Title	Delay of computed tomography is associated with poor outcome in patients with blunt traumatic aortic injury a nationwide observational study in Japan
Author(s)	Katayama, Yusuke; Kitamura, Tetsuhisa; Hirose, Tomoya; Kiguchi, Takeyuki; Matsuyama, Tasuku; Sado, Junya; Kiyohara, Kosuke; Izawa, Junichi; Tachino, Jotaro; Ebihara, Takeshi; Yoshiya, Kazuhisa; Nakagawa, Yuko; Shimazu, Takeshi
Citation	Medicine (United States). 97(35) P.e12112
Issue Date	2018-08
Text Version	publisher
URL	http://hdl.handle.net/11094/78393
DOI	10.1097/MD.0000000000012112
rights	© 2018 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.
Note	

Observational Study

Medicine®

OPEN

Delay of computed tomography is associated with poor outcome in patients with blunt traumatic aortic injury

A nationwide observational study in Japan

Yusuke Katayama, MD, PhD[a,*], Tetsuhisa Kitamura, MD, DrPH[b], Tomoya Hirose, MD, PhD[a,c], Takeyuki Kiguchi, MD, PhD[d], Tasuku Matsuyama, MD, PhD[e], Junya Sado, PhD[b], Kosuke Kiyohara, DrPH[f], Junichi Izawa, MD, DrPH[g], Jotaro Tachino, MD[a], Takeshi Ebihara, MD[a], Kazuhisa Yoshiya, MD, PhD[a], Yuko Nakagawa, MD, PhD[a], Takeshi Shimazu, MD, PhD[a]

Abstract

According to guidelines from the Eastern Association for the Surgery of Trauma, computed tomography (CT) with intravenous contrast is strongly recommended to diagnose clinically significant blunt traumatic aortic injury (BTAI). However, it remains unclear whether the timing of CT scanning is associated with the prognosis of BTAI patients.

We extracted data on emergency patients who suffered a BTAI in the chest and/or the abdomen from 2004 to 2015 from the Japanese Trauma Data Bank, a nationwide trauma registry. The primary outcome was death in the emergency department (ED) and secondary outcome was discharge to death. In addition, we assessed the relationship between death in the ED and the timing of CT scanning by shock status in subgroup analysis. We divided these patients into the tertile groups of early (≤26 minutes), middle (27–40 minutes), and late (≥41 minutes) phases based on the time interval from hospital arrival to start of first CT scanning, and assessed death of BTAI patients in the ED by CT scanning time with the use of a multivariable logistic regression model.

In total, 421 patients who suffered BTAI in the chest and/or the abdomen were eligible for our analysis. The proportion of patients dying at hospital admission was 7.7% (11/142) in the early group, 11.1% (15/135) in the middle group, and 17.6% (25/144) in the late group. In a multivariable logistic regression adjusted for confounding factors, the adjusted odds ratio (AOR) of death in the ED was 1.833 (95% confidence interval [CI]: 0.601–5.590, $P=.287$) in the middle group and 2.832 (95% CI: 1.007–7.960, $P=.048$) in the late group compared with the early group. Compared with the early group, the late group tended to have a higher rate of discharge to death (AOR: 1.438, 95% CI: 0.735–2.813). In the patients with shock, the AOR was 3.292 (95% CI: 0.495–21.902) in the middle group and 6.039 (95% CI: 0.990–36.837) in the late group compared with the early group.

This study revealed that a longer time interval from hospital arrival to CT scanning was associated with higher mortality in the ED in patients with BTAI.

Abbreviations: AIS = Abbreviated Injury Scale, AOR = adjusted odds ratio, BTAI = blunt traumatic aortic injury, CI = confidential interval, CT = computed tomography, EAST = Eastern Association for the Surgery of Trauma, ED = emergency department, EVAR = endovascular aortic repair, ISS = Injury Severity Score, JTDB = Japanese Trauma Data Bank.

Keywords: aortic injury, blunt trauma, computed tomography, prognosis, timing

Editor: Wilhelm Mistiaen.

Funding/support: This study was supported by the Clinical Investigator's Research Project in Osaka University Graduate School of Medicine and JSPS KAKENHI (Grant Number JP18H02902).

The authors have no conflicts of interest to disclose.

[a] Department of Traumatology and Acute Critical Medicine, [b] Division of Environmental Medicine and Population Sciences, Department of Social and Environmental Medicine, Osaka University Graduate School of Medicine, Suita, [c] Emergency and Critical Care Center, Osaka Police Hospital, Osaka, [d] Kyoto University Health Services, [e] Department of Emergency Medicine, Kyoto Prefectural University of Medicine, Kyoto, [f] Department of Public Health, Tokyo Women's Medical University, [g] Intensive Care Unit, Department of Anesthesiology, The Jikei University School of Medicine, Tokyo, Japan.

[*] Correspondence: Yusuke Katayama, Department of Traumatology and Acute Critical Medicine, Osaka University Graduate School of Medicine, 2-15 Yamada-oka, Suita 565-0871, Japan (e-mail: orion13@hp-emerg.med.osaka-u.ac.jp).

Medicine (2018) 97:35(e12112)

Received: 23 May 2018 / Accepted: 6 August 2018

http://dx.doi.org/10.1097/MD.0000000000012112

1. Introduction

Blunt traumatic aortic injury (BTAI) is one of the fatal traumatic injuries of the chest. In the 1990s, prehospital mortality of emergency patients with BTAI reached 75%, and about one half of these patients alive at hospital arrival died within the following 24 hours.[1,2] Recently, the prognosis of BTAI patients has been improved in accordance with the development of procedures such as endovascular aortic repair (EVAR).[3] Because BTAI might not be easily diagnosed with focused assessment with sonography in trauma and/or chest X-ray, it was previously diagnosed with the use of aortography.[4]

A number of previous studies revealed the usefulness of enhanced computed tomography (CT) scanning for the diagnosis of BTAI,[5–9] and in the guidelines of the Eastern Association for the Surgery of Trauma (EAST), enhanced CT scanning is strongly recommended to diagnose BTAI (Level 1).[10] If the time interval from the scene to treatments delayed, the outcome of trauma patients becomes worse. Therefore, it would be important to earlier conduct CT scanning and to subsequently consider therapeutic option among BTAI patients in order to improve their outcomes. However, whether earlier CT scanning leads to an improved prognosis for BTAI patients has not been extensively investigated.

The Japanese Trauma Data Bank (JTDB) is a nationwide trauma registry in Japan that is managed by The Japanese Association for the Surgery of Trauma. Data registration in the JTDB was launched in 2003 and approximately 230,000 emergency patients with trauma were enrolled by 2015. The aim of this study was to assess the relationship between the timing of CT scanning and the prognosis of BTAI patients using this database.

2. Methods

2.1. Study design, population, and setting

This study was a retrospective observation using the JTDB database. The study period spanned 12 years from January 2004 to December 2015. We included emergency patients who had a BTAI in the chest and/or the abdomen among those who were transported to the JTDB-participating hospitals and were registered in the database. We excluded those who were in cardiopulmonary arrest on hospital arrival, received inter-hospital transport, had no records on the time interval from hospital arrival to CT scanning, had penetrating trauma, or had an inappropriate dataset. We extracted BTAI patients based on the following Abbreviated Injury Scale (AIS) codes: 420299.4, 420292.4, 420204.5, 420206.4, 420208.4, 420210.5, 420212.5, 420216.5, 420218.6, 520299.4, 520202.4, 520204.4, 520206.4, and 520208.5. To assess the relationship between the timing of CT scanning and prognosis in the BTAI patients, we also excluded patients in whom the first elective CT scanning was performed ≥72 hours after hospital arrival. This study was approved by the ethics committee of Osaka University Graduate school of Medicine. Personal identifiers were removed beforehand from the JTDB database, and the patients' right to informed consent was waived.

2.2. Japanese Trauma Data Bank

The JTDB was launched in 2003 by the Japanese Association for the Surgery of Trauma (Trauma Surgery Committee) and the Japanese Association for Acute Medicine (Committee for Clinical Care Evaluation),[11,12] similar to trauma databases in North America, Europe, and Oceania.[13] In 2016, 256 major emergency medical institutions across Japan were registered in the JTDB database.[12] These hospitals could be regarded as being equal to Level I trauma centers in the United States. Data were collected via the Internet from participating institutions. In most cases, the physicians and medical assistants who attended the AIS coding course registered the data.[13]

The JTDB captures trauma patients with data on age, gender, mechanism of injury, AIS code (version 1998), Injury Severity Score (ISS), Revised Trauma Score (RTS), vital signs on hospital arrival, date and time series from hospital arrival to discharge, medical treatment such as interventional radiology, surgical operation, and CT scanning, complications, and survival at discharge.[14] ISS was calculated from the top 3 scores of the AIS in 9 sites classified by AIS code.

From the JTDB database, we extracted age, gender, time of day and day of the week of hospital admission, maximum AIS score for each site, ISS, and severe complications such as prolonged shock and acute renal failure in accordance with regular forms with coding items. This study defined daytime as 09:00 to 17:59 and nighttime as 18:00 to 08:59 and also defined shock as a systolic blood pressure below 90 mm Hg on hospital arrival.[15] The case volume was classified by the number of BTAI patients treated in each hospital (upper: over 4 patients, middle: 2–3 patients, and lower: only one patient). The tertile groups by CT scanning time were classified according to the time interval from hospital arrival to implementation of first CT scanning by a CT operator.

2.3. Endpoints

The primary endpoint was death in the emergency department (ED), and the secondary endpoint was discharge to death.

2.4. Statistical analysis

Patient characteristics in the 3 groups were assessed by chi-square test for categorical variables and analysis of variance for continuous variables. To evaluate the factors associated with death in the ED, we calculated the adjusted odds ratio (AOR) and its 95% confidential interval (CI) with use of a multivariable logistic regression model. The potential factors were age, gender, falling from a high place, pedestrian injured by traffic accident, calendar year, time of the day (daytime/nighttime), day of the week (weekday/weekend and holiday), shock at hospital arrival, RTS, ISS, case volume (upper/middle/lower), and the timing of CT scanning (early/middle/late in the manner of tertile). It was previously reported that the prognosis of trauma patients and emergency patients at night-time or weekends was worse than that at daytime or weekdays,[16,17] and we incorporated these variables into the model as confounding factors in this study. In addition, we assessed the relationship between death at discharge and these factors with use of multivariable logistic regression analysis. Because it would take much time to resuscitate patients with shock at hospital arrival and might influence their prognosis, we divided the patients into 2 groups, those with or without shock at hospital arrival, and also assessed the relationship between death in the ED and the timing of CT scanning by shock status. All tests were 2-tailed, and a P value of $<.05$ was considered statistically significant. Statistical analysis was performed by SPSS version 22.0J (IBM Corp., Armonk, NY). This manuscript was written based on the STROBE statement to assess the reporting of cohort and cross sectional studies.[18]

3. Results

Figure 1 shows the patient flow in this study. During the study period, 226,298 emergency patients were registered in the JTDB. Of them, 1541 patients suffered BTAI in the chest and/or the abdomen. After excluding 1120 patients for the reasons shown in Figure 1, a total of 421 patients were eligible for our analysis. We divided these patients into tertile groups according to the time interval from hospital arrival to first CT scanning: early group (≤26 minutes, n = 142), middle group (27–40 minutes, n = 135), and late group (≥41 minutes, n = 144).

Table 1 shows the characteristics of the BTAI patients by tertile group according to the timing of CT scanning. There were no statistically significant differences in any of the variables between these groups. Mean age was 60 years, and the proportion of male sex was 73.2%. The proportion of patients with shock at hospital arrival was 32.5%, and the median ISS was 34. The overall proportion of open surgery in chest and/or abdomen was 19.5% (82/421). The proportions of patients with the complications of prolonged shock and acute renal failure were 4.5% and 3.6%, respectively. The median time interval from ambulance call to hospital arrival was 38 minutes.

Table 2 shows the factors associated with the death of BTAI patients in the ED by a multivariable logistic regression model. Nighttime (AOR: 2.409, 95% CI: 1.035–5.604), RTS (AOR for increment of one score: 0.681, 95% CI: 0.535–0.866), ISS (AOR for increment of one score: 1.054, 95% CI: 1.029–1.079), and later timing of CT scanning (AOR: 2.864, 95% CI: 1.017–8.064) were associated with the death of BTAI patients in the ED. The increment of one category in the timing of CT scanning was also associated with the death of BTAI patients in the ED (AOR: 1.663, 95% CI: 1.012–2.732). As for the secondary endpoint shown in Table 3, compared with the early group, the late group tended to have a higher rate of discharge to death (AOR: 1.438, 95% CI: 0.735–2.813). The AOR for increment of one category in the timing of CT scanning was 1.207 (95% CI: 0.862–1.690).

Death in the ED of the BTAI patients with or without shock by the timing of CT scanning is shown in Table 4. In the patients with shock, the AOR was 3.292 (95% CI: 0.495–21.902) in the middle group and 6.039 (95% CI: 0.990–36.837) in the late group compared with the early group. The AOR for the increment of one category in the timing of CT scanning was 2.294 (95% CI: 1.018–5.170). The patients without shock also showed similar results, and there was no significant interaction of death in the ED between the timing of CT scanning and shock status.

4. Discussion

From the analysis of a nationwide trauma registry in Japan, this study revealed that later timing of the first CT scanning was associated with a higher incidence of death in the ED and at hospital discharge among emergency BTAI patients. In addition, these results were similar irrespective of shock status. Although the EAST guidelines recommend conducting enhanced CT scanning for BTAI patients, the influence of the timing of first CT scanning on the prognosis of BTAI patients was not sufficiently assessed. The JTDB nationwide large-scale trauma registry enabled us to assess the relationship between the timing of CT scanning and the prognosis of BTAI patients, and our findings suggest that quicker CT scanning would lead to earlier intervention with advanced procedures and improvement of the prognosis of these patients.

The time interval from hospital arrival to diagnosis and definitive treatment of trauma patients influences their prognosis. Clarke et al in the United States demonstrated that among hypotensive trauma patients at ED arrival or those with severe abdominal aortic injuries requiring emergency operation, the probability of death increased with the increasing length of time spent in the ED.[19] In addition, Bernhard et al in Germany reported that the implementation of an interdisciplinary treatment algorithm reduced mortality in the most severely injured patients.[20] However, although the accuracy of diagnosis

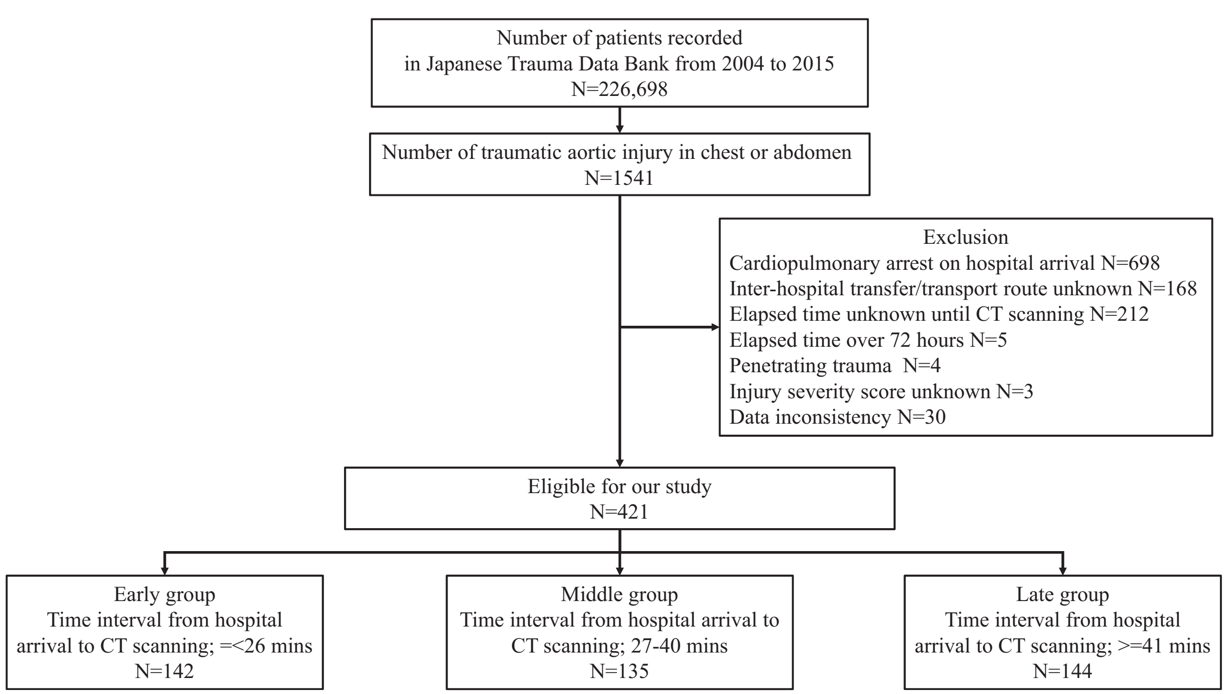

Figure 1. Chart of patient flow in this study.

Table 1

Patient characteristics among patients with blunt traumatic aortic injury by the timing of CT scanning.

	Total (n=421)	Early group (under 26 min) (n=142)	Middle group (27–40 min) (n=135)	Late group (over 41 min) (n=144)	*P* value
Age, median (IQR)	60 (39–73)	62 (47–77)	59 (38–71)	57 (37–73)	.496
Male, n, %	308 (73.2)	109 (76.8)	93 (68.9)	106 (73.6)	.332
Time of day, n, %					.679
Day-time (9:00–17:59)	200 (47.5)	67 (47.2)	68 (50.4)	65 (45.1)	
Night-time (18:00–8:59)	221 (52.5)	75 (52.8)	67 (49.6)	79 (54.9)	
Day of week, n, %					.269
Weekday	295 (70.1)	97 (68.3)	90 (66.7)	108 (75.0)	
Weekend/holiday	126 (29.9)	45 (31.7)	45 (33.3)	36 (25.0)	
Shock (systolic blood pressure < 90 mm Hg), n, %	137 (32.5)	37 (26.1)	48 (35.6)	52 (36.1)	.128
ISS, median (IQR)	34 (25–50)	34 (25–50)	34 (24–48)	35 (26–50)	.451
Number of patients with AIS ≥3 by body region					.370
Head, n, %	134 (31.8)	51 (35.9)	44 (32.6)	39 (27.1)	
Face, n, %	4 (1.0)	0 (0.0)	2 (1.5)	2 (1.4)	
Neck, n, %	2 (0.5)	0 (0.0)	1 (0.7)	1 (0.7)	
Thorax, n, %	367 (87.2)	123 (86.6)	116 (85.9)	128 (88.9)	
Abdomen, n, %	165 (39.2)	59 (41.5)	53 (39.3)	53 (36.8)	
Spine, n, %	46 (10.9)	17 (12.0)	18 (13.3)	9 (6.3)	
Upper extremity, n, %	30 (7.1)	5 (3.5)	10 (7.4)	15 (10.4)	
Lower extremity including pelvis, n, %	150 (35.6)	45 (31.7)	48 (35.6)	57 (39.6)	
Unspecified, n, %	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Case volume					.109
Upper, n (%)	306 (72.7)	115 (81.0)	93 (68.9)	98 (68.1)	
Middle, n, %	78 (18.5)	19 (13.4)	28 (20.7)	31 (21.5)	
Lower, n, %	37 (8.8)	8 (5.6)	14 (10.4)	15 (10.4)	
Calendar year					1.000
2004, n, %	9 (2.1)	3 (2.1)	2 (1.5)	4 (2.8)	
2005, n, %	6 (1.4)	3 (2.1)	2 (1.5)	1 (0.7)	
2006, n, %	12 (2.9)	3 (2.1)	5 (3.7)	4 (2.8)	
2007, n, %	31 (7.4)	8 (5.6)	9 (6.7)	14 (9.7)	
2008, n, %	24 (5.7)	6 (4.2)	12 (8.9)	6 (4.2)	
2009, n, %	35 (8.3)	14 (9.9)	6 (4.4)	15 (10.4)	
2010, n, %	42 (10.0)	13 (9.2)	16 (11.9)	13 (9.0)	
2011, n, %	39 (9.3)	14 (9.9)	14 (10.4)	11 (7.6)	
2012, n, %	54 (12.8)	14 (9.9)	18 (13.3)	22 (15.3)	
2013, n, %	55 (13.1)	24 (16.9)	16 (11.9)	15 (10.4)	
2014, n, %	63 (15.0)	20 (14.1)	18 (13.3)	25 (17.4)	
2015, n, %	51 (12.1)	20 (14.1)	17 (12.6)	14 (9.7)	
Surgical operation, n, %	82 (19.5)	28 (19.7)	20 (14.8)	34 (23.6)	.179
Complications					
Prolonged shock, n, %	19 (4.5)	9 (6.3)	4 (3.0)	6 (4.2)	.389
Acute renal failure, n, %	15 (3.6)	6 (4.2)	3 (2.2)	6 (4.2)	.594
Time interval from patient's call to hospital arrival, min, median (IQR)	38 (29–50)	38 (28–54)	38 (29–47)	38 (29–51)	.405

AIS = abbreviated injury scale, CT = computed tomography, IQR = interquartile range, ISS = Injury Severity Score.

with CT scanning for BTAI was previously lower than that with aortography,[5] CT scanning has recently become more useful as a screening tool in accordance with the improvements made in CT resolution. Considering the previous studies and our findings, the implementation of earlier CT scanning of emergency trauma patients on ED arrival would be useful to improve the prognosis of BTAI patients.

Based on the severity of vascular injury, BTAI was classified into grade 1, intimal tear; grade 2, intramural hematoma; grade 3, aortic pseudoaneurysm; and grade 4, free rupture.[21] In many previous reports, nonoperative management was performed for patients with BTAI of grades 1 and 2, and advanced procedures such as open repair and EVAR were performed for those with BTAI of grades 3 and 4.[21–27] The guidelines of the Society for Vascular Surgery suggested urgent (<24 hours) repair barring other serious concomitant nonaortic injuries, or repair immediately after other injuries have been treated, but at the latest prior to hospital discharge.[28] In the assessment of delayed management for BTAI, there was no difference between open repair and EVAR,[29] but the mortality of BTAI patients with delayed repair was significantly lower than that with immediate repair.[3] The EAST guidelines for BTAI also recommend lowering blood pressure even when delayed repair is performed.[10] Thus, both earlier detection of BTAI by early CT scanning and earlier initiation of blood pressure control could lead to the prevention of aortic rupture and improvement of the prognosis of BTAI patients.

Although this study divided BTAI patients into those with and without shock and assessed the relationship between the timing of first CT scanning and patient prognosis, the prognosis of BTAI

Table 2

Factors associated with death in the ED among patients with blunt traumatic aortic injury.

	Death in the ED				95% CI		
	%	(n/N)	Coeffcient	Adjusted OR			*P* value
Age (increment of one age)			0.015	1.015	0.994	1.037	.158
Gender							
Male	10.4	(32/308)	0.284	1.328	0.546	3.230	.532
Female	16.8	(19/113)	–	Reference	–	–	
Time of the day							
Daytime	7.5	(15/200)	–	Reference	–	–	
Nighttime	16.3	(36/221)	0.888	2.431	1.046	5.648	.039
Day of the week							
Weekday	13.2	(39/295)	–	Reference	–	–	
Weekend/holiday	9.5	(12/126)	−0.321	0.726	0.190	1.811	.492
Falling from a high place	14.8	(9/61)	−0.562	0.570	0.190	1.708	.316
Pedestrian injured by traffic accident	13.4	(13/97)	−0.031	0.970	0.371	2.533	.950
Shock (systolic BP < 90 mm Hg) at hospital arrival	26.4	(24/91)	−0.038	0.963	0.374	2.478	.937
RTS (increment of one score)			−0.363	0.696	0.548	0.884	.003
ISS (increment of one score)			0.053	1.054	1.029	1.080	.001
Case volume							
Upper	12.1	(37/306)	–	Reference	–	–	
Middle	9.0	(7/78)	−0.425	0.654	0.227	1.885	.432
Lower	18.9	(7/37)	0.674	1.963	0.615	6.261	.255
Calendar year (increment of 1 y)			0.014	1.014	0.886	1.160	.842
Timing of CT scanning							
Early	7.7	(11/142)	–	Reference	–	–	
Middle	11.1	(15/135)	0.606	1.833	0.601	5.590	.287
Late	17.6	(25/144)	1.041	2.832	1.007	7.960	.048
Increment of one category			0.508	1.662	1.011	2.732	.045

Cox–Snell R^2: 0.131, Nagelkerke R^2: 0.278. BP = blood pressure, CI = confidence interval, CT = computed tomography, ED = emergency department, ISS = injury severity score, OR = odds ratio, RTS = revised trauma score.

Table 3

Timing of CT scanning and death to discharge among patients with blunt traumatic aortic injury.

	Death to discharge				95% CI		
	%	(n/N)	Coefficient	Adjusted OR*			*P* value
Timing of CT							
Early	28.9	(41/142)	–	Reference	–	–	
Middle	31.9	(43/135)	0.031	1.032	0.517	2.059	.930
Late	38.2	(55/144)	0.363	1.438	0.735	2.813	.288
Increment of one category			0.188	1.207	0.862	1.690	.273

CI = confidence interval, CT = computed tomography, OR = odds ratio.

* Adjusted for age, gender, time of the day, day of the week, falling from a high place, pedestrian injured by traffic accident, revised trauma score, injury severity score, shock at hospital arrival, case volume, and calendar year.

Table 4

Timing of CT scanning and death in the ED with or without shock among patients with blunt traumatic aortic injury.

	Death in the ED				95% CI			
	%	(n/N)	Coefficient	Adjusted OR*			*P* value	*P* for interaction†
Shock (N = 137)								.295
Early group	13.5	(5/37)	–	Reference	–	–		
Middle group	20.8	(10/48)	1.192	3.292	0.495	21.902	.218	
Late group	26.9	(14/52)	1.798	6.039	0.990	36.837	.051	
Increment of one category			0.830	2.294	1.018	5.170	.045	
Nonshock (N = 284)								
Early group	5.7	(6/105)	–	Reference	–	–		
Middle group	5.7	(5/87)	0.436	1.527	0.337	7.103	.575	
Late group	12.0	(11/92)	0.772	2.165	0.533	8.785	.280	
Increment of one category			0.383	1.466	0.734	2.930	.278	

CI = confidence interval, CT = computed tomography, ED = emergency department, OR = odds ratio.

* Adjusted for age, gender, time of the day, day of the week, falling from a high place, pedestrian injured by traffic accident, revised trauma score, injury severity score, case volume, and calendar year.

† Calculated for the interaction between timing of CT scanning and shock/nonshock in death in the ED.

patients tended to worsen irrespective of shock status when the first CT scanning was delayed. Among BTAI patients with shock, delayed CT scanning could lead to delayed open repair or EVAR and subsequent worse prognosis. In contrast, BTAI patients without shock might have poor outcome due to concomitant injuries such as severe brain injury, but the definitive reason remains unclear in this study. For example, Rabin et al reported that severe patients with BTAI of grade 3 and pseudocoarctation, mediastinal hematoma, and large left hemothorax should be urgently repaired.[23] Even if these BTAI patients are not in shock, delay of first CT scanning can lead to the delay of blood pressure control and their prognosis may worsen.

In this registry, the time interval between hospital arrival and first CT scanning in the early group was ≤26 minutes and that in the late group was ≥41 minutes. In the REACT-2 study assessing the effect of total-body CT scanning compared with the standard work-up on in-hospital mortality among trauma patients, the time interval between arrival in the trauma room and completion of CT scanning was about 30 minutes for whole-body CT and 37 minutes for the standard work-up.[30] Although the time interval between hospital arrival and first CT scanning in both our early and middle groups were similar to the results from REACT-2, that in the late group was longer than the standard time interval. To improve this delay, revision of the guidelines and protocols in the emergency room to resuscitate emergency trauma patients as soon as possible is also needed.[20] In addition, a hybrid emergency room system that allows simultaneous resuscitation of trauma patients and performance of CT scanning might be of help in improving the prognosis of BTAI patients.[31,32]

Recently, several studies revealed that routine CT scanning improved the mortality of trauma patients.[33–35] On the other hand, there were also some reports that the use of selective CT imaging was not different from that of routine CT imaging in terms of mortality of trauma patients[36] and the risks of radiation exposure were larger than the benefits of routine CT scanning for trauma patients, especially among pediatric trauma patients.[37] Gupta et al revealed that selective CT scanning could reduce the number of scans, missing some injuries but few critical ones.[38] However, most patients in this report were mild trauma ones whose median of ISS score was 5 (IQR; 1–13). In our registry, we revealed that the delay of first CT scanning was associated with poor outcome in BTAI patients. In the REACT-2 study, the time interval from trauma room arrival to end of CT scanning for standard work flow was longer than that for whole-body CT. If CT scanning is delayed, doctors' recognition of BTAI would be delayed in trauma patients. The delay of diagnosis for BTAI would lead to the delay of BTAI treatments and the prognosis would be subsequently worse. Therefore, if severe traumas such as BTAI are suspected from mechanism of injury such as falling from a high place and clinical features at hospital arrival, it is important to conduct routine whole-body CT and detect BTAI as soon as possible. Further research is needed to reveal the benefits of routine whole-body CT for severe chest trauma patients suspected BTAI, especially children.

4.1. Limitations

There are several limitations in this study. First, although we analyzed the JTDB database in which major critical care centers in Japan participated, there were some sorts of selection biases because exhaustive research was not performed. Second, although we assessed the time interval from hospital arrival to first CT scanning, we did not obtain information on whether enhanced CT scanning was performed for BTAI patients. Third, we did not obtain detailed information on surgical operation such as aortic repair with artificial vessel as well as medication such as inotropes, and data on the implementation of EVAR and subsequent complications of BTAI or EVAR such as stroke and paraplegia are not also included in the JTDB database. Fourth, although the grade of BTAI and the time to definite care were important confounding factors associated with the prognosis of BTAI, we did not obtain information on the BTAI grade and did not incorporate the time in our analysis model because of the insufficient number. Last, as this was retrospective observational study, there might be some unmeasured confounding factors that affected our results. Considering these limitations, our findings showing the effectiveness of early CT scanning for BTAI patients should also be confirmed in other large-scale cohorts.

5. Conclusions

We showed in a retrospective review of a nationwide hospital-based trauma registry in Japan that the prognosis of BTAI patients in the ED worsened as the time to first CT scanning was delayed.

5.1. Ethics approval and consent to participate

This study was approved by the ethics committees of the Osaka Graduate School of Medicine (No. 16260), and the requirement to obtain patients' consent to participate was waived because the data were anonymous.

5.2. Consent for publication

Not applicable

5.3. Availability of data and material

The data that support the findings of this study are available from the JTDB, but the availability of these data is restricted.

Acknowledgments

The authors thank the emergency medical service personnel, nurses, and emergency physicians who participated in the JTDB.

Author contributions

YK analyzed the data and wrote the first draft of this manuscript. JS and KK did data-cleaning and supported to analyze the data. TK reviewed all statistical analyses and critically revised this manuscript. TH, TK, TM, JI, JT, TE, and YN interpreted the data and critically revised this manuscript. TS supervised the interpretation of data and critically revised this manuscript. All the authors read and approved the final manuscript.

Conceptualization: Yusuke Katayama, Tomoya Hirose.
Data curation: Yusuke Katayama, Tasuku Matsuyama, Junya Sado, Kosuke Kiyohara.
Formal analysis: Yusuke Katayama, Junya Sado, Kosuke Kiyohara.
Funding acquisition: Takeshi Shimazu.
Methodology: Yusuke Katayama, Takeyuki Kiguchi, Jotaro Tachino, Takeshi Ebihara.
Project administration: Yusuke Katayama.
Resources: Yuko Nakagawa.
Software: Yusuke Katayama, Kazuhisa Yoshiya.

Supervision: Yusuke Katayama, Tetsuhisa Kitamura.
Validation: Yusuke Katayama, Tasuku Matsuyama, Jinichi Izawa.
Visualization: Jinichi Izawa.
Writing – original draft: Yusuke Katayama.
Writing – review & editing: Tetsuhisa Kitamura.

References

[1] Fabian TC, Richardson JD, Croce MA, et al. Prospective study of blunt aortic injury: Multicenter Trial of the American Association for the Surgery of Trauma. J Trauma 1997;42:374–80. discussion: 380–383.
[2] Jamieson WR, Janusz MT, Gudas VM, et al. Traumatic rupture of the thoracic aorta: third decade of experience. Am J Surg 2002;183:571–5.
[3] Estrera AL, Gochnour DC, Azizzadeh A, et al. Progress in the treatment of blunt traumatic aortic injury: 12-year single-institution experience. Ann Thorac Surg 2010;90:64–71.
[4] Parmley LF, Mattingly TW, Manion TW, et al. Nonpenetrating traumatic injury of the aorta. Circulation 1958;17:1086–101.
[5] Fabian TC, Davis KA, Gavant ML, et al. Prospective study of blunt aortic injury: helical CT is diagnostic and antihypertensive therapy reduces rupture. Ann Surg 1998;227:666–76.
[6] Melton SM, Kerby JD, McGiffin D, et al. The evolution of chest computed tomography for the definitive diagnosis of blunt aortic injury: a single-center experience. J Trauma 2004;56:243–50.
[7] Parker MS, Matheson TL, Rao AV, et al. Making the transition: the role of helical CT in the evaluation of potentially acute thoracic aortic injuries. AJR Am J Roentgenol 2001;176:1267–72.
[8] Dyer DS, Moore EE, Ilke DN, et al. Thoracic aortic injury: how predictive is mechanism and is chest computed tomography a reliable screening tool? A prospective study of 1,561 patients. J Trauma 2000;48:673–82.
[9] Bruckner BA, DiBardino DJ, Cumbie TC, et al. Critical evaluation of chest computed tomography scans for blunt descending thoracic aortic injury. Ann Thorac Sur 2006;81:1339–46.
[10] Fox N, Schwartz D, Salazar JH, et al. Evaluation and management of blunt traumatic aortic injury: a practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2015;78:136–46.
[11] Yumoto T, Mitsuhashi T, Yamakawa Y, et al. Impact of Cushing's sign in the prehospital setting on predicting the need for immediate neurosurgical intervention in trauma patients: a nationwide retrospective observational study. Scand J Trauma Resusc Emerg Med 2016;24:147.
[12] Japan Trauma Care and Research. Japan Trauma Data Bank Annual Report 2011–2015. https://www.jtcr-jatec.org/traumabank/dataroom/data/JTDB2016.pdf. [Accessed August 21, 2017].
[13] Shoko T, Shiraishi A, Kaji M, et al. Effect of pre-existing medical conditions on in-hospital mortality: analysis of 20,257 trauma patients in Japan. J Am Coll Surg 2010;211:338–46.
[14] Nakada TA, Nakao S, Mizushima Y, et al. Association between male sex and increased mortality after falls. Acad Emerg Med 2015;22:708–13.
[15] Sasser SM, Hunt RC, Faul M, et al. Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage, 2011. MMWR Recomm Rep 2012;61:1–20.
[16] Stefano DB, Massimiliano M, Chiara V, et al. A population based study on the night-time effect in trauma care. Emerg Med J 2014;31:808–12.
[17] Walker AS, Mason A, Quan TP, et al. Mortality risks associated with emergency admissions during weekends and public holidays: an analysis of electronic health records. Lancet 2017;390:62–72.
[18] Von Elm E, Altman DG, Egger M, et al. STROBE Initiative: The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61:344–9.
[19] Clarke JR, Trooskin SZ, Doshi PJ, et al. Time to laparotomy for intra-abdominal bleeding from trauma does affect survival for delays up to 90 minutes. J Trauma 2002;52:420–5.
[20] Bernhard M, Becker TK, Nowe T, et al. Introduction of a treatment algorithm can improve the early management of emergency patients in the resuscitation room. Resuscitation 2007;73:362–73.
[21] Azizzadeh A, Keyhani K, Miller CC3rd, et al. Blunt traumatic aortic injury: initial experience with endovascular repair. J Vasc Surg 2009;49:1403–8.
[22] Chen SW, Wang SY, Liao CH, et al. Timing of intervention in blunt traumatic aortic injury patients: open surgical versus endovascular repair. Ann Vasc Surg 2015;29:1559–66.
[23] Rabin J, DuBose J, Sliker CW, et al. Parameters for successful nonoperative management of traumatic aortic injury. J Thorac Cardiovasc Surg 2014;147:143–9.
[24] Spencer SM, Safcsak K, Smith CP, et al. Nonoperative management rather than endovascular repair may be safe for grade II blunt traumatic aortic injuries: an 11-year retrospective analysis. J Trauma Acute Care Surg 2018;84:133–8.
[25] Osgood MJ, Heck JM, Rellinger EJ, et al. Natural history of grade I-II blunt traumatic aortic injury. J Vasc Surg 2014;59:334–41.
[26] Rousseau H, Elaassar O, Marcheix B, et al. The role of stent-grafts in the management of aortic trauma. Cardiovasc Intervent Radiol 2012;35:2–14.
[27] Durham CA, McNally MM, Parker FM, et al. A contemporary rural trauma center experience in blunt traumatic aortic injury. J Vasc Surg 2010;52:884–9. discussion 889–90.
[28] Lee WA, Matsumura JS, Mitchell RS, et al. Endovascular repair of traumatic thoracic aortic injury: clinical practice guidelines of the Society for Vascular Surgery. J Vasc Surg 2011;53:187–92.
[29] Di Eusanio M, Folesani G, Berretta P, et al. Delayed management of blunt traumatic aortic injury: open surgical versus endovascular repair. Ann Thorac Surg 2013;95:1591–7.
[30] Sierink JC, Treskes K, Edwards MJ, et al. Immediate total-body CT scanning versus conventional imaging and selective CT scanning in patients with severe trauma (REACT-2): a randomised controlled trial. Lancet 2016;388:673–83.
[31] Wada D, Nakamori Y, Yamakawa K, et al. Impact on survival of whole-body computed tomography before emergency bleeding control in patients with severe blunt trauma. Crit Care 2013;17:R178.
[32] Kinoshita T, Yamakawa K, Matsuda H, et al. The survival benefit of a novel trauma workflow that includes immediate whole-body computed tomography, surgery and interventional radiology, all in one trauma resuscitation room: a retrospective historical control study. Ann Surg 2017;doi: 10.1097/SLA.0000000000002527. (in press).
[33] Huber-Wagner S, Lefering R, Qvick LM, et al. Effect of whole-body CT during trauma resuscitation on survival: a retrospective, multicentre study. Lancet 2009;373:1455–61.
[34] Wurmb TE, Frühwald P, Hopfner W, et al. Whole-body multislice computed tomography as the first line diagnostic tool in patients with multiple injuries: the focus on time. J Trauma 2009;66:658–65.
[35] Hutter M, Woltmann A, Hierholzer C, et al. Association between a single-pass whole-body computed tomography policy and survival after blunt major trauma: a retrospective cohort study. Scand J Trauma Resusc Emerg Med 2011;19:73.
[36] Meltzer JA, Stone ME, Reddy SH, et al. Association of whole-body computed tomography with mortality risk in children with blunt trauma. JAMA Pediatrics 2018;doi: 10.1001/jamapediatrics.2018.0109. (in press).
[37] Holscher CM, Faulk LW, Moore EE, et al. Chest computed tomography imaging for blunt pediatric trauma: not worth the radiation risk. J Surg Res 2013;184:352–7.
[38] Gupta M, Schriger DL, Hiatt JR, et al. Selective use of computed tomography compared with routine whole body imaging in patients with blunt trauma. Ann Emerg Med 2011;58:407–16.