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ORIGINAL CONTRIBUTION

Association Between Male Sex and Increased Mortality After Falls

Taka-aki Nakada, MD, PhD, Shota Nakao, MD, Yasuaki Mizushima, MD, PhD, and
Tetsuya Matsuoka, MD, PhD

Abstract

Objectives: Whether sex affects the mortality of trauma patients remains unknown. The hypothesis of this study was that sex was associated with altered mortality rates in trauma.

Methods: A retrospective review of trauma patients' records in the Japan Trauma Data Bank was conducted (n = 80,813) from 185 major emergency hospitals across Japan. The primary outcome variable was in-hospital mortality within 28 days. Secondary outcome variables included serious injuries to different body regions with an Abbreviated Injury Scale of ≥3.

Results: In the analysis of 80,813 trauma patients, males had significantly greater 28-day mortality compared to females (adjusted p = 0.0072, odds ratio [OR] = 1.14, 95% confidence interval [CI] = 1.06 to 1.23) via logistic regression analysis adjusted for age, mechanism, Injury Severity Score, Revised Trauma Score, and potential preexisting risk factors. Of 10 injury categories examined, sex significantly affected in-hospital 28-day mortality rate in falls (adjusted p < 0.0001, OR = 1.34, 95% CI = 1.19 to 1.52). Further analysis of three fall subcategories by falling distance revealed that male patients who fell from ground level had significantly higher 28-day mortality (adjusted p < 0.0001, OR = 1.75, 95% CI = 1.43 to 2.14) and a significantly greater frequency of serious injury to the head, thorax, abdomen, and spine, but a lower frequency of serious injury to the extremities, compared to female patients.

Conclusions: Compared to female trauma patients, male trauma patients had greater 28-day mortality. In particular, ground-level falls had a significant sex difference in mortality, with serious injury to different body regions. Sex differences appeared to be important for fatalities from ground-level falls.

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Trauma is a leading cause of overall population mortality and a major health problem.[1,2] In the United States, road injury, one of the major trauma categories, is the fifth leading cause of years of life lost, ranking immediately below ischemic heart disease, lung cancer, stroke, and chronic obstructive pulmonary disease, while ranking above colorectal and breast cancer.[1] Falls, transport injuries, burns, and exposures to mechanical forces have also been mentioned in global public health studies aiming at reducing premature mortality in public health.[1,2]

Differences in clinical outcomes by patient sex have been extensively reported in common diseases or conditions, including heart diseases,[3,4] lung diseases,[5] stroke,[6] and critical illnesses.[7] Furthermore, recent proposals on sex-specific approaches to improve clinical outcomes, including sex-specific surveillance, screening, and interventions, have highlighted the importance of investigating sex differences.[3,5,8] Sex differences have been previously studied in trauma, focusing on dissimilar responses by sex to hemorrhagic shock[9,10] or altered risks of trauma-associated lung complications.[11,12] However, data on whether sex affects the mortality of trauma patients remain inconsistent.[7,13–16] Therefore, in this study, we tested the hypothesis that sex was associated with mortality rate in trauma patients using a large cohort across Japan. Because clinical outcomes are associated with not only the type of injury but also its severity, we investigated the differences in mortality by sex according to the type of injury with adjustment for severity. The primary outcome was in-hospital 28-day mortality, and the

From the Senshu Trauma and Critical Care Center (TN, SN, YM, TM), Osaka; and Department of Emergency and Critical Care Medicine, Chiba University Graduate School of Medicine (TN), Chiba, Japan.
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Supervising Editor: Richard Byyny, MD, MSc.
Address for correspondence and reprints: Taka-aki Nakada, MD, PhD; e-mail: taka.nakada@nifty.com.

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secondary outcome variables included serious injuries to various body regions.

Japan Trauma Data Bank

The Japan Trauma Data Bank (JTDB) is a trauma databank supported by the Japanese Association for the Surgery of Trauma and the Japanese Association for Acute Medicine, similar to trauma databases in North America, Europe, and Oceania.[17] The JTDB aims to improve the quality of trauma care[18,19] and provides annual reports.[20] The JTDB data were registered by 185 major emergency medical hospitals across Japan.

The JTDB captures trauma cases with data on age, sex, mechanism of injury, Abbreviated Injury Scale (AIS; 1998 version), Injury Severity Score (ISS), Revised Trauma Score (RTS), and in-hospital 28-day mortality. Patients are categorized by institutions into one of 10 categories according to their mechanism of injury, which includes eight blunt trauma categories (road injury, fall, compression injury, sports injury, machinery injury, falling object injury, railway injury, and other), penetrating trauma (stab, gunshot, impalement injury, and other), and burns. Similarly, patients who experience falls are divided into three subcategories according to the height of fall: low (falls from ground level), medium (falls from stairs), and high (falls from higher levels than stairs). Preexisting conditions such as cerebrovascular disease (hemiplegia, etc.), ischemic heart disease, liver cirrhosis, and dementia, as well as alcohol use on day of injury and use of anticoagulants, are also extracted from the medical record and entered into the JTDB by participating institutions.

METHODS

Study Design

This was a retrospective cohort study using the JTDB. The institutional review board at the Senshu Trauma and Critical Care Center approved this study, and because the JTDB is an anonymous registry, the institutional review board waived the need for patient consent.

Study Setting and Population

In this study, we analyzed the data set of 80,813 patients in Japan nationwide who experienced trauma between January 2004 and December 2012 and were registered in the JTDB.

Study Protocol

The primary outcome variable was in-hospital mortality within 28 days. We first focused on all trauma patients and tested for sex differences using a binary logistic regression test, which allowed for the correction of potential confounding factors including age, mechanism, ISS (anatomically based severity score), RTS (physiologically based severity score), and potential preexisting risk factors of trauma morality, such as preexisting cerebrovascular disease (hemiplegia, etc.), ischemic heart disease, liver cirrhosis, and dementia.[21] For the fall category, we further examined sex difference in the three height-of-fall subcategories mentioned above using the logistic regression method. Because alcohol use on day of injury and use of anticoagulants are potential factors for mortality risk in ground-level fall,[22] we added these as covariates in the logistic regression analysis of the ground-level fall.

The secondary outcome variables were serious injuries (AIS ≥ 3) to six body regions: head, thorax, abdomen, spine, upper, and lower extremities. We used the chi-square or Fisher's exact test for analysis. We further investigated sex differences in mortalities using a stratified analysis by anatomic injury location.

Data Analysis

Differences were considered significant with a two-tailed p-value of <0.05. Multiple comparisons were adjusted using the Bonferroni procedure. Absolute standardized differences in characteristics between male and female patients of ground-level falls were calculated. All analyses were performed using SPSS (version 21).

RESULTS

We first examined data on 80,813 trauma patients for differences in 28-day in-hospital mortality by sex. In the logistic regression test, adjusting for potential confounding factors including age, mechanism, ISS, RTS, and potential preexisting risk factors of trauma morality such as preexisting cerebrovascular disease (hemiplegia, etc.), ischemic heart disease, liver cirrhosis, and dementia, males had significantly greater 28-day mortality compared to females (adjusted p = 0.0072; odds ratio [OR] = 1.14; 95% confidence interval [CI] = 1.06 to 1.23).

Sex differences in 28-day in-hospital mortality in each injury category are shown in Table 1. Of the 10 injury categories, injuries from falls were significantly associated with altered 28-day in-hospital mortality by sex. Male patients who had fall injuries had significantly greater 28-day mortality compared to female patients (adjusted p < 0.0001, OR = 1.34, 95% CI = 1.19 to 1.52, via logistic regression analysis followed by Bonferroni correction; Table 1).

Patients experiencing falls were assigned to the three subcategories by the height: low (falls from ground level, *n* = 15,207), medium (falls from stairs, *n* = 8,553), and high (fall from levels higher than stairs, *n* = 9,725). We determined sex difference in mortality for each fall subcategory. No significant sex difference in in-hospital 28-day mortality was observed in the high (adjusted p = 0.21, OR = 1.15, 95% CI = 0.92 to 1.44) or medium (adjusted p = 0.76, OR = 1.04, 95% CI = 0.82 to 1.31) fall subcategories via logistic regression analysis adjusted by age, ISS, RTS, and preexisting risk factors. In contrast, male patients who fell from ground level had a significantly greater mortality rate compared to female patients (in-hospital 28-day mortality, male vs. female [total], 0.069 vs. 0.029 [0.045]; p < 0.0001, OR = 1.66, 95% CI = 1.35 to 2.03), via logistic regression analysis adjusted for age, ISS, and RTS, preexisting cerebrovascular disease (hemiplegia, etc.), ischemic heart disease, liver cirrhosis, and dementia; Table 2, Figure 1). Alcohol use on day of injury and use of anticoagulant are potential factors for mortality risk in ground-level falls.[21] Repeating the logistic regression analysis adding alco-

Table 1
In-hospital 28-day Mortality Rate by Sex in Ten Different Injury Categories

	Mortality (Death/Total cases)			
	Male	Female	Adjusted p-value	OR (95% CI)
Blunt trauma				
Road injury	0.120 (2,962/24,728)	0.136 (1,462/10,741)	0.85	1.01 (0.90–1.13)
Falls	0.121 (2,334/19,233)	0.086 (1,227/14,252)	<0.0001*	1.34 (1.19–1.52)
Compression injury	0.139 (143/1,030)	0.099 (10/101)	0.49	1.58 (0.44–5.73)
Sports injury	0.022 (20/892)	0.006 (1/166)	0.15	34.0 (0.28–4200)
Machinery injury	0.033 (25/749)	0.036 (4/111)	0.19*	0.09 (0.01–0.67)
Falling object injury	0.089 (57/643)	0.093 (5/54)	0.11	0.31 (0.08–1.28)
Railway injury	0.367 (106/289)	0.370 (61/165)	0.78	0.90 (0.42–1.92)
Others	0.080 (120/1,503)	0.075 (43/576)	0.21	1.47 (0.81–2.69)
Penetrating trauma	0.086 (179/2,090)	0.088 (71/804)	0.84	1.06 (0.62–1.82)
Burn	0.168 (291/1,735)	0.171 (163/951)	0.48	1.11 (0.83–1.50)
Total	0.118 (6,237/52,892)	0.109 (3,047/27,921)	0.0072*	1.14 (1.06–1.23)

*When the logistic regression p-value was <0.05, Bonferroni correction was subsequently performed; the Bonferroni corrected p-value is shown.

Table 2
Characteristics of Patients With Injury Due to Falls From Ground Level

Characteristics	Male (n = 6,385)	Female (n = 8,822)	Absolute Standardized Difference, %
Age, yr	67.2 (20.2)	79.1 (14.5)	67.7
Systolic blood pressure, mm Hg	142.4 (32.6)	147.7 (30.6)	16.8
Heart rate, beats/min	84.9 (20.5)	83.0 (16.8)	10.1
Respiratory rate, breaths/min	19.9 (5.5)	19.7 (4.8)	3.9
Glasgow Coma Scale score	13.3 (3.1)	14.2 (2.0)	34.5
Injury Severity Score	13.4 (7.3)	10.5 (5.0)	46.4
Revised Trauma Score	7.416 (1.011)	7.670 (0.633)	30.1
Alcohol use on day of injury, n (%)	1,332 (20.9)	215 (2.4)	60.2
Preexisting conditions, n (%)			
Cerebrovascular disease	826 (12.9)	1,002 (11.4)	4.6
Ischemic heart disease	425 (6.7)	655 (7.4)	2.7
Liver cirrhosis	120 (1.9)	85 (1.0)	7.5
Dementia	466 (7.3)	1,490 (16.9)	29.8
Use of anticoagulant	177 (2.8)	183 (2.1)	4.5

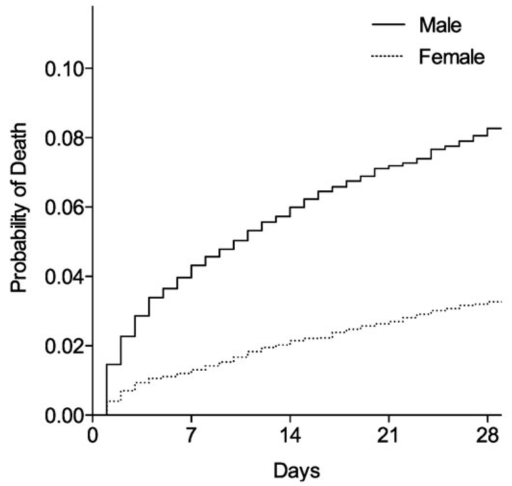
Data are presented as mean (SD) for continuous variables.

hol use on day of injury and use of anticoagulant as covariates yielded the same conclusions ($p < 0.0001$, OR = 1.75, 95% CI = 1.43 to 2.14).

In addition, we also examined sex differences in seriously injured body regions (AIS $\geq$ 3) among patients experiencing ground-level falls. Compared to female patients, male patients had a significantly greater frequency of serious injury to the head, thorax, abdomen, and spine, resulting in more surgical interventions to the head and abdomen (Table 3). However, female patients had a higher frequency of serious injury to the upper and lower extremities, resulting in more bone fixation procedures compared to those performed in male patients (Table 3). We next investigated sex differences in mortality using a stratified analysis by injury location. There was no significant sex difference in mortality in serious head, thorax, abdomen, or spine injury, while female patients who had serious lower extremity injury had significantly lower mortality compared to male patients (Table 4). It seems probable that the higher prevalence of injuries to the head, thorax, and spine in males, as well as higher prevalence of lower extremity with lower mortality in females, might explain the overall greater mortality in males.

DISCUSSION

Overall sex differences in mortality among trauma patients have been tested previously in multiple cohorts. In this study, when analyzing overall trauma mortality, we observed that male patients had a greater mortality rate compared to female patients. In accordance with our findings, a univariate analysis of all trauma patients admitted to three Level I trauma centers in the United States revealed that male patients had a significantly higher mortality rate than female patients (mortality, male vs. female, 0.07 vs. 0.05, $p < 0.002$ by chi-square test, patients younger than 50 years of age, n = 15,839).[23] However, two other single-institution studies from Level I trauma centers in Denver, Colorado,[24] and Maryland[25] reported no significant differences in mortality by sex via univariate analyses



Number at Risk					
Male	6365	4385	3257	2396	1719
Female	8822	7370	6321	4508	2777

Figure 1. Survival curves by sex during a 28-day period for patients with ground-level falls.

Table 3
Frequencies of Serious Injury (Abbreviated Injury Scale [AIS] of ≥ 3) and Surgical Intervention in the Cohort of Ground-level Falls

Variable	Male (n = 6,385)	Female (n = 8,822)	p-value
AIS score ≥ 3			
Head	0.456	0.185	<0.0001
Thorax	0.071	0.021	<0.0001
Abdomen	0.017	0.009	<0.0001
Spine	0.101	0.031	<0.0001
Upper extremity	0.026	0.039	<0.0001
Lower extremity	0.248	0.659	<0.0001
Surgical intervention			
Head	0.092	0.036	<0.0001
Thorax	0.002	0.001	0.067
Abdomen	0.005	0.003	0.010
Bone	0.232	0.556	<0.0001

(Denver, ISS > 15, n = 545—mortality, male vs. female, 0.093 vs. 0.096, p = 0.87 by chi-square test; Maryland, all trauma patients, n = 18,892—0.048 vs. 0.047, p = 0.93 by chi-square test). Nonetheless, these studies showed that male trauma patients had a significantly increased risk of infections.[24,25] A recent multivariate logistic regression analysis in a statewide trauma cohort demonstrated a nonsignificant sex difference (p = 0.093, n = 22,324).[13] Because the above-mentioned published studies did not include analysis by injury type, our significant findings on mortality difference by sex after falls has not been described.

We screened 10 injury categories and identified that a mortality difference by sex was only observed in the fall category, including its three subcategories according to the height of such falls (Table 1). Falls are the number one cause of geriatric trauma,[26] and surpassing traffic crashes, falls suffered by seniors both are the leading cause of spinal cord injury in the United States and have a trend of rising incidence.[27] In accordance with our results in the fall category, the Centers for Disease Control and Prevention (CDC) reported that male patients experiencing falls had a higher mortality rate than did female patients,[28] although the CDC report did not include subcategory analysis like ours. We found that, of the three fall subcategories, sex difference in mortality was significant only in ground-level falls.

Spaniolas et al.[29] studied ground-level falls using the National Trauma Databank of the American College of Surgeons and reported that fall patients older than 70 years of age with GCS scores of <15 had an increased mortality rate. Since the severity and hospital mortality rate of the American study[29] were slightly different from our Japanese study (Japanese vs. American, average ISS 12 vs. 8, hospital mortality 0.056 vs. 0.032), our study results are not generalizable to U.S. mechanical falls victims. However, interestingly, higher mortality in males after ground-level falls was similarly observed in the American study (mortality, male vs. female, 0.048% vs. 0.023%).

Ground-level falls have characteristics of lower magnitude of injury energy,[29] and higher occurrence in elderly patients,[30] compared to medium- or high-level

Table 4
28-day Mortality of Patients Who Had Serious Injury (Abbreviated Injury Scale [AIS] of ≥ 3) and Surgical Intervention in the Cohort of Ground-level Falls

	Mortality (Death/Total Cases)			
Measure, Injury Location	Total (N = 15,207)	Male (n = 6,385)	Female Mortality (n = 8,822)	p-value
AIS score ≥ 3				
Head	0.120 (545/4,543)	0.125 (364/2,910)	0.111(181/1,633)	0.16
Thorax	0.038 (24/635)	0.047 (21/451)	0.016 (3/184)	0.11
Abdomen	0.049 (9/185)	0.037 (4/109)	0.066 (5/76)	0.49
Spine	0.017 (16/917)	0.020 (13/642)	0.011 (3/275)	0.42
Upper extremity	0.012 (6/511)	0.006 (1/168)	0.015 (5/343)	0.67
Lower extremity	0.014 (101/7,403)	0.028 (44/1,586)	0.010 (57/5,817)	<0.0001
Surgical intervention				
Head	0.166 (150/905)	0.176 (104/590)	0.146 (46/315)	0.24
Thorax	0.267 (4/15)	0.300 (3/10)	0.200 (1/5)	1.0
Abdomen	0.105 (6/57)	0.029 (1/34)	0.217 (5/23)	0.034
Bone	0.007 (42/6,380)	0.010 (15/1,479)	0.006 (27/4,901)	0.053

falls. We speculate that there are possible links between these two characteristics and the sex differences in mortality of ground-level falls.

Female patients have been reported to more likely fall first on their hips, and sex differences in fall direction have also been reported.[31] In accordance with these observations, we found that female patients experienced more serious injuries to the lower extremities than did male patients. In addition, a slow gait speed was more likely to result in an impact on the hip,[32] and gait speed was reported to be lesser in women than in men.[33] Thus, gait speed might be a potential factor for the mortality difference by sex. Male patients experienced more serious injuries to the head and spine than did female patients in this study. Similar to our findings, male sex was reported to be a risk factor for head injury in patients with cervical spine fracture resulting from ground-level falls.[34] Our results suggest the possibility that the kinematics of ground-level falls may differ between sexes and deserves further exploration.

LIMITATIONS

The investigation was designed as a retrospective study. Additionally, although our results indicate that compared to female patients, male patients have an increased mortality rate and a higher frequency of serious injury to the head, thorax, and spine, these two significant findings do not prove causation. Another consideration might be that death may not have been directly related to the trauma. In addition, there is a possibility that the trauma database did not capture patients who received significant blunt trauma to any part of their body and eventually fell, in the "fall" trauma category. Further studies including detailed subcategories of fall would strengthen the study results.

CONCLUSIONS

Our analysis revealed that compared to female trauma patients, male trauma patients have a greater 28-day mortality rate, particularly in patients with injuries caused by ground-level falls. Significant differences in seriously injured body regions were observed between male and female patients experiencing ground-level falls. Compared to female patients, male patients had an increased frequency of serious injuries to the head, thorax, and spine, and more surgical intervention of head and abdomen, yet a decreased frequency of injuries to the extremities. These results suggested the potential importance of sex in fatalities resulting from falls.

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References

1. Murray CJ, Abraham J, Ali MK, et al. The state of US Health, 1990–2010: burden of diseases, injuries, and risk factors. JAMA 2013;10:591–608.
2. Murray CJ, Richards MA, Newton JN, et al. UK health performance: findings of the Global Burden of Disease Study 2010. Lancet 2013;381:997–1020.
3. Mega JL, Hochman JS, Scirica BM, et al. Clinical features and outcomes of women with unstable ischemic heart disease: observations from metabolic efficiency with ranolazine for less ischemia in non-ST-elevation acute coronary syndromes-thrombolysis in myocardial infarction 36 (MERLIN-TIMI 36). Circulation 2010;121:1809–17.
4. Bui AL, Horwich TB, Fonarow GC. Epidemiology and risk profile of heart failure. Nat Rev Cardiol 2011;8:30–41.
5. Townsend EA, Miller VM, Prakash YS. Sex differences and sex steroids in lung health and disease. Endocr Rev 2012;33:1–47.
6. Gall SL, Tran PL, Martin K, Blizzard L, Srikanth V. Sex differences in long-term outcomes after stroke: functional outcomes, handicap, and quality of life. Stroke 2012;43:1982–7.
7. Mahmood K, Eldeirawi K, Wahidi MM. Association of gender with outcomes in critically ill patients. Crit Care 2012;16:R92.
8. Greenberg MR, Kane BG, Totten VY, et al. Injury due to mechanical falls: future directions in gender-specific surveillance, screening, and interventions in emergency department patients. Acad Emerg Med 2014;21:1380–5.
9. Choudhry MA, Schwacha MG, Hubbard WJ, et al. Gender differences in acute response to trauma-hemorrhage. Shock 2005;24(Suppl 1):101–6.
10. Haider AH, Crompton JG, Chang DC, et al. Evidence of hormonal basis for improved survival among females with trauma-associated shock: an analysis of the National Trauma Data Bank. J Trauma 2010;69:537–40.
11. Heffernan DS, Dossett LA, Lightfoot MA, et al. Gender and acute respiratory distress syndrome in critically injured adults: a prospective study. J Trauma 2011;71:878–83.
12. Gannon CJ, Pasquale M, Tracy JK, McCarter RJ, Napolitano LM. Male gender is associated with increased risk for postinjury pneumonia. Shock 2004;21:410–4.
13. Gannon CJ, Napolitano LM, Pasquale M, Tracy JK, McCarter RJ. A statewide population-based study of gender differences in trauma: validation of a prior single-institution study. J Am Coll Surg 2002;195:11–8.
14. Bowles BJ, Roth B, Demetriades D. Sexual dimorphism in trauma? A retrospective evaluation of outcome. Injury 2003;34:27–31.
15. Schandl A, Bottai M, Hellgren E, Sundin O, Sackey P. Gender differences in psychological morbidity and treatment in intensive care survivors–a cohort study. Crit Care 2012;16:R80.
16. Schoeneberg C, Kauther MD, Hussmann B, Keitel J, Schmitz D, Lendemans S. Gender- specific differences in severely injured patients between 2002 and 2011: data analysis with matched-pair analysis. Crit Care 2013;17:R277.
17. Tohira H, Jacobs I, Mountain D, Gibson N, Yeo A. International comparison of regional trauma registries. Injury 2012;43:1924–30.
18. Shoko T, Shiraishi A, Kaji M, Otomo Y. Effect of pre-existing medical conditions on in-hospital mor-

tality: analysis of 20,257 trauma patients in Japan. J Am Coll Surg 2010;211:338–46.
19. Kondo Y, Abe T, Kohshi K, Tokuda Y, Cook EF, Kukita I. Revised trauma scoring system to predict in-hospital mortality in the emergency department: Glasgow Coma Scale, age, and systolic blood pressure score. Crit Care 2011;15:R191.
20. Japanese Association for Surgery of Trauma, Japanese Association for Acute Medicine. Japan Trauma Data Bank Report (2008-2012). Available at: https://www.jtcr-jatec.org/traumabank/dataroom/data/JTDB2013e.pdf. Accessed Mar 22, 2015.
21. Thompson HJ, Rivara FP, Nathens A, Wang J, Jurkovich GJ, Mackenzie EJ. Development and validation of the mortality risk for trauma comorbidity index. Ann Surg 2010;252:370–5.
22. Sarani B, Temple-Lykens B, Kim P, et al. Factors associated with mortality and brain injury after falls from the standing position. J Trauma 2009;67:954–8.
23. Wohltmann CD, Franklin GA, Boaz PW, et al. A multicenter evaluation of whether gender dimorphism affects survival after trauma. Am J Surg 2001;181:297–300.
24. Offner PJ, Moore EE, Biffl WL. Male gender is a risk factor for major infections after surgery. Arch Surg 1999;134:935–8.
25. Napolitano LM, Greco ME, Rodriguez A, Kufera JA, West RS, Scalea TM. Gender differences in adverse outcomes after blunt trauma. J Trauma 2001;50:274–80.
26. Chu I, Vaca F, Stratton S, Chakravarthy B, Hoonpongsimanont W, Lotfipour S. Geriatric trauma care: challenges facing emergency medical services. Cal J Emerg Med 2007;8:51–5.
27. Selvarajah S, Hammond ER, Haider AH, et al. The burden of acute traumatic spinal cord injury among adults in the united states: an update. J Neurotrauma 2014;31:228–38.
28. Centers for Disease Control and Prevention. Fatalities and injuries from falls among older adults–United States, 1993-2003 and 2001-2005. MMWR Morb Mortal Wkly Rep 2006;55:1221–4.
29. Spaniolas K, Cheng JD, Gestring ML, Sangosanya A, Stassen NA, Bankey PE. Ground level falls are associated with significant mortality in elderly patients. J Trauma 2010;69:821–5.
30. Rau CS, Lin TS, Wu SC, et al. Geriatric hospitalizations in fall-related injuries. Scand J Trauma Resusc Emerg Med 2014;22:63.
31. O'Neill TW, Varlow J, Silman AJ, et al. Age and sex influences on fall characteristics. Ann Rheum Dis 1994;53:773–5.
32. Smeesters C, Hayes WC, McMahon TA. Disturbance type and gait speed affect fall direction and impact location. J Biomech 2001;34:309–17.
33. Tolea MI, Costa PT, Terracciano A, et al. Sex-specific correlates of walking speed in a wide age-ranged population. J Gerontol B Psychol Sci Soc Sci 2010;65B:174–84.
34. Wang H, Coppola M, Robinson RD, et al. Geriatric trauma patients with cervical spine fractures due to ground level fall: five years experience in a level one trauma center. J Clin Med Res 2013;5:75–83.