamasına göre ortalama organ hasarı skoru (AAST/OIS) 3,86±1,25 idi. Altı olgu kaybedildi (mortalite %27,3). Bu hastaların PI, PCTI, PTTI ve AAST/OIS skorları kurtulanlara göre daha yüksekti ($p<0,05$). Tamponat mevcudiyeti ve karın yaralanma sıklığı bakımından fark yokken, sol ventrikül ve sol ön inen arter ve akciğer yaralanması kaybedilen hastalarda daha sık bulundu.

SONUÇ

Penetran kalp yaralanması nedeniyle kaybedilen hastalar, sağkalanlara göre daha ağır yaralanmalara ve daha yüksek PI, PCTI, PTTI ve AAST/OIS skorlarına sahip olmaktadır.

Anahtar Sözcükler: Ekokardiyografi; penetran kalp yaralanması; prekordiyal penetran yaralanmalar; travmatik kalp tamponadı.

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Penetrating cardiac injury is a life-threatening condition which usually requires emergent surgical intervention, excellent surgical technique and critical care of these patients in the postoperative period.[1] Clinical presentation of the patients depends on various factors such as the wounding mechanism; the time elapsed prior to arrival, the extent of the injury, the amount of blood loss, presence of cardiac tamponade or associated injuries. Some of the patients may present in hemodynamically stable conditions, others with mild shock or cardiac tamponade and a considerable amount with profound shock or in extremis.[1,2] While patients presenting in extremis or cardiopulmonary arrest may require emergency room thoracotomy, relatively stable hemodynamic situation of the others may provide some time for the performance of diagnostic tests. Echocardiography and ultrasonography have emerged as useful diagnostic techniques with high specificity and sensitivity rates.[1-4] Critical determinants for overall survival of these patients have been reported to be the time elapsing between injury and initiation of resuscitation, the extent and mechanism of injury, site of cardiac lesion, presenting vital signs of patients and the need for emergency room thoracotomy by various studies.[5] To our knowledge, among various papers from Turkey regarding penetrating injuries, grading of the clinical presentations of the patients were reported in some either according to the Physiologic Index as suggested by Ivatury et al. or else.[6-11] However, organ injuries or the extent of the wounds have not been scored according to some international classifications in most of the papers.[7-14] This retrospective study was planned in order to evaluate patients who were referred to our hospital with penetrating cardiac injuries and to identify their injury scores so that a comparison can be done properly.

MATERIALS AND METHODS

Twenty-five patients with suspected penetrating cardiac injury were referred to the author's hospital between May 1994 and September 2005. Among them, 20 patients had penetrating injury of the heart and two patients had pericardial injury and hematoma. As the latter had grade I injury according to the organ injury scales of the American Association for the Surgery of Trauma (AAST/OIS) they were included in the study as well.[1] Cases with iatrogenic lacerations of the heart were not included in the present study. Patients were evaluated retrospectively. Data regarding age, sex and initial physical and hemodynamic findings were gathered. Results of radiological and echocardiographic studies were revaluated if present. Physiological index (PI), penetrating cardiac trauma index (PCTI) and penetrating thoracic trauma index (PTTI) in accordance with Ivatury et al.'s suggestions and AAST heart injury scales were also calculated.[6,15] Physiological index (PI) of the patients in stable condition is 5, in conscious patients with systolic blood pressure less than 80 mmHg is 10, in semiconscious patients with thready pulse, gasping respiration and no measurable blood pressure is 15 and unconscious patients with no vital signs, respiratory effort, physical activity but with some sign of life in transit to hospital have the highest score 20.[6] While scoring penetrating thoracic trauma index (PTTI), each organ in thorax receives a risk factor from 4 to 5, and then this is multiplied with numbers from 1 to 5 according to the injury severity of the organ and the sum is PTTI of the patient (Ivatury)[6]. Penetrating cardiac trauma index is multiplication of 5 (risk factor of heart in PTTI) with injury severity number from 1 to 5 (1:tangential, involving pericardium or wall up to endocardium, 2:single right-sided chamber, 3:comminuted tears of a single chamber, 4:multiple chambers isolated right atrium or left ventricle and 5:coronary injury, major intracardiac defects).

If the patient's hemodynamic status was stable when he or she has been admitted to the emergency department, a physical examination was performed first. A chest X-ray and/or transthoracic echocardiography and hematological studies were performed if the patient has been hemodynamically stable. Echocardiographic diagnosis of cardiac tamponade was made if any sign of compression in any cardiac chamber was present. Effusions were usually reported in millimeters around each chamber. Intraoperative diagnosis of cardiac tamponade was based upon improvement of hemodynamic parameters after decompression of the pericardial cavity. In patients presenting with mild shock or shock, resuscitative measures including placement of central venous lines, rapid fluid administration, oxygen supplementation or endotracheal intubation were accomplished immediately. Facility of performing a major surgical procedure was available in the car-

diovascular surgery clinic on another floor. After the initial resuscitation, the patient was transferred to the intensive care unit or operating room where resuscitative efforts were carried on more effectively and the patient has been operated. The patients were usually explored through median sternotomy. Simple injuries of the cardiac chambers were controlled with Teflon pledgetted mattress sutures. If cardiopulmonary bypass should has been instituted, the patients were immediately cannulated. Then the patients were transferred to the intensive care unit and afterwards to the ward until being discharged.

All values were presented as the mean±SD. Continuous variables are expressed as median, %25th and %75th percentiles and the groups were compared by nonparametric Mann Whitney U-test. The differences among the groups were determined by Fisher's Exact test for the cathegorical variables. A p value less than 0.05 was considered statistically significant.

RESULTS

Twenty-five patients with penetrating injury in the precordial area between May 1994 and September 2005 were retrospectively evaluated. With the suspicion of penetrating cardiac injury all patients were referred to the authors' hospital from other centers where cardiac surgery is not employed. All of them were explored through a median sternotomy and twenty patients were found to have cardiac penetration while two patients had pericardial laceration and hematoma without cardiac penetration. Other three patients had left internal thoracic artery (LITA) and/or vein or intercostal artery and/or vein transection all of which required surgical control of the bleeding. Two of them were explored due to ongoing bleeding with hemodynamic deterioration and low hemoglobin values while in the third left thoracal effusion combined with echocardiographic suspect of cardiac injury led to surgical exploration.

Among 25 patients, preoperative transthoracic echocardiography could be performed in eleven patients in stable hemodynamic situation. Echocardiographic diagnosis of cardiac tamponade was made in six patients and they were confirmed intraoperatively. Among the five patients reported to have simple pericardial effusion only, two of them were found to have cardiac penetration and tamponade and two patients had pericardial hematoma and pericardial injury associated with left internal thoracic artery (LITA) and vein transection. However as mentioned above, the fifth case with left thoracic effusion due to the laceration of LITA and its vein was mistakenly reported to have pericardial effusion, therefore yielding one false positive echocardiographic result. Of note, one of the patients with pericardial hematoma without cardiac but with pericardial injury had bleeding of the transected LITA through the pericardial defect into the pericardial cavity causing cardiac tamponade.

Of the remaining 14 patients in whom transthoracic echocardiography could not be performed, 4 patients were in extremis and were immediately transferred to the operating room with external cardiac massage and cardiopulmonary resuscitation. Six patients were explored because of haemodynamic deterioration (systolic blood pressure lower than 80 mmHg one of them with LITA and the other with RIMA injuries, the rest with cardiac penetration), three patients due to suspicion of cardiac penetration and tamponade (confirmed at surgery) and one patient was found to have cardiac injury during laparotomy.

Regarding the twenty-two patients with penetrating cardiac/pericardial injury, there were 20 male and 2 female patients with a mean age of 30.79±17.54 years (range; 6-74 years). Twenty-one patients had stab wounds and one patient had gun shot wound. Seventeen patients (77%) had cardiac tamponade. Most injured cardiac chamber was right ventricle with 10 cases (45.5%). The mean physiologic index of the patients was 10.68±5.63 (5-20), mean penetrating cardiac trauma index was 14.09±6.3 (5-25) and the mean penetrating thoracic trauma index was 17±8.84 (10-43). The mean organ injury scales of the patients according to American Association for the Surgery of Trauma (AAST/OIS) was 3.86±1.25 (Table 1).[1-5]

Median sternotomy was performed in all patients. This incision was effective in all patients for both exploring the heart and controlling bleedings from LITA, RIMA and intercostal vessels. Emergent left thoracotomy and evacuation of the hematoma in the pericardial space with control of bleeding had been performed in one patient in another centre. As the patient's condition did not improve and the bleeding has continued from the

chest tube, he was transferred to our hospital. Cardiac tamponade with bleeding from the injury in the right ventricle was encountered.

Mortality rate was 27.3% in 6 out of 22 patients. Among four patients in extremis and immediately transferred to the operating theater with external cardiac massage, one patient had 3 stab wounds in the right ventricle, the second had transection of left anterior descending artery, the third patient had multiple injuries with a PTTI of 43 and associated abdominal and inguinal wounds; the latter had injury of left ventricle. None of them could survive. One patient with transection in left anterior descending (LAD) artery in its mid third portion necessitated institution of cardiopulmonary bypass and insertion of a saphenous bypass graft to the LAD. The patient received massive blood transfusion and required administration of inotropic agents in the intensive care unit. Acute renal failure and disseminated intravascular coagulation complicated his postoperative course. He could not survive and died on the third postoperative day due to multiorgan failure. The sixth patient who could not survive had a PI of 15, PTTI of 24 and had two injuries in the left ventricle. After relief of cardiac tamponade and injuries, he was transferred to the intensive care unit in good hemodynamic condition. However, he did not gain consciousness and brain death was confirmed.

Table 1. Preoperative hemodynamic and laboratory findings and operative findings of the patients

Age (years)	30.79±17.54
Sex	
Female	2 (0.9%)
Male	20 (91%)
Heart rate (beat/minute)	109.18±21.82
Blood pressure (mmHg)	
Systolic	83.05±24.2
Diastolic	49.72±20.03
Hematocrite (%)	33.83±5.01
Hemoglobin (g/dl)	11.08±1.89
Injured chamber	
LAD	2 (9.1%)
Left ventricle	7 (31.8%)
Right ventricle	10 (45.5%)
Right atrium	1 (4.5%)
Pericardium	2 (9.1%)
Associated abdominal injury	4 (18%)
Physiological index	10.68±5.63
Group I (5)	8 (36.4%)
Group II (10)	7 (31.8%)
Group III (15)	3 (13.6%)
Group IV (20)	4 (18.2%)
PCTI	14.09±6.3
PTTI	17±8.84
AAST/OIS	3.86±1.25
Mortality	6 (27.3%)
Complications	
Residual VSD	1
Arrhythmia	1
Hospital stay (days)	6.94±3.84

LAD: Left anterior descending artery; PCTI: Penetrating cardiac trauma index; PTTI: Penetrating thoracic trauma index; AAST/OIS: American Association for the Surgery of Trauma/Organ Injury Scale; VSD: Ventricular septal defect.

PI, PCTI, PTTI and AAST/OIS of the non-survivors were significantly higher than those of the survivors ($p<0.05$) (Table 2). When non surviving patients were compared with the survivors, non-survivors were found to have significantly more left ventricular and/or left anterior descending coronary artery and associated lung injuries ($p<0.05$) But presence of tamponade and associated abdominal injuries were not different between the two groups ($p>0.05$) (Table 2).

The postoperative course of the remaining patients was uneventful and the mean length of hospital stay was 6.9±3.84 days. Postoperative complications were rare. Residual ventricular septal defect was observed in another patient in the ward and follow up in the outpatient department was recommended, as the systemic to pulmonary shunt ratio was 1.6 however, the patient was lost to follow up.

DISCUSSION

The present series of 22 patients with penetrating cardiac injuries is a relatively small group when compared with other large series.[2,5,6-20] Most of the patients were referred to our hospital from other state hospitals where cardiac surgery was not employed. Therefore, it might not reflect the actual incidence of penetrating cardiac injuries especially the gunshot wounds, since they cause more tissue damage and most victims might be lifeless on the scene or could not have been transported to our hospital.

Table 2. Injury scores and some characteristics of the surviving and non surviving patients

	Survivors (n=16)				Non-survivors (n=6)				
	25th percentile	Median	75th percentile	Mean±SD	25th percentile	Median	75th percentile	Mean±SD	*p*
Physiological index*	5	7.5	10	7.81±3.15	15	20	20	18.33±2.58	0.001
PCTI*	10	10	17.5	11.88±5.12	17.5	20	25	20±5.98	0.008
PTTI*	10	10	20	13.94±5.78	17.5	24.5	32.5	25.17±10.87	0.011
AAST/OIS*	3	4	4	3.5±1.26	4.75	5	5	4.83±0.41	0.008
LV and/or LAD injury*				4 (25%)				5 (83.3%)	0.023
Associated lung injury*				1 (6.25%)				3 (50%)	0.046
Cardiac tamponade				12 (75%)				4 (66.7%)	>0.05
Associated abdominal injury				3 (18.8%)				1 (16.7%)	>0.05

PCTI: Penetrating cardiac trauma index; PTTI: Penetrating thoracic trauma index; AAST/OIS: American Association for the Surgery of Trauma/Organ Injury Scale; LV: Left ventricle; LAD: Left anterior descending coronary artery. (*): p<0.05.

Confirmation of the diagnosis of penetrating cardiac injury may be difficult especially in patients with unstable hemodynamic status. It must be kept in mind that all patients presenting with a precordial wound should be suspected of having a cardiac laceration.[2] Cardiac laceration has been confirmed in 60% of patients with a parasternal or precordial stab wound and 85% of patients confirmed to have a cardiac injury will have a stab wound in this area.[15]

Some authors advocate subxiphoid exploration as the gold standard of diagnostic procedures in patients with normal echocardiographic results who present with hypotension and respond to fluid therapy.[1,3,21,22] In patients with positive ultrasonographic examination and in stable condition, it is also recommended as a therapeutic procedure.[15] On the other hand, there are reports stressing the risk of subxiphoid exploration like catastrophic hemorrhage or waste of valuable resuscitative time.[23] This procedure has been abandoned in most centers in favour of echocardiography or ultrasound.[1,2] Subxiphoid exploration was undertaken in only one patient in the present series. A hematoma localized inferiorly was encountered and soon after bleeding started and the incision was converted to median sternotomy.

Echocardiography has been regarded as the investigation of choice in stable patients.[2,4,19,24] Also in stable patients the sensitivity, specificity and accuracy of computed tomography (CT) in detecting hemopericardium is highly reliable.[25] However, management of patients during CT examination may be very difficult if these patients deteriorate; then echocardiographic examination with a portable device is the preferred method. Experienced cardiologist or a resident familiar with the trauma setting is necessary for reliable results because subcutaneous emphysema, of massive hemothorax, or of abundant pericardial fat may limit the validity of this examination. Reports that consider ultrasound or echocardiography as time-consuming and ineffective or not accurate (false-negative results with 66% accuracy) are also present in the literature.[15,26] The sensitivity of TTE falls from 91 to 20% when a massive hemothorax is present.[20] There was one false positive echocardiogram in the present series. Differentiation between pericardial or pleural hematoma could not be made. We have observed in a previous study concerning postoperative cardiac tamponade that presence of pericardial effusion is recognized in all patients with 100% accuracy however echocardiographic diagnosis for tamponade could be made with only 34.5% accuracy. If echocardiographic diagnosis of pericardial hematoma or effusion is made, we think that surgical exploration should be undertaken in all patients with clinical signs regardless of echocardiographic signs of tamponade.[2,27]

Video assisted thoracic surgery has emerged as an alternative method for evaluating chest injuries recently.[28] It cannot be applied in patients with hemodynamic instability and intolerance to single lung ventilation. If major vessel or cardiac injury is found, thoracotomy is still recommended.

Emergency room thoracotomy is usually reserved for patients in extremis, lifeless, decompensating or for those who do not respond to rapid volume expansion with persistent bleeding in order to clamp the thoracic aorta.[1,18,29] Left thoracotomy is the preferred incision in such cases. Median sternotomy on the other hand, is the preferred surgical approach in our clinic for both being effective enough to explore the heart completely and the right and left hemi-thoraxes in relatively stable patients. Some centers also prefer median sternotomy in the majority of their cases due to better and rapid exposure of the heart without positioning the patient, feasibility of performing cannulation for cardiopulmonary bypass if required and less pain and pulmonary complications in the postoperative period.[1,2,23,26]

Various scores for estimating injury severity exist.[6,30] A good correlation between survival and injury severity scores have been demonstrated in most of the studies.[1,6,31] Among these, PI, PCTI and PTTI in the present series are in accordance with those in Ivatury et al.'s study and non-survivors had significantly higher scores compared to the survivors. However, Attar et al. could not find any difference between surviving and non-surviving patients regarding PTTI's in a large series of 109 patients.[5] AAST organ injury scaling is more complex and includes blunt cardiac injuries as well. A correlation between survivors and non-survivors regarding mortality and higher AAST cardiac injury scores was found in the present study.

In a retrospective study including all cases with penetrating cardiac injury in a single region during a 3-year interval with evaluation of also mortuary cases, the presence of cardiac tamponade, right ventricular injury, single chamber injury and sole injury were found to be associated with improved survival while coronary artery injury was not.[16] There are other reports emphasizing the presence of cardiac tamponade as a positive prognostic factor on survival rates but there are also some reports where this effect could not be demonstrated although they are prospective in nature.[1,17,19,30,32] As Asensio et al. have also stressed, there could be a period in which tamponade provides a protective effect. But after this undefined period of time, it demonstrates its adverse effect on cardiac function.[1] Despite its detrimental effects on myocardial performance are well known, it may prevent bleeding of the patient to hypovolemic shock. As Thourani et al. have pointed cardiac tamponade was the most common presentation (77%) in the present study thus maybe reflecting higher probability of reaching the hospital alive for the victims.[33] Although no difference was observed regarding the incidence of tamponade among the survivors and non-survivors in the present study, it is relatively a small study to make a good comparison and the exact number of penetrating heart injuries with mortuary cases in our district is not known to us at present.

Coronary artery damage results in myocardial ischemia and except patients bleeding from the terminal branches of the coronary circulation repair of injured LAD distal to the first septal perforator is not recommended by some authors. When left ventricle with coronary artery is injured mortality rates may reach to 40%.[22] According to injury severity scoring systems mentioned above, multi chamber, left ventricular and coronary artery injuries receive higher scores predicting worse outcome which were borne out in other studies.[17,19,32] However in the three prospective studies conducted by Asensio et al, anatomic site of injury or the presence of coronary artery injuries do not predict worse outcome although mechanism of injury (gunshot versus stab), physiological condition upon arrival, initial rhythm, emergency room thoracotomy for ongoing exsanguinations to clamp the thoracic aorta were significantly associated with outcome.[1] In the present series, left ventricular and/or left anterior descending injuries and associated lung injury were more prevalent in the non-survivors. However, risk analysis was not carried out due to the small number of the study group.

In the literature, reported mortality rates range from 8% to 47.4% reflecting a variety in presentations, injury sites and mechanisms and prehospital capabilities.[2,5,6,16-18,22,26,29,32] Patients who are lifeless on admission may have mortalities reaching 94%.[23] None of our patients lifeless on admission could survive although performing over 1800 open heart procedures annually an experienced cardiac surgery team exists in the hospital. It is beyond doubt that emergency departments with excellent facilities and better prehospital capabilities could improve mortality rates even in patients in extremis.

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