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Clinical characteristics of patients with snow sports trauma transported to a trauma care center: A retrospective observational study

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ABSTRACT

Background: Snow sports are a popular recreational activity; however, the incidence of injury of snow sports can be high for skiers and snowboarders. Our hospital receives severe trauma cases from snow resorts and hospitals throughout the region. This study aimed to determine whether the risk of snow sports-related major trauma that requires emergency surgery under general anesthesia varies by the equipment and injury mechanism.

Methods: This retrospective cohort study included patients with snow sports trauma referred to Gifu University Hospital, Japan between November 2010 and March 2020. We analyzed the need for emergency operation under general anesthesia within 24 h using Fisher's exact test. We identified 106 patients: (1) 90 in the snowboarders' group and 16 in the skiers' group or (2) 46 in the fall after jumping group (jumping group), 27 in the collide with other people and obstacle group (collision group), and 33 in the fall during gliding group (gliding group).

Results: Snowboarders were nearly twice as likely as skiers to require emergency surgery under general anesthesia (44% vs. 25%; $p = 0.236$]. No significant associations were found between emergency surgery under general anesthesia and injury mechanism, but half of the patients in the jumping group required emergency surgery.

Conclusions: Snowboard as equipment and falls after jumping as a mechanism of injury tended to be associated with emergency surgery under general anesthesia, with no significant differences. In order to provide adequate resources for snow sports trauma, the cause of the patient's injury is strongly related to the urgency of the condition, and transport to a trauma center should be actively considered. Further studies are warranted with respect to the effects of personal protective equipment and skill level.

Introduction

Snow sports are a popular recreational activity; however, the incidence of injury due to snow sports can be high for skiers and snowboarders [1,2]. In the United States, approximately 17 million people participate in snow skiing and snowboarding annually [3]. Emergency departments in the United States treat approximately 200,000 injuries related to skiing and snowboarding annually, and most patients are adults. Although most patients are discharged on the same day, roughly 7000 require hospitalization annually [4,5]. Skiers are often admitted to the floor or the operating room, whereas snowboarders are frequently sent to the intensive care unit (ICU) [6]. In Japan, the populations of skiers and snowboarders peaked in the 1990s and early 2000s, respectively, and the num-

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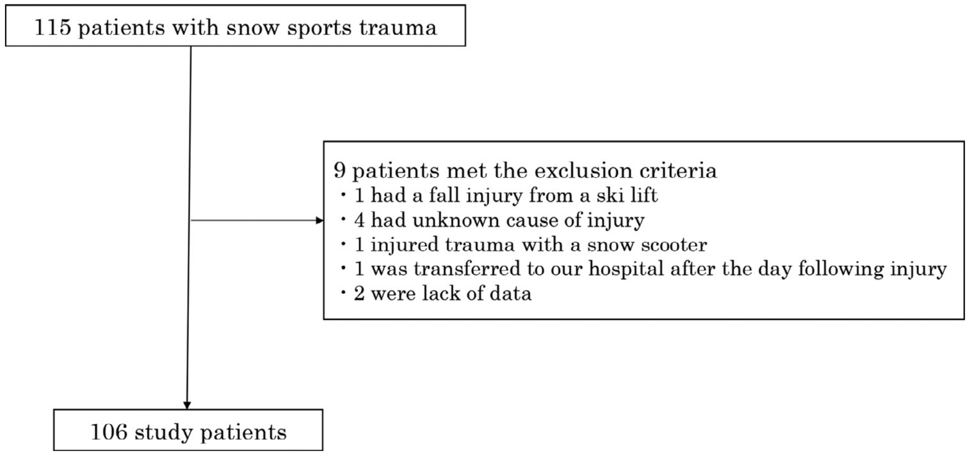

Fig. 1. Flowchart of participant enrolment in the study.

ber of both has been decreasing. However, there are still reports of trauma, especially among young people.

Our hospital receives severe trauma cases from snow resorts and hospitals throughout the region, which has one of the largest numbers of snow resorts in the country. There are 10 snow resorts within the main region, with 1–1.2 million resort guests per year, comprising 35% skiers and 65% snowboarders [7]. We also actively work with patrols and emergency medical services to provide transport and treatment, while utilizing a medical helicopter. Past studies have shown that snowboarding injuries are associated with a higher number of upper limb fractures and foot, head, and severe injuries compared with skiing [8].

We reviewed the injury profile of patients with alpine skiing or snowboarding trauma who were brought to our hospital, taking into account recent trends. This study aimed to determine whether the risk of snow sports-related major trauma that requires emergency surgery under general anesthesia varies by equipment and injury mechanism, which may lead to consideration of transport to a trauma center.

Materials and methods

Study oversight and design

We conducted a retrospective, single-center cohort study involving patients who were referred to the Advanced Critical Care Center, Gifu University Hospital between November 2010 and March 2020. This study conformed with the principles outlined in the Declaration of Helsinki [9]. Ethics approval was obtained from the institutional ethics committee of Gifu University (approval #2020–0103, approved on July 1, 2020). The institutional ethics committee of Gifu University Graduate School of Medicine approved the substitution of an opt-out notice for informed consent from patients owing to the retrospective nature of this study, whose design was based on data from electronic patient records reviewed and anonymized by the authors.

Study patients

Patients with snow sports trauma aged over 18 years who were referred to our trauma treatment center were included in this study. The mode of transport was direct transport from the snow resort on the day of injury or transfer from a hospital near the snow resort, and the mode of transport was ambulance or helicopter. Cases that were not related to skiing or snowboarding trauma at a snow resort, with unclear injury mechanisms, transported after the day following injury, and/or with missing data were excluded from the analysis (Fig. 1).

Data collection

We collected data from the electronic medical records on age, sex, mode of transport, transport time, medical history, sport (alpine skiing, snowboarding), cause of trauma, course of run at time of injury, blood test results, vital signs on arrival, shock index, injury severity score (ISS), Acute Physiological and Chronic Health Evaluation (APACHE II) score, overall transfusion requirement, durations of ICU and hospital days, ventilator use, functional sequelae, and mortality.

ISS is a severity rating method for patients with multiple trauma developed by Baker et al. and is calculated based on the Abbreviated Injury Scale (AIS). The ISS is defined as the maximum AIS score for each site, multiplied by the square of the maximum score for the top three sites and added together, with a range from 1 to 75 and with higher scores indicating more severe injuries. The APACHE II system is a severity-of-disease classification system and is one of the several ICU scoring systems. It is calculated within 24 h of admission to an ICU [10].

Primary and secondary outcomes

The primary outcome was emergency operation under general anesthesia within 24 h. The secondary outcomes were death, functional sequelae, transcatheter arterial embolization (TAE), ICU admission, duration of ICU and hospital stay, use of the ventilator in an ICU, days of using a ventilator, and requirement for transfusion overall and by formulation (red blood cells [RBCs], fresh frozen plasma [FFP], and platelet concentrate [PC]).

Statistical analyses

Patient characteristics by tools and by injury mechanisms were summarized using median and interquartile range (IQR) for continuous variables, and counts and percentages for categorical variables. Differences in characteristics between skiers and snowboarders were compared using the Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables. Differences in characteristics among the injury mechanisms were compared using the Kruskal-Wallis test for continuous variables and Fisher's exact test for categorical variables.

Table 1
Clinical characteristics of the participants by equipment.

Variable	N	Overall, $N = 106$[1]	Skiers, $N = 16$[1]	Snowboarders, $N = 90$[1]	*p*-value[2]
Age, yrs	106	26 (21, 34)	47(26, 58)	26(21,32)	0.003
Male	106	88 (83%)	14 (88%)	74 (82%)	0.922
HR, /min	106	81 (71, 92.5)	85.5 (72, 95.5)	81 (71, 90)	0.747
SBP, mmHg	106	127.5 (112, 144)	131 (114, 137.5)	126 (112, 146.3)	0.986
SI	106	0.64 (0.56, 0.77)	0.66 (0.54, 0.78)	0.64 (0.56, 0.76)	0.781
MAP, mmHg	105	91 (80, 103)	93.5 (79.3, 103.8)	91 (81, 103)	0.897
RR, /min	102	20 (16, 23)	18 (14, 19.5)	20 (16, 24)	0.044
BT, °C	98	36.7 (36.2, 37.4)	36.6 (36.3, 37.1)	36.8 (36.2, 37.4)	0.322
pH	106	7.36 (7.33, 7.39)	7.37 (7.34, 7.38)	7.36 (7.32, 7.39)	0.870
sNa, mmol/L	106	140 (138, 141)	140.5 (139, 142)	140 (138, 141)	0.238
sK, mmol/L	106	3.8 (3.4, 4.0)	3.8 (3.65, 3.92)	3.8 (3.4, 4.0)	0.856
sCre, mg/dL	106	0.74 (0.63, 0.86)	0.77 (0.64, 0.88)	0.74 (0.63, 0.85)	0.757
WBC, /mm³	106	14,845 (11,380, 19,720)	12,890 (10,690, 17,465)	15,600 (11,608, 20,883)	0.103
GCS, pts	106	15 (14, 15)	15 (14, 15)	15 (14, 15)	0.978
Hct,%	106	40.6 (37.9, 44)	41.7 (40.0, 42.8)	40.4 (37.8, 44.4)	0.649
Hb, g/dL	106	14.2 (12.9, 15.2)	14.6 (14.0, 14.9)	14.1 (12.7, 15.2)	0.563
Fib, mg/dL	106	209 (182, 245)	207 (188, 272)	210 (182, 244)	0.510
Plt, $\times 10^4/\mu L$	106	21.9 (19, 24.9)	22.6 (17.9, 24.1)	21.8 (19.1, 24.9)	0.919
Lac, mg/dL	106	16.5 (11.5, 23)	12.5 (10, 19.3)	17 (12.3, 23)	0.181
APACHEII score, pts	96	7 (3.8, 10.3)	6 (4.5, 11.5)	7 (3, 10)	0.940
ISS, pts	106	9 (9, 16)	16 (9, 17.8)	9 (9, 16)	0.136

Abbreviations: HR; heart rate, SBP; systolic blood pressure, SI; shock index, MAP; mean arterial pressure, RR; respiratory rate, BT; body temperature, sNa; serum sodium, sK; serum potassium, sCre; serum creatinine, WBC; white blood cell, GCS; Glasgow Coma Scale, Hct; hematocrit, Hb; hemoglobin, Fib; fibrinogen, Plt; platelet count, Lac; lactate, APACHE II score; Acute Physiology and Chronic Health Evaluation II score, ISS; Injury Severity Score.

[1] *Statistical data are presented as the median (interquartile range) or n (%).*

[2] *Statistical tests performed: Wilcoxon rank-sum test, Fisher's exact test.*

Fisher's exact test evaluated the association of tools and injury mechanism to emergency surgery with general anesthesia within 24 h. The same analysis approach was used to evaluate the association between tools and injury mechanisms for the secondary binary outcomes. Two-sided p-values for Fisher's exact test used for the two-group comparison were calculated as twice the one-sided p-value. All secondary continuous outcomes were evaluated using Mann-Whitney U test or Kruskal-Wallis test. All statistical analyses were conducted using R software version 4.1.1 (The R Project for Statistical Computing). A two-sided significance level of 5% was used.

Results

Baseline characteristics

A total of 115 records were reviewed between November 2010 and March 2020. The analysis included 106 eligible participants who met the criteria of this study (Fig. 1). In total, 93 (88%) patients were transported by air ambulance, and 13 (12%) patients were transported by road ambulance to our trauma center. Tables 1 and 2 summarize the clinical characteristics of the patients by equipment or injury mechanism. (Tables 1 and 2). In this study, snowboarders had more injured, a significantly younger median age than skiers (26 vs. 47 years old; $p = 0.003$), and a higher respiratory rate at arrival (20 vs. 18 /min; $p = 0.044$) (Table 1). There were significant differences in blood pH values at arrival among the three groups divided by the injury mechanism, but no significant differences were found in the other results (Table 2).

Outcomes

By equipment

Snowboarders were nearly twice as likely as skiers to require emergency surgery under general anesthesia, although the difference was not significant. (44% vs. 25%; $p = 0.236$). Snowboarders were also more likely than skiers to require treatment such as TAE and blood transfusion. (Table 3).

Mechanism of injury

There were significant differences among the three groups for overall transfusion ($p = 0.014$), RBC infusion volume ($p = 0.015$), and FFP transfusion volume ($p = 0.020$), with the collide with other people/obstacle group (collision group) requiring more for all formulations. No significant associations were found between emergency surgery under general anesthesia and injury mechanism, but half of the patients in the fall after jumping group (jumping group) required emergency surgery. (Table 4).

Injury sites

In the snowboarder group, the most common injury site was the spine, followed by the head, abdomen, and extremities. In the skier group, the most common injury site was the spine, followed by the head and thorax (Fig. 2A). By mechanism of injury, spine injuries were prominent in the jumping group, whereas abdomen and spine injuries were more common in the gliding group compared to the other groups. There was no obvious trend in the collision group (Fig. 2B).

DISCUSSION AND CONCLUSIONS

Highlight

In this retrospective study, we reported that snowboard as an equipment and falls after jumping as an injury mechanism tended to be associated with emergency surgery under general anesthesia, although no significant differences were found. To the best of our knowledge, this is the first study to analyze whether more urgent surgery is required for patients with snow sports trauma depending on the type of equipment and the mechanism of injury. However, we would like to add that present analysis was univariate, so bias adjustment was not performed, and the results may have been slightly conservative due to Fisher's exact test and nonparametric test. Since there are few medical facilities available for emergency surgery in our region and in other regions where snow sports trauma may occur, we believe this study can help to improve the patient trajectory from the time of injury and onwards.

Table 2
Clinical characteristics of the participants by injury mechanism.

Variable	N	Overall, $N = 106$[1]	Fall after jumping group, $N = 46$[1]	Collide with other people or obstacle group, $N = 27$[1]	Fall during gliding group, $N = 33$[1]	p-value[2]
Age, yrs	106	26 (21, 34)	26 (22, 32)	27 (20, 40)	28 (21, 43)	0.508
Male	106	88 (83%)	40 (87%)	21 (78%)	27 (82%)	0.543
HR /min	106	81 (71, 92.5)	84 (74.5, 94)	80 (74, 93)	80 (67, 87)	0.247
SBP, mmHg	106	127.5 (112, 144)	132 (110, 146.3)	127 (112, 138)	122 (115, 154)	0.915
SI	106	0.64 (0.56, 0.77)	0.67 (0.56, 0.78)	0.64 (0.56, 0.74)	0.64 (0.5, 0.71)	0.411
MAP, mmHg	105	91 (80, 103)	92.5 (79, 102.8)	90 (82.5, 102)	91 (83, 107)	0.876
RR /min	102	20 (16, 23)	20 (16, 23)	20 (16, 23.5)	20 (16, 23)	0.850
BT, °C	98	36.7 (36.2, 37.4)	36.8 (36.2, 37.4)	36.7 (36.2, 37.5)	36.6 (36.2, 37.2)	0.657
pH	106	7.36 (7.33, 7.39)	7.36 (7.32, 7.39)	7.34 (7.31, 7.37)	7.38 (7.36, 7.39)	0.041
sNa, mmol/L	106	140 (138, 141)	140 (138, 141)	140 (138, 140)	141 (138, 142)	0.272
sK, mmol/L	106	3.8 (3.4, 4.0)	3.8 (3.4, 4.0)	3.6 (3.2, 3.9)	3.8 (3.5, 4.0)	0.257
sCre, mg/dL	106	0.74 (0.63, 0.86)	0.74 (0.63, 0.88)	0.71 (0.60, 0.78)	0.82 (0.65, 0.91)	0.121
WBC, /mm³	106	14,845 (11,380, 19,720)	15,360 (12,033, 19,495)	15,670 (13,045, 20,360)	12,720 (10,160, 18,920)	0.468
GCS, pts	106	15 (14, 15)	15 (15, 15)	15 (13.5, 15)	15 (14, 15)	0.235
Hct,%	106	40.6 (37.9, 44)	40.5 (37.9, 44.8)	40.2 (37.5, 43.7)	41.3 (38.2, 42.8)	0.795
Hb, g/dL	106	14.2 (12.9, 15.2)	14.2 (12.9, 15.3)	14 (12.9, 15.1)	14.2 (13.1, 15)	0.813
Fib, mg/dL	99	209 (181.5, 245)	193 (179.5, 230)	198 (164.3, 259.5)	229 (205.3, 254.3)	0.075
Plt, $\times 10^4/\mu$L	106	21.9 (19, 24.9)	21.7 (19.1, 24.1)	20.9 (17.9, 25.1)	22.6 (19.2, 25.2)	0.884
Lac, mg/dL	106	16.5 (11.3, 23)	16 (12, 21)	20 (12.5, 30.5)	16 (10, 20)	0.097
APACHEII score, pts	96	7 (3.8, 10.3)	7 (3.8, 9.3)	8 (4.3, 12.5)	6 (3.3, 10.5)	0.580
ISS, pts	106	9 (9, 16)	11 (9, 16)	9 (5, 22.5)	9 (9, 16)	0.816

Abbreviations: HR; heart rate, SBP; systolic blood pressure, SI; shock index, MAP; mean arterial pressure, RR; respiratory rate, BT; body temperature, sNa; serum sodium, sK; serum potassium, sCre; serum creatinine, WBC; white blood cell, GCS; Glasgow Coma Scale, Hct; hematocrit, Hb; hemoglobin, Fib; fibrinogen, Plt; platelet counts, Lac; lactate, APACHE II score; Acute Physiology and Chronic Health Evaluation II score, ISS; Injury Severity Score.

[1] *Statistical data are presented as the median (interquartile range) or n (%).*

[2] *Statistical tests performed: Kruskal-Wallis test; Fisher's exact test.*

Table 3
The comparison of outcomes of treatment between types of equipment.

Outcome	N	Skier group, N = 16[1]	Snowboarder group, N = 90[1]	p-value[2]
Emergency operation under general anesthesia	44	4 (25%)	40 (44%)	0.236
Transcatheter arterial embolization	14	1 (6%)	13 (14%)	0.668
Transfusion	14	1 (6%)	13 (14%)	
Volume, mL		4230	2265 (790, 4330)	0.462
RBCs	13	1 (6%)	12 (13%)	
Volume, mL		2240	1120 (896.8, 2310)	0.457
FFP	14	1 (6%)	13 (14%)	
Volume, mL		1440	1200 (480, 1680)	0.393
PC	3	1 (6%)	2 (2%)	
Volume, mL		400	400 (300, 500)	–
Use of ventilator in ICU	19	3 (19%)	16 (18%)	
Duration of ventilator use, days		5 (4, 8.5)	4 (2, 10)	0.905
ICU admission	94	15 (94%)	79 (88%)	
Duration of ICU stay, days		3 (2, 6)	3 (2.5, 7.5)	0.723
Hospital stay, days		14 (6.5, 28.5)	19 (10, 29)	0.731
Functional sequelae	22	4 (25%)	18 (20%)	0.868

Abbreviations: RBCs; red blood cells, FFP; flesh frozen plasma, PC; platelet concentrate, ICU; intensive care unit.
[1] *Statistical data are presented as the median (interquartile range) or n (%).*
[2] *Statistical tests performed: Mann-Whitney U test; Fisher's exact test.*

Table 4
The comparison of outcomes of treatment among injury mechanisms.

Outcome	N	Fall during gliding group, N = 33[1]	Fall after jumping group, N = 46[1]	Collide with other people or obstacle group, N = 27[1]	p-value[2]
Emergency operation under general anesthesia	44	9 (27%)	24 (52%)	11 (41%)	0.089
Transcatheter arterial embolization	14	6 (18%)	5 (11%)	3 (11%)	0.627
Transfusion	14	1 (3%)	6 (13%)	7 (26%)	
mL		240	800 (760, 2209)	4230 (3460, 5180)	0.014
RBCs	13	1 (3%)	5 (11%)	7 (26%)	
mL		1120	560 (560, 1009)	2240 (1680, 2660)	0.015
FFP	14	1 (3%)	6 (13%)	7 (26%)	
mL		240	720 (540, 1080)	1680 (1560, 2520)	0.020
PC	3	0 (0%)	0 (0%)	3 (11%)	
mL		–	–	400 (300, 500)	–
Use of ventilator in ICU	19	6 (18%)	5 (11%)	8 (30%)	
Duration of ventilator use, days		3 (2, 10)	4 (3, 9)	6 (3.75, 8.5)	0.122
ICU admission	94	25 (76%)	43 (94%)	26 (96%)	
Duration of ICU stay, days		3 (3, 7)	3 (2, 5.5)	5 (2, 8.75)	0.196
Hospital stay, days		14 (10, 21)	21 (11, 32)	17 (7.5, 30)	0.074
Functional sequelae	22	5 (15%)	13 (28%)	4 (15%)	0.285

Abbreviations: RBCs; red blood cells, FFP; flesh frozen plasma, PC; platelet concentrate, ICU; intensive care unit.
[1] *Statistical data are presented as the median (interquartile range) or n (%).*
[2] *Statistical tests performed: Kruskal-Wallis rank sum test; Fisher's exact test.*

Site and cause of injury

Several previous studies have shown that snowboarders tend to be more admitted to the ICU and have more upper limb fractures and foot and head injuries than skiers [6,8]. Roulet et al. reported injuries requiring an operation, although not urgent, in a registry study from the National Trauma Data Bank of the United States. Of the 2569 collected cases of severe injuries associated with skiing and snowboarding with ISS >15 points, 43.2% of patients required surgical intervention: 21.3% in orthopedics, 12.5% in neurosurgery, 10.5% in thoracic surgery, and 7.8% in abdominal surgery [11]. In addition, a cohort study of 196 patients (56.6% skiers vs. 43.4% snowboarders) with major trauma related to winter sports (ISS >12 points) reported that the most common injury site was the head, with 43 (21.9%) patients admitted to the ICU and 79 (40.3%) patients requiring emergency operation. Extremities was the most common surgical area, followed by spinal, abdominal, and brain areas [12].

Our study showed that almost half of the patients experienced falls after jumping, and snowboarders had more severe injuries requiring emergency surgery than skiers. In addition, the number of injured patients with post-jump falls was higher in male than in female patients. Moreover, the jumping group tended to have higher ISS, ICU admission rates, and longer hospital stays than the gliding group.

Traumatic brain injury and spinal cord injury

Traumatic brain injuries (TBIs) are the most common injuries observed among skiers and snowboarders. In a multi-season study, the incidences of head injury were 6.5 per 100,000 visits for snowboarders and 3.8 per 100,000 visits for skiers. Furthermore, the frequent causes of snowboarding head injuries were fall during jumping, falling backward, and occipital impact [8]. Ackery et al. conducted a systematic review of head and spinal cord injuries in alpine skiing and snowboarding with 24 relevant articles from 10 different countries. The incidence rates of TBI and spinal cord injury increased because of the increase in acrobatic and high-speed activities [13].

In the current study, the spine was the most frequent injury site for snowboarders and skiers, and the spine was the most prominent injury site in the jumping group. This may be due to the fact that acrobatic activities have become more common. Studies on the use of helmets for snow sports trauma are relatively advanced,

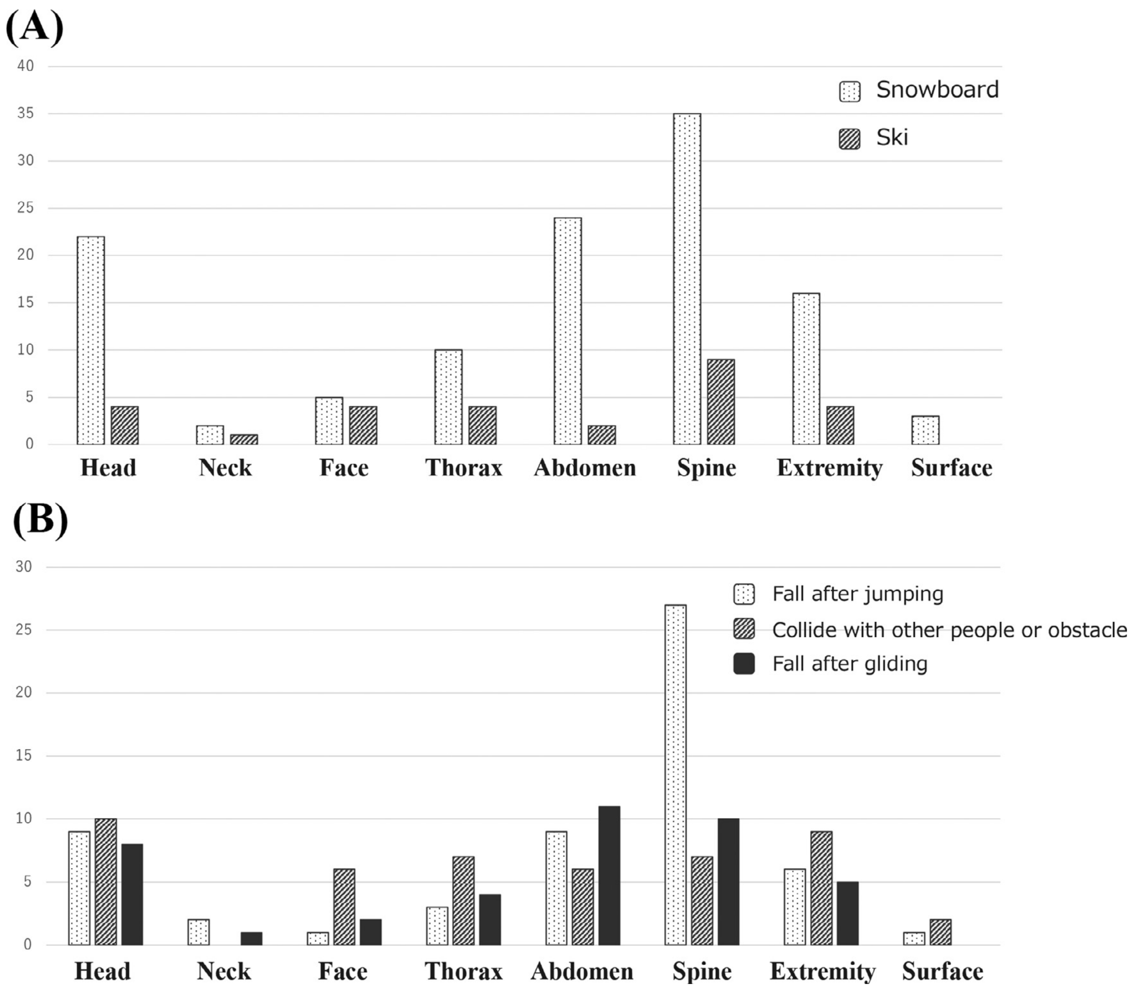

Fig. 2. Injury sites by equipment and injury mechanism The bar graph shows injury sites by equipment (A) and injury mechanism (B).

with studies reporting that helmets can reduce the risk of head injury by 22–60% and with a meta-analysis stating that skiers who wear helmets have a significantly lower probability of head injury and an unrelated higher risk of neck injury than skiers who do not wear helmets [18,19]. Those who tend not to wear helmets have been reported to be aged 18–29 years (OR, 1.4; 95% CI, 1.4–1.7; $p<0.001$), aged 30–39 years (OR, 1.3; 95% CI, 1.1–1.6; $p = 0.003$), smokers (OR, 1.5; 95% CI, 1.1–1.9; $p = 0.003$), positive for a drug test for an illegal substance (OR, 1.7; 95% CI, 1.1–2.7; $p = 0.016$), snowboarding (OR, 1.3; 95% CI, 1.1–1.4; $p<0.001$), and possibly at risk for severe head trauma [14].

Transport

In the aforementioned registry study, between 80% and 90% of patients with severe injuries used emergency medical services, of which 50.3% and 30.2% used ambulance and helicopter, respectively. They reported that the median transport time to the hospital was as long as 84 (IQR, 58–145) min, and 51% were interhospital transfer [11]. A study of trauma centers in Arizona, United States, found that the median transport time of cases transported directly from the scene of injury to a level I center took 0.9 and 1.8 h in urban and rural areas, respectively [15].

A current cohort study of trauma in winter sport athletes showed that snowboarding was associated with the highest prehospital intubation rate (40.9%, $p = 0.007$), although the Glasgow Coma Scale and prevalence of loss of consciousness at the scene was comparable with those of alpine skiers, who also had more head trauma [16]. This is an important aspect with regard to the wide area transport to a trauma center where emergency surgical intervention can be performed. In a cohort study of 1018 snowboarders and skiers with TBI using the National Trauma Data Bank in the United States, Sun et al. found that multivariate log-binomial models demonstrated an association between prehospital helicopter transport and increased survival (OR, 8.58; 95% CI, 1.09–67.64; $p = 0.041$; absolute risk reduction, 10.06%) and suggested the superiority of air transport. Furthermore, the results did not change when propensity score matching was performed (OR, 24.73; 95% CI, 5.74–152.55; $p<0.001$) [17].

Based on the above findings, including the results of the present study, we can determine the appropriate medical resources to provide, such as aggressive wide-area transport when snowboarders are injured by falling after jumping. However, there is a lack of solid evidence in this area, and no conclusions have been reached.

Although many studies have been conducted over a multi-year period in the field of snow sports trauma, this study was conducted over a long period of 10 seasons and included relatively severe cases. As the only trauma center in our prefecture with a major resort area visited by approximately one million skiers and snowboarders per season, we believe we have an efficient collection of cases, although the total number of cases is small. The strength of this study is that paper shows snowboarding as equipment and jump falls as a mechanism of injury tended to be associated with emergency surgery requiring general anesthesia. In general, places where such trauma can occur do not have advanced medical facilities, and this study will be useful in establishing a medical system, regarding the necessity of emergency surgery under general anesthesia and transporting the patient to the hospital.

However, this study has some limitations. First, this was a retrospective and single-center study, and was restricted to patients aged 18 years and older. In addition, we performed univariate analysis due to small sample size, so the possibility of bias such as age, proficiency, or gliding surface conditions, which should have been adjusted for, could not be eliminated. In addition, the small sample size may result in low power to detect statistical differences. Second, snowboarding is more popular than skiing in Japan, especially among young people, and the results of this study may not be universally applicable in snow countries such as Europe and Canada. Third, this study was limited by the medical records used in actual clinical practice. Details outlining the events preceding the injury, skill level of the patients, and protection tools were not well described. We believe that prospective studies with larger sample sizes are required.

Conclusion

In conclusion, snowboard as an equipment and falls after jumping as an injury mechanism tended to be associated with emergency surgery under general anesthesia, although no significant differences were found. In order to provide adequate resources for snow sports trauma, the cause of the patient's injury is strongly related to the urgency of the condition, and transport to a trauma center should be actively considered. Further studies are warranted with respect to the effects of personal protective equipment, skill level, and more detailed mechanism of injury to provide appropriate medical resources.

Data availability

The data that support the findings of this study are available from the corresponding author, RK, upon reasonable request.

Author contributions

G.Y., R. K., R. Yasuda, T. M., F. Y., Y. M., Y. K., T. F., K. S., T. M., S. N., N. K., T. D., H. O., T. Y., S. Y., and S. O.: Treatment of the patients.

G.Y. and R. K.: Writing – Original Draft.

R.K., H. O., and R. Yasuda: Writing – Review & Editing.

All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study conformed with the principles outlined in the Declaration of Helsinki. Ethics approval was obtained from the institutional ethics committees of Gifu University Graduate School of Medicine (approval #2020–0103, approved on July 1, 2020). The institutional ethics committees of Gifu University Graduate School of Medicine approved the substitution of an opt-out notice for informed consent from patients because of the retrospective nature of the study, whose design was based on computerized data with anonymous selection.

Consent for publication

Written informed consent was obtained from the patients for the publication of this retrospective cohort study and any accompanying images.

Declaration of Competing Interest

The authors declare no competing interests.

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