Original Article

Accidental falls related to clearing heavy snow on rooftops in a rural heavy snow area in Japan

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Aim: The purpose of this study is to describe our experience with patients who fell from rooftops while clearing snow. The falls occurred in rural areas that receive heavy snowfall and are undergoing depopulation and an increasing proportion of elderly residents.

Methods: A retrospective observational chart review was carried out at the sole hospital providing emergency services in a rural heavy snow area in Japan.

Results: A total of 70 patients were enrolled during four winter seasons between December 2009 and March 2013. Their mean age was 61 years, and 90% were male. The mean vertical height of falls was 4.1 m. A total of 174 injuries was observed, averaging 2.5 injuries per patient. Fractures accounted for 78% of all injuries, and main fractures included vertebra with lower extremities or rib fractures; 86% of patients sustained a maximum abbreviated injury scale score of 2–3.

Conclusions: In a rural heavy snow area in Japan, the incidence of accidental falls related to clearing snow was high, and the victims were elderly. Fractures accounted for 78% of all injuries, and most patients suffered from moderate to serious injuries.

Key words: Accidental fall injury, clearing heavy snow, elderly population, rooftop

INTRODUCTION

TOUKAMACHI CITY AREA including the Tunan area of Niigata Prefecture, Japan, is well known for a heavy and long-lasting snowfall. The annual average amount of snow is more than 1.3 m. Approximately 65,000 people live in this 760 km^2 area, and approximately 40% of the population is aged 65 years old or older.

Clearing heavy snow on rooftops is a common activity in areas with heavy snow accumulation. However, aging and depopulation of Japanese rural areas have caused a chronic and severe shortage of human resources for clearing snow. Thus, the Japanese government appointed 201 areas, including Toukamachi city and the Tunan area, as special heavy snow areas by an act on special measures for snow areas.[1]

Toukamachi Prefectural Hospital is located in Toukamachi city and is the sole core hospital in the area providing emergency services.

Advanced age is a well-known risk factor for adverse trauma outcomes.[2] According to an annual report of the Japanese fire and disaster management agency, a total of 95 victims clearing heavy snow on the roof died during the 2012 winter season, 67% of whom were 65 years old or older.[3]

To our knowledge, there have been no studies in the elderly population that describe injuries related to accidental falls while clearing snow. The purpose of this study was to describe our experience with such patients treated at the Toukamachi Prefectural Hospital, and to evaluate the characteristics of the fall injuries.

METHODS

AFTER OBTAINING INSTITUTIONAL approval, a retrospective observational chart review was carried out at Toukamachi Prefectural Hospital. The study group

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included all patients who fell from a rooftop or ladder while clearing heavy snow, and were transferred by ambulance to the Toukamachi Prefectural Hospital Emergency Department (ED) during the period December 2009–March 2013.

Detailed information about the fall (vertical height, fall from ladder or roof, and conditions of ground) was obtained from the patients, Emergency Medical Services personnel, family, and witnesses. Radiographs were obtained routinely for all patients. Computed tomographic scan or magnetic resonance imaging were also obtained as needed. All images were checked by a diagnostic radiologist.

Severity of injury was assessed using the following scores that were coded and calculated by trained assistants and physicians. To assess the anatomical severity, Abbreviated Injury Score (AIS)[4] was coded by the AIS 90 update 98[5] and Injury Severity Score (ISS)[6] was calculated. For assessment of severity of physiological derangements, the Revised Trauma Score (RTS)[7] was calculated based on the Glasgow Coma Scale, systolic blood pressure, and respiratory rate on arrival at the ED.

Climate data including temperature, wind speed, depth of snow on the incident day (9:00 AM) were obtained from the Japan Meteorological Agency webpage.[8]

Statistical analysis

Continuous variables are described as the mean ± standard deviation or 95% confidence interval. Categorical variables are described as number (n) and percentage (%). For comparisons of continuous variables without normality, the Mann–Whitney test or Kruskal–Wallis test was applied. For comparisons of continuous variables with normality, Student's t-test or one-way ANOVA with Scheffé's test was carried out. The relationship between the incidence of falls, season, and depth of snow was analyzed by calculating the Pearson correlation coefficient. All tests were two-sided, and statistical significance was considered when $P < 0.05$. All analyses were carried out using the SPSS statics package (version 20, IBM, Tokyo, Japan).

RESULTS

A TOTAL OF 70 patients were transferred to the Toukamachi Prefectural Hospital ED by ambulance during the four winter seasons. No patient had a depressed level of consciousness that could be accounted for by alcohol intoxication alone. No patient was wearing a helmet or safety harness. No patient complained about cardiac-related symptoms.

Table 1. Accidental fall incidence and amount of snowfall in Toukamachi city area including the Tunan area (Niigata Prefecture, Japan), 2009–2013

Season	No. of falls (n = 70)	Fall incidence (/10,000)	Mean amount of snowfall, (cm)
2009–2010	11	1.6	282
December	2		249
January	8		508
February	1		225
March	0		147
2010–2011	19	2.9	295
December	0		150
January	14		614
February	5		118
March	0		298
2011–2012	17	2.6	328
December	2		311
January	7		506
February	7		345
March	1		149
2012–2013	23	3.5	318
December	10		366
January	8		419
February	4		387
March	1		100
Seasonal average	17.5	2.7	305.8

Accidental fall incidence and amount of snowfall

The mean seasonal fall incidence was 2.7 per 10,000 inhabitants, with annual variations of 1.8–4.1; incidence was not correlated with the seasonal amount of snowfall (Table 1). Rather, the fall incidence per month was significantly correlated with the amount of snowfall per month (r = 0.8, $P < 0.05$). Thirty-seven (52.9%) and 17 (24.3%) falls occurred in January and February, respectively.

Time, day of the week, and climate

More than 70% of accidental falls were clustered on Friday (n = 15, 21.4%), Saturday (n = 15, 21.4%), and Sunday (n = 20, 28.6%). More than 85% of falls occurred during the day time (32 falls during 8:00 AM–12:00 PM and 28 falls during 12:00 PM–4:00 PM). The weather on the incident day (9:00 AM) was snowing for 50%, cloudy for 28.6%, and clear for 20%. The mean depth of snow, temperature, and

Table 2. Profiles of patients who fell from rooftops while clearing snow in a rural area of Japan and characteristics of their falls

Parameter	*n* (%)
No. of patients	70 (100)
Gender	
Male	63 (90.0)
Female	7 (10.0)
Age, years†	61 ± 14 (18–82)
≤50	14 (20.0)
50–70	31 (44.3)
≥70	25 (35.7)
Location	
Home	62 (88.6)
Workplace	8 (11.4)
Roof or ladder	
Roof	54 (77.1)
Ladder	16 (22.9)
Condition of ground	
Snow	34 (48.6)
Compacted snow	9 (12.9)
Asphalt/concrete	27 (38.6)
Vertical height, m†	4.1 ± 1.6 (1.5–8.0)
≤3	14 (20.0)
3–6	44 (62.9)
≥6	12 (17.1)
Disposition	
Treated/released from ED	15 (21.4)
Expired in ED (CPA at the scene)	2 (2.9)
Transferred to another hospital	1 (1.4)
Hospitalized	52 (74.3)

CPA, cardiopulmonary arrest; ED, emergency department.
†Values are expressed as mean ± SD (range).

wind speed on the incident day (9:00 AM) were 19 ± 17 cm (range, 0–73 cm), −0.6 ± 1.8°C (range, −3.4 to 4.4°C), and 1.0 ± 0.3 m/min (range, 0.5–2.0 m/min), respectively.

Patient profiles and fall characteristics

Patient profiles and fall characteristics are shown in Table 2. Of the 70 patients, 15 were treated and released from the ED. Two patients were in cardiac arrest at the scene due to asphyxia with a lump of snow or cervical spinal injury, and both died in the ED. One patient was transferred to another hospital for surgical procedures and survived. The remaining 52 patients were hospitalized, one of whom was taking warfarin and died due to a massive hemothorax within 12 h of admission.

The patient group was 90% male with a mean age of 61 ± 14 years (range, 18–82 years; median, 62 years; interquartile range, 54–72 years); 35.7% of the patients were 70 years or older.

Ground conditions were divided into snow, compacted snow, and asphalt/concrete, corresponding to soft, intermediate, and hard collision surfaces, respectively. Almost 50% of falls were to snow a surface; however, detailed data about snow depth at the fall location were not recorded.

The mean vertical height of falls was 4.1 ± 1.6 m (range 1.5–8.0 m), and 80% of patients fell from a height of more than 3 m. The vertical height was significantly different between roof and ladder (4.3 ± 1.6 versus 3.3 ± 1.4 m, $P < 0.05$).

The mean length of stay for the 52 hospitalized patients was 35.9 ± 27.7 days (range, 1–122 days).

Abbreviated Injury Scale and RTS

A total of 174 injuries were reported for the 70 patients, averaging 2.5 injuries per patient. Fractures accounted for 78.2% of all injuries (136/174). The number of fractures for vertebra, lower extremities/pelvis, upper extremities, and ribs were 40 (30.1%), 33 (25.4%), 12 (9.2%), and 51 (39.2%), respectively. Vertebra fractures, including minor injuries,[9] were seen in 31/70 (44.3%) patients. Figure 1 shows the fracture types at the vertebral level. Compression or burst fractures of lumbar vertebra occurred in 23 patients (total 31 injuries), accompanying a simultaneous calcaneal fracture in six patients.

Figure 2 shows AIS data for 70 patients. No injury was reported for the neck or body surface regions. Eighty-six percent of patients sustained a maximum AIS of 2–3. The common injuries overall were to the spine (n = 31, 32.6%), chest (n = 22, 23.0%), and lower extremity/pelvis (n = 22, 23.2%). The mean AIS was 2.0 ± 1.0 for the head/face, 2.6 ± 0.8 for the chest, 2.6 ± 0.9 for the abdomen, 2.5 ± 0.9 for the spine, 2.1 ± 0.4 for the upper extremities, and 2.3 ± 0.6 for the lower extremity/pelvis. A total of 17 surgical operations were undertaken. A total of 15 chest tubes were inserted.

There was no significant difference in AIS score among body regions. Severe multiple trauma, defined as an AIS score of 3 or more occurring in two or more body regions was seen in six patients, all of whom survived.

The mean RTS was 7.5 ± 1.2 (range 1.76–7.84). A significant difference of RTS was not observed between dispositions (treated/released from the ED versus hospitalized).

Injury Severity Score

The mean ISS was 8.6 ± 7.2 (range, 0–43) for all patients. There was a significant difference in ISS between patients

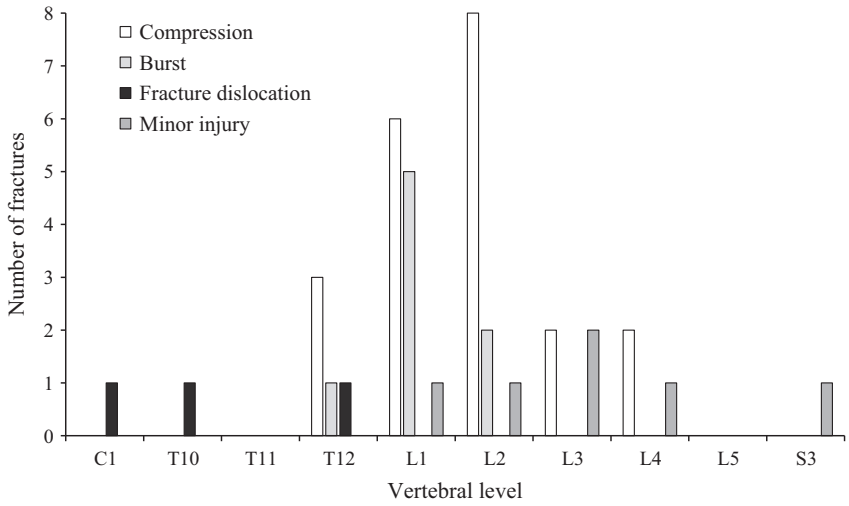

Fig. 1. Characteristics of vertebral fractures in patients who fell from rooftops while clearing snow in a rural area of Japan, 2009–2013. Minor injuries included isolated injuries of the transverse or spinous process, the articular pillars, and the pars interarticularis.

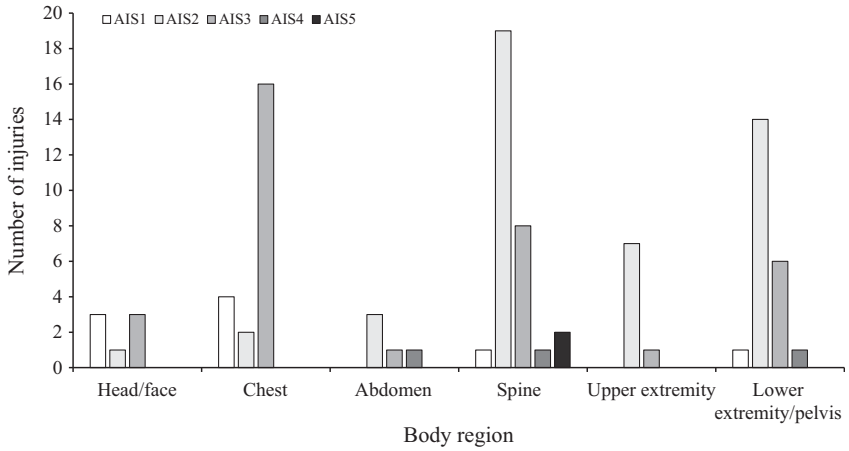

Fig. 2. Distribution of the Abbreviated Injury Scale (AIS) in patients who fell from rooftops while clearing snow in a rural area of Japan, 2009–2013. AIS1, minor; AIS2, moderate; AIS3, serious (not life threatening); AIS4, severe (life threatening); AIS5, critical. No injury was reported for the neck or body surface regions.

who were hospitalized versus treated/released from the ED (10.2 ± 7.0 versus 2.5 ± 1.7, $P < 0.05$). The mean ISS for a fall in a residential house was higher than for the workplace (9.3 ± 7.2 versus 3.0 ± 2.8, $P < 0.05$).

Injury Severity Score data for hospitalized patients ($n = 52$) are shown in Table 3. An ISS of 16 or more, indicating severe injury, was seen in nine patients (ISS 22.0 ± 8.5). The ISS was not significantly different in terms of age of patient, fall from roof or ladder, conditions of ground, or vertical height.

DISCUSSION

THE INCIDENCE OF accidental fall reported in this study was obviously high. Bylund *et al.*[10] reported that the fall incidence related with clearing snow from rooftops was 1.2–15.4 per 100,000 inhabitants during four winter seasons, and that the occurrence coincided with the seasonal snow depth. In contrast, when patients not requiring admission are included, as in the present study, the mean fall incidence of 2.7 per 10,000 inhabitants was still high and as

Table 3. Comparison of Injury Severity Score (ISS) for hospitalized patients who fell from rooftops while clearing snow in a rural area of Japan (n = 52)

Parameters		ISS (95% CI)
Age, years		
≤50	(n = 7)	9.3 ± 4.0 (5.6–13.0)
50–70	(n = 22)	9.7 ± 5.7 (7.2–12.3)
≥70	(n = 23)	10.9 ± 8.7 (7.2–14.7)
Location		
Home	(n = 49)	10.5 ± 7.0 (8.5–12.5)
Workplace	(n = 3)	5.3 ± 2.3 (0.4–11.1)
Roof or ladder		
Roof	(n = 37)	10.4 ± 7.8 (7.8–13.0)
Ladder	(n = 15)	9.7 ± 4.3 (7.3–11.6)
Conditions of ground		
Snow	(n = 18)	9.4 ± 6.1 (6.4–12.5)
Compacted snow	(n = 8)	10.0 ± 5.3 (5.6–14.4)
Asphalt/concrete	(n = 26)	10.7 ± 8.0 (7.5–14.0)
Vertical height, m		
≤3	(n = 12)	7.7 ± 4.8 (4.7–10.7)
3–6	(n = 33)	10.6 ± 8.0 (7.8–13.5)
≥6	(n = 7)	12.4 ± 3.3 (9.4–15.4)

Values are expressed as mean ± SD and 95% confidence interval (CI).

much as 20-fold higher; the incidence was well correlated with snow depth per month. The discrepancy between studies may be explained by both the constant seasonal and overwhelming amount of snowfall. In fact, more than 77% of the falls occurred in January and February, both of which are heavy snowfall months in Japan.

Our patients were elderly, approximately 6–15 years older than reported in previous similar studies.[10–12] In Japan, the elderly population is the fastest growing segment of the entire population, which is more predominant in rural areas that are suffering from depopulation. The mean age of patients in this study was 61 years, and the number of patients aged ≥65 years and ≥75 years accounted for 32 (45.7%) and 14 (20%), respectively.

The mean vertical height of falls in the present study was 4 m. In contrast, the mean height reported in previous studies was approximately 3 m, which is equivalent to the height of a single-story residential house.[10,12] In the heavy snowfall areas, Japanese residential houses are built with the floor raised by 1 m above the ground for convenient entrance and exit.

A total of 174 injuries were observed, averaging 2.5 injuries per patient. Fractures accounted for 78% of all injuries. Main fractures included vertebral with lower extremities fractures or rib fractures, without cranial fractures, strongly indicating that patients landed on their feet or trunk, which is in agreement with previous studies.[12–15] The high number of compression or burst fractures of L1 and L2 may be characteristic, presumably reflecting osteoporosis in the elderly population.[16] Moderate to serious injuries were sustained by 86% of patients.

Several studies have reported that age is a significant predictive factor for in-hospital mortality in geriatric (age, ≥65 years) trauma patients.[2,17,18] Nevertheless, the in-hospital mortality rate of our elderly patients was 1.9% (one patient died), presumably associated with small derangements of physiological parameters, as indicated by the high RTS.

CONCLUSION

IN THE RURAL heavy snowfall areas in Japan, the incidence of accidental fall related with clearing snow was high (mean seasonal fall incident, 2.7 per 10,000 inhabitants), and the patients were elderly (mean age, 61 years). Fractures accounted for 78% of all injuries, and main fractures included spinal fractures with lower extremities or rib fractures, strongly indicating that patients landed on their feet or trunk. Most patients suffered from moderate to serious injuries.

CONFLICT OF INTEREST

NONE DECLARED.

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