J Neurosurg 113:1004–1010, 2010

Analysis of the subdural evacuating port system for the treatment of subacute and chronic subdural hematomas

Clinical article

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Object. The subdural evacuating port system (SEPS; Medtronic, Inc.) is a minimally invasive means of draining subacute or chronic subdural fluid collections. The purpose of this study was to examine a single institution's results with the SEPS.

Methods. A retrospective chart review was undertaken for all patients who underwent SEPS drainage of subdural collections. Demographic and radiographic characteristics were evaluated. Both pre- and post-SEPS CT studies were analyzed to determine the volume of subdural collection and midline shift. Hospital charts were reviewed for SEPS output, and periprocedural complications were noted. Results were classified as a success (S) or failure (F) based on the need for further subdural drainage procedures. Groups were then compared to identify factors predictive of success.

Results. Eighty-five subdural collections were treated in 74 patients (unilateral collections in 63 patients and bilateral in 11). Sixty-three collections (74%) were successfully drained. In a comparison of the success and failure groups, there were no statistically significant differences ($p < 0.05$) in the mean age pre-SEPS, Glasgow Coma Scale score, presenting symptoms, underlying coagulopathy or use of anticoagulation/antiplatelet agents, laterality of SDH, pre-SEPS subdural volume or midline shift, or any of the measurements used to characterize SEPS placement. There were a greater number of male patients in the success group (45 [82%] of 55 patients vs 11 [58%] of 19 patients; $p = 0.04$). The only statistically significant ($p < 0.05$) factor predictive of success was the radiographic appearance of the subdural collection. More hypodense collections were successfully treated (32 [51%] of 63 collections vs 4 [18%] of 22 collections; $p = 0.005$), whereas mixed density collections were more likely to fail SEPS treatment (S: 11 [17%] of 63 collections vs F: 14 [64%] of 22 collections; $p < 0.00001$). In the success group, the percentage of the collection drained after SEPS was greater (S: 47.1 ± 32.8% vs F: 19.8 ± 28.2%; $p = 0.001$) and a larger output was drained (S: 190.7 ± 221.5 ml vs F: 60.2 ± 63.3 ml; $p = 0.001$). In the patients with available but delayed scans (≥ 30 days since SEPS placement), the residual subdural collection following successful SEPS evacuation was nearly identical to that remaining after open surgical evacuation in the failure group. In 2 cases (2.4% of total devices used), SEPS placement caused a new acute subdural component, necessitating emergency evacuation in 1 patient.

Conclusions. The SEPS is a safe and effective treatment option for draining subacute and chronic SDHs. The system can be used quickly with local anesthesia only, making it ideal in elderly or sick patients who might not tolerate the physiological stress of a craniotomy under general anesthesia. Computed tomography is useful in predicting which subdural collections are most amenable to SEPS drainage. Specifically, hypodense subdural collections drain more effectively through an SEPS than do mixed density collections. Although significant bleeding after SEPS insertion was uncommon, 1 patient in the series required urgent surgical hematoma evacuation due to iatrogenic injury.
(DOI: 10.3171/2010.5.JNS1083)

Key Words • subdural hematoma • minimally invasive technique • subdural evacuating port system

The traditional operative intervention for draining radiographically hypodense subdural fluid collections is twist drill or bur hole craniostomy or craniotomy. Each of these modalities aims to drain the liquid component of the hematoma, while also fenestrating or removing subdural membranes to varying degrees in an effort to prevent hematoma reaccumulation. Although it is the most definitive treatment for chronic or subacute subdural collections, craniotomy in this setting is associated with significant morbidity (0–25%) and mortality (0–11%) rates.[17] Therefore, less invasive techniques that can be performed without the attendant risks of general anesthesia, including bur hole and twist drill craniostomy, have been used as alternatives. Another such technique involves the use of the SEPS (Medtronic, Inc.), a quick and simple bedside procedure that can be performed with local analgesia and conscious sedation.

As a minimally invasive system, the SEPS can limit the morbidity generally associated with traditional SDH evacuation.[5,9,11,12,15,17] Lower morbidity can be particularly beneficial to patients with serious cardiac and pulmonary

Abbreviations used in this paper: F = failure; GCS = Glasgow Coma Scale; SDH = subdural hematoma; S = success; SEPS = subdural evacuating port system.

pathology in whom the inherent risks of general anesthesia are high, as is the probability of a prolonged need for ventilatory support.[3] Furthermore, as many patients with SDHs have medical comorbidities requiring the use of anticoagulant medications,[6,14] the potential for periprocedural blood loss and hemorrhage-related complications can be minimized with a less invasive approach. Additionally, the evacuation of SDHs has been shown to increase the risk of postoperative seizures.[10] The lack of a subdural component to the SEPS device may limit this morbidity by eliminating the cortical irritation and potential epileptogenic nature of intraoperative catheters used for irrigation or postoperative drains.

As with all newly introduced medical devices, a rigorous investigation of the efficacy and safety of the SEPS must be conducted to support its routine use and purported benefits. Recently, Rughani et al.[13] published a study comparing the SEPS to bur hole craniostomy and concluded that the 2 treatments were similar in safety and efficacy. That study included 21 patients who underwent SEPS drainage. To date, a review of this drainage system in a larger series of patients has not been published. The current study was designed to evaluate the effectiveness of SEPS in evacuating presumed subacute and chronic subdural fluid collections without having to perform an additional craniostomy or craniotomy. In addition, we attempted to identify any risk factors that may be associated with the need for further operative intervention following attempted SEPS drainage.

Methods

Patient Characteristics

We conducted a retrospective review of patients who underwent placement of an SEPS for the treatment of a subdural fluid collection. These patients were all treated at a single institution (Albany Medical Center) over a 53-month period (October 2005 to February 2010).

Surgical Decision Making

In the current series of patients, the decision to place an SEPS was made by the treating neurosurgeon. In general, if a symptomatic patient presented with a subdural fluid collection that was largely iso- or hypodense on CT scanning, he or she was considered for SEPS placement. No patient had a predominantly acute SDH. Presenting symptoms included headaches, confusion/disorientation, lethargy, hemiparesis, ataxia, seizures, aphasia, and postcraniectomy hygromas. One patient was treated after experiencing an acute cerebral herniation syndrome from bilateral subdural hygromas.

Surgical Technique

Each SEPS was placed in patients in the emergency department, an intensive care unit, a neurological step-down unit, or, occasionally, the operating room. The system was placed with minimal intravenous analgesia and sedation along with a local anesthetic, using the method described by Asfora and Schwebach.[1] Briefly, once the decision to place an SEPS is made, any underlying coagulopathy, either pathological or pharmaceutically induced, is corrected and prophylactic intravenous antibiotics are administered. Device placement is usually planned to occur over the area of the subdural collection's greatest thickness. Hair on the overlying scalp is clipped, and the area is prepared and draped in the usual fashion. An approximately 2-cm skin incision is made, and the underlying periosteum is stripped from the skull. A hand drill is used to create a twist hole. A durotomy is made using a scalpel, and the stainless steel evacuating port is threaded into the bur hole. The silicone tubing and accompanying suction reservoir bulb are attached to the evacuation port. Low negative pressure is applied to the bulb in a manner similar to that used for a Jackson-Pratt surgical drain, allowing for external drainage of the subdural fluid. A 1-way valve mechanism inside the bulb prevents fluid reflux from the bulb back into the subdural space.

While undergoing SEPS drainage, all patients were closely monitored in either an intensive care unit or a neurological step-down unit. Draining was discontinued when drainage output decreased to a nominal amount (usually < 20 ml daily), when a significant improvement was seen in the radiological appearance of the subdural collection, and/or when the patient's symptoms resolved. The SEPS was considered a failure when a patient required formal operative evacuation of the subdural collection via craniotomy or bur hole craniostomy. Such failure occurred when the SEPS output was considered inadequate, when sufficient improvement in the size of the SDH was not seen on cranial CT, and/or when the patient's symptoms persisted or worsened.

Patient Demographics

Presenting demographics reviewed for each patient included the following: age, sex, presenting symptoms, preprocedural GCS score, main presenting symptom, presence of preprocedural coagulopathy, including the use of anticoagulation or antiplatelet agents, and laterality and CT density of subdural collection. The latter was determined by 3 independent neurosurgeons, each blinded to the treatment and outcome of the patients (Fig. 1). In the few cases in which all 3 neurosurgeons did not agree, the predominating characterization of the subdural collection was used and validated against the official radiological report.

Radiographic Analysis

For each patient undergoing SEPS drainage, both the immediate preprocedural and postprocedural cranial CT studies were reviewed and classified based on the SDH volume (using the ABC/2 method previously verified[16]) and the degree of midline shift. The immediate post-SEPS CT was analyzed to characterize placement of the system. Any subsequent cranial imaging was reviewed to determine the long-term efficacy of subdural drainage.

Clinical Analysis

The clinical inpatient chart was reviewed for each patient to determine the duration of drainage via the SEPS, the total as well as the daily volume (ml) of SEPS output, and the need for further operative evacuation of the sub-

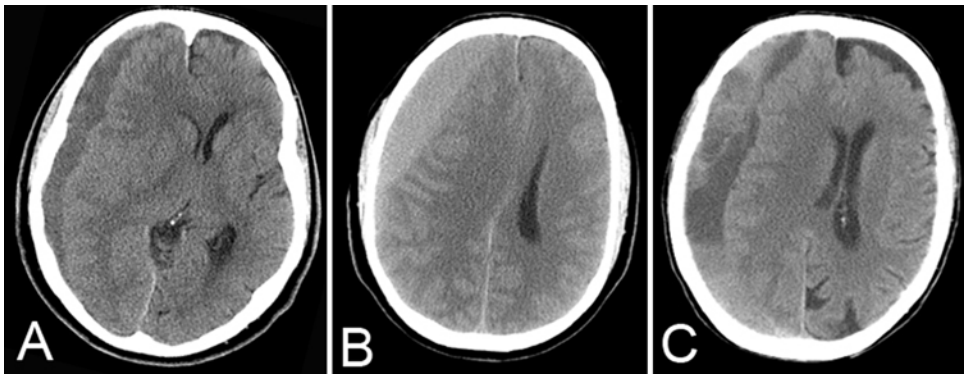

Fig. 1. Axial cranial CT scans demonstrating differing density collections. **A:** Right hypodense SDH. **B:** Right isodense SDH. **C:** Right mixed density SDH.

dural collection (that is, craniotomy or bur hole craniostomy in the operating room). The results of SEPS placement were classified as a success (S) or failure (F) based on the need for further operative intervention. These groups were compared to identify risk factors predictive of SEPS failure.

Statistical Analysis

Clinical and radiographic characteristics were compared between the success and failure groups. The independent 2-sample t-test was used for comparison of the variables of normal distribution. For nonparametric analysis, the Wilcoxon-Mann-Whitney test was used. Statistical significance was defined as $p < 0.05$.

Results

Data for 80 patients who underwent placement of an SEPS for the treatment of a subdural fluid collection were reviewed. Six of these patients were excluded from our analysis because of the unavailability of pre-SEPS cranial imaging, and thus making for a cohort of 74 patients. Sixty-three patients presented with unilateral subdural collections and 11 presented with bilateral collections. In total, 85 subdural collections were treated with the SEPS. The system was successful in 63 cases (74%) and failed in 22 (26%) requiring further surgical evacuation.

Patient Demographics

In comparing the success and failure groups, among the pre-SEPS demographic variables, there were no significant differences ($p < 0.05$) in any of the following categories: patient age, presenting GCS score, presenting symptoms, presence of coagulopathy, use of anticoagulation/antiplatelet agents including specific agents, and unilateral or bilateral location of collections (Table 1); however, there was a greater number of males in the success group ($p = 0.04$). In addition, more of the subdural collections responding favorably to the SEPS were hypodense ($p = 0.005$), whereas more mixed density hematomas were in the failure group ($p < 0.00001$). The treatment of isodense collections was equivocal, as no statistically significant difference existed between the success and failure groups.

Radiographic Analysis

Analyzing the immediate pre- and post-SEPS cranial CT studies for both the success and failure groups revealed no significant differences in laterality or location of SEPS placement in terms of the relationship to the superior temporal line, middle fossa floor, and coronal suture (Table 2). The volume of the pre-SEPS subdural collection as

TABLE 1: Summary of demographics in 74 patients with SDHs*

Characteristic	Treatment Success	Treatment Failure	p Value
no. of patients	55	19	
mean age in yrs	69.2 ± 17.1	75.1 ± 14.6	NS
M/F ratio	45:10	11:8	0.04
presenting mean GCS score	13.2 ± 2.8	14.6 ± 0.8	NS
main presenting symptom (%)			
headache	17 (31)	4 (21)	NS
confusion	8 (15)	3 (16)	NS
lethargy	4 (7)	2 (11)	NS
paresis	10 (18)	6 (32)	NS
ataxia	11 (20)	4 (21)	NS
aphasia	3 (5)	1 (5)	NS
postcraniectomy	4 (7)	0 (0)	NS
cerebral herniation syndrome	1 (2)	0 (0)	NS
seizure	2 (4)	0 (0)	NS
anticoagulation/antiplatelet (%)	29 (53)	14 (72)	NS
ASA/Plavix	18 (33)	7 (39)	NS
Coumadin	13 (24)	7 (33)	NS
ESLD	1 (2)	0 (0)	NS
treated subdural collections	63	22	
unilat/bilat collections ratio	47:8	16:3	NS
SDH character			
hypodense	32 (51)	4 (18)	0.005
isodense	20 (32)	4 (18)	NS
mixed density	11 (17)	14 (64)	<0.00001

* ASA = aspirin; ESLD = end-stage liver disease; NS = not significant.

TABLE 2: Summary of characteristics regarding SEPS placement*

Characteristic	Treatment Success	Treatment Failure	p Value
no. treated subdural collections (%)	55 (72)	21 (28)	
laterality of SEPS			
rt	29	10	NS
lt	26	11	NS
relation to superior temporal line			
above	41	15	NS
below	14	6	NS
mean distance above middle fossa floor	74.5 ± 16.2	70.1 ± 16.3	NS
relation to coronal suture			
ant	26	7	NS
pst	29	13	NS
mean distance from coronal suture	18.4 ± 18.7	13.5 ± 9.7	NS

* ant = anterior; MLS = midline shift; pst = posterior.

TABLE 3: Summary of radiographic characteristics*

Characteristic	Treatment Success	Treatment Failure	p Value
pre-SEPS			
mean SDH vol (ml)	107.8 ± 54.6	129.3 ± 61.0	NS
mean MLS (mm)	7.6 ± 5.2	8.1 ± 5.6	NS
immediate post-SEPS			
mean SDH vol (ml)	53.9 ± 34.3	94.8 ± 32.3	<0.00001
mean % evacuated	47.1 ± 32.8	19.8 ± 28.2	0.001
mean MLS (mm)	3.9 ± 3.4	6.4 ± 5.4	NS
mean % MLS change	47.5 ± 34.4	22.0 ± 29.2	0.005
last available CT post-SEPS			
mean time since SEPS (days)	70.9 ± 76.0	NA	NA
mean SDH vol (ml)	28.1 ± 32.5	NA	NA
mean % evacuated	75.0 ± 26.7	NA	NA
mean MLS (mm)	1.8 ± 4.1	NA	NA
mean % MLS change	83.0 ± 33.5	NA	NA
≥30 days postintervention CT			
mean time since intervention (days)	108.2 ± 77.3†	76.9 ± 46.2‡	NS
mean SDH vol (ml)	24.7 ± 34.7†	15.5 ± 18.0‡	NS
mean % evacuated	80.3 ± 22.5†	81.1 ± 24.6‡	NS
mean MLS (mm)	0.6 ± 1.3†	0.4 ± 1.1‡	NS
mean % MLS change	93.3 ± 10.8†	90.0 ± 22.4‡	NS

* NA = not applicable.
† Post-SEPS.
‡ Postcraniotomy.

well as the degree of midline shift was similar between the 2 groups (Table 3). As expected, the post-SEPS CT scans revealed several significant differences. The SDH volume was smaller in the patients in the success group (S: 53.9 ± 34.3 ml vs F: 94.8 ± 32.3 ml; $p < 0.00001$), and the SEPS in these patients evacuated a greater percentage of the initial collection (S: 47.1 ± 32.8% vs F: 19.8 ± 28.2%; $p = 0.001$). While the initial magnitude of the midline shift was not different, when compared with the pre-SEPS CT, a greater percent change in the midline shift occurred in the success group (S: 47.5 ± 34.4% vs F: 22.0 ± 29.2%; $p = 0.005$).

In the success group, the effects of SEPS drainage were long lasting, as demonstrated on the last available post-SEPS CT scans for these patients; results were the same even when our analysis was limited to only 20 patients with images obtained at least 30 days after SEPS placement. In both sets of CT studies, roughly 80% of the subdural collection had been removed by the SEPS, and after a month, any midline shift had almost completely resolved. These results were nearly identical to the findings on follow-up cranial imaging in patients whose SEPS drainage failed and required operative evacuation in the operating room.

Clinical Analysis

Eighty-five subdural collections were treated with SEPS drainage. Except in 4 patients, each collection was treated with a single SEPS device. In these other 4 patients, before removal of the initial SEPS, a second device was placed to attempt drainage of a residual, presumably loculated, collection. This strategy was successful in avoiding further surgical intervention in 2 of these 4 patients.

Output on the first day of SEPS drainage (S: 160.3 ± 98.1 ml vs F: 38.3 ± 47.3 ml; $p = 0.001$) as well as the overall total output (S: 190.7 ± 221.5 ml vs F: 60.2 ± 63.3 ml; $p = 0.001$) was significantly greater in the success group than in the failure group (Table 4). Comparing daily outputs for drainage Days 2–5, there were no significant differences between the 2 groups. The duration of SEPS drainage was similar between the 2 groups (S: 2.6 ± 0.9 days vs F: 2.3 ± 1.2 days; $p > 0.05$).

In patients classified as having an SEPS failure, the time between the revision surgery and initial SEPS placement was 3.6 ± 3.8 days (range 0–17 days). All of these patients were treated with craniotomies for SDH evacuation; the exception was 1 patient in whom bur hole craniostomies were initially attempted for bilateral collections. This procedure also failed, and bilateral craniotomies were performed 16 days later. This patient was the only one to require more than 1 operation for the treatment of an SDH after SEPS drainage failed. Almost universally, the intraoperative findings in patients with a failed procedure included fibrinous SDHs with significant membrane formation.

In 8 patients (11% of total), SEPS placement resulted in an increase in the volume of the ipsilateral subdural collection according to immediate follow-up imaging. While the collection was minimal in 2 patients, subdural volume increased by at least 15% compared with its

TABLE 4: Summary of clinical analysis*

Characteristic	Treatment Success	Treatment Failure	p Value
mean SEPS output			
total	190.7 ± 221.5	60.2 ± 63.3	0.001
Day 1	160.3 ± 98.1	38.3 ± 47.3	0.001
Day 2	49.4 ± 86.6	12.1 ± 14.6	NS
Day 3	52.7 ± 91.4	24.7 ± 22.1	NS
Day 4	60.6 ± 56.8	4.5 ± 1.0	NS
Day 5	1.0 ± 1.7	NA	NA
mean days of SEPS drainage	2.6 ± 0.9	2.3 ± 1.2	NS
mean days btwn SEPS placement & OR evac	NA	3.6 ± 3.8	NA

* OR evac = operating room evacuation.

pre-SEPS imaging appearance in 6 patients. Of these 8 patients, 4 each were in the success and failure groups. Four of the 8 patients were treated with bilateral SEPS devices and demonstrated an increase in the hypodense volume of a unilateral collection after near resolution of the contralateral side. This unilateral collection required eventual surgical evacuation in 2 patients. The immediate post-SEPS imaging in the other 2 patients in the success group revealed a new CSF subdural hygroma ipsilateral to a decreased SDH. Both of these patients eventually demonstrated complete resolution of these collections on delayed imaging (> 30 days post-SEPS). Finally, SEPS placement in 2 other patients in the failed procedure group resulted in a new acute component to the SDH. While the increased volume was small and asymptomatic in 1 patient, emergency craniotomy was required for a large acute SDH and neurological deterioration following SEPS placement in the other patient, who had been taking aspirin and clopidogrel preoperatively. Intraoperatively, both a cortical vein and an adjacent artery were lacerated at the site of SEPS placement.

Discussion

The utilization of a hollow cranial screw with an attached catheter and hermetically sealed drainage system is not a novel technique and has been reported in various forms.[2,4] Similar to these other methods, the SEPS is attractive as a means of evacuating SDHs while avoiding general anesthesia and the other associated risks of craniotomy. Additionally, it can be quickly performed at the bedside under local anesthesia and does not involve intrusion into the subdural space. While these latter characteristics may be shared with traditional twist drill or bur hole drainage, an analysis of a large group of patients treated with the SEPS is required to determine the system's efficacy and risk factors for failure.

Our review of the SEPS at our institution over a 53-month period indicates that it is a reasonable therapy for subacute and chronic SDHs. We considered the use of the device successful when further operative interventions were avoided. Our overall success rate of 74% was nearly identical to the 74.1% described by Rughani et al.[13] and fell within the widely reported range of recurrence rates documented in other studies of twist drill or bur hole drainage and craniotomy.[5,7–9,12,15,17]

The only identified risk factor for the failure of SEPS treatment was the radiological characterization of the subdural collection: hypodense collections were more likely to respond favorably to SEPS drainage, whereas mixed density collections failed more frequently and required further operative intervention. The SEPS treatment of these mixed density collections was likely limited by the membranous septations that were later noted during surgery. Given that both hypodense and mixed density hematomas were found in each group (that is, success and failure groups), this characterization alone will not define successful SEPS drainage. Therefore, we believe the device can be considered in the treatment of all SDHs with a sizeable hypodense component. Furthermore, because there was no statistically significant difference between the success and failure groups with isodense collections, we believe that the treatment of such patients by using an SEPS is reasonable as long as these patients can be closely and safely observed.

Surprisingly, an underlying coagulopathy did not predict the failure of SEPS drainage; this remained true even when the cause of the coagulopathy was stratified into individual agents (for example, aspirin/clopidogrel or Coumadin). Although a greater percentage of patients in the failure group were taking these medications at the time of admission, this factor was not statistically significant. Neither did a patient's presenting symptom(s) significantly affect SEPS drainage. Given that patients with seizures, cerebral herniation syndromes, and some degree of limb paresis were all treated successfully and definitively with an SEPS, the severity of a patient's symptoms should not necessarily limit placement of the device for the treatment of a subacute or chronic SDH. In fact, for a patient with significant neurological symptoms and a low-density collection, an SEPS might be the ideal treatment because it can be easily and rapidly placed.

We performed a number of calculations to determine the ideal location for the placement of an SEPS. As the majority of subdural collections in this study were located within the frontotemporoparietal region, the 2 areas of interest were the relation to the coronal suture and the superior temporal line/middle fossa floor. The coronal suture was examined because it was initially speculated that placing the SEPS as close as possible to the suture and its dural attachment would allow continued effectiveness of the device as the collection drained and any potential expansion of the epidural space occurred. This theory was revealed to be untrue, as it appeared that the device's location in the anteroposterior direction was not significant. Furthermore, we evaluated the height of SEPS placement in the superoinferior cranial direction. It was originally believed that if the device was placed too low and through the temporalis muscle, muscular bleeding could cause acute blood to enter the subdural space during placement. Moreover, it was believed that low placement would ultimately result in the SEPS being less effective because as

the hematoma drained, the brain parenchyma would fill the lower portion of the subdural space and the remaining collection would be forced superiorly. Again, these considerations did not prove true in our study. As a result, we recommend placing the SEPS drain over the subdural collection's area of greatest depth.

In regard to the definitive nature of SEPS drainage for subdural collections, we reviewed all of the cranial CT scans available after the devices were removed. These imaging studies showed that radiologically SEPS drainage had a lasting effect when successful. This finding remained true when patients with available delayed imaging (≥ 30 days after SEPS removal) were reviewed (20 of 55 patients). In this group, roughly 20% of the original subdural collection remained and almost the entire midline shift had resolved. This reduction rate was greater than the 40.5% reported by Rughani et al.[13] However, their radiological review only extended to a mean of 37.7 days as opposed to the 108.2 days in our study. In fact, our early analysis yielded numbers similar to those in the Rughani et al. study as well as other published series[9] and continued to show improvement with further follow-up. Although limited to only a portion of the patients we designated "successes," our results indicate that the effects of SEPS drainage, when successful in circumventing operative intervention, can be trusted to be long lasting and seldom require further procedures. Further (delayed) imaging was not performed in the remaining 35 patients in the success group because of either resolution of their symptoms on outpatient follow-up (28 patients) or loss to follow-up (7 patients).

When the device is ineffective, however, it is evident shortly after its placement. All patients in whom the procedure failed in this study underwent either a craniotomy or a bur hole craniostomy during the same inpatient stay as the SEPS placement. The 2 signs of SEPS failure, which were statistically significant in this study, consisted of a lack of improvement in radiological imaging and limited SEPS output. A third factor, which was not evaluated here but is at least equally important, is the absence of clinical improvement.

Of importance are the 8 patients who experienced an increase in the volume of their subdural collection following SEPS placement. Four of these patients would require further operative intervention, whereas the other 4 would eventually demonstrate resolution of their collections. Among the 85 systems placed, acute post-SEPS hemorrhage occurred in only 2 patients (2.4%). This rate is comparable with the 4.8% noted by Rughani et al.[13] in their SEPS study as well as with published rates of acute hemorrhage following bur hole craniostomy (5.4–6%) and even craniotomy (4%).[5,9] The other 6 subdural collections with an increase in volume after SEPS placement occurred after resolution of a contralaterally treated subdural collection or because of the formation of a CSF hygroma, which would later resolve.

Study Limitations

Limitations of this study include its retrospective nonrandomized nature, limited size, and lack of long-term clinical outcomes. As there was no standardization regarding which patients would undergo SEPS drainage versus craniotomy or bur hole drainage, selection bias limits the strength of our conclusions. This lack of standardization also applies to the variability in the determination for removal of the SEPS device and reoperation. Because of the heterogeneous radiological appearance of some of the subdural collections, there was not always a consensus among the reviewers regarding the CT characterization of collection density. In 6 patients who had been treated with an SEPS, baseline radiological studies were not available, rendering these patients ineligible for inclusion in the study. Furthermore, several patients were lost to follow-up or did not undergo delayed cranial imaging (> 30 days post-SEPS placement) to fully reveal the lasting effects of SEPS drainage, and therefore, this portion of our analysis was limited to just 20 patients.

Conclusions

Our results suggest that the SEPS drainage of subacute or chronic SDHs is a viable option. The SEPS works best for homogeneous, hypodense subdural collections. Although mixed density collections may respond favorably to this device, patients with these collections are more likely to require further operative intervention.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Kenning. Acquisition of data: Kenning, Drazin. Analysis and interpretation of data: Kenning, Dalfino, German. Drafting the article: Kenning, Adamo. Critically revising the article: Dalfino, German, Adamo. Reviewed final version of the manuscript and approved it for submission: all authors. Statistical analysis: Kenning, Drazin. Administrative/technical/material support: Kenning. Study supervision: Kenning.

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Manuscript submitted January 17, 2010.
Accepted May 4, 2010.
Please include this information when citing this paper: published online May 28, 2010; DOI: 10.3171/2010.5.JNS1083.
A portion of this data was presented in poster abstract form at the 2009 Annual Meeting of the Congress of Neurological Surgeons held in New Orleans, Louisiana, in October 2009.
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