Primary Enlarged Craniotomy in Organized Chronic Subdural Hematomas

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Abstract

The aim of the study is to evaluate the efficacy of craniotomy and membranectomy as initial treatment of organized chronic subdural hematoma (OCSH). We retrospectively reviewed a series of 34 consecutive patients suffering from OCSH, diagnosed by magnetic resonance imaging (MRI) or contrast computer tomography (CCT) in order to establish the degree of organization and determine the intrahematomal architecture. The indication to perform a primary enlarged craniotomy as initial treatment for non-liquefied chronic subdural hematoma (CSDH) with multilayer loculations was based on the hematoma MRI appearance—mostly hyperintense in both T_1- and T_2-weighted images with a hypointense web- or net-like structure within the hematoma cavity. The reason why some hematomas evolve towards a complex and organized architecture remains unclear; the most common aspect to come to light was the "long standing" of the CSDHs which, in our series, had an average interval of 10 weeks between head injury and initial scan. Recurrence was found to have occurred in 2 patients (6% of cases) in the form of acute subdural hematoma. One patient died as the result of an intraventricular and subarachnoid haemorrhage, while 2 patients (6%) suffered an haemorrhagic stroke ipsilateral to the OCSH. Eighty-nine percent of cases had a good recovery, while 11% remained unchanged or worsened. In select cases, based on the MRI appearance, primary enlarged craniotomy seems to be the treatment of choice for achieving a complete recovery and a reduced recurrence rate in OCSH.

Key words: organized chronic subdural hematoma, craniotomy, membranectomy, recurrence, magnetic resonance imaging

Introduction

Chronic subdural hematoma (CSDH) is a common intracranial haemorrhage affecting elderly people. Generally, in the last 20 years, burr hole craniostomy with irrigation and closed-system drainage have been considered the most effective procedure in the treatment of typical CSDH consisting of a fibrous capsule composed with an inner and outer membrane filled with bloody fluid.[1–4] In some cases, the CSDH presents different degrees of organization with internal architecture of the hematoma which may appear as multilobule, multiseptated, or multilayered. This subtype of CSDH is defined as organized chronic subdural hematoma (OCSH) in which thick membranes with multiple septations develop, leading to the formation of encapsulated areas of a solid consistency.[5,6]

Despite general agreement about the surgical indi-

cation, the extent of surgery for adequate treatment of CSDH is still controversial.[1,7,8] A disadvantage of burr hole craniostomy is a high frequency of recurrence ranging from 2.7% to 37%.[9–12] Among the most frequently confirmed causes of recurrence is the presence of thick membranes in the hematoma, which lead to a higher recurrence rate.[13–15] Magnetic resonance imaging (MRI) is useful in predicting the propensity of CSH to recur[16–18] and some authors[5,11,13–15,19–22] maintain that craniotomy with extended membranectomy is indicated in cases of inhomogeneous, multilocular, solid hematomas with rehaemorrhage, in order to support the re-expansion of the cerebral parenchyma[23] and minimize the risk of recurrence;[24,25] while burr hole craniostomy is indicated in the case of more homogeneous and liquid hematoma.

Weigel et al.,[26] having evaluated the results of treatment of CSDH using evidence-based criteria and reviewed 48 publications, stated that craniotomy should be considered the treatment of last resort

only for recurrences, in light of the higher morbidity (12.3%) in the craniotomy series in comparison with twist drill craniostomy (3%) and burr hole craniostomy (3.8%). Craniotomy should therefore be considered the treatment of choice only in the case of re-accumulating CSDH, failure of brain re-expansion or marked brain swelling.[10,13,27–29]

We here report our experience regarding the primary treatment of OCSH by craniotomy and membranectomy, in order to assess how this surgical technique facilitate parenchymal re-expansion and prevent recurrence. Surgical strategy was based on preoperative knowledge of the degree of organization and the internal architecture of the hematoma, obtained by MRI or contrast computer tomography (CCT).

Materials and Methods

From 2002 to 2010, 175 patients suffering from CSDH were treated at our institution, 34 cases (19% of the series) were suffering from multilobule, multilayered hematomas with extensive septations. Eighty-nine percent of patients underwent MRI or CCT in the preoperative setting, while in the remaining 4 cases (11%), due to their rapid clinical evolution, the indication to craniotomy was established solely on the basis of the initial CT study. All cases were treated by craniotomy and membranectomy, with irrigation and closed-system drainage. Our series consists of 21 male (62%) and 13 female (38%), ranging in age from 17 to 89 years (mean 71). The limits of craniotomy were based upon the extension of the hematoma. The outer and intrahematomal membranes and solid component were resected as widely as possible, separating the hematoma from the arachnoid layer. Adhesions on the arachnoidal plane or involving bridging veins were left in situ.

Results

Average length of hospital stay was 12 days. Aetiology and concomitant diseases are reported (Table 1). A prevalent minor head injury was present in 60% of patients while in the remaining it was unclear whether there was a traumatic event, especially in patients with associated coagulopathy. In 35% of cases no underlying risk factors were detected, and the average interval between head injury and initial scan was 10 weeks (range: from 2 weeks to 8 months). The OCSH was left-sided in 52% of the patients, right-sided in 40%, and bilateral in 8%. Early symptoms are summarized in Table 2.

We used the neurological grading score for CSDH

Table 1 Aetiology and concomitant disease

Trauma	21 (60%)
Unknown	13 (40%)
Concomitant disease*	
Cardiovascular	4
Hypertension	10
Anticoagulant	8
Diabetes	4
Malignant tumour	3
Alcohol abuse	3
No concomitant disease	12

*More than one disease per patient is considered.

Table 2 Clinical presentation

Headache	14 (26%)
Disturbance of consciousness	9 (17%)
Hemisyndrome	15 (27%)
Aphasia	6 (11%)
Gait disturbance	9 (17%)
Seizure	1 (2%)

as proposed by Markwalder et al.[10] (Table 3) to compare preoperative and postoperative neurological conditions at time of discharge. At admission, the majority of patients were Grade 2 or Grade 3 (82%), and none were Grade 4 (comatose with absent motor responses to painful stimuli). The 68% improved with regard to their preoperative status and were neurologically intact or had a "minimal" neurological deficit at the time of discharge. Patients who were Grade 2 (21%) or Grade 3 (11%) were started on rehabilitation treatments.

The prevailing CT findings on admission consisted of mixed density hematoma, with multiple compartments, mostly septated—recent rehaemorrhage was observed in 41% of the series (Fig. 1). Midline shift had an average of 10 mm. In 22 cases (66%), an MRI was performed due to suspicion of OCSH—in 15 cases, the hematoma was hyperintense in both T_1- and T_2-weighted images, while the remainder were hypointense in T_1 and hyperintense in T_2; all cases displayed a hypointense web- or net-like structure within the hematoma cavity (Figs. 2, 3). A CCT scan was performed in 8 patients (23%), due to logistical issues, showing a non-liquefied hematoma with multilayer loculations: thickness ranging from 15 to 25 mm, with clear enhancement of the intrahematomal membrane after contrast medium (Fig. 4a, b). In the remaining 4 cases (11%) the craniotomy was performed based solely on the data obtained from CT without

contrast medium, due to the rapid deterioration of clinical conditions.

In Table 4 were compared the radiological features of individual cases with the intraoperative findings. We have observed three main different degrees of organization—in 27% (9 cases) the CSDH was partially liquefied with not more than two loculations; in 53% (18 cases) the hematoma was multilayered with multiple septations, with thickened outer and inner membranes including paste-like materials; and in the other 20% (7 cases) the hematoma was completely solid with extensive septations.

In relation to the entire series of CSH: the solid multiseptated group represents 4%, while the group multilayered with paste like material is 10% and

Table 3 Neurological grade according to Markwalder et al.*

	Preoperative	Discharge
Grade 0	–	18 (53%)
Grade 1	6 (18%)	5 (15%)
Grade 2	20 (58%)	7 (21%)
Grade 3	8 (24%)	3 (8%)
Grade 4	–	
Exitus		1 (3%)

*Neurologic grading system:

Grade   State of patient
Grade 0 Patient neurologically normal.
Grade 1 Patient alert and orientated: mild symptoms such as headache; absent or mild symptoms or neurological deficit, such as reflex asymmetry.
Grade 2 Patient drowsy or disorientated with variable neurological deficit, such as hemiparesis.
Grade 3 Patient stuporous but responding appropriately to noxious stimuli: severe focal signs, such as hemiparesis.
Grade 4 Patient comatose with absent motor response to painful stimuli; decerebrate or decorticate posturing.

the 5% is partially liquefied.

Complications

The complications are summarized in Table 5. Recurrences were observed in 2 cases (6%) in the form of acute subdural bleeding observed in the first 48 hours following surgery; these patients were Grade 2 at time of admission and were undergoing anticoagulant treatment. Re-operation did not interfere with the outcome, as these cases were classified as Grade 0 at the time of discharge.

In one case (3%) an intraventricular and subarachnoid haemorrhage occurred which led to exitus. Two cases (6%) presented an haemorrhagic stroke ipsilateral to the OCSH, with worsening of the patient's clinical conditions; in one case (3%) the patient developed an hygroma which was treated with an Ommaya reservoir. Two cases (6%) presented cardio-respiratory complications.
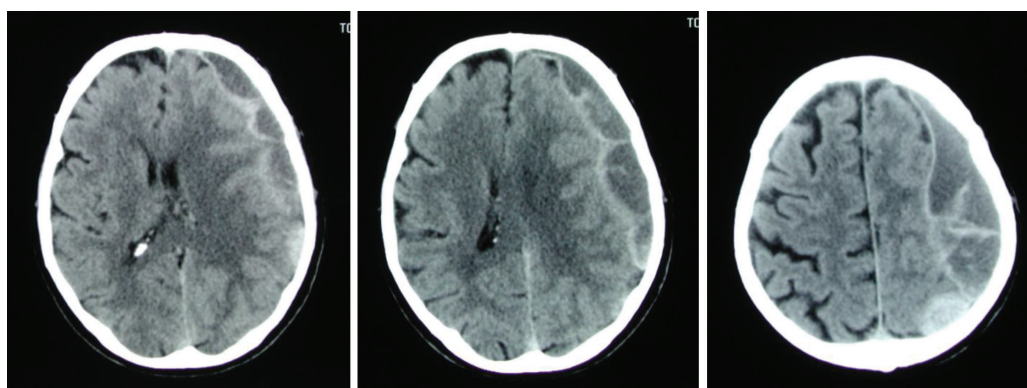
Discussion

The majority of CSDHs are liquid hematomas and tend to gradually expand as a result of repeated episodes of bleeding from the outer membrane and local hyperfibrinolysis.[18,25,30–32] The reason for which there is no observable organization of the hematoma seems to be linked to prevalently local hyperfibrinolytic activity within the hematoma.[33] It is not yet clear why some hematoma become organized; the most common feature seems to be the "long-standing" of the CSDH, with a range from 6 to 12 months.[5,15] In these cases, the neomembrane which develops is similar to granulation tissue[34] and fragile sinusoidal vessels are present at the junction of inner and outer membranes,[19] provoking repeated multifocal haemorrhages.[18,35] Fibrous material slowly


Fig. 1 Computed tomography appearance of OCSH without contrast medium: left, mixed density, multiseptated OCSH, with signs of recent hemorrage, midline shift and thickening of the inner membrane. OCSH: organized chronic subdural hematoma.
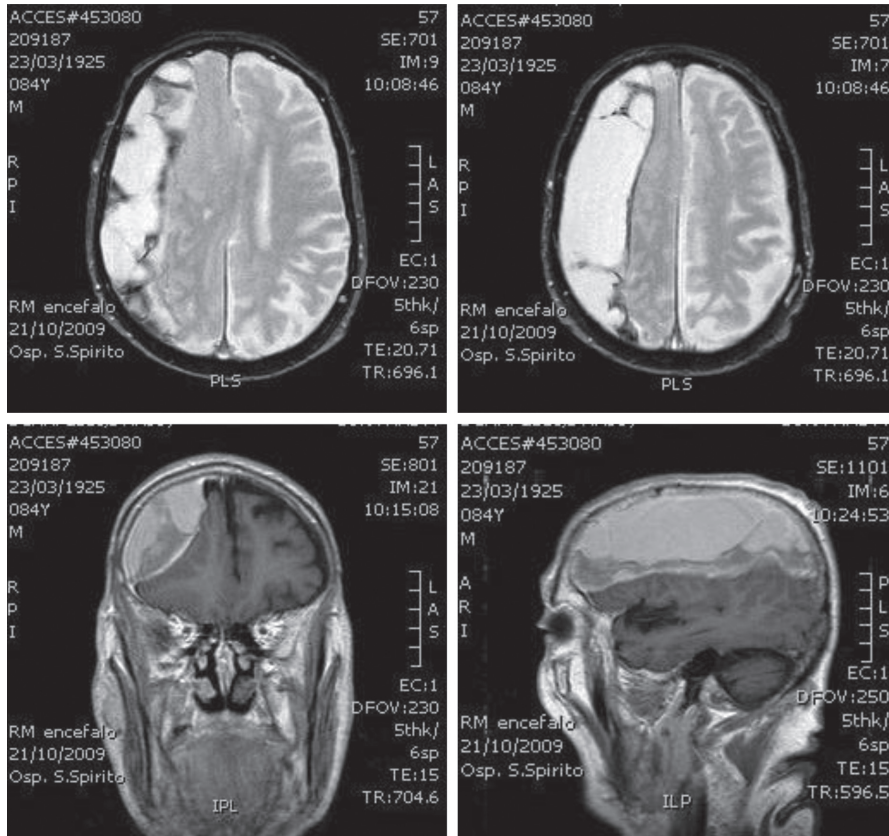
Fig. 2 Preoperative T$_2$-weighted magnetic resonance imaging showing multiple intrahematomal loculations with hypointense web-net-like structure within right hemispheric organized chronic subdural hematoma.
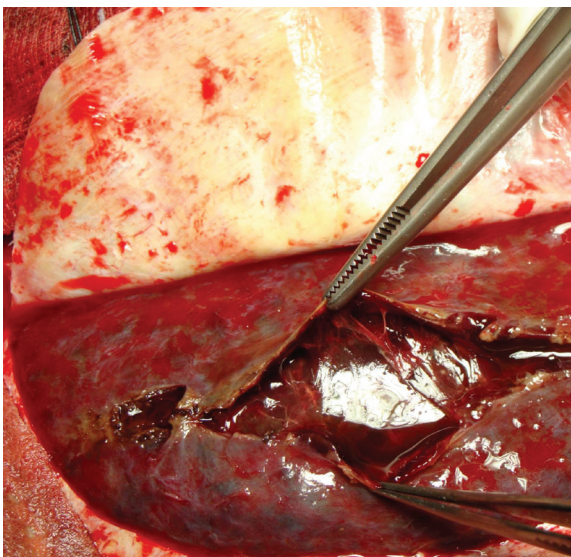
Fig. 3 Intraoperative view of Fig. 1; thick outer membrane and multiseptated intrahematomal architecture containing paste-like materials.

increases in volume, forming a solid structure in which the inner and outer membranes tend to fuse completely.[5,19,36]

The initial treatment of the CSDH with burr holes and drainage may be ineffective, with a re-operation rate ranging from 3% to 37%.[1,7,9,12,27]

The reason behind the failure of this procedure should be viewed in the light of a number of factors:

1. excessive formation of solid neomembrane[13,25,37]
2. multilayered intrahematomal architecture[6,18,35]
3. non-liquefied hematoma with different haemorrhagic foci[29] with layering effects.[38]

In order to reduce recurrence rate, it is useful to have already determined the degree of organization and the internal architecture of the hematoma itself preoperatively. This information about the inner structure must provide the indication for surgical strategy, especially with regard to the extension of the craniotomy and membranectomy. MRI, which, moreover, is not routinely employed in the diagnosis of CSDH, appears to be clearly superior to CT when detecting layering and membranes[6,36,39] with heterogeneous web- or net-like appearances within the hematoma cavities. It has also been shown that the hematoma appears thicker on MR images in comparison with CT,[17] and that contrast-enhanced MRI shows connective tissue reaction
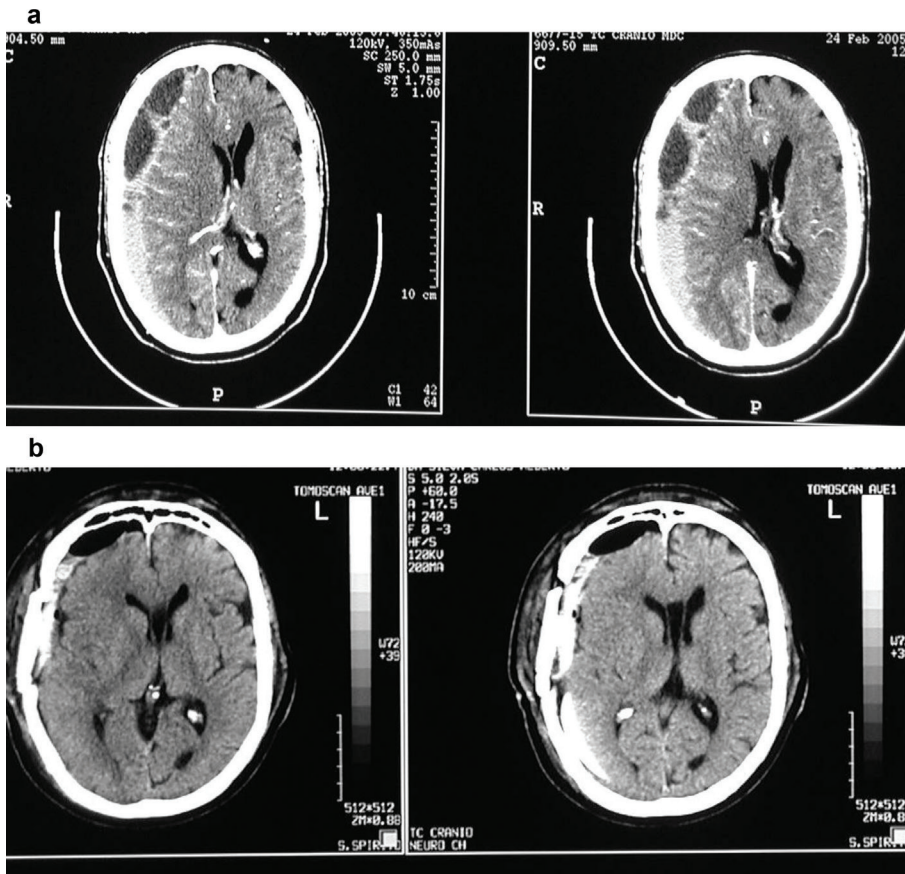
Fig. 4 a: Contrast computer tomography: non-liquefied hematoma with multilayer loculations with clear enhancement of the intrahematomal membrane. b: Early postoperative computed tomography showing satisfactory hemisphere re-expansion.

occurring during the hematoma's evolution.[37)] In some instances, the degree of organization can lead to partial calcification of the walls, with an incidence ranging from 0.5 % to 2% of CSDH,[40–43)] or a tumour-like appearance.[33)]

If the initial CT makes it clear that the hematoma may have a complex architecture, multilobilated–multilayered with a prevalent solid component a contrast-enhanced MRI is indicated as exam of choice.[6,15,44)]

In our series, 27% of cases were partially liquefied with not more than two loculations, in these cases a two burr hole craniostomy can be considered as the solution of initial choice. We have however treated, even these cases, by craniotomy in the conviction of the need to achieve the widest possible membranectomy.

Reviewing the major series (Table 6) of the last 10 years focusing on treatment of OCSH by craniotomy, the frequency of recurrence ranges from 0%[6,13,15)] to 23% in Lee et al.[2)] and 30% in Isobe et al.[14)] These data appear dissimilar and difficult to compare, as the series differ with regard to both the extension of craniotomy (small craniotomy of 3–5 cm in diameter versus large craniotomy with extended membranectomy) and case selection.

In some series[9,14)] the choice to perform craniotomy was made only after failed burr hole craniostomy, while in the Lee et al. series,[2)] with 13 cases of large craniotomy with a recurrence rate of 23%, specific reference is made to a partial membranectomy, a technical choice which could explain the relatively high frequency of recurrence.

In-hospital mortality rate in CSDH cases ranges from 0% to 15.6%[1,45)]; in our series we observed one death due to intraventricular and subarachnoid haemorrhage (3%), and in two cases we recorded the occurrence of an haemorrhagic stroke ipsilateral to the hematoma (6%), with a temporary worsening of patient's clinical conditions; these complications should be viewed in the light of the surgical procedure performed. A transient hyperaemia following rapid decompression of the CSDH is the mechanism most likely behind the development of intracerebral haemorrhages.[46)]

Conclusion

In this study, which, moreover, does not share comparative features with other techniques for the treatment of CSDH, we observed satisfactory results

Table 4 Summary of radiological features and intraoperative degree of organization

Cases	Age	CT density	MR/CCT	Midline shift	Intraoperative findings
1	70	mixed	multilobule	14 mm	PLH
2	80	mixed + RH	multilayered	20 mm	MLP
3	82	mixed + Sept	–	15 mm	MLP
4	60	mixed + RH	septations	10 mm	MLP
5	76	mixed	septations	12 mm	MLP
6	79	isodense	multilayered	14 mm	PLH
7	56	mixed + RH	septations	4 mm	MLP
8	86	mixed + Sept	multilobule	10 mm	PLH
9	79	mixed + RH	septations	10 mm	SME
10	68	mixed	multilobule	4 mm	PLH
11	85	mixed + RH + Sept	multilobule	14 mm	SME
12	77	mixed + Sept	septations	5 mm	MLP
13	74	mixed + Sept	–	10 mm	MLP
14	70	mixed	multilobule	7 mm	MLP
15	78	isodense + RH	multilobile	10 mm	PLH
16	89	mixed + Sept	multilayered	15 mm	SME
17	80	mixed + RH + Sept septatons	–	10 mm	MLP
18	63	low + RH	multilobule	18 mm	PLH
19	76	mixed	multilayered	12 mm	MLP
20	70	mixed + Sept	multilobule	21 mm	SME
21	61	mixed + Sept	multilobule	20 mm	PLH
22	82	mixed + RH	–	10 mm	MLP
23	31	mixed + RH + Sept	multilobule	10 mm	SME
24	65	mixed + RH + Sept	multilobule	10 mm	SME
25	78	mixed + Sept	–	20 mm	MLP
26	59	mixed + RH	septations	8 mm	MLP
27	17	mixed	multilobule	5 mm	PLH
28	81	isodense + Sept	multilobule	4 mm	PLH
29	86	isodense + Sept	septations	6 mm	MLP
30	84	high + Sept	multilayered	10 mm	MLP
31	76	mixed + RH + Sept	multilobule	4 mm	MLP
32	80	mixed + Sept	multilobule	15 mm	SME
33	77	mixed + RH	septations	6 mm	MLP
34	56	mixed + RH + Sept	septations	20 mm	MLP

CCT: contrast computer tomography, CT: computed tomography, MLP: multilayered loculation + paste like material, MR: magnetic resonance, PLH: partially liquefied hematoma, RH: signs of recent hemorrhage, Sept: septations, SME: solid multiseptated hematoma.

with primary enlarged craniotomy, especially when CSDH was organized and primarily with regard to reduced incidence of procedure-related recurrence and morbidity. This strategy, therefore, seems to be indicated not only in cases of burr-hole failure, but appears to resolve the hematoma at the first intervention with a clear reduction in rate of surgical revision, and with an overall decrease in length of hospital stay.

MRI should be performed both when a suspected OCSH is seen on CT presenting a mixed-density appearance with multiple lobulations (more than two) and prevalent solid component and in cases of recurrent CSDH. The indication for craniotomy and membranectomy exists in those cases where it is not possible, with a maximum of two burr holes, to adequately intercept and drain all the multiloculations of the hematoma and extensively excise the inner membrane. On the basis of our experience it appears that in select cases, large

Table 5 Complications

	No. of cases	Rate
Recurrences	2	6%
Subarachnoid haemorrhage	1	3%
Stroke	2	6%
Hygroma	1	3%
Cardiopulmonary	2	6%

Table 6 Craniotomy series

Author/year	No. of cases	Recurrence rate
Imaizumi et al. (2001)[13]	5	0%
Tanikawa et al. (2001)[6]	16(S)	0%
Mohamed (2003)[29]	39	5%
Lee JY et al. (2004)[2]	13	23%
Rocchi et al. (2007)[15]	14	0%
Isobe et al. (2008)[14]	6	30%
Lee JK et al. (2009)[9]	30(S)	3%
Kim et al. (2011)[44]	42	9%
Present series	34	6%

S: small craniotomy 3–5 cm in diameter.

craniotomy represents a valid alternative to burr hole craniostomy, especially in consideration of the reduced recurrence rate, for which reason in cases of OCSH, craniotomy should be performed as a primary procedure without attempting other approaches.

Conflicts of Interest Disclosure

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices in the article.

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