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Management of Chronic Subdural Hematomas with Bedside Placement of Twist Drill Subdural Evacuation Port System: A Single Center Retrospective Review

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Abstract:

Objective: Chronic subdural hematoma (cSDH) is prevalent globally and its management is evolving to minimize morbidity while optimizing theater utilization. We present our institution's experience with subdural evacuation port system (SEPS) as a first-line treatment approach to cSDHs. **Methods**: A retrospective review was performed of patients undergoing bedside SEPS placement in a single institution. Pre- and post-procedural radiographic and clinical data were collected and analyzed to identify predictive variables of procedural success for the SEPS approach. For procedure failures, subsequent procedures were analyzed for rates of success. **Results**: 268 patients were identified for a total of 326 initial procedures. Pre-procedural variables associated with improved odds of a good outcome were: unilateral cSDH, prior use of anticoagulation, GCS > 13 at presentation, larger cSDH, and greater degree of midline shift (MLS). 65% success rate was observed for initial SEPS placement and an overall success of 78% after repeat SEPS. Bilateral SDH with bilateral SEPS placement had 56% success, a significantly lower success rate than unilateral placement (p=0.0147). Patients with subsequent failures underwent craniotomy. Patients who had a successful SEPS procedure had an average LOS of 13 ± 39 days compared to 25 ± 65 in incidents of failure (p=0.047). Average follow-up after discharge was 2.8 ± 3.8 months. **Conclusions**: Bedside SEPS placement is a low-risk option for first-line treatment of cSDH and may spare patients from the risks of general anesthesia while reducing burden on surgical theaters in resource-limited settings. Performing a repeat SEPS procedure is a reasonable surgical option if the first procedure fails to completely evacuate the cSDH.

Key Words: chronic subdural hematoma, SDH, subdural evacuation port system, SEPS, burr hole, chronic subdural hematoma

Introduction:

Chronic subdural hematoma (cSDH) represents an increasingly prevalent disease, affecting around 20 per 100,00 people annually in the United States (1, 2). Initial management is variable with multiple procedures having been proposed historically (3). The most definitive method of cSDH evacuation with minimal recurrence remains the open craniotomy. In some cases, particularly with thick hematoma membranes, large craniotomy is even advocated as the first-line treatment to reduce recurrence (3-6). However, cSDH is most prevalent in the elderly population with multiple medical comorbidities who are increasingly on anticoagulant medications (7). Thus, surgical intervention is often associated with higher complications, with morbidity and mortality of craniotomy for cSDH reaching 25% and 11%, respectively (8).

Burr hole craniotomy (BHC) using a Hudson hand brace, pneumatic drill, or electric drill was adopted early on as a minimally invasive operative technique with reduced overall complications (9). This gained traction with minimal complications, but in exchange had recurrence rates between 2.7% and 37% (3). The natural evolution of this concept became a minimally invasive, single twist burr hole and placement of a closed-system drain that was first reported in 1977 and has gained significant traction in recent years. Since conception, one system that has been adopted is the subdural evacuation port system (SEPS) (Medtronic, Inc., Minneapolis, MN), which has been shown to have relatively high success rates with minimal complication risk, requiring no anesthesia and only moderate sedation and/or local anesthesia (1, 9).

In the present study, we perform a single-center retrospective review of patients with cSDH undergoing the SEPS procedure. We report on clinical and radiographic variables affecting procedural success and recurrence. Our objective is to identify patients who are most likely to have a successful procedure, preventing unnecessary exposure to surgical risk of anesthesia and open craniotomy.

Methods:

Patient selection and data collection

Following institutional review board (IRB) approval, a retrospective database was generated using REDCap (Research Electronic Data Capture) to capture data for the investigation. Billing records from July 2009 to September 2018 were searched for all patients receiving a SEPS for the purpose of treating a cSDH. Patients were excluded if the SEPS device was not used as the first-line treatment, or for evacuation of an epidural hematoma or subdural hygroma. Electronic chart review was completed to obtain age, gender, symptoms upon presentation, Glasgow Coma Scale (GCS), use of anticoagulation/antiplatelet, platelet count, international normalized ratio (INR), length of stay (LOS), discharge disposition and exam at clinic follow-up. Success was evaluated based on two primary endpoints: radiographic resolution of the subdural hematoma and clinical improvement at the time of discharge or clinical follow up. SEPS procedures were considered a failure if the SDH recurred within 30 days or required surgical intervention (craniotomy or burr hole evacuation).

Computed tomography (CT) images were reviewed to calculate degree of midline shift (MLS), maximal SDH thickness, average Hounsfield unit (HU) at the location where the SEPS was placed, and whether septations were present. Maximal hematoma thickness was calculated perpendicular to the skull on coronal views and degree of MLS was measured on the axial slice where the foramen of Monro was present. These measurements were performed both on the pre- and post-procedure CT scan (post-procedure CT scans were routinely performed after removal of the SEPS).

SEPS procedure

Placement of the SEPS drain is performed with local anesthesia at the incision site with or without conscious sedation (1-2 mg of midazolam and 50-100 micrograms of fentanyl). Location of the SEPS drain is generally placed at the discretion of the attending consultant or chief neurosurgical resident, with the most common location being at the greatest maximal thickness of the SDH on the head CT coronal slices, preferably superior to temporalis muscle and posterior to the hairline, while anterior enough to avoid the skull overlying the vein of Trolard and and anterior enough that the patient can still rest their head on a pillow. The external auditory meatus and superior temporal lines are used as landmarks for identifying optimal location on a patient's scalp. A small, 10-15 mm incision is made in the scalp and a twist-drill is used to create a full thickness burr hole the same outer diameter as the threaded port system. An 11-blade is used to penetrate the dura, and spinal needle is used to confirm the opening of dura which can be widened to maintain patency. A threaded SEPS port (bolt) is then screwed in place. Over this outer port an equal diameter plastic tubing connected distally to the suction bulb is secured.

The device is removed if post-procedural head CT demonstrates no residual SDH or if the device fails to have more than 20 cc of output per 12-hour shift despite "stripping" of the drain. The device is also generally removed if the character of the output resembles cerebrospinal fluid. Patients presenting with an elevated INR, or who are on an anticoagulant or antiplatelet medication are reversed based on institutional protocol. In general, any pre-existing antiplatelet or anticoagulant therapy is temporarily discontinued upon admission and re-established approximately two weeks after the procedure.

Statistical analysis

Bivariate analyses were performed to investigate the dependence of the success of the SEPS procedure on the tabulated categorical and continuous patient variables. The statistical tests were conducted for all procedures, regardless of SEPS location, and the location of SEPS placement (left, right, or bilateral) was added as an independent variable in the analysis. For categorical data with only two categories, a chi-square test was performed to investigate the dependence of procedure success on the variables. If the independent variable contained three or more variables, a nonparametric Kruskal-Wallis test was performed. For continuous variables, the mean and standard deviation of each category was calculated, and a t-test was performed to investigate dependence. All statistical tests were performed in MATLAB (Natick, MA, USA).

Results:

Patient demographics and presentation

268 patients were identified with the appropriate inclusion criteria. Average age was 70.4 ± 15 and 98 patients (36.5%) were female. 100 patients (37%) had right sided SEPS placed, 110 had left sided, and 58 patients had bilateral SEPS placed (table 1). A total of 326 procedures were included in the study (with 116 procedures accounting for right and left within the bilateral SEPS cohort). A total of 65% (211 cases) had a successful SEPS procedure, defined as complete resolution of SDH or partial resolution of SDH with complete resolution of symptoms and not requiring a repeat surgery. There were no significant differences in success between females and

males (69% and 62.5%, respectively, p=0.24). Laterality of SEPS placement was not significantly related to success, with right and left placement having 64% and 75% success rate, respectively (p=0.093). Bilateral SDH with bilateral SEPS placement had 56% success, a significantly lower success rate than unilateral placement (p=0.0147).

Patients presenting with a GCS above 13 had a significantly higher rate of success than low GCS groups, 66% compared to 44% (GCS 8-13) and 50% (GCS<8) (p=0.039). However, no other presenting symptoms had any association with success (table 1). Anticoagulation and/or antiplatelet use on admission were significantly associated with success of procedure (p=0.0042). Although a higher platelet count was closely associated with procedural success, this did not reach statistical significance (p=0.06). Patients who had a successful SEPS procedure had an average LOS of 13 ± 39 days compared to 25 ± 65 in incidents of failure (p=0.047). Average follow-up after discharge was 2.8 ± 3.8 months.

Radiographic features

The age of the bleed was identified by HU, visualization, and radiology report (Table 2). Age of bleed was sub-grouped into acute, subacute, chronic, acute on chronic, hygroma, and other. The highest success rates of SEPS were found in hygromas, subacute SDH, and chronic SDH (73%, 71%, and 65%, respectively). However, there was no significance in the determined age of the bleed and resultant procedural success (p>0.05). Furthermore, lobar and hemispheric SDH carried a success rate of 59% and 67%, respectively, but did not reach statistical significance (p=0.19). In contrast, initial size of the subdural was directly correlated with procedural success, regardless of laterality, with larger subdurals more likely to be successful (successful initial size of right: 18.7 ± 7.1 mm and left: 18.6 ± 7.2 mm vs failed initial size of right: 15.9 ± 7.2 mm and left: 15.6 ± 5.6 mm). Successful procedures had a final SDH size of approximately 8.8 mm on average vs 12.9mm for failed (p<0.001). Although initial MLS was not correlated with outcome, a final MLS of 3.1 mm was directly correlated (p<0.001). Evidence of new acute blood (in any intracranial location) on post-SEPS head CT was noted in 30% (99 cases) and significantly reduced the success rate to 57% (p=0.0242).

Patient outcomes

Of all patients undergoing SEPS placement, the success of the initial SEPS procedure was 65% (211 cases). Of the unsuccessful cases (115), 52 underwent replacement of SEPS and had an 85% success rate (44 patients), 6 underwent BHC with a 100% success, and 44 underwent an open craniotomy with 98% success (Table 3). When including repeat SEPS procedures the success rate increases to 78% (256 cases) (Figure 1). The 60-day mortality was 7% while 60% of patients were successfully discharged home with or without home health services (160 patients) (Table 4).

Table 1. Baseline characteristics according to SEPS success

Variables (N*)	Successful	Unsuccessful	p-value
Total Procedures (326)	211 (65%)	115 (35%)	
Gender			
Female (110)	76 (69%)	34 (31%)	
Male (216)	135 (62.5%)	81 (37.5%)	0.24
Age	69.3 ± 13.9	65.8 ± 18	
Side of SDH			
Right (100)	64 (64%)	36 (36%)	0.093
Left (110)	82 (75%)	28 (25%)	0.093
Bilateral (116), 58 patients	65 (56%)	51 (44%)	**0.0147**
Neurological deficits			
Altered mental status (127)	81 (64%)	46 (36%)	0.7756
Headache (131)	79 (60%)	52 (40%)	0.1712
Hemiparesis (102)	69 (68%)	33 (32%)	0.8062
Seizure (12)	5 (42%)	7 (58%)	0.1629
Aphasia	21 (60%)	14 (40%)	0.5359
Falls (95)	60 (63%)	35 (37%)	0.7043
Glascow Coma Score (GCS)			
GCS >13 (300)	199 (66%)	101 (34%)	**0.0390**
GCS 8-13 (16)	7 (44%)	9 (56%)	0.0718
GCS <8 (10)	5 (50%)	5 (50%)	0.5133
Prior known trauma (171)	110 (64%)	61 (36%)	0.84
Alcohol abuse (34)	20 (59%)	14 (41%)	0.36
Anticoagulation (78)	61 (78%)	17 (22%)	**0.0042**
ASA (41)	32 (78%)	9 (22%)	0.0564
Warfarin (31)	24 (77%)	7 (23%)	0.1207
NOAC (10)	8 (80%)	2 (20%)	0.306
Platelet number	237.7 ± 88	214 ± 106	0.06
Length of Stay	13 ± 39	25 ± 65	**0.0473**
Follow-up (months)	2.3 ± 2.5	3.5 ± 4.8	**0.0402**

*SEPS = subdural evacuation port system; SDH = subdural hematoma; ASA = acetylsalicylic acid; NOAC = novel oral anticoagulant. *Counts are based on number of procedures, not individual patients*

Table 2. Radiographic findings

Variable (N*)	Successful	Unsuccessful	p-value
Age of bleed			
Acute (9)	4 (44%)	5 (56%)	0.3485
Subacute (91)	65 (71%)	26 (29%)	0.1149
Chronic (105)	68 (65%)	37 (35%)	0.9921
Acute on chronic (96)	57 (59%)	39 (41%)	0.1916
Hygroma (15)	11 (73%)	4 (27%)	0.4749
Other (3)	2 (67%)	1 (33%)	0.7600
Location			
Lobar (85)	50 (59%)	35 (41%)	0.1866
Holohemispheric (241)	161 (67%)	80 (33%)	0.1866
Average density			
Right (HU)	32.3 ±10.0	34.2 ± 1	0.3586
Left (HU)	32.2 ± 10.7	31.7 ±10.5	0.7877
Membranous on CT (77)	53 (69%)	24 (31%)	0.4844
Brain atrophy (127)	87 (69%)	40 (31%)	0.4400
Initial SDH size			
Right (mm)	18.7 ± 7.1	15.9 ± 7.3	**0.0236**
Left (mm)	18.6 ± 7.2	15.6 ± 5.6	**0.0068**
Final SDH size	8.8 ± 4.9	12.9 ± 6.1	**<0.001**
Initial midline shift	7 ± 4.9	6.7 ± 4.7	0.5904
Final midline shift	3.1 ± 3.0	4.7 ± 4.0	**<0.001**

*HU = Hounsfield Units; CT = computed tomography; SDH = subdural hematoma *Counts are based on number of procedures, not individual patients*

Table 3. Reoperation Outcome

Variables	Successful	Unsuccessful	p-value
Reoperation (102)			
SEPS (52)	44 (85%)	8 (15%)	
Burr hole (6)	6 (100%)	0 (0%)	
Craniotomy (44)	43 (98%)	1 (2%)	
2nd reoperation (8)			
SEPS (1)	1 (100%)	0 (0%)	
Craniotomy (7)	4 (57%)	3 (43%)	
Post-SEPS hemorrhage (99)	56 (57%)	43 (43%)	**0.0242**

SEPS = subdural evacuation port system

Table 4. Clinical outcomes (Total 268 patients)

Variables	N (%)
60-day mortality	20 (7%)
Disposition	
Home	125 (47%)
Home with services	35 (13%)
Acute rehab	47 (17%)
LTAC/Assisted living	34 (13%)
Hospice	7 (3%)

LTAC = Long Term Acute Care

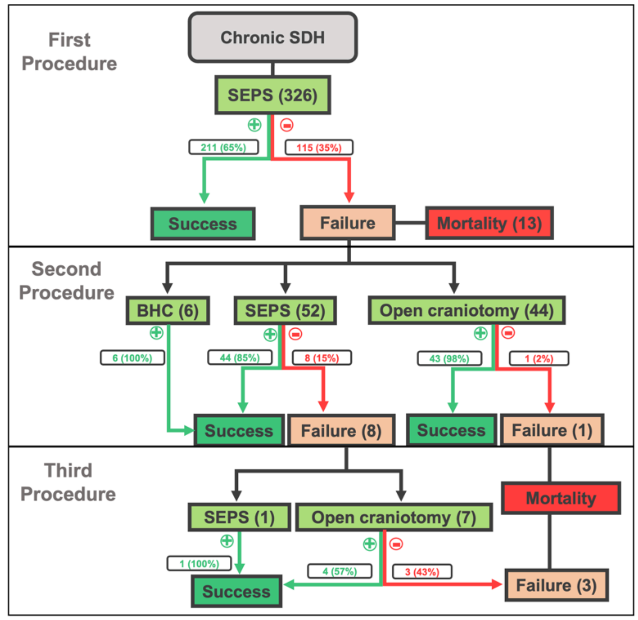

Figure 1. Flow chart demonstrating outcomes from initial SEPS procedure and subsequent second and third procedures in circumstances of failure.

Discussion:

Current management of chronic subdural hematomas remains controversial given the different surgical approaches and lack of randomized clinical trials to evaluate procedure efficacy and safety. Additionally, interest in endovascular treatment through middle meningeal artery embolization has picked up with studies demonstrating the efficacy of endovascular treatment as an adjunct or first line treatment for cSDHs (10-12). In our institution, a middle meningeal artery (MMA) embolization is often paired with SEPS placement in appropriately selected patients. The use of the SEPS system has been reported relatively recently in two other retrospective reviews (1, 9). We believe there is a need to further evaluate the various options to manage chronic subdural hematomas given the current prevalence and expected increase in the number of patients developing cSDHs (13, 14).

We have reported our outcomes with regard to both clinical and radiographic success of treating cSDHs with the SEPS approach. In comparison to the reports by Flint et al. and Hoffman et al., we found the overall rate of success to be similar to Hoffman et al. (76%) and slightly lower than Flint et al (84%). Based on our radiographic analysis, it is likely that our use of the SEPS approach in smaller SDH contributed to a higher rate of failure. Radiographic features such as HU and membranous features did not demonstrate a correlation with outcomes similar to Hoffman et al. This is likely due to the limitation of selection of a small area of the cSDH to assign a HU to the scan and the subjective nature of defining what is a membranous cSDH. Pre-operative radiographic criteria, not utilized in this study, have shown the ability to predict recurrence rates for patients treated with burr hole irrigation and small craniotomy (15-17), Additionally, these studies demonstrate that HU alone are not indicative of the viscosity of the blood being drained.

The SEPS system has pitfalls that could include anatomic misplacement and failure to adequately fenestrate dura for adequate evacuation. However, even with adequately positioned SEPS devices, some patients will have a prolonged course with multiple SEPS replacements necessary. After factoring in successful second SEPS procedures, the overall success rate in our patient population rose to 78%. One possible explanation for the increased success rate with a second SEPS is providing a fresh drainage system without clot. Flint et al. demonstrated that heparinization of the SEPS line improved success rate and we demonstrate here that patients on antiplatelet and/or anticoagulation had a higher success rate as well (9). Ultimately, a small percentage will undergo BHC or open craniotomy for evacuation of SDH. In this study, we have identified some features that help clinicians predict success of SEPS. For patients with a low likelihood of success, we advocate for operative consideration to minimize hospitalization time and recurrence rate.

Reducing the numbers of patients undergoing BHC or open craniotomy may also reduce overall mortality in this advanced-age and high-risk population. In this study, we report a mortality rate of 7%, compared to 11-17% reported in the literature for open craniotomy (8, 18). As new surgical techniques like MMA embolization continue developing, the combination of SEPS and such procedures may ultimately provide patients with more successful and durable outcomes that reduce the need for more invasive alternatives.

Conclusion:

cSDH is an increasingly prevalent disease in the elderly and frail population. Numerous approaches have been adopted to treat cSDH, but minimally invasive procedures have been favored for reduced complications and minimizing exposure to anesthesia. We present an institution's experience with using the SEPS as a first line treatment approach to cSDHs. The use of the SEPS procedure provides a safe alternative to open surgical evacuation of cSDH with a relatively high success rate in a complication-prone patient population. Repeat SEPS procedure is often successful if the first attempt fails.

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