

# Factors Associated with Poor Outcomes in Patients with Mild or Moderate Acute Subdural Hematomas

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## Abstract

The factors influencing the outcomes of mild/moderate acute subdural hematoma (ASDH) are still unclear. Retrospective analyses were performed to identify such factors. The medical records of all patients who were admitted to Saiseikai Shiga Hospital with mild (Glasgow Coma Scale [GCS] score of 14–15) or moderate (GCS score of 9–13) ASDH between April 2008 and March 2017 were reviewed. Comparisons between the patients who exhibited favorable and poor outcomes were performed. Then, independent factors that contributed to poor outcomes were identified via logistic regression analyses. A total of 266 patients with a mean age of 70.2 were included in this study. The most common concomitant injuries were subarachnoid hemorrhages (SAHs; 56.8%). The patients' Injury Severity Scores (ISS) ranged from 16 to 75 (median: 21). The 66 moderate ASDH patients exhibited significantly higher frequencies of surgery and mortality (24.2% and 13.6%, respectively) than the 200 mild ASDH patients (8.0% and 4.5%, respectively). The factors associated with poor outcomes were age (odds ratio [OR]: 1.06) and the ISS (OR: 1.24) in the mild ASDH patients, and older age (OR: 1.09) and the higher ISS (OR: 1.15) in the moderate group, too.

Keywords: acute subdural hematoma, mild, moderate, prognostic factor, outcome

## Introduction

Head injuries are the most common cause of traumatic death, and 49% of head injury-related deaths are due to acute subdural hematomas (ASDHs).<sup>1)</sup> ASDHs are commonly encountered in emergency departments. Recently, due to developments in neurosurgery and urgent interventions, the mortality rate of ASDH has begun to decline to around 14%.<sup>2)</sup> Severe ASDHs, which are associated with Glasgow Coma Scale (GCS) scores of  $\leq 8$ ,<sup>3)</sup> exhibit poor outcomes and a high mortality rate. Among severe ASDH patients, 47–66% die, and only 19–26% achieve functional outcomes.<sup>4,5)</sup> The background data, clinical parameters, and outcomes of patients with severe or surgically treated ASDH have been examined in previous studies. The GCS score, the Injury Severity Score (ISS), age, the timing of surgery,

pupillary reactivity, and the thickness of ASDH are considered to influence outcomes.<sup>2,4-8)</sup>

Most patients with head injuries are fully or partially conscious when they are evaluated.<sup>2)</sup> According to a trauma registry (One Week Study 2012) in Japan, mild or moderate traumatic brain injury with GCS score of 9–15 accounted for 86% of all ASDH which needed hospitalization.<sup>9)</sup> Therefore, most ASDH patients who require medical interventions have mild or moderate ASDH. For most of these mild or moderate ASDH, the prognosis of the patient was considered as relatively good even if required operation. However, in some of these patients, general condition worsened and subsequently achieved poor outcomes. Therefore, to improve the management for these patients, the risk factors influencing outcomes of patients with mild/moderate ASDH should be investigated. Although Japan Neurotrauma Data Bank (JNTDB) was conducted and analyses were performed in Japan, the registered patients were with GCS score 8 or less, getting worse to GCS score 8 or less in 48 hours, or who needed surgical interventions and excluded mild or moderate head trauma patients with no surgical

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interventions.<sup>10)</sup> So, risk factors influencing outcomes of patients with mild/moderate ASDH have not fully understood.

To identify outcome and factors that influence the outcomes of patients with mild or moderate ASDH, retrospective analyses were performed.

## Materials and Methods

### Subjects

This study targeted patients with ASDH who were admitted to Saiseikai Shiga Hospital in Shiga Prefecture, Japan. This hospital is the only emergency medical center in the south of Shiga and serves a population of about 330000. Shiga Prefecture is located next to Kyoto Prefecture and has the biggest lake in Japan, Lake Biwa. Our emergency medical center receives approximately 25000 patients, including >7000 traumatic patients and >6000 ambulance-transported patients, each year. Patients with ASDH were extracted from the hospital records of the patients who were admitted between April 2008 and March 2017. Then, patients with GCS scores of  $\leq 8$ , who had undergone surgery for other types of head injuries (e.g., contusions, acute epidural hematomas, etc.), or were aged  $\leq 15$  years old were excluded.

### Methods

The hospital records of all enrolled patients were reviewed, and the following parameters, in addition to general information (e.g., age and gender), were examined.

*Severity of ASDH:* We categorized the severity of ASDH according to the patients' GCS scores in emergency room. The patients with GCS scores of 14 or 15 were classified into the mild group, and those with GCS scores of 9–13 were classified as belonging to the moderate group.

*Mechanisms of injury:* We surveyed how each patient was injured. We classified the mechanisms of injury as follows: falling down, traffic accident (pedestrian, bicyclist, motorcyclist, or four-wheeled vehicle (4WV) driver/passenger), falling from a height, and others.

*Use of antithrombotic medicines:* We examined whether the patients had used antiplatelet medicines or anticoagulants.

*Location of hematoma:* We classified the location of hematoma into frontal, temporal, occipital, parietal, interhemispheric, and tentorial.

*Other head injuries:* Head injuries other than ASDH were summarized, such as subarachnoid hemorrhage (SAH), contusions, acute epidural hematomas, diffuse brain injuries, and skull fractures (calvarial and skull base).

*Extracranial injuries with Abbreviated Injury Scale scores of  $\geq 3$ :* We assessed the extracranial injuries of all patients, using the Abbreviated Injury Scale (AIS) 1990, revision update 98. The AIS score is used to categorize injuries according to their type and severity in each body region on a scale from 1 (minor) to 6 (clinically untreatable). We investigated whether each patient had extracranial injuries with AIS scores of  $\geq 3$ .

*ISS:* ISS was calculated for each patient. The ISS, which is useful for assessing the severity of multiple injuries, is the sum of the squares of the highest AIS score for each of the three most severely injured body regions.

*Operation:* We surveyed the patients to determine whether they had undergone surgery involving the head, including burr-hole surgery and craniotomy to remove a hematoma. The surgical interventions for ASDH were performed in accordance with the guidelines developed by the Japan Society of Neurotraumatology.<sup>11)</sup> The indications for surgery were as follows: the thickness of the hematoma was  $\geq 10$  mm, or a midline shift of  $\geq 5$  mm was noted together with a disturbance of consciousness; a mass effect or neurological symptoms were present; or the patient's neurological symptoms worsened rapidly. Surgical interventions were not recommended for patients who had not displayed brain stem function for a long time.

*Outcomes at discharge from hospital:* We classified the patients' outcomes as favorable or poor according to the Glasgow Outcome Scale (GOS) at discharge. The GOS is the most commonly used clinician-reported outcome measure in studies of head injuries. It is comprised of a five-point scale: death, vegetative state, severe disability, moderate disability, and good recovery. Good recovery and moderate disability were defined as favorable outcomes, whereas severe disability, vegetative state, and death were defined as poor outcomes.

*Cause of death:* When a patient died during hospitalization, cause of death was examined.

Data for categorical variables are summarized as proportions or frequencies. For continuous variables, the data are shown as mean and standard deviation values for normally distributed data and as median and interquartile range (IQR) values for non-normally distributed data. The chi-square test was used to compare frequencies between the two groups. To determine the significance of differences between the two groups, the t-test was used for normally distributed data, and the Mann–Whitney test was used for non-normally distributed data. P values of  $< 0.05$  were considered statistically significant. To identify variables that were independently associated

with poor outcomes, we performed a logistic regression analysis. Risk factors that exhibited  $p$  values of  $<0.05$  in the univariate analyses were included in the multivariate model. All analyses were performed with SPSS ver. 23, and  $p$  values of  $<0.05$  were considered significant.

The study approval was obtained from the Institutional Review Board of Saiseikai Shiga Hospital.

## Results

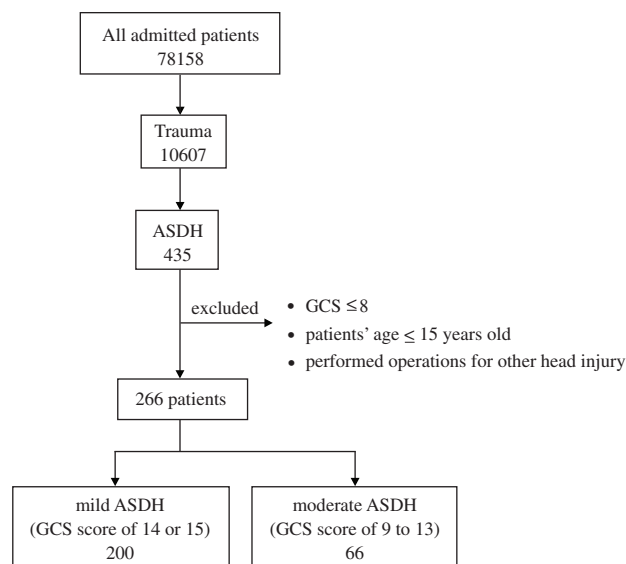
### Basic information for all subjects

A total of 266 patients were included in this analysis (Fig. 1). The characteristics of the patients are shown in Table 1. The subjects' mean age was  $70.2 \pm 17.1$  years (range: from 16 to 96 years). Males accounted for 63.9% of the patients. The mechanisms of injury were as follows: falling down: 33.5%, pedestrian collisions: 9.8%, bicycle collisions: 19.5%, motorcycle collisions: 4.5%, 4WV collisions: 3.4%, and falling from a height: 17.7%. In total, 20.7% of the patients had taken antithrombotic drugs before admission. As for the location of hematoma, temporal was the most common (39.5%), followed by frontal (19.2%) and interhemispheric (15.4%). Regarding concomitant injuries, SAH was the most common type of injury (56.8%), followed by contusions (35.7%) and skull fractures (26.3%). In all, 44 patients (16.5%) had suffered extracranial injuries with AIS of  $\geq 3$ . The patients' ISS ranged from 16 to 75, and the median ISS was 21. The frequency of surgery and the outcomes seen at discharge are shown in Table 2. Twelve percent of patients underwent surgery. Favorable outcomes were achieved in 75.9% of cases, and the mortality rate was 6.8%. As for the severity of ASDH, the patients were divided into a mild group, which included 200 patients (75.2%), and a moderate group, which included 66 patients (24.8%).

### Comparison between mild and moderate ASDH

We compared the characteristics of the mild and moderate groups (Table 1). Significant intergroup differences were found in the mean systolic blood pressure on arrival ( $p = 0.005$ ), the prevalence of SAH ( $p = 0.02$ ) and contusions ( $p = 0.02$ ), and the median ISS ( $p = 0.002$ ). As for the mechanisms of injury, falling down was the most common mechanism of injury in both of the mild and moderate group without statistical significance.

We also compared the frequency of surgery and the outcomes at discharge between the two groups. Surgical interventions were performed three times more often in the moderate group (24.2%) than in the mild group (8.0%) ( $p = 0.001$ ). In the mild group, 81.5% of patients exhibited favorable outcomes,



**Fig. 1** Patient flow diagram for patients that were admitted to Saiseikai Shiga Hospital between April 2008 and March 2017. ASDH: acute subdural hematoma, GCS: glasgow coma scale.

which was significantly higher than the frequency of favorable outcomes in the moderate group (59.1%,  $p = 0.0004$ ). The mortality rate in the mild group was 4.5%, whereas in the moderate group it was 13.6% ( $p = 0.027$ ). Regarding causes of death, 77.8% of deaths in the moderate group were caused by trauma, including ASDH, contusions, or traumatic hemorrhagic shock, and the remaining 22.2% were caused by complications following trauma. On the contrary, in the mild group, the major cause of death was complications, including pneumonia, urinary tract infections, and non-occlusive mesenteric ischemia, which accounted for 66.7% of deaths, while traumatic deaths only accounted for 33.3% of deaths.

### Factors influencing outcomes in the mild group

We performed a comparison between favorable (163 patients) and poor (37 patients) outcomes in the mild group (Table 2). In the univariate analyses, we found significant differences in median age ( $p < 0.001$ ), the frequencies of falling down ( $p = 0.002$ ) and traffic accidents ( $p = 0.01$ ), the median ISS ( $p < 0.001$ ), the use of antithrombotic drugs ( $p = 0.04$ ), and the frequency of extracranial injuries with AIS of  $\geq 3$  ( $p = 0.04$ ). Among the various types of traffic accident victims, bicyclists were more likely to exhibit favorable outcomes.

To investigate independent predictors of outcomes in the mild group, we performed a logistic regression analysis (Table 3, A). The variables that exhibited significant differences in the univariate analyses

**Table 1** Characteristics of all patients and a comparison between patients with mild and moderate ASDH

	All (n = 266)	Mild (n = 200)	Moderate (n = 66)	p value
Age	70.2 ± 17.1	74 [64, 81.3]	72 [62.3, 84]	0.77*
Male	170 (63.9%)	124 (62.0%)	46 (69.7%)	0.33 <sup>†</sup>
Mechanism of injury				
Falling down	89 (33.5%)	73 (36.5%)	16 (24.2%)	0.09 <sup>†</sup>
Traffic accident				
Pedestrians	26 (9.8%)	17 (8.5%)	9 (21.2%)	0.33 <sup>†</sup>
Bicyclists	52 (19.5%)	39 (19.5%)	13 (19.7%)	1.0 <sup>†</sup>
Motorcyclists	12 (4.5%)	7 (3.5%)	5 (7.6%)	0.30 <sup>†</sup>
4WV	9 (3.4%)	7 (3.5%)	2 (3.0%)	1.0 <sup>†</sup>
Falling from a height	47 (17.7%)	34 (17.0%)	13 (19.7%)	0.76 <sup>†</sup>
SBP on arrival	146.4 ± 28.8	149.4 ± 27.3	136.8 ± 31.5	0.005 <sup>*</sup>
Anti-thrombotic drug use	55 (20.7%)	40 (20.0%)	15 (22.7%)	1.0 <sup>†</sup>
Location of hematoma				
Frontal	51 (19.2%)	45 (22.5%)	6 (9.1%)	0.02 <sup>†</sup>
Temporal	105 (39.5%)	73 (36.5%)	32 (48.5%)	0.11 <sup>†</sup>
Occipital	4 (1.5%)	3 (1.5%)	1 (1.5%)	1.0 <sup>†</sup>
Parietal	5 (1.9%)	5 (2.5%)	0 (0.0%)	0.34 <sup>†</sup>
Interhemispheric	41 (15.4%)	34 (17.0%)	7 (10.6%)	0.29 <sup>†</sup>
Tentorial	6 (2.3%)	5 (2.5%)	1 (1.5%)	1.0 <sup>†</sup>
Multiple	54 (20.3%)	35 (17.5%)	19 (28.8%)	0.07 <sup>†</sup>
Other head injuries				
SAH	151 (56.8%)	105 (52.5%)	46 (69.7%)	0.02 <sup>†</sup>
Contusion	95 (35.7%)	63 (31.5%)	32 (48.5%)	0.02 <sup>†</sup>
AEDH	25 (9.4%)	15 (7.5%)	10 (15.2%)	0.11 <sup>†</sup>
DBI	3 (1.1%)	1 (0.5%)	2 (3.0%)	0.31 <sup>†</sup>
Fractures	70 (26.3%)	48 (24.0%)	22 (33.3%)	0.18 <sup>†</sup>
Calvaria	67 (25.2%)	45 (22.5%)	22 (33.3%)	0.11 <sup>†</sup>
Skull base	10 (3.8%)	6 (3.0%)	4 (6.1%)	0.45 <sup>†</sup>
ISS	21 [17, 26]	20.5 [17, 26]	25.0 [17, 27]	0.002 <sup>*</sup>
Extracranial injuries with AIS scores of ≥3	44 (16.5%)	30 (15.0%)	14 (21.2%)	0.32 <sup>†</sup>

\*Mann–Whitney's U test, <sup>†</sup> $\chi^2$  test, <sup>\*</sup>Student's t-test

4WV: four-wheeled vehicles, AEDH: acute subdural hematoma, AIS: abbreviated injury scale, ASDH: acute subdural hematoma, DBI: diffuse brain injury, ISS: injury severity score, SAH: subarachnoid hemorrhaging, SBP: systolic blood pressure.

were included in the logistic regression analysis. Finally, age (OR: 1.06, 95% CI: 1.01–1.11), and the ISS (OR: 1.24, 95% CI: 1.12–1.36) were identified as independent predictors of poor outcomes.

#### Factors influencing outcomes in the moderate group

A similar analysis was performed in the moderate group (66 patients). In all, 39 patients (59.1%) achieved

favorable outcomes, whereas the other 40.9% displayed poor outcomes. A significantly higher age ( $p < 0.001$ ), a higher prevalence of falling down ( $p = 0.004$ ), and a higher ISS ( $p = 0.014$ ) were found among the patients with poor outcomes (**Table 4**). Antithrombotic-drug use ( $p = 0.20$ ) did not influence on the outcome.

Logistic regression analysis involving median age, falling down-based mechanism of injury, and the

**Table 2 Comparison between mild ASDH patients that exhibited favorable and poor outcomes**

	Favorable outcomes (n = 163)	Poor outcomes (n = 37)	p value
Age	73 [63.5, 80.5]	81 [76, 87]	<0.001
Male	102 (62.6%)	22 (59.5%)	0.84 <sup>†</sup>
Mechanism of injury			
Falling down	51 (31.3%)	22 (59.5%)	0.002 <sup>†</sup>
Traffic accident			
Pedestrians	14 (8.6%)	3 (8.1%)	1.0 <sup>†</sup>
Bicyclists	37 (22.7%)	2 (5.4%)	0.03 <sup>†</sup>
Motorcyclists	6 (3.7%)	1 (2.7%)	1.00 <sup>†</sup>
4WV	7 (4.3%)	0 (0.0%)	0.43 <sup>†</sup>
Falling from a height	26 (16.0%)	8 (21.6%)	0.12 <sup>†</sup>
SBP on arrival	148.7 ± 25.5	152.3±34.6	0.49 <sup>‡</sup>
Anti-thrombotic drug use	39 (23.9%) (unknown 2)	15 (40.5%) (unknown 1)	0.04 <sup>†</sup>
Other head injuries			
SAH	82 (50.3%)	23 (62.2%)	0.26 <sup>†</sup>
Contusions	51 (31.3%)	12 (32.4%)	1.00 <sup>†</sup>
AEDH	14 (8.6%)	1 (2.7%)	0.42 <sup>†</sup>
DBI	0 (0.0%)	1 (2.7%)	0.42 <sup>†</sup>
Fractures	40 (24.5%)	8 (21.6%)	0.87
Calvaria	38 (23.3%)	7 (18.9%)	0.72 <sup>†</sup>
Skull base	5 (3.0%)	1 (2.7%)	1.0 <sup>†</sup>
ISS	17 [17, 26]	26 [25, 27]	<0.001 <sup>*</sup>
Extracranial injuries with AIS scores of ≥3	20 (12.3%)	10 (27.0%)	0.04

\*Mann–Whitney's U test, <sup>†</sup> $\chi^2$  test, <sup>‡</sup>Student's t-test

4WV: four-wheeled vehicles, AEDH: acute epidural hematoma, AIS: abbreviated injury scale, ASDH: acute subdural hematomas, DBI: diffuse brain injury, ISS: injury severity score, SAH: subarachnoid hemorrhaging, SBP: systolic blood pressure.

ISS, which exhibited statistical significance in the univariate analyses, demonstrated that older age (OR: 1.09, 95% CI: 1.03–1.16) and a higher ISS (OR: 1.15, 95% CI: 1.05–1.27) were independent predictors of poor outcomes (**Table 3, B**).

## Discussion

In this study, we assessed the severity of ASDH based on the patients' GCS scores in emergency room, that is, mild ASDH was defined as a GCS score of 14 or 15, and moderate ASDH was defined as a GCS score of 9–13. There was a concern whether ASDH with GCS score of 13 is included in mild or moderate. Although head injury patients with GCS score of 13 relatively got favorable outcome, they needed more surgical intervention than those with GCS score of 14 and 15.<sup>9)</sup> Therefore, we classified ASDH patients with GCS score of 13 to moderate as described in a previous report and Japan Advanced Trauma Evaluation and Care.<sup>3,12)</sup> In this study, 8.0%

of the patients in the mild group and 24% of the patients in the moderate group underwent surgery. According to the Japan Advanced Trauma Evaluation and Care program, 7% of patients with moderate head injuries require surgery.<sup>3)</sup> As ASDH require surgical interventions more frequently than other head injuries, the data regarding the frequency of surgery obtained in the present study are considered to be reasonable. The number of patients that underwent surgery was three times higher in the moderate group than in the mild group. This result was well accordance with the previous result that risk of surgical lesion of the moderate head injuries with GCS of 9–13 was 3.2 times higher than that of mild head injuries with GCS 14–15.<sup>13)</sup> In the current study, the patients with moderate ASDH had worse outcomes than the patients with mild ASDH, that is, the mortality was more than three times higher in the moderate group. On the other hand, we found that the patients with mild ASDH mainly died of complications, such as infections or

**Table 3 Results of the logistic regression analysis**

A. Mild ASDH			
	Odds ratio	95% Confidence interval	p value
Traffic accident	0.18	0.04–0.76	0.01
Age	1.06	1.01–1.11	<0.001
ISS	1.24	1.12–1.36	<0.001
B. Moderate ASDH			
	Odds ratio	95% Confidence interval	p value
Age	1.09	1.03–1.16	<0.001
ISS	1.15	1.05–1.27	0.014

ASDH: acute subdural hematoma, ISS: injury severity score.

non-occlusive mesenteric ischemia. Therefore, even for patients with mild ASDH, whole-body management is needed to improve outcomes.

In the early stages after a trauma, being able to predict patient outcomes based on information obtained in the initial examination would be useful for both medical staff and patients or their families. Although multiple predictive models have been developed, most of these models do not predict mortality, but rather try to differentiate between the potential for a good clinical outcome versus disability, vegetative state, or death.<sup>8,14–16</sup> In the present study, being elderly and a higher ISS were found to be independent predictors of poor outcomes in both the mild and moderate groups. A previous study, involving both moderate and mild ASDH patients (GCS: 9–15), examined the factors that were independently associated with patient outcomes. As a result, logistic regression analysis showed that the ISS was the only independent predictor.<sup>4</sup> The discrepancies between the results of our study and those of the previous study were probably due to differences in the age distributions of the two studies (the mean age of our patients was 70, whereas that of the previous study was 39). As ASDH is associated with high mortality and morbidity rates in elderly people, and aging is a big issue in developed countries, including Japan, age is considered to be an important predictor of outcomes among ASDH patients.

Regarding mechanisms of injury, traffic accident, falling down, and falling from a height were the most common causes of ASDH, which agrees with previous findings.<sup>2,5,6,8,17</sup> According to an analysis of ASDH patients that underwent surgery, the mortality rate of the patients who experienced out-of-vehicle traffic accidents was high, while the patients with isolated head trauma exhibited a low mortality rate.<sup>2</sup> In the current study, the mechanism of injury was not correlated with outcomes in the moderate ASDH group. A systematic review into the prognosis of

ASDH in the elderly demonstrated that the mechanism of injury was not a predictor of mortality.<sup>18</sup> Although another study found that injuries caused by traffic accidents were associated with poor outcomes, as this study was performed 37 years ago,<sup>19</sup> its findings may no longer be accurate.

Although the interhemispheric subdural hematoma was reported as uncommon type and accounting for 6% of all traumatic SDH patients, it corresponded to 15% of all ASDH patients in our study.<sup>20,21</sup> Because the interhemispheric subdural hematoma is considered as rare especially the isolated one and, also shown in severe cases, analyses focused on the interhemispheric subdural hematoma would be performed in future.

Recently, antithrombotic agents have been administered increasingly frequently, especially to elderly patients, and hence, major hemorrhaging is a concern.<sup>22,23</sup> In some studies, anticoagulation therapy has been shown to increase mortality from large ASDHs, and elderly patients on anticoagulant therapy are more likely to develop ASDHs if they fall and suffer a head trauma.<sup>24,25</sup> However, most recent studies that investigated the associations between pre-injury anticoagulation therapy and the outcomes of ASDH patients have suggested that such treatment was not a significant predictive factor.<sup>26–31</sup> Our findings agree with this. Recent evidence suggested that anticoagulant use in patients aged >65 years with small subdural hematomas is not a significant determinant of hematoma volume expansion.<sup>31</sup> The subjects of our study had mild or moderate ASDH, which are associated with low levels of hemorrhaging. Therefore, our results confirmed that the use of antithrombotic agents is not a predictor of outcomes in patients with mild or moderate ASDH.

This study had some limitations. First, we did not use computed tomography (CT) to determine the sizes of the patients' hematomas. As brain hematomas and the concomitant brain edema can

**Table 4** Comparison between moderate ASDH patients that exhibited favorable and poor outcomes

	Favorable outcomes (n = 39)	Poor outcomes (n = 27)	p value
Age	68 [49, 77]	82 [72, 86.5]	<0.001*
Male	29 (74.4%)	19 (70.4%)	1.0 <sup>†</sup>
Mechanism of injury			
Falling down	4 (10.3%)	12 (44.4%)	0.004 <sup>†</sup>
Traffic accident			
Pedestrians	5 (12.8%)	4 (14.8%)	1.0 <sup>†</sup>
Bicyclists	9 (23.1%)	4 (14.8%)	0.61 <sup>†</sup>
Motorcyclists	3 (7.7%)	2 (7.4%)	1.0 <sup>†</sup>
4WV	1 (2.6%)	1 (3.7%)	1.0 <sup>†</sup>
Falling from a height	11 (28.2%)	2 (7.4%)	0.08 <sup>†</sup>
SBP on arrival	137.5 ± 31.2	138.1 ± 32.6	0.95 <sup>†</sup>
Anti-thrombotic drug use	7 (17.9%) (unknown 4)	8 (29.6%) (unknown 7)	0.20 <sup>†</sup>
Other head injuries			
SAH	29 (74.4%)	17 (63.0%)	0.47 <sup>†</sup>
Contusion	21 (53.8%)	11 (40.7%)	0.43 <sup>†</sup>
AEDH	7 (17.9%)	3 (11.1%)	0.68 <sup>†</sup>
DBI	0 (0.0%)	2 (7.4%)	0.32 <sup>†</sup>
Fractures	14 (35.9%)	8 (29.6%)	0.79
Calvaria	14 (35.9%)	8 (29.6%)	0.79 <sup>†</sup>
Skull base	4 (10.2%)	0 (0.0%)	0.14 <sup>†</sup>
ISS	21 [17, 26.5]	26 [25, 32]	0.014*
Extracranial injuries with AIS scores of ≥3	6 (15.4%)	8 (29.6%)	70.22 <sup>†</sup>

\*Mann–Whitney's U test <sup>†</sup> $\chi^2$  test, <sup>†</sup>Student's t-test

4WV: four-wheeled vehicles, AEDH: acute epidural hematomas, AIS: abbreviated injury scale, ASDH: acute subdural hematoma, DBI: diffuse brain injury, ISS: injury severity score, SAH: subarachnoid hemorrhaging, SBP: systolic blood pressure.

cause a midline shift on CT, some predictive models mainly focus on midline shifts as a separate entity.<sup>32)</sup> In patients with traumatic ASDH, a clear correlation between the extent of midline shifts and the thickness of hematomas was found.<sup>32)</sup> In addition, it was reported that the midline shifts caused by ASDH are related to the GCS score and mortality.<sup>33)</sup> Second, individual comorbidities were not considered in this analysis. Although our study included patients with a wide age range (16–95), the patients' mean age was relatively high at 70 years. In a previous study of elderly ASDH patients with a similar mean age to our study population, medical comorbidities, including hypertension, atrial fibrillation, diabetes, Parkinson's disease, a previous stroke, and malignancy, were not found to be predictors of outcomes.<sup>34)</sup> Therefore, we consider that our results are reliable. However, as the elderly population grows and the proportion of ASDH patients with comorbidities might increase, further

research that considers patients' medical histories might be needed. Third, the outcome of the patient was determined according to the GOS at discharge. This measure can classify the short outcome of the patient but difficult to understand the ultimate outcome of the patients. In future, similar analyses may be required to find the factors influencing on the long-term outcome. Fourth, this study was performed at a single center. Our hospital is the sole tertiary emergency medical center serving a population of about 330000, and most of the patients that develop mild to severe ASDH in this area are transported to our hospital. Therefore, there was little selection bias.

## Conclusion

1. The rate of surgical interventions and mortality rate in the moderate group were three times higher in the mild group.

2. In the mild ASDH group, age (OR: 1.06, 95% CI: 1.01–1.11) and the ISS (OR: 1.24, 95% CI: 1.12–1.36) were considered to be independent predictors of poor outcomes.
3. In the moderate ASDH group, an older age (OR: 1.09, 95% CI: 1.03–1.16) and a higher ISS (OR: 1.15, 95% CI: 1.05–1.27) contributed to poor outcomes.

In this study, we first clarified the independent predictors of the outcomes of patients with mild or moderate ASDH separately. As the development of medical interventions and changes in injury trends might influence the outcomes of ASDH, the analyses performed in this study should be repeated in future.

### Conflicts of Interest Disclosure

The authors no report conflicts of interest concerning the materials or methods used in this study.

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