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A single center's experience with the bedside subdural evacuating port system: a useful alternative to traditional methods for chronic subdural hematoma evacuation

Clinical article

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Object. The traditional methods for managing symptomatic chronic subdural hematoma (SDH) include evacuation via a bur hole or craniotomy, both with or without drain placement. Because chronic SDH frequently occurs in elderly patients with multiple comorbidities, the bedside approach afforded by the subdural evacuating port system (SEPS) is an attractive alternative method that is performed under local anesthesia and conscious sedation. The goal of this study was to evaluate the radiographic and clinical outcomes of SEPS as compared with traditional methods.

Methods. A prospectively maintained database of 23 chronic SDHs treated by bur hole or craniotomy and of 23 chronic SDHs treated by SEPS drainage at Tufts Medical Center was compiled, and a retrospective chart review was performed. Information regarding demographics, comorbidities, presenting symptoms, and outcome was collected. The volume of SDH before and after treatment was semiautomatically measured using imaging software.

Results. There was no significant difference in initial SDH volume (94.5 cm^3 vs 112.6 cm^3, respectively; $p = 0.25$) or final SDH volume (31.9 cm^3 vs 28.2 cm^3, respectively; $p = 0.65$) between SEPS drainage and traditional methods. In addition, there was no difference in mortality (4.3% vs 9.1%, respectively; $p = 0.61$), length of stay (11 days vs 9.1 days, respectively; $p = 0.48$), or stability of subdural evacuation (94.1% vs 83.3%, respectively; $p = 0.60$) for the SEPS and traditional groups at an average follow-up of 12 and 15 weeks, respectively. Only 2 of 23 SDHs treated by SEPS required further treatment by bur hole or craniotomy due to inadequate evacuation of subdural blood.

Conclusions. The SEPS is a safe and effective alternative to traditional methods of evacuation of chronic SDHs and should be considered in patients presenting with a symptomatic chronic SDH.
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Key Words • **chronic subdural hematoma** • **subdural evacuating port system** • **bur hole** • **craniotomy** • **subdural drain** • **traumatic brain injury**

Chronic subdural hematomas are relatively common in the elderly population and are a common reason for neurosurgical consultation. The pathology of chronic SDHs has been described to arise in patients who suffered either an acute SDH or a chronic subdural hygroma.[7,8,12–15,18,24] Acute SDHs may be managed by surgical intervention in the acute stage or, if stable, may be allowed to resolve into a liquefied clot. The majority of acute SDHs that are not immediately treated surgically will become chronic and will spontaneously resorb. Fewer than 1%–3% of acute SDHs become chronic SDHs.[9,15,17] Chronic SDHs have been thought to form because of the creation of a sufficient potential subdural space due to age, cortical atrophy, or loss of brain tissue after trauma. It is hypothesized that this additional space allows for the formation of a membrane around the hematoma and, therefore, allows its transformation into a chronic SDH.[11–13,15,23]

While there are many differences, chronic SDHs appear to be more related to subdural hygromas than to acute SDHs. They both have a tendency to occur at infancy and in senescence (where the subdural space appears to be more a potential space) and are often bilateral (acute

Abbreviations used in this paper: SDH = subdural hematoma; SEPS = subdural evacuating port system.

* Drs. Safain and Roguski contributed equally to this work.

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SDHs are almost always unilateral); they rarely have associated focal brain injuries.[13] The strongest hypothesis is that chronic SDHs may sometimes arise from subdural hygromas.[7,23] Once a neomembrane forms, capillaries begin to proliferate and over time these numerous vessels are observed in the membrane wall.[7,23] These vessels are hypothesized to tear, and therefore subdural hygromas are considered to be possible precursors to the majority of chronic SDHs.

Although chronic SDH is commonly observed in neurosurgical practice, there is very little agreement on the optimal treatment of this disease.[5,19] There are several surgical techniques that have been reported for managing this condition. These techniques include closed-system drainage after 1- or 2-bur hole craniostomy (with or without saline irrigation),[6,20] twist-drill craniostomy with or without drainage (and with or without saline irrigation),[22] craniotomy and evacuation of the SDH and its surrounding membranes,[10] and many additional although less commonly practiced methods.[2,4,25,26] To date, there are few randomized controlled trials[5,16] comparing the efficacy of various treatments. A recent randomized clinical trial of 47 patients[19] compared bur hole craniotomy to twist-drill craniostomy and showed no major differences between the 2 modalities. Although that trial is still ongoing, there has been an early indication that twist-drill craniostomy has the potential for faster resolution, quicker procedural time, and fewer adverse risks. Given the paucity of literature on this topic, a recent decision analysis was published with the goal of trying to sort out the best operative management for chronic SDH.[16] With the inherent limitations of decision analysis, this study found that a bur hole was the most efficient choice for surgical drainage of uncomplicated chronic SDHs. However, the study did mention that craniotomy yielded fewer recurrences but resulted in significantly more frequent and serious complications.

A new technique of treating chronic SDH was introduced in 2003.[1] This method, a variation of twist-drill craniostomy, adds the advantage of an airtight seal while allowing gentle vacuum suction to the subdural space. This device is called the SEPS (Medtronic) and consists of a 6-mm stainless steel port that is threaded through a 5.8-mm twist-drill craniostomy, which is then attached to a Jackson-Pratt bulb and left to bulb suction (Fig. 1). The SDH is then allowed to drain over several days, and repeat CT is performed to assess for a decrease in SDH size as well as reexpansion of the brain parenchyma. This system appears to have multiple advantages over previous methods of twist-drill craniostomy, 1 or 2 bur holes, or a small craniotomy, because it provides an airtight seal with no catheter left in the subdural space. Additionally, placement of this system can be performed at bedside with minimal sedation and analgesia. To date and to the best of the authors' knowledge, there has only been 1 case-control study assessing the effectiveness of this approach.[21] This study found that the SEPS appeared to have a higher recurrence rate, but the efficacy and safety were similar to that of twist-drill craniostomy. The present study reviews our experience with the SEPS and compares it to bur hole and/or small craniotomy drainage of chronic SDH.



Fig. 1. Subdural evacuating port of the SEPS attached to a Jackson-Pratt bulb via a silicone tube.

Methods

Patient Selection and Data

Using a prospectively compiled database, we performed a retrospective chart review of the first 23 chronic SDHs treated by SEPS placement at Tufts Medical Center. These procedures were performed between November 2006 and December 2009. To minimize selection bias, we reviewed twist-drill craniostomy and open craniotomy cases from a time period when SEPS placement was not routinely performed. We thus retrospectively reviewed 23 twist-drill craniostomy or open craniotomy cases performed between November 2005 and January 2007. For each patient, basic demographics, time from reported trauma to presentation, whether the patient was receiving anticoagulation therapy, neurological deficits (weakness, drift, sensory loss, change in mental status), length of stay, follow-up interval, and stability of SDH at follow-up were analyzed. Our primary study end point was determination of residual SDH at the first follow-up visit. Computed tomography prior to any procedure and follow-up CT at the first outpatient clinical visit were used for measurements of subdural volume. This study was approved by the Tufts Medical Center Institutional Review Board.

Subdural Hematoma Measurement

We used the OsiriX software package to measure the volume of SDH by first delineating the hematoma using pixel values and 2D thresholding, followed by manually measuring the area of hematoma in each 2D slice, and lastly computing a total 3D volume using the built-in function of OsiriX. The same operator was used for all measurements.

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Surgical Procedure

The SEPS procedure was performed according to the method described by Asfora and Schwebach.[1] The area overlying the thickest portion of the subdural collection, typically overlying the parietal boss, was prepared, draped, and anesthetized with 1% lidocaine with epinephrine (1:100,000). A 0.5–1-cm incision was made on the skin and a 5.8-mm twist-drill craniostomy was made with a hand drill. The dura was opened widely with the tip of an 18-gauge needle in a circumferential manner. The stainless steel port was then threaded through this hole and tightened to the skull. A short silicone catheter was attached to a Jackson-Pratt bulb and bulb suction was applied. No irrigation of the subdural space was performed. Drain output and CT scans were obtained for monitoring of the subdural collection and determination of the length of drainage.

For the traditional group, 1 or 2 bur holes or small craniotomy was made overlying the thickest portion of the SDH in the typical described fashion. Saline irrigation was then copiously infused into the subdural space and, depending on surgeon preference, a subdural catheter was sometimes placed. Duration of drainage was based on drain output and CT scan appearance.

Statistical Analysis

The Fisher exact test was used to evaluate differences in demographic features. Two-tailed, unpaired Student t-tests were performed to evaluate for differences in initial volume, final volume, and change in subdural volume between the SEPS and traditional methods groups. The change in volume was standardized between procedures and among patients by using the percentage change in volume measured by the following equation: [1-(final volume/initial volume)] × 100. In addition, a subgroup analysis was performed to evaluate differences in outcome between the use of bur hole and small craniotomy.

Results

The groups did not differ significantly with respect to demographic features (Table 1). The average age of patients in the SEPS group was 68 years (95% CI 62–75 years, range 38–95 years) compared with an average age of 61 years in the traditional group (95% CI 52–70 years, range 2–84 years). This difference did not reach statistical significance (p = 0.17). There was a male predominance in both groups (65% vs 68%, respectively; p = 1). Overall, more patients reported trauma in the SEPS group (82.6%) than in the traditional methods group (59%), but this difference did not reach statistical significance (p = 0.1075). The incidence of seizures was similar in both groups, and the presence of any oral anticoagulant was similar. The percentage of patients presenting with a neurological deficit was 71.4% and 65.2% in the SEPS and traditional groups, respectively. A variety of neurological deficits were noted including, but not limited to, confusion, cranial nerve palsies, hemiplegia, and aphasia.

Clinical outcomes did not differ significantly between the 2 groups (Table 2). The inhospital mortality rates in the SEPS and traditional groups were 4.35% (1 of 23) and 9.09% (2 of 22), respectively; this difference was not statistically significant (p = 0.6078). The cause of death in the SEPS group was respiratory failure in the setting of end-stage liver disease in a 53-year-old man. The causes of death in the traditional group were aspiration pneumonia in an 82-year-old woman, and bowel infarction in an 80-year-old woman whose anticoagulation had been reversed with fresh-frozen plasma for surgery. There were no significant differences in length of stay or in the interval between the procedure and discharge.

TABLE 1: Demographic and presenting features of SEPS versus traditional groups

Variable	SEPS	Traditional	p Value
average age in yrs (range)	68 (38–95)	61 (2–84)	0.17
no. <18 yrs old	0	2	0.49
% male	65	68	1
% w/ history of trauma	82.6	59	0.11
% w/ neurological deficit	71.4	65.2	0.75
% w/ seizure	9	17.4	0.67
% w/ anticoagulation	45	33	0.54

Patients were instructed to return for follow-up 4 to 6 weeks after discharge. Four (20%) and 2 (10%) patients in the SEPS and traditional methods groups, respectively, were lost to follow-up (Table 2). Two additional patients in the SEPS group were excluded only from long-term follow-up statistics because they eventually underwent traditional subdural drainage and, therefore, long-term follow up results are not representative of SEPS long-term outcomes. Of the remaining patients who were followed up, 93.8% (15 of 16) and 83.3% (15 of 18), respectively, had radiographically stable or improved SDH at follow up (p = 0.6041). None of the patients with larger SDHs required intervention. The average follow-up intervals prior to discharge from neurosurgical care for the SEPS and traditional methods groups were 11.5 weeks and 15.8 weeks, respectively.

The initial volume, final volume, and percentage change in volume after treatment did not significantly differ between the SEPS and traditional groups (Fig. 2, Table 3). The average initial volumes of SDH in the SEPS and traditional groups were 94.5 cm^3 (95% CI 75.4–113.5 cm^3) and 112.6 cm^3 (95% CI 88.6–136.7 cm^3), respec-

TABLE 2: Clinical outcome of SEPS versus traditional groups*

Variable	SEPS	Traditional	p Value
mortality %	4.35	9.09	0.61
LOS in days (range)	11 (3–29)	9.1 (2–22)	0.48
interval from procedure to discharge in days (range)	7 (2–16)	7.8 (2–22)	0.57
% lost to follow-up	20 (4/20)	10 (2/20)	0.66
% stable SDH at follow-up	93.8 (15/16)	83.3 (15/18)	0.60
average follow-up in wks (range)	11.5 (2–30)	15.8 (4–52)	0.30

* LOS = length of stay.

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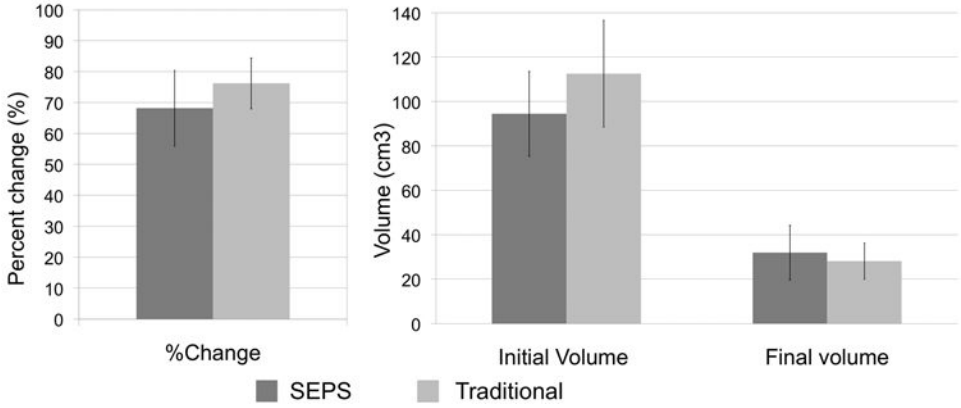


Fig. 2. Bar graphs depicting comparisons of SEPS versus traditional methods for initial volume, final volume, and percentage change (95% CIs depicted within the bars). There were no statistically significant differences between the SEPS and traditional groups.

tively (p = 0.25). The average final volumes in the SEPS and traditional groups were 31.9 cm^3 (95% CI 19.7–44.2 cm^3) and 28.18 cm^3 (95% CI 19.9–36.4 cm^3), respectively (p = 0.65). The average percentage changes, calculated as described above, also did not significantly differ. The average percentage changes for the SEPS and traditional groups were 68.2% (95% CI 57.6%–78.8%) and 76.2% (95% CI 68.0%–84.4%), respectively (p = 0.25).

Four of the 23 patients treated with SEPS were deemed to have an unsatisfactory radiographic resolution of their SDH. Two of these 4 patients then underwent bur hole evacuation, and both subsequently experienced satisfactory resolution of their SDH. The remaining 2 patients did not undergo further operative intervention. The first of these patients experienced clinical improvement despite poor radiographic improvement; therefore, further operative intervention was not pursued. The final patient had a complex SDH with multiple septations and, on presentation, was believed to require bur hole or small craniotomy instead of SEPS. This patient had multiple medical comorbidities and end-stage liver disease; therefore, general anesthesia was believed to be high risk, and thus bedside SEPS was attempted as an alternative treatment. This attempt led to minimal resolution of his SDH and he died during his hospitalization due to complications of end-stage liver disease. No patient from the traditional group had an unsatisfactory result or recurrence.

The traditional methods group included both bur hole and craniotomy with and without the placement of a subdural drain. A subgroup analysis was performed to determine if there was a difference between these 2 methods. Again, there was no statistically significant difference between initial volume, final volume, and percentage change (Table 4). The average initial volumes of SDH in the bur hole and craniotomy groups were 134.1 cm^3 (95% CI 88.3–179.9 cm^3) and 98.8 cm^3 (95% CI 73.6–123.9 cm^3), respectively (p = 0.16). The average final volumes in the bur hole and craniotomy groups were 31.4 cm^3 (95% CI 11.7–51.0 cm^3) and 26.1 cm^3 (95% CI 14.1–38.1 cm^3), respectively (p = 0.64). The average percentage change also did not differ: 76.7% (95% CI 61.8%–91.6%) for the bur hole group and 75.9% (95% CI 65.9%–85.9%) for the craniotomy group (p = 0.93).

The traditional groups also differed in whether a subdural drain was placed and maintained postoperatively (Fig. 3). Surprisingly, despite a similar average initial volume, patients without subdural drains had significantly greater average volume changes and lower final volumes than those in whom subdural drains were placed. The average initial volumes of SDH in the subdural drain and no subdural drain groups were 123.2 cm^3 (95% CI 96.7–149.6 cm^3) and 98.9 cm^3 (95% CI 55.29–142.47 cm^3), respectively (p = 0.33). The average final volumes in the subdural drain and no subdural drain groups were 40.1 cm^3 (95% CI 27.7–52.6 cm^3) and 12.6 cm^3 (95% CI 0.19–25.0 cm^3), respectively (p = 0.0067). The average percentage changes for the subdural drain and no subdural drain groups were 64.4% (95% CI 54.7%–74.1%) and 91.6% (95% CI 85.5%–97.8%), respectively (p = 0.00029).

Discussion

The incidence of chronic SDH in the general population is difficult to estimate with certainty. However, it is a common condition treated by neurosurgeons and, given the association of SDHs with increasing age and with antico-

TABLE 3: Radiographic outcomes for SEPS and traditional methods for evacuation of SDH*

Radiographic Variable	SEPS (95% CI)	Traditional (95% CI)	p Value
initial vol in cm^3	94.5 (75.4–113.5)	112.6 (88.6–136.7)	0.25
final vol in cm^3	31.9 (19.7–44.2)	28.18 (19.9–36.4)	0.65
percentage change	68.2 (57.6–78.8)	76.2 (68.0–84.4)	0.25

* There were no statistically significant differences between any of these parameters.

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TABLE 4: Outcomes associated with bur hole and with craniotomy for evacuation of SDH*

Variable	Bur Hole (95% CI)	Craniotomy (95% CI)	p Value
no. of patients	9	14	
initial vol (cm^3)	134.1 (88.3–179.9)	98.8 (73.6–123.9)	0.16
final vol (cm^3)	31.4 (11.7–51.0)	26.1 (14.1–38.1)	0.64
percentage change	76.7 (61.8–91.6)	75.9 (65.9–85.9)	0.93
% w/ subdural drain	66	50	

* There were no statistically significant differences between any of these parameters.

agulation, its prevalence is likely to increase as the population of the US ages. The methods for treating symptomatic chronic SDH have traditionally been operative evacuation through a bur hole or a craniotomy, with or without placement of a subdural drain. This generally requires general anesthesia and a stay in an intensive care unit. As patients are becoming increasingly older and as medical care improves over time, patients are likely to present with advanced age and significant comorbidities that place them at high risk for operative complications. Thus, bedside drainage via the SEPS method provides an attractive alternative method for treatment of chronic SDH.

As previously noted, the initial volume of chronic SDH in the SEPS and traditional methods groups was similar ($p = 0.25$). The final volume of SDH was 31.9 cm^3 and 28.2 cm^3 in the SEPS and traditional groups, respectively. This difference was not statistically significant ($p = 0.65$), and furthermore was not clinically significant. The percentage change was similar in the 2 groups as well ($p = 0.25$). The results of this study show that SEPS provides similar outcomes to traditional methods of chronic SDH evacuation and is a safe and effective method. In addition, there was no significant difference between SEPS and either bur hole or craniotomy with respect to final subdural volume ($p = 0.65$ and 0.26, respectively) and percentage change for final volume ($p = 0.17$ and 0.12, respectively).

Based on these findings, our center now always attempts SEPS drainage of chronic SDH prior to proceeding with operative evacuation via traditional methods unless other extenuating factors, such as extensive membrane formation or patient/family preference, are present. As previously mentioned, only 4 of 23 SEPS procedures were considered to have inadequate radiographic evacuation of the SDH. Despite this, only 2 patients then proceeded to undergo traditional evacuation via bur hole placement. In these patients, the smaller bur hole made at the bedside was enlarged and used for evacuation of the SDH. The reoperation rate after traditional methods has been reported to be between 12% and 23%[3,11] and our study finds a similar rate with SEPS usage. Although not noted in this series of patients, acute SDH as a complication of SEPS placement has been reported.[21] We have observed this complication in 1 patient after enrollment into this prospectively compiled database was completed.

The data in this paper support noninferiority of bedside SEPS drainage compared with traditional methods with respect to radiographic resolution of SDH. In addition, we have shown that SEPS drainage produces similar results in regard to mortality, length of stay, and stability of SDH at an average follow-up duration of 12 weeks.

Subdural evacuating port system drainage is increasingly being used for the treatment of chronic SDH. Yet there are only 2 publications that evaluated outcomes of SEPS drainage versus outcomes of traditional methods. A noncontrolled retrospective chart review of 74 patients by Kenning et al.[9] showed that SEPS was effective and safe. These investigators reported a 74% radiographic success rate, a rate similar to the current study. However, this was a retrospective chart review with no control group and a significant number of patients lost to follow-up. Rughani et al.[21] also showed no radiographic difference in SDH thickness or recurrence rates between SEPS and a con-

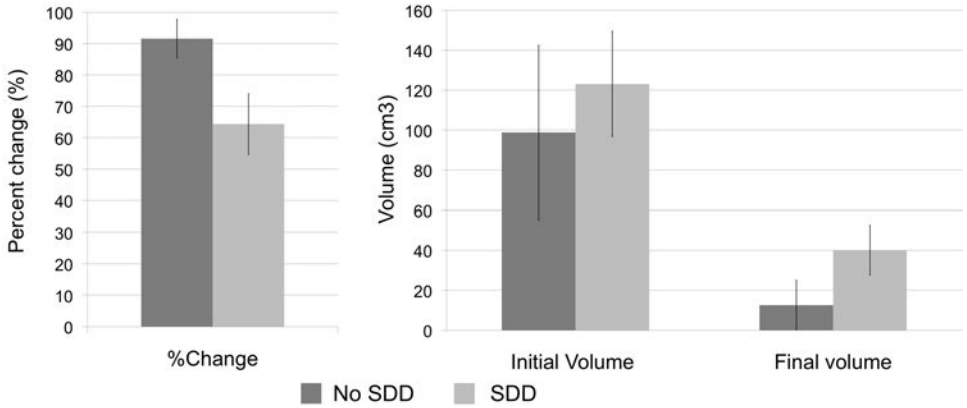


Fig. 3. Bar graphs depicting resolution of SDH in the traditional methods group (bur hole and craniotomy) with and without placement of a postoperative subdural drain (SDD; 95% CIs depicted within bars). Patients without SDDs had a significantly higher rate of SDH resolution as compared with patients with SDD placement ($p = 0.00029$).

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trol bur-hole treatment group with a similar radiographic recurrence rate to both the Kenning study as well as the current study. Our results provide further evidence that SEPS drainage is a safe and effective method of chronic SDH treatment. Furthermore, our study evaluates subdural volume instead of thickness, which provides a more accurate measurement of SDH size. In addition, our study shows that the treatment effect of SEPS drainage is durable. Only 4 of 20 patients treated successfully with SEPS were lost to follow-up, and of the 16 patients who underwent follow-up evaluation, 15 (93.8%) had stable or improved SDH at an average follow up of 11.5 weeks (range 2–30 weeks). In comparison, of the 20 patients treated successfully with traditional methods, 2 were lost to follow-up. Of the 18 remaining patients, 15 (83.3%) had stable or improved chronic SDH at an average follow-up of 15.8 weeks (range 4–52 weeks).

This study does have some limitations. First, although the database is a prospectively compiled series, the data were acquired through a retrospective chart review and patients were not randomized. Patients undergoing traditional evacuation of SDH were treated between November 28, 2005, and January 24, 2007, and patients undergoing SEPS drainage were treated between November 20, 2006, and December 29, 2009. We intentionally chose adjoining time periods with minimal overlap instead of overlapping time periods to minimize selection bias. We first began using SEPS drainage in November 2006; thus, many of the SDHs treated by the traditional methods prior to this date would likely have been amenable to SEPS drainage as well. The choice of adjoining time periods reduces the tendency of selecting simple chronic SDHs for SEPS drainage and more complex SDHs for evacuation via traditional methods. Patients treated in these 2 time periods received similar medical management and differed only by the treatment option that was offered. Furthermore, there was a very small learning curve associated with SEPS drainage, but this learning curve would tend to skew the results toward inferiority of SEPS compared with traditional methods because all of these procedures were performed by attending neurosurgeons well versed with traditional methods of chronic SDH evacuation.

Finally, although the placement of a subdural catheter intraoperatively does not pertain to SEPS drainage per se, it was interesting to note that the absence of a subdural catheter was associated with a lower final SDH volume and a greater percentage change. The decision to leave a subdural catheter is often made intraoperatively and is also heavily affected by surgeon preference. It is unclear why we found this result. It may be that the presence of a subdural catheter may create a potential space in which fluid may accumulate or irritate the dura or subdural membranes, causing additional fluid accumulation. Further studies are needed to understand the significance of this finding.

Conclusions

Our results show that SEPS is a viable alternative to traditional methods of evacuation of chronic SDHs and should be considered in patients presenting with chronic SDH.

Disclosure

Dr. Malek has overseen support of non–study-related clinical or research effort for Stryker Neurovascular, Codman Neurovascular, and Microvention-Terumo.

Author contributions to the study and manuscript preparation include the following. Conception and design: Riesenburger, Safain, Schirmer. Acquisition of data: Safain, Antoniou, Schirmer. Analysis and interpretation of data: Riesenburger, Safain, Roguski, Schirmer, Malek. Drafting the article: Safain, Roguski. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Statistical analysis: Roguski. Administrative/technical/material support: Riesenburger. Study supervision: Riesenburger, Safain, Schirmer, Malek.

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