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Technical Notes & Surgical Techniques

Burr hole craniostomy with novel use of subdural drain for evacuation of chronic subdural hematoma: Case series, literature review, and technical note

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ABSTRACT

Background: Controversy continues to exist regarding optimal management of chronic subdural hematoma. We present a different way of using a subdural drain during the post-operative period to assist with drainage.
Method: We present a case series of five consecutive patients who underwent subdural hematoma drainage utilizing this technique.
Results: Post-operative films revealed good hematoma evacuation, minimal subdural pneumocephalus, and good brain re-expansion.
Conclusion: Intraoperative subdural drain irrigation and post-operative distal drain flushing may have beneficial effects on hematoma drainage. Further testing is needed to make definitive conclusions.

1. Introduction

Chronic subdural hematoma (cSDH) is one of the most common neurosurgical conditions encountered in everyday practice, but preferred surgical and nonsurgical management continues to bring controversy [1]. The estimated annual incidence of cSDH has been reported to be as high as 13.3 case per 100,000 persons, and it has increased markedly in the elderly population [2]. The mortality rate is about 2% [3]. Surgical options are numerous and include bedside twist-drill craniostomy with subdural drain placement, subdural evacuating port system, burr hole (BH) with or without irrigation, and craniotomy. Recurrence rate after BH evacuation of cSDH has been reported between 9 and 26%, and is reduced by nearly 15% if a subdural drain (SDD) is placed [4]. We present a case series of five patients who have undergone BH with SDD placement for cSDH evacuation as a novel way to improve drain output and brain re-expansion and to reduce postoperative pneumocephalus (PCP).

2. Methods

We obtained Internal Review Board approval and conducted a retrospective review of the neurosurgery database to obtain a series of patients who underwent cSDH evacuation via burr hole craniostomy with placement of subdural drain between October 2017 and January 2018. Charts were reviewed and data was abstracted for patient demographics, surgery time, drainage duration, drain output, complications, past medical history (PMH), antiplatelet medication, and anticoagulation medication (see Table 1). Imaging was reviewed by a senior certified neuroradiologist (SJG).

2.1. Description of operative and postoperative technique

After 2 standard BH craniostomies centered over the cSDH were made 7 cm apart utilizing a perforator, dura was coagulated with bipolars, incised with a 11 knife, and dural leaflets coagulated, cSDH was visualized. Visible membrane was coagulated and cSDH allowed to drain. At this point the visible membrane overlaying the brain was also incised and coagulated. The subdural space was then irrigated with lactate ringer (LR) solution. Once it was felt that the cSDH was adequately evacuated the SDD was placed into the subdural space via the frontal BH towards the posterior caudal location after it was tunneled. The head of the bed was elevated to 45 degrees in an effort to minimize postoperative pneumocephalus. The SDD was then connected to a continuous irrigation system consisting of a 60 cc syringe without the

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Table 1
Patients' demographics, surgery time, drainage duration, drain output, complications, past medical history (PMH), antiplatelet medication, and anticoagulation medication.

Case:	1	2	3	4	5	
Sex	Male	Male	Male	Male	Female	**Mean**:
Age (years)	59	53	92	81	91	75.2
Surgery time (minutes)	67	45	43	42	54	50.2
SDD duration (days)	2	3	2	2	2	2.2
Output POD 1 (cc)	250	100	250	315	550	293
Output POD 2 (cc)	300	90	75	40	50	111
Output POD 3 (cc)	N/A	20	N/A	N/A	N/A	
Total SDD output (cc)	550	210	325	355	600	408
Complication(s)	None	Recurrence[a]	None	None	None	
PMH:						**Total**:
HTN	X		X	X	X	4
PE	X					1
Pulmonary HTN	X					1
DM	X			X		2
Obesity	X					1
HLD	X			X		2
Lymphoma		X				1
aFib			X		X	2
CKD			X			1
Cardiomyopathy			X			1
AAA				X		1
Syncope					X	1
Vertigo					X	1
Asthma					X	1
Medications:						
Aspirin			X			1
Plavix						
Coumadin	X					1

Hypertension (HTN), Pulmonary embolus (PE), Diabetes Mellitus (DM), Hyperlipidemia (HLD), Atrial fibrillation (aFib), Chronic Kidney Disease (CKD), Abdominal Aortic Aneurysm (AAA). Postoperative day (POD).

[a] Patient was later diagnosed with spinal cerebrospinal fluid leak, received a blood patch, and showed improvement of the recurrent SDH.

plunger and 3-way connector (see Fig. 6A & B). The 60 cc syringe was kept above patient's head, and kept full with LR by the scrub tech. The subdural space was allowed to fill with LR until active drainage was noted at the posterior BH. At this point the post BH was plugged with gelfoam, covered with BH cover, and scalp incision closed in standard fashion. Once LR was actively draining from the frontal BH, the BH was plugged with gelfoam, the SDD was secured in place with a 2–0 Silk, and scalp incision was closed in standard fashion. The SDD was then disconnected from the 60 cc syringe, and connected to the MoniTorr ICP™ (Integra Neuroscience, Plainsboro, NJ) drainage bag with 3-way connector (see Fig. 6B1 and B2). Our institution prefers using LR intraoperatively instead of normal saline, but either solution is acceptable to use. This procedure can be done either under local or general anesthesia. We base this decision on each patient's degree of comorbidities and a lengthy discussion with our anesthesia team. Postoperatively, the SDD tubing was flushed distally with 10 cc of normal saline into the bag every 3–4 h by the nursing or house staff (see Fig. 6C). The SDD was removed after 48 h. The head of the bed was kept at least at 30 degrees angle or more while the SDD was in place. Patients were allowed to mobilize with physical therapy on postoperative day (POD) 0 once they fully recovered from anesthesia. Supplies used for the SDD included a 60 cc syringe x1, 10 French (medium) silicone round drain with attached trocar (Reference 0070310, C.R. Bard Inc., Covington, GA), 3-way intravenous connector, and MoniTorr ICP™ external CSF drainage system (Reference 10150, Integra Neuroscience, Plainsboro, NJ). In our opinion continuous intraoperative irrigation via SDD while closing and distal SDD flushing during the 2 postoperative days will minimize airlock within the tubing, thus improving residual cSDH draining.

3. Results

Five consecutive patients were found, all of whom were treated by a single neurosurgeon with burr hole craniotomy with a novel subdural drain use (see Table 1). Four patients were male and one patient was female. The mean patient age was 75.2 years (53 to 92 years). The mean surgery time was 50.2 min (42 to 67 min). The mean duration before the SDD was removed was 2.2 days (the SDD was removed on postoperative day (POD) 3 in one patient). The mean SDD output on postoperative day (POD) 1 was 293 cc (100 to 550 cc). The mean SDD output on POD 2 was 111 cc (40 to 300 cc). The mean total SDD output was 408 cc (210 to 600 cc). Four out of five patients had no complications (80%), and one patient had SDH recurrence (20%). The patient with recurrent SDH was later diagnosed with spinal CSF leak, received a blood patch, and noted improvement in recurrent SDH. One patient was on aspirin (20%) and one patient was on coumadin (20%).

4. Case series

4.1. Case 1

A 59-year-old male with PMH significant for pulmonary embolism, pulmonary hypertension, diabetes, obesity, and hyperlipidemia presented to the emergency department with a four week history of headache and was found to have a 1.5 cm cSDH with 8 mm of midline shift. He had no focal neurologic deficits. His medications included warfarin, losartan, aripiprazole, duloxetine, simvastatin, trazodone, and metformin. He underwent evacuation of cSDH via BH craniostomies with SDD with placement the following day. There were no complications. The SDD was removed two days later after draining 550 cc of serosanguinous fluid. At follow-up 28 days after surgery he was doing well and had returned to his neurologic baseline (see Fig. 1).

4.2. Case 2

A 53-year-old male with PMH significant for lymphoma (in remission) initially presented to his primary care doctor with three weeks of headache described as similar to what he experienced secondary to a lumbar puncture five years previously. He takes no medications. He underwent brain imaging, which revealed bilateral cSDH (see Fig. 2). He had no focal neurologic deficits, was admitted overnight for observation, and was discharged home the following day on levetiracetam. He re-presented two weeks later with new headache, speech difficulties, and confusion. CT head revealed bilateral acute on cSDH (acSDH). He was admitted for observation, two days later experienced a seizure, and underwent evacuation of the acSDH via BH craniostomies with SDD placement. The SDD was removed three days later after draining 210 cc of serosanguinous fluid. At follow-up appointment one week later the patient was found to have bilateral re-accumulation of SDH. He was subsequently diagnosed with an underlying cerebrospinal fluid leak, which was treated with an epidural blood patch in the lumbar region. At follow-up 39 days after his initial operation there was significant resorption of the SDH and progressive improvement in overall condition, without headaches or neurologic deficit (see Fig. 2).

4.3. Case 3

A 92-year-old male with PMH significant for atrial fibrillation, hypertension, chronic kidney disease, and cardiomyopathy presented with left frontal headache and significant left lower extremity weakness that started with a fall that morning. His medications included aspirin, digoxin, carvedilol, spironolactone, and furosemide. He was noted to have acSDH that was drained via BH craniostomies with SDD placement two days after admission. The SDD was removed two days after, and drained a total of 325 cc of serosanguinous fluid. He experienced no complications, and at discharge demonstrated improved mild lower

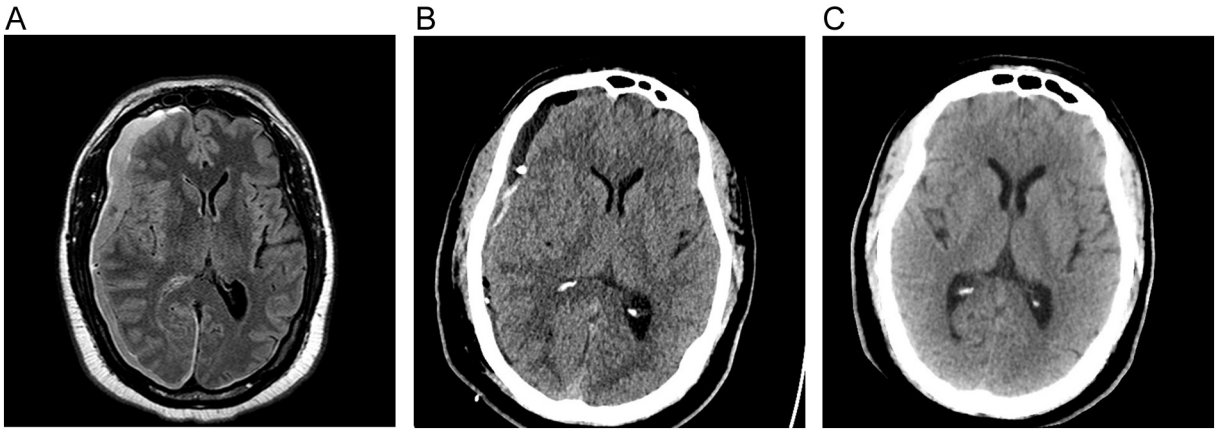

Fig. 1. Imaging from case 1. A: Pre-operative MR (FLAIR) demonstrating right subdural collection with mass effect and midline shift. B: Post-operative CT demonstrating the presence of the SDD. Decreased size of the subdural collection and decreased mass effect. A small amount of pneumocephalus is present anteriorly. C: 1-month follow-up CT demonstrating resolution of the SDH.

extremity weakness (see Fig. 3).

4.4. Case 4

An 81-year-old male with PMH for hyperlipidemia, hypertension, diabetes, and abdominal aortic aneurysm presented with hemiparesis and increasing fall frequency for the last two days. Medications included lantus, metoprolol, quinapril, citalopram, and simvastatin. He was found to have an acSDH, which was evacuated via BH craniostomies with SDD placement the next day. The SDD was removed two days later after draining a total of 355 cc of serosanguinous fluid. He experienced no complications. At follow-up 34 days later he demonstrated baseline motor strength and significant improvement in cognition and speech but with continued word finding difficulty (see Fig. 4).

4.5. Case 5

A 91-year-old female with PMH significant for syncope, vertigo, atrial fibrillation, hypertension, and asthma presented initially with a small acute SDH after ground-level fall, which was managed non-operatively. Her medications included losartan and metoprolol. One month later she presented to outpatient follow-up with a two-day history of worsening headache, pronator drift, and word finding difficulty. She was found to have an expanding acSDH, which was evacuated via BH craniostomies with SDD placement the next day. The SDD was removed two days later after draining a total of 600 cc of serosanguinous fluid. She experienced no complications. At follow-up 30 days later she had returned to her neurologic baseline (see Fig. 5).

5. Discussion

cSDH is an abnormal collection of liquefied blood products underneath the dura matter that may result in increased intracranial pressure and neurological complications [4]. cSDH primarily effects the elderly population, and is one of the most common neurosurgical conditions encountered in everyday practice [1]. The annual incidence of cSDH ranges between 5.3 and 13.3 individuals per 100,000 [2,5]. The pathophysiology of cSDH is still not clear. It usually follows a minor trauma to the brain due to a head injury, which results in bleeding of the parasagittal bridging veins [6]. Surgical options for evacuation are numerous and controversial. Craniotomy (12.3%) is associated with much higher morbidity than craniostomy (3 to 4%), but recurrence with twist-drill craniostomy (33%) is much higher than with BH craniostomy (12.1%) and craniotomy (10.8%) [7].

The recurrence rate after cSDH evacuation has been reported between 2.3 and 38.7% [2]. An increased rate of recurrence has been associated with coagulopathy or anticoagulant drug use, male gender, hypertension, diabetes, bilateral hematomas, larger preoperative

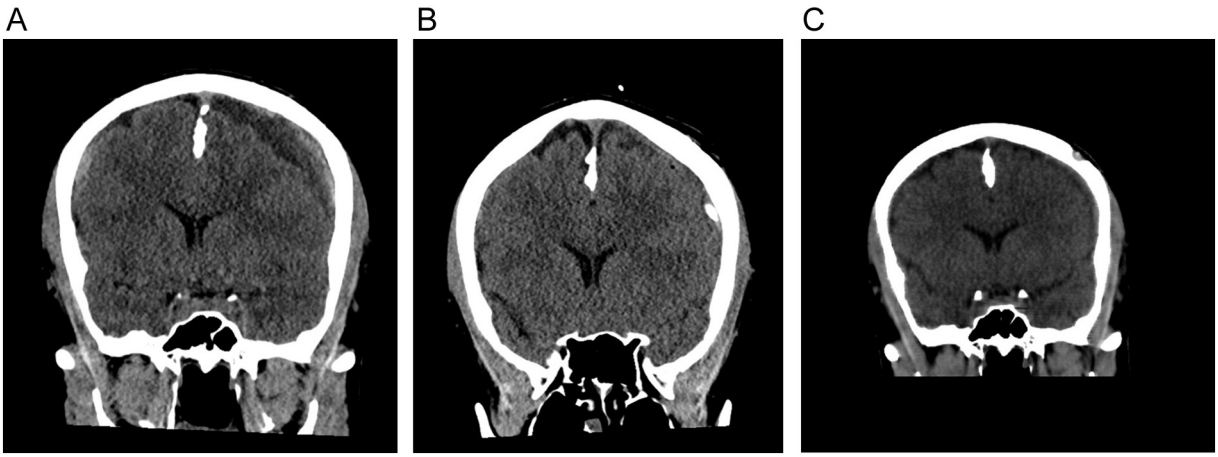

Fig. 2. Imaging from case 2. A: Pre-operative coronal reformatted CT image demonstrating mixed attenuation left SDH with mass effect on the left lateral ventricle and mild midline shift. A small right SDH is also present. B: Post-operative coronal reformatted CT image demonstrating the SDD, with decreased size of the SDH, and decreased mass effect. A small amount of pneumocephalus is present. Right sided collection is not changed. C: 1-month follow-up CT demonstrating small residual SDH.

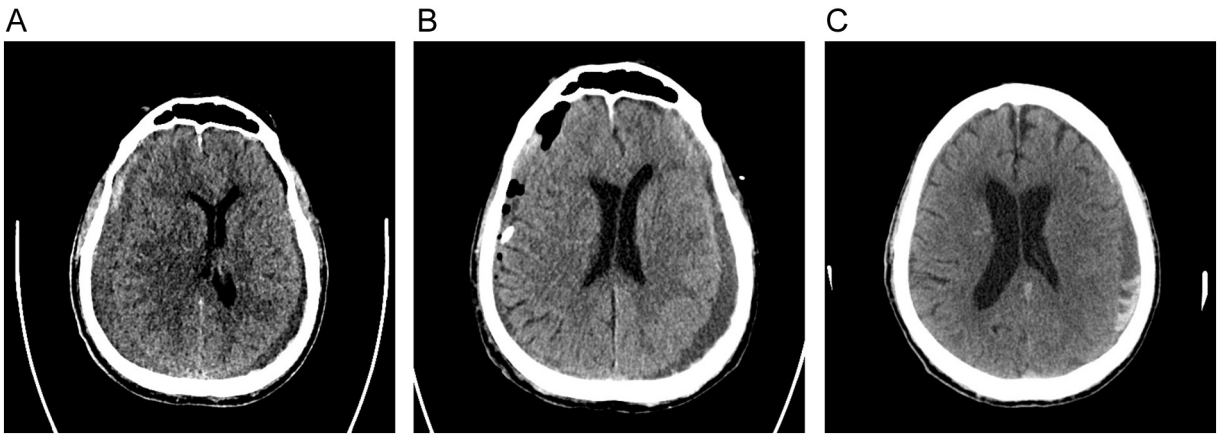

Fig. 3. Imaging from case 3. A: Pre-operative axial CT image demonstrating bilateral mixed attenuation SDH with mass effect on the right hemisphere and right to left midline shift. B: Post-operative CT demonstrating SDD with decreased size of right side SDH with decreased mass effect and shift. There is moderate pneumocephalus. The left SDH is slightly larger. C: 1-month follow-up CT demonstrating very small residual right SDH and stable left SDH.

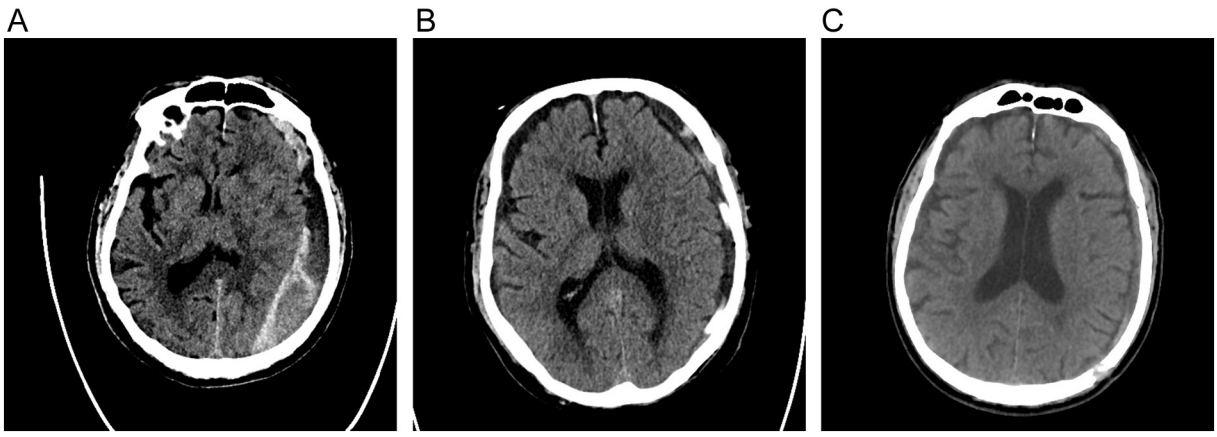

Fig. 4. Imaging from case 4. A: Pre-operative axial CT image demonstrating mixed attenuation left SDH with mass effect on the left hemisphere and midline shift. B: Post-operative CT demonstrating SDD with decreased size of left side SDH with decreased mass effect and shift. There is mild pneumocephalus. C: 1-month follow-up CT demonstrating small residual SDH.

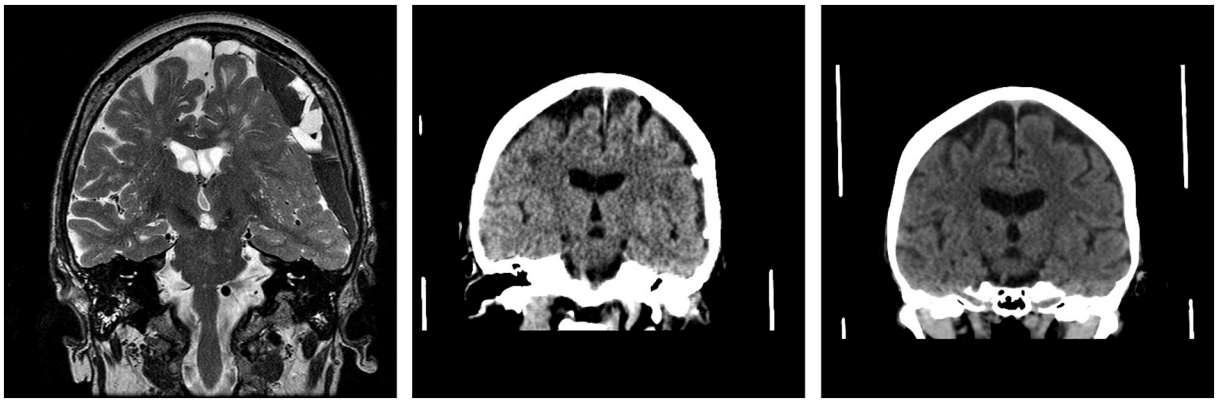

Fig. 5. Imaging from case 5. A: Pre-operative coronal T2 weighted MRI image demonstrating mixed signal intensity left SDH with mass effect on the left hemisphere and midline shift. B: Post-operative coronal reformatted CT demonstrating SDD with decreased size of left side SDH with decreased mass effect and shift. There is mild pneumocephalus. C: 1-month follow-up CT demonstrating almost complete resolution of SDH.

hematoma volume, presence of septations, heterogeneous or mixed density findings on CT, iso- or hypointense appearance on T1-weighted MRI, presence of preoperative midline shift, persistence of mass effect after surgery, larger postoperative residual hematoma, and presence of postoperative pneumocephalus. The risk of recurrence was decreased with hematoma that appeared homogenous on preoperative imaging [8]. When cSDH was evacuated via BH, the recurrence rate was reduced to 9.3% when a SDD was used, compared to 24% without [7]. Additionally, the mortality rate was reduced from 18.1% to 8.6% at 6 months follow-up [7].

There have been several studies over the years that have looked at postoperative patient posture as related to the cSDH recurrence rate. Abouzari et al. [9] randomly allocated 84 patients into 2 groups where patients were either left on supine flat bedrest or head of the bed (HOB)

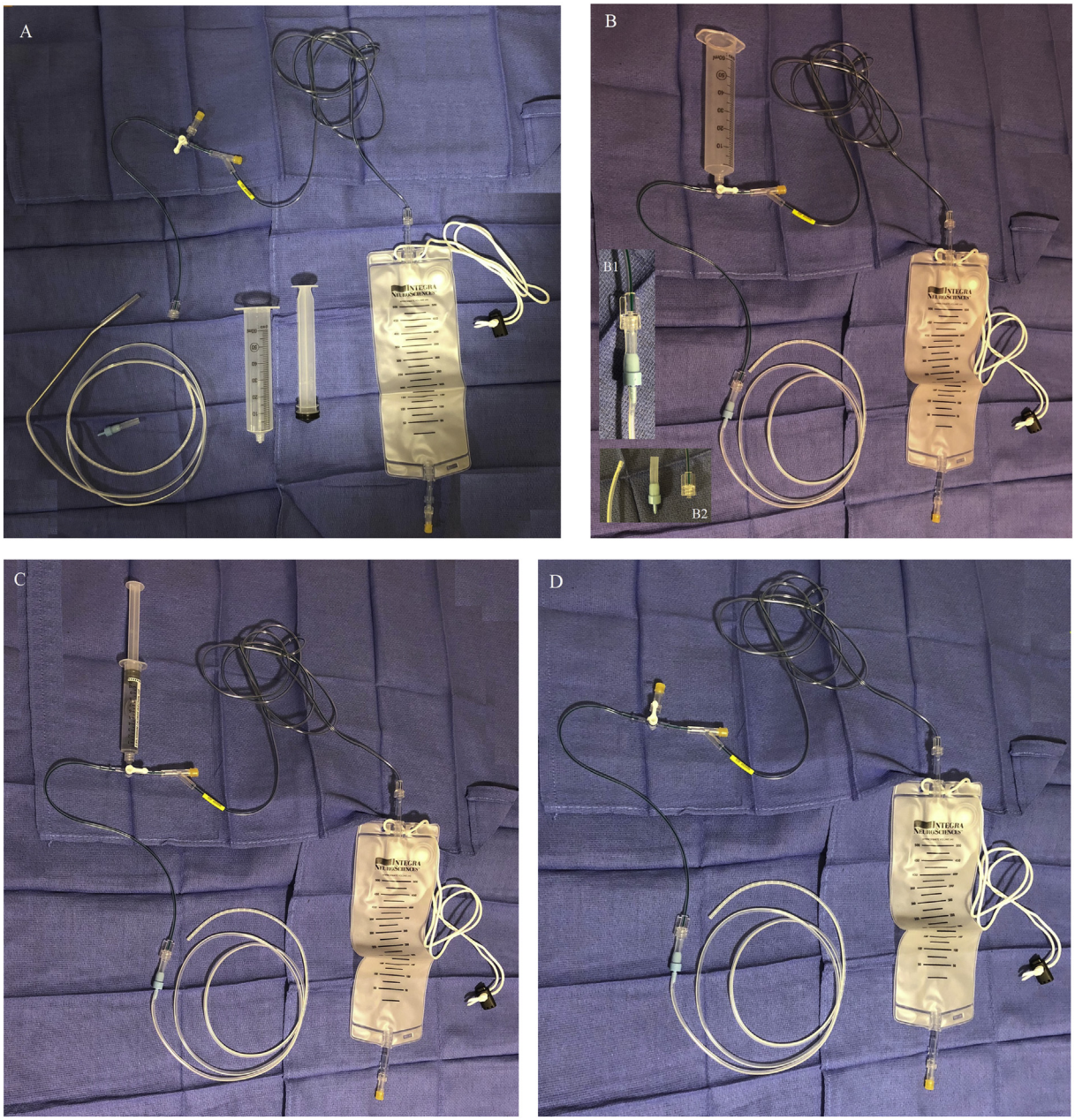

Fig. 6. SDD setup. A: Demonstrates each component of the SDD system before it is assembled. B: Demonstrates intraoperative SDD continuous irrigation system setup. The 60 cc syringe is affixed to the mayo stand and is kept above patient's head. It is constantly refilled with LR. The silicone tubing is placed through the frontal BH into the subdural space after it is tunneled under the scalp. B1 and B2 inserts demonstrate how the silicone tubing is connected to the 3-way connector and the MoniTorr ICP™ external CSF drainage system. The posterior BH incision is closed, while the frontal BH is kept open until the subdural space is filled with irrigation. We believe that this displaces the air and helps to decrease post-op pneumocephalus, along with tubing airlock. After both incisions are closed, the 60 cc syringe is removed and the connector is capped. C: Demonstrates the configuration of the SDD when the drain is flushed distally, which is done every 3–4 h with 10 cc via the 3-way connector after it is turned off proximally and left open distally to the draining bag. We believe that this also decreases airlock within the tubing, thus further assists with SDH drainage, decreases post-op pneumocephalus, and ultimately improves brain re-expansion. D: Demonstrates the configuration of the SDD during the post-op period while it is draining.

elevated to 30–40 degrees for 3 PODs. The recurrence rate was 2.3% in the flat group, and 19.0% in the elevated HOB group. Nakajima et al. [10] performed prospective randomized trial of 46 patients with cSDH where 1 groups was also kept on flat supine bedrest for 3 days, while the other group had HOB elevated to sitting position on POD 1. There was no significance in the recurrence rate. Brennan et al. [11] retrospectively reviewed 1205 patients from British Neurosurgical Trainee Collaborative database with cSDHs. Multivariate analysis demonstrated that failure to leave a SDD independently predicted recurrence and unfavorable functional outcome ($p = 0.011$ and $p = 0.048$, respectively). Other independent predictors of unfavorable functional outcome were increased patient age ($p < 0.00001$), postoperative bedrest ($p = 0.019$), and use of a single burr hole ($p = 0.020$).

Interestingly, Nakaguchi et al. [12] looked at SDD location after cSDH drainage via BH. Sixty three patients had SDD tips placed into frontal, parietal, or occipital regions. Patients with parietal or occipital SDD had a higher rate of cSDH recurrence and much more pneumocephalus than those with frontal SDD. Also, patients with residual pneumocephalus on CT scans obtained on POD 7 had a higher recurrence rate than those without subdural air collections. Furthermore,

patients with a subdural space wider than 10 mm on POD 7 CT scans had a higher recurrence rate than those with a 10 mm or less space. You et al. [13] also found that patients with postoperative pneumocephalus after cSDH evacuation had significantly higher recurrence rate then the control groups, 32.6% and 17.7% respectively.

Hennig et al. [14] looked at continuous irrigation and drainage (CID) with LR after cSDH was evacuated via BH. The recurrence rate with CID was 2.6% (2/77), while BH without SDD demonstrated recurrence rate of 32.6% (15/46) and BH with passive subdural drainage (PD) of 23.8% (5/21). Ram et al. [15] prospectively randomized 37 patients with cSDH into BH with CID (19) and BH with PD (18). They noted similar complication rate in the two groups with reoperation rate of 5.3% (1/19) in CID group and 22.2% (4/18) in PD group. Sjavik et al. [16] examined 3 different drainage setups: CID, PD, and active subgaleal drainage (AD). The cSDH recurrence requiring surgery within 6 months was noted in 10.8% of the CID group, 20% in the PD group, and 11.1% in the AD group. Unfortunately, the CID group experienced more complications (14.5%) compared to the PD (7.3%) and AD (8.1%) groups.

More recently, Benshalom at el [17] used rigid 0 degree endoscope after cSDH was evacuated via BH to inspect the subdural space, evacuate the residual clots, fenestrate internal membrane, and occasionally coagulate vessels. Their preliminary results were promising and are pending validation. In our practice, four items are observed during the 48 h postoperative period before the SDD is removed: the drain is only irrigated distally towards the collection bag every 3–4 h, the drain is kept hanging off of the bed above the ground, the HOB is set at 30 degrees or more while patient is in bed but not on bedrest, and patient is allowed to mobilize with physical therapy on POD 0, once fully recovered from anesthesia. We also try to minimize postoperative pneumocephalus by raising HOB and filling the subdural space with LR intraoperatively.

6. Conclusion

Controversy still exists on the most appropriate surgical options in managing cSDH. We believe that continuous intraoperative irrigation via SDD at the time of closure and distal flushing of the SDD every 3–4 h during the 48 h postoperatively will minimize airlock within the tubing, improve residual cSDH draining, perhaps assist with brain expansion, and decrease postoperative pneumocephalus. Further testing is required to assess if this technique will result in lower cSDH recurrence.

Disclosures

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IRB

Dartmouth Hitchcock Committee for the Protection of Human Subjects, IRB # 00030885. No identifiable patient information was collected. No consent was needed given that the retrospective research involved no more than minimal risk to subjects and data had already been collected as part of the normal clinical process.

Declaration of Competing Interest

None.

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None.

References

[1] Y.R. Yadav, V. Parihar, H. Namdev, J. Bajaj, Chronic subdural hematoma, Asian J. Neurosurg. 11 (4) (2016) 330–342 Oct-Dec.
[2] S.U. Kim, D.H. Lee, Y.I. Kim, S.H. Yang, J.H. Sung, C.B. Cho, Predictive factors for recurrence after burr-hole craniostomy of chronic subdural hematoma, J. Korean Neurosurg. Soc. 60 (6) (2017) 701–709 Nov.
[3] G. Rocchi, E. Caroli, M. Salvati, R. Delfini, Membranectomy in organized chronic subdural hematomas: indications and technical notes, Surg. Neurol. 67 (4) (2007 Apr) 374–380 (discussion 80).
[4] L. Sivaraju, R.K. Moorthy, V. Jeyaseelan, V. Rajshekhar, Routine placement of subdural drain after burr hole evacuation of chronic and subacute subdural hematoma: a contrarian evidence based approach, Neurosurg. Rev. 41 (1) (2018) 165–171 Jan.
[5] R. Sahyouni, K. Goshtasbi, A. Mahmoodi, D.K. Tran, J.W. Chen, Chronic subdural hematoma: a historical and clinical perspective, World Neurosurg. 108 (2017) 948–953 Dec.
[6] Q.P. Wang, Y. Yuan, J.W. Guan, X.B. Jiang, A comparative study of irrigation versus no irrigation during burr hole craniostomy to treat chronic subdural hematoma, BMC Surg. 17 (1) (2017 Sep 11) 99.
[7] T. Santarius, P.J. Kirkpatrick, D. Ganesan, H.L. Chia, I. Jalloh, P. Smielewski, H.K. Richards, H. Marcus, R.A. Parker, S.J. Price, R.W. Kirollos, J.D. Pickard, P.J. Hutchinson, Use of drains versus no drains after burr-hole evacuation of chronic subdural haematoma: a randomised controlled trial, Lancet 374 (9695) (2009) 1067–1073 Sep 26.
[8] R. Motiei-Langroudi, M. Stippler, S. Shi, N. Adeeb, R. Gupta, C.J. Griessenauer, E. Papavassiliou, E.M. Kasper, J. Arle, R.L. Alterman, C.S. Ogilvy, A.J. Thomas, Factors predicting reoperation of chronic subdural hematoma following primary surgical evacuation, J. Neurosurg. 15 (Dec) (2017) 1–8.
[9] M. Abouzari, A. Rashidi, J. Rezaii, K. Esfandiari, M. Asadollahi, H. Aleali, M. Abdollahzadeh, The role of postoperative patient posture in the recurrence of traumatic chronic subdural hematoma after burr-hole surgery, Neurosurgery 61 (4) (2007 Oct) 794–797 Comparative Study Randomized Controlled Trial. (discussion 7).
[10] H. Nakajima, T. Yasui, M. Nishikawa, H. Kishi, M. Kan, The role of postoperative patient posture in the recurrence of chronic subdural hematoma: a prospective randomized trial, Surg. Neurol. 58 (6) (2002 Dec) 385–387 Clinical Trial Randomized Controlled Trial. (discussion 7).
[11] P.M. Brennan, A.G. Kolias, A.J. Joannides, J. Shapey, H.J. Marcus, B.A. Gregson, P.J. Grover, P.J. Hutchinson, I.C. Coulter, The management and outcome for patients with chronic subdural hematoma: a prospective, multicenter, observational cohort study in the United Kingdom, J. Neurosurg. 127 (4) (2017) 732–739 Oct.
[12] H. Nakaguchi, T. Tanishima, N. Yoshimasu, Relationship between drainage catheter location and postoperative recurrence of chronic subdural hematoma after burr-hole irrigation and closed-system drainage, J. Neurosurg. 93 (5) (2000) 791–795 [Clinical Trial]. Nov.
[13] C.G. You, X.S. Zheng, Postoperative pneumocephalus increases the recurrence rate of chronic subdural hematoma, Clin. Neurol. Neurosurg. 166 (Mar) (2018) 56–60 [Observational Study].
[14] R. Hennig, R. Kloster, Burr hole evacuation of chronic subdural haematomas followed by continuous inflow and outflow irrigation, Acta Neurochir. 141 (2) (1999) 171–176 Clinical Trial Comparative Study.
[15] Z. Ram, M. Hadani, A. Sahar, R. Spiegelmann, Continuous irrigation-drainage of the subdural space for the treatment of chronic subdural haematoma. A prospective clinical trial, Acta Neurochir. 120 (1–2) (1993) 40–43 Clinical Trial Randomized Controlled Trial.
[16] K. Sjavik, J. Bartek Jr., L.M. Sagberg, M.L. Henriksen, S. Gulati, F.L. Stahl, H. Kristiansson, O. Solheim, P. Forander, A.S. Jakola, Assessment of drainage techniques for evacuation of chronic subdural hematoma: a consecutive population-based comparative cohort study, J. Neurosurg. (2017) 1–7 Jun 23.
[17] S.H. Netanel Benshalom, Uzi Ben David, 194 endoscopic assisted evacuation of chronic subdural hematoma a paradigm shift or a waste of time? Neurosurgery 64 (CN_suppl_1) (2017) 251–252. August 24.