Cardiac Trauma: Has Survival Improved? A University Hospital Experience in Bangkok, Thailand

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Background: *Cardiac trauma, if not recognized and properly treated, will lead to a fatal outcome. For the past 16 years, the authors' policy for diagnosing and treating cardiac trauma has not changed but the survival rate in our institute has improved when compared between the two cohorts.*
Objective: *Study the factors for survival in patients with cardiac trauma.*
Material and Method: *Data was collected from chart review between September 1994 and April 2010. Patients presenting in extremis with suspected cardiac trauma will receive emergency room thoracotomy. Patients with equivocal Focused Assessment with Sonography for Trauma will receive formal transthoracic echocardiography. If still in doubt, the authors' policy will proceed with intra operative subxiphoid window and a set up for median sternotomy.*
Results: *Throughout the study period, 44 patients had cardiac trauma and the overall mortality rate was 13.6%. Four patients had blunt injury resulting in one ventricular septal defect and three ruptured right atrium. Right ventricle was injured the most 44%, right atrium 23%, left ventricle 20%, left atrium 2%, one patient had superior vena cava injury, and another patient had inferior vena cava injury. In this cohort, 30% underwent emergency room thoracotomy. Associated injuries were presented in 38% of cases.*
Conclusion: *High index of suspicion and prompt management for cardiac trauma should be considered in patients presenting with injuries to the chest, which has been the authors' policy for the past 16 years. The mortality rate had dropped from 26% to 4% but is not statistically significant.*

Keywords: *Cardiac trauma, Focused assessment with sonography for trauma, Echocardiography, Subxiphoid window*

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Injury to the heart may appear in many forms such as electrical shock, radiation, thermal, chemical, and ischemia. In the sense of a trauma surgeon, cardiac trauma usually means kinetic energy transferring to the heart either by blunt or penetrating force.

Before the nineteen century, cardiac trauma had been known to be fatal. The first report of an attempt to repair the myocardium was by Axel Cappelen in 1895 but the patient died three days after surgery from sepsis[1,2]. First successful report of repairing the heart was from Germany by Ludwig Rehn in 1896. Rehn repaired a young man's heart that was stabbed to the right ventricle by using interrupted silk sutures[1]. The chance of surviving cardiac trauma depends on many factors such as the amount of energy inflicting to the heart, the chambers and structures that are involved, the tamponade effect, and the promptness in diagnosing and managing the patient just to name a few. The most important factor for the patient to survive once arriving in the hospital is awareness of the cardiac trauma.

Penetrating cardiac trauma has a better chance of surviving, in the authors' series all four patients with blunt cardiac trauma survived[3,4]. The mortality rate for cardiac trauma, from many series, ranges from 9% to 97%[1]. During the present study period, the mortality was 13.6%[5,6]. For the past 16 years, the authors' policy for diagnosing and treating cardiac trauma has not changed but the survival rate in our institute has improved. If the authors divided the study period in two halves the former eight years mortality rate would be 26% and the later eight years 4%.

The purpose of the present study was to examine results of treatment of patients with cardiac trauma at our institution in two periods. Details of the study include demographic data, mechanism of injury,

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point of entry, associated injuries, mode of diagnosis, complications, and mortality.

Material and Method

After IRB was approved, retrospective and observational chart of King Chulalongkorn Memorial Hospital (KCMH) between September 1994 and April 2010 were reviewed. KCMH is a level-one trauma center in Bangkok, Thailand with 18,000 emergency department visits and 1,000 trauma admissions annually. Inclusion criteria were all patients presenting with suspected cardiac trauma arriving at KCMH emergency room. Cardiac contusion, commotio cordis, and iatrogenic cardiac injury were not included in the present study and patients with cardiac trauma who were dead on arrival were excluded. The period of study was divided in to two timelines between 1994 and 2001, and between 2002 and 2010. The reason is that in 2002, the authors began the observational study.

Cardiac trauma was suspected when penetrating injuries occurred to the precordium or danger zone of Sauer and Murdock, which is the topographical area of the heart and great vessel on the chest wall, traverse mediastinal wounds, and questionable injuries[7]. Blunt chest injuries, fracture of the sternum, and mechanism of injury will arises suspicion of cardiac trauma. Initial assessment and resuscitation of the trauma patients were performed according to the Advanced Trauma Life Support protocol of the American College of Surgeons Committee on Trauma and was managed as diagram depicted in Fig. 1. Patients presenting in extremis with suspected cardiac trauma received emergency room thoracotomy (ERT) to release cardiac tamponade and stabilize active problems. Once the vital signs were stable, the patient was transferred to the operating room for definitive repair and closure. The group of patients who were not in extremis with suspected cardiac trauma received Focused Assessment with Sonography for Trauma (FAST) by the trauma team. Cohort with positive FAST was sent to the OR for either median sternotomy or thoracotomy depending on the mechanism of injury. If penetrating injury occurred to the precordium, median sternotomy was chosen. This is because of the nature of injury to the heart, which can be managed through this incision. In gunshot wound and traverse mediastinal wound, the authors would proceed with thoracotomy and possibly extend to clamp shell incision because of the greater injury and to address injuries in both hemithoraces. In questionable FAST performed by trauma team, we will obtain transthoracic echocardiography (TTE) by a cardiologist to determine pericardial effusion. At our institution, the cardiologist is available to perform TTE upon request. If cardiac injury was still suspected after a negative TTE, the authors' policy was to proceed with intra operative subxiphoid window under general anesthesia and proceed to median sternotomy if the subxiphoid window was positive. Patients who need immediate exploratory laparotomy or other injuries that require operation with suspected cardiac trauma received a subxiphoid window and proceed with median sternotomy if subxiphoid window was positive. Negative subxiphoid window excludes cardiac trauma. The authors do not perform transesophageal echocardiography, thoracoscope, pericardiocentesis, or using cardiac enzyme for achieving the diagnosis of cardiac trauma. Computed tomography was not a priority in diagnosing cardiac injury even though there were two patients who received CT scan for other reasons and found to have hemopericardium. Prior to discharge, all patients received formal TTE to rule out intra cardiac injuries.

Statistical analysis for continuous data was compared using unpaired Student's t-test and Chi-square test or Fisher's exact test for categorical data. A p-value less than 0.05 was considered to be statistically significant for comparison.

Results

During the 16-year study period, there were 44 cardiac trauma patients. The age ranged from 15 to 63 years old (mean28.3±10). Forty patients (91%) were male and four (9%) were female. The initial average

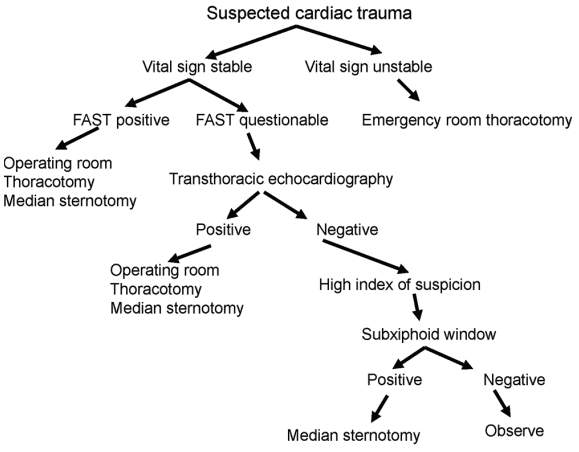

Fig. 1 Diagram depicting suspected cardiac trauma management.

Table 1. Demographic, vital signs and cause of death

	1994-2001	2002-2010	p-value
Patient	19	25	NA
Male	18 (94%)	22 (88%)	0.62
Age	28.1±8.1	29.7±13.0	0.62
Initial systolic blood pressure (mmHg)	80.0±17.0	96.0±23.0	0.007*
Initial heart rate (beat per minute)	99.0±55.0	109.0±19.0	0.03*
Length of ICU stay (day)	5	3	0.58
Length of hospital stay (day)	24	12	0.57
Mortality	5 (26%)	1 (4%)	0.07
Exsanguination	3	1	0.30
Multiorgan failure	1	0	0.43
Sepsis	1	0	0.43

* Statistically significant p-value <0.05

systolic blood pressure on arrival was significantly lower in the first period of the study group. The heart rate was significantly higher in the second period of the present study group (Table 1). Seventy percent of the patient population arrived between 6 pm and 6 am. Three patients (7%) were HIV positive of which one received ERT and all three patients survived. Mechanism of injury was 34 stab wounds (77%), five gunshot wounds (11%), four blunt chest injuries (9%), and one shrapnel injury (2%) (Table 2). The mechanism of injury was not statistically significant between the two cohorts. Patients were divided into three categories hemodynamic stable, hemodynamic unstable, and agonal. The hemodynamic stable group (48%) received full investigation and were sent to the OR, which was significantly higher in the second half of the study period. Hemodynamic unstable group (20%) included patients partially responding to rapid fluid transfusion. The trauma team will perform FAST and treat the patient accordingly to the findings. The agonal group (32%) could not maintain vital signs, thus, received ERT (Table 3). ERT was performed in 13 (30%) patients and seven survived the procedure (53%). ERT was performed significantly more during the first half of the study period. Most common point of entry was the left chest 70% (Table 4). The most common chamber injured with penetrating injury was the right ventricle 40% and in blunt injury was right atrium 75% (Table 5). The point of entry and chamber injured were not statistically significant in both cohorts. No coronary vessels were injured in this study group. One patient had a through and through left ventricle injury but no intra cardiac structure damage. It was repaired successfully without using cardiopulmonary bypass. Intra pericardial great vessel injury was encountered in 6% of the cases. Eight patients had only hemopericardium with no cardiac trauma. The source of the bleeding was from internal mammary artery and

Table 2. Mechanism of injury

	1994-2001	2002-2010	p-value
Stab wound	17	17	0.14
Gun shot wound	1	4	0.37
Blunt	1	3	0.62
Shrapnel	0	1	1

Fisher's exact test

Table 3. Category according to vital signs on arrival

	1994-2001	2002-2010	p-value
Stable	3	18	0.002*
Unstable	5	4	0.46
Agonal	11	3	0.01*

* Statistically significant p-value <0.05

Table 4. Point of penetrating injury

	1994-2001	2002-2010	p-value
Left chest	13	18	0.79[a]
Right chest	5	4	0.46[b]
Traverse mediastinum	1	3	0.62[b]

[a] Chi-square test
[b] Fisher's exact test

surrounding tissues. Associated injuries that are found were nine lung injuries (20%), four rib fractures (9%), four diaphragm injuries (9%), and three liver injuries (7%) (Table 6). The amount of blood transfusion on average was seven units of packed red cells, four units of fresh frozen plasma, and 12 units of platelets per patient. Cardiac trauma was diagnosed by FAST in 22 patients (50%) and needed TTE in 15 cases (34%). Subxiphoid window was performed in eight patients (18%) including one patient that had only pericardial injury. That patient did not proceed to median sternotomy (patient with CT scan that found pericardial fluid who was transferred from an outside hospital) (Table 7).

One patient had to go on cardiopulmonary bypass to repair a muscular ventricular septal defect. The ventricular septal defect was repaired electively six months after the injury due to head injury and general conditions. Two patients had CT scan of the chest for other reasons and found pericardial fluid the management was changed and proceeded to subxiphoid window. One patient had a CT scan from an outside hospital for an impaling broken knife in the left chest in proximity to the left ventricle. He was referred to our institute. The median sternotomy found the tip of the knife in the left ventricle (Fig. 2) and the patient was discharged seven days postoperative. Two patients developed post pericardiotomy syndrome and were treated successfully with indomethacin. Four patients had cerebral complication, two from prolong shock and two from emboli (Table 8). Two patients developed arrhythmias, one atrial fibrillation and one supra ventricular tachycardia. Both were treated successful medically. One patient with ruptured right atrium developed progressive dyspnea after discharged from hospital. The workup found subglottic stenosis and was treated successfully with endoscopic laser. One patient needed reoperation from a bleeding

Fig. 2 CT scan of a broken knife in proximity to the left ventricle.

Table 5. Intrapericardial injuries (may be more than one)

	1994-2001	2002-2010	p-value
Right atrium	4	4	0.70
Right ventricle	9	9	0.44
Left atrium	1	0	0.43
Left ventricle	4	5	1
Ventricular septal defect	0	1	1
Superior vena cava	1	0	0.43
Inferior vena cava	1	0	0.43
Ascending aorta	0	1	1
Hemopericardium	2	6	0.43

Fisher's exact test

Table 6. Associated injuries

	1994-2001	2002-2010	p-value
Lung contusion	2	7	0.25
Rib fractures	1	3	0.62
Diaphragm	1	3	0.62
Liver	1	2	1
Stomach	1	1	1
Internal mammary artery	1	2	1
Head	0	1	1
Neck	1	0	0.43
Small bowel	0	1	1
Spleen	1	0	0.43
Long bone fracture	0	1	1

Fisher's exact test

Table 7. Mode of diagnosis (may be more than one)

	1994-2001	2002-2010	p-value
FAST	17	23	1
ER thoracotomy	11	2	0.003*
Transthoracic echocardiography	5	10	0.34
Subxiphoid window	1	7	0.11
Computer tomography	0	3	0.24

* Statistically significant p-value <0.05

Table 8. Complications

	1994-2001	2002-2010	p-value
Post pericardiotomy syndrome	2	0	0.18
Cerebral hypoxia	2	0	0.18
Pneumonia	2	0	0.18
Embolic stroke with seizure	1	1	1
Pancreatitis	1	0	0.43
Atrial fribillation	1	0	0.43
Supra ventricular tachycardia	0	1	1
Subglotic stenosis	0	1	1
Re bleeding	0	1	1

Fisher's exact test

internal mammary artery, which was not addressed during the ERT. Length of surgical intensive care unit stay and hospital stay were shorter in the second half of the study group but was not statistically significant (Table 1). The major cause of death was exsanguination. The other causes were multiorgan failure and sepsis (Table 1). In the present study, the authors did not encounter thoracic compartment syndrome from cardiac trauma.

Discussion

The purpose of the present study was to evaluate and compare the survival rate of cardiac trauma in our institution, which the guideline has not changed for the past sixteen years. High index of suspicion for cardiac trauma and prompt management has an important role for the patients to survive. Beck's triad and Kussmal's sign may be present in cardiac trauma patients but in our experience, all patients with cardiac trauma presents with some degree of restlessness even with stable vital signs[8]. Many modalities could be used to diagnose cardiac trauma in moribund patients. Those necessitate ERT. The diagnosis is made immediately after opening the pericardium during the attempt to perform internal cardiac massage and the lesion is addressed immediately. Patients who are not in moribund will receive FAST during the initial assessment and are promptly diagnosed if pericardial fluid is encountered. In questionable FAST, which pericardial fluid is not obviously observed by the trauma team, an in house cardiologist will be available to do a TTE. We do not use trans-esophageal echocardiography in diagnosing cardiac trauma but it may be used intraoperatively by an anesthesiologist in monitoring patients hemodynamic and detecting traumatic rupture of the aorta. After a negative TTE, and if the cardiac injury is still in doubt, we would proceed with a subxiphoid window in the operating theater and a full setup for median sternotomy in case of positive finding. If subxyphoid window does not reveal blood in the pericardium, cardiac injury is ruled out. Subxiphoid window is still a useful tool in suspected cardiac trauma, especially in patients who have to go to the operating room immediately without complete cardiac work up[9]. Patients with multiple injuries who need immediate laparotomy or craniotomy will be sent to the operating theater and subxiphoid window will be performed in suspected cardiac trauma patients. Thoracoscopy has no role in diagnosing cardiac trauma in our institution because of the setup of the procedure, which makes it difficult in repairing cardiac trauma and does not have a higher yield in detecting cardiac trauma than subxiphoid window. The role for thoracoscopy in our institution is only for evacuating retained clot. The authors do not advocate pericardiocentesis to diagnose cardiac trauma due to the potential false positive and false negative of the procedure. In our series a patient, we had a positive pericardiocentesis and found to have only multiple puncture holes to the heart from the procedure. Ultrasound guiding the needle to perform pericardiocentesis may be used to release cardiac tamponade rather than diagnose cardiac trauma. CT scan has an increasing role in detecting pericardial fluid. Two patients had negative FAST, underwent CT scan for other reasons, and found to have hemopericardium. In general, CT scan is not used as a primary tool for diagnosing cardiac injury, but in unexplained pericardial effusion on CT scan, it should raise suspicion of cardiac trauma.

In the present series, the chambers that were involved were similar to other studies[10-12]. The most common chamber injured in penetrating, especially stab wound, and is the right ventricle due to the anterior anatomical position. In blunt injuries, the most common chamber that is involved is the right atrium because of the thin wall nature. Blood transfusion in recent years has been shifting to pack red cell to fresh frozen plasma to platelets to 1:1:1. Additionally, the more understanding of damage control might have a role in better survival in later years. The latter period of the present study show more severe mechanism of injuries but they are not statistically significant. The

hemodynamic on arrival of this group is significantly better. Reason for this may be due to the better pre-hospital system that makes the patient arriving earlier than the past. In our series, we did not encounter thoracic compartment syndrome and no damage control of the chest was performed for cardiac injury.

In conclusion, during the past 16 years the authors' approach and management for cardiac trauma have not changed even though the survival rate has improved but was not statistically significant. The authors believe that the algorithm proposed is practical and useful for decision making of these lethal injuries. Furthermore, the authors found that CT scan maybe helpful in detecting pericardial effusion leading to diagnosis of cardiac injury in selected patients.

Potential conflicts of interest

None.

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การบาดเจ็บต่อหัวใจ: ประสบการณ์ของโรงเรียนแพทย์, อัตราการรอดชีวิตดีขึ้นหรือไม่?

กฤตยา กฤตยากีรณ, สุกัญญา ศรีอัษฎาพร, รัฐพลี ภาคอรรถ, ศุภฤกษ์ ปรีชายุทธ, พสุรเชษฐ์ สมร, สุวิทย์ ศรีอัษฎาพร

วัตถุประสงค์: *เพื่อศึกษาผู้ป่วยที่ได้รับบาดเจ็บต่อหัวใจในโรงเรียนแพทย์ ว่าช่วงสิบหกปีที่ผ่านมามีการเปลี่ยนแปลงวิธีวินิจฉัยและการรักษาผู้ป่วยที่ได้รับบาดเจ็บต่อหัวใจหรือไม่ ซึ่งการบาดเจ็บต่อหัวใจแบบทะลุ ผู้ป่วยจะมีโอกาส รอดชีวิตสูงกว่าแบบกระแทก แต่ในการศึกษานี้ผู้ป่วยทั้งสี่รายที่ได้รับบาดเจ็บแบบกระแทกรอดชีวิตหมด*

วัสดุและวิธีการ: *เป็นการศึกษาประวัติผู้ป่วยที่ได้รับบาดเจ็บต่อหัวใจย้อนหลังตั้งแต่กันยายน พ.ศ. 2537 ถึง เมษายน พ.ศ. 2553 ผู้ป่วยที่มาถึงโรงพยาบาลแล้วสัญญาณชีพไม่สามารถแก้ไขได้ด้วยสารน้ำเป็นปริมาณมากจะได้รับการผ่าตัดเปิดอกในห้องฉุกเฉิน ผู้ป่วยที่สามารถแก้ไขให้สัญญาณชีพกลับมาเกือบเป็นปกติจะได้รับการตรวจด้วยคลื่นเสียงความถี่สูง ถ้าผลตรวจที่ได้ยังไม่ชัดเจนจะปรึกษาแพทย์เฉพาะทางหัวใจมาช่วยตรวจซ้ำ ถ้ายังไม่สามารถสรุปได้ว่ามีการบาดเจ็บต่อหัวใจหรือไม่ แพทย์จะนำผู้ป่วยไปยังห้องผ่าตัดเพื่อเปิดเยื่อหุ้มหัวใจดูว่ามีเลือดหรือไม่ ถ้าไม่พบเลือดก็สามารถวินิจฉัยได้ว่าไม่มีการบาดเจ็บต่อหัวใจ ถ้าพบเลือดในเยื่อหุ้มหัวใจแพทย์จะทำการผ่าตัดเปิดหน้าอกเพื่อซ่อมหัวใจ*

ผลการศึกษา: *ตลอดระยะเวลาการศึกษามีผู้ป่วยที่ได้รับบาดเจ็บต่อหัวใจ 44 ราย อัตราการเสียชีวิตรวมร้อยละ 13.6 มีผู้บาดเจ็บแบบกระแทกสี่ราย เป็นผนังกั้นห้องหัวใจล่างรั่วหนึ่งราย หัวใจห้องบนขวาแตกสามรายซึ่งรอดชีวิตหมดทั้งสี่ราย หัวใจห้องล่างขวาได้รับบาดเจ็บมากสุดร้อยละ 44 หัวใจห้องบนขวาร้อยละ 23 หัวใจห้องล่างซ้ายร้อยละ 20 และห้องบนซ้ายร้อยละ 2 Superior และ Inferior Venacava อย่างละหนึ่งราย ในการศึกษานี้มีผู้ป่วยที่ได้รับการผ่าตัดเปิดอกในห้องฉุกเฉินร้อยละ 30 และมีการบาดเจ็บอื่นร่วมด้วยร้อยละ 38*

สรุป: *แพทย์ผู้ทำการรักษาผู้ป่วยต้องมีความตระหนักอย่างสูงว่าอาจมีการบาดเจ็บต่อหัวใจในผู้ป่วยที่ได้รับบาดเจ็บบริเวณทรวงอก ซึ่งเป็นนโยบายในการดูแลผู้ป่วยตลอดสิบหกปี และอัตราการเสียชีวิตลดลงจากร้อยละ 26 เหลือร้อยละ 4 เนื่องจากความรู้ความเข้าใจในการดูแลผู้ป่วยอุบัติเหตุฉุกเฉินที่มากขึ้น*