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Original Article

Differences between the sexes in motorcycle-related injuries and fatalities at a Taiwanese level I trauma center

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ABSTRACT

Background: Female patients present with unique physiological and behavioral characteristics compared to male patients. The aim of this study was to investigate and compare the injury patterns, injury characteristics, and mortality of male and female patients hospitalized for treatment of motorcycle accident-related trauma in a level I trauma center.

Methods: Retrospective analysis of motorcycle-related injuries from the Trauma Registry System was performed to identify and compare 4028 male and 2919 female patients hospitalized for treatment between January 1, 2009 and December 31, 2013.

Results: The female patients were younger, less often drunken, more often wore helmets, were transported by emergency medical services, and arrived at the emergency department between 7 a.m. and 5 p.m. compared to male patients. Analysis of Abbreviated Injury Scale scores revealed that female patients sustained significantly higher rates of injuries to the extremities, but lower rates of injuries to the head/neck, face, and thorax than male patients did. Female patients had a significant lower Injury Severity Score (ISS) and adjusted odds ratio of in-hospital mortality (AOR 0.83, 95% CI: 0.83–0.86) after adjustment by ISS. However, the logistic regression analysis of propensity score-matched patients with adjusted confounders including helmet-wearing status and alcohol intoxication revealed that the gender did not significantly influence mortality (OR 0.82, 95% CI 0.47–1.43; $p = 0.475$), implying the an associated risky behaviors may attribute to the difference of odds of mortality between the male and female patients. In addition, a significantly fewer female patients were admitted to the intensive care unit (ICU), and female patients had a significantly shorter hospital and ICU length of stay.

Conclusion: Female motorcycle riders have different injury characteristics, lower ISS and in-hospital mortality, and present with a bodily injury pattern that differs from that of male motorcycle riders.

Level of evidence: Epidemiologic study, level III.

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At a glance commentary

Scientific background on the subject

Although strong evidence indicates that the risk of road traffic injury varies by sex, there remains a lack of consensus over the detailed characteristics of injury pattern and injury severity between women and men in motorcycle traffic accidents.

What this study adds to the field

This study revealed that the female motorcycle riders had a lower mortality than male motorcycle riders. However, analysis of propensity score-matched patients with adjusted confounders including helmet-wearing status and alcohol intoxication revealed that the associated risky behaviors, but not the gender, may attribute to the difference of odds of mortality.

Motorcycle use is popular in many cities as a less expensive, easier, and more fuel-efficient means of transportation. Road traffic accidents involving motorcycle riders often result in severe morbidity and mortality. Motorcyclists make up 13% and 16% of all annual traffic-related fatalities and inpatient injuries, respectively, despite being a small fraction of the travel [1]. The National Highway Traffic Safety Administration (NHTSA) reported that at the national level, motorcyclists were approximately 30 times more likely to die in a motor vehicle crash than a motor vehicle occupant in 2011 [2]. In addition, motorcycle riders were 8 times more likely to be injured per vehicle mile [3], and 58 times more likely to be killed on a per-trip basis [4]. Women have been reported to have a significantly higher risk of slight injury than men when travelling by bus, bicycle, and car, but no differences are observed between the sexes as pedestrians, nor as motorcycle or moped drivers [5]. Analysis using a travel-based measure of exposure in a U.S. state with a population with roughly equal numbers of men and women revealed that the women accounted for 39% of traffic-related inpatient injuries and 32% of traffic-related fatalities [1]. The higher risk of non-fatal injury among female drivers has also been reported in studies that used driving distance as a measure of exposure [6,7]. In contrast, some authors reported the male:female ratio in motorcycle injuries was as high as 4.8:1 [8]. However, although strong evidence indicates that the risk of road traffic injury varies by sex [4,5,9], there remains a lack of consensus over the detailed characteristics of injury pattern, and whether injury is higher among women or men in motorcycle traffic accidents.

Identifying high-risk injury patterns and gaining a greater understanding major trauma epidemiology in different sexes is vital to the integration of trauma knowledge in the trauma system to maximize the provision of services and the quality of care delivered [10,11]. Moreover, considering that nearly all motorcycles are forbidden on highways in Asian cities, and that most traffic accidents occur in relatively crowded streets in these cities at relatively low speeds, we hypothesize that the discrepancy between the sexes might differ from those of previous Western studies. This study investigated the injury pattern, mechanisms, severity, and mortality of male and female patients treated for injuries sustained in motorcycle accidents in a level I trauma center in Taiwan using data from a population-based trauma registry.

Methods

Ethics statement

This study was approved by the hospital institutional review board (IRB) with approval number 103-3020B before its initiation. An informed consent was waived according to the regulation of IRB.

Study design

This retrospective study reviewed all of the data added to the Trauma Registry System of a 2400-bed Level I regional trauma center, which provides care to trauma patients primarily from South Taiwan. Cases of hospitalization for trauma sustained in motorcycle accidents from January 1, 2009 to December 31, 2013 were selected. Among the 6947 registered patients entered in the database, 4028 (58.0%) were male and 2919 (42.0%) were female. Detailed patient information was retrieved from the Trauma Registry System of our institution, which included patient age, admission vital signs, injury mechanism, and helmet use. The method of transportation to the emergency department was also examined, and included emergency medical services (EMS), private vehicle, or transfer by ambulance from another hospital. Other data collected included the first Glasgow Coma Scale (GCS) in the emergency department, details of the procedures performed at the emergency department (cardiopulmonary resuscitation, intubation, chest tube insertion, and blood transfusion), an Abbreviated Injury Scale (AIS) of each body region, Injury Severity Score (ISS), New Injury Severity Score (NISS), Trauma-Injury Severity Score (TRISS), hospital length of stay (LOS), intensive care unit (ICU) LOS, in-hospital mortality, and associated complications. Adjusted odd ratios (AORs) and 95% confidence intervals (CI) for mortality according to age and stratified ISS were calculated. In our study, the primary outcomes were injury severity as measured by different scoring system (GCS, AIS, ISS, NISS, and TRISS) and in-hospital mortality. The secondary outcomes were the associated complications, and hospital and ICU LOS. The data collected were analyzed using SPSS v. 20 statistical software (IBM, Armonk, NY) for Pearson's chi-squared tests, Fisher's exact tests, or the independent Student's *t*-tests, as applicable. A 1:1 matched study group was created by the Greedy method using NCSS software (NCSS 10; NCSS Statistical software, Kaysville, Utah). After adjusting for confounding factors such as status of helmet-wearing and alcohol intoxication, a conditional logistic regression was used for evaluating the effect of gender on mortality. All results are presented as the mean ± standard

error. A p-value less than 0.05 was considered statistically significant.

Results

Patient characteristics

As shown in Table 1, the mean patient age was 40.4 ± 19.3 and 44.8 ± 18.5 years, respectively, in the male and female patient groups. Among women, fewer patients were aged between 10 and 19, 20–29, 30–39, and 80–89 years, but a greater number of patients were aged between 50–59 and 60–69 years. Most of the injured patients were drivers, with significant more male drivers and female pillions. There were significantly more women transported to the hospital by EMS than men ($p < 0.001$). In contrast, significantly more men than women were transferred by ambulance from other hospitals ($p < 0.001$). Helmet-wearing status was recorded as 97.6% and 98.3% for men and women, respectively; however, at the time of injury, significantly more female patients were wearing helmets than male patients (88.9% *vs.* 83.9%, $p < 0.001$). More female patients arrived at the emergency department between 7 a.m. and 5 p.m. ($p < 0.001$), while more male patients arrived between 5 p.m. and 11 p.m. and 11 p.m.–7 a.m. ($p < 0.001$). A positive blood alcohol content (BAC) was more frequent among men than women (14.0% vs. 2.4%, respectively; $p < 0.001$).

We found a significant difference in GCS scores between male and female patients (14.0 ± 2.6 *vs.* 14.4 ± 2.1, respectively; $p < 0.001$), as well as the distribution of scores among the patients (GCS ≤8, 9–12, or ≥13). Female patients had higher GCS scores than did male patients, and a higher proportion of patients with a GCS score of ≥13 were women. In contrast, a higher proportion of patients with a GCS score of either ≤8 or between 9 and 12 were men. Our analysis of AIS scores revealed that male patients had sustained significantly higher rates of injuries to the head/neck, face, and thorax, while female patients sustained significantly higher rates of injuries to the extremities [Table 1]. The comparison of trauma injury scores between the male and female patients indicated significant differences regarding the ISS (10.0 ± 7.9 *vs.* 8.7 ± 7.1, respectively; $p < 0.001$). When stratified by injury severity (ISS of <16, 16–24, or ≥25), more women had an ISS of <16 compared to men (82.4% vs. 79.5%, respectively; $p = 0.003$), while more men had an ISS between 16 and 24, compared to women (14.4% vs. 11.6%, respectively; $p = 0.001$). There was no significant difference in the sex of the patients with an ISS of ≥25. We also found significant differences in male and female patients regarding NISS (11.8 ± 9.7 *vs.* 10.1 ± 8.4, respectively; $p < 0.001$), TRISS (0.960 ± 0.109 *vs.* 0.964 ± 0.108, respectively; $p < 0.001$), and in-hospital mortality rates (1.9% *vs.* 1.2%, respectively; $p = 0.014$). After adjusting for ISS, we found that female patients had a significantly lower AOR for patient mortality than did male patients (AOR 0.83, 95% CI 0.83–0.86), indicating that the differences in injury severity between the sexes are not wholly responsible for their different mortality rates. The mortality of male and female patients is shown based on age-group in Fig. 1, revealing that there was a narrower age-range among women experiencing fatalities compared to men. Further, mortality increased in older patients, regardless of sex. The major injuries associated with mortality are listed in Table 2, and reveal that there was no significant difference between the sexes in trauma causing mortality, except that the female patients had higher odds for sustaining subarachnoid

Table 1 Demographics of hospitalized trauma male and female motorcycle riders.

Variables	Male N = 4028	Female N = 2919	p
Age	40.4 ± 19.3	44.8 ± 18.5	0.115
0-9	34(0.8)	34(1.2)	0.180
10-19	518(12.9)	287(9.8)	<0.001
20-29	989(24.6)	513(17.6)	<0.001
30-39	590(14.6)	288(9.9)	<0.001
40-49	570(14.2)	377(12.9)	0.138
50-59	521(12.9)	684(23.4)	<0.001
60-69	421(10.5)	526(18.0)	<0.001
70-79	292(7.2)	195(6.7)	0.359
80-89	86(2.1)	15(0.5)	<0.001
≧90	7(0.2)	0(0.0)	0.024
Seat			<0.001
Driver	3836(95.2)	2608(89.3)	
Pillions	192(4.8)	311(10.7)	
Transpose, n(%)			
EMS	1910(47.4)	1552(53.2)	<0.001
Private vehicle	674(16.7)	489(16.8)	0.983
Transferred	1444(35.8)	878(30.1)	<0.001
Helmet, n(%)			
Yes	3379(83.9)	2595(88.9)	<0.001
No	551(13.7)	275(9.4)	<0.001
Unspecific	98(2.4)	49(1.7)	0.031
Time, n(%)			
7:00–17:00	2022(50.2)	1799(61.6)	<0.001
17:00–23:00	1261(31.3)	733(25.1)	<0.001
23:00–7:00	742(18.4)	384(13.2)	<0.001
Unspecific	3(0.1)	3(0.1)	–
Alcohol>50, n(%)	564(14.0)	69(2.4)	<0.001
GCS	14.0 ± 2.6	14.4 ± 2.1	<0.001
≤8	282(7.0)	124(4.2)	<0.001
9-12	208(5.2)	93(3.2)	<0.001
≥13	3538(87.8)	2702(92.6)	<0.001
AIS,n(%)			
Head/Neck	1419(35.2)	869(29.8)	<0.001
Face	1094(27.2)	642(22.0)	<0.001
Thorax	723(17.9)	366(12.5)	<0.001
Abdomen	301(7.5)	197(6.7)	0.248
Extremity	2853(70.8)	2215(75.9)	<0.001
ISS	10.0 ± 7.9	8.7 ± 7.1	<0.001
<16	3202(79.5)	2404(82.4)	0.003
16-24	581(14.4)	339(11.6)	0.001
≥25	245(6.1)	176(6.0)	0.927
NISS	11.8 ± 9.7	10.1 ± 8.4	<0.001
TRISS	0.960 ± 0.109	0.964 ± 0.108	0.001
Mortality, n(%)	77(1.9)	34(1.2)	0.014
AOR	0.83		<0.001
		[95% CI = 0.83–0.86]	
LOS in hospital (days)	10.1 ± 10.8	9.1 ± 9.2	<0.001
LOS in ICU			
Patients, n(%)	859(21.3)	431(14.8)	<0.001
<16	281(8.8)	154(6.4)	0.001
16-24	364(62.7)	180(53.1)	0.004
≥25	214(87.3)	97(55.1)	<0.001
LOS in ICU (days)	7.6 ± 9.3	6.5 ± 7.7	0.002

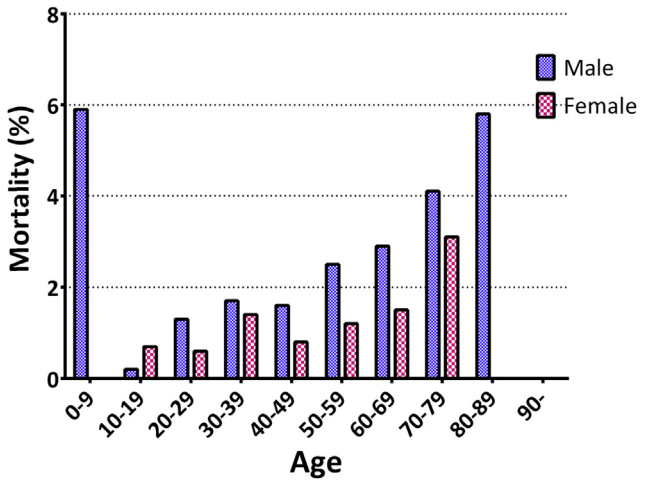

Fig. 1 Mortality percentage of male and female patients admitted for treatment of motorcycle-related trauma injury under stratification by age of decade.

hemorrhage (SAH) (OR 3.33, 95% CI 1.58–9.09; $p < 0.001$) than the male patients. Women experienced a significantly shorter hospital LOS than men did (9.1 days *vs*. 10.1 days, respectively; $p < 0.001$). A significantly smaller proportion of female patients was admitted to the ICU compared to male patients (14.8% *vs*. 21.3%, respectively; $p < 0.001$) regardless of ISS stratification (<16, 16–24, or ≥25).

To clarify the influence of alcohol consumption in different gender, further analysis of the patients who have a positive or negative BAC in the subgroup of male and female patients revealed the impact of alcohol intoxication is similar in different gender regarding GCS score, ISS, injury areas based on the AIS, hospital LOS, the proportion of patients admitted to the ICU [Table 3]. However, the significant higher mortality in the patients with a positive BAC than those who had a negative BAC in the male patients (OR 2.4, 95% CI 1.41–2.92; $p < 0.001$) was not found in the female patients (OR 2.6, 95% CI 0.62–11.20; $p = 0.191$). Additionally, the significant longer ICU LOS in the patients with a positive BAC than those who had a negative BAC in the male patients ($p = 0.009$) was not revealed in the female patients ($p = 0.411$). In addition, to investigate the impact of wearing status of helmet on the outcome in different gender, further analysis revealed the impact of helmet-wearing status is similar in different gender regarding GCS score, ISS, injury areas based on the AIS except the abdomen, mortality, the proportion of patients admitted to the ICU, and the ICU LOS [Table 4]. A significant longer hospital LOS in the patients without helmet-wearing than those with helmet-wearing was found in the male patients ($p < 0.001$), but not the female patients ($p = 0.324$). Adjusted mortality in propensity-score matched patient population.

To reduce the impact of difference of associated helmet-wearing status and alcohol intoxication on the mortality assessment between the male and female patients, 111 well-balanced pairs of patients were selected for comparison [Table 5]. In these propensity score–matched patients, there was no significant difference in helmet-wearing status and alcohol intoxication. The conditional logistic regression analysis of these well-balanced pairs of patients showed that the gender did not significantly influence mortality (OR 1.11, 95% CI 0.74–1.68; $p = 0.606$), implying the higher odds of mortality of the male patients were attributed to population with a risky behaviors that associated with mortality, such as no helmet-wearing and alcohol intoxication, but not the gender *per se*.

Female patients had lower odds ratios (ORs) for presenting with more severe hemodynamic measures than did the male patients [Table 6]. These measures included heart rates of >100 beats/min (OR 0.83, 95% CI 0.75–1.68; $p = 0.009$) and shock indices of >0.9 (OR 0.77, 95% CI 0.64–0.94; $p = 0.010$). No significant difference was noted between the sexes in the measures of systolic blood pressure (SBP) of <90 mmHg and respiratory rate of <10 or >29 times/min. In addition, women had lower odds of requiring procedures at the emergency department, including intubation (OR 0.48, 95% CI 0.36–0.60; $p < 0.001$) and chest tube insertion (OR 0.38, 95% CI 0.26–0.57; $p < 0.001$) than men, but similar requirements for cardiopulmonary resuscitation or blood transfusion.

Table 7 shows the findings regarding the types of injuries associated with motorcycle accidents. A significantly higher percentage of female motorcycle riders sustained SAH, as well as lumbar vertebral, sacral vertebral, humeral, radial, ulnar, pelvic, tibial, and calcaneal fractures. However, compared to

Table 2 Injuries attributed to the fatality of male and female motorcycle riders.

Variables	Male N = 77	Female N = 34	Odds ratio (95% CI)	*p*
Epidural hematoma (EDH)	23(29.9)	9(26.5)	0.83(0.48–2.92)	0.715
Subdural hematoma (SDH)	42(54.5)	20(58.8)	1.25(0.53–2.70)	0.676
Subarachnoid hemorrhage (SAH)	16(20.8)	17(50.0)	3.33(1.58–9.09)	0.002
Intracerebral hematoma (ICH)	10(13.0)	4(11.8)	0.91(0.26–3.03)	0.858
Cerebral contusion	17(22.1)	11(32.4)	1.67(0.69–4.17)	0.251
Hemothorax	8(10.4)	2(5.9)	0.53(0.11–2.70)	0.445
Pneumothorax	3(3.9)	3(8.8)	2.50(0.46–12.5)	0.290
Hemopneumothorax	7(9.1)	2(5.9)	0.63(0.12–3.13)	0.568
Lung contusion	11(14.3)	3(8.8)	0.59(0.15–2.22)	0.424
Hepatic injury	9(11.7)	2(5.9)	0.48(0.10–2.33)	0.345
Splenic injury	7(9.1)	1(2.9)	0.30(0.04–2.56)	0.248
Pelvic fracture	6(7.8)	1(2.9)	0.36(0.04–3.13)	0.332

Table 3 Comparison of injury characteristics between those patients who have a positive or negative BAC in the male and female patients.

	Male				Female			
	Alcohol>50 n = 564	Alcohol≦50 n = 3464	OR(95%CI)	p	Alcohol>50 n = 69	Alcohol≦50 n = 2850	OR(95%CI)	p
GCS	12.1 ± 3.9	14.3 ± 2.2	–	<0.001	11.6 ± 4.0	14.4 ± 2.0	–	<0.001
ISS	13.2 ± 9.8	9.5 ± 7.4	–	<0.001	13.3 ± 10.7	8.6 ± 6.9	–	0.001
AIS≥2, n(%)								
Head/Neck	249(44.1)	762(22.0)	2.8(2.33–3.37)	<0.001	30(43.5)	537(18.8)	3.3(2.04–5.38)	<0.001
Face	192(34.0)	542(15.6)	2.8(2.29–3.39)	<0.001	27(39.1)	354(12.4)	4.5(2.76–7.44)	<0.001
Thorax	94(16.7)	484(14.0)	1.2(0.97–1.57)	0.092	9(13.0)	274(9.6)	1.4(0.69–2.87)	0.306
Abdomen	55(9.8)	205(5.9)	1.7(1.26–2.35)	0.001	12(17.4)	162(5.7)	3.5(1.84–6.64)	0.001
Extremity	252(45.0)	2216(64.0)	0.5(0.39–0.55)	<0.001	36(52.2)	1941(68.1)	0.5(0.32–0.83)	0.006
Mortality	21(3.7)	56(1.6)	2.4(1.41–2.92)	<0.001	2(2.9)	32(1.1)	2.6(0.62–11.20)	0.191
Hospital LOS								
days	12.2 ± 11.6	9.7 ± 10.7	–	<0.001	12.2 ± 10.0	9.0 ± 9.2	–	0.010
ICU LOS								
n (%)	214(37.9)	645(18.6)	2.7(2.21–3.23)	<0.001	23(33.3)	408(14.3)	3.0(1.80–4.99)	<0.001
days	6.5 ± 6.3	8.0 ± 10.1	–	0.009	7.8 ± 8.0	6.4 ± 7.7	–	0.411

Table 4 Comparison of injury characteristics between those male and female patients with or without helmet-wearing.

	Male				Female			
	Helmet(–) n = 551	Helmet(+) n = 3379	OR(95%CI)	p	Helmet(–) n = 275	Helmet(+) n = 2595	OR(95%CI)	p
GCS	12.6 ± 3.8	14.3 ± 2.1	–	<0.001	13.4 ± 3.3	14.5 ± 1.8	–	<0.001
ISS	12.9 ± 9.0	9.4 ± 7.3	–	<0.001	11.6 ± 8.9	8.2 ± 6.3	–	<0.001
AIS≥ 2, n(%)								
Head/Neck	281(51.0)	670(19.8)	4.2(3.49–5.07)	<0.001	110(40.0)	431(16.6)	3.3(2.58–4.35)	<0.001
Face	140(25.4)	573(17.0)	1.7(1.35–2.06)	<0.001	50(18.2)	316(12.2)	1.6(1.15–2.23)	0.006
Thorax	74(13.4)	482(14.3)	0.9(0.72–1.21)	0.645	30(10.9)	248(9.6)	1.2(0.78–1.73)	0.520
Abdomen	33(6.0)	217(6.4)	0.9(0.64–1.35)	0.709	25(9.1)	146(5.6)	1.7(1.08–2.61)	0.024
Extremity	235(42.6)	2199(65.1)	0.4(0.33–0.48)	<0.001	141(51.3)	1815(69.9)	0.5(0.35–0.58)	<0.001
Mortality	22(4.0)	41(1.2)	3.4(2.00–5.73)	<0.001	8(2.9)	15(0.6)	5.2(2.17–12.27)	0.001
Hospital LOS								
days	12.2 ± 12.7	9.5 ± 9.7	–	<0.001	9.6 ± 9.8	9.0 ± 9.1	–	0.324
ICU LOS								
n (%)	213(38.7)	594(17.6)	3.0(2.44–3.58)	<0.001	83(30.2)	330(12.7)	3.0(2.24–3.93)	<0.001
days	7.9 ± 9.8	7.3 ± 8.8	–	0.368	6.5 ± 6.0	6.4 ± 8.0	–	0.918

Table 5 Covariates of the trauma patients before and after propensity score matching (1:1 greedy matching) for mortality assessment.

	Before				After			
	Death n = 111	Survival n = 6836	OR(95%CI)	p	Death n = 111	Survival n = 111	OR(95%CI)	p
Helmet, n(%)								
Yes	56(50.5)	5918(86.6)	0.2(0.11–0.23)	<0.001	56(50.5)	56(50.5)	1.0(0.59–1.69)	1.000
No	30(27.0)	796(11.6)	2.8(1.84–4.30)	<0.001	30(27.0)	30(27.0)	1.0(0.55–1.81)	1.000
Unspecific	25(22.5)	122(1.8)	16.0(9.90–25.85)	<0.001	25(22.5)	25(22.5)	1.0(0.53–1.88)	1.000
Alcohol>50, n(%)	23(20.7)	610(8.9)	2.7(1.67–4.25)	<0.001	23(20.7)	23(20.7)	1.0(0.52–1.91)	1.000

men, women had a significantly lower percentage of cranial, cervical vertebral, maxillary, mandibular, nasal, rib, scapular, femoral, and patella fractures, as well as epidural (EDH), subdural (SDH), and intracerebral (ICH) hematomas, pneumothorax, hemopneumothorax, lung contusions, and splenic, retroperitoneal, and renal injuries.

Discussion

In the present study, the influential role of sex upon different characteristics of motorcycle accident-related injuries was investigated. The female patients were younger, more often

Table 6 Physiological status on arrival and procedures performed at the emergency department.

Variables	Male N = 4028	Female N = 2919	Odds Ratio (95%CI)	*p*
Physiology at ER, n(%)				
SBP < 90 mmHg	104(2.6)	71(2.4)	0.91(0.22–1.28)	0.695
Heart rate > 100 beats/min	825(20.5)	524(18.0)	0.83(0.75–1.68)	0.009
Respiratory rate <10 or >29	34(0.8)	16(0.5)	0.67(0.36–1.18)	0.150
Shock index >0.9	298(7.4)	170(5.8)	0.77(0.64–0.94)	0.010
Proceduresat ER, n(%)				
Cardiopulmonary resuscitation	9(0.2)	6(0.2)	0.91(0.33–2.56)	0.874
Intubation	255(6.3)	89(3.0)	0.48(0.36–0.60)	<0.001
Chest tube	115(2.9)	33(1.1)	0.38(0.26–0.57)	<0.001
Blood transfusion	159(3.9)	105(3.6)	0.91(0.70–1.16)	0.451

pillions, wore helmets, were transported by EMS, and arrived at the emergency department between 7 a.m. and 5 p.m. The age distribution of the female patients is different from that of the male patients; fewer female patients were aged between 10–39 and 80–89 years, while more female patients were aged between 50 and 69. This finding is partly consistent with the report that among young motorcycle drivers (14–24 years), the risk of slight injury is higher in men than in women, a trend which is reversed in older age groups (25–54 and 65–74 years) [5]. Some authors have reported the relationship between this increased risk for young men and their greater inclination to engage in risky behaviors, such as speeding, consumption of alcohol or drugs, etc., compared to women [12–14]. In the current study, a positive BAC was found more frequently among men than women. Notably, it has been reported in Taiwan that those patients having undergone an alcohol test also had higher ISS, NISS, and in-hospital mortality [15].

According to the analysis of 10,607 motorcyclists who were admitted to hospital following accidents in the Netherlands [15], upper extremity and spine injuries (25.7% and 5.9%, respectively) were the most common injury types. When considering only the most severe injuries, severe thorax (24.3%) and severe lower extremity (39.1%) injuries were most common [15]. In this study, the distribution of the injury location was different from that of previous reports. Based on analysis of AIS, our study revealed that 73.0% of injuries were localized to the extremities, followed by head/neck (32.9%) and face (25.0%). In addition, the women presented with a different bodily injury pattern than the men. Female patients sustained significantly higher rates of extremity injuries, but lower rates of head/neck, face, and thorax injuries than male patients did. The injury types are different between the sexes; a significantly higher percentage of female motorcycle riders sustained SAH, as well as lumbar vertebral, sacral vertebral, humeral, radial, ulnar, pelvic, tibial, and calcaneal fractures. Investigation of the impact of wearing status of helmet on the outcome in different gender revealed the wearing of helmet was associated with a higher incidence of injures to the extremities than those without helmet-wearing both in male and female patients. Furthermore, the female riders still sustained a higher incidence of extremities than those male riders regardless of helmet-wearing status. Therefore, the reason that the female motorcycle riders tend to have more limb injuries than male patients could not be explained by the helmet-wearing status. Additionally, the patients without helmet-wearing sustained an remarkably significant higher incidence of injuries to head/neck region than those who had worn the helmet regardless the gender of patients; therefore, the fewer incidence of head/neck injuries in female than male patients could not be explained by a higher incidence of helmet-wearing of female motorcycle riders and may be due to other unidentified factors.

A previous study found that the risk of fatal injury is higher in men than in women aged 25–34 years when using time travelled as a measure of exposure [5]. In a time-series study with data from 580 motorcyclist fatalities in the Brazilian Federal District from 1996 to 2007, most of the deaths were in men (94.3%) and those aged between 20 and 39 years (73.8%) [16]. When comparing age-groups for the 10,607 hospitalized Dutch motorcyclists, the relative risk (RR) of death following a motorcycle accident after hospital admission was highest in the youngest age group (RR: 1.64, 95% CI:1.24–2.16) [15]. In Taiwan, motorcyclist fatalities account for nearly 60% of all driving fatalities [17], often associated with men, and factors including advanced age, unlicensed status, not wearing a helmet, and riding under the influence of alcohol, particularly after heavy alcohol consumption (>550 cc) [17]. In this study, after the reduction of the impact of associated helmet-wearing status and alcohol intoxication on the mortality assessment between the male and female patients, the logistic regression analysis of these propensity score-matched patients showed that the gender did not significantly influence mortality (OR 0.82, 95% CI 0.47–1.43; $p = 0.475$), implying the an associated risky behaviors may attribute to the difference of odds of mortality between the male and female patients. In the current study, head injuries (including EDH, SDH, SAH, ICH, and cerebral contusions) were the major factor leading to mortality, followed by thoracic (including hemothorax, hemopneumothorax, and lung contusion), and abdominal (including hepatic and splenic) injuries. Of note, our data also shows that besides the aforementioned injuries, pelvic injuries also caused fatalities in motorcycle riders, regardless of sex.

In the 10,607 hospitalized Dutch motorcyclists, those who were fatally injured were most frequently diagnosed with severe head injury (47%), followed by thoracic injury (20%) [15]. Among a number of preventive measures, helmet-wearing in particular has been shown to both protect against head and other serious injuries, and be cost effective [18–20]. In the current study, the female motorcycle riders were more likely to wear a helmet than the male motorcycle riders. A significant difference in GCS scores and the distribution of scores

Table 7 Associated injuries of the male and female motorcycle riders.

Variables	Male N = 4028	Female N = 2919	p
Head trauma, n(%)			
Neurologic deficit	40(1.0)	21(0.7)	0.228
Cranial fracture*	443(11.0)	157(5.4)	<0.001
Epidural hematoma (EDH)*	288(7.1)	91(3.1)	<0.001
Subdural hematoma (SDH)*	502(12.5)	240(8.2)	<0.001
Subarachnoid hemorrhage (SAH)+	293(7.3)	319(10.9)	<0.001
Intracerebral hematoma (ICH)*	113(2.8)	55(1.9)	0.014
Cerebral contusion	257(6.4)	164(5.6)	0.189
Cervical vertebral fracture*	38(0.9)	14(0.5)	0.027
Maxillofacial trauma, n(%)			
Maxillary fracture*	454(11.3)	241(8.3)	<0.001
Mandibular fracture*	164(4.1)	89(3.0)	0.025
Orbital fracture	126(3.1)	72(2.5)	0.102
Nasal fracture*	74(1.8)	31(1.1)	0.009
Thoracic trauma, n(%)			
Rib fracture*	506(12.6)	278(9.5)	<0.001
Sternal fracture	5(0.1)	4(0.1)	0.883
Hemothorax	88(2.2)	45(1.5)	0.054
Pneumothorax*	108(2.7)	38(1.3)	<0.001
Lung contusion*	82(2.0)	20(0.7)	<0.001
Hemopneumothorax*	87(2.2)	25(0.9)	<0.001
Thoracic vertebral fracture	30(0.7)	20(0.7)	0.772
Abdominal trauma, n(%)			
Intra-abdominal injury	68(1.7)	42(1.4)	0.411
Hepatic injury	119(3.0)	68(2.3)	0.112
Splenic injury*	74(1.8)	31(1.1)	0.009
Retroperitoneal injury*	12(0.3)	1(0.0)	0.012
Renal injury*	37(0.9)	10(0.3)	0.004
Urinary bladder injury	12(0.3)	3(0.1)	0.084
Lumbar vertebral fracture+	36(0.9)	46(1.6)	0.009
Sacral vertebral fracture+	17(0.4)	23(0.8)	0.047
Extremity trauma, n(%)			
Scapular fracture*	118(2.9)	49(1.7)	0.001
Clavicle fracture	554(13.8)	361(12.4)	0.092
Humeral fracture+	150(3.7)	219(7.5)	<0.001
Radial fracture+	334(8.3)	386(13.2)	<0.001
Ulnar fracture+	176(4.4)	179(6.1)	0.001
Metacarpal fracture	158(3.9)	97(3.3)	0.190
Pelvic fracture+	122(3.0)	122(4.2)	0.010
Femoral fracture*	494(12.3)	267(9.1)	<0.001
Patella fracture*	146(3.6)	49(1.7)	<0.001
Tibial fracture+	406(10.1)	349(12.0)	0.013
Fibular fracture	239(5.9)	162(5.5)	0.499
Calcaneal fracture+	197(4.9)	181(6.2)	0.018
Metatarsal fracture	97(2.4)	89(3.0)	0.102

* Indicates a higher incidence of male than female patients; + indicates a higher incidence of female than male patients.

between the sexes (GCS ≤8, 9–12, or ≥13) was also found. In addition, female motorcycle riders sustained a significantly lower percentage of intracranial injuries including cranial fracture, EDH, SDH, and ICH. These findings indicate that helmet-wearing may have prevented head injuries among the female motorcycle riders studied. However, a significantly higher percentage of female motorcycle riders sustained SAH. Women experience a greater number of intracranial aneurysms than men [21,22]. It has been reported that not only do more women suffer from SAH, but that the average age of female SAH survivors is greater, compared to male survivors; however, the overall mortality and neurological outcomes for men are not better, despite their younger age [23]. Sex appears to influence the risk, initial impact, and early phase of SAH, while age influences its outcome [23,24].

The limitations of this study include its retrospective design and the lack of available data regarding injury mechanism and circumstance, including motorcycle speed and type, helmet material, and exposure data (e.g., number of trips, hours of riding, and/or miles traveled). Although some identified factors may explain a better outcome of the female motorcycle riders than those male patients, however, these factors may not be independent from each other (for example, those who was drunken when riding tend not to wear the helmet, and BAC level had been reported to be related to the sustained injury severity [25–27]) and it is hard to clarify their real impacts on the outcome from this retrospective study. Additionally, the number of patients we included in the study was not adequate to analyze the association of age with different accident characteristics, other than mortality. Thus, it is not possible to describe the effect of age on the various risk factors experienced by the two sexes, as has been previously described [5,28]. Finally, the injured patients who were pronounced dead at the scene of the accident or those who were discharged from the emergency department were not included in the sample, which may have introduced a survival bias.

Conclusion

This study analyzed the differences between the sexes in the demographics and injury characteristics of patients hospitalized at a level I trauma center with motorcycle-related. Analysis of the data indicates that women motorcycle riders have unique injury characteristics, including bodily injury pattern, as well as a lower ISS and in-hospital mortality when compared to male motorcycle riders.

Conflicts of interest

The authors declare that they have no competing interests.

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