Article published online: 2022-08-16

Original Article

# Identification of Prognostic Factors in Surgically Treated Patients with Acute Epidural Hematoma


## Abstract

**Context:** Only few comprehensive studies have investigated acute epidural hematoma (AEDH), and a low incidence of the lesion has been observed in comparison with other types of traumatic brain injuries such as subdural hematoma, traumatic subarachnoid hemorrhage, and contusion. **Aim:** This study aims to identify the prognostic factors of surgically treated AEDH. **Settings and Design:** The medical records of 58 consecutive patients with surgically treated AEDH between September 2011 and 2018 were retrospectively reviewed. **Subjects and Methods:** All patients were diagnosed with AEDHs using 5-mm-slice computed tomography (CT). Information regarding the following demographic and clinical characteristics was collected: age, sex, antithrombotic drug use, mechanisms of injury, time from onset to operation, neurological examination, vital signs, blood examination, and CT findings. **Statistical Analysis Used:** We analyzed prognostic factors in patients with AEDH using univariate and multivariate regression analyses. **Results:** Univariate and multivariate regression analyses revealed that age ($P < 0.01$) and the Glasgow Coma Scale (GCS; $P < 0.01$) were independent predictive factors for good prognosis. In addition, receiver operating characteristics (ROC) analysis showed that an age of <55 years and a GCS score of >12 were optimal cutoff values for predicting good prognoses, with the areas under the ROC curve of 0.827 and 0.810, respectively. **Conclusions:** Age and GCS are useful predictors of prognosis in patients with surgically treated AEDH. These findings are appropriate prognostic indicators for urgent surgery performed to treat AEDH and intended to help clinicians make a prompt diagnosis.


**Keywords:** *Acute subdural hematoma, age of onset, Glasgow Coma Scale, prognostic factors, traumatic brain injury*

**Koki Onodera, Tomoya Kamide, Tatsuki Kimura, Shinya Tabata, Toshiki Ikeda, Yuichiro Kikkawa, Hiroki Kurita**

*Department of Neurosurgery, International Medical Center, Saitama Medical University, Hidaka, Saitama, Japan*

## Introduction

Many studies have investigated traumatic brain injury (TBI) and acute subdural hematoma (ASDH);[1-5] however, only few comprehensive studies that focus on acute epidural hematoma (AEDH), a lesion observed at a much lower incidence in comparison with other types of TBIs, are available. In the present study, we retrospectively analyzed outcomes when urgent surgery was used to treat patients with AEDH in a single medical center to identify the prognostic factors for this relatively rare condition.

## Subjects and Methods

### Study population and data collection

The medical records of 58 consecutive patients with surgically treated AEDH admitted to our hospital between September 2011 and 2018 were retrospectively reviewed. All patients were diagnosed with AEDHs using 5-mm-slice computed tomography (CT). Information regarding the following demographic and clinical characteristics was collected: age, sex, antithrombotic drug use, mechanisms of injury (MOIs), time from onset to operation, neurological examination, vital signs, blood examination, and CT findings [Table 1]. The requirement for informed consent was waived due to the retrospective nature of this study. The Institutional Review Board of Saitama Medical University International Medical Center approved all aspects of this study (application number, 18-283).

### Radiographical analysis

A computer-assisted calculation was used to measure the thickness, length, volume, and midline shift of preoperative AEDHs. The margins were traced using SYNAPSE

***Address for correspondence:***
*Dr. Tomoya Kamide, Department of Neurosurgery, International Medical Center, Saitama Medical University, 1397-1 Yamane, Hidaka, Saitama 350-1298, Japan. E-mail: kamide@med.kanazawa-u.ac.jp*

Access this article online

**Website:** www.asianjns.org

**DOI:** 10.4103/ajns.AJNS_129_20

Quick Response Code:



**How to cite this article:** Onodera K, Kamide T, Kimura T, Tabata S, Ikeda T, Kikkawa Y, *et al.* Identification of prognostic factors in surgically treated patients with acute epidural hematoma. Asian J Neurosurg 2020;15:532-6.

**Submitted:** 01-Apr-2020
**Accepted:** 19-Apr-2020 **Published:** 28-Aug-2020

**Table 1: Patient demographics and univariate analysis of prognostic factors and comparison between good and poor prognosis (*n*=58)**

| Variables | Total (*n*=58) | Good outcome (GR, MD) (*n*=29) | Poor outcome (SD, VS, D) (*n*=29) | *P* |
|---|---|---|---|---|
| Age (years) | 49.8±24.3 | 35.7±22.4 | 63.9±16.8 | <0.01* |
| Male sex, *n* (%) | 39 (67.2) | 20 (69.0) | 19 (65.5) | 0.78 |
| Antithrombotic drug, *n* (%) | 3 (5.2) | 1 (3.4) | 2 (6.9) | 0.50 |
| MOI, *n* (%) | | | | 0.36 |
| Motor vehicle | 16 (27.6) | 10 (34.5) | 6 (20.7) | |
| Fall | 37 (63.8) | 17 (58.6) | 20 (69.0) | |
| Unknown | 4 (6.9) | 1 (3.4) | 3 (10.3) | |
| Others | 1 (1.7) | 1 (3.4) | 0 (0) | |
| Time to operation (min) | 441±308 | 478±336 | 383±271 | 0.39 |
| Neurological factors | | | | |
| GCS score, median (IQR) | 12 (7-14) | 14 (13-15) | 6 (6-12) | <0.01* |
| GCS decrease, *n* (%) | 14 (24.1) | 8 (27.6) | 6 (20.7) | 0.54 |
| Anisocoria, *n* (%) | 12 (20.7) | 4 (13.8) | 8 (27.6) | 0.15 |
| Vital signs | | | | |
| sBP (mmHg) | 147±32 | 141±31 | 154±33 | 0.152 |
| dBP (mmHg) | 80±18 | 83±16 | 79±18 | 0.73 |
| BT (°C) | 36.3±0.7 | 36.3±0.7 | 36.4±0.8 | 0.71 |
| Blood examination | | | | |
| Hb (g/dL) | 12.9±2.0 | 13.6±2.2 | 12.2±1.5 | 0.01* |
| AST (U/L) | 36±19 | 34.4±4.8 | 37.9±2.8 | 0.07 |
| ALT (U/L) | 25±14 | 22.7±3.0 | 27.1±2.4 | 0.11 |
| Creatinine (mg/dl) | 0.63±0.25 | 0.66±0.07 | 0.62±0.03 | 0.89 |
| APTT (s) | 30±6.5 | 30.2±1.1 | 30.6±1.3 | 0.75 |
| PT (s) | 12.5±1.1 | 12.5±1.0 | 12.4±1.2 | 0.80 |
| PT-INR | 1.07±0.09 | 1.07±0.09 | 1.07±0.10 | 0.90 |
| D-dimer (µg/ml) | 68.1±70.4 | 22.0±19.1 | 109±70 | <0.01* |
| EDH characteristics | | | | |
| Thickness (mm) | 28±11 | 25.5±9.6 | 30.1±12.8 | 0.12 |
| Length (mm) | 80±19 | 75.4±18.5 | 83.4±18.4 | 0.11 |
| Volume (ml) | 73±49 | 79.5±13.8 | 76.6±12.5 | 0.22 |
| Midline shift (mm) | 5.8±4.8 | 5.2±4.8 | 6.4±5.0 | 0.37 |
| Location of EDH, *n* (%) | | | | 0.62 |
| Supratentorial | 51 (87.9) | 25 (86.2) | 26 (89.7) | |
| Infratentorial | 7 (12.1) | 4 (13.8) | 3 (10.3) | |
| CT findings of ICH with EDH[a], *n* (%) | | | | |
| Contusion | 30 (51.7) | 10 (34.5) | 20 (69.0) | <0.01* |
| Traumatic SAH | 44 (75.9) | 17 (58.6) | 27 (93.1) | <0.01* |
| ASDH | 26 (44.8) | 9 (31.0) | 17 (58.6) | 0.04* |
| Skull fracture | 50 (86.2) | 25 (86.2) | 25 (86.2) | 0.65 |

Data presented as mean±SD, median (IQR) or number of patients (%). [a]Because patients can have more than one CT finding, the total is >58; *$P<0.05$. MOI – Mechanism of injury; GCS – Glasgow Coma Scale; IQR – Interquartile range; sBP – Systolic blood pressure; dBP – Diastolic blood pressure; BT – Body temperature; EDH – Epidural hematoma; ICH – Intracranial hemorrhage; SAH – Subarachnoid hemorrhage; ASDH – Acute subdural hematoma; CT – Computed tomography; SD – Standard deviation; Hb – Hemoglobin; APPT – Activated partial thromboplastin time; AST – Aspartate transaminase; ALT – alanine aminotransferase; PT – Prothrombin time; INR – International normalized ratio; GR – Good recovery; MD – Moderate disability; SD – Severe disability; VS – Vegetative state; D – Dead

software (version 4.1, Fujifilm, Tokyo, Japan) for every axial slice and automatically analyzed to measure the volume of AEDHs. The sum of all the slides was calculated as the overall hematoma volume. In addition, the location of AEDH (supratentorial or infratentorial) with or without intracranial hemorrhage (contusion, traumatic subarachnoid hemorrhage [SAH], and ASDH) was analyzed.

### Statistical analysis

Surgically treated patients were categorized into the following two groups according to the measure of disability

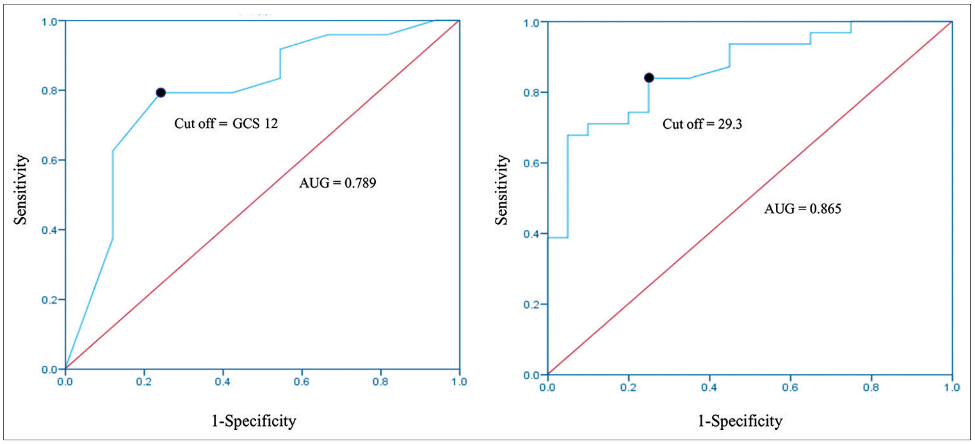


**Figure 1: Receiver operating characteristics curve analysis reveals the optimal cutoff value for predicting a good prognosis of acute epidural hematoma. The cutoff value for years of age is 55. The cutoff value for Glasgow Coma Scale before the operation is 12**

**Table 2: Multivariate regression analysis of factors related to good prognostic factors**

| Variables | OR | 95% CI | *P* |
|---|---|---|---|
| Age (years) | 1.08 | 1.03-1.14 | <0.01* |
| GCS | 1.48 | 1.17-1.87 | <0.01* |
| AST (U/L) | 1.02 | 0.97-1.07 | 0.40 |
| Hb (g/dl) | 1.09 | 0.66-1.81 | 0.74 |
| D-dimer (µg/ml) | 1.02 | 0.98-1.03 | 0.12 |
| Contusion (yes vs. no) | 1.08 | 0.10-11.11 | 0.95 |
| Traumatic SAH (yes vs. no) | 2.63 | 0.11-62.50 | 0.54 |
| ASDH (yes vs. no) | 1.97 | 0.28-13.7 | 0.49 |

*$P<0.05$. OR – Odds ratio; CI – Confidence interval; GCS – Glasgow Coma Scale; SAH – Subarachnoid hemorrhage; ASDH – Acute subdural hematoma; Hb – Hemoglobin; AST – Aspartate transaminase

using the Glasgow Outcome Scale at discharge [Table 1]: good (good recovery, moderate disability) and poor (severe disability, vegetative state, dead). Demographic and clinical characteristics were compared between these two groups using univariate analysis with Chi-square, Fisher's exact test, Student's *t*-test, and Mann–Whitney U-test. After univariate analysis, multivariate regression analysis was conducted to identify independent factors related to a good prognosis [Table 2]. Factors with $P < 0.010$ were selected for stepwise multivariate regression analysis. Odds ratios (ORs) with 95% confidence intervals (CIs) were obtained from the regression analysis. $P < 0.05$ was considered statistically significant. Receiver operating characteristics (ROC) curve was used to predict the prognostic factors of AEDHs and decide the cutoff value where the risk for a good prognosis was significantly high [Figure 1]. Statistical data were analyzed using IBM SPSS Statistics (version 24; IBM Corp, Armonk, NY, USA).

## Results

The demographic and clinical characteristics of the 58 patients (39 men and 19 women) are summarized in Table 1. The mean age was 49.8 ± 24.0 years and the mean time from the onset of AEDH to the operation was 441 ± 308 min. The median Glasgow Coma Scale (GCS) score before the operation was 12 (range, 7–14). Among the 58 patients, 14 (24.1%) had progressive neurological deterioration (a decreased GCS score) between arrival and operation and 12 (20.7%) had anisocoria before surgery. Blood examination results were as follows: mean hemoglobin level, 12.9 ± 2.0 g/dL; mean aspartate aminotransferase and alanine aminotransferase levels, 36 ± 19 and 25 ± 14 U/L, respectively; mean creatinine value, 0.63 ± 0.25 mg/dL; and mean D-dimer value, 68.1 ± 70.4 µg/mL. The mean thickness, length, and volume of AEDHs were 28 ± 11 mm, 80 ± 19 mm, and 73 ± 49 ml, respectively. CT findings revealed that the mean distance of midline shift was 5.8 ± 4.8 mm. AEDH was localized in the supratentorial and infratentorial regions in 51 (87.9%) and 7 (12.1%) patients, respectively. Furthermore, majority of patients (48; 82.8% patients) presented with other types of traumatic hemorrhages including contusion (30; 51.7%), traumatic SAH (44; 75.9%), and ASDH (26; 44.8%). Univariate analysis of prognostic factors demonstrated that age, GCS score, hemoglobin level, D-dimer, incidence of contusion, traumatic SAH, and ASDH were significantly associated with prognosis.

The results of multivariate regression analysis of factors related to a good prognosis are shown in Table 2. Age ($P < 0.01$) and GCS ($P < 0.01$) had significant effects on good prognoses. In addition, ROC curve analysis revealed the relationship of age and GCS to a good prognosis with areas under the curve of 0.827 and 0.810, respectively [Figure 1]. The optimal cutoff value of age was 55 years, yielding optimal sensitivity and specificity of 72.4% and 79.3%, respectively. In addition, the optimal cutoff value of GCS before the operation was 12, yielding optimal sensitivity and specificity of 75.9% and 82.1%, respectively.

## Discussion

To date, very few comprehensive studies of AEDH have been conducted and its incidence is very low. Orlando *et al*. investigated 125 patients with TBI who had surgical intervention and found that the number of patients with isolated SDH, SAH, contusion, or epidural hematoma was 97, 1, 2, or 0, respectively;[6] furthermore, multiple hemorrhages were present in 25 patients. Our findings also support the notion of the very low incidence of isolated AEDH in patients with TBI; among 58 patients undergoing urgent surgical evacuation of AEDH, only 10 had isolated AEDH.

Previous TBI studies have indicated that the prognosis is affected by MOI and falls are likely to result in poor prognosis. Fu *et al*. demonstrated that falls correlate with 69% nonsurvivors and 49% survivors ($P < 0.01$).[7] However, in the present study, falls did not significantly differ between the good and poor prognosis groups. Our findings indicate that in the context of AEDH, the mechanisms of TBI may not affect the outcome.

Some studies on chronic subdural hematoma (CSDH) or ASDH demonstrated the association of hematoma volume with the recurrence of CSDH or increased mortality with ASDH.[2,8,9] However, to the best of our knowledge, no studies have investigated the association of hematoma volume of AEDH with prognosis. A higher volume of hematoma in the brain possibly causes irreversible damage; therefore, we assessed the mean thickness, length, volume, and the mean distance of midline shift of AEDH and examined whether increase in these parameters correlated with poor prognosis. However, our findings revealed no relationships between these parameters and the prognosis, probably because all patients included in the study had large hematoma volumes, which were immediately eliminated by surgery before they lead to irreversible brain injury. Accordingly, the time from the onset to operation was not distinctively different between the good and poor prognosis groups.

Previous TBI and ASDH studies revealed that the probability of a favorable outcome decreases with increasing age.[10] In the present study, age affected the prognosis of patients with AEDH. No patients required additional surgical interventions to treat other organs; this indicates that cerebral damage caused poor prognoses as observed in older patients. Although hematoma characteristics (mean thickness, length, and volume and the mean distance of midline shift) of AEDH had no correlation with the prognosis, the potential cerebral damage caused by hematoma may have influenced this result because the brains of older individuals are more fragile and susceptible to traumatic damage. Moreover, it is hypothesized that brain plasticity decreases as age advances and physiological reserves decline due to the accumulation of minor but repetitive damage.[11-13]

Regardless of the distinct age difference ($P < 0.01$), we found no significant differences between vital signs such as blood pressure and body temperature between patients with good and poor prognosis of AEDH. However, in the present study, the GCS score was the second independent factor of good prognosis of AEDH, and a GCS score of 12 was the optimal cutoff value to reflect patient prognosis, as reported in previous studies on ASDH and TBI.[2,10,14-19] Indeed, functional brain damage could be reflected by neurological evaluation, not by radiographical findings, and a GCS score of 12 could be the threshold to indicate whether the brain damage is irreversible.

The present study has several limitations. The results in this study are subject to the well-known methodological limitations of retrospective analysis of single-center data. In addition, surgical selection bias could exist because only patients with severe CT findings and neurological conditions underwent surgical treatment. Furthermore, only ten patients developed isolated AEDH, and the majority of patients had other types of traumatic brain hemorrhages. Multivariate analyses revealed no significant associations between prognosis and other types of traumatic brain hemorrhages; however, such types of traumatic brain hemorrhages might cause primary axonal injury, which could not be evaluated in the present study.

## Conclusion

We analyzed the outcomes of urgent surgery in patients with AEDH who had undergone surgical intervention. Univariate and multivariate regression analyses revealed that age and GCS were independent prognostic factors, and the optimal cutoff values for age and GCS were 55 and 12, respectively. These findings can help clinicians predict the prognosis of AEDH and make decisions for optimal surgical interventions in patients with AEDH.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

## References

1. Ostermann RC, Joestl J, Tiefenboeck TM, Lang N, Platzer P, Hofbauer M. Risk factors predicting prognosis and outcome of elderly patients with isolated traumatic brain injury. J Orthop Surg Res 2018;13:277.
2. Kuhn EN, Erwood MS, Oster RA, Davis MC, Zeiger HE, Pittman BC, *et al*. Outcomes of subdural hematoma in the elderly with a history of minor or no previous trauma. World Neurosurg 2018;119:e374-82.
3. Kelly ML, Shammassian B, Roach MJ, Thomas C, Wagner AK. Craniectomy and craniotomy in traumatic brain injury: A propensity-matched analysis of long-term functional and quality of life outcomes. World Neurosurg 2018;118:e974-81.
4. McGinity MJ, Michalek JE, Rodriguez JS, Floyd JR. Surgical evacuation of acute subdural hematoma in octogenarians: A ten-year experience from a single trauma center. Br J Neurosurg 2017;31:714-7.
5. Fountain DM, Kolias AG, Lecky FE, Bouamra O, Lawrence T, Adams H, *et al*. Survival trends after surgery for acute

subdural hematoma in adults over a 20-year period. Ann Surg 2017;265:590-6.
6. Orlando A, Levy AS, Carrick MM, Tanner A, Mains CW, Bar-Or D. Epidemiology of mild traumatic brain injury with intracranial hemorrhage: Focusing predictive models for neurosurgical intervention. World Neurosurg 2017;107:94-102.
7. Fu TS, Jing R, McFaull SR, Cusimano MD. Recent trends in hospitalization and in-hospital mortality associated with traumatic brain injury in Canada: A nationwide, population-based study. J Trauma Acute Care Surg 2015;79:449-54.
8. Kawabata S, Tani S, Imamura H, Adachi H, Sakai N. Postoperative subdural air collection is a risk factor for chronic subdural hematoma after surgical clipping of cerebral aneurysms. Neurol Med Chir (Tokyo) 2018;58:247-53.
9. Stavrinou P, Katsigiannis S, Lee JH, Hamisch C, Krischek B, Mpotsaris A, *et al*. Risk factors for chronic subdural hematoma recurrence identified using quantitative computed tomography analysis of hematoma volume and density. World Neurosurg 2017;99:465-70.
10. Wan X, Liu S, Wang S, Zhang S, Yang H, Ou Y, *et al*. Elderly patients with severe traumatic brain injury could benefit from surgical treatment. World Neurosurg 2016;89:147-52.
11. Hukkelhoven CW, Steyerberg EW, Rampen AJ, Farace E, Habbema JD, Marshall LF, *et al*. Patient age and outcome following severe traumatic brain injury: An analysis of 5600 patients. J Neurosurg 2003;99:666-73.
12. Rovlias A, Theodoropoulos S, Papoutsakis D. Chronic subdural hematoma: Surgical management and outcome in 986 cases: A classification and regression tree approach. Surg Neurol Int 2015;6:127.
13. Kwon CS, Al-Awar O, Richards O, Izu A, Lengvenis G. Predicting prognosis of patients with chronic subdural hematoma: A new scoring system. World Neurosurg 2018;109:e707-14.
14. Tian HL, Chen SW, Xu T, Hu J, Rong BY, Wang G, *et al*. Risk factors related to hospital mortality in patients with isolated traumatic acute subdural hematoma: Analysis of 308 patients undergone surgery. Chin Med J (Engl) 2018;121:1080-4.
15. Taussky P, Widmer HR, Takala J, Fandino J. Outcome after acute traumatic subdural and epidural haematoma in Switzerland: A single-centre experience. Swiss Med Wkly 2008;138:281-5.
16. Kiboi JG, Kitunguu PK, Angwenyi P, Mbuthia F, Sagina LS. Predictors of functional recovery in African patients with traumatic intracranial hematomas. World Neurosurg 2011;75:586-91.
17. Moussa WM, Khedr WM, Elwany AH. Prognostic significance of hematoma thickness to midline shift ratio in patients with acute intracranial subdural hematoma: A retrospective study. Neurosurg Rev 2018;41:483-8.
18. Baum J, Entezami P, Shah K, Medhkour A. Predictors of outcomes in traumatic brain injury. World Neurosurg 2016;90:525-9.
19. Lenell S, Nyholm L, Lewén A, Enblad P. Clinical outcome and prognostic factors in elderly traumatic brain injury patients receiving neurointensive care. Acta Neurochir (Wien) 2019;161:1243-54.