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Geriatric trauma prognosis trends over 10 years: analysis of a nationwide trauma registry

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ABSTRACT

Purpose With Japan's population rapidly skewing toward aging, the number of geriatric trauma patients is expected to increase. Since we need to continue to improve the quality of geriatric trauma patient care, this study aimed to evaluate in-hospital mortality trends among geriatric trauma patients in Japan over a recent 10-year period.

Methods This was a retrospective cohort study of data from a Japanese nationwide trauma registry (the Japan National Trauma Data Bank) on patients admitted between January 1, 2008 and December 31, 2017. Geriatric patients were defined as those 65 years old and older. The primary outcome was to clarify in-hospital mortality trends and changes over these 10 years.

Results We identified 265 268 eligible trauma patients. Excluding those under 65 years old and those with inadequate or unknown age data, missing prognosis, out-of-hospital cardiac arrest, and burns, 107 766 patients were enrolled in this study. The total trauma patient in-hospital mortality trend was evaluated using the Cochran-Armitage test and showed a significant decrease ($p<0.001$). Although severe trauma patients (Injury Severity Score (ISS) ≥16) showed a significant decreasing trend ($p<0.001$) over time (from 26.1% to 14.5%), less-severe trauma patients (ISS <16) did not ($p=0.41$) (from 2.7% to 2.1%). Mixed logistic regression analysis showed that the number of year patients stayed in the hospital was significantly associated with mortality.

Conclusions While recognizing the limitations of the current analysis, our data demonstrated that prognoses for severe trauma patients over 65 years old improved dramatically over these 10 years, especially in those with severe trauma.

Level of evidence III—retrospective cohort study.

BACKGROUND

Populations, especially in high-income countries, have been skewing towards elderly as the number of aged citizens continues to increase. In the USA, it is predicted that 20% of the population will be composed of individuals aged 65 years or over.[1] Likewise, the accelerated aging of the Japanese population is well-recognized; 26.6% of the Japanese citizens are 65 years or older.

Elderly trauma patients have significantly different shock responses, physiology, and types and mechanisms of injury than younger trauma patients.[2 3] Elderly patients tend to have a higher number of chronic medical conditions, which complicates early diagnosis due to altered physiological response to trauma and increases the risk of death in traumatic injuries. Appreciating these differences decreases the danger of under-triaging; investigation and diagnosis delays should be avoided to decrease morbidity and mortality. To resolve these problems, geriatric trauma patients are transferred to rehabilitation hospital or nursing home soon after treating recognized disease in emergency hospital in Japan.[4]

Although several studies on age-related characteristics of severe trauma patients have been conducted,[5] the natural history of elderly trauma patients in Japan based on prognosis are not fully understood. This study aimed to analyze in-hospital mortality status over 10 years (2008–2017) in Japan using a nationwide, multicenter trauma patient database. Sharing our data regarding elderly trauma patients may help establish trauma care systems and strategies for the coming aging society, leading to improvements in geriatric trauma patient care.

MATERIALS AND METHODS

Study design

We analyzed information from the Japan Trauma Data Bank (JTDB), a nationwide, multicenter trauma patient database, on patients admitted between January 1, 2008 and December 31, 2017. More than 250 hospitals including trauma centers and emergency medical centers anticipate in JTDB. Patients 65 years or older were eligible. To eliminate and minimize confounders, patients with inadequate and unknown age data, missing prognosis, out-of-hospital cardiac arrest (OHCA), and burns were excluded.

To meet the primary objective to study the trend of in-hospital mortality among geriatric trauma patients over these 10 years, we divided trauma patients into two groups according to Injury Severity Score (ISS) (ISS ≥16 or ISS <16) to detect the relationship of mortality by trauma severity. Severe trauma was defined as ISS ≥16, and less-severe trauma as ISS <16.

Data collection

The JTDB includes patient characteristics, vital signs on admission, systolic blood pressure (SBP), Glasgow Coma Scale (GCS), respiratory rate (RR), trauma type and mechanism, means of transportation (ambulance, ambulance with doctor, or helicopter), ISS, Revised Trauma Score, Abbreviated Injury Scale (AIS), Trauma and Injury Severity Score, whole-body CT on admission, emergent intervention for hemorrhage (craniotomy, thoracotomy, celiotomy, bone fixation, and arterial embolization), discharge location (home, hospital transfer, or other), hospitalization (intensive care unit, ward, or other), length of hospital stay, and in-hospital mortality.

Statistical analysis

We characterized the study population using descriptive statistics. Continuous variables were described using means with SD. Ordinal variables were described using medians with IQR. Categorical variables were described using percentages.

To detect in-hospital mortality trends over these 10 years, we performed a Cochran-Armitage test and logistic regression. First, we conducted the Cochran-Armitage test. An analysis was performed by dividing patients according to ISS into a severe trauma group, a less-severe trauma group, and total patients. Second, a mixed-effect multivariable logistic regression was performed with in-hospital mortality as the dependent variable and age, gender, mechanism of trauma (blunt or penetrating), ISS, patients' vital signs (GCS, SBP, RR) on arrival, method of transportation (ambulance, ambulance with doctor, or helicopter), whole-body CT on admission, and hospital admission year as independent variables among the total geriatric group. Year was calculated and analyzed based on mortality in 2013. A similar methodology was previously used to evaluate in-hospital mortality.[6]

Statistical analysis was performed using Stata/IC V.15 (StataCorp, Lakeway, Texas, USA). The results of logistic regression are described using OR and a 95% CI. A p value <0.05 was considered statistically significant.

RESULTS

Baseline characteristics

From 265 268 patients admitted to the hospital between January 1, 2008 and December 31, 2017, we excluded those under 65 years old, of inadequate age or with missing age data, missing prognosis, OHCA, and burns, leaving 107 769 patients who were enrolled (figure 1).

Table 1 shows enrolled patient demographics by year. There were remarkable changes in the number of registered patients every year. In particular, trauma patients had increased and peaked in 2015 (n=17 622) and dropped dramatically in 2016 (n=9387) and 2017 (n=9374). The average patient age was 77 (71–83) years in 2008 and 80 (73–86) years in 2017. The number of patients 85–94 and over 94 kept increasing. About a half of injured patients were women. Most of the mechanisms for trauma were blunt, particularly motor vehicle accidents (MVAs) and falls. Motorcycle accidents were less common. Regarding falls, falls from steps or ground level falls happened frequently than falls from heights. Transportation means data showed an increase in cases with ambulances staffed with a doctor or helicopter over the 10 years.

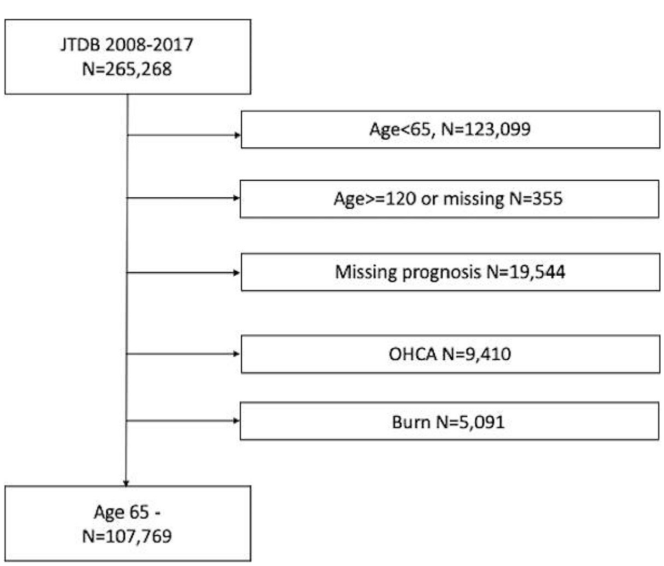


Figure 1 Study population flow chart. JTDB, Japan Trauma Data Bank; OHCA, out-of-hospital cardiac arrest.

Table 2 shows the severity of trauma by years. The proportion of severe trauma patients decreased as the years progressed. Severe head injury (AIS >3) occurred frequently than severe chest or abdominal injury. Extremity injuries happened at an almost similar frequency throughout the study period.

Table 3 demonstrated hospitalization and mortality in study periods. The number of whole-body CT on admission roughly tripled over the 10 years. Although emergent interventions have been decreasing overall, bone fixation doubled (23.0%–38.9%). The patients spent an average of 33–35 days in the hospital. Total geriatric trauma patient mortality constantly decreased over the study period (13.6%–6.7%).

Cochran-Armitage test

Figure 2 shows mortality trends over the study period, which were analyzed using the Cochran-Armitage test. Overall mortality (p<0.001) and severe trauma (p<0.001) decreased over the study period. However, mortality in less-severe patients in the geriatric trauma group did not differ statistically (p=0.41).

Mixed-effect logistic regression analysis

Table 4 shows the results of mixed-effect logistic regression analysis among geriatric trauma patients. In-hospital mortality was strongly associated with patient age (OR 1.05, 95% CI 1.048 to 1.057, p<0.001), male gender (OR 1.48, 95% CI 1.39 to 1.57, p<0.001), ISS (OR 1.06, 95% CI 1.057 to 1.064, p<0.001), and patient's vital sign on admission (GCS: OR 0.74, 95% CI 0.73 to 0.741, p<0.001; SBP: OR 0.997, 95% CI 0.996 to 0.998, p<0.001; RR: OR 1.023, 95% CI 1.019 to 1.028, p<0.001). Blunt trauma was also a significant risk factor compared with penetrating injury (OR 1.42, 95% CI 1.01 to 1.83, p=0.025). Based on normal ambulance transportation, aggressive prehospital activity with a doctor-staffed ambulance (OR 0.77, 95% CI 0.66 to 0.89, p=0.001) and helicopter medicine (OR 0.76, 95% CI 0.68 to 0.84, p<0.001) were strongly associated with reduction of mortality. Whole-body CT did not show an association with good prognosis (OR 0.96, 95% CI 0.90 to 1.03, p=0.27). Using mortality in 2013 as a standard, mortality in total geriatric patients was strongly associated with the year patients were admitted; there was a tendency for worse outcomes for earlier admission years and better outcomes for later admission years during the study period. This tendency was strongly apparent in the severe trauma patient group; however, it was not apparent in the less-severe trauma patients.

DISCUSSION

Our report is the first evaluation/analysis to compare geriatric trauma patients with younger trauma patients in Japan. Our results indicate that the overall quality of geriatric trauma patient care in Japan has improved over these 10 years, although there has been some fluctuation. Previous studies have reported 14.8% overall mortality rates in geriatric trauma and 26.5% in severely injured patients.[7] Therefore, our results support that geriatric trauma patients' prognosis in Japan is acceptable.

Table 1 Characteristics of patient demographics

Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Patient number		3814	5438	7277	9421	12 689	15 803	16 944	17 622	9387	9374
Age (years)		77 (71–83)	78 (72–84)	78 (72–85)	79 (72–85)	79 (72–85)	79 (72–85)	79 (72–85)	79 (72–85)	79 (72–86)	80 (73–86)
	65–74	1562 (41.0)	1921 (35.3)	2553 (35.1)	3213 (34.1)	4215 (33.2)	5038 (31.9)	5646 (33.3)	5966 (33.9)	3064 (32.6)	2863 (30.5)
	75–84	1506 (39.5)	2175 (40.0)	2876 (39.5)	3707 (39.3)	5016 (39.5)	6296 (39.8)	6671 (39.4)	6714 (38.1)	3623 (38.6)	3481 (37.1)
	84–94	667 (17.5)	1223 (22.5)	1658 (22.8)	2242 (23.8)	3083 (24.3)	3999 (25.3)	4166 (24.6)	4489 (25.5)	2399 (25.6)	2717 (29.0)
	95-	79 (2.1)	119 (2.9)	190 (2.6)	259 (2.7)	375 (3.0)	470 (3.0)	461 (2.7)	453 (2.6)	301 (3.2)	313 (3.3)
Gender	Male %	1798 (47.1)	2907 (53.5)	3820 (52.5)	4938 (52.4)	6745 (53.2)	8532 (54.0)	8865 (52.3)	9179 (52.1)	4908 (52.3)	4869 (51.9)
Cause of trauma											
	Blunt	3610 (94.7)	5203 (95.7)	6933 (95.3)	9031 (95.9)	12 214 (96.3)	15 233 (96.4)	16 344 (96.5)	16 957 (96.2)	9091 (96.8)	9051 (96.6)
	Penetrating	101 (2.6)	122 (2.2)	165 (2.3)	197 (2.1)	257 (2.0)	327 (2.1)	295 (1.7)	351 (2.0)	150 (1.6)	157 (1.7)
	Other	103 (2.7)	113 (2.1)	179 (2.5)	193 (2.0)	218 (1.7)	243 (1.5)	305 (1.8)	314 (1.8)	146 (1.6)	166 (1.8)
Mechanism of trauma											
	MVA driver	189 (5.0)	252 (4.6)	372 (5.1)	419 (4.4)	584 (4.6)	717 (4.5)	752 (4.4)	827 (4.7)	502 (5.3)	459 (4.9)
	MVA passenger	71 (1.9)	118 (2.2)	129 (1.8)	190 (2.0)	253 (2.0)	298 (1.9)	314 (1.9)	366 (2.1)	183 (1.9)	165 (1.8)
	Motorcycle	201 (5.3)	229 (4.2)	245 (3.4)	337 (3.6)	439 (3.5)	484 (3.1)	568 (3.4)	548 (3.1)	286 (3.0)	263 (2.8)
	Bicycle	320 (8.4)	425 (7.8)	509 (7.0)	614 (6.5)	709 (5.6)	836 (5.3)	898 (5.3)	913 (5.2)	473 (5.0)	448 (4.8)
	Pedestrian	407 (1.1)	467 (8.6)	590 (8.1)	699 (7.4)	900 (7.1)	1040 (6.6)	1143 (6.7)	1201 (6.8)	576 (6.1)	523 (5.6)
	Fall from height	257 (6.7)	297 (5.5)	398 (5.5)	480 (5.1)	557 (4.4)	768 (4.9)	803 (4.7)	846 (4.8)	422 (4.5)	384 (4.1)
	Fall from step	514 (13.5)	685 (12.6)	948 (13.0)	1364 (14.5)	1800 (14.2)	2135 (13.5)	2415 (14.3)	2597 (14.7)	1439 (15.3)	1431 (15.3)
	GLF	1424 (37.3)	2360 (43.4)	3387 (46.5)	4514 (47.9)	6422 (50.6)	8132 (51.5)	8589 (50.7)	8780 (49.8)	4794 (51.1)	4971 (53.0)
	Other	431 (11.3)	605 (11.1)	699 (9.6)	804 (8.5)	1025 (8.1)	1393 (8.8)	1462 (8.6)	1544 (8.7)	712 (7.6)	730 (7.8)
Transportation											
	Ambulance	3098 (81.2)	4230 (77.8)	5680 (78.1)	7308 (77.6)	9678 (76.3)	12 190 (77.1)	13 250 (78.2)	13 688 (77.7)	7082 (75.4)	7069 (75.4)
	Ambulance with doctor	51 (1.3)	64 (1.2)	127 (1.7)	168 (1.8)	250 (2.0)	281 (1.8)	429 (2.5)	416 (2.4)	210 (2.2)	229 (2.4)
	Helicopter	246 (6.4)	325 (6.0)	344 (4.7)	480 (5.1)	672 (5.3)	887 (5.6)	965 (5.7)	1087 (6.2)	715 (7.6)	647 (6.9)
	Other	419 (11.0)	819 (15.1)	1126 (15.5)	1465 (15.6)	2089 (16.5)	2445 (15.5)	2300 (13.6)	2431 (13.8)	1380 (14.7)	1429 (15.2)

GLF, ground level fall; MVA, motor vehicle accident.

Table 2 Trauma severities of patient demographics

Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ISS mean (IQR)		13 (9–21)	10 (9–18)	9 (9–17)	9 (9–17)	9 (9–17)	9 (9–17)	9 (9–17)	9 (9–17)	9 (9–17)	9 (9–17)
	≥16	1688 (44.3)	2134 (39.2)	2864 (39.4)	3690 (39.2)	4695 (37.0)	5435 (34.4)	6103 (36.0)	6510 (37.0)	3616 (38.5)	3301 (35.2)
AIS											
	Head >3	937 (24.6)	1194 (22.0)	1625 (22.3)	2149 (22.8)	2759 (21.7)	3027 (19.2)	3434 (20.3)	3695 (21.0)	2018 (21.5)	1849 (19.7)
	Neck >3	2 (0.05)	2 (0.03)	2 (0.02)	4 (0.04)	2 (0.01)	5 (0.03)	11 (0.06)	4 (0.02)	4 (0.04)	0 (0)
	Face >3	2 (0.05)	1 (0.01)	3 (0.04)	6 (0.06)	6 (0.04)	7 (0.04)	8 (0.04)	7 (0.04)	2 (0.02)	2 (0.02)
	Chest >3	366 (9.6)	425 (7.8)	569 (7.8)	713 (7.6)	921 (7.3)	1077 (6.8)	1202 (7.1)	1282 (7.3)	799 (8.5)	682 (7.3)
	Abdomen >3	75 (2.0)	79 (1.4)	79 (1.1)	110 (1.2)	144 (1.1)	118 (0.7)	146 (0.8)	155 (0.8)	75 (0.7)	56 (0.5)
	Spine >3	188 (4.9)	242 (4.5)	351 (4.8)	486 (5.2)	548 (4.3)	701 (4.4)	758 (4.5)	821 (4.7)	470 (5.0)	433 (4.6)
	Extremities >3	146 (3.8)	179 (3.3)	222 (3.1)	235 (2.5)	375 (3.0)	383 (2.4)	393 (2.3)	450 (2.6)	220 (2.3)	177 (1.9)
	Surface >3	2 (0.05)	2 (0.03)	1 (0.01)	0 (0)	6 (0.04)	3 (0.01)	4 0.02)	1 (0.005)	3 (0.03)	5 (0.05)
RTS		7.84 (6.90–7.84)	7.84 (7.55–7.84)	7.84 (7.55–7.84)	7.84 (7.55–7.84)	7.84 (7.55–7.84)	7.84 (7.84–7.84)	7.84 (7.84–7.84)	7.84 (7.84–7.84)	7.84 (7.84–7.84)	7.84 (7.84–7.84)
TRISS <0.5		321 (8.4)	340 (6.3)	395 (5.4)	537 (5.7)	720 (5.7)	743 (4.7)	831 (4.9)	818 (4.6)	447 (4.8)	344 (3.7)

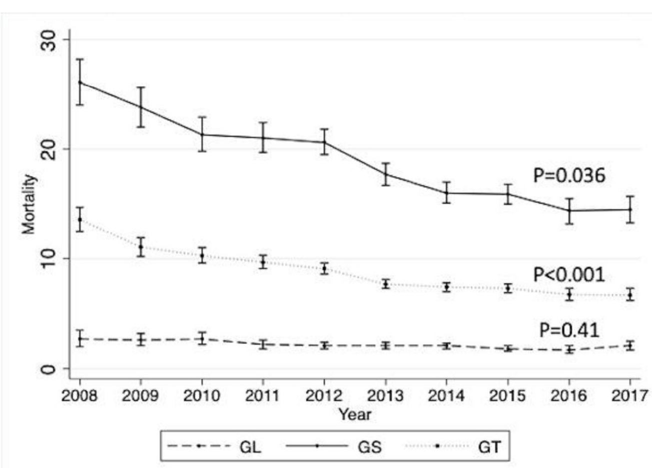
AIS, Abbreviated Injury Scale; ISS, Injury Severity Score; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

Table 3 Hospitalization and mortality of patient demographics

Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Whole-body CT		272 (7.1)	426 (7.8)	643 (8.8)	773 (8.2)	1320 (10.4)	1921 (12.2)	2607 (15.4)	3026 (17.2)	1888 (20.1)	1905 (20.3)
Emergent intervention											
	Craniotomy	156 (4.1)	197 (3.6)	264 (3.6)	352 (3.7)	424 (3.3)	454 (2.9)	553 (3.3)	501 (2.8)	288 (3.1)	238 (2.5)
	Thoracotomy	54 (1.4)	48 (0.88)	67 (0.92)	67 (0.71)	81 (0.64)	79 (0.5)	78 (0.46)	95 (0.54)	43 (0.46)	41 (0.44)
	Celiotomy	128 (3.4)	138 (2.5)	156 (2.1)	178 (1.9)	202 (1.6)	224 (1.4)	271 (1.6)	242 (1.4)	124 (1.3)	134 (1.4)
	Bone fixation	876 (23.0)	1741 (32.0)	2448 (33.6)	3211 (34.1)	4597 (36.2)	5846 (37.0)	6190 (36.5)	6366 (36.1)	3401 (36.2)	3644 (38.9)
	TAE	121 (3.2)	155 (2.9)	183 (2.5)	231 (2.5)	330 (2.6)	386 (2.4)	449 (2.7)	514 (2.9)	257 (2.7)	223 (2.4)
Hospitalization											
	ICU	2262 (59.3)	2807 (51.6)	3583 (49.2)	4519 (48.0)	6072 (47.9)	7312 (46.3)	8105 (47.8)	8291 (47.0)	4050 (43.1)	4137 (44.1)
	Ward	1285 (33.7)	2338 (43.0)	3388 (46.6)	4465 (47.4)	6027 (47.5)	7864 (49.8)	8278 (48.9)	8649 (49.1)	4939 (52.6)	4913 (52.4)
	Other	267 (7.0)	293 (5.4)	306 (4.2)	437 (4.6)	590 (4.6)	627 (4.0)	561 (3.3)	682 (3.9)	398 (4.2)	324 (3.5)
Discharge											
	Home	1116 (29.3)	1644 (30.2)	2288 (31.4)	3182 (33.8)	4529 (35.7)	5760 (36.4)	6014 (35.5)	6125 (34.8)	3287 (35.0)	3036 (32.4)
	Hospital transfer	2131 (55.9)	3050 (56.1)	4025 (55.3)	5009 (53.2)	6649 (52.4)	8363 (52.9)	9182 (54.2)	9610 (54.5)	5178 (55.2)	5391 (57.5)
	Other	567 (14.9)	744 (13.7)	964 (13.2)	1230 (13.1)	1511 (11.9)	1680 (10.6)	1748 (10.3)	1887 (10.7)	922 (9.8)	947 (10.1)
LOS		33 (9–107)	33 (11–105)	35 (13–109)	33 (12–107)	33 (12–102)	34 (13–108)	34 (13–107)	33 (12–105)	35 (14–105)	32 (13–105)
Mortality in hospital		519 (13.6)	601 (11.1)	747 (10.3)	911 (9.7)	1152 (9.1)	1213 (7.7)	1258 (7.4)	1287 (7.3)	633 (6.7)	625 (6.7)

ICU, intensive care unit; LOS, length of hospital stay; TAE, transarterial embolization.

We conducted an additional important analysis of trauma patients grouped according to severe or less-severe injury. Analysis results showed that mortality in the less-severe geriatric patients did not statistically improve over the study period. Early rehabilitation and the early intervention of bone fixation have been implemented recently. These strategies may be the key to enabling change to the stagnant trend.[8] Fortunately, mortality among severe trauma patients has been decreasing, even though it is still high. We are convinced that we should continue developing our skills and knowledge in the same manner as we have been doing thus far.



Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total	13.6	11.1	10.3	9.7	9.1	7.7	7.4	7.3	6.7	6.7
Less-severe	2.7	2.6	2.7	2.2	2.1	2.1	2.1	1.8	1.7	2.1
Severe	26.1	23.8	21.3	21.0	20.6	17.7	16.0	15.9	14.4	14.5

Figure 2 Mortality trends among geriatric trauma patients over the 10-year time period. Significant decrease was found among total geriatric patients and severe geriatric trauma patients, however, mortality in geriatric less-severe trauma patients did not differ. GL, geriatric, less-severe trauma patient group; GS, geriatric, severe trauma patient group; GT, geriatric, total trauma patient group.

In our study, the prevalent injury mechanisms for elderly trauma patients were blunt, such as vehicle collisions, falls and pedestrian events. This is compatible with findings from previous epidemiological studies of geriatric trauma.[9, 10] Particularly, rates of low-energy falls, for instance, falls from steps (13.5%–15.3%) and ground level falls (37.3%–53.0%) and MVAs as a pedestrian (1.1%–5.6%) have been increasing. In contrast, the rate of falls from heights has decreased (6.7%–4.1%). Rates of MVAs as a driver (5.0%–4.9%) or passenger (1.9%–1.8%) have remained almost the same. We argue that this shift toward low-energy falls in this demographic might be the reason for the downward trend in ISS and decrease in the proportion of severe trauma patients. Also, functional improvements in motor vehicle safety devices such as airbags, as well as body absorption and crash avoidance systems may contribute to favorable outcomes. In our study, more severe traumatic head injuries were seen in elderly patients. Anatomical changes that come with aging affect the pathophysiology of head trauma in geriatric trauma patients. The stronger adherence of the dura to the skull and subsequent underlying bridging veins in elderly patients are more prone to damage in head trauma.

Presumably, improvement of resuscitation and intensive care modalities may have supported the progressive success of geriatric trauma care, including pharmacological intervention,[11] blood transfusion protocol,[12] hypotensive resuscitation strategy[13] and the concept of damage control surgery and damage control resuscitation.[14]

Table 4 Mixed-effect logistic regression analysis for mortality among total geriatric patients

		All patients		ISS <16		ISS ≥16	
		OR	95% CI	OR	95% CI	OR	95% CI
Age		1.05	1.048 to 1.057	1.06	1.056 to 1.07	1.052	1.048 to 1.057
Gender							
	Female	–	–	–	–	–	–
	Male	1.48	1.39 to 1.57	1.97	1.70 to 2.78	1.278	1.192 to 1.373
Mechanism of injury							
	Penetrating	–	–	–	–	–	–
	Blunt	1.42	1.10 to 1.83	2.01	1.28 to 3.16	0.93	0.68 to 1.28
ISS		1.06	1.057 to 1.064	1.05	1.03 to 1.08	1.049	1.045 to 1.052
GCS		0.74	0.73 to 0.741	0.46	0.43 to 0.50	0.41	0.399 to 0.421
SBP		0.997	0.996 to 0.998	0.989	0.987 to 0.991	0.998	0 .997 to 0.999
RR		1.023	1.019 to 1.028	1.034	1.025 to 1.043	1.015	1.011 to 1.020
Transportation							
	Ambulance	–	–	–	–	–	–
	Ambulance with doctor	0.77	0.66 to 0.89	1.09	0.68 to 1.74	0.77	0.66 to 0.90
	Helicopter	0.76	0.68 to 0.84	0.75	0.53 to 1.06	0.76	0.69 to 0.85
Whole-body CT		0.96	0.90 to 1.03	1.1	0.90 to 1.35	0.93	0 .86 to 1.01
Year							
	2008	1.53	1.32 to 1.88	1.10	0.76 to 1.61	1.65	1.39 to 1.95
	2009	1.50	1.30 to 1.73	1.35	0.98 to 1.86	1.52	1.29 to 1.78
	2010	1.27	1.11 to 1.46	1.12	0.83 to 1.52	1.30	1.12 to 1.51
	2011	1.11	0.98 to 1.27	0.81	0.59 to 1.11	1.18	1.03 to 1.36
	2012	1.17	1.04 to 1.32	0.91	0.69 to 1.19	1.23	1.08 to 1.40
	2013	–	–	–	–	–	–
	2014	0.91	0.81 to 1.02	0.93	0.73 to 1.20	0.89	0.77 to 1.02
	2015	0.89	0.80 to 0.999	0.76	0.66 to 1.09	0.90	0.79 to 1.02
	2016	0.79	0.69 to 0.91	0.76	0.56 to 1.04	0.79	0.68 to 0.91
	2017	0.88	0.76 to 1.01	0.98	0.74 to 1.30	0.84	0.72 to 0.99

GCS, Glasgow Coma Scale; ISS, Injury Severity Score; RR, respiratory rate; SBP, systolic blood pressure.

Alternatively, progress in education for trauma care may have contributed to improvements in outcomes. In reference to the American College of Surgeons Committee on Trauma Care's Advanced Trauma Life Support program, we launched a Japanese-originated Japan Advanced Trauma Evaluation and Care Association in 2002 and Japan Expert Trauma Education and Care in 2014.[15] Early diagnosis and intervention followed by the early intervention of sepsis and acute distress syndrome after trauma in the intensive care unit might have contributed to the improvements in intensive care.[16 17]

According to prehospital activity, our study showed that ambulances with doctors (OR 0.77, 95% CI 0.66 to 0.89, p<0.001) and helicopter transport (OR 0.76, 95% CI 0.66 to 0.84, p<0.001) were associated with decreased mortality compared with normal ambulance transport. The prevalence of ambulances staffed by doctors, helicopter transportation, and early intervention to acute hemorrhage in prehospital activity have the potential to reduce mortality. Prehospital management of severe trauma patients by emergency medical service teams, including physicians, might be associated with lower mortality.[18] Prehospital administration of thawed plasma to injured patients resulted in lower 30-day mortality.[19] However, the efficacy of ambulances staffed by doctors in Japan was not clear.[20] Further studies are necessary to describe the relationship between prehospital activity and mortality in Japan.

Optimal care of injured elderly patients includes formally setting goals of care early in these patients' hospital courses. Whole-body CT and emergent CT scan have also been considered optimal methods to reduce trauma patients' mortality. Whole-body CT has been reported to be effective among severe trauma patients with at least one abnormal vital sign.[21] The method using emergent department with interventional radiology suite and CT improved mortality in severe trauma patients.[22] However, whole-body CT did not show this effectiveness in our study (OR 0.96, 95% CI 0.90 to 1.03, p=0.27). This is because our study data were collected from a trauma center and a non-trauma center. As an acute phase of trauma care, enough manpower and adequate capability as a trauma center are necessary. To make the most of whole-body and emergent CT, these factors might be essential.

In the USA, it is reported that patients over 70 years old have a significantly greater risk than all younger age groups,[23] and the highest level trauma activation should be mandatory for all injured patients 70 years old and older on emergency department arrival, which decreases mortality.[24] Both age and trauma patients' nutritional status are important when predicting prognosis. Frailty is an independent predictor of in-hospital complications.[25] Recently, sarcopenia has been considered a critical factor and predictor of poor mortality and comorbidities.[26 27] To evaluate accurate prognosis and mortality, further methods and analyses are still under consideration due to the complexity of trauma among geriatrics.[5 28 29] In addition, physicians must be aware that the adverse and predominant effects of anemia in the elderly are enhanced in the traumatic injury setting, which often involves acute blood loss and may hinder erythropoiesis by interfering with bone marrow function and iron metabolism due to increased levels of circulating catecholamines and inflammatory mediators.[30]

Our study has several limitations. First, this is a retrospective study, which may cause information bias. In addition, not all hospitals participate in the JTDB. Our results and the proportion of geriatric patients may be affected by the area where the hospital is located. Furthermore, patients' information in the JTDB is limited, and data about comorbidities or medication, which is strongly associated with mortality especially in elderly, are unavailable. Second, the small sample size of trauma patients in the database relative to those in Europe and the USA might limit interpretation of the results. Third, the number of trauma patients dropped from 2015 to 2016 unnaturally, which may indicate inaccuracy in these data. This may have caused a selection bias. Fourth, trauma severity decreased dramatically over the study period, which may affect patients' prognosis. To minimize and adjust for this confounder, we conducted mixed-effect logistic regression analysis. Fifth, information about withdrawal of treatment or living wills were not considered in this study design. This issue is always problematic when trying to make conclusions about geriatric treatment care.

Our analysis of geriatric trauma care showed that it improved in Japan over a recent 10-year period (2008–2017). However, less-severe trauma patient mortality has not changed statistically significantly. We need to promote the quality of trauma systems and prepare for a further aging society. To accomplish this, improvement in mortality among less-severe trauma patients may be the main factor.

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