Objective: To evaluate the clinical outcomes and prognostic factors in surgically treated patients with severe brain injury (Glasgow Coma Scale [GCS] score ≤8) diagnosed with traumatic epidural hematoma (EDH).

Methods: From January 2018 to June 2021, 1,122 patients with an initial GCS score ≤8 were retrospectively enrolled in the Korean Neuro-Trauma Data Bank System. Clinical data of 79 surgically treated patients with EDH were compared between the unfavorable (scores of 1-4 on the Glasgow Outcome Scale-Extended [GOSE]) and favorable (score of 5-8 on the GOSE) outcome groups.

Results: The overall mortality rate was 13.9%, and 60.8% of the patients had good outcomes at six months post-trauma. In the univariate analysis, increasing age (p=0.010), lower initial GCS score (p=0.001), higher Rotterdam computed tomography (CT) score (p=0.012), craniotomy rather than craniectomy (p=0.032), larger EDH volume (p=0.007), and loss of pupillary reactivity (unilateral unreactive pupil, p=0.026; bilateral unreactive pupils, p<0.001), were significantly correlated with unfavorable outcomes. Of these factors, increasing age (p=0.011) and bilateral unreactive pupils (p=0.002) were the most significant risk factors in the multivariate logistic regression analysis. The interval from admission to the brain CT scan was not correlated with the outcome; however, it was significantly longer in the unfavorable outcome group.

Conclusion: Despite severe brain injury, more than half of the patients with EDH had favorable outcomes after surgical treatment. Our findings suggest that prompt diagnosis and surgical treatment should be considered for such cases.

Keywords: Cranial epidural hematoma; Glasgow Coma Scale; Glasgow Outcome Scale; Traumatic brain injury
INTRODUCTION

Traumatic epidural hematoma (EDH) is a neurosurgical emergency that occurs in 14%–35% of patients with severe traumatic brain injury (TBI).\(^{11,25}\) Although the benefits of surgery for diffuse or intraparenchymal brain injury remain controversial,\(^{8,15,23}\) surgical evacuation of a hematoma is accepted as the gold standard treatment for symptomatic patients with EDH.\(^{3,4}\) The morbidity and mortality rates of surgically treated EDH have improved owing to advances in prehospital and in-hospital management and the widespread application of computed tomography (CT); nevertheless, these are still relatively high in patients with severe TBI.\(^{2,10,28}\)

Factors considered to affect the outcome of EDH include increasing age,\(^{2,19,22,30}\) preoperative Glasgow Coma Scale (GCS)\(^{12,18,19,22,28}\) score, loss of pupillary reactivity,\(^{4,5,12,39}\) concomitance with other intracranial injuries,\(^{10,16,19,22,28}\) interval from trauma to surgery,\(^{3,22,26-29}\) and hematoma volume.\(^{19,22,26,28,32}\) However, the association between factors and outcomes is inconsistent in the literature, and unfavorable outcomes are mostly observed in patients undergoing surgery for severe brain injury.\(^{2,21}\) This study aimed to evaluate the clinical outcomes and the prognostic factors of surgically treated patients with severe brain injury who were diagnosed with traumatic EDH.

MATERIALS AND METHODS

This retrospective study was approved by the Institutional Review Board (GBIRB2021-303), and the requirement for written consent was waived.

Study population
From January 2018 to June 2021, the Korean Neuro-Trauma Data Bank System (KNTDBS) included patients with severe TBI (GCS score of ≤8) aged ≥19 years without prior head surgery from 18 hospitals. In the KNTDBS, one representative diagnosis among EDH, subdural hematoma, subarachnoid hematoma, intracerebral hematoma, diffuse axonal injury, and skull fracture was recorded. Among a total of 1,122 patients that enrolled in the database, 97 were diagnosed with traumatic EDH. Seventeen patients who were treated conservatively were excluded. One of the remaining patients was excluded because of incorrect values. After exclusion, 79 patients were enrolled in this study.

Data analysis
The data retrieved from the database for analysis were as follows: patient characteristics (age and sex), initial vital signs (systolic/diastolic blood pressure, pulse rate, respiration rate, and body temperature), injury mechanisms, initial GCS score, initial pupil reactivity, Rotterdam CT score\(^{24}\) obtained on brain CT before surgery, time interval from admission to CT scan, treatment after initial CT (surgery or follow-up CT), EDH volume, mannitol use, time interval from admission to surgery, time interval from the last CT to surgery, types of surgery (craniotomy or craniectomy), surgery time, estimated blood loss during surgery, postoperative complications (intracranial hemorrhages requiring surgical treatment and surgical site infection), and clinical outcome at 6 months after injury measured by the Glasgow Outcome Scale-Extended (GOSE) score.\(^{17}\) EDH volume was measured using the ABC/2 method.\(^{13}\)
Clinical outcomes were dichotomized into the unfavorable and favorable groups. An unfavorable outcome was defined as a composite of death, vegetative state, or severe disability (scores of 1–4 on the GOSE), and a favorable outcome was defined as a composite of moderate disability or good recovery (scores of 5–8 score on the GOSE).

Statistical analysis
The Kolmogorov–Smirnov test was performed to test the normal distribution of continuous variables. Nonparametric continuous variables were analyzed using the Mann–Whitney U tests and reported as medians and interquartile ranges. Parametric continuous variables were analyzed using Student’s t-test and are presented as mean ± standard deviation. Categorical variables were expressed as frequencies and analyzed using Pearson’s χ² test or Fisher’s exact test. Factors related to the outcome in the univariate analysis (p<0.1) were considered as independent variables and included in the multivariate logistic regression analysis. Statistical significance was set at p<0.05. The analysis was performed using SPSS Statistics (version 22.0; IBM, Armonk, NY, USA).

RESULTS
Thirty-one (39.2%) of 79 surgically treated patients had unfavorable outcomes at 6 months after injury. Eleven patients (13.9%) died, and 8 (10.1%) were in a vegetative state (FIGURE 1). Age (p=0.010), initial GCS score (p<0.001), initial pupil reactivity (p<0.001), Rotterdam CT score (p=0.008), time interval from admission to CT scan (p=0.023), and EDH volume (p=0.012) were significantly different between the unfavorable and favorable outcome groups (TABLE 1).

The interval from admission to brain CT scan was significantly longer in the unfavorable outcome group (p=0.023); however, the interval from admission to surgery and interval from the last CT scan to surgery were not significantly different (p=0.584 and p=0.242, respectively). Craniectomy was performed at a significantly higher rate in patients with favorable outcomes (p=0.038).

Bilateral unreactive pupils at the initial assessment were observed in 26 (32.9%) of 79 patients, of whom 8 (30.8%) died and 4 (15.4%) were in a vegetative state. Eight (30.8%) patients had favorable outcomes.

![FIGURE 1. Clinical outcome at 6 months after injury according to the Glasgow Outcome Scale–Extended. The dotted line represents the distinction between the unfavorable and favorable outcomes.](https://doi.org/10.13004/kjnt.2022.18.e62)
In the univariate analysis (TABLE 2), increasing age (odds ratio [OR], 1.04; 95% confidence interval [CI], 1.01–1.08; p=0.010), lower initial GCS (OR, 0.59; 95% CI, 0.44–0.80; p=0.001), higher Rotterdam score (OR, 1.67; 95% CI, 1.12–2.49; p=0.012), craniotomy rather than craniectomy (OR, 2.77; 95% CI 1.09–7.03; p=0.032), and larger EDH volume (OR, 1.01; 95% CI, 1.00–1.02; p=0.007) were significantly correlated with unfavorable outcomes (TABLE 2). Initial pupil reactivity also showed a significant correlation, with bilateral fixed pupils (OR, 10.92; 95% CI, 2.33–51.22; p=0.002) in the multivariate logistic regression analysis.

The two independent predictors of unfavorable outcomes were increasing age (OR, 1.06; 95% CI, 1.01–1.11; p=0.011) and bilateral fixed pupils (OR, 10.92; 95% CI, 2.33–51.22; p=0.002) in the multivariate logistic regression analysis.

**TABLE 1.** Comparison of clinical factors between the two groups

| Variables                              | Favorable outcome (n=48, 60.8%) | Unfavorable outcome (n=31, 39.2%) | p-value  |
|----------------------------------------|---------------------------------|----------------------------------|----------|
| Age (years) (median [IQR])             | 49.5 (31.3–60.0)                | 57.0 (44.0–67.0)                 | 0.010*   |
| Sex (female)                           | 7 (14.6)                        | 9 (29.0)                         | 0.155    |
| Injury mechanisms                      |                                 |                                  | 0.947    |
| Slip down                              | 11 (22.9)                       | 6 (19.4)                         |          |
| Fall                                   | 14 (29.2)                       | 8 (25.8)                         |          |
| Traffic accident                       | 15 (31.3)                       | 11 (35.5)                        |          |
| Other unknown                          | 8 (16.7)                        | 6 (19.4)                         |          |
| Initial vital signs                    |                                 |                                  |          |
| sBP (mmHg)                             | 133.2±19.6                      | 128.8±37.4                       | 0.493    |
| PR (per minute) (median [IQR])         | 89.0 (77.0–106.8)               | 89.0 (77.0–106.8)                | 0.948    |
| RR (per minute) (median [IQR])         | 20.0 (18.0–22.0)                | 20.0 (18.0–20.0)                 | 0.225    |
| BT (°C)                                | 36.3±0.9                        | 36.4±1.1                        | 0.606    |
| Initial GCS score                      | 6.6±1.5                         | 5.2±1.7                         | <0.001*  |
| Initial pupil reactivity               |                                 |                                  | <0.001*  |
| Reactive                               | 36 (75.0)                       | 8 (25.8)                         |          |
| Unilateral unreactive                  | 4 (8.3)                         | 5 (16.1)                         |          |
| Bilateral unreactive                   | 8 (16.7)                       | 18 (58.1)                        |          |
| Rotterdam CT score                     | 2.7±1.2                         | 3.5±1.2                         | 0.008*   |
| Interval from admission to CT (minutes) (median [IQR]) | 23.5 (17.0–36.5) | 33.0 (22.0–50.0) | 0.023*   |
| Treatment after initial CT             |                                 |                                  | 0.607    |
| Surgery                                | 34 (70.8)                       | 24 (77.4)                        |          |
| Follow-up CT                           | 14 (29.2)                       | 7 (22.6)                         |          |
| EDH volume (mL) (median [IQR])         | 54.0 (33.3–96.8)                | 92.0 (46.0–160.0)                | 0.012*   |
| Interval from admission to surgery (minutes) (median [IQR]) | 155.5 (120.3–207.3) | 172.0 (122.0–243.0) | 0.584    |
| Interval from last CT to surgery (minutes) (median [IQR]) | 109.0 (88.0–161.5) | 100.0 (73.0–139.0) | 0.242    |
| Types of surgery                       |                                 |                                  | 0.038*   |
| Craniotomy                             | 16 (33.3)                       | 18 (58.1)                        |          |
| Craniectomy                            | 32 (66.7)                       | 13 (41.9)                        |          |
| Surgery time (minutes) (median [IQR])  | 140.0 (120.0–177.5)             | 145.0 (110.0–175.0)              | 0.699    |
| EBL (mL) (median [IQR])                | 700.0 (500.0–1,275.0)           | 900.0 (500.0–1,500.0)            | 0.418    |
| Mannitol use                           | 30 (62.5)                       | 22 (71.0)                        | 0.476    |
| Postoperative complications            |                                 |                                  |          |
| EDH                                    | 4 (8.3)                         | 1 (3.2)                          | 0.366    |
| SDH                                    | 1 (2.1)                         | 2 (6.5)                          | 0.324    |
| ICH                                    | 3 (6.3)                         | 3 (9.7)                          | 0.577    |
| SSI                                    | 1 (2.1)                         | 0 (0.0)                          | 0.422    |

Values are presented as the mean ± standard deviation or number (%). IQR: interquartile range, sBP: systolic blood pressure, PR: pulse rate, RR: respiration rate, BT: body temperature, GCS: Glasgow Coma Scale, CT: computed tomography, EDH: epidural hematoma, EBL: estimated blood loss, SDH: subdural hematoma, ICH: intracerebral hematoma, SSI: surgical site infection.

* p<0.05, statistically significant difference.
DISCUSSION

We reviewed 79 surgically treated patients with EDH with a GCS score of ≤8 who were enrolled in the KNTDBS study. The mortality rate was 13.9%, which is comparable with that reported in previous studies.\(^{10,20,22}\) Increasing age and bilateral unreactive pupils were the most significant risk factors for unfavorable outcomes.

Increasing age is a known risk factor for morbidity and mortality.\(^{2,19,22,30}\) Although the medical or medication history of the patients was not collected in detail in the KNTDBS database, in general, elderly people often have multiple comorbidities and use antithrombotic agents,\(^ {21}\) are at higher risk of falls,\(^ {31}\) and have a reduced capacity to recover their neurological functions.\(^ {1}\)

Pupil reactivity was found to be a strong predictor of unfavorable functional outcomes in this study. In patients with bilateral unreactive pupils, both the mortality rate and favorable outcomes were 30.8%. In unilateral unreactive pupils, the mortality rate and favorable outcomes were 11.1% and 55.6%, respectively. Pupil reactivity is one of the most widely accepted independent risk factors for predicting patient outcomes, particularly bilateral fixed dilated pupils with the worst outcome.\(^ {5,12}\) The bilateral fixed dilated pupils in patients with severe TBI are suggestive of significant brainstem herniation. Scotter et al.\(^ {30}\) reported a systematic review and meta-analysis of surgically treated epidural or subdural hematoma in patients with bilateral fixed dilated pupils. Compared with subdural hematoma, the mortality rate was 29.7% versus 66.4%, and favorable outcome (scores of 4–5 on the GOSE) was 54.3% versus 6.6%. Sakas et al.\(^ {29}\) reported that the majority of patients who underwent surgery within 3 h of bilateral loss of pupillary reactivity survived; however, there were no survivors who underwent surgery within ≥6 hours. Therefore, a more favorable outcome can be achieved if surgery is appropriately performed, even in cases of bilateral unreactive pupils.

Initial GCS scores have been reported to be a good predictor of outcomes in patients with EDH.\(^ {3,19,28}\) In this study, the initial GCS scores in the unfavorable outcome group were significantly lower than those in the favorable outcome group. The overall mortality rate in this study was 13.9%, compared with 35.3% (6 of 17 patients) for patients with an initial GCS score of 3 or 4.

### TABLE 2. Univariate and multivariate analyses of factors for unfavorable outcomes

| Variables                      | Univariate analysis | Multivariate analysis |
|--------------------------------|---------------------|----------------------|
|                                | OR (95% CI)         | p-value              | Adjusted OR (95% CI) | p-value            |
| Age                            | 1.04 (1.01–1.08)    | 0.010*               | 1.06 (1.01–1.11)     | 0.011*             |
| Initial GCS score              | 0.59 (0.44–0.80)    | 0.001*               | 0.70 (0.47–1.03)     | 0.079              |
| Initial pupil reactivity       |                     |                      |                      |                    |
| Reactive                       | 1 (reference)       |                      | 1 (reference)        |                    |
| Unilateral unreactive          | 5.63 (1.23–25.76)   | 0.026*               | 4.74 (0.63–35.85)    | 0.132              |
| Bilateral unreactive           | 10.13 (3.27–31.39)  | <0.001*              | 10.92 (2.33–51.22)   | 0.002*             |
| Interval from admission to CT (minutes) | 1.018 (1.00–1.04) | 0.126                | -                    | -                  |
| Rotterdam CT score             | 1.67 (1.12–2.49)    | 0.012*               | 0.92 (0.50–1.67)     | 0.776              |
| Types of surgery               |                     |                      |                      |                    |
| Cranietomy                     | 1 (reference)       |                      | 1 (reference)        |                    |
| Craniotomy                     | 2.77 (1.09–7.03)    | 0.032*               | 2.00 (0.60–6.71)     | 0.261              |
| EDH volume                     | 1.01 (1.00–1.02)    | 0.007*               | 1.01 (1.00–1.03)     | 0.110              |

OR: odds ratio, CI: confidence interval, GCS: Glasgow Coma Scale, CT: computed tomography, EDH: epidural hematoma.

*\(p<0.05\), statistically significant difference.
EDH volume on CT was significantly larger in the unfavorable outcome group and correlated with the outcome in the univariate analysis. EDH volume has been reported to be associated with mortality and functional outcome.\textsuperscript{19,22,26,28,32} A large hematoma causes brain herniation within 3–24 hours after head trauma, which induces persistent suppression of the cerebral blood supply and venous drainage, resulting in massive cerebral infarction and brain edema.\textsuperscript{32}

In this study, the Rotterdam CT scores were significantly higher in the unfavorable outcome group. The Rotterdam CT score,\textsuperscript{24} a composition of a score of 1–6 that is attained by adding 1 to the sum of the status of basal cisterns, midline shift, epidural mass lesion, and traumatic subarachnoid or intraventricular blood scores, is known as a prognosticator in patients with severe TBI undergoing surgery.\textsuperscript{6,14} Previous studies on patients with EDH have reported that basal cistern compression, midline shift, and concomitant brain injuries are associated with mortality and functional outcomes.\textsuperscript{10,16,19,22,26}

The interval from admission to surgery and interval from brain CT to surgery were not different between the unfavorable and favorable outcome groups in this study. However, the interval from admission to CT was significantly longer in the unfavorable outcome group ($p=0.023$). Although previous studies have suggested that the interval from trauma to surgery is a significant factor related to mortality, the interval from trauma to surgery was not included as a variable in this study because there were cases in which trauma onset was unknown. Delayed diagnosis and treatment of EDH are related to increased mortality and worse functional outcomes; therefore, early surgical decompression can markedly reduce the risk of morbidity and mortality, particularly in patients with accompanying brain herniation.\textsuperscript{3,27,29}

This study has several limitations. First, we could not ascertain the number and characteristics of the patients not enrolled in the KNTDBS database. Among conservatively treated patients, the reasons for not undergoing surgery were uncertain in some cases. Therefore, we cannot rule out the possibility of a selection bias in our data. Second, concomitance with other intracranial injuries cannot be identified because only one diagnosis can be recorded in the KNTDBS. Third, the clinical outcome may have been affected by extracranial traumatic injury; however, the presence or severity of extracranial injury cannot be confirmed.

**CONCLUSION**

Despite severe brain injury, more than half of the patients with EDH had favorable outcomes after surgical treatment in this study. Our findings suggest that a prompt diagnosis and aggressive surgical treatment should be considered in such cases.

**ACKNOWLEDGMENTS**

We are thankful to members of the KNTDB investigators: Jung Hwan Lee (Pusan National University Hospital), In Bok Chang (Hallym University Sacred Heart Hospital), Ki Seong Eom (Wonkwang University Hospital), Eun Sung Park (Wonkwang University Hospital), Jong Yeon Kim (Wonju Severance Christian Hospital), Min Kyun Na (Hanyang University Medical Center), Jeong Ho Lee (Daegu Fatima Hospital), Kwang Wook Jo (Bucheon St. Mary's Hospital), Han Seung Ryu (Chonnam National University Hospital), Kyung Hwan Kim

https://kjnt.org  https://doi.org/10.13004/kjnt.2022.18.e62
(Chungnam National University Hospital), Yu Deok Won (Hanyang University Guri Hospital), Min Su Kim (Ulsan University Hospital), Jin Gyu Choi (Yeuoido St. Mary's Hospital), Sae Min Kwon (Keimyung University Hospital), Jae Sang Oh (Soonchunhyang University Hospital), and Soon O Hong (Seoul Medical Center).

REFERENCES

1. Balasch I Bernat M, Balasch I Parisi S, Noé Sebastián E, Dueñas Moscardó L, Ferri Campos J, Lopez-Bueno L. Study of the recovery patterns of elderly subacute stroke patients in an interdisciplinary neurorehabilitation unit. J Stroke Cerebrovasc Dis 24:2213-2218, 2015
2. Bir SC, Maiti TK, Ambekar S, Nanda A. Incidence, hospital costs and in-hospital mortality rates of epidural hematoma in the United States. Clin Neurol Neurosurg 138:99-103, 2015
3. Bricolo AP, Pasut LM. Extradural hematoma: toward zero mortality. A prospective study. Neurosurgery 14:8-12, 1984
4. Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, et al. Surgical management of acute epidural hematomas. Neurosurgery 58 Suppl:S7-S15, 2006
5. Chamoun RB, Robertson CS, Gopinath SP. Outcome in patients with blunt head trauma and a Glasgow Coma Scale score of 3 at presentation. J Neurosurg 111:683-687, 2009
6. Cheung PS, Lam JM, Yeung JH, Graham CA, Rainer TH. Outcome of traumatic extradural haematoma in Hong Kong. Injury 38:76-80, 2007
7. Cooper DJ, Rosenfeld JV, Murray L, Arabi YM, Davies AR, D’Urso P, et al. Decompressive craniectomy in diffuse traumatic brain injury. N Engl J Med 364:1493-1502, 2011
8. Gutowski P, Meier U, Rohde V, Lemcke J, von der Brelie C. Clinical outcome of epidural hematoma treated surgically in the era of modern resuscitation and trauma care. World Neurosurg 118:e166-e174, 2018
9. Heinzelmann M, Platz A, Imhof HG. Outcome after acute extradural haematoma, influence of additional injuries and neurological complications in the ICU. Injury 27:345-349, 1996
10. Hoffmann M, Lefering R, Rueger JM, Kolb JP, Izbicki JR, Ruecker AH, et al. Pupil evaluation in addition to Glasgow Coma Scale components in prediction of traumatic brain injury and mortality. Br J Surg 99 Suppl 1:122-130, 2012
11. Hu TT, Yan L, Yan PF, Wang X, Yue GF. Assessment of the ABC/2 method of epidural hematoma volume measurement as compared to computer-assisted planimetric analysis. Biol Res Nurs 18:5-11, 2016
12. Huang YH, Deng YH, Lee TC, Chen WF. Rotterdam computed tomography score as a prognosticator in head-injured patients undergoing decompressive craniectomy. Neurosurgery 71:80-85, 2012
13. Hutchinson PJ, Koliás AG, Timofeev IS, Corteén EA, Czosnyka M, Timothy J, et al. Trial of decompressive craniectomy for traumatic intracranial hypertension. N Engl J Med 375:1119-1130, 2016
14. Jamjoom A. The influence of concomitant intradural pathology on the presentation and outcome of patients with acute traumatic extradural haematoma. Acta Neurochir (Wien) 115:86-89, 1992

https://kjnt.org
https://doi.org/10.13004/kjnt.2022.18.e62
17. Jennett B, Snoek J, Bond MR, Brooks N. Disability after severe head injury: observations on the use of the Glasgow Outcome Scale. J Neurol Neurosurg Psychiatry 44:285-293, 1981

18. Jeong YH, Oh JW, Cho S; Korean Trauma Data Bank System Committee. Korean Trauma Data Bank System C. Clinical outcome of acute epidural hematoma in Korea: preliminary report of 285 cases registered in the Korean Trauma Data Bank System. Korean J Neurotrauma 12:47-54, 2016

19. Lee EJ, Hung YC, Wang LC, Chung KC, Chen HH. Factors influencing the functional outcome of patients with acute epidural hematomas: analysis of 200 patients undergoing surgery. J Trauma 45:946-952, 1998

20. Leitgeb J, Erb K, Mauritz W, Janciaik I, Wilbacher I, Rusnak M, et al. Severe traumatic brain injury in Austria V: CT findings and surgical management. Wien Klin Wochenschr 119:56-63, 2007

21. Lima MG, Barros MB, César CL, Goldbaum M, Carandina L, Ciconelli RM. Health related quality of life among the elderly: a population-based study using SF-36 survey. Cad Saude Publica 25:2159-2167, 2009

22. Lobato RD, Rivas JJ, Cordobes F, Alted E, Perez C, Sarabia R, et al. Acute epidural hematoma: an analysis of factors influencing the outcome of patients undergoing surgery in coma. J Neurosurg 68:48-57, 1988

23. Lu J, Gary KW, Neimeier JP, Ward J, Lapane KL. Randomized controlled trials in adult traumatic brain injury. Brain Inj 26:1523-1548, 2012

24. Maas AI, Hukkelhoven CW, Marshall LF, Steyerberg EW. Prediction of outcome in traumatic brain injury with computed tomographic characteristics: a comparison between the computed tomographic classification and combinations of computed tomographic predictors. Neurosurgery 57:1173-1182, 2005

25. Paci GM, Sise MJ, Sack DI, Shackford SR, Kureshi SA, et al. Preemptive craniectomy with craniotomy: what role in the management of severe traumatic brain injury? J Trauma 67:531-536, 2009

26. Rivas JJ, Lobato RD, Sarabia R, Cordobés F, Cabrera A, Gomez P. Extradural hematoma: analysis of factors influencing the courses of 161 patients. Neurosurgery 23:44-51, 1988

27. Rosyidi RM, Priyanto B, Al Fauzi A, Sutiono AB. Toward zero mortality in acute epidural hematoma: a review in 268 cases problems and challenges in the developing country. Interdiscip Neurosurg 17:12-18, 2019

28. Ruff LM, Mendelow AD, Lecky FE. Improving mortality after extradural haematoma in England and Wales. Br J Neurosurg 27:19-23, 2013

29. Sakas DE, Bullock MR, Teasdale GM. One-year outcome following craniotomy for traumatic hematoma in patients with fixed dilated pupils. J Neurosurg 82:961-965, 1995

30. Scooter J, Hendrickson S, Marcus HJ, Wilson MH. Prognosis of patients with bilateral fixed dilated pupils secondary to traumatic extradural or subdural haematoma who undergo surgery: a systematic review and meta-analysis. Emerg Med J 32:654-659, 2015

31. Sierra F, Hadley E, Suzman R, Hodes R. Prospects for life span extension. Annu Rev Med 60:457-469, 2009

32. Wang WH, Hu LS, Lin H, Li J, Luo F, Huang W, et al. Risk factors for post-traumatic massive cerebral infarction secondary to space-occupying epidural hematoma. J Neurotrauma 31:1444-1450, 2014