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Trends in Isolated Pelvic Fracture and 30-Day Survival during a Recent 15-Year Period: A Nationwide Study of the Japan Trauma Data Bank

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Background: The epidemiology and treatment of isolated pelvic fracture in Japan are not well understood. This study evaluated epidemiological trends in isolated pelvic trauma and in-hospital survival rates during a recent 15-year period.

Methods: This retrospective cohort study analyzed data from the Japan Trauma Data Bank for 2004-2018. Patients of any age with isolated pelvic fracture were grouped according to time period, as follows: 2004-2008 (Phase 1), 2009-2013 (Phase 2), and 2014-2018 (Phase 3). The main outcome was 30-day in-hospital survival rate. The data were analyzed using the chi-square, Kruskal-Wallis, and Mantel-Haenszel trend tests. We analyzed change in the main outcome over time in multiple logistic regression analysis fitted with a generalized estimating equation, accounting for within-cluster association.

Results: In total, 5,348 isolated pelvic fractures were identified during the study period. There was no significant between-phase difference in proportions of patients who underwent resuscitative balloon occlusion of the aorta or external fixation. The proportion of patients who underwent transcatheter arterial embolization significantly increased with time (p=0.003), as did the survival rate (Phase 1, 77%; Phase 2, 86%; and Phase 3, 91%; p<0.001). The 30-day in-hospital mortality rate was significantly lower in Phase 3 than in Phase 1 and Phase 2, even after adjustment for hospital clustering and other confounders (p<0.01).

Conclusions: The 30-day in-hospital survival rate after isolated pelvic fracture improved over a 15-year period in Japan. (J Nippon Med Sch 2022; 89: 309–315)

Key words: isolated pelvic fracture, external fixation, transcatheter arterial embolization

Introduction

Pelvic fracture is often accompanied by multiple injuries and is associated with a high mortality rate, because of life-threatening hemorrhage[1]. The mortality rate in patients with severe pelvic fracture is approximately 40-60%[2]. The main cause of death is hemorrhage from presacral and retroperitoneal veins and arteries. Several methods of stabilizing severe pelvic fracture and treating hemodynamic instability have been developed recently, including resuscitative balloon occlusion of the aorta (REBOA), transcatheter arterial embolization (TAE), and external fixation[3–5]. Although these methods are associated with better outcomes, their efficacy remains controversial because of the limited data available.

Pelvic fracture is usually accompanied by high-energy trauma at other sites in the body[6]. A previous study showed that pelvic fracture increased mortality risk in patients with severe multiple trauma[7]. However, isolated pelvic fracture (i.e., without multiple trauma) may occur after lower-energy trauma, especially in elderly adults,

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and one study found that cases of pelvic trauma increased as a society aged[8]. A recent report from the World Health Organization indicated that the world population is rapidly aging and that in the near future many countries will experience an unprecedented era of the aging society[9]. We therefore speculate that the incidence rate of mild pelvic fractures increases as the population ages. However, recent trends in the survival rate and treatment for isolated pelvic trauma have not been fully investigated.

To test the hypothesis that mortality after isolated pelvic injury has been decreasing in recent years, we analyzed 15 years of data from a nationwide trauma database to identify any changes in the causes of isolated pelvic fracture and its in-hospital survival rate in Japan.

Materials and Methods

Study Design and Population

This research was approved by the institutional ethics committee of the Nippon Medical School Musashikosugi Hospital. The need for written informed consent was waived because of the anonymity of the data.

We analyzed data registered in the Japan Trauma Data Bank (JTDB) for 2004-2018. The JTDB is a nationwide trauma database administered by Japan Trauma Care and Research and includes data on trauma cases with an Abbreviated Injury Scale (AIS) score of ≥3 from 289 participating hospitals[10,11]. The database includes patient age and sex, mechanism of injury, AIS score, and clinical outcome. Other variables recorded include vital signs (i.e., systolic blood pressure, heart rate, respiration rate) and treatment (supplemental oxygen, assisted ventilation, transfusion) before hospital admission, vital signs (systolic blood pressure, heart rate, respiration rate, body temperature) in hospital, details of treatment provided (external fixation, TAE, REBOA), and the need for blood transfusion within 24 hours of hospital arrival.

Patient Selection

We evaluated all patients with isolated pelvic fracture registered in the JTDB between 2004 and 2018, regardless of age, and selected those with an isolated pelvic injury and an AIS score of ≥3. We excluded cases with an AIS grade 3 or higher injury in other body regions.

Outcome Measures

The main study outcome was 30-day in-hospital survival.

Statistical Analysis

We classified the patients according to whether the isolated pelvic fracture occurred in 2004-2008 (Phase 1), 2009-2013 (Phase 2), or 2014-2018 (Phase 3). Categorical variables were analyzed with the chi-square test, and continuous variables with the Kruskal-Wallis test. We compared patient characteristics, treatment, and survival rate over time using the Mantel-Haenszel trend test. We also performed multiple imputation and multivariable analyses to compare patient characteristics, treatment, and clinical outcomes. Although a complete-case analysis should be performed for data with no missing values, some values were missing in the JTDB data. Therefore, we performed multiple imputation analysis and handled missing data appropriately in the multivariate analysis[11–13]. First, we performed multiple imputation whereby each missing value was replaced with a set of 5 substitute plausible values, to reduce bias caused by incomplete data. We then analyzed changes in the main outcome over time in a multiple logistic regression analysis fitted with a generalized estimating equation, accounting for the within-cluster association[11,14]. We used this method because we anticipated the possibility of clustering—for example, in the comparison between emergency departments that do and do not routinely use REBOA. In addition, there may be other factors associated with mortality that are related to how individual emergency departments (institutions) manage patients. We therefore adjusted for factors that were independently associated with the 30-day survival rate in previous studies (i.e., sex, AIS, Trauma Revised Injury Severe Probability of Survival Score [TRISS-PS], and implementation of TAE, REBOA, or external fixation)[3,4,15–17]. The TRISS method is based on 3 factors: (1) Revised Trauma Score, which is a simple index of physiological severity of trauma calculated from 3 important vital signs at the time of admission (respiratory rate, systolic blood pressure, and level of consciousness on the Glasgow Coma Scale); (2) the sum of the anatomical severity of trauma in each part of the body (AIS/Injury Severity Score); and (3) patient age[17]. All statistical analyses were performed using SPSS version 27 software (IBM Corp., Armonk, NY, USA). A p-value of <0.05 was considered statistically significant.

Results

We analyzed 5,348 isolated pelvic fractures from 208 hospitals during the study period (**Fig. 1**). **Table 1** shows the patient characteristics, vital signs before hospital admission, and details of pre-hospital treatment. There were 627 in Phase 1, 1,998 in Phase 2, and 2,723 in Phase 3. There was a significant difference in median patient age between the 3 phases ($p<0.001$) but not in the proportion

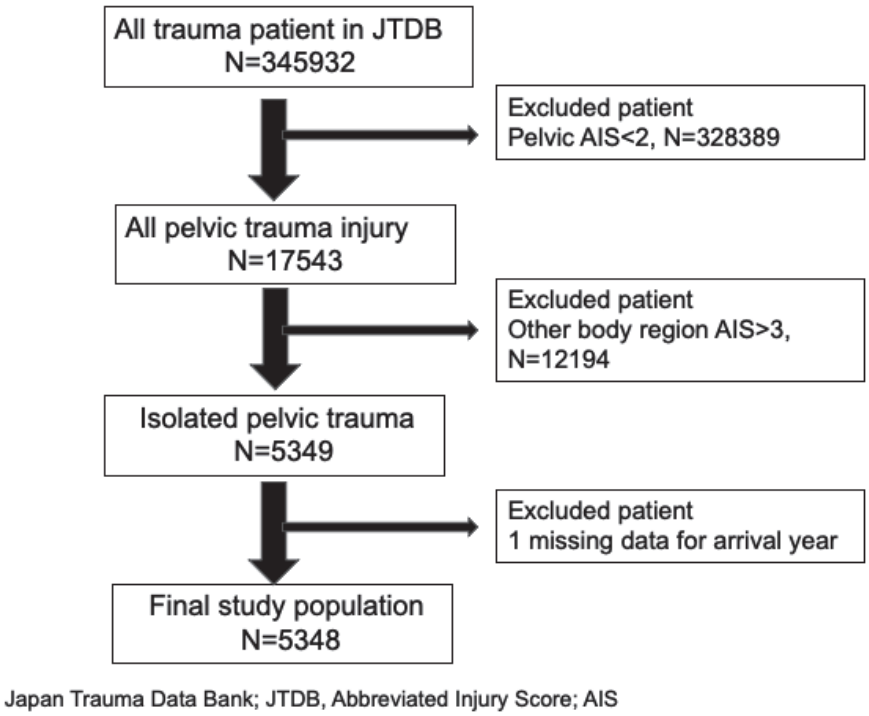

Fig. 1 Patient selection

Table 1 Characteristics of patients with pelvic fracture

	Phase 1 (n=627)	Phase 2 (n=1,998)	Phase 3 (n=2,723)	p value
Age, year	53.0 (37.0)	60.0 (36.0)	64.0 (34.0)	<0.001
Sex (male), n (%)	385 (61)	1,168 (59)	1,633 (60)	0.98
Blunt Injury, n (%)	538 (94)	1,915 (96)	2,647 (97)	<0.001
-traffic accident, n (%)	318 (51)	910 (46)	1,080 (40)	
-fall, n (%)	205 (33)	803 (40)	1,280 (47)	
-other, n (%)	65 (10)	202 (10)	287 (11)	
-missing data, n (%)	36 (5.7)	78 (3.9)	69 (2.5)	
Prehospital vital signs				
-SBP, mmHg	118.0 (40.5)	119.0 (40.0)	126.0 (41.0)	<0.001
-HR, /minute	84.0 (30.0)	84.0 (28.0)	84.0 (25.0)	0.38
-RR, /minute	20.0 (6.0)	20.0 (6.0)	20.0 (6.0)	0.39
Prehospital treatment				
Intravenous, n (%)	34 (5.4)	121 (6.1)	173 (6.4)	0.39
Supplemental oxygen, n (%)	374 (60)	1,099 (55)	1,167 (43)	<0.001
Assisted ventilation, n (%)	11 (1.8)	50 (2.5)	56 (2.1)	0.91

Analysis based on records from the Japan Trauma Data Bank; Phase 1: 2004-2008, Phase 2: 2009-2013, Phase 3: 2014-2018

Data given as number of positive observations/total number of observations (percentage) or as median (interquartile range).

SBP: Systolic blood pressure HR: Heart Rate RR: Respiration Rate

of patients who were male (p=0.98). The main mechanism of pelvic trauma was blunt injury, the proportion of which increased significantly during the study period (p <0.001). Pre-hospital systolic blood pressure was significantly higher in Phase 3 than in Phase 1 (p<0.001); however, there was no significant between-phase difference in pre-hospital heart rate or respiratory rate. Analysis of data on pre-hospital treatment revealed a significant difference in the proportion of patients receiving supplemental oxygen (p<0.001).

Table 2 shows measurements recorded after admission to hospital. All vital signs improved significantly be-

Table 2 Characteristics of patients after hospital admission

	Phase 1 (n=627)	Phase 2 (n=1,998)	Phase 3 (n=2,723)	p value
Vital signs				
-SBP, mmHg	114.0 (43.0)	120.0 (42.0)	125.0 (40.0)	<0.001
-HR, /minute	85.0 (30.0)	85.0 (27.0)	83.0 (25.0)	0.033
-RR, /minute	20.0 (7.0)	20.0 (8.0)	20.0 (7.0)	<0.001
-Body temperature	36.4 (1.1)	36.5 (1.0)	36.6 (0.9)	<0.001
Pelvic AIS (%)				<0.001
-3 (%)	270 (43)	919 (46)	1,457 (54)	
-4 (%)	215 (34)	701 (35)	941 (35)	
-5 (%)	142 (23)	378 (19)	325 (12)	
TRISSPs	0.967 (0.071)	0.965 (0.066)	0.965 (0.059)	0.46
-missing data (n=666)	86	245	335	

Analysis based on records from the Japan Trauma Data Bank; Phase 1: 2004-2008, Phase 2: 2009-2013, Phase 3: 2014-2018
Data given as number of positive observations/total number of observations (percentage) or as median (interquartile range).
SBP: Systolic blood pressure (mmHg) RR: Respiration Rate (/minute) HR: Heart Rate (/minute)
AIS: Abbreviated Injury Score TRISSPs: Trauma Revised Injury Severe Provability of Survival

Table 3 Medical treatment received while hospitalized

	Phase 1 (n=627)	Phase 2 (n=1,998)	Phase 3 (n=2,723)	p value
IABO, n (%)	9 (1.4)	40 (2.0)	43 (1.6)	0.75
TAE, n (%)	109 (17)	388 (19)	600 (22)	0.003
EF, n (%)	122 (20)	412 (21)	592 (22)	0.16
Blood transfusion within 24 hours, n (%)	237 (41)	756 (40)	890 (34)	<0.001

Analysis based on records from the Japan Trauma Data Bank; Phase 1: 2004-2008, Phase 2: 2009-2013, Phase 3: 2014-2018
Data given as number of positive observations/total number of observations (percentage) or as median (interquartile range).
IABO: Intra-Aortic Balloon Occlusion TAE: Transcatheter Arterial embolization EF: External Fixation

tween Phase 1 and Phase 3 (systolic blood pressure, p< 0.001; heart rate, p=0.033; respiration rate, p<0.001). The proportion of patients admitted for pelvic trauma with an AIS score of ≥3 increased over time (p<0.001). The proportion of patients with trauma of any grade was larger in Phase 3. However, there was no significant difference in the TRISS-PS value (p=0.46).

Table 3 shows treatment received after hospital admission. There was no significant between-phase difference in the proportions of patients who underwent REBOA (p =0.75) or external fixation (p=0.16). However, the proportion of patients who underwent TAE significantly increased over time (p=0.003). In addition, the need for blood transfusion within 24 hours significantly decreased over time (p<0.001).

Table 4 summarizes clinical outcomes for isolated pelvic fractures, and **Figure 2** shows trends in the 30-day in-hospital survival rate. There was a significant increase in survival rate over time (77% in Phase 1, 86% in Phase 2, and 91% in Phase 3; p<0.001). After adjustments for hospital clustering and other confounding factors, the 30-day in-hospital survival rate was significantly higher in Phase 3 than in Phase 1 and Phase 2 (p<0.01).

Discussion

This study used a nationwide database in Japan to evaluate epidemiological trends in isolated pelvic fracture during a recent 15-year period. To our knowledge, this is the largest such study of the Japanese population. Our findings suggest that the 30-day in-hospital survival rate in patients with isolated pelvic fracture has improved over time in Japan, even after adjustment for hospital clustering and other clinically important confounding factors.

The JTDB is the largest trauma database in Japan. Using this database, we investigated trends in isolated pelvic trauma not only in terms of mortality but also type of

Table 4 Thirty-day survival rate after pelvic fracture during a recent 15-year period

	30-day survival (%)	Original data		After multiple imputation	
		Odds ratio (95%CI)	p value	Odds ratio (95%CI)	p value
Phase 1 (n=627)	480 (77)	1		1	
Phase 2 (n=1,998)	1,723 (86)	2.41 (1.36-4.27)	0.003	2.27 (1.36-3.78)	0.002
Phase 3 (n=2,723)	2,470 (91)	3.40 (1.74-6.65)	<0.001	2.88 (1.60-5.16)	<0.001

Analysis based on records from the Japan Trauma Data Bank; Phase 1: 2004-2008, Phase 2: 2009-2013, Phase 3: 2014-2018
CI: Confidence Interval

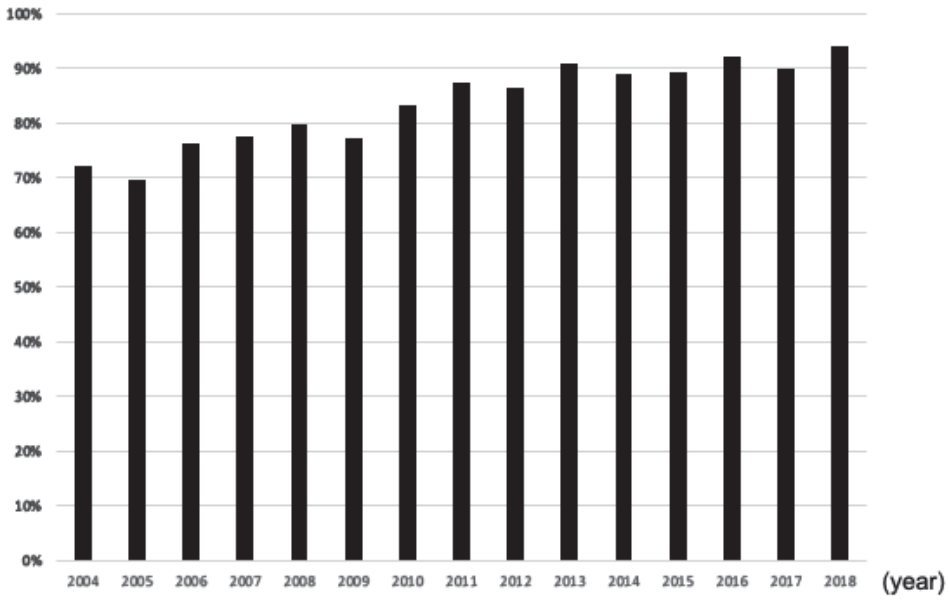

Fig. 2 Change in 30-day in-hospital survival rate

injury, vital signs, and treatments provided. We found that the 30-day survival rate improved over time. We also used a multiple logistic regression model adjusted for clinically important cofounding factors and the within-hospital clustering effect with a generalized estimating equation to account for inter-institutional differences in treatment provided for trauma cases and the survival rate. Although the proportion of patients who underwent REBOA or external fixation did not differ by time period, the proportion of those who underwent TAE increased over time. This increase in TAE use may have improved outcomes in these patients. However, given the retrospective nature of our study, we cannot draw any robust conclusions regarding a cause-effect relationship.

We speculate that the rapid improvement potentially attributable to TAE is associated with a decrease in the number of blood transfusions. However, we should also consider early provision of blood transfusion, especially for elderly pelvic patients. In addition to coagulopathy directly caused by severe pelvic trauma, many elderly patients receive anticoagulant or antiplatelet therapy for cerebrovascular diseases or arrhythmia.

Studies in other countries have used data from nationwide trauma databases to examine pelvic fracture. A study in the United States investigated the epidemiological characteristics of pelvic and lower extremity fractures by using the National Trauma Data Bank, which has been operating in that country since 1994 and includes data from more than 6 million patients from 746 institutions[18]. Another study, in the United Kingdom, similarly investigated the incidence of pelvic and lower extremity fractures in its elderly population[19]. The strength of the present study is that we focused on isolated pelvic fractures and investigated changes in clinical outcomes, along with treatments provided in the pre-hospital setting and procedures performed after admission to hospital.

As is often the case in an aging society, our data show

that the median age of the study population is increasing. Elderly patients are usually fragile and their mortality rate after trauma is higher than that of younger adults[20]. Moreover, even minor external forces may cause isolated pelvic trauma in an elderly adult[21]. This has implications for aging societies worldwide, and further studies are required.

This study has some limitations. First, we could not evaluate the effect of treatment type, including TAE and external fixation. Although success of treatment is critically important when evaluating outcomes, this information is not included in the JTDB database. Second, the possibility that our pelvic trauma data included some cases of lower extremity fracture cannot be excluded, because of the way fractures are coded in the JTDB database. However, the effect of pelvic fracture on mortality is much greater than that of lower extremity trauma. Third, we only evaluated data for patients with isolated pelvic fracture and excluded those with pelvic fracture accompanied by multiple injuries. Accordingly, our results cannot be generalized to patients with multiple traumas. Fourth, we performed a multiple imputation analysis, which is only valid for data that are missing completely at random (MCAR) or missing at random (MAR). There is no statistical method for analyzing data that are not missing at random (MNAR). However, it is usually difficult to determine whether a value is MAR or MNAR. Although there is no optimal way to deal with missing data, multiple imputation is one of the most popular methods to address this problem[12,13,22].

In conclusion, the present findings indicate that the 30-day in-hospital survival rate improved for patients with isolated pelvic fracture during a 15-year period in Japan.

Conflict of Interest: None declared.

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