Comparison of surgical techniques for the treatment of chronic subdural hematomas: A single-center case series

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Abstract. Chronic subdural hematoma (CSDH) is one of the most challenging realities in the neurosurgical world. The aim of the present study was to compare different surgical techniques, such as burr hole evacuation with subperiosteal drain or subdural drain and mini-craniotomy, and to review the diverse outcomes on the post-operative clinical state of patients. The present study was a retrospective cohort study with 122 patients with CSDH treated at a single center. The patients were separated into three groups according to the surgical technique used as follows: group 1, two burr holes with the placement of a subperiosteal drain; group 2, single burr hole per hematoma with the placement of an intradural drain; and group 3, mini-craniotomy. The duration of hospitalization, hematoma recurrence, complications, Glasgow coma scale at discharge and mortality were reported as outcome measures. A total of 3 patients succumbed following hematoma evacuation; of these 2 patients were from group 2 and 1 patient was from group 3. The patients from groups 1 and 3 exhibited a significantly lower odds ratio (OR) of hematoma recurrence than patients in group 2 (OR, 0.76; P<0.01; and OR, 0.8; P<0.01, respectively). The patients in group 1 exhibited a significantly lower probability of having a depressed level of consciousness on discharge (OR, 0.249; P=0.031). Group 2 was associated with a statistically significant prolongation of hospitalization. On the whole, the present study demonstrates that multiple burr hole hematoma evacuation with subperiosteal drain placement and mild suction is a very promising technique with very beneficial post-operative outcomes, such as zero mortality, a low CSDH recurrence risk, a reduced period of hospitalization and an improved post-operative quality of life.

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Introduction

Chronic subdural hematoma (CSDH), first described in 1857 by R. Virchow, is the insidious accumulation of blood and blood products within the subdural space (1). It mainly affects the elderly, with an incidence of 58.1/100,000 individuals/year aged ≥65 years and 1.72-20.6/100,000 individuals/year in the general population (2). It is estimated that due to the aging population and the increasing use of anticoagulation agents, the incidence of CSDH will double by 2030 in the USA (2-4).

Asymptomatic patients are managed conservatively with pharmacological treatment, pressure control and anti-coagulation reversal (5). The gold standard of treatment for symptomatic CSDH is surgical evacuation; yet, guidelines do not mandate the use of a specific technique; therefore, the selection of the surgical technique relies on the expertise of the neurosurgeon (6). The three most popular approaches among neurosurgeons are twist-drill trepanation, burr hole trepanation and mini-craniotomy (7). A literature review revealed that burr hole trepanation and subsequent drain insertion are the most commonly used methods for the treatment of CSDH (5,8).

The recurrence of the subdural hematomas and the subsequent need for reoperation can vary depending on the surgical technique, with some authors mentioning rates as high as 38.7% (9). The literature indicates that the use of a surgical drain can significantly help minimize the risk of post-operative rebleeding, with some authors demonstrating a >2-fold reduction by placing a subperiosteal or subdural drain (10-12). The meta-analysis by Alcalá-Cerra *et al* demonstrated that the risk of poor functional outcomes was also lowered by inserting a subdural drain post-operatively, demonstrating improvement in short- and long-term neurological outcomes (13). Newer studies focus on the optimal drain type between

subdural and subperiosteal drains. The recent meta-analysis by Ding *et al* (12) compared the two types of post-operative drain placement and found no differences in mortality or post-operative outcomes. Additionally, they found a lower overall recurrence rate in patients in which a subperiosteal drain was used compared with those in which a subdural drain was used, and a lower incidence of parenchymal injuries (12).

Patients and methods

Setting and study population. The present study was a retrospective cohort of adult patients with chronic subdural hematoma conducted at the Nicosia General Hospital (Nicosia, Cyprus); the patients had been admitted between 2016 and 2021. A thorough search in the database of the hospital was carried out using the national ICD-10 coding system, focusing both on traumatic (S06.50) and non-traumatic (I62.0) causes of chronic subdural hematomas. A manual review of the medical records was performed to screen for patients who received surgical treatment. The retrieved database was extended from January 1, 2016 to 8 December, 2021. The total number of patients that were registered under the ICD-10-CY code was 472. From these patients, only the ones that fulfilled the criteria were included, which were the patients who received surgical treatment for the management of CSDH. CSDHs that were treated non-surgically were excluded from the study. The population selection process resulted in 122 patients in total, of whom 77 were from the non-traumatic subgroup. Patient files were accessed in an anonymous manner.

Study design. The present study was a retrospective study that collected data from 122 patients with SDH treated at a single center. Demographic data included age and sex. Clinical data included treatment with antiplatelet or anticoagulant agents at presentation, comorbidities, presenting manifestations, Glasgow coma scale (GCS) upon admission, and uni- or bilateral subdural hematoma collection. Data regarding the surgical procedure included craniotomies or burr holes with intradural or subperiosteal drains, duration of the procedure, and the type of anesthesia used (general anesthesia vs. local anesthesia with sedation). The duration of hospitalization, hematoma recurrence, complications, GCS at discharge, and mortality were reported as outcome measures.

The cases were grouped into three groups according to the surgical technique as follows: Group 1, two burr holes with the placement of a subperiosteal drain and, if present, membrane septal perforation; group 2, single burr hole per hematoma with the placement of an intradural drain; and group 3, mini-craniotomy. Presenting manifestations were classified on an ordinal scale as follows: 1, headache; 2, an altered level of consciousness; 3, focal neurological deficits; and 4, an altered level of consciousness combined with focal neurological deficits. Complications were classified on an ordinal scale as follows: 0, None; 1, pneumocephalus; 2, bleeding; and 3, infarction or hydrocephalus.

Standard protocol approvals, registrations and patient consents. The present study was approved by the Nicosia General Hospital Bioethics Committee (protocol no. NGH/02-03-2023) but informed consent was not required as the study was retrospective and the patients could not be identified in the text or the tables.

Statistical analysis. Mortality, recurrence, complications and GCS at discharge and the duration of hospitalization were considered dependent outcome variables. All five continuous dependent (GCS at discharge and the duration of hospitalization) and independent variables (age, GCS at admission, procedure duration) were tested for normality with the Shapiro-Wilk test, and their distribution was found to differ significantly from the normal distribution ($P<0.0001$). An exploratory correlation analysis of continuous variables was performed using Spearman's correlation coefficient. Binomial logistic regression was used to explore the effects of evacuation procedures and other factors (age, sex, presentation, comorbidities, anesthesia, GCS on admission, duration of procedure) on mortality, recurrence, the level of consciousness on discharge, and the emergence of complications (the latter coded as follows 0, no complications; or 1, any complication). Ordinal logistic regression analysis was used to explore the effects of evacuation procedures and other factors (age, sex, presentation, comorbidities, anesthesia, GCS on admission, duration of procedure) on the emergence of complications. A main effects general linear model analysis was performed to examine the effects of the hematoma evacuation method and other independent variables on the duration of the hospital stay. A value of $P<0.05$ for two-sided hypothesis tests was considered to indicate a statistically significant difference. All statistical calculations were performed using the SPSS version 29.0 statistical program for Microsoft Windows (IBM Corp.), licensed to the European University Cyprus.

Results

Duration of hospitalization in correlation with GCS score and patient age. The median duration of hospitalization was 8 days (IQR, 5.25). A weak, yet significant correlation was observed between GCS upon admission and the patient age and the duration of hospitalization, indicating that the lower the level of consciousness upon admission ($rs=-0.184$, $P<0.05$) or the younger the patient age ($rs=-0.204$, $P<0.05$), the more prolonged the hospital stay. A weak, yet significant correlation was also observed between GCS upon admission and GCS at discharge ($rs=0.220$, $P<0.05$).

GCS upon admission is an independent prognostic factor of the outcome. A total of 3 patients succumbed following hematoma evacuation; of these, 2 patients were treated with single burr hole evacuation with an intradural drain placement (group 2), and 1 patient was treated with craniotomy (group 3). A binary logistic regression analysis was performed to examine the effects of hematoma evacuation method, age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement, duration of procedure and GCS upon admission on mortality. All independent parameters, apart from GCS upon admission were tested; however, they were not found to improve model fit and were hence removed. Higher GCS scores upon admission exhibited a significantly lower odds ratio (OR) of mortality compared to lower GCS scores

Table I. Binary logistic regression model for mortality.

	B	SE	P-value	OR	95% CI for OR
Independent variable					
GCS on admission	-0.538	0.270	0.046	0.548	0.344 to 0.990
Constant	1.015	1.936	0.6	2.758	

Model Chi^2=6.371, d.f.=1, P<0.012; Hosmer and Lemeshow test: Chi^2=3.625, d.f.=7, P=0.822; Nagelkerle R^2=0.247. SE, standard error; OR, odds ratio; CI, confidence interval; B, regression coefficient; d.f., degrees of freedom.

(OR=0.548; P=0.046) (Table I). These results indicate that GCS is an independent parameter affecting the mortality rate.

SDH recurrence. A total of 19 patients exhibited a recurrence of subdural hematomas following evacuation. A binary logistic regression analysis was performed to examine the effects of hematoma evacuation method, age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement, duration of the procedure and GCS upon admission on SDH recurrence. All independent parameters, apart from the hematoma evacuation method were tested, but were not found to improve model fit and were hence removed. Patients in group 1 (multiple burr holes with a subperiosteal drain) and patients in group 3 (craniotomy) exhibited a significantly lower OR of exhibiting hematoma recurrence than those in group 2 (single burr hole per collection with a subdural drain) (OR=0.76; P<0.001; and OR=0.8; P=0.03, respectively) (Table II). This analysis revealed that craniotomy or hematoma evacuation with multiple burr holes with a subperiosteal drain are associated with a lower risk of hematoma recurrence than the single burr-hole per collection with subdural drain technique.

Complications. A total of 21 patients developed complications following hematoma evacuation. These included the development of pneumocephalus, bleeding, infarction, or hydrocephalus. Ordinal logistic regression was used to examine the effects of hematoma evacuation method, age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement, duration of the procedure, and GCS upon admission on the development of complications coded as follows: 0, no complications; 1, pneumocephalus; 2, bleeding, infarct, or hydrocephalus. No significant ordinal logistic regression model could be fit with hematoma evacuation methods or any other factor alone or in combination (age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement, duration of procedure and GCS) as independent variables. Complications were then dummy coded as follows: 0, no complication; or 1, any complication, and binary logistic regression analysis was performed to re-examine the effects of independent variables on the probability of developing any complication. Only a higher GCS score upon admission was found to be associated with a significantly decreased risk of developing any complication (OR= 0.825; P=0.014). Hematoma evacuation method, age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement and duration of the procedure were removed from the model as they did not appear to improve model fit (Table III).

Level of consciousness at discharge. The level of consciousness at discharge and upon admission was assessed as a GCS score. In total, 18 patients exhibited a depressed level of consciousness (GCS <15). The level of consciousness at discharge was coded as follows: 0, GCS=15; and 1, GCS <15, and binary logistic regression analysis was performed to examine the effects of hematoma evacuation method, age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement, duration of the procedure and GCS upon admission on the probability of a depressed level of consciousness on discharge. Only the methods of hematoma evacuation and GCS upon admission were found to significantly improve the fit of the model, and hence all other independent variables were removed. Hematoma evacuation with multiple burr holes and the placement of a subperiosteal drain (group 1) exhibited a significantly lower risk for a depressed level of consciousness at discharge (OR=0.249; P=0.031, compared to the single burr hole with intradural drain placement method), and a higher GCS score on admission was associated with a lower risk for depressed level of consciousness on discharge (OR=0.790; P=0.007). The craniotomy method also exhibited a reduced risk of depressed level of consciousness at discharge compared to the single burr hole with intradural drain method, which was nevertheless non-statistically significant (OR=0.569; P=0.414) (Table IV).

Duration of hospitalization. The duration of hospitalization varied in the study cohort (median: 8 days; range: 2 to 40 days). A main effects general linear model analysis was performed to examine the effects of hematoma evacuation method, age, sex, prior use of anticoagulants or antiplatelets, uni/bilateral involvement, duration of the procedure and GCS upon admission on the duration of hospitalization. Age, sex, prior use of anticoagulants or antiplatelets, comorbidities and the duration of the procedure did not improve model fit and were removed. Evacuation with single burr holes and intradural drain placement (group 2) was associated with a statistically significant prolongation of hospitalization compared with the multiple burr hole (group 1) and/or craniotomy (group 3) evacuation methods (Table V). Bilateral vs. unilateral subdural hematomas were also significantly associated with longer hospitalization and the presence of bilateral vs. unilateral hematomas would explain 42% of the variance in hospitalization days (partial eta^2=0.42) (Table V). Lower GCS scores upon admission were also marginally associated to a statistically significant degree (P=0.05) with a prolonged period of hospitalization, with lower GCS scores on admission explaining 3.3% of the variance in days of hospitalization (partial eta2=0.033) (Table V).

Table II. Binary logistic regression model for SDH recurrence.

	B	SE	P-value	OR	95% CI for OR
Independent variable					
Group 2			<0.001		
Group 1	-2.580	0.618	<0.001	0.76	0.23 to 0.254
Group 3	-2.526	0.841	0.03	0.80	0.015 to 0.416
Constant	0	0.408	1	1	

Model Chi^2=21.837, d.f.=2, P<0.001; Hosmer and Lemeshow test: Chi^2=0.0001, d.f.=1, P=1.0; Nagelkerle R^2=0.283. SE, standard error; OR, odds ratio; CI, confidence interval; B, regression coefficient; d.f., degrees of freedom.

Table III. Binary logistic regression model for the development of any complication.

	B	SE	P-value	OR	95% CI for OR
Independent variable					
GCS on admission	-0.192	0.078	0.014	0.825	0.709 to 0.961
Constant	0.455	0.814	0.576	1.576	

Model Chi^2=6.319, d.f.=1, P<0.012; Hosmer and Lemeshow test: Chi^2=5.5.73, d.f.=7, P=0.590; Nagelkerle R^2=0.084. SE, standard error; OR, odds ratio; CI, confidence interval; B, regression coefficient; d.f., degrees of freedom.

Table IV. Binary logistic regression model for the prediction of depressed level of consciousness on discharge.

	B	SE	P-value	OR	95% CI for OR
Independent variable					
GCS on admission	-0.236	0.087	0.007	0.790	0.666 to 0.937
Group 2			0.092		
Group 1	-1.391	0.644	0.031	0.249	0.070 to 0.879
Group 3	-0.564	0.690	0.414	0.569	0.147 to 2.202
Constant	1.550	0.990	0.117	4.710	

Model Chi^2=14.804, d.f.=3, P<0.002; Hosmer and Lemeshow test: Chi^2=9.354, d.f.=8, P=0.313; Nagelkerle R^2=0.197. SE, standard error; OR, odds ratio; CI, confidence interval; B, regression coefficient; d.f., degrees of freedom.

Discussion

It is important to mention that although CSDH surgical management has developed and includes new surgical techniques, it still presents major challenges. Chronic subdural hematomas often appear in the elderly population, which has pre-existing comorbidities, and their treatment needs to be individualized in every case. Medications that affect hemostasis, such as anticoagulants, the formation of a pseudomembrane, which can cause a secondary hemorrhage, misplacement of the surgical drain, recurring hemorrhage in the subdural space, and direct brain injury during the operation, can all lead to high rates of readmission, higher infection risks, high inpatient costs and a high mortality rate.

In general, CSDHs are considered surgical lesions, particularly if they cause symptoms or midline shift (14), even though medical treatment is advocated in selective cases by a number of neurosurgeons (14). As regards the surgical treatment of a CSDH, there is no gold standard technique, and the treatment depends on the experience of the neurosurgeon and personal preference (15). There are multiple options in the current armamentarium (single burr hole, multiple burr holes, craniotomy, subperiosteal drain, subdural drain, the use of temporalis muscle in order to absorb the hematoma, no drain, suction in the drain, no suction), and it known in the neurosurgical community that a CSDH is not approached surgically in the same manner by more than one consultant, even in the same institute. The present retrospective study verified the last statement, as all the consultants in the authors' department are using a different combination of the available surgical choices. For a better evaluation of the results, the treatment options were categorized into three groups as follows: Group 1, multiple burr holes per collection with the placement of a subperiosteal

Table V. Univariate main effects general linear model for the prediction of the duration of hospital stay after subdural hematoma evacuation.

	B	SE	t	P-value	95% CI	Partial Eta^2
Intercept	16.124	2.146	7.513	<0.001	11.87 to 20.37	0.325
GCS upon admission	-0.328	0.165	-1.984	0.050[a]	-0.655 to -0.001	0.033
Group 2	3.494	1.616	2.162	0.033[a]	0.29 to 6.69	0.038
Group 1	-2.229	1.258	-1.772	0.079	-4.72 to 0.263	0.026
Group 3						
Unilateral vs. bilateral (ref)	-3.118	1.371	-2.273	0.025[a]	-5.83 to -0.40	0.42

Corrected model mean square: 331.968, d.f.=4, F: 11.100; P<0.001; R^2=0.275 (adjusted 0.250). [a]Indicates a statistically significant difference. SE, standard error; GCS, Glasgow coma scale; CI, confidence interval; B, regression coefficient; d.f., degrees of freedom.

drain and mild suction; group 2, single burr hole per collection with the placement of an intradural drain; and group 3, mini-craniotomy +/- subcutaneous drain.

In the general part of the patient cohort in the present study, a significant correlation was observed between the location of the CSDHs and the duration of hospitalization. Bilateral subdural hematomas were associated with prolonged periods of hospitalization compared with unilateral hematomas (Table V). Additionally, a weak, yet significant correlation between the GCS upon admission, patient age, and the duration of hospitalization was found, indicating that the lower the level of consciousness upon admission or the younger the patient age, the longer the period of hospitalization. This result can be justified by the fact that younger patients do not experience cerebral atrophy, as do older patients, who often suffer from this brain-aging reality. This phenomenon of the limited space between the cortical structures can cause greater pressure when there is chronic subdural hematoma formation and can lead to a longer period of hospitalization (16).

The GCS upon admission also had a marked effect on mortality and post-operative complications, since higher GCS scores upon admission exhibited significantly lower ORs of mortality compared to lower GCS scores (Table I) and were also associated with a significantly decreased probability of developing any complication (Table III) (17,18).

As regards the mortality rate following each hematoma evacuation method, the surgical procedure used in group 1 (two burr holes with a subperiosteal drain) appeared to have zero mortality. On the other hand, 3 patients succumbed following hematoma evacuation; of these, 2 patients were treated with single burr hole evacuation with an intradural drain placement (group 2), and 1 patient was treated with a craniotomy (group 3) (Table I).

As regards CSDH recurrence following each hematoma evacuation method, the patients who were treated with multiple burr holes with subperiosteal drain (group 1) and those who received a craniotomy as a CSDH treatment (group 3) exhibited a significantly lower ORs of having hematoma recurrence than patients who were treated with a single burr hole per collection and a subdural drain (Group 2, Table II). Moreover, it is important to mention that the patients in groups 1 and 3 expressed a significantly lower probability of a depressed level of consciousness at discharge and a decreased duration of hospitalization. In the operative room, the surgical procedure used in group 2 (single burr hole and an intradural drain) requires theoretically less time and there is minimal blood loss, while the patients do not remain sedated for a long period of time. These are critical factors for the prognosis, since the majority of patients who suffer from CSDH are elderly, and the shorter the intraoperative time, the lower the risk of a long operation-induced complication or exposure to any infectious agent and consecutive hospital-acquired pneumonia. On the other hand, the procedures used in groups 1 and 3 require more time in the operation theater, which could lead to increased blood loss and complications associated with a long period of intubation. Moreover, the more invasive approach that was selected in groups 1 and 3 could generate iatrogenic complications, such as pseudo-membrane tearing, brain laceration, or epilepsy. Notwithstanding, even if in theory, the surgical hematoma evacuation used in group 2 appears superior compared to the methods used in groups 1 and 3, this was not verified in the present study, since the neurosurgical methods used in groups 1 and 3 appeared to be better for the post-operative state of the patients. This superiority of the surgical treatments used in groups and 3 in the present study may be due to the better hemorrhage control, if there was such a complication, due to the better visualization, improved pseudo-membrane management, which can prevent re-bleeding and/or recurrence, and the greater hematoma flushing, reducing the blood load and subsequently the possibility of any recurrence. On the other hand, in the single burr hole approach, hematoma flushing could be ineffective, the pseudomembrane microbleeds could not be well controlled due to the limited space, and the air invaded during the operation could be trapped, causing post-operative pneumocephalus. The sum of these complications could justify the prolonged hospitalization time and the higher recurrence and complication rate of patients in group 2.

Another issue in the treatment of CSDHs is the use and optimal location of the drain. In the past, subperiosteal drainage and subdural drainage have been compared in the bibliography for their advantages and disadvantages in the management of CSDH. Although both hematoma aspiration methods appear to be beneficial for the treatment of CSDH, subperiosteal drain appears to be more effective and is associated with fewer complications. Other academic studies (8,12) have confirmed this assertion, which is also supported by the findings of the present study. In detail, subperiosteal drainage

reduces the probability of hematoma recurrence and has a lower risk of complications compared to subdural drainage, since it is not positioned directly in contact with cortical structures, bridging vessels, or neomembranes. As regards the risk of infection, subperiosteal drain requires a longer intraoperative time than subdural drain, and this theoretically can lead to a higher probability if infection (19). However, in a previous study (8), subperiosteal drain appeared to have a lower infection risk compared with subdural drain, which is another advantage of SDH over subdural drain.

It is also worth mentioning that in the present study, the patients in groups 2 and 3 had a longer period of hospitalization compared with the patients in group 1, who, due to the mild suction set on their drain, could be mobilized shortly after the surgery. Early post-operative mobilization is a good prognostic factor for the outcomes of patients and reduces the length of hospitalization (20). That could explain why the patients where an intradural drain with no suction was used were associated with a statistically significant prolongation of hospitalization compared to the patients where a subperiosteal drain with suction was used.

It is clear that a new technique for the treatment of CSDHs remains to be invented. Currently, a specific combination from the modern neurosurgery arsenal is employed, and the present study revealed that the combination of multiple burr holes and a suction-assisted subperiosteal drain subperiosteal yielded superior results compared to other treatment options. As a result, other colleagues are encouraged to use the surgical approach used herein in their efforts to improve the treatment outcomes of patients with CSDH.

Some limitations of the present retrospective study should be mentioned. Since each doctor completed his or her own preferred surgical management, the same neurosurgeon initially did not perform the three different hematoma evacuation procedures. In addition, the morphology of the CSDHs was not similar, and each hematoma had a different etiology and imaging appearance. The use of anticoagulants by several patients was another limitation of the present study as, in some cases, it could increase the patients' possibility of rebleeding or recurrence. Moreover, the present case series took place in a single hospital setting and not in multiple healthcare centers. It is also important to mention that the study had a limited number of participants due to the nature of the hospital environment. Finally, there is heterogeneity in the long-term follow-up, as the chronologically first patients were followed-up for a longer period of time compared to the patients recruited last. Notwithstanding, the post-operative outcomes were well-analyzed.

In conclusion, it is commonly known that CSDHs are one of the most challenging realities in a neurosurgical hospital setting. Nowadays, there is no gold standard technique for the management of CSDH, since the ideal treatment depends on the nature of each hematoma and the personal experience of the neurosurgeon. Nevertheless, multiple burr hole hematoma evacuation with a subperiosteal drain placement and mild suction is a very promising technique with very beneficial post-operative outcomes, since it has a zero mortality rate, while reducing the recurrence of the hematoma, the risk of infection, the period of hospitalization and the probability of drainage misplacement, factors that could provide an improved post-operative quality of life for the patient.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

DP and KF conceptualized the study. VEG, GF, NT, DAS, PS, DP, SC, KF, ZMB and AY made a substantial contribution to data interpretation and analysis, and wrote and prepared the draft of the manuscript. DP and KF analyzed the data and provided critical revisions. SC and DP confirm the authenticity of all the raw data. All authors contributed to manuscript revision, and have read and approved the final version of the manuscript.

Ethics approval and consent to participate

The present study was approved to be conducted by the Nicosia General Hospital Bioethics Committee (approval no. NGH/02-03-2023), but informed consent was not required as the study was retrospective, and the patients could not be identified in the text or the tables.

Patient consent for publication

Not applicable.

Competing interests

DAS is the Editor-in-Chief for the journal, but had no personal involvement in the reviewing process, or any influence in terms of adjudicating on the final decision, for this article. The other authors declare that they have no competing interests.

References

1. Virchow R: The hematoma of the dura mater. Negot Phys Med Soc Würzburg 7: 134-142, 1857.
2. Balser D, Farooq S, Mehmood T, Reyes M and Samadani U: Actual and projected incidence rates for chronic subdural hematomas in United States Veterans Administration and civilian populations. J Neurosurg 123: 1209-1215, 2015.
3. Fountas K, Kotlia P, Panagiotopoulos V and Fotakopoulos G: The outcome after surgical vs nonsurgical treatment of chronic subdural hematoma with dexamethasone. Interdiscip Neurosurg 16: 70-74, 2019.
4. Pahatouridis D, Alexiou GA, Fotakopoulos G, Mihos E, Zigouris A, Drosos D and Voulgaris S: Chronic subdural haematomas: A comparative study of an enlarged single burr hole versus double burr hole drainage. Neurosurg Rev 36: 151-155, 2013.
5. Feghali J, Yang W and Huang J: Updates in chronic subdural hematoma: Epidemiology, etiology, pathogenesis, treatment, and outcome. World Neurosurgery 141: 339-345, 2020.

6. 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: 449-457, 2014.
7. Weigel R, Schmiedek P and Krauss JK: Outcome of contemporary surgery for chronic subdural haematoma: Evidence based review. J Neurol Neurosurg Psychiatry 74: 937-943, 2003.
8. Soleman J, Lutz K, Schaedelin S, Kamenova M, Guzman R, Mariani L and Fandino J: Subperiosteal vs subdural drain after burr-hole drainage of chronic subdural hematoma: A randomized clinical trial (cSDH-Drain-trial). Neurosurgery 85: E825-E834, 2019.
9. Motiei-Langroudi R, Stippler M, Shi S, Adeeb N, Gupta R, Griessenauer CJ, Papavassiliou E, Kasper EM, Arle J, Alterman RL, *et al*: Factors predicting reoperation of chronic subdural hematoma following primary surgical evacuation. J Neurosurg 129: 1143-1150, 2018.
10. Greuter L, Lutz K, Fandino J, Mariani L, Guzman R and Soleman J: Drain type after burr-hole drainage of chronic subdural hematoma in geriatric patients: A subanalysis of the cSDH-Drain randomized controlled trial. Neurosurg Focus 49: E6, 2020.
11. Santarius T, Kirkpatrick PJ, Ganesan D, Chia HL, Jalloh I, Smielewski P, Richards HK, Marcus H, Parker RA, Price SJ, *et al*: Use of drains versus no drains after burr-hole evacuation of chronic subdural haematoma: A randomised controlled trial. Lancet 374: 1067-1073, 2009.
12. Ding H, Liu S, Quan X, Liao S and Liu L: Subperiosteal versus subdural drain after burr hole drainage for chronic subdural hematomas: A systematic review and meta-analysis. World Neurosurg 136: 90-100, 2020.
13. Alcalá-Cerra G, Young AM, Moscote-Salazar LR and Paternina-Caicedo A: Efficacy and safety of subdural drains after burr-hole evacuation of chronic subdural hematomas: Systematic review and meta-analysis of randomized controlled trials. World Neurosurg 82: 1148-1157, 2014.
14. Lee KS: How to treat chronic subdural hematoma? Past and now. J Korean Neurosurg Soc 62: 144-152, 2019.
15. Pathoumthong K and Jetjumnong C: Comparative study of subdural drain (SDD) versus sub periosteal drain (SPD) in treating patient with chronic subdural hematoma (CSDH). Surg Neurol Int 12: 421, 2021.
16. Lo WL, Lee TC, Fang PS and Huang YH: Chronic subdural hematoma in patients under age 65 years: A comparative study of age cohort. Formos J Surg 46: 10-14, 2013.
17. Amirjamshidi A, Abouzari M and Rashidi A: Glasgow coma scale on admission is correlated with postoperative glasgow outcome scale in chronic subdural hematoma. J Clin Neurosci 14: 1240-1241, 2007.
18. Amirjamshidi A, Abouzari M, Eftekhar B, Rashidi A, Rezaii J, Esfandiari K, Shirani A, Asadollahi M and Aleali H: Outcomes and recurrence rates in chronic subdural haematoma. Br J Neurosurg 21: 272-275, 2007.
19. Patel S, Thompson D, Innocent S, Narbad V, Selway R and Barkas K: Risk factors for surgical site infections in neurosurgery. Ann R Coll Surg Engl 101: 220-225, 2019.
20. Adeolu AA, Rabiu TB and Adeleye AO: Post-operative day two versus day seven mobilization after burr-hole drainage of subacute and chronic subdural haematoma in Nigerians. Br J Neurosurg 26: 743-746, 2012.