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Original Article

Gender differences in adult traumatic brain injury according to the Glasgow coma scale: A multicenter descriptive study

Ki Seong Eom [a,*], Jang Hun Kim [b], Sang Hoon Yoon [b], Seong-jong Lee [c], Kyung-Jae Park [d], Sung-Kon Ha [e], Jin-gyu Choi [f], Kwang-Wook Jo [g], JongYeon Kim [h], Suk Hyung Kang [i], Jong-Hyun Kim [j]

[a] Department of Neurosurgery, Institute of Wonkwang Medical Science, Wonkwang University School of Medicine, Iksan, South Korea
[b] Department of Neurosurgery, Armed Forces Capital Hospital, Seongnam, South Korea
[c] Department of Neurosurgery, Armed Force Hospital, Yangju, South Korea
[d] Department of Neurosurgery, Korea University Anam Hospital, Seoul, South Korea
[e] Department of Neurosurgery, Korea University Ansan Hospital, Ansan, South Korea
[f] Department of Neurosurgery, Yeouido St. Mary's Hospital, Catholic University, Seoul, South Korea
[g] Department of Neurosurgery, Catholic University St. Mary's Hospital, Bucheon, South Korea
[h] Department of Neurosurgery, Wonju Severance Christian Hospital, Wonju, South Korea
[i] Department of Neurosurgery, Hallym University Sacred Heart Hospital, Chuncheon, South Korea
[j] Department of Neurosurgery, Korea University Guro Hospital, Seoul, South Korea

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ABSTRACT

Purpose: Patients' gender, which can be one of the most important determinants of traumatic brain injury (TBI) outcomes, is also likely to interact with many other outcome variables of TBI. This multicenter descriptive study investigated gender differences in epidemiological, clinical, treatment, mortality, and variable characteristics in adult TBI patients.

Methods: The selection criteria were defined as patients who had been diagnosed with TBI and were admitted to the hospital between January 1, 2016 and December 31, 2018. A total of 4468 adult TBI patients were enrolled at eight University Hospitals. Based on the list of enrolled patients, the medical records of the patients were reviewed and they were registered online at each hospital. The registered patients were classified into three groups according to the Glasgow coma scale (GCS) score: mild (13–15), moderate (9–12), and severe (3–8), and the differences between men and women in each group were investigated. The risk factors of moderated and severe TBI compared to mild TBI were also investigated.

Results: The study included 3075 men and 1393 women and the proportion of total males was 68.8%. Among all the TBI patients, there were significant differences between men and women in age, past history, and GCS score. While the mild and severe TBI groups showed significant differences in age, past history, and clinical symptoms, the moderate TBI group showed significant differences in age, past history, cause of justice, and diagnosis.

Conclusion: To the best of our knowledge, this multicenter study is the first to focus on gender differences of adult patients with TBI in Korea. This study shows significant differences between men and women in many aspects of adult TBI. Therefore, gender differences should be strongly considered in TBI studies.

Introduction

Traumatic brain injury (TBI) is an intracranial injury resulting from an external mechanical force, leading to permanent or temporary neurological or neuropsychological problems, such as the impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness.[1,2] TBI is

* Corresponding author.
E-mail address: kseom@wonkwang.ac.kr (K.S. Eom).
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a major cause of death and disability in approximately 10 million people worldwide each year and is a leading global socioeconomic and health problem.[2–5] It is a difficult phenomenon to study because it is a very heterogeneous injury and many outcome variables interact dynamically to affect the patient's recovery process. In particular, the patient's gender is likely to interact with many other outcome variables in TBI, and can be one of the most important determinants of TBI outcomes.[6] However, gender was not previously considered an important risk factor in the majority of studies on TBI because the incidence of TBI was higher in men or data were not analyzed or reported separately by gender.[6] Therefore, the unique characteristics and differences associated with female patients with TBI have not been studied in detail, and there is little data to properly guide the care of female patients with TBI.

While public interest in trauma and the need for rapid treatment of TBI are increasing in Korea, there is little multicenter study related to the epidemiology and characteristics of TBI patients. The study of 2617 patients with TBI registered through the Korea Neurotrauma Data Bank System of the Korean Society of Neurotraumatology from 2010 to 2014 was the only multicenter study in Korea.[7,8] In 2019, 10 hospitals, including two military hospitals and two regional trauma centers, voluntarily recruited under the leadership of the Armed Forces Capital Hospital as part of the project to optimize and strengthen the military medical specialization (Consignment), conducted a descriptive study for the first time in Korea to identify the current status of adult patients with TBI. The present study was designed based on the data registered through the above-mentioned projects. Although both men and women suffer from the same TBI, there are various gender-based differences in epidemiology, clinical course, treatment, and outcome.[6,9] However, there have been no gender-focused multicenter studies with TBI in Korea. Gender-based epidemiological studies of TBI are essential for the gender-specific prevention and effective treatment of both male and female TBI patients. Therefore, this multicenter descriptive study investigated differences in epidemiological, clinical, treatment, mortality, and variable characteristics between them.

Methods

The study was approved by the Institutional Ethical Committee of OO University Hospital (UH) and was in compliance with the institute's ethical requirements (UH 201907014). Under the leadership of the Armed Forces Capital Hospital, 4601 patients were registered in 10 hospitals. Two military hospitals (107 patients at the Armed Forces Capital Hospital and 26 patients at the Armed Force Yangju Hospital) were excluded from this study because the patients in military hospitals are all soldiers and most of them are men in their twenties, and there are many differences in age, sex, past history, and cause of injury from ordinary patients in University Hospitals. A total of 4468 adult TBI patients were thus enrolled at eight University Hospitals. The selection criteria were defined as patients who had been diagnosed with TBI and had been admitted to the hospital between January 1, 2016 and December 31, 2018. Based on the list of patients secured, the medical records of the patients were reviewed and they were registered online at each hospital. The diagnosis of TBI included disease codes corresponding to the area of neurological trauma in the International Classification of Diseases Version 10 (ICD-10) codes. The disease codes were as follows: F07.2, post-concussional syndrome; G44.3, post-traumatic headache; G96.0, cerebrospinal fluid leak; S00. X, superficial injury of head; S01. X, open wound of head; S02. X, fracture of skull and facial bones; S03. X, dislocation, sprain, and strain of joints and ligaments of head; S06. X, intracranial injury; S07. X, crushing injury of head; S08. X, traumatic amputation of part of head; and S09. X, other and unspecified injuries of head (X contains all subcodes). The exclusion criteria were children under 15 years of age, re-admitted due to other complications after establishing the diagnosis of existing head trauma, if the final outcome was difficult to check for reasons such as transfer to another hospital during treatment, if head trauma was unclear, and other reasons that were inappropriate for the researcher to judge (e.g., medical records that did not make sense). The registered patients were classified into three groups according to the Glasgow coma scale (GCS) score: mild (13–15), moderate (9–12), and severe (3–8), and the differences between men and women in each group were investigated. The demographic characteristics of patients with TBI included age, age distribution, past history, cause of injury, diagnosis, clinical symptoms, neurological symptoms, neurological status, neurological aggravation, treatment, operation, outcome, and modified rankin scale (mRS). Considering the life cycle suggested by the Ministry of Economy and Finance, age was divided into youth (15–30 years), middle-age (31–49 years), prime-age (50–64 years), elderly (65–79 years), and superaged elderly (≥80 years).[10] The cause of trauma included passenger traffic accident (TA), pedestrian TA, motorcycle TA, unknown, sports-related, fall or slip, and assault or being struck on the head. Diagnoses included acute epidural hematoma (AEDH), acute subdural hematoma (ASDH), chronic subdural hematoma (CSDH), skull fracture (simple and complex), traumatic intracerebral hemorrhage (TICH), traumatic subarachnoid hemorrhage (TSAH), and diffuse axonal injury (DAI), and others.

SPSS version 22.0 (IBM SPSS Inc., Armonk, NY, USA) was used for statistical analyses. The independent *t*-test and Mann-Whitney *U* test was used for continuous variables. The categorical variables were assessed using Pearson's Chi-square test and Fisher's exact test. The risk factors of moderated and severe TBI compared to mild TBI were investigated using the logistic regression analysis. Differences were considered statistically significant if $p < 0.05$.

Results

Demographic characteristics of patients with TBI according to gender

A total of 4468 patients with TBI were included in this study. The demographic characteristics of the patients based on sex are summarized in Table 1. This study included 3075 men and 1393 women. The proportion of males was 68.8%. The mean age was (61.1 ± 17.4) years, ranging (15–112) years. The mean age of TBI in men (59.0 ± 17.2) years was lower than that in women (65.7 ± 17.0) years and this difference was statistically significant ($p = 0.000$). There was also a significant difference between men and women in the age distribution, which converts age to an ordinal scale ($p = 0.000$). For all age groups (15–30, 31–49, 50–64, 65–79, and ≥80 years), there were significant differences between men and women ($p = 0.002$, $p = 0.000$, $p = 0.000$, $p = 0.000$, and $p = 0.000$). Hypertension, hyperlipidemia, alcoholism, smoking, cardiovascular disease, liver disease, and nervous system disorder were significantly different between men and women in their past history ($p = 0.000$, $p = 0.021$, $p = 0.000$, $p = 0.000$, $p = 0.026$, $p = 0.025$, and $p = 0.002$), while diabetes and kidney disease were not significantly different ($p = 0.054$ and $p = 0.570$). In the hematological history, none and the use of anticoagulant, and hemostatic disorder showed significant differences between men and women ($p = 0.001$, $p = 0.001$, and $p = 0.043$), but there was no difference between the use of antiplatelet agent and dual antiplatelet and anticoagulant usage ($p = 0.087$ and $p = 0.421$). The most common cause of trauma was a fall or slip (48.0%, $n = 2145$), followed by unknown causes (16.4%, $n = 734$), motorcycle TA (10.9%, $n = 489$), passenger TA (9.2%,

$n = 413$), pedestrian TA (8.5%, $n = 378$), assault or being struck on the head (6.2%, $n = 276$), and sports-related injury (0.7%, $n = 33$). The difference in the causes of injury according to sex was not statistically significant ($p = 0.099$). The most common diagnosis was ASDH (36.9%, $n = 1648$), followed by cerebral contusion or TICH (13.9%, $n = 622$), CSDH (13.5%, $n = 603$), TSAH (11.8%, $n = 526$), cerebral concussion (11.1%, $n = 494$), AEDH (8.4%, $n = 374$), skull fracture (2.9%, $n = 129$), others (0.7%, $n = 30$), DAI (0.6%, $n = 29$), and not-available (0.3%, $n = 13$). The difference in the diagnoses according to sex was not statistically significant ($p = 0.419$). The GCS score (mild, moderate, and severe) showed significant differences between men and women ($p = 0.000$, $p = 0.013$, and $p = 0.004$). The mRS scale also showed significant differences between men and women ($p = 0.025$). In addition, there was a significant

Table 1
Demographic characteristics of patients with traumatic brain injury.

Characteristics	Men, *n*	Women, *n*	Total, *n* (%)	Proportion of men (%)	*p* value
Number	3075	1393	4468	68.8	
Mean age (years)	59.0 ± 17.2	65.7 ± 17.0	61.1 ± 17.4		0.000[a,e]
Age group (years)					0.000[b,e]
15–30	256	79	335 (7.5)	76.4	0.002[c,e]
31–49	545	157	702 (15.7)	77.6	0.000[c,e]
50–64	1026	304	1330 (29.8)	77.1	0.000[c,e]
65–79	932	559	1491 (33.4)	62.5	0.000[c,e]
≥80	316	294	610 (13.7)	51.8	0.000[c,e]
Past history					
Hypertension	1158	622	1780 (39.8)	65.1	0.000[c,e]
Diabetes	588	301	889 (19.9)	66.1	0.054[c]
Hyperlipidemia	136	84	220 (4.9)	61.8	0.021[c,e]
Alcoholism	174	25	199 (4.5)	87.4	0.000[c,e]
Smoking	666	29	695 (15.6)	95.8	0.000[c,e]
Cardiovascular disease	255	144	399 (8.9)	63.9	0.026[c,e]
Liver disease	85	23	108 (2.4)	78.7	0.025[c,e]
Nervous system disorder	428	243	671 (15.0)	63.8	0.002[c,e]
Kidney disease	96	48	144 (3.2)	66.7	0.570[c]
Hematology					0.000[b,e]
None	2804	1226	4030 (90.2)	69.6	0.001[c,e]
AP	228	124	352 (7.9)	64.8	0.087[c]
AC	23	26	49 (1.1)	46.9	0.001[c,e]
Dual AP & AC	16	10	26 (0.6)	61.5	0.421[c]
Hemostatic disorder	4	7	11 (0.2)	36.4	0.043[d,e]
Cause of injury					0.099[b]
Passenger TA	275	138	413 (9.2)	66.6	
Pedestrian TA	193	185	378 (8.5)	51.1	
Motorcycle TA	401	88	489 (10.9)	82.0	
Unknown	525	209	734 (16.4)	71.5	
Sports-related	26	7	33 (0.7)	78.8	
Fall or slip	1449	696	2145 (48.0)	67.6	
Assault or struck on the head	206	70	276 (6.2)	74.6	
Diagnosis					0.419[b]
AEDH	298	76	374 (8.4)	79.7	
ASDH	1090	558	1648 (36.9)	66.1	
CSDH	417	186	603 (13.5)	69.2	
Concussion	289	205	494 (11.1)	59.2	
Skull fracture, simple	47	5	52 (1.2)	90.4	
Skull fracture, complex	67	10	77 (1.7)	87.0	
TICH	451	171	622 (13.9)	72.5	
TSAH	360	166	526 (11.8)	68.4	
DAI	22	7	29 (0.6)	75.9	
Others	23	7	30 (0.7)	76.7	
Not available	11	2	13 (0.3)		
GCS score					0.000[b,e]
Mild (13–15)	2332	1133	3465 (77.6)	67.3	0.000[c,e]
Moderate (9–12)	293	101	394 (8.8)	74.4	0.013[c,e]
Severe (3–8)	450	159	609 (13.6)	73.9	0.004[c,e]
mRS					0.072[b]
0	1649	764	2413	68.3	
1	821	418	1239	66.3	
2	50	20	70	71.4	
3	88	21	109	80.7	
4	62	21	83	74.7	
5	137	57	194	70.6	
6	268	92	360	74.4	

AP: antiplatelet agent, AC: anticoagulant, TA: traffic accident, AEDH: acute epidural hematoma, ASDH: acute subdural hematoma, CSDH: chronic subdural hematoma, TICH: traumatic intracerebral hemorrhage, TSAH: traumatic subarachnoid hemorrhage, DAI: diffuse axonal injury, GCS: Glasgow coma scale, mRS: modified Rankin Scale.
[a] Independent *t*-test.
[b] Mann-Whitney *U* test.
[c] Pearson's Chi-square test.
[d] Fisher's exact test.
[e] $p < 0.05$ indicates statistical significance.

difference in the mRS scores 1, 3, and 6 ($p = 0.007$, $p = 0.002$, and $p = 0.005$), but no significant difference in the mRS scores 0, 2, 4, and 5 ($p = 0.330$, $p = 0.554$, $p = 0.402$, and $p = 0.412$).

Demographic characteristics of patients with mild TBI according to sex

The demographic characteristics of patients with mild TBI based on sex are summarized in Table 2. Among 4468 patients with TBI, 3465 patients (77.6%) had mild TBI with a GCS score ≥13. The mild TBI group included 2332 men and 1133 women. The proportion of males was 67.3%. The mean patients' age was (61.3 ± 17.4) years, ranging (15–104) years. The mean age of TBI in men (59.2 ± 17.4) years was lower than that in women (65.7± 16.8) years and this difference was statistically significant ($p = 0.000$). There was also a significant difference between men and women in the age distribution, which converts age to an ordinal scale ($p = 0.000$). For all age groups (15–30, 31–49, 50–64, 65–79, and ≥80 years), there were significant differences between men and women ($p = 0.002$, $p = 0.000$, $p = 0.000$, $p = 0.000$, and $p = 0.000$). Hypertension, hyperlipidemia, alcoholism, smoking, liver disease, and nervous system disorder were significantly different between men and women in their past history ($p = 0.001$, $p = 0.017$, $p = 0.000$, $p = 0.000$, $p = 0.019$, and $p = 0.015$), while diabetes, cardiovascular disease, and kidney disease were not significantly different ($p = 0.060$, $p = 0.378$, and $p = 0.952$). In the hematological history, none and the use of anticoagulant showed significant differences between men and women ($p = 0.002$ and $p = 0.000$), but there was no difference between the use of antiplatelet agent, dual antiplatelet and anticoagulant usage, and hemostatic disorder ($p = 0.155$, $p = 0.287$, and $p = 0.067$). The most common cause of trauma was a fall or slip (49.7%, $n = 1722$), followed by unknown causes (15.2%, $n = 528$), motorcycle TA (10.4%, $n = 360$), passenger TA (10.0%, $n = 347$), assault or being struck on the head (7.0%, $n = 242$), pedestrian TA (6.8%, $n = 235$), and sports-related injury (0.9%, $n = 31$). The difference in the causes of injury according to sex was not statistically significant ($p = 0.143$). The most common diagnosis was ASDH (32.2%, $n = 1115$), followed by CSDH (15.9%, $n = 552$), cerebral contusion or TICH (14.4%, $n = 499$), cerebral concussion (14.3%, $n = 494$), TSAH (11.5%, $n = 399$), AEDH (8.1%, $n = 281$), skull fracture (2.8%, $n = 98$), others (0.5%, $n = 19$), and DAI (0.2%, $n = 8$). The difference in the diagnoses according to the sex was not statistically significant ($p = 0.227$). Among the men, 10.2% ($n = 239$) suffered scalp damage, and among women, 11.6% ($n = 131$) suffered scalp bleeding ($p = 0.240$). The most common clinical symptom was headache (64.8%, $n = 2244$), followed by loss of consciousness (LOC) or seizure-like activity (21.0%, $n = 728$), dizziness (16.2%, $n = 563$), and nausea or vomiting (9.1%, $n = 315$). Among the clinical symptoms, dizziness and nausea or vomiting were significantly different between men and women ($p = 0.011$ and $p = 0.004$), while headache and LOC or seizure-like activity were not significantly different ($p = 0.636$ and $p = 0.075$). The most common neurological symptom was motor dysfunction (14.7%, $n = 511$, $p = 0.993$), followed by verbal disturbance (6.3%, $n = 218$, $p = 0.092$), altered mentality (4.6%, $n = 161$, $p = 0.253$), memory disturbance or disorientation (3.4%, $n = 117$, $p = 0.063$), and cranial nerve abnormalities (0.9%, $n = 30$, $p = 0.479$). The difference in all neurological symptoms according to sex was not statistically significant. Patients whose GCS score worsened from mild to moderate or severe after hospitalization were 3.9% ($n = 90$) of the men and 2.7% ($n = 31$) of the women, and this difference was not statistically significant ($p = 0.091$). Surgical treatment was received by 26.3% ($n = 614$) of the men and 20.3% ($n = 230$) of the women, and this difference was statistically significant ($p = 0.000$). The mRS scale showed no significant differences between men and women ($p = 0.062$).

Demographic characteristics of patients with moderate TBI according to sex

The demographic characteristics of patients with moderate TBI based on sex are summarized in Table 3. Among 4468 patients with TBI, 394 patients (8.8%) had moderate TBI with a GCS score of 9–12. The moderate TBI group included 293 men and 101 women and the proportion of men was 74.4%. The mean patient age was (60.6 ± 17.1) years, ranging (15–96) years. The mean age of TBI in men (58.6 ± 16.6) years was lower than that in women (66.4 ± 17.4) years and this difference was statistically significant ($p = 0.000$). There was also a significant difference between men and women in the age distribution, which converts age to an ordinal scale ($p = 0.000$). Although there were significant differences between men and women in the age groups of 31–49, 50–64, and ≥80 years ($p = 0.003$, $p = 0.005$, and $p = 0.000$), no significant differences were present in the age groups of 15–30 and 65–79 years ($p = 0.803$ and $p = 0.056$). Among the past history, hypertension, smoking, and cardiovascular disease were significantly different between men and women ($p = 0.005$, $p = 0.000$, and $p = 0.030$), while diabetes, hyperlipidemia, alcoholism, liver disease, nervous system disorder, kidney disease, and hematological history were not significantly different ($p = 0.523$, $p = 0.721$, $p = 0.306$, $p = 0.477$, $p = 0.053$, $p = 1.000$, and $p = 0.459$). The cause of injury in the moderate TBI group showed significant differences between men and women ($p = 0.037$). The most common cause of trauma was a fall or slip (45.2%, $n = 178$), followed by unknown causes (21.6%, $n = 85$), pedestrian TA (12.9%, $n = 51$), motorcycle TA (11.9%, $n = 47$), passenger TA (5.1%, $n = 20$), assault or being struck on the head (3.0%, $n = 12$), and sports-related injury (0.3%, $n = 1$). Among the causes of trauma, pedestrian TA ($p = 0.000$) and motorcycle TA ($p = 0.004$) showed significant differences between men and women. The most common diagnosis was ASDH (41.4%, $n = 163$), followed by cerebral contusion or TICH (16.2%, $n = 64$), TSAH (13.7%, $n = 54$), CSDH (9.9%, $n = 39$), AEDH (9.6%, $n = 38$), skull fracture (4.4%, $n = 17$), DAI (2.0%, $n = 8$), non-available (1.8%, $n = 7$), and others (1.0%, $n = 4$). The difference in the diagnosis of ASDH according to sex was statistically significant ($p = 0.009$). The difference in all abnormal neurological statuses according to sex was not statistically significant. The most common abnormal neurological status was motor dysfunction, including hemiparesis or hemiplegia (11.2%, $n = 44$, $p = 0.319$), followed by verbal disturbance (7.1%, $n = 28$, $p = 0.154$), bilateral fixed pupil (3.0%, $n = 12$, $p = 0.513$), unilateral dilated pupil (2.8%, $n = 11$, $p = 0.736$), and decorticated or decerebrated posture (1.5%, $n = 6$, $p = 1.000$). A total of 66 patients (16.8%) received surgical treatment for extracranial injury, and 192 (48.7%) received surgical treatment for cranial injury; these differences according to sex were not statistically significant ($p = 0.776$ and $p = 0.521$). Among the 394 moderate TBI patients, 342 patients (86.8%) survived and 52 (13.2%) died; the difference in the mortality according to sex was not statistically significant ($p = 0.427$). The mRS scale showed no significant differences between men and women ($p = 0.463$).

Demographic characteristics of patients with severe TBI according to sex

The demographic characteristics of patients with severe TBI based on sex are summarized in Table 4. Among 4468 patients with TBI, 609 patients (8.8%) had severe TBI with a GCS score of 3–8. The severe TBI group included 450 men and 159 women and the proportion of men was 73.9%. The mean patient age was (60.2 ± 17.6) years, ranging (15–112) years. The mean age of TBI in men (58.3 ± 16.9) years was lower than that in women (65.5 ± 18.5) years and this difference was statistically significant ($p = 0.000$).

Table 2
Demographic characteristics of patients with mild traumatic brain injury.

Characteristics	Men, *n*	Women, *n*	Total, *n* (%)	Proportion of men (%)	*p* value
Number	2332	1133	3465	67.3	
Mean age (years)	59.2 ± 17.4	65.7 ± 16.8	61.3 ± 17.4		0.000[a,e]
Age group (years)					0.000[b,e]
15–30	190	59	249 (7.2)	76.3	0.002[c,e]
31–49	419	130	549 (15.8)	76.3	0.000[c,e]
50–64	752	252	1004 (29.0)	74.9	0.000[c,e]
65–79	716	457	1173 (33.9)	61.0	0.000[c,e]
≥80	255	235	490 (14.1)	52.0	0.000[c,e]
Past history					
Hypertension	907	506	1413 (40.8)	64.2	0.001[c,e]
Diabetes	441	245	686 (19.8)	64.3	0.060[c]
Hyperlipidemia	116	79	195 (5.6)	59.5	0.017[c,e]
Alcoholism	125	18	143 (4.1)	87.4	0.000[c,e]
Smoking	497	21	518 (14.9)	95.9	0.000[c,e]
Cardiovascular disease	205	110	315 (9.1)	65.1	0.378[c]
Liver disease	54	13	67 (1.9)	80.6	0.019[c,e]
Nervous system disorder	322	192	514 (14.8)	62.6	0.015[c,e]
Kidney disease	75	36	111 (3.2)	67.6	0.952[c]
Hematology					0.001[b,e]
None	2123	993	3116 (89.9)	68.1	0.002[c,e]
AP	183	105	288 (8.3)	63.5	0.155[c]
AC	13	21	34 (1.0)	38.2	0.000[c,e]
Dual AP & AC	10	8	18 (0.5)	55.6	0.287
Hemostatic disorder	3	6	9 (0.3)	33.3	0.067[d]
Cause of injury					0.143[b]
Passenger TA	222	125	347 (10.0)	64.0	
Pedestrian TA	118	117	235 (6.8)	50.2	
Motorcycle TA	283	77	360 (10.4)	78.6	
Unknown	371	157	528 (15.2)	70.3	
Sports-related	25	6	31 (0.9)	80.6	
Fall or slip	1137	585	1722 (49.7)	66.0	
Assault or struck on the head	176	66	242 (7.0)	72.7	
Diagnosis					0.227[b]
AEDH	223	58	281 (8.1)	79.4	
ASDH	708	407	1115 (32.2)	63.5	
CSDH	378	174	552 (15.9)	68.5	
Concussion	289	205	494 (14.3)	58.5	
Skull fracture, simple	47	3	50 (1.4)	94.0	
Skull fracture, complex	41	7	48 (1.4)	85.4	
TICH	360	139	499 (14.4)	72.1	
TSAH	266	133	399 (11.5)	66.7	
DAI	6	2	8 (0.2)	75.0	
Others	14	5	19 (0.5)	73.7	
Scalp injury	239	131	370 (10.7)	64.6	0.240[c]
Clinical symptom					
Headache	1504	740	2244 (64.8)	67.0	0.636[c]
Dizziness	353	210	563 (16.2)	62.7	0.011[c,e]
Nausea or vomiting	189	126	315 (9.1)	60.0	0.004[c,e]
LOC or seizure-like activity	510	218	728 (21.0)	70.1	0.075[c]
Neurological symptom					
Cranial nerve symptom	22	8	30 (0.9)	73.3	0.479[c]
Verbal disturbance	158	60	218 (6.3)	72.5	0.092[c]
Motor dysfunction	344	167	511 (14.7)	67.3	0.993[c]
Altered mentality	115	46	161 (4.6)	71.4	0.253[c]
Memory disturbance or disorientation	88	29	117 (3.4)	75.2	0.063[c]
Neurological aggravation[f]	90	31	121 (3.5)	74.4	0.091[c]
Treatment					0.000[c,e]
Conservative	1718	903	2621 (75.6)	65.5	
Surgery	614	230	844 (24.4)	72.7	
Trephination	396	164	560	70.7	
Craniotomy	144	39	183	78.7	
Craniectomy	62	18	80	77.5	
Others	12	9	21	57.1	
mRS					0.062[b]
0	1612	753	2365 (68.3)	68.2	
1	720	380	1100 (31.7)	65.5	

AP: antiplatelet agent, AC: anticoagulant, TA: traffic accident, AEDH: acute epidural hematoma, ASDH: acute subdural hematoma, CSDH: chronic subdural hematoma, TICH: traumatic intracerebral hemorrhage, TSAH: traumatic subarachnoid hemorrhage, DAI: diffuse axonal injury, LOC: loss of consciousness, mRS: modified Rankin Scale.
[a] Independent *t*-test.
[b] Mann-Whitney *U* test.
[c] Pearson's Chi-square test.
[d] Fisher's exact test.
[e] $p < 0.05$ indicates statistical significance.
[f] Neurological aggravation refers to a case of progression from mild GCS to moderate or severe GCS after hospitalization.

Table 3
Demographic characteristics of patients with moderate traumatic brain injury.

Characteristics	Men, *n*	Women, *n*	Total, *n* (%)	Proportion of men (%)	*p* value[a,b]
Number	293	101	394	74.4	
Mean age (years)	58.6 ± 16.6	66.4 ± 17.4	60.6 ± 17.1	74.4	0.000[b,e]
Age group (years)					0.000[b,e]
15–30	21	8	29 (7.4)	72.4	0.803[c]
31–49	53	6	59 (15.0)	89.8	0.003[c,e]
50–64	115	24	139 (35.3)	82.7	0.005[c,e]
65–79	78	37	115 (29.2)	67.8	0.056[c]
≥80	26	26	52 (13.2)	50.0	0.000[c,e]
Past history					
Hypertension	97	49	146 (37.1)	66.4	0.005[c,e]
Diabetes	58	23	81 (20.6)	71.6	0.523[c]
Hyperlipidemia	7	3	10 (2.5)	70.0	0.721[d]
Alcoholism	27	6	33 (8.4)	81.8	0.306[c]
Smoking	67	5	72 (18.3)	93.1	0.000[c,e]
Cardiovascular disease	16	12	28 (7.1)	57.1	0.030[c,e]
Liver disease	17	4	21 (5.3)	81.0	0.477[c]
Nervous system disorder	40	22	62 (15.7)	64.5	0.053[c]
Kidney disease	7	2	9 (2.3)	77.8	1.000[d]
Hematology					0.459[b]
None	271	93	364 (92.4)	74.5	
AP	18	7	25 (6.3)	72	
AC	2	0	2 (0.5)	100	
Dual AP & AC	2	3	5 (1.3)	40	
Hemostatic disorder	0	0	0 (0.0)		
Cause of injury					0.037[b,e]
Passenger TA	17	3	20 (5.1)	85.0	0.264[c]
Pedestrian TA	24	27	51 (12.9)	47.1	0.000[c,e]
Motorcycle TA	43	4	47 (11.9)	91.5	0.004[c,e]
Unknown	62	23	85 (21.6)	72.9	0.734[c]
Sports-related	0	1	1 (0.3)	0.0	0.446[d]
Fall or slip	136	42	178 (45.2)	76.4	0.400[c]
Assault or struck on the head	11	1	12 (3.0)	91.7	0.311[d]
Diagnosis					0.023[b,e]
AEDH	29	9	38 (9.6)	76.3	0.772[c]
ASDH	110	53	163 (41.4)	67.5	0.009[c,e]
CSDH	30	9	39 (9.9)	76.9	0.700[c]
Skull fracture, simple	0	1	1 (0.3)	0.0	0.256[d]
Skull fracture, complex	15	1	16 (4.1)	93.8	0.082[d]
TICH	48	16	64 (16.2)	75.0	0.899[c]
TSAH	43	11	54 (13.7)	79.6	0.340[c]
DAI	7	1	8 (2.0)	87.5	0.686[d]
Others	4	0	4 (1.0)	100.0	0.576[d]
Not available	7	0	7 (1.8)	100.0	0.198[d]
Neurological status					
Bilateral fixed pupil	8	4	12 (3.0)	66.7	0.513[d]
Unilateral dilated pupil	9	2	11 (2.8)	81.8	0.736[d]
Verbal disorder	24	4	28 (7.1)	85.7	0.154[c]
Hemiparesis or hemiplegia	30	14	44 (11.2)	68.2	0.319[c]
Decorticated or decerebrated posture	5	1	6 (1.5)	83.3	1.000[d]
Unresponsiveness	0	0	0		
Operation					
Extracranial injury requiring surgery	50	16	66 (16.8)	75.8	0.776[c]
Cranial injury requiring surgery	140	52	192 (48.7)	72.9	0.521[c]
Outcome					0.427[c]
Survival	252	90	342 (86.8)	73.7	
Death	41	11	52 (13.2)	78.8	
mRS					0.463[b]
0	28	6	34 (8.6)	82.4	
1	74	26	100 (25.4)	74.0	
2	32	14	46 (11.7)	69.6	
3	47	19	66 (16.8)	71.2	
4	33	10	43 (10.9)	76.7	
5	38	15	53 (13.5)	71.7	
6	41	11	52 (13.2)	78.8	

AP: antiplatelet agent, AC: anticoagulant, TA: traffic accident, AEDH: acute epidural hematoma, ASDH: acute subdural hematoma, CSDH: chronic subdural hematoma, TICH: traumatic intracerebral hemorrhage, TSAH: traumatic subarachnoid hemorrhage, DAI: diffuse axonal injury, LOC: loss of consciousness, mRS: modified rankin scale.

[a] Independent *t*-test.
[b] Mann-Whitney *U* test.
[c] Pearson's Chi-square test.
[d] Fisher's exact test.
[e] $p < 0.05$ indicates statistical significance.

There was also a significant difference between men and women in the age distribution, which converts age to an ordinal scale (p = 0.000). Although there were significant differences between men and women in the age groups of 50–64, 65–79, and ≥80 years (p = 0.000, p = 0.019, and p = 0.000), no significant differences were seen in the age groups of 15–30 and 31–49 years (p = 0.361 and p = 0.366). Among the past history characteristics, alcoholism, smoking, and cardiovascular disease were significantly different between men and women (p = 0.015, p = 0.000, and p = 0.018), while hypertension, diabetes, hyperlipidemia, liver disease, nervous system disorder, kidney disease, and hematological history were not significantly different (p = 0.074, p = 0.791, p = 0.375, p = 0.687, p = 0.286, p = 0.077 and p = 0.129). The cause of injury in the severe TBI group showed no significant differences between men and women (p = 0.519). The most common cause of trauma was a fall or slip (40.2%, n = 245), followed by unknown causes (19.9%, n = 121), pedestrian TA (15.1%, n = 92), motorcycle TA (13.5%, n = 82), passenger TA (7.6%, n = 46), assault or being struck on the head (3.6%, n = 22), and sports-related injury (0.2%, n = 1). The diagnosis in the severe TBI group showed no significant differences between men and women (p = 0.152). The most common diagnosis was ASDH (60.8%, n = 370), followed by TSAH (12.0%, n = 73), cerebral contusion or TICH (9.7%, n = 59), AEDH (9.0%, n = 55), skull fracture (2.3%, n = 14), DAI (2.1%, n = 13), CSDH (2.0%, n = 12), others (1.1%, n = 7), and non-available (1.0%, n = 6). The difference in all abnormal neurological statuses according to sex was not statistically significant. The most common abnormal neurological status was a bilateral fixed pupil (31.2%, n = 190, p = 0.749), followed by decorticated or decerebrated posture (11.2%, n = 68, p = 0.942), unilateral dilated pupil (11.0%, n = 67, p = 0.184), motor dysfunction including hemiparesis or hemiplegia (8.4%, n = 51, p = 0.058), verbal disturbance (3.6%, n = 22, p = 0.389), and unresponsiveness (2.6%, n = 16, p = 0.103). A total of 139 patients (22.8%) received surgical treatment for extracranial injury and 362 (59.4%) received surgical treatment for cranial injury; these differences according to sex were not statistically significant (p = 0.109 and p = 0.158). Among the 609 severe TBI patients, 302 patients (49.6%) survived and 307 (50.4%) died; the difference in mortality according to sex was not statistically significant (p = 0.876). The mRS scale showed no significant differences between men and women (p = 0.350).

Risk factors for moderate and severe TBI compared to mild TBI

Table 5 shows the results of logistic regression analysis conducted to investigate the risk factors of moderated TBI compared to mild TBI. Gender, hyperlipidemia, alcoholism, liver disease, and cause of injury (pedestrian TA) were identified as risk factors (p = 0.026, p = 0.032, p = 0.010, p = 0.001, and p = 0.000). Table 6 shows the results of logistic regression analysis conducted to investigate the risk factors of moderated TBI compared to mild TBI. Gender, age group (≥80 years), hyperlipidemia, hematological history (anticoagulant), and cause of injury (pedestrian TA, motorcycle TA, and unknown) were identified as risk factors (p = 0.001, p = 0.045, p = 0.007, p = 0.006, p = 0.000, p = 0.009, and p = 0.001).

Discussion

In this study, the proportion of men was 68.8%. Gender differences in the incidence of TBI are well known. Men are more likely to expose to injuries than women because they are more likely to engage in injury-prone work or in dangerous behavior.[4,11] As a result of this increased risk, many studies related to TBI have focused primarily on men or have not considered gender effects. Although men have more TBI than women, women still constitute a significant portion of patients with TBI.[6] Several studies have shown that there is no gender difference in the incidence of TBI in children.[12,13] It is known that the incidence of TBI between gender differs only from puberty to middle age and the TBI ratio between genders is similar for the rest of the age groups.[12,13] There was no gender difference in the TBI ratio in elderly patients (≥65 years of age). After the age of 75, women have a slightly higher incidence of mild TBI than men due to more falls.[14] Munivenkatappa et al.[9] found that nearly two-thirds of female TBI patients were in the third to sixth decade. This is probably because these age groups are more vulnerable to road injuries and disputes. In the current study, the mean age of women was 6.7 years higher than that of men, and the incidence of TBI was significantly different between men and women in all age groups. The TBI incidence in men was high in the youth, middle-aged, and prime-aged, while the proportion of women increased significantly with age in the elderly and super-aged elderly. Among the past history characteristics, the occurrence of hypertension, hyperlipidemia, cardiovascular disease, and nervous system disorders were higher in women than in men, but alcoholism, smoking, liver disease, and hematological history were higher in men than in women (p < 0.05). Since women participate in more sports and other TBI-risk behavior, the incidence of TBI in women may be increasing.[6] In this study, although there were no significant differences between men and women in terms of the cause of injury, the proportion of motor cycle TA and sport-related injury, and of assault or being struck on the head was higher in men, and the proportion of pedestrian TA, passenger TA, and fall or slip was higher in women. Skull fracture, AEDH, DAI, TICH, and CSDH affected a higher proportion of men than women, while concussion, ASDH and TSAH affected a higher proportion of women than men (p > 0.05). The GCS scores showed significant differences between the sexes in all groups, and the proportion of women in the mild group and the proportion of men in the moderate and severe groups were high. Although epidemiological studies of sex differences in the outcome after TBI are limited, several studies suggested that the outcome after TBI may be worse in women than in men.[6] Klauber et al.[15] reported that there was an independent association between age and survival according to GCS scores, but there was no association between sex and survival in their study of 1311 TBI patients. The overall mRS tended to be worse in men in this study. Although there was no statistical significance between mRS and gender, the proportion of women affected was higher in mRS grade 1 and 0, and the proportion of men affected by mRS grade 3, 4, 6, 2, and 5 was higher.

The proportion of males in the mild TBI group was 67.3%, slightly lower than the total male percentage of 68.8%. The mild TBI group accounted for 77.6% of the total TBI patients included in the study. Of the 1.5 million TBIs that occur in the United States each year, mild TBI accounts for over 85%.[16] Bazarian et al.[16] found that the average incidence of mild TBI was 503.1/100,000 people, with peaks among males (590/100,000), American Indians/Alaska Natives (1026/100,000), and those <5 years of age (1115.2/100,000). The incidence of mild TBI was highest in the Midwest region (578.4/100,000) and in non-urban areas (530.9/100,000) of the United States. Bicycles and sports accounted for 26.4% of mTBI in the 5–14 years age group. Rimel et al.[17] have established that many more men than women sustain a mild TBI. Kraus and Nourjah[1] reported that the incidence

Table 4
Demographic characteristics of patients with severe traumatic brain injury.

Characteristics	Men, *n*	Women, *n*	Total, *n* (%)	Proportion of men (%)	*p* value
Number	450	159	609	73.9	
Mean age (years)	58.3 ± 16.9	65.5 ± 18.5	60.2 ± 17.6		0.000[a,e]
Age group (years)					0.000[b,e]
15–30	45	12	57 (9.4)	78.9	0.361[c]
31–49	73	21	94 (15.4)	77.7	0.366[c]
50–64	159	28	187 (30.7)	85.0	0.000[c,e]
65–79	138	65	203 (33.3)	68.0	0.019[c,e]
≥80	35	33	68 (11.2)	51.5	0.000[c,e]
Past history					
Hypertension	154	67	221 (36.3)	69.7	0.074[c]
Diabetes	89	33	122 (20.0)	73.0	0.791[c]
Hyperlipidemia	13	2	15 (2.5)	86.7	0.375[d]
Alcoholism	22	1	23 (3.8)	95.7	0.015[c,e]
Smoking	102	3	105 (17.2)	97.1	0.000[c,e]
Cardiovascular disease	34	22	56 (9.2)	60.7	0.018[c,e]
Liver disease	14	6	20 (3.3)	70	0.687[c]
Nervous system disorder	66	29	95 (15.6)	69.5	0.286[c]
Kidney disease	14	10	24 (3.9)	58.3	0.077[c]
Hematology					0.129[b]
None	410	140	550 (90.3)		
AP	27	12	39 (6.4)	69.2	
AC	8	5	13 (2.1)	61.5	
Dual AP & AC	4	1	5 (0.8)	80.0	
Hemostatic disorder	1	1	2 (0.3)	50.0	
Cause of injury					0.519[b]
Passenger TA	36	10	46 (7.6)	78.3	
Pedestrian TA	51	41	92 (15.1)	55.4	
Motorcycle TA	75	7	82 (13.5)	91.5	
Unknown	92	29	121 (19.9)	76.0	
Sports-related	1	0	1 (0.2)	100.0	
Fall or slip	176	69	245 (40.2)	71.8	
Assault or struck on the head	19	3	22 (3.6)	86.4	
Diagnosis					0.152[b]
AEDH	46	9	55 (9.0)	83.6	
ASDH	272	98	370 (60.8)	73.5	
CSDH	9	3	12 (2.0)	75.0	
Skull fracture, simple	0	1	1 (0.2)	0.0	
Skull fracture, complex	11	2	13 (2.1)	84.6	
Cerebral contusion (TICH)	43	16	59 (9.7)	72.9	
TSAH	51	22	73 (12.0)	69.9	
Diffuse axonal injury	9	4	13 (2.1)	69.2	
Others (vascular injury)	5	2	7 (1.1)	71.4	
Not available	4	2	6 (1.0)	66.7	
Neurological status					
Bilateral fixed pupil	141	48	190 (31.2)	74.7	0.749[c]
Unilateral dilated pupil	45	22	67 (11.0)	67.2	0.184[c]
Verbal disorder	18	4	22 (3.6)	81.8	0.389[c]
Hemiparesis or hemiplegia	32	19	51 (8.4)	62.7	0.058[c]
Decorticated or decerebrated posture	50	18	68 (11.2)	73.5	0.942[c]
Unresponsiveness	9	7	16 (2.6)	56.2	0.103[b]
Operation					
Extracranial injury requiring surgery	110	29	139 (22.8)	79.1	0.109[c]
Cranial injury requiring surgery	275	87	362 (59.4)	76.0	0.158[c]
Outcome					
Survival	223	78	301 (49.4)	74.1	0.876[c]
Death	227	81	308 (50.6)	73.7	
mRS					0.350[b]
0	9	5	14 (2.3)	64.3	
1	27	12	39 (6.4)	69.2	
2	18	6	24 (3.9)	75.0	
3	41	2	43 (7.1)	95.3	
4	29	11	40 (6.6)	72.5	
5	99	42	141 (23.2)	70.2	
6	227	81	308	73.7	

AP: antiplatelet agent, AC: anticoagulant, TA: traffic accident, AEDH: acute epidural hematoma, ASDH: acute subdural hematoma, CSDH: chronic subdural hematoma, TICH: traumatic intracerebral hemorrhage, TSAH: traumatic subarachnoid hemorrhage, DAI: diffuse axonal injury, LOC: loss of consciousness, mRS: modified Rankin Scale.
[a] Independent *t*-test.
[b] Mann-Whitney *U* test.
[c] Pearson's Chi-square test.
[d] Fisher's exact tests.
[e] $p < 0.05$ indicates statistical significance.

Table 5
Risk factors for moderate traumatic brain injury compared to mild traumatic brain injury.

Characteristics	*OR*	95% *CI*		*p* value
		Lower	Upper	
Gender				
Male	1.33	1.03	1.72	0.026
Age group (ref. 15–30) (years)				
31–49	0.88	0.54	1.42	0.590
50–64	1.20	0.76	1.88	0.431
65–79	0.85	0.53	1.35	0.489
≥80	0.93	0.55	1.58	0.797
Past history				
Hypertension	0.89	0.69	1.14	0.366
DM	1.17	0.88	1.56	0.271
Hyperlipidemia	0.49	0.25	0.94	0.032
Alcoholism	1.73	1.14	2.64	0.010
Smoking	1.08	0.80	1.45	0.617
Cardiovascular disease	0.83	0.54	1.28	0.410
Liver disease	2.48	1.47	4.19	0.001
Nervous system disorder	1.12	0.83	1.52	0.456
Kidney disease	0.68	0.33	1.38	0.283
Hematology (ref. none)				
AP	0.82	0.52	1.29	0.397
AC	0.65	0.15	2.79	0.562
Dual AP & AC	1.48	0.42	5.26	0.544
Hemostatic disorder	–	–	–	
Cause of injury (ref. Passenger TA)				
Pedestrian TA	4.21	2.43	7.30	0.000
Motorcycle TA	2.29	1.32	3.98	0.003
Unknown	2.96	1.76	4.98	0.000
Sports-related	0.54	0.07	4.19	0.556
Fall or slip	1.84	1.13	2.99	0.014
Assault or struck on the head	0.86	0.41	1.79	0.682

[a] $p < 0.05$ indicates statistical significance. OR: odds ratio, CI: confidence interval, AP: antiplatelet agent, AC: anticoagulant, TA: traffic accident.

Table 6
Risk factors for severe traumatic brain injury compared to mild traumatic brain injury.

Characteristics	*OR*	95% *CI*		*p* value
		Lower	Upper	
Gender				
Male	1.41	1.14	1.74	0.001[a]
Age group (ref. 15–30) (years)				
31–49	0.79	0.54	1.15	0.221
50–64	0.89	0.63	1.26	0.506
65–79	0.79	0.55	1.14	0.208
≥80	0.65	0.42	0.99	0.045[a]
Past history				
Hypertension	0.88	0.71	1.08	0.215
Diabetes	1.08	0.86	1.37	0.507
Hyperlipidemia	0.48	0.28	0.82	0.007[a]
Alcoholism	0.77	0.48	1.23	0.275
Smoking	1.09	0.85	1.39	0.498
Cardiovascular disease	1.03	0.74	1.44	0.847
Liver disease	1.68	0.99	2.85	0.053
Nervous system disorder	1.14	0.88	1.46	0.325
Kidney disease	1.25	0.78	2.00	0.353
Hematology (ref. none)				
AP	0.81	0.56	1.18	0.282
AC	2.60	1.31	5.18	0.006[a]
Dual AP & AC	1.57	0.56	4.38	0.387
Hemostatic disorder	1.17	0.24	5.65	0.849
Cause of injury (ref. Passenger TA)				
Pedestrian TA	3.35	2.25	4.99	0.000[a]
Motorcycle TA	1.69	1.14	2.52	0.009[a]
Unknown	1.86	1.27	2.71	0.001[a]
Sports-related	0.21	0.03	1.61	0.134
Fall or slip	1.15	0.81	1.62	0.436
Assault or struck on the head	0.71	0.41	1.21	0.210

[a] $p < 0.05$ indicates statistical significance. OR: odds ratio, CI: confidence interval, AP: antiplatelet agent, AC: anticoagulant, TA: traffic accident.

of mild TBI was approximately twice as high in males than in females. Munivenkatappa et al.[9] found that the proportion of women affected in the age group under 18 was greater than men. Mild TBIs were more common in women, especially in the pediatric and elderly age groups. In this study, the mean age in the mild TBI group was 6.5 years higher in women than in men, and there were significant differences between men and women in the occurrence of mild TBI across all age groups. In the youth, middle-aged, and prime-aged, the incidence of mild TBI in men was high, and the proportion of women increased significantly with age in the elderly and superaged elderly. This pattern was similar to the age distribution of the TBI patients overall. Among the past history variables, the occurrence of hyperlipidemia, hypertension, nervous system disorder, and hematological history were higher in women than in men, but the occurrence of alcoholism, smoking, and liver disease were higher in men than in women ($p < 0.05$). Bazarian et al.[16] reported that fall and motor cycle TA were the most common cause of injury in mild TBI. In their study, the cause of mild TBI varied considerably according to age; fall occurred frequently at extremes of age, and assaults and motor cycle TA occurred frequently in middle-aged people. Combining bicycle accidents and sports was the biggest cause of mTBI in the 5–14 age group, accounting for 26.4% of the total mildTBIs. In the current study, although there were no significant differences between men and women in terms of the cause of injury, the proportion of sport-related injury, motor cycle TA, and assault or being struck on the head was higher in men, and the proportion of pedestrian TA, passenger TA, and fall or slip was higher in women. This was similar to the cause of injury of TBI patients overall. Skull fracture, AEDH, DAI, TICH, and CSDH affected a higher proportion of men than women, while concussion, ASDH, and TSAH affected a higher proportion of women than men ($p > 0.05$). This was also similar to that of the TBI patients overall. Scalp injury was more in women than in men ($p > 0.05$). Clinical symptoms, dizziness, and nausea or vomiting were also significantly higher in women. Although there were no significant differences, the incidence of headache was higher in women, and the incidence of LOC or seizure-like activity was higher in men. Neurological symptoms were common in men (memory disturbance or disorientation, cranial nerve abnormalities, verbal disturbance, and altered mentality) except motor dysfunction (which was the same as in women), but neurological aggravation was more common in women ($p > 0.05$). Surgical treatment was more common in men and this difference in gender was statistically significant. This is believed to be due to more conservative treatment in women because of the high proportion of concussion in them and the high rate of neurological symptoms in men. There were no deaths in the mild TBI group. The mRS grade 0 was more for men and grade 1 was more for women ($p > 0.05$).

The difference in prognosis between men and women after moderate to severe TBI is still controversial. Kraus et al.[18] examined gender as an independent predictor of survival following TBI. They reported that the overall mortality rate after moderate to severe TBI was 1.28 times higher in women than in men. Women were 1.75 times more likely to die from TBI than men if they had controlling for age, admission GCS, penetrating injury, and multiple traumas. They also reported that women were 1.57 times more likely to experience severe disabilities or a persistent vegetative state than men. However, Groswasser et al.[19] reported better outcomes after severe TBI in women compared with men. They suggested that this result could be related to the role of gonadal hormones with progesterone as a central nervous system protector, as reported in previous experimental studies. Some animal studies have emphasized the role of the gonadal hormones in determining the severity of injury and functional consequences after TBI. Roof and Hall[5] showed no evidence of brain edema at the lesion site in

contusion in female rat models with a high progesterone status (pseudopregnancy). They also reported that the progesterone treatment to mate rat models prior to injury reduces the incidence of brain edema and improves function recovery. They concluded that high levels of progesterone seem to protect the brain from secondary damage after TBI. Slewa-Yunan et al.[20] investigated the effect of sex on injury severity and outcome measurement of patients after TBI. Reflecting upon their lower GCS scores and longer post-traumatic amnesia duration, they have shown that men have a higher severity of injury than women. There was no significant difference in measuring outcomes between men and women.

In the current study, the proportion of males in the moderate TBI group was 74.4%, higher than the total male percentage of 68.8%. The moderate TBI group had the highest proportion of males among the three groups. The moderate TBI group had the lowest number of patients, with only 8.8% of the total TBI patients. The mean age in the moderate TBI group was 7.8 years higher in women than in men, and the moderate TBI group had the largest age difference among the three groups. The proportion of women was higher in the youth. The incidence of moderate TBI in men was higher in the middle-aged and prime-aged, while the proportion of women increased significantly with age in the elderly and superaged elderly. Among the past history characteristics, the occurrence of cardiovascular disease and hypertension was higher in women than in men, and smoking was higher in men than in women ($p < 0.05$). Among the three groups, only moderate TBI showed significant differences in the cause of injury between men and women. Pedestrian TA was higher in women and motorcycle TA was higher in men ($p < 0.05$). The incidence of ASDH in the diagnosis of the moderate TBI group was higher in women than in men ($p < 0.05$). Women patients with moderate TBI complained more of dizziness and nausea or vomiting ($p < 0.05$). Scalp injury and headache were higher in women, while LOC or seizure like activity were higher in men ($p > 0.05$). Among the neurological status characteristics, bilateral fixed pupil and hemiparesis or hemiplegia were higher in women, and verbal disorder, decorticated or decerebrated posture, and unilateral dilated pupils were higher in men with moderate TBI ($p > 0.05$). Extracranial injury requiring surgery and mortality were higher in men and cranial injury requiring surgery was higher in women ($p > 0.05$). In the moderate TBI group, mRS grade 4, 6, and 0 were more for men and grade 2, 3, 5, and 1 were more for women ($p > 0.05$).

The proportion of males in the severe TBI group was 73.9% and the mean age was 7.2 years higher in women than in men. In the youth, middle-aged, and prime-aged groups, the incidence of TBI in men was high, and the proportion of women increased significantly with age in the elderly and superaged elderly. Among the past history characteristics, cardiovascular disease was more in women than in men, and smoking and alcoholism were more in men than in women. Although there were no significant differences in the cause of injury in the severe TBI group, the proportion of pedestrian TA and fall or slip were higher in women, and the proportion of motorcycle TA, assault or being struck on the head, and passenger TA were higher in men. The diagnoses except for skull fractures, AEDH and CSDH had a higher proportion in women than men ($p > 0.05$). The neurological status, verbal disorder, and bilateral fixed pupil were higher in men, while unresponsiveness, hemiparesis or hemiplegia, unilateral dilated pupil, and decorticated or decerebrated posture were higher in women ($p > 0.05$). Although both extracranial injury requiring surgery and cranial injury requiring surgery were more common in men, the mortality rate was similar to that of the severe group ($p > 0.05$). In the severe TBI group, mRS grade 3 and 2 were more for men and grade 0, 1, 5, 4, and 6 were more for women ($p > 0.05$).

To the best of our knowledge, this multicenter study is the first to focus on the gender differences of adult patients with TBI in Korea. The authors identified the gender differences in epidemiological, clinical, treatment, mortality, and variable characteristics between men and women in adult TBI patients according to GCS. This study shows significant differences between men and women in many aspects of adult TBI. Therefore, gender differences should be strongly considered in TBI studies. Although there are many limitations, the results of this descriptive study may help to identify the current status of TBI patients in Korea and make important contributions to treating TBI in the future.

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Ethical statement

The manuscript does not report on or involve the use of any animal or human tissue.

Declaration of competing interest

No potential conflict of interest relevant to this article is reported.

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