ORIGINAL ARTICLE

An evaluation of factors affecting clinical outcomes in penetrating cardiac injuries: A single center experience

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ABSTRACT

BACKGROUND: Penetrating cardiac injury (PCI) has highly mortal outcome. Therefore, management of this emergency situation is extremely important. The present study is an investigation of main factors that can affect mortality and morbidity in PCI.

METHODS: Records of 112 patients who were admitted to emergency department with PCI in the last decade were evaluated retrospectively. Demographic data, initial approach, transfer duration and conditions, vital status and findings, type of injury, localization, characteristics, and type of surgical application were recorded.

RESULTS: Demographic findings (age, sex, cause of injury) were not found to be significant factors affecting mortality. Early mortality (1-week observation period) occurred in 14 (12.5%) patients. Method of transfer to hospital (under medical team supervision by ambulance, or without supervision), transfer duration, initial vital findings upon arrival (blood pressure, rhythm, breathing, consciousness), operation timing (elective or emergency), and injuries to additional organs were determined to be important predictors of survival.

CONCLUSION: Cardiac injury is highly mortal emergency situation. Expert medical management is important for survival. However, basic first aid measures and immediate hospital transfer are as important as expert clinical management.

Keywords: Mortality; penetrating cardiac injuries; predictors of survival.

INTRODUCTION

Penetrating cardiac injury (PCI) is highly mortal acute clinical emergency. Timely diagnosis and immediate treatment is important for survival. Despite the fact that cardiac structures are affected by only 10% of all thorax traumas, cardiac injuries are responsible for 40% of overall mortality due to thorax trauma.[1] Some regions have high risk for injuries due to war, individual armament, and other reasons. In such regions, specialized intervention centers, trauma clinics, or expert first aid teams can decrease mortality and morbidity rates with appropriate collaboration, rapid transfer, and immediate intervention by experienced hands.[2] Although there have been advances in opportunities and techniques for prehospital referral and clinical management in recent years, only 6% of patients with these injuries reach the hospital alive, and only 50% of them can be saved.[1]

PCI can be accompanied by hypotension following hypovolemic shock, or cardiac tamponade findings and breathing problems due to concomitant pulmonary injuries, such as contusions, lacerations, and pneumothoraces.[1,3] In previous reports, injured cardiac site of PCI was listed as right ventricle (35%), left ventricle (25%), right atrium (33%), left atrium (14%), and aorta (14%).[3]

When possible with vitally stable patients, diagnostic methods can facilitate approach of clinician.[1,3] Chest radiogram can provide evidence of concomitant lung injury, but it is inadequate to evaluate injuries involving the heart and the pericardium. Echocardiography, which is non-invasive and easily available, can provide knowledge about valvular function, wall motion, and left ventricular ejection fraction, which are helpful for detecting pericardial effusion and tamponade.[3] However, device wires, tubes, wound dressings, or chest bleeding, and even electrocardiogram cables and lead wires, often limit visualization of echocardiogram.[1,3] Multidetector computed tomography (CT) is highly sensitive for evaluation of lung and cardiac structures. It can help identify wound track of penetrating trauma and guide clinicians.[3,4]

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Qucik Response Code

Ulus Travma Acil Cerrahi Derg
2017;23(1):23–28
doi: 10.5505/tjtes.2016.95994

In the current study, clinical outcomes and associated risk factors for mortality, such as injury type, length of time before hospital referral, vital signs, concomitant organ injuries, and surgical procedures, were evaluated in PCIs.

MATERIALS AND METHODS

Files of 112 patients with PCI from last decade were evaluated retrospectively. Demographic findings (age, sex, cause of injury), injury type, time for transfer to hospital, transfer type, concomitant organ injury, initial vital signs, diagnostic methods, cardiac findings (rhythm, hypovolemia, tamponade, coronary injury, incision or injury length, involved site), and operational procedures were recorded. Approval for the study was obtained from the ethics committee of Dicle University Faculty of Medicine.

Injuries that involved principal areas (anterior axillary line on left side, vertical line that crosses the right breast areola at right side, jugular area on upper side and upper part of the epigastrium at lower side) were considered suspected cardiac injuries1. Patients with severely disrupted vital findings were operated on without additional diagnostic examination, according to injuries involved. Blood transfusion and volume replacement were utilized for patients with cardiogenic shock. [1,5] Hemodynamically stable patients were evaluated with additional diagnostic methods (chest radiogram, echocardiography, CT). Pericardiocentesis and subxiphoid drainage were not performed for diagnosis or treatment.

Central venous catheterization was used for all patients, and standard median sternotomy, or anterior, anteromedial, or anterolateral thoracotomy via fourth or fifth intercostal area was performed under general anesthesia to reach intrathoracic structures. Pericardia were incised vertically from 1 to 2 cm of proximal side of the phrenic nerve. Bleeding was controlled with finger compression until repair. Cardiac injury was repaired with Teflon pledget, and the pericardium was secured with 3.0 monofilament polypropylene suture.

Statistical Analysis

SPSS 13.0 statistical software (IBM, Corp., Armonk, NY, USA) was used for statistical analysis. Variables were expressed as mean±standard deviation. Categorical variables were expressed as frequency percentages. Differences were evaluated with chi-squared distribution for categorical variables and Student's t-test for continuous variables. P<0.05 was considered significant.

RESULTS

There were 99 (88%) males and 13 (12%) females with mean age of 29.3±14.1 years in the study. Age and gender distribution were statistically similar according to mortality rate. However, important relationship was detected between mortality and length of time until hospital arrival (Table 1). Mean arrival time for all patients was 39.4±22.6 minutes (min-max: 14–108 minutes). Mean arrival time was determined to be 53.2±17.8 minutes for expired group and 30.8±15.4 minutes for survival group. Difference between time until hospital arrival and mortality or survival was found to be significant (p=0.001).

Distribution of injuries according to etiological factors was as follows: 79 (71%) patients had stab wound, 26 (23%) patients had gunshot wound, and 7 (6%) patients had iatrogenic injury. Mortality was not observed in iatrogenic injuries; however, mortality was observed in 10 (13%) patients in stab wound injury group and 4 (15%) patients in gunshot injury group. Difference in mortality between gunshot and stab wound groups was statistically insignificant (p>0.05).

Eighty-five (76%) patients arrived at hospital by their own means, and 27 (24%) patients were transferred by authorized ambulance. Mean length of transfer time was 47.6±32.3 minutes for transfer by ambulance and 35.1±11.3 minutes for self-transfer. Mortality rate with ambulance transfer (n=10) rose with longer transfer time (p<0.001).

Twenty-two (20%) patients were taken directly for resuscitative thoracotomy. Cardiac injury was thought to be critical in 24 (21%) patients, and they were immediately taken to surgery. Further radiological diagnosis was performed for 66 (59%) patients, and operation procedures were determined according to radiological findings. Highest mortality rate

Table 1. Relationship between mortality and initial data

	Mortality			Survival			p
	n	%	Mean±SD	n	%	Mean±SD	
Age (years)			28.7±9.2			27.1±11.3	>0.05
Sex							
Male	13	13		86	87		>0.05
Female	1	8		12	92		>0.05
Transfer time to hospital (min)			53.2±17.8			30.8±15.4	0.001

SD: Standard deviation.

was detected in resuscitative thoracotomy (RT) group, with 8 (50%) patients expiring (p=0.005). Mortality rate in clinical diagnosis and radiological diagnosis groups was 4 (43%) patients and 2 (7%) patients, respectively. Mortality rate in radiological diagnosis group was markedly lowest (p<0.001). One of these patients had multiple stab wounds, and injuries to the lung, the liver, and the heart were detected with CT and echocardiograms. Right ventricular repair, hepatic repair, and left tube thoracostomy were performed; however, the patient died on third day due to sepsis. The other patient also had multiple wounds (the right ventricle, the liver, the lung, and the trachea) detected in CT scans that were result of shotgun wound. Simultaneous right ventricular and hepatic repairs were made, and left lower lobectomy was performed due to uncontrolled bleeding. This patient died on fifth day due to multiple organ failure.

Initial vital findings were found to be important predictors of mortality. Mortality rate was 6 (43%) patients in group of those classified as in agony on arrival (n=9), 6 (43%) patients among those in shock (n=46), 1 (7%) from group of those who were hypotensive (n=20), and 1 (7%) from normotensive group (n=37) (p<0.001). Tamponade was detected in 30 (27%) patients, 1 of whom (3%) died. Thirteen (16%) patients died in group without tamponade (n=82). Mortality rate was insignificantly lower in tamponade group compared with patients without tamponade (p=0.108). Although statistically insignificant, higher mortality rate of 23% was observed in patients with hemothorax (n=44; p>0.05). In contrast, lower mortality rate of 5% was seen in patients with pericardial hematoma (n=75; p=0.005).

Highest mortality rate (33%) was found in left ventricular injuries (n=30). Mortality rate was 5% in right ventricular injuries (n=72). Mortality was not observed in injuries to other sites [right atrium (n=6), left atrium (n=2) and 2-site (n=2)]. Two-site injury was detected in 2 patients: right and left atria were injured in 1 patient, and right atrium and ventricle were injured in other patient. Isolated cardiac injury was detected in 63 (56%) patients, and concomitant organ injury was seen in 49 (44%) patients. Most common concomitant organ injury was lung injury. Other organs injured were the diaphragm, the liver, the spleen, the abdominal aorta, the stomach, the left internal mammarian artery, the right internal mammarian artery, and the pulmonary artery. Mortality rate was markedly higher in patients with concomitant organ injury, as expected (p=0.014). Concomitant organ injuries and mortality rates are presented in Table 2.

Lower mortality rate (n=8) was observed in patients with sinus rhythm (n=100). Mortality (n=6; 50%) was significantly higher (p=0.001) in patients with asystole or ventricular fibrillation (n=12). Coronary injury was detected in 5 (4%) patients. The left anterior descending artery was injured in 1 patient, and direct ligation was applied due to inappropriate location of injured vessel for bypass (patient died on second day due to left ventricular failure). Acute margin of right coronary artery was injured in 3 patients, and distal side of the left anterior descending artery was injured in 1 patient; direct ligation was applied in all of these cases.

Table 2. Concomitant organ injury and mortality rates

Involved organ	n	Mortality	
		n	%
Lung*	33	7	21
Diaphragm*	5	3	60
Liver*	7	5	71
Spleen*	4	3	75
Pancreas*	2	2	100
Abdominal aorta	1	0	0
Gastrointestinal tract*	5	0	0
Left internal mammarian artery	3	1	33
Right internal mammarian artery	1	0	0
Pulmonary artery	1	1	100

*Multiple organ injury.

Mortality rate was found to be closely associated with incision or injury length in PCI. Higher mortality rate (42%) was detected in patients (n=26) with incision length of >2 cm (p<0.001). Standard median sternotomy was performed for 19 patients. Left thoracotomy was performed for 88, and right thoracotomy was performed for 5 patients. Relationship between surgical approach and mortality rate was found to be statistically insignificant (p>0.05).

Total mortality rate was 13% for all PCI. Causes were determined to be prolonged shock for 6 (43%) patients, multiple organ failure due to multiple organ injury and ventricular failure for 4 (29%) patients, brain death for 3 (21%) patients, and sepsis for 1 (7%) patient.

Clinical features and mortality rates are comprehensively summarized in Table 3.

DISCUSSION

Despite recent advances in trauma and emergency medical care, PCI remains the most challenging of all injuries seen in the field of trauma surgery.[6,7] Therefore, prehospital management, initial assessment and findings, and appropriate procedures are important to increase likelihood of survival.[8] In this study, etiology, manner and duration of hospital transfer, and concomitant organ injuries were detected as most significant risk factors affecting survival. Age and gender were insignificant factors for mortality.

Yavuz et al. reported that length of time elapsed before arrival to hospital was important risk factor that determined mor-

Table 3. Clinical features and mortality rates

	Injury		Mortality		p*
	n	%	n	%	
Mechanism of injury					
Stab wound	79	71	10	71	0.599
Gun shot	26	23	4	29	
Iatrogenic	7	6	0	0	
Surgical decision					
Resuscitative thoracotomy	22	20	8	50	<0.001
Clinical diagnosis	24	21	4	43	
Radiological diagnosis	66	59	2	7	
Transfer type					
Ambulance	27	24	10	71	<0.001
Self	85	76	4	29	
Arrival status					
Agony	9	8	6	43	<0.001
Shock	46	41	6	43	
Hypotensive	20	18	1	7	
Normotensive	37	33	1	7	
Tamponade					
+	30	27	1	7	0.108
–	82	73	13	93	
Coronary injury					
+	5	4	1	7	0.657
–	107	96	13	93	
Concomitant organ injury					
+	49	44	11	79	0.014
–	63	56	3	21	
Arrival rhythm					
Sinus	100	89	8	57	0.001
Asystole/ventricular fibrillation	12	11	6	43	
Incision length					
>2 cm	26	23	11	79	<0.001
≤2 cm	86	77	3	21	
Hemothorax					
+	44	39	10	71	0.022
–	68	61	4	29	
Pericardial hematoma					
+	75	67	4	29	0.005
–	37	33	10	71	
Injury site					
Right ventricle	72	64	4	29	0.003
Left ventricle	30	27	10	71	
Other (right atrium, left atrium, multiple sites)	10	9	0	0	
Surgical incision					
Medial sternotomy	19	17	3	21	0.814
Right thoracotomy	88	79	10	72	
Left thoracotomy	5	4	1	7	
Total	112	100	14	100	

p<0.05 was considered significant. Each p value represents comparison of event with entire group.

tality.[1] In another study, it was reported that only 4% of PCI patients reached hospital alive via ambulance transfer.[9] Rhee et al. indicated that prehospital time is important in order to maintain signs of life until arrival.[10] Patients with prehospital mortality were excluded from our study. We found elapsed time until transfer to be significant risk factor for mortality, as in previous reports. Moreover, means of transfer (self-effort or ambulance) was also determined to be factor for mortality. Eighty-five (76%) of patients transported themselves, and 27 (24%) patients were transferred with authorized ambulances. Prolonged transfer duration was observed with ambulance transfer. Self-transfer seems to reduce transfer duration, as there can be wait for an ambulance.

Most of the previous reports indicated that gunshot wounds have higher mortality rates than stab wounds. Tyburski et al. found that gunshot wounds have poorer survival rate (23%) than stab wounds (58%).[9] According to Tang et al.'s report, stab wound has 5-fold higher survival rate when compared with gunshot wound.[11] Conversely, mortality rate for these injuries was similar in current study. According to our data, most stab wound patients had multiple stab wounds. Similarity in mortality between gunshot wounds and stab wounds may have been due to this feature of stab wound patients. Lowest mortality rate was in group with iatrogenic injuries, which may have been associated with timely diagnosis and early intervention due to hospital conditions.

Initial findings (cardiac rhythm, blood pressure), presence of cardiac tamponade, presence of hemothorax, and location of injury were reported as other mortality predictors in recent population-based studies.[12] Higher mortality rate was identified in PCI patients with preoperative arrhythmia.[13] Yavuz et al. reported lower mortality rate in patients with sinus rhythm compared with patients with asystole or ventricular fibrillation.[1] Presence of tamponade in PCI patients can prevent exsanguination; it also causes subendocardial ischemia, which may lead to sudden cardiac failure.[9] Presence of tamponade was associated with higher survival rate in previous reports.[9] It has been reported that 18% of deaths could potentially be saved due to compression of bleeding site in isolated cardiac wounds with tamponade.[14] Furthermore, hemorrhagic shock due to hemothorax is an important determinant for clinical outcomes in PCI.[15] Presence of hemothorax was associated with high mortality rate.[1] In the current study, sinus rhythm, normal blood pressure, presence of cardiac tamponade, and hematoma were detected as positive indicators for survival. In contrast, high mortality rate was found in patients with hemothorax.

RT and efficient open cardiac massage play essential role in recovery for patients who have loss of vital signs.[16,17] Approximately 35% success rate was reported with RT in PCI patients.[16] Nevertheless, higher mortality rate was reported in RT when compared with other operations performed with clinical or radiological diagnosis.[1] Algorithms for RT were designed according to loss of vitality and signs of life.[18] Poor outcome after RT was associated with poor vital signs. Injury localization is another important parameter for mortality in PCI. Main injury sites were reported as follows: right and left ventricle with range of 40%, right atrial injury with range of 24%, left atrial injury with range of 3%, and complex (more than 1 site or additive coronary artery, papillary muscle injury, etc.) injuries with range of approximately 5%.[8] Better survival rate was reported for right ventricle injuries.[19] Also, poor outcome was reported with concomitant coronary artery injury.[19] Yavuz et al. reported approximately 33% mortality rate in patients with concomitant coronary artery injury.[1] The other major predictor has been reported to be concomitant organ injury, which can contribute to loss of vital signs.[20] Thus, these types of multiple injuries have been labeled situation of "double jeopardy" in previous studies.[21] Most common concomitant organ injury reported was lung injury.[1,21] Increased mortality rate has been reported in patients in patients with longer injury length due to larger incision size, as expected. Yavuz et al. reported 45% mortality rate in patients with more than 2-cm incision.[1] According to our series, high mortality rate was detected in patients who underwent initial RT. Most common anatomical localization was right ventricle (64%), with rate of 5% mortality. Left ventricle injury (27%) was determined to be most fatal (71%) anatomical localization in this study, and 20% mortality rate was observed with concomitant coronary injury. Difference in mortality rate between patients with coronary injury and patients without coronary injury was not statistically significant. However, in our series, group with coronary injury was small (4% of the patients), which could explain statistical insignificance. Most frequently injured concomitant organ was the lung, but most fatal concomitant organ injuries were determined to be those to the pancreas, the spleen, the liver, and the diaphragm. Higher mortality might be associated with features such as high vascularization, important regulatory functions, etc. Mortality rate was found to be 42% greater with longer injury incision length (>2 cm). Additionally, some reports have mentioned benefits of cardiopulmonary bypass (CPB) for cardiac injury. Although it is rarely required, CPB can provide bloodless and stable operating area to optimize conditions for more effective repair.[13] Most often, CBP is required for complex injuries with concomitant coronary or valvular injury, or uncontrollable, excessive bleeding.[13,20] Coronary artery injuries can be controlled with ligation, or bypass can be performed if proximal site is affected.[13,20] In our series, there were no valvular injuries. We used ligation to control coronary injuries without using CBP.

In conclusion, cardiac injury is still challenging emergency situation. As described in the literature, many factors may be associated with mortality. However, hospital transfer duration seems to be the primary modifiable risk factor that is important determinant for survival. We suggest that advanced hospital transfer strategies and collaborative management are important for avoiding time lag and enhancing survival rate.

Funding

There authors certify that no financial support was provided for this study.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - ÖZET

Penetran kardiyak yaralanmalarda klinik sonuçları etkileyen faktörlerin değerlendirilmesi: Tek merkez deneyimi

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AMAÇ: Penetran kalp yaralanmaları (PKY) yüksek ölümcül sonuçlara sahiptir. Bu nedenle, bu acil durumların yönetimi özellikle önemlidir. Bu çalışmada, PKY'de ölümü ve sakat kalmayı etkileyebilen ana faktörler araştırıldı.

GEREÇ VE YÖNTEM: Geriye dönük olarak son on yıl içerisinde PKY ile acil servise başvuran 112 hasta değerlendirildi. Demografik veriler, ilk müdahaleler, transfer süreleri ve durumları, hayati durum ve bulgular, yaralanma şekli, bölgesi, karakteristikleri ve uygulanan cerrahinin şekli kayıt edildi.

BULGULAR: Demografik veriler (yaş, cinsiyet, yaralanma sebebi) ölüm için anlamlı etken olarak bulunmadı. Erken mortalite (1 haftalık izlem süresi içerisinde) 14 (%12.5) hasta da gözlendi. Ayrıca, hastaneye transfer şekli (sağlık ekibi gözetiminde ambulansla veya gözetimsiz), transfer süresi, ilk gelişteki hayati bulgular (kan basıncı, ritim, solunum, bilinç), operasyon zamanlaması (elektif veya acil) ve ek organ yaralanması sağ kalım için önemli belirleyiciler olarak saptandı.

TARTIŞMA: Kalp yaralanmaları son derece ölümcül acil durumlardır. Sağ kalım için tecrübeli tıbbi yönetim önemlidir. Nitekim, temel ilk yardım yaklaşımları ve acil hastane transferi tecrübeli klinik yaklaşım kadar önemlidir.

Anahtar sözcükler: Mortalite; penetran kalp yaralanmaları; sağ kalım belirteçleri.

Ulus Travma Acil Cerrahi Derg 2017;23(1):23–28 doi: 10.5505/tjtes.2016.95994