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Risk of Traumatic Intracranial Hemorrhage From Low-Energy Falls in the Oldest-Old Patients

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Background: The population of individuals classified as oldest-old (aged ≥85 years) has increased rapidly in recent years. The rates of morbidity from chronic diseases and physical dependence tend to be higher in the oldest-old compared with individuals classified as young-to-middle-old (aged 65–84 years). Therefore, the classification and evaluation of traumatic injuries in the oldest-old group are necessary. Herein we focused on the risk of traumatic intracranial hemorrhage from low-energy falls in older patients. **Methods:** Patient medical records from the Emergency Department after low-energy falls that occurred between November 2014 and April 2016 were retrospectively analyzed. Patients were divided into an older group (aged ≥65 years) and an adult group (aged 18–64 years); the older group was subdivided into the oldest-old group (aged ≥85 years) and a young-to-middle-old group (aged 65–84 years). The rate of intracranial hemorrhage and related factors were also investigated. **Results:** The older group had a greater risk of traumatic intracranial hemorrhage than the adult group (20% vs. 12.6%, p=0.019). Furthermore, more cases of traumatic intracranial hemorrhage were found in the oldest-old group than in the young-to-middle-old group (37.5% vs. 18.0%, p=0.024). Similarly, the risk of traumatic intracranial hemorrhage in the oldest-old was higher than in the young-to-middle-old group (p=0.032). **Conclusion:** The risk of traumatic intracranial hemorrhage from low-energy falls in the oldest-old patients was higher than in the young-to-middle-old patients. Therefore, physicians need to pay particular attention to oldest-old patients, even to those with mental integrity and without neurological deficits.

Key Words: Oldest old, Accidental falls, Intracranial hemorrhage, Emergency

INTRODUCTION

The rate of traumatic injuries among the older population has increased as older adults remain active longer and engage in economic and leisure activities[1]. Falls are the most common and significant causes of traumatic injuries among older adults[2,3]. Older adults are at a greater risk of falls than their younger counterparts and are more likely to sustain an injury after a fall, with a higher likelihood of complications[4,5]. Even a simple fall can cause a severe injury in older individuals[6]; broken hips, limbs, and head injuries are the most common fall-related injuries in this population. The incidence of head injuries, in particular, has increased at a fast rate in this population[7]. Intracranial hemorrhage, a serious consequence of traumatic head injury, is common in older adults and the prognosis is relatively worse[8,9].

Within the older population, the individuals who belong to the young-to-middle-old subgroup (aged 65–84 years) can maintain a better health status than in the past because of improvement in economic status, nutrition, and health behavior (including check-up consultations). On the other hand, the risk of trauma and associated complications is greater among the older individuals from the oldest-old subgroup because they tend to be frailer than the younger subgroups. While working at an emergency medical center, the author examined oldest-old patients who sustained a head injury following a fall and observed that traumatic intracranial hemorrhages occurred more frequently among the oldest-old than in the other subgroups. Despite the rapidly increasing rate of head injuries among the older population[10], no previous studies have determined the rate of fall-related traumatic intracranial hemorrhages in each of these subgroups.

Therefore, herein we determined the rate of intracranial hemorrhage among oldest-old patients admitted to the emergency medical center following a low-energy fall and compared that in young-to-middle-old patients.

MATERIALS AND METHODS

1. Study Subjects

This retrospective study examined the medical records of patients aged 18 years and older admitted to the Emergency Medical Center of Kyung Hee University Medical Center between November 2014 and April 2016 because of head injuries following low-energy falls. The center is a regional emergency medical center located in Seoul and approximately 30,000 patients visited the center annually. During the study period, 3,044 patients with head injuries visited the center, 2,565 of whom were aged 18 years and older. Patients whose head injuries were not fall-related or with unclear causes, those who did not receive computed tomography (CT) imaging by decision of the medical staff or the patient, those whose medical records were missing or contained errors, those admitted to the center more than 24 hours after the incident, and those who had been transferred from another medical facility, were excluded. Therefore, 552 subjects were included in the analysis. The present study was approved by the Institutional Review Board of Kyunghee University (KHUH 2016-09-053).

2. Method

The study subjects were divided into 2 groups: an adult group (aged 18–64 years) and an older group (65 years and older). The older group was subdivided into 3 subgroups: the young-old (aged 65–74 years), the middle-old (aged 75–84 years), and the oldest-old (aged 85 years and older). In the analysis, a fall was defined as 'an unplanned descent to the floor or other lower level without loss of consciousness'[11]. A low-energy fall was defined as 'a ground-level fall from a standing or sitting position, a fall from a height of 1 m or less, a fall from a height of 3 stairs or less.' The falls that did not meet this definition were excluded. The medical records were reviewed to extract data on age and sex distribution, estimated period between the fall incident and admission to the center, level of consciousness at the time of admission (Glasgow Coma Scale, GCS), drinking status at the time of the incident, brain CT imaging results, underlying diseases, and prognosis of each subgroup. The estimated period between the fall incident and admission was calculated on the basis of data provided by the patient or caregiver at admission to the center. The initial scoring of the injury using the GCS was based on the evaluation of the patient by the physicians at the center. Drinking status was determined on the basis of data provided by the patient, caregiver, and the emergency medical crew, and using other parameters, including odors. All CT scans were evaluated by radiologists to assess the presence of traumatic intracranial hemorrhage. The underlying diseases included hypertension, diabetes, stroke, cardiac diseases, history of anticoagulant therapy, Parkinson disease, dementia, and cancers because these diseases are known to contribute to falls and traumatic intracranial hemorrhage. For prognosis of the patients who were hospitalized because of traumatic intracranial hemorrhage, the GOS was used at the time of hospital discharge. The favorable outcomes included good recovery and moderate disability, and the unfavorable outcome included severe disability, vegetative state, and death.

3. Data Analysis

Data were analyzed using the PASW Statistics ver. 18.0 (SPSS Inc., Chicago, Il, USA.). Categorical variables were presented as percentages, and continuous variables were presented as mean±standard deviation. In the univariate analysis, categorical variables were analyzed with a chi-square or Fisher exact test. Continuous variables were analyzed with Shapiro-Wilk test. Student t-test was conducted in cases of normal data distribution. The variables considered significant in the univariate analysis were included in the binary logistic regression analysis. The results were considered statistically significant for p-values smaller than 0.05.

RESULTS

A total of 3,044 patients were admitted to the Emergency Medical Center of Kyung Hee University Medical Center during the study period because of head injuries. Of these, several patients were excluded from the analysis because of age younger than 18 years (479 patients), the injuries that were not caused by low-energy falls or with unclear causes (1,574 patients), absence of CT imaging data (283 patients), missing or erroneous medical records (77 patients), admission

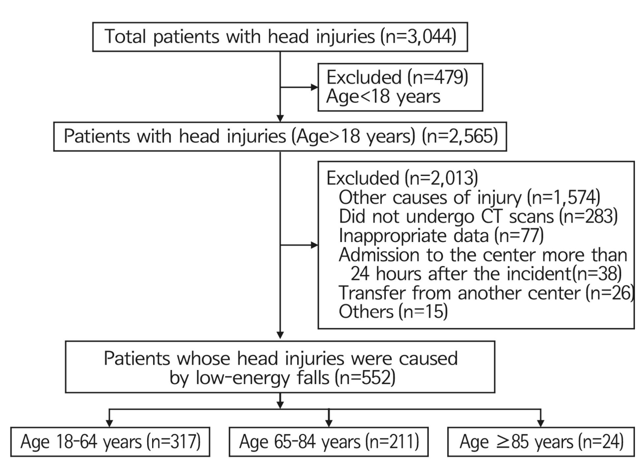

Fig. 1. Flowchart demonstrating patient selection criteria.

to the center more than 24 hours after the incident (38 patients), transfer from another medical facility (26 patients), and other reasons (15 patients). Therefore, 552 patients were included in the analysis. Of these, 317 were adults (aged 18–64 years), 211 were young-to-middle-old patients, and 24 were oldest-old patients (Fig. 1).

A total of 115 men accounted for 48.9% of the 235 older patients, whereas 188 men accounted for 59.3% of the 317 adult patients, indicating a similar sex distribution in the 2 groups (p=0.015). No significant difference in the period between the incident and admission to the Emergency Center was found between the 2 groups. With regard to the drinking status at the time of the incident, more adult patients were found to have been under the influence of alcohol than older patients (15.7% vs. 46.4%, p<0.001). The rate of the following underlying diseases was significantly higher in the older group than in the adult group: hypertension (47.7% vs. 14.2%, p<0.001), diabetes (23.8% vs. 5.7%, p<0.001), stroke (14.5% vs. 3.5%, p<0.001), cardiac disease (9.4% vs. 0.9%, p<0.001), history of anticoagulant regimen (18.3% vs. 7.3%, p<0.001), Parkinson disease (5.1% vs. 0.3%, p<0.001), dementia (4.3% vs. 0%, p<0.001), and cancer (5.5% vs. 0.6%, p=0.001). No significant intergroup difference was found for other diseases (14.0% vs. 8.8%, p=0.054). The rate of traumatic intracranial hemorrhage and subdural hematoma was higher in the older group than in the adult group (20% vs. 12.6%, p=0.019 and 15.7% vs. 6.6%, p=0.001, respectively). No significant intergroup difference was found in the rate of other types of hemorrhage. A total of 46 older patients and 36 adult patients were hospitalized for traumatic intracranial hemorrhage. With regard to prognosis, unfavorable outcomes were more prevalent in the older group than in the adult group (26.1% vs. 8.3%, p=0.039) (Table 1).

Of the 235 older patients, 24 patients belonged to the oldest-old group, while whereas 211 patients belonged to the young-to-middle-old group. No significant sex differences were found between the 2 groups (p=0.107). Similarly, no significant differences in the initial GCS and the period between the incident and admission to the Emergency Center were observed.

Although more young-to-middle-old patients were under the influence of alcohol at the time of the incident, the

Table 1. Characteristics of the study groups

Characteristic	Older adults (≥65 yr) (n=235)	Adults (18-64 yr) (n=317)	p-value*
Male sex	115 (48.9)	188 (59.3)	0.015
Initial GCS	14.74±1.51	14.90±0.83	0.127
Required time of arrival (min)	141.85±277.18	141.33±260.28	0.982
Alcohol ingestion	37 (15.7)	147 (46.4)	<0.001
Previous medical illness			
Hypertension	112 (47.7)	45 (14.2)	<0.001
Diabetes mellitus	56 (23.8)	18 (5.7)	<0.001
Cerebrovascular accident	34 (14.5)	11 (3.5)	<0.001
Dementia	10 (4.3)	0 (0)	<0.001
Cardiovascular disease	22 (9.4)	3 (0.9)	<0.001
Antithrombotic agent	43 (18.3)	23 (7.3)	<0.001
Parkinson disease	12 (5.1)	1 (0.3)	<0.001
Malignancy	13 (5.5)	2 (0.6)	0.001
Others	33 (14.0)	28 (8.8)	0.054
Intracranial hemorrhage	47 (20.0)	40 (12.6)	0.019
Subdural hemorrhage	37 (15.7)	21 (6.6)	0.001
Subarachnoid hemorrhage	22 (9.4)	21 (6.6)	0.235
Epidural hemorrhage	4 (1.7)	7 (2.2)	0.766
Hemorrhagic contusion	24 (10.2)	21 (6.6)	0.128
Intraventricular hemorrhage	2 (0.9)	2 (0.6)	1.000
Multiple lesion	24 (10.2)	21 (6.6)	0.128
Unfavorable outcome†	12/46 (26.1)	3/36 (8.3)	0.039

Values are presented as number (%) or mean±standard deviation.
GCS, Glasgow Coma Sale.
*All variables were analyzed with the chi-square test, Fisher exact test, and Student t-test. †Outcomes were measured in patients who were hospitalized after diagnosis of traumatic intracranial hemorrhage. The number of hospitalized patients in the older group and adult group was 46 and 36, respectively.

Table 2. Comparison of the characteristics of the oldest-old and young-to-middle-old groups

Variable	Oldest-old (≥85 yr) (n=24)	Young-to-middle-old (65-84 yr) (n=211)	p-value*
Male sex	8 (33.3)	107 (50.7)	0.107
Initial GCS	14.50±2.06	14.77±1.45	0.406
Required time of arrival (min)	137.00±295.52	142.40±275.76	0.920
Alcohol ingestion	1 (4.2)	36 (17.1)	0.139
Previous medical illness			
Hypertension	11 (45.8)	101 (47.9)	0.850
Diabetes mellitus	5 (20.8)	51 (24.2)	0.716
Cerebrovascular accident	7 (29.2)	27 (12.8)	0.031
Dementia	2 (8.3)	8 (3.8)	0.271
Cardiovascular disease	2 (8.3)	20 (9.5)	1.000
Antithrombotic agent	7 (29.2)	36 (17.1)	0.146
Parkinson disease	1 (4.2)	11 (5.2)	1.000
Malignancy	2 (8.3)	11 (5.2)	0.628
Others	3 (12.5)	30 (14.2)	1.000
Intracranial hemorrhage	9 (37.5)	38 (18.0)	0.024
Subdural hemorrhage	6 (25.0)	31 (14.7)	0.189
Subarachnoid hemorrhage	4 (16.7)	18 (8.5)	0.255
Epidural hemorrhage	1 (4.2)	3 (1.4)	0.352
Hemorrhagic contusion	3 (12.5)	21 (10.0)	0.720
Intraventricular hemorrhage	0 (0)	2 (0.9)	1.000
Multiple lesion	3 (12.5)	21 (10.0)	0.720
Unfavorable outcome†	3/9 (33.3)	9/37 (24.3)	0.678

Values are presented as numbers (%) or mean±standard deviation.
GCS, Glasgow Coma Scale.
*All variables were analyzed with the chi-square test, Fisher exact test, and Student t-test. †Outcomes were measured in patients who were hospitalized after diagnosis of traumatic intracranial hemorrhage. The number of hospitalized patients in the oldest-old group and young-to-middle-old group was 9 and 37, respectively.

intergroup differences were not statistically significant (17.1% vs. 4.2%, p=0.139). History of stroke was more prevalent in the oldest-old patient group (29.2% vs. 12.8%, p=0.031). No significant intergroup difference in other underlying diseases was found. However, the rate of sustained traumatic intracranial hemorrhage in the oldest-old patients (37.5%) was higher than that in the young-to-middle-old patients (18.0%) (p=0.024). No significant intergroup difference in the types of hemorrhage was found. Nine oldest-old patients and 37 young-to-middle-old patients were hospitalized for traumatic intracranial hemorrhage. As for prognosis, 9 oldest-old patients, and 3 young-to-middle-old patients had unfavorable outcomes, although the difference was not statistically significant (33.3% vs. 24.3%, p=0.678) (Table 2).

In the oldest-old group, traumatic intracranial hemorrhage was significantly correlated with old age, hypertension, cardiac diseases, anticoagulant regimen, and other chronic conditions (p=0.024, p=0.031, p=0.044, p=0.023, and p=0.039, respectively), whereas the correlation with sex, drinking status, and other underlying conditions was not statistically significant (Table 3).

Table 3. Clinical variables related to the development of traumatic intracranial hemorrhage from low-energy falls in older patients

Variable	Intracranial hemorrhage (n=47)	Nonintracranial hemorrhage (n=188)	p-value*
Oldest-old age	9 (19.1)	15 (8.0)	0.024
Male sex	20 (42.6)	95 (50.5)	0.328
Alcohol ingestion	4 (8.5)	33 (17.6)	0.178
Previous medical illness			
Hypertension	29 (61.7)	83 (44.1)	0.031
Diabetes mellitus	14 (29.8)	42 (22.3)	0.284
Cerebrovascular accident	5 (10.6)	29 (15.4)	0.404
Dementia	4 (8.5)	6 (3.2)	0.116
Cardiovascular disease	8 (17.0)	14 (7.4)	0.044
Antithrombotic agent	14 (29.8)	29 (15.4)	0.023
Parkinson disease	3 (6.4)	9 (4.8)	0.711
Malignancy	5 (10.6)	8 (4.3)	0.087
Others	11 (23.4)	22 (11.7)	0.039

Values are presented as number (%).
*All variables were analyzed using the chi-square test, Fisher exact test, and Student t-test.

Table 4. Evaluation of the risk factors related to the development of traumatic intracranial hemorrhage from low-energy falls in older patients using logistic regression analysis

Variable	Odds ratio	95% CI	p-value
Oldest-old	2.825	1.091-7.312	0.032
Hypertension	1.809	0.903-3.623	0.094
Cardiovascular disease	2.117	0.784-5.720	0.139
Antithrombotic agent	1.571	0.698-3.535	0.275
Others	2.104	0.894-4.954	0.089

Variables with $p<0.05$ in the univariate analysis were entered into the binary logistic regression analysis.
CI, confidence interval.

A binary logistic regression analysis of the variables considered significant in the univariate analysis was conducted to examine the relationship between traumatic intracranial hemorrhage and older age. Of these variables, only 'very old age' was found to be independently significant (p=0.032). Among the older subgroups, the risk of traumatic intracranial hemorrhage in the oldest-old group was 2.825 fold greater than in the other subgroups (odds ratio, 2.825; 95% confidence interval, 1.091–7.312) (Table 4).

DISCUSSION

The studies on the socioeconomic and medical impact of aging define an older age as a chronological age of 65 years and older. Data from a 2015 Population and Housing Survey conducted by the Statistics Korea indicate that individuals aged 65 years and older account for 13.2% (approximately 6,570,000 people) of the national population, and this rate is projected to increase to 20% by 2025[12]. The rapid growth of this population has stimulated the research in the field of geriatric medicine and gerontology. However, the gradual improvement in the overall standards of living has resulted in discrepancies in the health status of the older population and required a better classification of old age. Although previous studies used different criteria for old age, some studies used the range 75–80 years as the basis for the classification of 'early' old age and 'late' old age, whereas other studies distinguished the young-old (aged 65–74 years), the middle-old (aged 75–84 years), and the oldest-old (aged ≥85 years)[13-15]. In Korea, the proportion of the oldest-old has increased. The number of oldest-old individuals increased from 60,000 in 1980 to approximately 530,000 in 2015. In fact, the growth rate of this subgroup is higher than that of any other subgroup, and the number of oldest-old adults is projected to reach 1,150,000 individuals by 2026[12].

It is well-known that ageing-related decline in vision, hearing, and balance, combined with physical and cognitive impairment, loss of strength, chronic illnesses, and the use of various medication regimens decrease the reaction time of older people, which increase their risk of traumatic injuries[16,17]. Older trauma patients are also known to have significantly higher mortality rates than their younger counterparts because of the decreased biophysical resilience to external changes[18,19]. The high social and economic costs associated with long-term hospitalization, in particular, has attracted the interest of the healthcare sector in the research of traumatic injuries in the older population[20,21].

Intracranial hemorrhage is the most common cause of death in older trauma patients, and the most common cause of head injuries in these patients is falls[22,23]. The number of older patients with fall-related head injuries has increased rapidly worldwide[10]. Although a recent U.S. study reported a decrease in the overall rate of head injury, the trend was primarily associated with the decrease in the number of traffic accidents, which are a major cause of head injuries in nonolder patients. However, the rate of head injuries is increasing among the older population whose leading cause of injury is falls[23].

Falls are closely correlated with head injuries, and both severely affect older people. The present study also found that the rate of traumatic intracranial hemorrhage following a low-energy fall was 1.6 times greater in the older group than in the adult group, and the prognosis was poorer in the former. These findings are consistent with those of other studies on head injury[8,9,24-26]. However, most of these studies evaluated head injury patients regardless of the causes or classified the patients according to the initial GCS. In contrast, the unique contribution of this study was the finding that the rate of traumatic intracranial hemorrhage in the older group was higher even in cases in which the causes of injuries were narrowed to simple low-energy falls. Also of note is that the rate of men and alcohol use was significantly higher in the adult group than in the older group, which is attributable to the greater participation of men in the labor force and the higher rate of drinking-related accidents in the nonolder male group. Underlying diseases were more prevalent in older individuals, which appear to reflect their physiological characteristics and increase their vulnerability to traumatic injuries[16,17]. Furthermore, the rate of subdural hematoma was significantly higher in the older group. This result is attributed to the enlargement of the subarachnoid space caused by brain atrophy, as well as increased stiffening and fragility of degenerating vessels[22,27].

The incidence and prevalence of falls increase with old age[11]. After a fall, an older individual may begin to limit his or her physical activities because of fear of another incident, and this limited mobility further weakens the individual and increases the risk of falls[28]. Falls are responsible for 40% of deaths in older trauma patients. In the U.S., approximately 30% of individuals aged 65 years and older experience a fall annually[29]. In Korea, the alarming rate of falls among the older population has increased healthcare costs[11]. The increase in the older population due to the increase in the average lifespan, and the improved quality of life in later years due to socioeconomic advancement, have demanded a broader classification of 'old people' that involves more than grouping individuals aged 65 years and older. Young-old individuals are relatively healthy and active, and many of them continue to achieve self-development and enjoy leisure activities because they are still too young to be on the margins of society. In comparison, the oldest-old are the focus of the healthcare system because of the increased demand for the management of chronic illnesses, nursing care, and management of dementia in long-term care facilities, among other factors[13]. Data from a 2011 National Health Insurance Service indicated that the cost of healthcare for individuals aged 85 years and older increased fourfold during the 7-year period between 2004 and 2011[30]. The oldest-old group has a higher rate of morbidity caused by chronic illnesses than the young-to-middle-old group. Moreover, decreased independence for everyday activities and lower biophysical capacity to respond to external changes increase their vulnerability to accidents, including falls, which can cause traumatic injuries[31,32]. Decreased muscle strength is the most common risk factor for falls, followed by gait and balance disorders[33]. Oldest-old individuals experience a rapid decline in strength and balance, which increase the risk of falls[13]. Nevertheless, few trauma studies have classified the older population into subgroups according to age. Furthermore, to the best of our knowledge, no studies have examined the rate of traumatic intracranial hemorrhage in the oldest-old population.

In the present study, the rate of traumatic intracranial hemorrhage in the oldest-old group was 2.1 times greater than in the other groups. Susman et al.[34] examined older patients hospitalized for head injuries and found that the rate of mortality increased as age increased, which supports our findings. Falls in the older population are typically ground-level or low-height falls, which only cause mild injuries because they do not involve a lot of energy transfer. Unfortunately, diminished reflex and reaction time, which are prevalent in older people, make them sustain the impact directly in the head[35,36]. Therefore, oldest-old individuals are likely to sustain worse head injuries from a fall than the younger subgroups. In addition, various medications (such as anticoagulants) used by older people for treatment of various underlying diseases tend to accelerate brain atrophy and cerebrovascular degeneration[37,38], which increase the vulnerability of oldest-old people to traumatic intracranial hemorrhage compared to the younger subgroups. In the present study, history of anticoagulant therapy was more prevalent in the older group than in the adult group and was more prevalent in the oldest-old group than in the other older subgroups.

History of hypertension, cardiovascular disease, anticoagulant regimen, other chronic illnesses, in addition to very old age, may contribute to traumatic intracranial hemorrhage in older subjects. However, the results of the binary logistic regression analysis indicated that no other factors other than very old age had statistical significance.

According to the Health Insurance Review and Assessment, 1.8% of the total use of healthcare services on a national level in 2009 was attributed to head injuries, 22.4% of which involved the execution of brain CT scans. Moreover, 53.4% of head injury patients admitted to an emergency medical center underwent CT[39]. A 2011 U.S. study also reported a 330% increase in brain CT scans during the past 12 years among the patients admitted to an emergency medical center[40]. Some studies indicate that the use of brain CT imaging for the evaluation of head injuries has increased in emergency medical centers. However, the criteria used to determine whether brain CT scans are necessary are ambiguous. Furthermore, the medical staff cannot evaluate all potential risk factors owing to the time-sensitive nature of the emergencies that occur at emergency medical centers. The cause of a head injury is considered a critically important predictor of a patient's injury severity. In addition, because low-energy falls are more common than other traumatic accidents, and because these falls are considered relatively less severe, brain CT imaging is not actively pursued in many cases. Furthermore, because brain CT imaging is a relatively costly procedure, patients and caregivers often strongly oppose the procedure, and this problem is commonly faced by healthcare providers. On the basis of the author's experience, the children, adolescents, and non-older adults who sustained a head injury visited the emergency center on their own or with caregivers, and these caregivers requested a brain CT scan. On the other hand, older patients with head injuries tended to be less sensitive to injuries, and low-income older people, in particular, did not undergo CT imaging because of the high costs.

In the present study, the rate of traumatic intracranial hemorrhage was higher among the oldest-old admitted to the emergency medical center for fall-related head injuries than among the younger subgroups. Therefore, it is important that physicians actively pursue brain CT scans even when oldest-old patients with head injuries do not show signs of altered consciousness or neurological deficits. Furthermore, from a preventive standpoint, oldest-old patients with head injuries should be more closely monitored than their younger counterparts with the same type of injury.

The present study has some limitations. First, a bias for the distribution of the study subjects might have occurred because the study involved a single emergency medical center located in a major urban area. Second, the severity of the injuries, particularly in older patients, might have been underestimated because the study relied on injury data collected from patients and caregivers. Third, delayed intracranial hemorrhage following a trauma needs to be considered. Our study examined only the patients visiting the emergency medical center and did not evaluate the delayed intracranial hemorrhage via monitoring of patients who were discharged following the initial examinations. Therefore, multicenter follow-up studies involving a larger number of patients will confirm the rate of traumatic intracranial hemorrhage among oldest-old patients.

Conflicts of Interest Disclosures: The researchers claim no conflicts of interest.

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