Original Article

Comparison of the effectiveness of pericardiocentesis and surgical pericardiotomy in the prognosis of patients with blunt traumatic cardiac tamponade: a multicenter study using the Japan Trauma Data Bank

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Aim: To compare the prognostic impact of pericardiocentesis (PCC) and surgical pericardiotomy (SP) in blunt traumatic pericardial tamponade.

Methods: Among 361,706 trauma patients registered in the Japan Trauma Data Bank from January 2004 to December 2018, we included those with blunt traumatic cardiac tamponade who underwent PCC and/or SP. We excluded patients with penetrating trauma, age younger than 15 years, Injury Severity Score (ISS) equal to 75, blood pressure 0 mmHg at the time of admission, head Abbreviated Injury Scale (AIS) score 5 or more, and those with missing data for outcomes. To examine the effect of SP, patients were divided into a PCC group and an SP-only group. Missing values of age, sex, systolic blood pressure, respiratory rate, pulse rate, time from emergency call to hospital arrival, head AIS, chest AIS, abdomen/pelvis AIS, Glasgow Coma Scale score, and ISS were estimated using multiple imputation. In-hospital mortality was analyzed using multivariable analysis, and we undertook a survival analysis.

Results: We analyzed 305 patients, 150 (49.2%) in the PCC group and 155 (50.8%) in the SP-only group. The in-hospital mortality rate was 40.7% in the PCC group and 76.8% in the SP-only group. Multivariable analysis after multiple imputation showed an odds ratio of SP for in-hospital mortality 5.34 (95% confidence interval, 2.80–10.18; $P < 0.01$) compared with PCC. Using the Kaplan–Meier method, SP showed a significant risk of mortality (hazard ratio 2.16; 95% confidence interval, 1.58–2.95; $P < 0.01$).

Conclusions: In patients with blunt traumatic cardiac tamponade, SP was associated with poor prognosis.

Key words: Blunt trauma, cardiac tamponade, percutaneous pericardiocentesis, pericardial drainage, surgical pericardiotomy

INTRODUCTION

CARDIAC TAMPONADE DUE to blunt trauma is a serious condition that can be fatal as a result of obstructive shock. The incidence of blunt traumatic heart injury is reportedly 8%–86%[1] for chest trauma, whereas the proportion of cardiac rupture is only 0.3%–0.9%.[2] Most patients with traumatic cardiac tamponade are in a state of cardiopulmonary arrest on arrival at the scene[3] and emergency department thoracotomy is indicated for these dying patients.[4] Therefore, patients in whom emergency pericardial drainage is indicated are rare. However, for those patients in whom this procedure is indicated, there are two methods of pericardial drainage: pericardiocentesis (PCC) and surgical pericardiotomy (SP). Previous studies have shown that the survival rates of PCC and SP are comparable[5–8]; the survival rate of SP is higher[9] in patients with endogenous disease, but these patients cannot be considered to have trauma because of differences in the underlying disease and nature of the fluid reservoir. There are a few small studies on cases of blunt traumatic cardiac tamponade[10–14] and the evidence is insufficient.

In Japan, it is difficult for many facilities to employ sufficient emergency physicians, surgeons, and cardiovascular

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surgeons who can perform SP, so as to have this option available at all times. In contrast, PCC is simpler and can be performed by cardiologists and emergency physicians at almost any hospital with a tertiary emergency center and does not require surgical skills. Therefore, although there may be situations in which emergency room thoracotomy or SP must be performed for rapid drainage purposes in circulatory crises, it is clinically important to clarify whether there is a difference in prognosis when the choice between PCC and SP is possible.

The aim of this study was to compare the effectiveness of PCC with that of SP in terms of mortality among patients with blunt traumatic cardiac tamponade using data from the Japan Trauma Data Bank (JTDB).

METHODS

Study design and population

THIS STUDY WAS approved by our hospital ethics committee.

Of the 361,706 trauma patients enrolled in the JTDB from January 2004 to December 2018, a total of 305 patients who underwent PCC and/or SP were retrospectively included in this study. We excluded patients with blunt trauma, those younger than 15 years of age, patients with missing outcome data, and patients with the following expected poor prognoses: cardiac arrest on arrival, Injury Severity Score (ISS) equal to 75, and severe head injury (Abbreviated Injury Scale [AIS] 5 or more). To investigate the effect of SP, patients were divided into two groups: the PCC group and the SP-only group.

The JTBD is a nationwide database with 288 participating hospitals in Japan as of March 2020 and contains information such as patients' age, sex, vital signs at the scene or emergency center, time of injury, arrival on scene and hospital arrival, name of injury or illness, mechanism, computed tomography imaging time, emergency treatment, date of emergency department discharge, date of hospital discharge, transfer or in-hospital death, AIS by site, ISS, diagnosis, surgery/transcatheter arterial embolization, and outcome. Pericardiocentesis and SP, along with resuscitative endovascular balloon occlusion of the aorta, extracorporeal membrane oxygenation, and retroperitoneal packing, are documented as emergency procedures for cardiovascular crises independent of surgery, performed in the time between arrival and definite surgery. This database contains the surgical methods and indications. The surgical method is recorded with the major name and minor name. The major names of methods are categorized into head, face, chest, abdomen, orthopedics, and skin. The minor names for thoracic procedures are classified myocardial suture, pericardial suture, pulmonary suture, partial lung resection, lobectomy, artificial vessel replacement, hemostasis of the thoracic cavity and rib cage, and exploratory thoracotomy and others. Indications for thoracic surgery are classified intrapleural hemorrhage, diaphragmatic rupture, massive air leak, mediastinal hematoma, flail chest, and others.

Data collection

The following data were collected from the selected patients: age, sex, systolic blood pressure (sBP) at hospital arrival, diastolic blood pressure at hospital arrival, pulse rate at hospital arrival, respiratory rate at hospital arrival, body temperature at hospital arrival, Glasgow Coma Scale (GCS) score at hospital arrival, AIS score 3 or more (head, neck, face, abdomen /pelvis, spinal cord, upper extremity, lower extremity, and body surface), ISS, method of pericardial drainage, blood transfusion within 24 h, surgery within 24 h, time from emergency call to hospital arrival, time from hospital arrival to emergency surgery, length of stay in the emergency department, length of hospital stay, and outcome. An AIS score of 9 was considered unclassifiable, and AIS and ISS without a score were considered AIS unknown. Surgical procedures were classified after estimation based on integration of methods and indications. The main outcome measure was in-hospital mortality.

Statistical analysis

Continuous variables are presented as mean (standard deviation), and nominal variables are presented as number and percentage. The *t*-test was used for comparison of continuous variables, and the χ^2-test and Fisher's exact test were used for comparison of nominal variables. Missing data are presented in 10 variables (time from emergency call to hospital arrival, sBP, respiratory rate, GCS score, head AIS, chest AIS, abdomen/pelvis AIS, and ISS). Next, multivariable analyses were undertaken to examine the association of PCC and SP with in-hospital mortality using variables considered to be independently associated with mortality (age, sex, time from emergency call to hospital arrival, sBP, respiratory rate, pulse rate, GCS score, head AIS, chest AIS, abdomen/pelvis AIS, and ISS). To reduce bias due to incomplete data, we undertook multiple imputation using 20 datasets generated by replacing missing values with alternative values.[15,16,17] Finally, we examined the temporal trend of survival using the Kaplan–Meier method. The level of statistical significance was set at a *P*-value of <0.05. All statistical analyses were carried out using IBM SPSS version 23 (IBM Corp., Armonk, NY, USA).

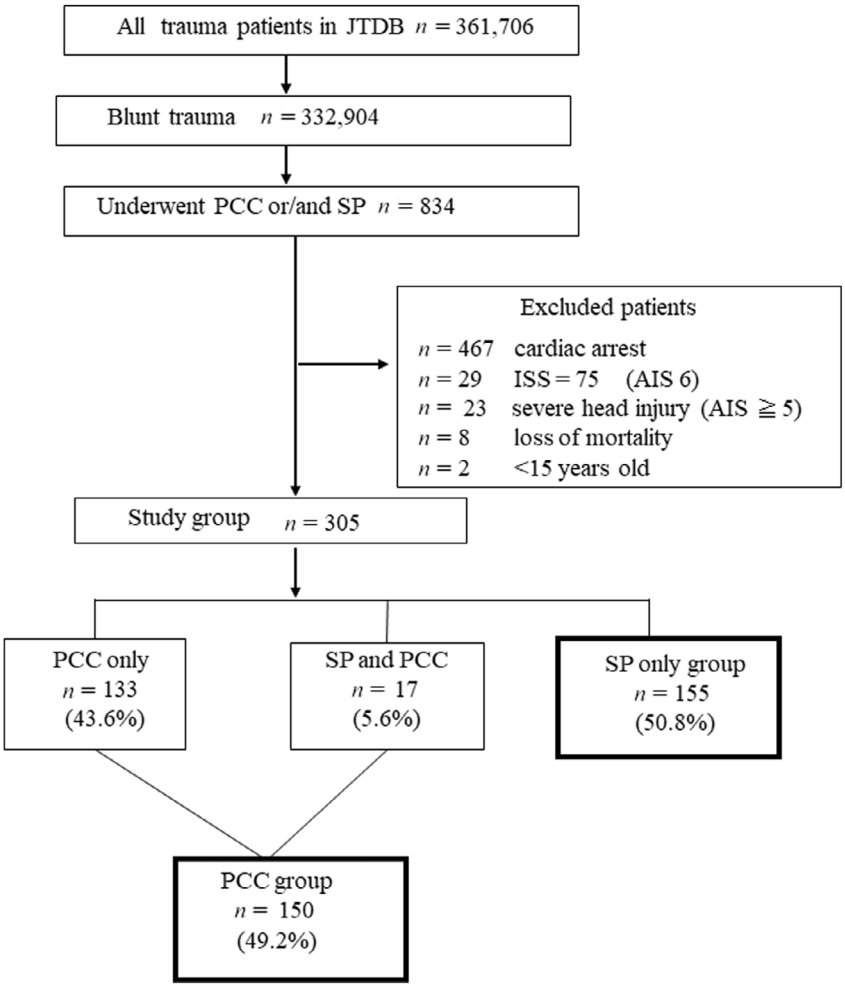

Fig. 1. Flow diagram depicting study enrollment in the pericardiocentesis (PCC) and surgical pericardiotomy (SP)-only groups of patients with blunt traumatic cardiac tamponade. AIS, Abbreviated Injury Scale; ISS, Injury Severity Score; JTDB, Japan Trauma Data Bank.

RESULTS

THE PROCESS OF participant selection in the analysis is shown in Figure 1. A total of 305 participants were categorized into three groups: 133 (43.6%) who underwent PCC only, 17 (5.6%) who underwent SP and PCC, and 155 (50.8%) who underwent SP only. To examine the effect of SP, participants who underwent PCC and SP, and those who underwent PCC only, were included in the PCC group: 150 participants (49.2%).

In terms of patient background, GCS scores, and chest AIS were significantly higher in the PCC group (9.2 versus 7.7, $P = 0.01$; and 4.2 versus 3.9, $P = 0.02$); furthermore, the time from hospital arrival to emergency surgery was significantly longer in the PCC group (170.8 min versus 78.9 min, $P < 0.01$). The ISS and rate of emergency surgery within 24 h were higher in the SP-only group than in the PCC group (29.8 versus 34.0, $P < 0.01$, and 41.1% versus 55.1%, $P < 0.01$; Tables 1 and 2). In terms of chest trauma that led to the need for drainage, heart injury and sternal fracture were significantly higher in the PCC group (29.2% versus 19.3%, $P = 0.04$, and 11.5% versus 1.2%; $P < 0.01$), and lung injury was higher in the SP-only group (7.3% versus 22.9%, $P = 0.02$; Table 3). The rates of heart surgery only were significantly higher in the PCC group (30.9% versus 5.4%, $P < 0.01$) and surgery/transcatheter arterial embolization of the chest wall and abdomen/pelvis was more frequent in the SP-only group (0.0% versus 15.2%,

Table 1. Comparison of demographic and clinical characteristics between the percutaneous pericardiocentesis (PCC) group and surgical pericardiotomy (SP)-only group of patients with blunt traumatic cardiac tamponade

Variable	PCC group (n = 150)		SP-only group (n = 155)		P-value
Age, years	150	56.0 (21.3)	155	53.8 (21.8)	0.37
Male, %	93	62.0	112	72.2	0.06
sBP on arrival, mmHg	143	87.9 (37.9)	146	89.1 (49.0)	0.82
dBP on arrival, mmHg	106	62.3 (26.0)	101	65.9 (33.1)	0.39
Pulse rate on arrival, b.p.m.	141	105.6 (29.2)	144	103.7 (36.7)	0.63
Respiratory rate on arrival, breaths/min	127	24.7 (9.6)	130	22.2 (11.6)	0.61
Body temperature on arrival, °C	92	35.5 (1.1)	108	35.5 (1.2)	1.00
Glasgow Coma Scale on arrival	144	9.2 (4.6)	143	7.7 (4.6)	0.01
AIS (head)	146	0.8 (1.4)	150	1.1 (1.6)	0.07
AIS (neck)	146	0.3 (0.8)	34	2.1 (1.9)	0.86
AIS (face)	146	0.0 (0.4)	151	0.0 (0.0)	0.15
AIS (chest)	146	4.2 (1.7)	149	3.9 (1.4)	0.02
AIS (abdomen/pelvis)	145	2.9 (1.3)	151	1.2 (1.6)	0.23
AIS (spine)	146	0.4 (0.9)	151	0.6 (1.2)	0.05
AIS (upper extremities)	146	0.5 (1.0)	151	0.5 (0.9)	0.82
AIS (lower extremities)	146	1.3 (1.5)	151	2.0 (2.0)	<0.01
AIS (surface injury)	146	0.1 (0.2)	151	0.1 (0.2)	0.66
Injury Severity Score	144	29.8 (11.6)	145	34.0 (12.9)	<0.01

Analysis based on records from the Japan Trauma Data Bank.
Data are provided as the total number of observations (percentage) or as mean (standard deviation).
AIS, Abbreviated Injury Scale; dBP, diastolic blood pressure; sBP, systolic blood pressure.

Table 2. Comparison of prognosis between the percutaneous pericardiocentesis (PCC) group and surgical pericardiotomy (SP)-only group of patients with blunt traumatic cardiac tamponade

Variable	PCC group (n = 150)		SP-only group (n = 155)		P-value
Blood transfusion within 24 h	150	73.8	138	73.8	0.25
Emergency surgery within 24 h	62	41.1	89	55.1	<0.01
Time from EC to hospital arrival, min	126	53.0 (64.4)	172	44.9 (41.1)	0.15
Time from arrival to emergency surgery, min	62	170.8 (147.9)	89	78.9 (130.5)	<0.01
Length of ED stay, day	137	13.3 (20.6)	174	8.3 (20.0)	0.10
Length of hospital stay, day	149	22.0 (27.9)	185	14.5 (33.5)	0.09
Mortality	150	61 (40.7)	155	119 (76.8)	<0.01

Analysis based on records from the Japan Trauma Data Bank.
Data are provided as the total number of observations (percentage) or as mean (standard deviation).
EC, emergency call; ED, emergency department.

$P < 0.01$; Table 4). The in-hospital mortality rate was 40.7% for the PCC group versus 76.8% for the SP-only group ($P < 0.01$; Table 2); the odds ratio was 5.34 (95% confidence interval, 2.80–10.18; $P < 0.01$) after multiple imputation (Table 5). Kaplan–Meier analysis showed that the SP-only group had a significantly lower cumulative survival rate than the PCC group (hazard ratio 2.16; 95% CI, 1.58–2.95; $P < 0.01$) (Fig. 2).

Table 3. Comparison of the frequency of chest trauma that led to the need for drainage between the percutaneous pericardiocentesis (PCC) group and surgical pericardiotomy (SP)-only group of patients with blunt traumatic cardiac tamponade

	PCC group (n = 96)		SP-only group (n = 83)		*P*-value
Heart injury	28	(29.2)	16	(19.3)	0.04
Chest wall injury	21	(21.9)	29	(34.9)	0.27
Pericardial injury	14	(14.6)	8	(9.6)	0.16
Sternal fracture	11	(11.5)	1	(1.2)	<0.01
Lung injury	7	(7.3)	19	(22.9)	0.02
Aortic injury	4	(4.2)	2	(2.4)	0.44
Nonaortic arterial injury	3	(3.1)	0	(0.0)	0.12
SVC or/and IVC injury	2	(2.1)	3	(3.6)	1.00
Thoracic vertebral fracture	1	(1.0)	3	(3.6)	0.62
Heart and lung injury	1	(1.0)	1	(1.2)	1.00
Heart and chest wall injury	1	(1.0)	0	(0.0)	0.49
Heart and sternal fracture	1	(1.0)	0	(0.0)	0.49
Heart and SVC or/and IVC injury	1	(1.0)	0	(0.0)	0.49
Heart, lung, and pericardiac injury	1	(1.0)	0	(0.0)	0.49
Diaphragmatic injury	0	(0.0)	1	(1.2)	1.00

Analysis based on records from the Japan Trauma Data Bank.
Data are provided as the total number of observations (percentage).
IVC, inferior vena cava; SVC, superior vena cava.

Table 4. Comparison of the frequency of surgery/transcatheter arterial embolization carried out within 24 h in patients with blunt traumatic cardiac tamponade: percutaneous pericardiocentesis (PCC) group and surgical pericardiotomy (SP)-only group by organ

	PCC group (n = 55)		SP-only group (n = 92)		*P*-value
Heart	17	(30.9)	5	(5.4)	<0.01
Chest wall	9	(16.4)	25	(27.2)	0.49
Abdomen/pelvis	8	(14.5)	10	(10.9)	0.76
Pericardium	3	(5.5)	1	(1.0)	0.31
Arteries except aorta	3	(5.5)	0	(0.0)	0.07
Extremities/spine	2	(3.6)	3	(3.3)	1.00
Aorta	2	(3.6)	1	(1.0)	0.57
Lung	1	(1.8)	7	(7.6)	0.14
Neck and abdomen/pelvis	1	(1.8)	1	(1.0)	1.00
Heart and abdomen/pelvis	1	(1.8)	1	(1.0)	1.00
Head	1	(1.8)	0	(0.0)	0.41
Heart and pericardium	1	(1.8)	0	(0.0)	0.41
Heart, pericardium, and abdomen/pelvis	1	(1.8)	0	(0.0)	0.41
Heart and extremities/spine	1	(1.8)	0	(0.0)	0.41
Chest wall and abdomen/pelvis	0	(0.0)	14	(15.2)	<0.01
Lung and abdomen/pelvis	0	(0.0)	5	(5.4)	0.08
Pericardium and abdomen/pelvis	0	(0.0)	3	(3.3)	0.27
SVC/IVC	0	(0.0)	2	(2.2)	0.51
Head, chest wall, and extremities/spine	0	(0.0)	1	(1.1)	1.00

Table 4. (Continued)

	PCC group (n = 55)		SP-only group (n = 92)		*P*-value
Chest wall and lung	0	(0.0)	1	(1.1)	1.00
Heart and lung	0	(0.0)	1	(1.1)	1.00
Heart, pericardium, and lung	0	(0.0)	1	(1.1)	1.00
Chest wall and head	0	(0.0)	1	(1.1)	1.00
Chest wall and extremities/spine	0	(0.0)	1	(1.1)	1.00
Aorta and abdomen/pelvis	0	(0.0)	1	(1.1)	1.00
Heart and arteries except aorta	0	(0.0)	1	(1.1)	1.00
Heart, lung, and abdomen/pelvis	0	(0.0)	1	(1.1)	1.00
Heart, SVC/IVC, and abdomen/pelvis	0	(0.0)	1	(1.1)	1.00
Heart and SVC/IVC	0	(0.0)	1	(1.1)	1.00
Abdomen/pelvis and extremities/spine	0	(0.0)	1	(1.1)	1.00
Lung, abdomen/pelvis, and extremities/spine	0	(0.0)	1	(1.1)	1.00
Unknown	4	(7.3)	1	(1.1)	0.16

Analysis based on records from the Japan Trauma Data Bank.
Data are provided as the total number of observations (percentage).
IVC, inferior vena cava; SVC, superior vena cava.

Table 5. Logistic regression analysis for risk of mortality, adjusted for pericardial drainage method and other confounding factors, in patients with blunt traumatic cardiac tamponade

	Original dataset			After multiple imputation		
	Odds ratio	95% CI	*P*-value	Odds ratio	95% CI	*P*-value
SP	4.20	1.87–9.43	<0.01	5.34	2.80–10.18	<0.01
PCC (reference)	1.00			1.00		
Age	1.05	1.02–1.07	<0.01	1.03	1.02–1.05	<0.01
Male	1.05	0.45–2.47	0.91	1.01	0.52–1.97	0.98
Female (reference)	1.00			1.00		
Time from EC to hospital arrival, min	0.99	0.98–1.01	0.29	1.00	0.99–0.99	0.48
sBP on hospital arrival, mmHg	0.99	0.99–1.00	0.21	0.99	0.99–1.00	0.07
Respiratory rate on hospital arrival, breaths/min	0.96	0.92–1.00	0.06	0.97	0.93–1.00	0.08
Pulse rate on hospital arrival, b.p.m.	1.01	1.00–1.03	0.19	1.01	0.99–1.02	0.33
GCS on hospital arrival	0.85	0.79–0.91	<0.01	0.82	0.76–0.89	<0.01
ISS on hospital arrival	1.04	1.01–1.07	<0.01	1.06	1.02–1.10	0.01
AIS (head)	0.93	0.68–1.29	0.68	0.94	0.73–1.20	0.60
AIS (chest)	0.71	0.48–1.06	0.10	0.78	0.56–1.08	0.14
AIS (abdomen/pelvis)	0.98	0.75–1.27	0.85	0.91	0.72–1.14	0.40

AIS, Abbreviated Injury Scale; CI, confidence interval; EC, emergency call; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; PCC, percutaneous pericardiocentesis; sBP, systolic blood pressure; SP, surgical pericardiotomy.

DISCUSSION

THIS WAS THE first nationwide cohort study to examine emergency procedures and prognoses in blunt traumatic cardiac tamponade. After multivariable adjustment for confounding factors, the survival rate was still worse in the SP-only group than in the PCC group. These results are useful in determining the initial

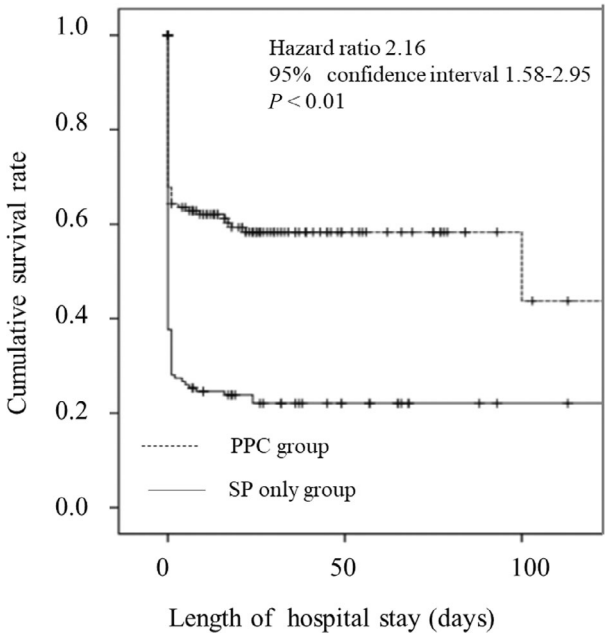

Fig. 2. Kaplan–Meier analysis between the pericardiocentesis (PCC) and surgical pericardiotomy (SP)-only groups of patients with blunt traumatic cardiac tamponade. The cumulative survival rate was significantly lower in the SP-only group (log–rank test, $P < 0.01$).

treatment strategy for patients with traumatic cardiac tamponade.

Traumatic cardiac tamponade is characterized by the presence of coagulated fresh blood in the pericardium. In the case of traumatic injury, the cardiac tamponade carries a risk of becoming lethal in a short time due to poor drainage due to blood coagulation.[13]

The usefulness of SP cannot be denied because it can rapidly release cardiac tamponade and might have to be chosen in a circulatory crisis. However, this study showed that SP is associated with a poor prognosis unless the patient is in such an urgent situation. Moderate hypotension and compression caused by the tamponade could control bleeding and achieve hemostasis[3]; therefore, some previous studies have suggested that hemodynamic balance can be maintained by the tamponade.[18,19] In trauma cases, a moderate amount of fresh blood coagulation could have a favorable effect on hemostasis.

This study had several limitations. First, to account for treatment selection bias, we performed a multivariable analysis using vital signs and degree of injury as adjustment factors to account for bias in treatment selection; however, unmeasured confounders might have affected the results. Second, the variety of trauma names and definitive surgical procedures that required drainage might have affected the outcome. Finally, details of the surgical pericardiotomy technique were not included in the registry and might have influenced mortality.

CONCLUSION

IN PATIENTS WITH blunt traumatic cardiac tamponade, our study findings showed that SP was associated with poor prognosis in comparison with PCC.

DISCLOSURE

APPROVAL OF THE research protocol with approval no. and committee name: The protocol was approved by the Ethics Committee of Nippon Medical School Tama Nagayama Hospital (IRB No.732).

Informed consent: The requirement for informed consent from patients was waived.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None.

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