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Blunt Cardiac Injuries That Require Operative Management: A Single-Center 7-Year Experience

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Purpose: Blunt cardiac injuries (BCI) have a wide clinical spectrum, ranging from asymptomatic myocardial contusion to cardiac rupture and death. BCIs rarely require surgical intervention, but can be rapidly fatal, requiring prompt evaluation and surgical treatment in some cases. The aim of this study was to identify potential factors associated with in-hospital mortality after surgery in patients with BCI.
Methods: The medical records of 15 patients who had undergone emergency cardiac surgery for BCI between January 2014 and August 2020 were retrospectively reviewed. We included trauma patients older than 18 years admitted to Regional Trauma Center, Gachon University Gil Medical Center during the study period. Clinical and laboratory variables were compared between survivors and non-survivors.
Results: Non-survivors showed a significantly higher Injury Severity Score (p=0.001) and Abbreviated Injury Scale in the chest region (p=0.001) than survivors. American Association for the Surgery of Trauma-Organ Injury Scale Grade V injuries were significantly more common in non-survivors than in survivors (p=0.031). Non-survivors had significantly more preoperative packed red blood cell (PRBC) transfusions (p=0.019) and were significantly more likely to experience preoperative cardiac arrest (p=0.001) than survivors. Initial pH (p=0.010), lactate (p=0.026), and base excess (BE; p=0.026) levels showed significant differences between the two groups.
Conclusions: Initial pH, lactate, BE, ventricular injury, the amount of preoperative PRBC transfusions, and preoperative cardiac arrest were potential predictors of in-hospital mortality.

Keywords: Blunt; Trauma; Heart

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INTRODUCTION

Blunt cardiac injuries (BCIs) have a wide clinical spectrum, ranging from asymptomatic myocardial contusion to cardiac rupture and death. BCIs have been reported to occur in 20% to 76% of all patients with blunt thoracic trauma, whereas blunt cardiac rupture has been reported to occur in 0.16% to 2% of affected patients [1-6]. BCIs rarely require surgical intervention, but can be rapidly fatal. Therefore, a severe BCI may require prompt evaluation and surgical treatment [7]. In addition, it may be necessary to evaluate the prognosis to determine the surgical method before surgery [8]. Thus, the aim of this study was to identify potential factors associated with in-hospital mortality after surgery in patients with BCI and to review our experiences of the surgical management of BCI.

METHODS

The study was approved by the Institutional Review Board (IRB) of the Gachon University Gil Medical Center (IRB No. GDIRB2020-392), which waived the requirement for informed consent because of the retrospective nature of the study.

Study design and patient

We conducted a retrospective study in a single center from January 2014 to August 2020. We included patients ≥18 years of age who underwent emergency cardiac surgery for BCI. We excluded patients who were dead on arrival. Patients were divided into survivors and non-survivors. These groups were compared with respect to clinical and laboratory variables.

Clinical and laboratory variables

Baseline characteristics included age, sex, mechanism(s) of injury, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS), Glasgow Coma Scale, the American Association for the Surgery of Trauma-Organ Injury Scale (AAST-OIS) grade, the number of units of preoperative packed red blood cells (PRBCs) transfused, preoperative cardiac arrest, presence of preoperative cardiac tamponade, abnormal electrocardiogram (ECG) findings, the presence of sternum fracture, preoperative vasopressor use, diagnostic methods, and the time to surgery. Hemodynamic and laboratory results were measured immediately after arrival at the emergency department and compared between survivors and non-survivors. Intraoperative parameters, such as injury site, operation time, skin incision, intraoperative fluid replacement, type of operation, and any concomitant operations were compared between the two groups. Clinical outcomes, such as length of hospital stay (LOHS), length of intensive care unit stay (LOICUS), duration of mechanical ventilation (MV), and postoperative complications were collected and analyzed.

Statistical analysis

Categorical variables are expressed as numbers (%) and were evaluated using the Fisher exact test. Continuous variables are expressed as medians and interquartile ranges, and were compared between the groups using the Mann-Whitney *U* test. Statistical significance was accepted for two-sided *p*-values of <0.05. Statistical analysis was performed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA)

RESULTS

The overall mortality rate after surgery was 26.6%. Non-survivors showed a significantly higher ISS (p=0.001) and AIS in the chest region (p=0.001) than survivors. AAST-OIS grade V was significantly more frequent in non-survivors than in survivors (p=0.031). Non-survivors had a significantly higher median number of units of preoperative PRBC transfusions (p=0.019) and were significantly more likely to have preoperative cardiac arrest (p=0.001) than survivors (Table 1). There was no significant difference between the two groups with respect to preoperative troponin I (p=0.392) and creatine kinase-myocardial band levels (p=0.851). However, initial pH (p=0.010), lactate (p=0.026), and base excess (BE; p=0.026) levels showed significant differences between the two groups (Table 2).

The left ventricle was the most common site of injury

Table 1. Baseline characteristics of patients

	Total (n=15)	Survivors (n=11)	Non-survivors (n=4)	*p*-value
Age (years)	52.0 (49.0–59.0)	52.0 (49.0–64.0)	54.5 (47.5–58.5)	0.851
Sex				1.000
Male	12 (80.0)	9 (81.8)	3 (75.0)	
Female	3 (20.0)	2 (18.2)	1 (25.0)	
Injury mechanism				0.684
MVA, passenger	5 (33.3)	4 (36.4)	1 (25.0)	
MVA, pedestrian	5 (33.3)	3 (27.3)	2 (50.0)	
Motorcycle accidents	2 (13.3)	1 (9.1)	1 (25.0)	
Falls	3 (20.0)	3 (27.3)	0 (0.0)	
ISS	34.0 (26.0–75.0)	29.0 (24.5–35.5)	35.0 (30.0–39.5)	0.001
AIS				
Head and neck	2.5 (2.0–3.0)	2.0 (2.0–3.0)	0.0 (0.0–3.0)	0.500
Face	3.0 (2.0–3.0)	2.0 (2.0–3.0)	0.0 (0.0–0.0)	
Thorax	5.0 (4.0–5.0)	4.0 (4.0–5.0)	5.0 (4.5–5.0)	0.001
Abdomen or pelvic contents	2.0 (2.0–2.5)	2.0 (2.0–4.0)	1.0 (0.0–2.0)	1.000
Extremities or pelvic girdle	3.0 (2.0–3.0)	2.0 (2.0–3.0)	1.0 (0.0–3.0)	0.327
External	1.0 (1.0–1.0)	1.0 (0.0–1.0)	0.0 (0.0–1.0)	1.000
GCS	7.0 (6.0–13.0)	8.0 (6.5–13.5)	5.0 (3.5–7.0)	0.078
AAST-OIS grade				0.031
1	2 (13.3)	2 (18.2)	0 (0.0)	
2	0 (0.0)	0 (0.0)	0 (0.0)	
3	3 (20.0)	3 (27.3)	0 (0.0)	
4	7 (46.7)	6 (54.5)	1 (25.0)	
5	3 (20.0)	0 (0.0)	3 (75.0)	
Preoperative PRBC transfusion	3.0 (2.0–6.0)	3.0 (2.0–3.0)	7.5 (3.7–11.3)	0.019
Preoperative cardiac arrest	4 (26.7)	0 (0.0)	4 (100.0)	0.001
Preoperative cardiac tamponade	13 (86.7)	10 (90.9)	3 (75.0)	0.476
Abnormal ECG[a]	3 (3/11–27.3)	3 (27.3)	0 (0.0)[b]	N/A
Sternum fracture	9 (60.0)	7 (63.6)	2 (50.0)	1.000
Preoperative use of vasopressor	8 (53.3)	4 (36.4)	4 (100.0)	0.077
Diagnostic method				0.604
Chest CT	6 (40.0)	5 (45.5)	1 (25.0)	
Ultrasound	9 (60.0)	6 (54.5)	3 (75.0)	
Time to surgery (min)	68.0 (60.0–95.0)	68.0 (60.5–100.0)	74.0 (48.0–87.0)	0.602

Values are presented as number (%) or median (interquartile range).
MVA: motor vehicle accident, N/A: not applicable, ISS: Injury Severity Score, AIS: Abbreviated Injury Scale, GCS: Glasgow Coma Scale, AAST-OIS: the American Association for the Surgery of Trauma-Organ Injury Scale, PRBC: packed red blood cell, ECG: electrocardiogram, CT: computed tomography.
[a]Abnormal ECG findings are as follows: ST segment elevation, right bundle branch block, or first-degree atrioventricular block.
[b]A preoperative ECG was not obtained in the non-survivor group.

Table 2. Comparison of preoperative hemodynamic and laboratory findings between survivors and non-survivors

	Survivors (n=11)	Non-survivors (n=4)	*p*-value
SBP (mmHg)	76.0 (64.0–96.5)	60.5 (0.0–121.0)	0.923
HR (BPM)	115.0 (97.5–128.0)	113.0 (55.5–133.5)	0.949
Hb (g/dL)	11.6 (9.7–12.9)	11.5 (10.3–11.6)	0.661
Troponin I (pg/mL)	3.9 (1.7–33.9)	20.8 (6.8–40.6)	0.392
CK-MB (ng/mL)	25.8 (8.3–58.6)	25.3 (19.3–30.9)	0.851
pH	7.24 (7.12–7.29)	7.00 (6.91–7.07)	0.010
BE (mmol/L)	-7.4 (-15.7 to -5.5)	-19.3 (-21.5 to -16.2)	0.026
Lactate (mmol/L)	5.5 (4.6–8.6)	10.6 (9.0–13.2)	0.026

Values are presented as number (%) or median (interquartile range).
SBP: systolic blood pressure, HR: heart rate, BPM: beat per minute, Hb: hemoglobin, CK-MB: creatine kinase-myocardial band, BE: base excess.

Table 3. Comparison of operative findings between survivors and non-survivors

	Survivors (n=11)	Non-survivors (n=4)	*p*-value
Injury region			0.053
Right atrium	2 (18.2)	0 (0.0)	
Right ventricle	0 (0.0)	0 (0.0)	
Left atrium	1 (9.1)	1 (25.0)	
Left ventricle	0 (0.0)	2 (50.0)	
Pericardium	5 (45.5)	0 (0.0)	
Right atrium+SVC	2 (18.2)	0 (0.0)	
Right atrium and ventricle	1 (9.1)	1 (25.0)	
Intraoperative blood loss (mL)	1,000.0 (650.0–1,525.0)	3,500.0 (2,400.0–12,000.0)	0.010
Operation time (min)	135.0 (125.0–145.0)	109.0 (67.5–151.0)	0.280
Incision			0.016
Median sternotomy	11 (100.0)	2 (50.0)	
Left (anterolateral) thoracotomy[a]	0 (0.0)	1 (25.0)	
Clamshell incision[a]	0 (0.0)	1 (25.0)	
Intraoperative fluid replacement (mL)			
Crystalloids	4,500.0 (1,900.0–6,350.0)	5,000.0 (1,250.0–10,000.0)	0.753
Colloid	750.0 (250.0–1,000.0)	1,750.0 (500.0–2,625.0)	0.280
Intraoperative PRBC transfusion	7.0 (4.0–10.0)	17.0 (10.5–27.2)	0.030
Postoperative PRBC transfusion	2.0 (1.0–5.0)	2.0 (1.0–10.0)	0.786
Operation name			0.256
Hematoma evacuation	2 (18.2)	0 (0.0)	
Primary repair	6 (54.5)	4 (100.0)	
Suture ligation	3 (27.3)	0 (0.0)	
Co-operation	1 (9.1)	2 (50.0)	0.154

Values are presented as number (%) or median (interquartile range).
SVC: superior vena cava, PRBC: packed red blood cell.
[a]These surgeries were performed in emergency room.

in non-survivors and the pericardium was the most common site of injury in survivors; however, this difference did not reach statistical significance (p=0.053). Median sternotomy was performed all survivors, but in non-survivors, left anterolateral thoracotomy and clamshell thoracotomy were performed, as well as median sternotomy (p=0.016) (Table 3). Postoperative complications, such as severe coagulopathy (n=2) or heart failure (n=1), were significant more frequent in non-survivors than in survivors (p=0.009) (Table 4).

DISCUSSION

BCIs may range from asymptomatic cardiac contusion with minor ECG abnormalities to fatal cardiac rupture [1-5]. While blunt cardiac rupture is rare, it may result in rapid hemodynamic deterioration [4,5]. Therefore, a rapid diagnostic tool is needed to detect BCI early. In addition, it is necessary to evaluate prognostic factors for BCI in the initial phase of trauma.

In our results, non-survivors had higher ISS, AIS in the chest region, and AAST-OIS grades, more preoperative PRBCs transfused, and a higher frequency of preoperative cardiac arrest. These factors reflect high-energy, severe injuries, and have been identified as poor prognostic factors in previous studies [2,8-10]. The overall mortality after surgery was 26.6%, which is similar to that of prior studies [1,11]. Cardiac tamponade was common in both groups before surgery. A previous study also reported a high incidence of cardiac tamponade after blunt cardiac rupture [12]. Cardiac tamponade secondary to BCI is extremely serious and requires rapid management.

Table 4. Comparison of postoperative outcomes between survivors and non-survivors

	Survivors (n=11)	Non-survivors (n=4)	p-value
LOHS (days)	38.0 (21.5–63.5)	1.0 (0.5–1.5)	0.001
LOICUS (days)	8.0 (4.5–17.0)	1.0 (0.5–1.5)	0.001
MV duration (days)	4.0 (2.0–11.5)	1.0 (0.5–1.5)	0.018
Complications			0.009
Severe coagulopathy	0 (0.0)	2 (50.0)	
Heart failure	0 (0.0)	1 (25.0)	

Values are presented as number (%) or median (interquartile ranges).
LOHS: length of hospital stay, LOICUS: length of intensive care unit stay, MV: mechanical ventilation.

Our data revealed that, unlike previous studies [13-16], ECG and cardiac enzymes had low diagnostic value and prognostic value in the early of BCI. Instead, pH, lactate, and BE emerged as potential prognostic factors associated with in-hospital mortality related to severe bleeding. In a previous study, increased lactate levels were identified as a strong predictor of in-hospital mortality [9]. Although we could not perform a multivariate analysis due to the small number of subjects, preoperative cardiac arrest, injury site, blood transfusion requirements, and the above blood measurements were important factors for predicting in-hospital mortality; further research is needed to validate these findings in the future.

Furthermore, non-survivors mainly had atrial and ventricular injuries, of which half were left ventricular. These results are consistent with other studies [1,8,12]. LOHS, LOICUS, MV duration, and complications were analyzed as clinical outcomes. Since most non-survivors died shortly after arrival at the emergency room, LOHS, LOICUS, and MV duration cannot be regarded as meaningful results. However, postoperative complications were significantly more common in non-survivors, and these complications were mainly severe coagulopathy and heart failure. These complications are similar to those reported in previous studies [5,7,12]. In survivors, median sternotomy was the primary approach, whereas in non-survivors, half of patients underwent left anterolateral thoracotomy or clamshell thoracotomy. This is because most of the survivors had pericardial injuries or localized injuries to the heart on preoperative imaging studies, whereas non-survivors had associated thoracic injuries or severe hemorrhage. If the patient was hemodynamically unstable or had cardiac arrest before surgery, surgeons showed a tendency to initially select resuscitative thoracotomy as a therapeutic option. This approach has also been recommended in recent guidelines [17,18].

This study has some limitations. First, this was a retrospective, single-center study. Second, the small sample size limits the ability to generalize the findings. Third, a multivariate analysis could not be performed to identify predictors of in-hospital mortality because of the small number of subjects. Thus, we are planning a multicenter study to overcome these limitations.

In conclusion, we found that initial pH, lactate, BE, ventricular injury, the amount of preoperative PRBC transfusions, and preoperative cardiac arrest may be predictors of in-hospital mortality. If patients with BCI before surgery have these factors, surgeons should consider expeditious salvage interventions, including cardiopulmonary bypass or damage control surgery.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

INFORMED CONSENT

This type of study does not require informed consent.

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