



# Treatment results of cardiac tamponade due to thoracic trauma at Jeju Regional Trauma Center, Korea: a case series

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**Purpose:** The purpose of this study was to report the treatment results of patients with traumatic cardiac tamponade after the opening of Jeju Regional Trauma Center.

**Methods:** We analyzed the treatment outcomes of patients with traumatic cardiac tamponade who were treated at Jeju Regional Trauma Center from January 2018 to August 2022.

**Results:** Seven patients with traumatic cardiac tamponade were treated. The male to female ratio was 1.33:1 (four male and three female patients) and the average age was  $60.3 \pm 7.2$  years. The mechanism of injury was blunt trauma in six cases and penetrating injury in one case. Upon arrival at the emergency department, pericardiostomy was performed in four cases, and an emergency operation was performed in six cases. Pericardiostomy alone was performed in one patient, who had cardiac tamponade due to extrapericardial suprahepatic inferior vena cava rupture. The causes of cardiac tamponade were right atrium appendage rupture in one case, right ventricle rupture in one case, inferior vena cava rupture in two cases, right atrium and left atrium rupture in one case, both atria and left ventricle rupture in one case, and intercostal artery rupture in one case. In three cases, intraoperative cardiopulmonary bypass was required. Two of the seven patients died (mortality rate, 28.5%).

**Conclusions:** Relatively favorable treatment results were observed for traumatic cardiac tamponade patients after Jeju Regional Trauma Center was established.

**Keywords:** Thoracic injury; Cardiac tamponade; Trauma center

## INTRODUCTION

### Background

The treatment of traumatic cardiac tamponade remains a difficult problem when treating severe trauma patients [1]. In all trauma patients, the incidence of traumatic cardiac tamponade due to thoracic injury is very low (0.16%–2%), but the mortality

rate is relatively high (postoperative mortality, 24%) [2]. For the successful treatment of traumatic cardiac tamponade patients, it is important to promptly transport them from the scene of the accident to an emergency center where a prompt diagnosis and surgical treatment are possible. For this, there must be appropriate medical equipment for diagnosis and treatment, and close cooperation between skilled medical team members is required [3,4].

## Objectives

This study analyzed the electronic medical records of patients with traumatic cardiac tamponade who were treated after the establishment of Jeju Regional Trauma Center to determine their treatment results and factors affecting the treatment outcomes.

## METHODS

### Ethics statement

The study was approved by the Institutional Review Board of Cheju General Hospital (No. 2022-L04-01). The requirement for informed consent was waived due to the retrospective nature of the study.

### Study design and patients

From January 2018 to August 2022, seven patients with traumatic cardiac tamponade were treated at Jeju Regional Trauma Center. We conducted a retrospective study based on a review of the patients' medical records. The subjects were patients in whom cardiac tamponade was confirmed by a physical examination and imaging studies, including ultrasonography, at the time of arrival at the emergency department. Patients with confirmed cardiac tamponade who could not be resuscitated due to cardiac arrest before arriving at the emergency department were excluded from the study.

### Data collection

We reviewed patients' medical records and collected data related to their general characteristics. Sex, age, transport time, injury mechanism, vital signs, Glasgow Coma Scale, the Injury Severity Score (ISS), and the Trauma and Injury Severity Score (TRISS) were collected. Emergency medical records, operative records, and the outcomes of the intervention were reviewed to obtain data related to the operative procedure and findings, the results of treatment, and postoperative complications.

### Statistical analysis

Statistical analyses were performed using IBM SPSS ver. 20 (IBM Corp). Descriptive statistics of the basic characteristics of patients were calculated. We examined whether there were differences in the mean scores of basic characteristics and the trauma score of patients according to whether they survived or died. The independent samples t-test was used to determine whether any variables showed significant differences between the survival and death groups.

## RESULTS

From January 2018 to August 2022, nine patients were diagnosed with traumatic cardiac tamponade at Jeju Regional Trauma Center. Among them, two patients presented to the hospital in cardiac arrest although resuscitation was performed; since they did not recover, they were excluded from the analysis. Therefore, seven patients were included in the study (Table 1).

The average age of the patients was  $60.3 \pm 7.2$  years, and the male to female ratio was 1.33:1. The average transport time to the emergency department after the accident was  $48 \pm 26.6$  minutes, and the causes of the accidents were blunt chest injury due to traffic accidents in six cases (85.7%) and a thoracic penetrating injury due to a stab wound in one case (14.3%).

The diagnosis of traumatic cardiac tamponade in the emergency department was made on the basis of a physical examination and emergency ultrasonography (extended focused assessment with sonography for trauma [eFAST]). When the vital signs were stable, a whole-body computed tomography (CT) was performed immediately to make an accurate diagnosis. eFAST is a diagnostic test that plays an important role in the diagnosis and treatment of cardiac tamponade. If necessary, pericardiostomy can be performed under ultrasound guidance, and accompanying thoracic and abdominal injuries can also be screened. All seven patients treated at this center were diagnosed with cardiac tamponade by ultrasound examinations, and two patients underwent surgery immediately after the ultrasound examination without additional imaging tests.

Six patients had bony thorax injuries (sternum or rib fractures), and five patients had lung injuries, including lung laceration, hemothorax, and pneumothorax. Associated injuries other than those to the chest were observed in three cases: abdominal injuries in two cases and pelvic bone fractures in one case (Table 2).

An emergency operation was performed in six of the seven patients. Median sternotomy was performed in all operations. During surgery, extracorporeal circulation support was required in three cases, and the other cases could be sutured directly without extracorporeal circulation support (Fig. 1). In one patient, venoarterial extracorporeal membrane oxygenation (VA-ECMO; i.e., extracorporeal cardiopulmonary resuscitation [ECPR]) was applied because the blood pressure was not maintained in the emergency department before the operation. After transfer to the operation department, surgery was performed with the patient switched from VA-ECMO to extracorporeal circulation using a cardiopulmonary bypass machine.

The cardiac and vascular injury sites identified during surgery

**Table 1.** Basic characteristics of patients

Patient	Age (yr)	Sex	Injury type	Diagnosis	Arrival (min)	BP (mmHg)	PR (beats/min)	RR (breaths/min)	GCS	ISS	RTS	TRISS (%)	Treatment	Operation finding	ICU Adm	Result	Cx	
1	69	Female	TA Blunt	Cardiac tamponade Right hemothorax Right MRF	60	86/53	91	21	15	25	7.11	93.1	RA repair No CPB	RAA rupture	3	14	None	
2	61	Male	TA Blunt	Cardiac tamponade	59	158/97	82	32	6	37	5.68	5.0	Pericardiostomy Repair of IVC, RAA, LV VA-ECMO	IVC rupture RA appendage LV	0	1	None	
3	68	Female	TA Blunt	Cardiac tamponade Right hemothorax Left MRF Sternum fracture Spleen rupture	29	78/39	93	28	13	52	7.11	10.9	Repair of atrium rupture (both) Partial CPB	RA rupture LA rupture	2	2	None	
4	60	Male	Stab penetrate	Cardiac tamponade Right hemothorax Lung laceration	23	78/54	134	20	10	26	6.17	85.1	Ligation of intercostal a. Pericardial drainage No CPB	Right intercostal a. cut Pericardium laceration Noncardiac injury	3	119	Alive (discharge)	Left MCA infraction
5	62	Female	TA Blunt	Cardiac tamponade Both MRF Liver laceration	60	67/47	101	20	15	29	6.38	75.7	Pericardiostomy Delayed tamponade	IVC (diaphragmatic) rupture	16	42	Alive (discharge)	None
6	50	Male	TA Blunt	Cardiac tamponade Both MRF Both hemothorax Pelvis fracture	15	112/86	172	32	13	29	7.55	97.3	Pericardiostomy Repair of IVC Partial CPB	IVC (RA junction) rupture	28	95	Alive (discharge)	None
7	52	Male	TA Blunt	Cardiac tamponade Flail chest Left hemothorax Left pneumothorax	90	80/50	75	23	14	27	7.10	95.4	Repair of RV No CPB	Epicardial laceration of apex RV rupture <5mm	6	21	Alive	None

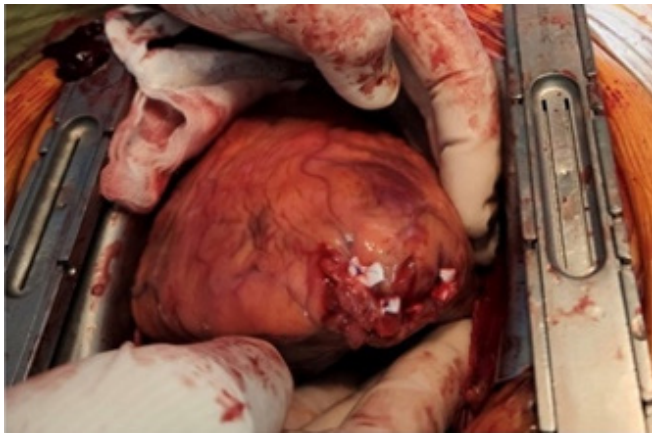
Arrival, transport time; BP, blood pressure; PR, pulse rate; RR, respiratory rate; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score; ICU, intensive care unit stay time; Adm, admission day; Cx, complication; TA, traffic accident; MRF, multiple rib fracture; RA, right atrium; CPB, cardiopulmonary bypass; RAA, right atrium appendage; IVC, inferior vena cava; LV, left ventricle; VA-ECMO, venoarterial extracorporeal membrane oxygenation; LA, left atrium; MCA, middle cerebral artery; RV, right ventricle.

were the right atrium in one case, inferior vena cava (IVC) in two cases, right ventricle in one case, right atrium and left atrium in one case, and right atrium, left ventricle, and IVC in one case. In patients who died, the rupture of the heart involved two or more chambers (Table 3).

Five patients survived and were discharged, and two died, re-

**Table 2.** Associated injury

Associated injury	No. of cases
Fracture of bony thorax (rib or sternum)	6
Hemothorax or hemopneumothorax	5
Lung contusion or laceration	1
Spleen rupture	1
Liver laceration	1
Pelvic bone fracture	1



**Fig. 1.** Repair of rupture of right ventricle apex using polytetrafluoroethylene felt reinforced suture without cardiopulmonary bypass.

sulting in a mortality rate of 28.5%. Although there was a small number of treated patients, we did perform a statistical analysis between the survival and death groups. As a result, the ISS was significantly higher in patients who died ( $P=0.09$ ) and the TRISS was significantly higher in patients who survived ( $P<0.001$ ) (Table 4).

One patient who presented to the hospital with a chest penetrating injury caused by a right anterior chest stab wound underwent surgery. At the time of arrival, the patient's blood pressure was 78/54 mmHg and cardiac tamponade was diagnosed on eFAST. According to the operative findings, the right third rib and intercostal artery were cut, and an open wound of 1 cm was observed on the right side of the pericardium. This was a very rare case where intercostal artery bleeding flowed into the pericardium and caused cardiac tamponade (Fig. 2).

In one patient with suprahepatic IVC rupture, treatment was possible by pericardiostomy alone without open thoracic surgery. The patient was a 60-year-old female presented to the emergency

**Table 3.** Comparison of injury site of cardiac chamber between survival and death group

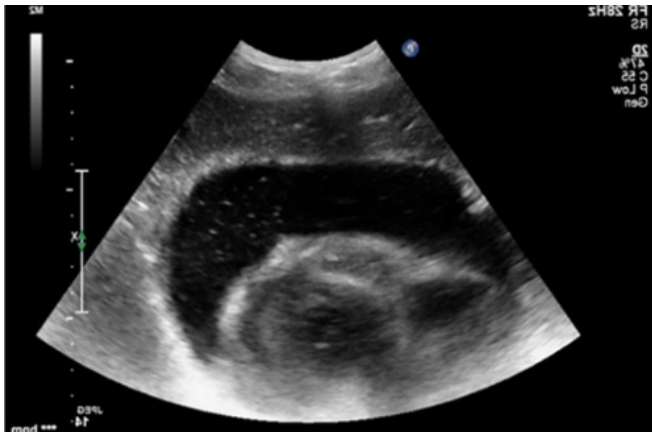
Cardiac injury	Survival group (n=5)	Death group (n=2)
RA	1	0
IVC	2	0
RA+LA	0	1
RV	1	0
IVC+RA+LV	0	1
Extrapericardial vascular injury	1	0

RA, right atrium; IVC, inferior vena cava; LA, left atrium; RV, right ventricle; LV, left ventricle.

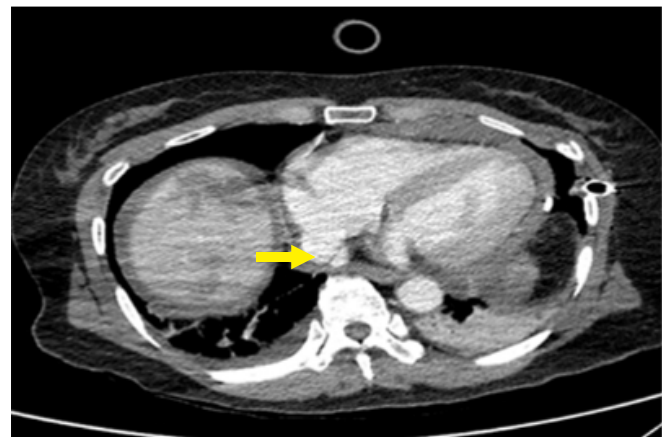
**Table 4.** Comparison of parameter between the survival group and the death group

Parameter	Survival group (n=5)	Death group (n=2)	P-value
Age (yr)	58.6±7.7	64.5±5.0	0.846
Male to female ratio	1.5	1.0	0.376
Arrival time (min)	49.6±30.6	44.0±21.2	0.827
Systolic blood pressure (mmHg)	84.6±16.8	118.0±56.6	0.233
Pulse rate (beats/min)	114.6±38.7	87.5±7.8	0.394
Respiration rate (breaths/min)	23.2±5.1	30.0±2.8	0.145
Glascow Coma Scale	13.4±2.1	9.5±4.9	0.167
Injury Severity Score	27.2±1.8	44.5±10.1	0.009
Revised Trauma Score	6.9±0.5	6.4±1.01	0.387
Trauma and Injury Severity Score (%)	89.3±8.9	32.3±1.47	<0.001

Values are presented as mean±standard deviation unless otherwise indicated.



**Fig. 2.** Emergency ultrasonography of thoracic multiple stab wounds in case 4.



**Fig. 3.** Cardiac tamponade (arrow) due to extrapericardial suprahepatic inferior vena cava rupture in case 5.

department with a blunt chest injury due to a traffic accident. At that time, her blood pressure was 67/47 mmHg, cardiac tamponade was confirmed on eFAST, and pericardiostomy was performed immediately. Enhanced chest CT showed a suprahepatic IVC rupture near the diaphragm, and a difficult operation was expected. No additional bleeding was observed after the first 300 mL of blood was drained following pericardiostomy. Then, the vital signs remained stable without any bleeding, and the pericardiostomy tube could be removed 7 days after the procedure. On the 14th day after admission, delayed cardiac tamponade (perhaps related to novel oral anticoagulant rivaroxaban use) occurred, but this was also treated with pericardiostomy, and she was discharged without any problems (Figs. 3, 4).

**DISCUSSION**

From January 2018 to August 2022, seven traumatic cardiac tamponade patients were treated at Jeju Regional Trauma Center. Five patients survived and two patients died, resulting in a mortality rate of 28.5%. This result is similar to a 26.6% rate reported at a trauma center in Korea and a 28.6% rate reported at trauma centers abroad [5,6].

Although the difference was not statistically significant, higher ISS and lower TRISS were found in the patients who died. These results are similar to those of previous studies [5,7].

When comparing the anatomical locations of the damaged heart and great vessels in the surviving and deceased cases based on the surgical findings, single atrium and single ventricle ruptures were observed in the surviving cases, and multichamber damage was observed in the deceased cases. This result also



**Fig. 4.** Follow-up computed tomography in case 5. Healed inferior vena cava ruptured site and delayed cardiac tamponade (arrow).

aligns with those of previous studies [5,7].

Most patients with traumatic pericardial tamponade require surgical treatment [7–10]. Among the treatment cases at Jeju Regional Trauma Center, one case of IVC rupture at the diaphragm level was treated with pericardiostomy alone without open thoracic surgery. In this case, the rupture of the IVC was at a site where compression hemostasis was possible due to the diaphragm structure and the connective tissue around the liver, and natural healing was possible. If an IVC rupture does not extend into the pericardium, the bleeding volume after pericardiostomy is less than 100 mL/hr, and if the blood pressure is stably maintained, natural healing without open thoracic surgery can be expected.

For the effective treatment of traumatic cardiac tamponade, a

rapid prediction based on clinical findings, prompt diagnosis, and surgical treatment are important [11,12]. Emergency ultrasonography can be performed immediately after the patient arrives at the hospital to diagnose cardiac tamponade, and it can also predict accompanying major abdominal and chest injuries. Pericardiostomy to relieve cardiac tamponade before open thoracic surgery can also be performed under ultrasonography. In blunt chest trauma, patients have severe soft tissue edema, subcutaneous emphysema, and a distended abdomen and pneumothorax [13,14]. These conditions reduce the accuracy of ultrasonography in blunt cardiac injury. However, repeated ultrasonography examinations can overcome these problems.

In one case, VA-ECMO (ECPR) was applied before open thoracic surgery because the blood pressure was not maintained even after pericardiostomy. Multichamber rupture was observed, and this patient died from multiorgan dysfunction syndrome caused by massive intraoperative bleeding and postoperative low cardiac output syndrome. If a patient is hemodynamically very unstable, switching to extracorporeal circulation in the operating department after VA-ECMO (ECPR) in the emergency department may be considered [15].

### Limitations

This study had some limitations. First, few cases of traumatic cardiac tamponade were analyzed in this study; therefore, a meaningful statistical analysis was not possible. Also, this was a retrospective study conducted at a single trauma center. To obtain meaningful statistical data, we need to obtain data related to the treatment of cardiac tamponade from multiple centers over a longer period.

### Conclusions

Over the past 4 years, after establishing Jeju Regional Trauma Center, seven patients were treated for traumatic pericardial tamponade. Five patients survived, showing a relatively favorable survival rate of 71.5%.

## ARTICLE INFORMATION

### Author contributions

Conceptualization: JWO; Data curation: JWO; Formal analysis: MC; Writing—original draft: JWO; Writing—review & editing: all authors. All authors read and approved the final manuscript.

### Conflicts of interest

The authors have no conflicts of interest to declare.

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### Data availability

Data of this study are available from the corresponding author upon reasonable request.

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