

Endoscope-assisted Manipulation of Chronic Subdural Hematomas Provides a Novel Solution for Eliminating the Septum and Inner Membrane Leading to Reduced Recurrence

KUN-TING HONG^{1,2,3}, SHIH-WEI HSU^{1,4}, CHAO-HSUAN CHEN^{1,5}, DUENG-YUAN HUENG², YUAN-HAO CHEN², DA-TONG JU², DA-TIAN BAU^{1,6} and CHI-TUN TANG²

¹Graduate Institute of Biomedical Sciences, China Medical University, Taichung, Taiwan, R.O.C.;

²Department of Neurological Surgery, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan, R.O.C.;

³Department of Neurological Surgery, Tri-Service General Hospital Penghu Branch, Magong, Taiwan, R.O.C.;

⁴Taichung Armed Forces General Hospital, Taichung, Taiwan, R.O.C.;

⁵Department of Neurosurgery, China Medical University Hospital, Taichung, Taiwan, R.O.C.;

⁶Department of Bioinformatics and Medical Engineering, Asia University, Taichung, Taiwan, R.O.C.

Abstract. *Background/Aim:* Canonical burr-hole craniostomy (BHC) with drainage is the primary treatment for chronic subdural hematomas. However, complicated situations such as organized clots or compartmentation may result in recurrent chronic subdural hematoma (CSDH). Herein, we introduce a novel technique by applying an endoscope for tearing the inner membrane and septum, in addition to evacuating the hematoma in the subdural space where in-line visualization is not possible. *Patients and Methods:* Two hundred and twenty-nine cases of CSDH were enrolled in this study. Of these, 13 patients were treated endoscopically. The 0-degree and 30-degree, 2.7 mm endoscope was applied after a BHC. The arachnoid knife for microsurgery was used to tear the inner

membrane to open the compartments. *Results:* Non-endoscope-assisted operated (non-Endo group) and endoscope-assisted membranectomy patients (Endo group) demonstrated no differences in sex, age, body mass index, trauma, other diseases, or use of anticoagulation agents. Although the surgery time spent for the Endo patients was longer (128.53±49.56 min) than that for the non-Endo group (65.18±32.89 min), no recurrence was found among the Endo group, whereas a higher rate was observed in the non-Endo group. *Conclusion:* Novel endoscope-assisted membranectomy is a powerful technique capable of reducing recurrence and improving surgical outcomes.

Correspondence to: Chi-Tun Tang, MD, 4F, No. 325, 2nd Sec., Cheng-Kung Road, Neihsu District, Taipei City, Taiwan, R.O.C. Tel: +886 287927177, Fax: +886 287927178, e-mail: omeprazon8@hotmail.com; Da-Tian Bau, Ph.D., Terry Fox Cancer Research Laboratory, Department of Medical Research, China Medical University Hospital, 2 Yuh-Der Road, Taichung, 404 Taiwan, R.O.C. Tel: +886 422053366 ext. 5805, e-mail: artbau2@gmail.com

Key Words: Burr hole craniostomy with drainage, chronic subdural hematoma, endoscope-assisted membranectomy, body mass index, endoscopic transsphenoidal approach.



This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY-NC-ND) 4.0 international license (<https://creativecommons.org/licenses/by-nc-nd/4.0/>).

Subdural hematomas are classified into acute, subacute, and chronic according to the total duration of symptoms (1), with chronic subdural hematomas (CSDH) being the most prevalent type and symptomatically mimicking other disease entities. Globally, the incidence of CSDH is approximately 13.5 per 100,000 persons less than 65-years-old per year; 58 per 100,000 persons of the population 65 years old or older. More importantly, it is approximately five times higher among patients with CSDHs older than 65 years than CSDH patients of less than 65 years (2, 3). In Asia, CSDH is typically caused by minor head trauma (approximately 50%) and occurs predominantly in males around the age of 65 years (4). Two common mechanisms have been proposed in which blood or fluids accumulate within the dura cell layers or at the borders between the dura layers. The most typical mechanism involves a head trauma, which causes tearing of bridging veins within the involved subdural space (5).

Another theory suggests that microbleeds are produced between the dura mater and arachnoid membrane, forming neo-membranes 3-4 weeks after a brain insult. The inner membrane is thin and avascular, whereas the outer membrane is thick and rich in fragile blood vessels (neo-membrane) and can be two- or three-layered after repeated episodes of trivial trauma (6). The most complicated situation leading to postsurgical recurrence after burr-hole craniostomy with drainage, abbreviated as (BHC)-D, is the separation or compartmentalization of SDH spaces at different time periods. Symptomatic CSDH frequently requires urgent neurosurgical management. There are several treatment strategies for CSDH, such as twist drill craniostomy, traditional craniotomy, and BHC-D (4). Among these, BHC-D has been the mainstream neurosurgical treatment for CSDH. Symptomatic recurrence has been noted in 2.5% to 33% of post-operative patients and warrants re-exploration or more aggressive craniotomy, which neurosurgeons usually attempt to avoid (2, 7). Radiologically, the double-crescent sign on computed tomography (CT) or magnetic resonance imaging (MRI), namely compartmentation, is a predictor of recurrent CSDH, implying non-liquefaction of CSDH (8). Clinically, it is difficult for neurosurgeons to clean up the arachnoid septum composed of trabecular adhesions and the inner membrane perfectly with simple maneuvers, such as with twist drill craniostomy or BHC-D. Therefore, it is of great value to exploit a novel solution for eliminating the septum and inner membrane to prevent ominous recurrence of CSDH. We believe that endoscope-assisted membranectomy maneuver is more appropriate than BHC-D considering the compartmental restrains of the re-expansion of the compressed brain substance, as other novel techniques such as catheterization and tearing of the inner membrane could eliminate recurrence of CSDH (9).

Patients and Methods

Collection of patients with CSDH. A total of 229 patients with CSDH receiving neurosurgical treatment were recruited from the National Defense Medical Center from July 2016 to June 2020. Among them, forty-eight were bilateral CSDH cases (21.0%), one hundred and three were unilateral left CSDH cases (44.9%), and seventy-eight were unilateral right CSDH cases (34.1%). All procedures were conducted after approval and under the supervision of the Institutional Review Board (IRB) of National Defense Medical Center (IRB number: B202105050).

Non-endoscope-assisted surgery for CSDH. Two hundred and sixteen cases of CSDHs were treated with standardized steps of BHC-D without endoscopic assistance but with surgical loupes or naked eyes. In detail, they were irrigated with warm normal saline or ringer lactate solution into the BHC to decrease osmotic pressure, then placed and closed with a drainage system followed by suction clearance of the residual blood for three-five days. These cases were

Table I. Basic characteristics of 216 non-endoscope-assisted operated patients and 13 endoscope-assisted operated patients.

Characteristics	Non-Endo cases	Endo cases	p-Value
Age	71.06±15.78	71.23±9.89	0.6884
Sex			0.1080
Female	54 (25.0%)	6 (46.2%)	
Male	162 (75.0%)	7 (53.8%)	
Body mass index	23.58±3.58	24.46±3.10	0.2596
Trauma			0.9820
No	117 (54.2%)	7 (53.8%)	
Yes	99 (45.8%)	6 (46.2%)	
Hypertension			0.5386
No	114 (52.8%)	8 (61.5%)	
Yes	102 (47.2%)	5 (38.5%)	
Diabetes mellitus			1.0000
No	171 (79.2%)	11 (84.6%)	
Yes	45 (20.8%)	2 (15.4%)	
Hemodialysis			1.0000
No	193 (89.4%)	12 (92.3%)	
Yes	23 (10.6%)	1 (7.7%)	
Cardiovascular disease			0.4747
No	177 (81.9%)	12 (92.3%)	
Yes	39 (18.1%)	1 (7.7%)	
Cerebrovascular disease			0.4820
No	206 (95.4%)	12 (92.3%)	
Yes	10 (4.6%)	1 (7.7%)	
Anticoagulation agent			0.3549
No	147 (68.1%)	11 (84.6%)	
Yes	69 (31.9%)	2 (15.4%)	

Non-Endo: Non-endoscope-assisted operated patients; Endo: endoscope-assisted operated patients; statistical analyses were based on chi-square tests.

defined as the non-endoscope-assisted group for CSDH treatment (non-Endo group).

Endoscope-assisted membranectomy for CSDH. Patients with organized clots and compartmentation seen on preoperative CT scans were assigned for endoscope-assisted membranectomy (Endo group). This method was modified from that used by Masopust *et al.* (10). Thirteen patients were enrolled with informed consent signed by themselves or their family. In this group, we specifically made the personalized burr-hole with an average diameter of 3.5 cm (named as the BHC), at the morphological center of the hematoma island under brain computed tomography. A rigid endoscope (0-degree and 30-degree, 2.7 mm) was used to “circum-illuminate” the residual organized hematoma and performed tearing and splitting of the inner membrane with an arachnoid knife used in microsurgery. Bayonet-shaped microsuctions of 5 and 7 French were reciprocally used to clean the residual clot. Patients were followed-up for six months until July 2021.

Statistical methodology. The Student’s paired *t*-test was used to compare the distributions of demographic parameters between the non-Endo and Endo groups. Pearson’s Chi-square methodology was used to check the distribution pattern of the other indexes. A *p*-value of less than 0.05 was considered statistically significant. Analyses

were conducted by SPSS software package (IBM SPSS Statistics for Windows, Version 20.0. IBM Corp., Armonk, NY, USA).

Results

Comparison of basic demographic characteristics. The basic characteristics of the 216 non-Endo and 13 Endo patients are summarized and compared in Table I. There were no significant differences (all $p>0.05$) between the groups regarding age, sex, body mass index, and hypertension. With regard to comorbid chronic disease status, including diabetes mellitus, hemodialysis, and cardiovascular and cerebrovascular diseases, there were no significant differences (all $p>0.05$). Theoretically, anticoagulant and anti-platelet drugs may increase the risk of CSDH after trivial trauma (11, 12). However, according to our analysis, patients taking anticoagulants did not show a significant propensity to develop future CSDH ($p>0.05$).

Comparison of surgical characteristics. The surgical characteristics of 216 non-Endo and 13 Endo patients are summarized and compared in Table II. First, regarding the laterality of the lesion, there was no differential distribution between the two groups ($p>0.05$). Intracranial pressures (ICP) were recorded in 34.7% of the non-Endo and 30.8% of the Endo patients, and the ICP monitoring showed no significant difference between groups ($p>0.05$). The surgical time for the Endo group was about two-fold significantly longer (128.54±49.56 min) than that of the non-Endo group (65.18±32.89 min) ($p<0.0001$). The instrumentation and endoscopic video system settings may be responsible for the time- and effort-consuming preparation for delicate manipulation and postponed the surgical time. Interestingly, the recurrence rate in the non-Endo group patients was 6.5%, whereas the Endo group had no recurrence at follow-up (Table II).

Surgical images were obtained with the assistance of an endoscope. Typical and real-time images acquired using the endoscope are shown in Figure 1. During the endoscopic procedures, a burr hole was made specifically at the morphological center of the hematoma island (Figure 1A). Technically, the temporal base can usually be observed using an endoscope-assisted technique and cannot be visualized using the canonical BHC-D approach. Furthermore, cortical vessels can be vividly observed during the BHC procedure (Figure 1B). As shown in Figure 1C, the septum can be manipulated with an instrument tracking the margins, so that any abnormally organized adhesive separation can be opened up with an arachnoid knife or a bipolar coagulator (Figure 1C). The avascular inner membrane can also be visualized with the assistance of an endoscope, which serves as the main barrier limiting re-expansion of the brain (9) (Figure 1D).

Table II. Basic characteristics of 216 non-endoscope-assisted operated patients and 13 endoscope-assisted operated patients.

Characteristics	Non-Endo cases	Endo cases	p-Value
Lesion site			0.1473
Bilateral	48 (22.2%)	0 (0.0%)	
Left	96 (44.4%)	7 (53.8%)	
Right	72 (33.3%)	6 (46.2%)	
Intracranial pressure			1.0000
No	141 (65.3%)	9 (69.2%)	
Yes	75 (34.7%)	4 (30.8%)	
Surgery time	65.18±32.89	128.54±49.56	<0.0001*
Recurrence			ND
No	202 (93.5%)	13 (100.0%)	
Yes	14 (6.5%)	0 (0.0%)	

Non-Endo: Non-endoscope-assisted operated patients; Endo: endoscope-assisted operated patients; statistical analyses were based on chi-square tests; ND: not detectable. *Statistically significant.

Discussion

For neurosurgeons, unsuccessful treatment usually results in surgical recurrence after CSDH operations (13, 14). The well-known pathophysiology of CSDH indicates that increased osmotic pressure due to fibrinolysis of CSDH leads to hematoma expansion (15). According to the pathophysiology of CSDH, the arachnoid septum or accumulated layered fluid are important factors leading to recurrence. Therefore, the inner membrane and compartment have been the focus of modern surgical treatments for CSDH (16).

Based on the pathophysiology of CSDH formation, outer membrane breakage is not sufficient to avoid CSDH recurrence. However, eliminating the osmotic gradient is the most important factor. Currently, the endoscopic technique prevails over the endoscopic transsphenoidal approach (TSA), and optical technology has enhanced the complete removal of the inner membrane, eliminating the osmotic elevation that leads to recurrence of CSDH. In the current study, in the results of the Endo population, cases of bilateral lesions are lacking (Table II); this may confound or underestimate the recurrence rate. The data indicated that bilateral CSDHs are frequently prone to recurrence, owing to the osmotic imbalance (Table II). Based on our experience, bilateral CSDHs may experience a pressure shift during side-by-side BHC-D. Therefore, we now utilize simultaneous open-up of the outer membranes of bilateral BHC-D, although pneumocephalus remains an issue during post-operative care. We attempted to use one-sided endoscope-assisted membranectomy to pass through the falx cerebri, but in vain, contralateral endoscope-assisted membranectomy was not possible. Hence, we recommend endoscope-assisted membranectomy for one-sided CSDH complicated by septations or compartments. According to the literature, patients on hemodialysis may carry an increased risk

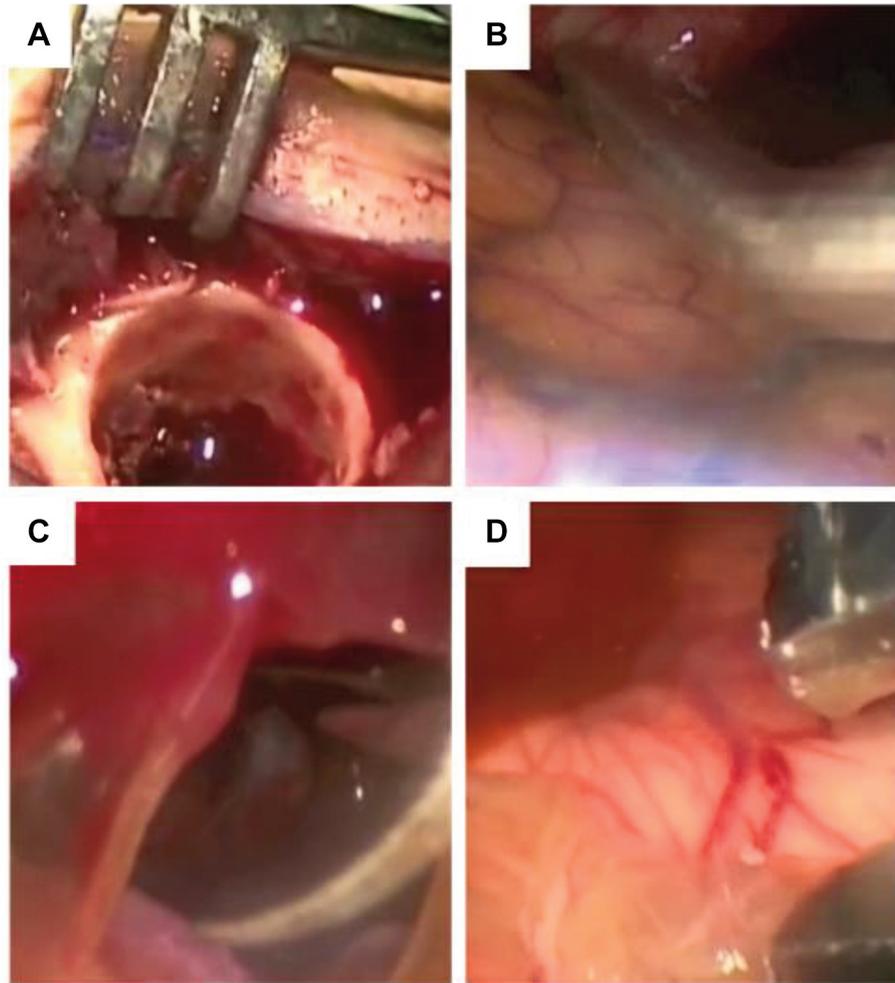


Figure 1. Surgical pictures obtained with the assistance of the endoscope. (A) Typically, an average 3.5 cm burr hole was made specifically at the morphological center of the hematoma island. The figure shows the real image obtained using the rigid endoscope (4 mm, 0 degree). (B) Specifically, the temporal base can only be observed clearly via the endoscope-assisted technique. (C) The abnormally organized septum can be cleared only with the endoscope-assisted technique. (D) Only with the assistant of the endoscope, the inner membrane can be nicely eliminated.

of recurrence for CSDH, since the intracranial pressure tends not to be as flexible as that in healthy people according to the Monro-Kellie doctrine (17), whereas our patients on hemodialysis in the Endo group did not show higher recurrence than non-Endo patients (Table I). In addition, it is an unexplainable observation that patients with left-sided CSDH visited our hospital more frequently than patients with right-sided CSDH (Table I). Patients with left-sided CSDH often presented with Wernicke aphasia and were easily identified and sent to hospital. The left site predominance is consistent with previous reports and remains unexplainable and unexplained (18, 19). One explanation for this may be that the aphasic symptom is more frequently observed by the family than the non-specific presentation of the right-side non-dominant hemisphere. Lastly, taking anticoagulants, such as warfarin or a non-vitamin K antagonist oral anticoagulant (NOAC), may

contribute to coagulopathy, leading to chronic inflammation and microbleeding. There is still no solid evidence of the association between anticoagulant agents and CSDH recurrence (20). Neurosurgery for CSDH is relatively emergent, thus it is the best strategy to cut the diagnose-to-treatment time as short as possible (21, 22). Interesting, in the present study, although it seemed to take twice as long to finish the surgery for the Endo group than that of the non-Endo group, the outcome of the Endo group was significantly better than that of the non-Endo group (Table II). The critical point is that the amount of bleeding did not differ between groups. Additionally, surgical complications, such as post-operative acute subdural hematoma and other types of iatrogenic brain damage, did not occur in either group during the patients' hospital stay. Therefore, we believe that the endoscope-assisted membranectomy maneuver for CSDH provides better

outcomes in preventing surgical recurrence, although it may be more time-consuming. Under the National Health Insurance (NHI) system of Taiwan, CSDH patients should be encouraged to undergo endoscope-assisted membranectomy to reduce the risk for recurrence, which also reduces medical expenses. In the current study, we propose an improved method rather than the typical BHC-D method by adopting variable-angled endoscopes to lower the recurrence rate. The preliminary results in Table II show that 13 Endo patients of CSDH were recurrence-free for at least 4 years (Table II). The age and sex ratios are in accordance with the literature published in Asia and other countries (4). However, one limitation is the sample size of the Endo group, and thus studies with higher numbers of patients are urgently required.

Conclusion

Evidence from 229 cases, including Endo and non-Endo patients, suggests the novel incorporation of the endoscopic technique into canonical CSDH to enhance the capacity of separating the septum and inner membrane more efficiently. Emerging endoscope-assisted manipulation is worth validating for its clinical value in modern neurosurgical practices.

Conflicts of Interest

All the Authors declare no conflicts of interest regarding this study.

Authors' Contributions

Conceptualization: Hong KT, Tang CT; Data curation: Hong KT, Hsu SW, Chen CH; formal analysis: Hong KT, Hsu SW, Chen CH; Investigation: Hsu SW; Methodology: Chen CH; Project administration: Hueng DY; Resources: Hueng DY, Chen YH, Ju DT, Tang CT; Supervision: Hueng DY, Chen YH, Ju DT, Tang CT; Validation: Tang CT; Writing the original draft: Hong KT, Tang CT, Bau DT; Review and editing: Hong KT, Tang CT, Bau DT.

Acknowledgements

The Authors thank all patients who participated in the study and the experts who provided their expertise and comments. The help of nurses and colleagues is highly appreciated by all Authors.

References

- Alves JL, Santiago JG, Costa G and Mota Pinto A: A standardized classification for subdural hematomas- I. *Am J Forensic Med Pathol* 37(3): 174-178, 2016. PMID: 27428027. DOI: 10.1097/PAF.0000000000000255
- Almenawer SA, Farrokhyar F, Hong C, Alhazzani W, Manoranjan B, Yarascavitch B, Arjmand P, Baronia B, Reddy K, Murty N and Singh S: Chronic subdural hematoma management: a systematic review and meta-analysis of 34,829 patients. *Ann Surg* 259(3): 449-457, 2014. PMID: 24096761. DOI: 10.1097/SLA.0000000000000255
- Kudo H, Kuwamura K, Izawa I, Sawa H and Tamaki N: Chronic subdural hematoma in elderly people: present status on Awaji Island and epidemiological prospect. *Neurol Med Chir (Tokyo)* 32(4): 207-209, 1992. PMID: 1378564. DOI: 10.2176/nmc.32.207
- Guo S, Gao W, Cheng W, Liang C and Wu A: Endoscope-assisted surgery vs. Burr-Hole craniostomy for the treatment of chronic subdural hematoma: a systemic review and meta-analysis. *Front Neurol* 11: 540911, 2020. PMID: 33250840. DOI: 10.3389/fneur.2020.540911
- Yamashima T and Friede RL: Why do bridging veins rupture into the virtual subdural space? *J Neurol Neurosurg Psychiatry* 47(2): 121-127, 1984. PMID: 6707651. DOI: 10.1136/jnnp.47.2.121
- Mehta V, Harward SC, Sankey EW, Nayar G and Codd PJ: Evidence based diagnosis and management of chronic subdural hematoma: A review of the literature. *J Clin Neurosci* 50: 7-15, 2018. PMID: 29428263. DOI: 10.1016/j.jocn.2018.01.050
- Ivamoto HS, Lemos HP Jr and Atallah AN: Surgical treatments for chronic subdural hematomas: a comprehensive systematic review. *World Neurosurg* 86: 399-418, 2016. PMID: 26485412. DOI: 10.1016/j.wneu.2015.10.025
- Miki K, Abe H, Morishita T, Hayashi S, Yagi K, Arima H and Inoue T: Double-crescent sign as a predictor of chronic subdural hematoma recurrence following burr-hole surgery. *J Neurosurg* 131(6): 1905-1911, 2019. PMID: 30611142. DOI: 10.3171/2018.8.JNS18805
- Kayaci S, Kanat A, Koksal V and Ozdemir B: Effect of inner membrane tearing in the treatment of adult chronic subdural hematoma: a comparative study. *Neurol Med Chir (Tokyo)* 54(5): 363-373, 2014. PMID: 24477064. DOI: 10.2176/nmc.0a.2013-0147
- Masopust V, Netuka D and Häckel M: Chronic subdural haematoma treatment with a rigid endoscope. *Minim Invasive Neurosurg* 46(6): 374-379, 2003. PMID: 14968410. DOI: 10.1055/s-2003-812507
- Bartek J Jr, Sjävik K, Kristiansson H, Ståhl F, Fornebo I, Förander P and Jakola AS: Predictors of recurrence and complications after chronic subdural hematoma surgery: a population-based study. *World Neurosurg* 106: 609-614, 2017. PMID: 28735129. DOI: 10.1016/j.wneu.2017.07.044
- Motiei-Langroudi R, Stippler M, Shi S, Adeeb N, Gupta R, Griessenauer CJ, Papavassiliou E, Kasper EM, Arle J, Alterman RL, Ogilvy CS and Thomas AJ: Factors predicting reoperation of chronic subdural hematoma following primary surgical evacuation. *J Neurosurg* 129(5): 1143-1150, 2018. PMID: 29243977. DOI: 10.3171/2017.6.JNS17130
- Chen FM, Wang K, Xu KL, Wang L, Zhan TX, Cheng F, Wang H, Chen ZB, Gao L and Yang XF: Predictors of acute intracranial hemorrhage and recurrence of chronic subdural hematoma following burr hole drainage. *BMC Neurol* 20(1): 92, 2020. PMID: 32169039. DOI: 10.1186/s12883-020-01669-5
- Liu LX, Cao XD, Ren YM, Zhou LX and Yang CH: Risk factors for recurrence of chronic subdural hematoma: a single center experience. *World Neurosurg* 132: e506-e513, 2019. PMID: 31450003. DOI: 10.1016/j.wneu.2019.08.089
- Holl DC, Volovici V, Dirven CMF, Peul WC, van Kooten F, Jellema K, van der Gaag NA, Miah IP, Kho KH, den Hertog HM, Lingsma HF, Dammers R and Dutch Chronic Subdural Hematoma Research Group (DSHR): Pathophysiology and

- nonsurgical treatment of chronic subdural hematoma: from past to present to future. *World Neurosurg* 116: 402-411.e2, 2018. PMID: 29772364. DOI: 10.1016/j.wneu.2018.05.037
- 16 Ducruet AF, Grobelny BT, Zacharia BE, Hickman ZL, DeRosa PL, Andersen KN, Sussman E, Carpenter A and Connolly ES Jr: The surgical management of chronic subdural hematoma. *Neurosurg Rev* 35(2): 155-69; discussion 169, 2012. PMID: 21909694. DOI: 10.1007/s10143-011-0349-y
- 17 Atsumi H, Sorimachi T, Honda Y, Sunaga A and Matsumae M: Effects of pre-existing comorbidities on outcomes in patients with chronic subdural hematoma. *World Neurosurg* 122: e924-e932, 2019. PMID: 30408607. DOI: 10.1016/j.wneu.2018.10.176
- 18 Hammer A, Tregubow A, Kerry G, Schrey M, Hammer C and Steiner HH: Predictors for recurrence of chronic subdural hematoma. *Turk Neurosurg* 27(5): 756-762, 2017. PMID: 27593834. DOI: 10.5137/1019-5149.JTN.17347-16.1
- 19 Rahimi AR and Poorkay M: Subdural hematomas and isolated transient aphasia. *J Am Med Dir Assoc* 1(3): 129-131, 2000. PMID: 12818026.
- 20 Aspegren OP, Åstrand R, Lundgren MI and Romner B: Anticoagulation therapy a risk factor for the development of chronic subdural hematoma. *Clin Neurol Neurosurg* 115(7): 981-984, 2013. PMID: 23128014. DOI: 10.1016/j.clineuro.2012.10.008
- 21 Krieg SM, Aldinger F, Stoffel M, Meyer B and Kreutzer J: Minimally invasive decompression of chronic subdural haematomas using hollow screws: efficacy and safety in a consecutive series of 320 cases. *Acta Neurochir (Wien)* 154(4): 699-705; discussion 705, 2012. PMID: 22370998. DOI: 10.1007/s00701-012-1294-4
- 22 Lee GS, Park YS, Min KS and Lee MS: Spontaneous resolution of a large chronic subdural hematoma which required surgical decompression. *J Korean Neurosurg Soc* 58(3): 301-303, 2015. PMID: 26539279. DOI: 10.3340/jkns.2015.58.3.301

Received September 16, 2022

Revised September 30, 2022

Accepted October 5, 2022