

Recurrence of Chronic Subdural Hematomas Requiring Reoperation: Could Small Trephination Be a Valid Alternative to Conventional Approaches?

Danil Adam^{1,2}, Dragos Iftimie², Cristiana Moisescu²

¹„Carol Davila” University of Medicine and Pharmacy, Bucharest, ROMANIA

²Department of Neurosurgery, „Saint Pantelimon” Clinical Emergency Hospital, Bucharest, ROMANIA

Abstract: *Background:* Chronic subdural hematomas (CSDHs) are one of the most common intracranial lesions treated in a neurosurgical department. They associate significant morbidity and mortality that increase in the case of recurrences requiring reoperation. Despite extensive published literature, there is still significant debate regarding optimal management of CSDHs and their potential recurrence. *Objective:* Identify factors for recurrence requiring reoperation of CSDHs in order to adjust our management strategies. *Methods:* A retrospective review of 64 cases harbouring 71 CSDHs that were surgically treated in the Neurosurgery Department of “Saint Pantelimon” Clinical Emergency Hospital over a period of two years (January 2016 - December 2017). Two main surgical techniques were used: small trephine and large bone flap craniotomy, according to the operating surgeon’s preference. CT scans were performed at admission and 24 hours postoperatively. Postoperative management was similar in all cases. *Results:* Recurrence requiring reoperation (RrR) was encountered in 16 (25%) of the reviewed cases. Reoperation was found to be significantly more often encountered in particular preoperative CT characteristics: laminar type (RrR=38,10%, p=0.027) and maximal thickness above 22 mm (43,75%, p = 0,013). Surgical technique had a substantial impact on recurrence: in trephinated cases, reoperation was required in only 8 of 51 patients (RrR=15,69%, p = 0.007), while large bone flap craniotomy associated a RrR of 61,54% (p = 0.008), which increased when associated with inner membranectomy (RrR=87,5%, p = 0,007) or subdural drain placement (88,89%, p = 0.007). Reoperations not only doubled the neurosurgical hospital length of stay, but also associated higher perioperative mortality rates (18.75% versus 14,58%). *Conclusions:* In our series, surgical technique had a decisive impact on the rate of recurrence. CSDH surgery is another example of “in medio stat virtus”, where finding

the right balance between the least and most aggressive technique has the potential of providing the best outcomes, and thus small trephination could be taken into consideration.

Key words: chronic subdural hematoma, recurrence requiring reoperation, risk factors, small trephination

Introduction

First described by Swiss pathologist Johann Jakob Wepfer in 1658 in his treatise on strokes entitled “Historiae apoplecticorum”, chronic subdural hematomas (CSDHs) nowadays represent a common intracranial lesion treated in a neurosurgical department.

The elderly population is more frequently affected by this condition due to a series of predisposing factors, including: increased use of antithrombotic medication, vascular fragility, larger subdural space and susceptibility to frequent mild traumatic brain injuries secondary to same-level falls. [1]

The incidence of CSDH is estimated at 1.7 to 18 per 100 000 people/year and rises to 58 per 100 000/year in individuals > 65 years of age. [2] As the population > 65 years is expected to double by 2030, an increase in the incidence of CSDH in the coming years is also expected. [3]

Surgical evacuation remains the treatment of choice for symptomatic CSDH, with several surgical methods including twist drill craniotomy or burr hole with drainage, and large craniotomy being used. [4,5] Despite its high incidence and extensive published literature regarding risk factors, management and outcome, the optimal surgical strategy as

well as postoperative management of CSDHs continue to attract significant debate.

Current management of symptomatic CSDHs is accompanied by a rather high mortality rate, of 13%, which translates into approximately 4 deaths a year due to this disorder in a typical neurosurgical department. [6,7] In spite of rather simple operative procedures, the recurrence rate is relatively high (up to 33%), as compared with other traumatic brain injuries. [8,9] Recurrences requiring reoperation (RrR) lead to an increase of morbidity and mortality rates. They also translate into a prolonged hospital length of stay and, implicitly, into increased financial costs. [10]

The aim of the current study was to investigate factors predicting RrR in patients who underwent surgery for CSDHs in our department, in an effort to adjust our treatment strategies and consequently improve the surgical outcome.

Material and methods

We retrospectively reviewed data of 70 consecutive patients with CSDHs which were surgically treated in the Neurosurgery Department of “Saint Pantelimon” Clinical Emergency Hospital over a period of two years, between January 2016 and December 2017.

Patients that, for various reasons, lacked a postoperative 24-hour control CT scan were excluded from the study, resulting in a total number of 64 patients harbouring 71 surgically treated CSDHs who met de inclusion criteria.

General characteristics

Patient demographics such as age, sex, medical history and risk factors for CSDH were recorded.

The specific risk factors that were taken into consideration are represented by alcohol abuse and antithrombotic medication. In all cases included, any pre-existing antiplatelet or anticoagulant therapy was temporarily

discontinued upon admission and resumed after hospital discharge.

The preoperative Glasgow Coma Scale (GCS) score and relevant neurological findings were also noted, warranting the subsequent choice of surgical management.

CSDHs were diagnosed by head CT scan on the day of admission and subsequently confirmed by intraoperative findings. Hematomas were grouped into 4 types based upon imagistic appearance, as classified by Nakaguchi et al. All types included in this classification were found in our cohort (Fig. 1): homogeneous, laminar, separated, and trabecular.[11]

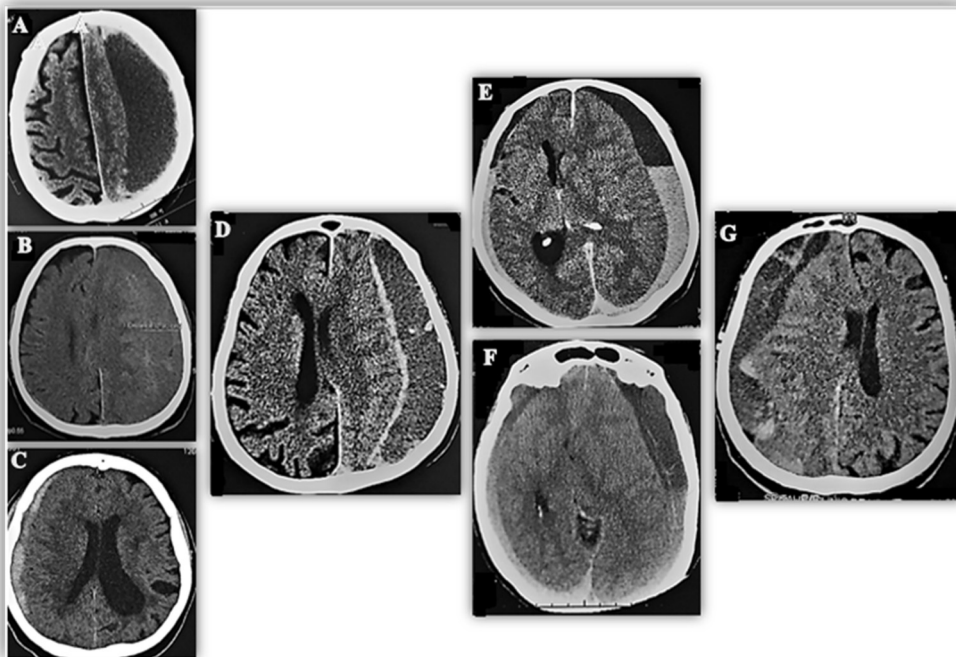


Figure 1 - Preoperative CT scans of included patients according to the classification of Nakaguchi et al.: homogenous hypodense subtype (A), isodense subtype (B), hyperdense subtype (C); laminar type (D); separated type (E), with gradation subtype (F); trabecular type (G)

The preoperative CT scan findings additionally evaluated were: maximum hematoma thickness (assessed in mm), midline shift, and whether the hematoma was uni- or bilateral. In order to determine hematoma size in bilateral cases, the maximum thickness was considered.

Surgical management

All patients underwent surgery under general anaesthesia and orotracheal intubation. The CSDHs were evacuated using two distinct surgical techniques: small trephine (25 mm diameter) craniotomy and 5 or 6 burr-holes bone flap craniotomy.

In small trephination cases, a 5 – 6 cm linear scalp incision was performed, followed by a 25 mm craniotomy centred on the maximal thickness of the hematoma and a star-shaped incision of the underlying dura mater. The external membrane of the hematoma was opened in a circular fashion, preserving a 0.5 cm margin from the craniotomy. After hematoma evacuation, this margin was coagulated under visual control, and retracted as far as the craniotomy allowed. The remaining cavity was irrigated with warm saline solution in order to eliminate any residual blood clots.

In some cases, a partial inner membranectomy was performed, while in others it was left intact. An epidural or subdural closed-system drainage was placed and maintained for at least 24 h. The bone flap was repositioned and secured with nylon sutures (Fig. 2).

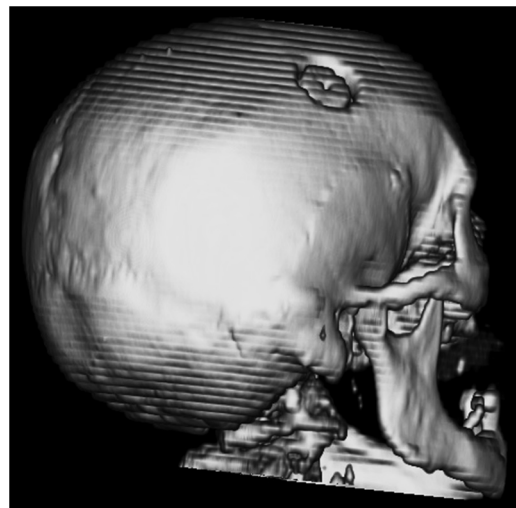


Figure 2 - 1-month postoperative CT reconstruction after using the small trephination technique and reposition of the bone flap

The operative technique used was chosen according to the surgeon's preference. In cases of bilateral symptomatic CSDHs, the operation was performed on both sides in the same manner, during the same operative session.

Postoperative management

A standard procedure was applied in all cases: after surgery, the patients were transferred from the OR to the ICU for at least 24 h for general monitoring, bed rest and treatment consisting of intravenous hydration with 1000 mL of saline solution and 500 mL 10% glucose solution.

Antiepileptic prophylaxis with a single loading dose of phenytoin was started during surgery; antiepileptic medication was continued only in the cases of at least one preoperative seizure. Low dose heparin was also prophylactically prescribed, in order to prevent vascular occlusive events. In cases of

pre-existing antiplatelet or anticoagulant therapy, medication was resumed after discharge, depending on indications.

Neurological status was constantly monitored and logged at least once every day.

In all cases, follow – up CT scans were performed in the first postoperative day, comparing residual hematoma thickness and midline shift with the preoperative value.

Recurrence of CSDH requiring reoperation was diagnosed when neurological status did not improve postoperatively, new neurological symptoms occurred or the existing ones worsened, and re-accumulation of a subdural collection on the operated side was visible on follow – up CT scan.

General outcome (home discharge, discharge to another hospital or death in hospital), as well as hospital length of stay, were also evaluated.

Statistical Analysis

Data were described using means (standard deviations) and numbers of patients (percentages) for continuous and

categorical variables, respectively. The tests were performed using IBM's SPSS statistical analysis software (IBM SPSS v20).

Univariate and multivariate linear regression analyses were performed to assess the relationship between risk factors for chronic subdural hematomas, preoperative hematoma thickness, hematoma characteristics based on CT appearance (uni-/bilateral, type of hematoma based on Nakaguchi's classification) and type of operation, with RrR.

In all circumstances a probability (P) value of <0.05 was considered statistically significant and all tests were 2-tailed.

Results

Out of the 64 patients included, 16 developed recurrence requiring reoperation, representing 25% of all cases.

Patients demographics consisting of sex, age, risk factors and GCS score on admission are presented in Table 1.

Table 1 - General patient characteristics and associated rate of recurrence

Characteristics	Total no (%)	Nonrecurrent no (%)	Recurrent no (%)	P-value
Gender				
• Male	47 (73.44)	33 (70.21)	14 (29.79)	.03
• Female	17 (26.56)	15 (88.24)	2 (13.33)	
Age groups				
• ≥ 65	49 (76.56)	36 (73.44)	13 (26.53)	.17
• < 65	15 (23.44)	12 (80)	3 (20)	
Risk factors				
• Chronic alcohol abuse	29 (45.31)	22 (75.86)	7 (24.14)	.05
• Antiplatelet	14 (21.88)	9 (64.29)	5 (35.71)	.41

medication				
• Anticoagulant medication	9(14.06)	7 (77.78)	2 (22.22)	.98
Preoperative GCS score				
• 3 – 8	12 (18.75)	9 (75)	3 (25)	.53
• 9 – 12	8 (12.5)	5 (62.5)	3 (37.5)	.61
• 13 -15	44 (68.75)	34 (77.27)	10 (22.73)	.40

Out of the 64 patients included in the study, 47 (73,44%) were males and 17 (26.56%) were females, with a male-to-female ratio of approximately 2:1. A lower recurrence rate was noted among the female population, male sex being associated with a higher rate of recurrence ($p=0.03$)

A number of 42 patients (65.5%) have suffered repeated mild traumatic brain injuries before admission, while the rest of the patients (34.5%) could not mention notable head trauma in the past 3 months.

Age at presentation varied between 45 and 89 years, with an average of 69.56 years and a considerably high percentage (76.56%) 65 years old or older, consistent with the increased incidence of CSDHs among the elderly population. However, age did not correlate with recurrence requiring reoperation ($p=0.17$).

Regarding risk factors for CSDH development, previous antiaggregant

treatment associated an increased, yet not statistically significant, rate of hematoma recurrence requiring reoperation ($p = 0.41$). Chronic alcohol abuse, although frequently encountered among our patients (45.31%), did not present a statistically significant association with recurrence.

The leading symptoms at admission were headache, dizziness, confusion and motor deficit, with an average GCS score of 12. A recurrence rate above our overall average can be observed in the 9-12 GCS group, although not statistically significant ($p = 0.61$).

Preoperative CT scan identified 7 cases of bilateral chronic subdural hematomas, 3 of which subsequently required reoperation, with a recurrence rate of 42.86%, higher than 22.81%, associated with the unilateral group, but the association did not prove to be statistically relevant ($p = 0.051$, Table 2).

Table 2 - CT characteristics of CSDHs and associated rate of recurrence

Characteristics	Total no (%)	Nonrecurrent no (%)	Recurrent no (%)	P-value
Unilateral	57 (89.06)	44 (77.19)	13 (22.81)	
Bilateral	7 (10.94)	4 (57.14)	3 (42.86)	.051
Maximal thickness				
• ≥ 22 mm	32 (50.00)	18 (56.25)	14 (43.75)	.013

• < 22mm	32 (50.00)	30 (93.75)	2 (6.25)	
Type				
• Homogenous hypodense	8 (12,50)	7 (87.50)	1 (12.50)	.78
• Homogenous isodense	8 (12,50)	6 (75.00)	2 (25.00)	.82
• Homogenous hyperdense	5 (7,81)	5 (100.00)	0 (0.00)	.96
• Laminar	21 (32.81)	13 (61.90)	8 (38.10)	.027
• Separated	14 (21,88)	11 (78.57)	3 (21.43)	.56
• Gradation	4 (6,25)	3 (75.00)	1 (25.00)	.67
• Trabecular	4 (6,25)	3 (75.00)	1 (25.00)	.73

Maximum hematoma thickness was calculated between 9 and 46 mm, with an average of 21,75 mm. The selection of cut-off values for hematoma thickness was based on assessment of ROC curves to find the best predictive ability. Regarding the ROC curve of thickness ≥ 22 mm, the area under the ROC curve was 0.712 (95% CI = [0.584-0.840], $p = 0.013$, Fig. 3). A cut-off of thickness at 22.50 mm produced a sensitivity of 66% and a specificity of 40%. The probability of no RrR was estimated to be 95% if thickness was below 22.50 mm, and 78% if thickness was above 22.50 mm. Regression analysis demonstrated that hematoma thickness ≥ 22 mm represented a significant predictor for CSDH RrR ($p = 0.013$).

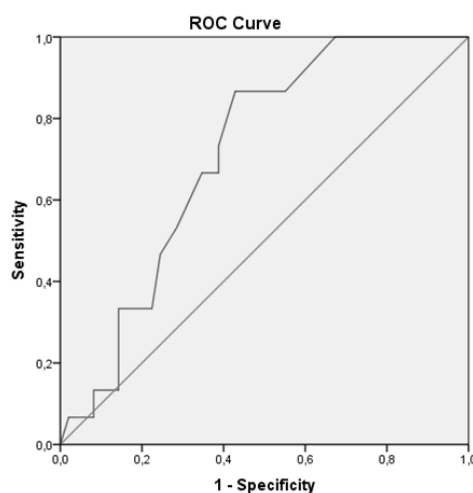


Figure 3 - ROC curve of preoperative thickness ≥ 22 mm

All types of chronic subdural hematomas according to the Nakaguchi's classification were encountered in our case series. The laminar type was most frequently found (21 cases), also associating the highest recurrence rate (38.10%). It was also the only type of hematoma with a statistically significant association with recurrence ($p=0.027$; Table 2). Homogenous hypo- and hyperdense subtypes presented a below average reoperation rate, but it was not found to be statistically significant ($p = 0.78$ and $p = 0.96$ respectively; Fig. 4).

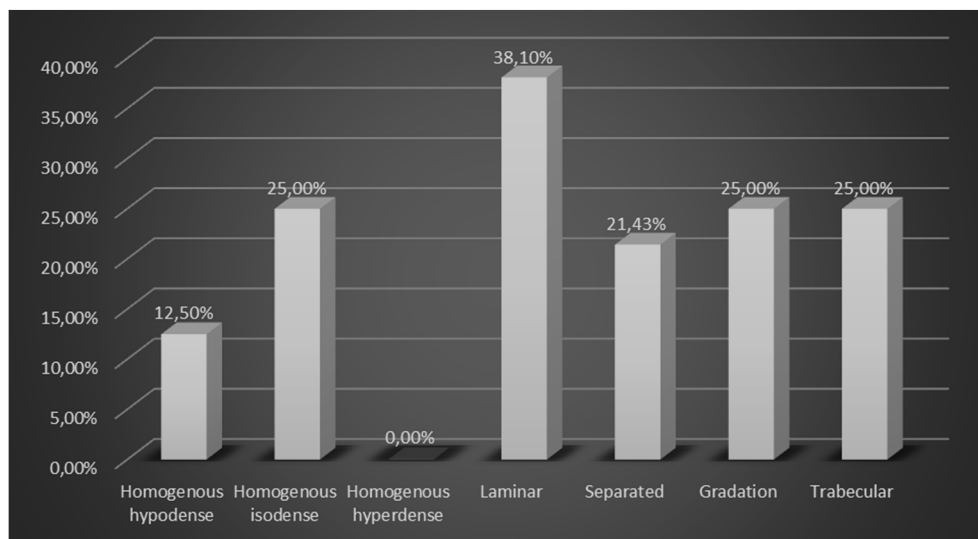


Figure 4 - Rate of recurrence in different types of hematomas according to the Nakaguchi classification

Regarding surgical management, there were only 2 types of procedures used for hematoma evacuation, depending on the surgeon's preference. The majority (79,69%) were operated through a small trephine craniotomy. This approach associated a recurrence rate of 15,69%, lower than the 61,54% encountered when a large bone flap craniotomy was performed. This result proved to be statistically relevant ($p = 0.008$). Hematoma inner membrane was partially resected in 39% of cases, while in the remaining patients it was left intact. Reoperation was more often encountered

after this debatable surgical manoeuvre was performed (40% versus 15,38%).

However, when considering the type of approach in association with partial inner membranectomy, the least invasive approach (trephine without membranectomy) presented the lowest recurrence rate (14,71%), while the most aggressive one (bone flap craniotomy and inner membranectomy) presented an unexpectedly high recurrence rate (87,5%, Fig. 5). The results proved to be statistically significant ($p = 0.007$, Table 3).

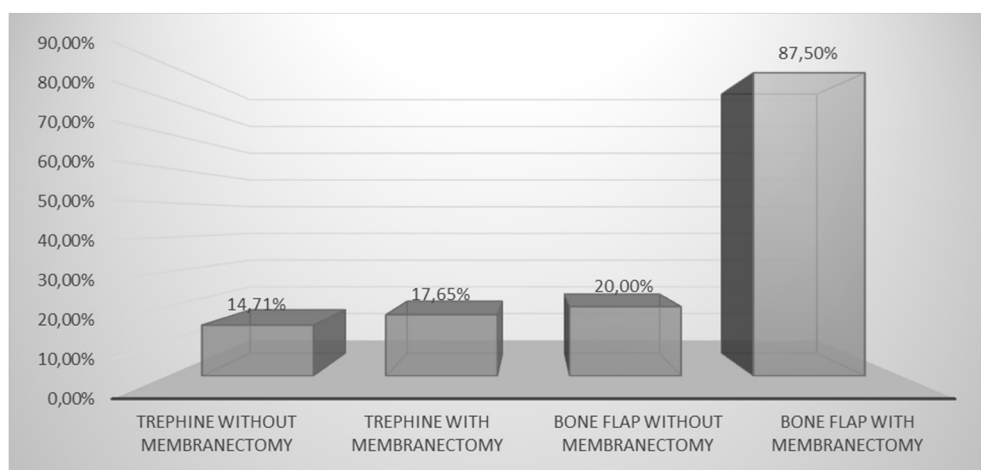


Figure 5 - Rate of recurrence when considering surgical approach and membranectomy

Table 3 - Type of operation and associated rate of recurrence

Type of operation	Total no (%)	Nonrecurrent no (%)	Recurrent no (%)	P-value
Small trephine craniotomy	51 (79.69)	43 (84.31)	8 (15.69)	.007
Large bone flap craniotomy	13 (20.31)	5 (38.46)	8 (61.54)	.008
Type of operation ± partial inner membranectomy				
• small trephine craniotomy without membranectomy	34 (53.13)	29 (85.29)	5 (14.71)	.52
• large bone flap craniotomy without membranectomy	5 (7.81)	4 (80.00)	1 (20.00)	.43
• small trephine craniotomy with membranectomy	17 (26.56)	14 (82.35)	3 (17.65)	.49
• large bone flap craniotomy with membranectomy	8 (12.50)	1 (12.50)	7 (87.50)	.007
Type of operation + epidural/ subdural drainage				
• small trephine craniotomy + epidural drain	26 (40.63)	22 (84.61)	4 (15.38)	.23
• large bone flap craniotomy + epidural drain	4 (6.25)	4 (100.00)	0 (0.00)	.39
• small trephine craniotomy + subdural drain	25 (39.06)	21 (84.00)	4 (16.00)	.11
• large bone flap craniotomy + subdural drain	9 (14.06)	1 (11.11)	8 (88.89)	.007

Also, evaluating surgical approach together with drainage placement, regardless of membranectomy, a similar significantly high rate of recurrence (88,89%) can be observed when associating a large bone flap with subdural drainage ($p = 0.007$; Table 3).

Length of hospital stay varied greatly, between 1 and 74 days with an average of

14,31 days. Patients that were re-operated spent on average 22 days in our neurosurgical department, almost two times the number of days compared with nonrecurrent cases that were discharged after an average of 11,58 days.

Overall in-hospital mortality was 15,63%, slightly higher in the recurrent group

(18,75%) compared with the nonrecurrent group (14,58%). Causes of death were in all cases associated with comorbidities, especially previous heart conditions. There was however a notable difference regarding number of cases that required transfer to another

department and were not immediately discharged home. Also, more cases in the recurrent group needed additional medical care in neurological or rehabilitation departments (Fig. 6).

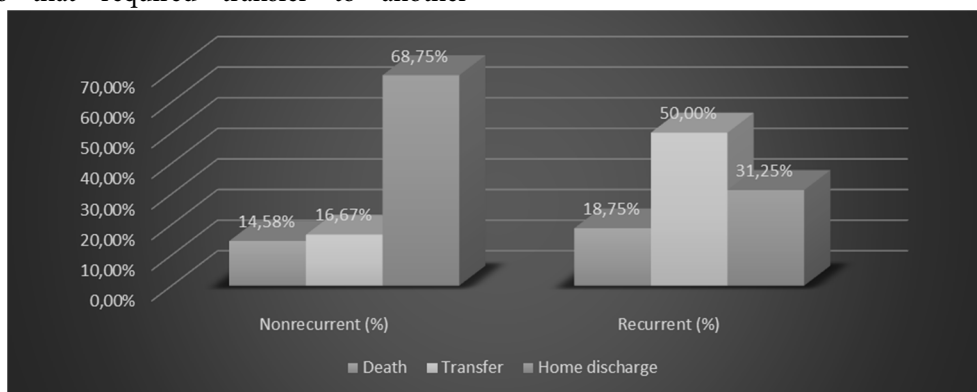


Fig. 6 - Comparison of outcomes in recurrent and nonrecurrent groups

Discussion

In 1857, Virchow (1821 – 1902) described CSDH as “pachymeningitis haemorrhagica interna”. At that time, the condition was considered fatal. Over the last 150 years, there was a great improvement in outcomes of this disorder, mainly due to better understanding the pathophysiology, introduction of modern imaging, especially the CT scan in the 1970’s, and refinement of operative techniques. Although a frequently encountered pathology in neurosurgery, there has been relatively little progress in its management during the past 20 years. This is contrasting the evolution of concepts and surgical techniques in other neurosurgical subspecialties, such as functional, spinal, oncologic or vascular neurosurgery. [12]

The poor outcome is directly related to the high risk of recurrence requiring reoperation

associated with CSDHs. In the last decade, many studies have proposed a series of risk factors that are associated with an increased recurrence rate.

Relationship between CSDH’s RrR and age.

There were few sporadic studies that suggested a causality relationship between advanced age and recurrence of CSDHs requiring reoperation. [13–15] However, most recent studies have demonstrated no correlation between advanced age and an increased rate of recurrence. [11,16] Also, in our cohort of 64 surgically treated patients, age over 65 years did not correlate with recurrence.

Advanced age is however a known risk factor for the development of CSDH. This relationship can be explained by the development of cerebral atrophy that is associated with aging, as demonstrated by

Yang et al in a study published in 2012. [17] Yang proved his theory by studying previous research regarding the pathogenesis of CSDH. Considering CSDH patients, 29 – 38% of them have no memorable precipitating trauma, unlike acute subdural hematoma cases that are almost always preceded by compelling trauma. [18] This observation was confirmed in our patients, 34% of them having no recollection of previous head trauma. Most of CSDH patients suffer mild, unremarkable trauma, usually with no loss of consciousness. [19] Cerebral atrophy enables minor stress or trauma to determine separation of the dura–arachnoid interface. Once these two layers are separated, fibrin, from either serum or exudates, can induce proliferation of granulation tissue on the inner dural surface which leads to formation of a neomembrane and consequent growth of new vessels directly within the subdural space. [20] Subsequent studies have proven that CSDHs can develop secondary to bleeding from these vessels. [21] It has also been stated that atrophy leads to tearing of bridging veins between the rigidly fixed dura and mobile arachnoid layer. [22] Thus, studies assessing the pathogenesis of CSDH supported Yang’s hypothesis that patients with cerebral atrophy associate a greater risk of developing CSDH.

This connection between cerebral atrophy and CSDH contributes to further understanding why patients older than 65 years, who have a higher incidence of brain atrophy present an increased risk for CSDH development. [23] The results of our study support Yang’s theory, when considering that

more than 70% of patients included were over 65 years.

Relationship between CSDH’s RrR and alcoholism

The Framingham Heart Study demonstrated an important correlation between alcoholism and cerebral atrophy. [24] The results suggested that cerebral atrophy may be one characteristic feature of alcoholic patients and thus is a risk factor for CSDH development. [18] In this study, a significant number of subjects presented chronic alcohol abuse (45,31%). However, the rate of recurrence requiring surgery for these patients is similar to the general overall reoperation rate.

The fact that a considerable proportion of the included patients were represented by elders and chronic alcoholics merely supports results from previous studies, advanced age and alcohol abuse representing risk factors for the development of chronic subdural hematoma, not for its recurrence.

Relationship between CSDH’s RrR and antithrombotic medication

The significantly higher prevalence of chronic subdural hematoma among the elderly could also be partially explained by the fact that 41% of them take antithrombotic medication, usually prescribed for prevention or treatment of coronary artery disease.[25] Nevertheless, CSDH patients under antiplatelet or anticoagulant therapy can pose a serious challenge for the neurosurgeon, generally associating a greater risk of intra- and postoperative bleeding.

Despite the absence of a definitive protocol, most neurosurgeons prefer to preoperatively discontinue and substitute antithrombotic therapy. Once discontinued however, the optimal timing for operation, as well as for resuming antithrombotic medication is unclear. Decision making remains a challenge: there is an unknown risk of intracranial re-bleeding when therapy is restarted too early and, simultaneously, a constant risk of vascular thrombotic events under suboptimal anticoagulation.

In our study, 35,9% of patients were under antithrombotic or anticoagulant medication which, in all cases, was discontinued and replaced with low dose heparin before surgery. Patients were operated after a variable interval, from a few hours up to 10 days, depending on the neurological status and associated conditions necessitating antithrombotic medication. Antithrombotic medication was not resumed during hospitalization in the neurosurgical department in any of the aforementioned cases. This decision was made in accordance with recommendations in published literature. [26] Concerning recurrence requiring reoperation in these patients, we found a higher recurrence rate in cases with antiplatelet treatment (37,5%), by comparison with the overall rate (25%).

Relationship between CSDH's RrR and CT characteristics

CT scanning of patients with CSDH provides a significant amount of information regarding the intracranial status and remains the most important diagnostic investigation for this disorder. Numerous CT

characteristics traditionally related to CSDH recurrence have been reported and widely debated in the literature. These included bilateral site of CSDH, preoperative and postoperative haematoma thickness or volume, preoperative and postoperative midline shift, haematoma densities, postoperative presence of air in the CSDH cavity, and postoperative persistence of residual CSDH space. [18,27,28] However, the influence of these CT features on outcome was not consistent between studies.

Therefore, we evaluated possible associations between the radiological characteristics of chronic subdural hematomas and their recurrence rate in our series. The imaging appearance of CSDHs based on the density changes was assessed using the classification described by Nakaguchi et al. into four types: the homogeneous (including hypodense, isodense, and hyperdense subtypes), laminar, separated (including gradation subtype) and trabecular.¹¹ We also evaluated if chronic subdural hematomas were uni- or bilateral, the pre-and postoperative hematoma thickness, as well as midline shift.

We found only two significant predictors for postoperative recurrence: laminar type and preoperative haematoma thickness > 22 mm.

Isodense, hyperdense, laminar and separated appearances are considered to have a greater tendency towards re-bleeding due to a greater vascularity, compared to homogenous types. [11,29] Our data suggested that the laminar type was an important predictor of postoperative

recurrence, associating a rate of 38,10%, significantly higher than the overall recurrence rate in our cohort (25%). The other types of hematoma: homogenous, separated and trabecular, presented similar associated recurrence rates. These findings generally correspond with some results reported in literature. In 2001, Mori et al. reported the outcome of 500 patients with surgically treated CSDH and did not find a positive correlation between CT densities of hematomas and the rate of recurrence. [18] More recent studies however have different results. In 2017, Stanisic et al proposed a grading system for prediction of chronic subdural hematoma recurrence requiring reoperation called the Oslo score, 2 of the 5 maximum possible points being attributed for certain types of the Nakaguchi classification (laminar, separated, isodense and hyperdense). [30]

In our study we found a much higher reoperation rate (42,86%) associated to bilateral chronic subdural hematomas, compared to the overall 25%. The fact that bilateral CSDHs associate a much higher recurrence rate compared to unilateral ones has been confirmed by numerous other studies. Torihashi et al. reviewed 343 cases of CSDH, including 61 patients who had a recurrence and his analyses showed that a bilateral CSDH was an independent predictor for the recurrence of CSDH. [31] The correlation seems to be caused by poor brain re-expansion that creates the potential for recurrence of the hematoma. [14]

There are numerous reports that evaluated the preoperative volume of CSDH on CT scan

as a prognostic factor for recurrence. It was included in the Oslo score, which considered that a preoperative hematoma volume greater than 130 mL has a significant impact on recurrence. In our study, we evaluated preoperative maximal hematoma thickness on CT scan, a characteristic much less discussed in the literature compared to preoperative volume, but readily available in our standard radiological reports. We found that a preoperative hematoma thickness > 22 mm associated a recurrence rate of 43,75%, in great contrast with a rate of only 6,25% when thickness was lower than 22 mm. Based on this difference, it appears that preoperative hematoma thickness greatly influences the recurrence rate.

Relationship between CSDH's RrR and type of operation

The treatment of CSDH is an extremely debated topic. In 1925, Putnam and Cushing suggested craniotomy and removal of the outer membrane as a treatment option. [32] For many years craniotomy has been accepted as the optimal technique in the treatment of CSDH despite the high associated surgical mortality rate of 30%. Nowadays however, the following techniques have been adopted world-wide for CSDH management: (1) two burr holes and irrigation; (2) single "large" burr hole with irrigation and aspiration; (3) single burr hole with placement of a subdural drain, maintained 24-48 hours, (4) twist drill craniotomy with aspirative drainage and (5) large craniotomy with excision of the subdural membrane. [33,34]

Lega et al. performed in 2009 a "Medline search on articles published between January

1966 and September 2006 about CSDHs and made a decision analysis". They suggested that burr hole craniotomy is superior to twist-drill craniotomy and large craniotomy in treating CSDHs. [35] Regan et al. compared burr hole craniotomy and large craniotomy, proving the superiority of the latter technique when considering reoperation rates [36] Also, Williams et al. compared burr hole and twist drill craniotomy and found a much higher reoperation rate (64%) associated to the latter procedure and only 11 % reoperation rate associated with burr hole craniotomy. [37]

The 64 patients included in the study were operated using two main types of surgical approaches: small trephination applied for the majority of the patients (79%), and large craniotomy used in the rest of the cases (20,31%). When strictly considering the type of the approach, the recurrence rate was significantly higher in cases where a large craniotomy was performed (61,54%), compared to 15,69%, the recurrence rate associated to small trephine craniotomy.

Another systematically discussed topic throughout the literature is the necessity of internal membranectomy after hematoma evacuation and whether its resection has any influence upon the recurrence rates. Many authors have addressed this issue but the conclusions were not altogether consistent, some favouring membranectomy, while others regarding it as a main prognostic factor for recurrence.

Lee et al compared three different primary surgical methods (burr-holes, enlarged and extended craniectomy with partial membranectomy) in 172 patients with CSDH.

The rate of re-operation was 16% in the group of burr-hole drainage, whereas it was 18% and 23% in partial membranectomy with enlarged and extended craniectomy, respectively.16 Also, Khadka et al. reported favourable outcome in 98.6% of 365 patients who underwent single burr-hole drainage, with no membranectomy. [38] On the other hand, Kim et al. compared a group of 16 patients who underwent a small craniotomy and another group of 42 patients who underwent a large craniotomy, with partial and extended membranectomy respectively. They concluded that the large craniotomy with extended membranectomy reduced the re-operation rate, compared with the small craniotomy group. [39]

In our cohort, there were 25 cases (39,06%) in which a partial internal membranectomy was performed, in the rest of the cases the inner membrane being left intact (60,94%). Membrane incision was associated with a significantly increased recurrence rate (40% versus 15,38%). This rate was even higher when associating a large craniotomy with inner membranectomy (RrR=87,5%). A cause for this high recurrence rate after operated CSDH via this technique could be the fragile sinusoidal vessels that are present at the junction of inner and outer membranes which had not been adequately coagulated, provoking repeated multifocal hemorrhages. [40] Another reason could be stretching and rupturing of bridging veins entering the superior sagittal sinus once brain begins to re-expand. [39] Similar results were encountered in Balevi's cohort which included 148 patients

with surgically treated CSDH's, 28 of them being operated by large craniotomy with inner membrane excision. [41] The latter group associated a recurrence rate of 28.5%, while the reported rate associated to burr hole drainage is 4%–8%. [42] Given the high recurrence rate associated with inner membranectomy that we observed, we do not recommend performing this surgical manoeuvre.

„To drain or not to drain?” is a disputed question to which Santarius et al provided an answer in the Lancet in 2008. They conducted a randomized controlled trial in which patients with CSDH were assigned to receive a subdural drain or no drain after evacuation. Surprisingly enough, the trial was ended prematurely due to a significant reduction of recurrence, morbidity, and mortality at 6 months in patients receiving a drain. Recurrence occurred in 10 of 108 (9.3%) patients with a drain, and 26 of 107 (24%) without. [3]

In our cohort, a drain was placed in all cases, with a variation regarding its position: epidurally or subdurally. We did not find a significant difference regarding recurrence rate when comparing epidural with subdural drainage following small trephine craniotomy (15,38% versus 16%, respectively). The results are similar to the ones presented by Kaliaperumal et al. They compared two types of drainage, subperiosteal drainage and subdural drainage following burr hole, in a cohort of 50 patients with operated CSDH, detecting no significant differences between recurrence rates. [43] Concerning the considerably more aggressive technique, we

found an increase of recurrence rate when associating large craniotomy with subdural drain (88,89%).

As a result of a literature data review, it appears that there is a great diversity regarding approaches for CSDHs, varying from small, less invasive techniques (twist drill, burr hole) to large sized, more aggressive ones (bone flap). The trephination method that we currently practice can be adequately considered an intermediate technique between the two extremes, clearly leaning towards the less invasive category. When considering small sized approaches, burr hole and small trephine craniotomies are very similar regarding recurrence rates. The exception from this category is the twist drill craniotomy which usually associates higher reoperation rates.

Small trephine craniotomy, with a 25 mm diameter, offers a good operative field in order to coagulate the external hematoma membrane, as well as the possibility to easily aspirate hematoma content, especially in the trabecular type cases where septa could prevent complete evacuation, or in the cases where hematoma content is not completely liquefied. Another advantage consists in the possibility to easily reposition the bone flap, thus avoiding any poor cosmetic results, regardless of trephine positioning.

Amongst the two extremes represented by small (burr hole, twist drill) and large craniotomies, the approach that we use (small sized trephination) could be considered a valid alternative in CSDH surgery.

Limitations

This is a retrospective, single-centre study so it presents certain limitations and the results presented should be interpreted accordingly. The number of patients is small despite the relatively long inclusion period and high incidence of operated CSDH in a typical neurosurgical department. No member of our Neurosurgical Department used the burr hole or twist drill techniques so, unfortunately, we could not compare it to our small trephination. There were a few patients excluded due to lack of postoperative imaging studies. Also, the surgical interventions were performed by different neurosurgeons included in our department, each with certain unquantifiable particularities regarding technique.

Conclusions

Certain CT characteristics of chronic subdural hematomas associate a significantly higher rate of recurrence: laminar type and increased thickness (>22 mm). Nevertheless, these are nonmodifiable factors.

In our series, surgical technique had a decisive impact on the rate of recurrence. While some surgeons might still argue in favour of large bone flap craniotomies, subdural drainage and / or membranectomy, their negative influence on the rate of recurrence is undeniable. CSDH surgery is another example of “in medio stat virtus”, where finding the right balance between the least and most aggressive technique has the potential of providing the best outcomes, and thus small trephination could be taken into consideration.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required.

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