Interdisciplinary Neurosurgery 21 (2020) 100736

Contents lists available at ScienceDirect

Interdisciplinary Neurosurgery

journal homepage: www.elsevier.com/locate/inat

Technical notes & surgical techniques

New tools in percutaneous minimally invasive chronic subdural hematomas evacuation

Giuseppe Emmanuele Umana[a,*], Stefano Chiriatti[a], Elena Roca[b], Gianluca Scalia[c], Marco Fricia[a], Nicola Alberio[a], Giovanni Federico Nicoletti[d], Salvatore Cicero[a], Angelo Spitaleri[a]

[a] Department of Neurosurgery, Cannizzaro Hospital, Trauma Center, Gamma Knife Center, Catania, Italy
[b] Neurosurgery, Poliambulanza Foundation Hospital, Brescia, Italy
[c] Division of Neurosurgery, Department of Biomedical and Dental Sciences and Morpho-Functional Imaging, University of Messina, Italy
[d] Department of Neurosurgery, ARNAS Garibaldi, Catania, Italy

ARTICLE INFO

Keywords:
Minimally invasive
Chronic subdural hematoma
Twist drill

ABSTRACT

Background: Incidence of chronic subdural hematomas (cSDH) is expected to progressive rise in the next decades. There is no univocal indication of the approach to be used. Furthermore, there is no data about the efficacy of twist drill craniostomy (TDC) in hematomas with membranes.
Objective: To describe our modified technique for TDC in patients affected by cSDH with membranes and in treatment with antiplatelets.
Methods: We analyzed a group of 37 patients, affected by cSDH with membrane (type D laminar membrane and type G trabecular membrane according to Nakaguchi classification), treated with mushroom TDC using a modified technique.
Results: After surgery the average maximum thickness of the common postoperative liquoral subdural collection decreased from 18.8 to 6.21 mm. We documented one acute subdural hematoma (2.7%), asymptomatic and not treated, and one recurrence of cSDH (2.7%) after 2 months that needed re-intervention with single burr hole.
Conclusions: We presented a modified twist drill technique, characterized by the introduction of an application of a new device that optimizes both surgical results, clinical outcome and surgical procedure time. The presence of membrane type D and G does not affect the efficacy of drainage, that is negatively related to the presence of clots or acute hematoma. This modified technique is safe, fast, effective and represents a valid first line treatment of an unstable and unpredictable pathology such as cSDH. We suggest performing such technique on a larger patients' cohort to further validate its effectiveness.

1. Introduction

Incidence of chronic subdural hematomas (cSDH) is expected to progressive rise in the the next decades, becoming the most frequent intracranial neurosurgical entity, because of the common practice of anticoagulants or anti platelets in a progressive aging population [1–5].

cSDH is a complex and unpredictable disease, characterized by high morbidity and mortality rates (32% 1-year mortality in patients over-70 [6]). The development of cSDH is considered only the precursor of a systemic worsening, similarly to major pathological event in the elderly such as pneumonia or hip fractures [7].

There is no univocal indication of the approach to be used, and common surgical techniques to evacuate cSDH are: twist drill craniostomy (TDC), burr hole craniostomy (BHC), and craniotomy. Furthermore, there is no available data about the efficacy of TDC in hematomas with membranes. We presented a modified twist drill technique for cSDH with membranes evacuation.

2. Materials and methods

We analyzed a cohort of 37 patients, affected by cSDH with membrane (type D laminar membrane and type G trabecular membrane according to Nakaguchi et al. [8] classification), treated with mushroom TDC using a modified technique. Patient in treatment with antiplatelets, midline shift and cSDH > 1 cm underwent urgent surgery, those in treatment with anticoagulants, stopped its administration and

Abbreviations: TDC, twist drill craniostomy; cSDH, chronic subdural hematoma; BHC, burr hole craniostomy; CSF, cerebrospinal fluid; CT, computed tomography

* Corresponding author at: Department of Neurosurgery, Cannizzaro Hospital, Trauma Center, Gamma Knife Center, Via Messina, 829, 95126 Catania, Italy.
E-mail address: umana.nch@gmail.com (G.E. Umana).

https://doi.org/10.1016/j.inat.2020.100736
Received 18 March 2020; Received in revised form 29 March 2020; Accepted 29 March 2020
2214-7519/ © 2020 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/BY-NC-ND/4.0/).

corrected laboratories values before surgery. We administered low dose of enoxaparin (4000 I.U. once daily), low-dose corticosteroids and tranexamic acid for 1 month. Patients with acute hematomas, fibrous hematomas with thick and complex membrane, skull fractures, vascular malformations, subdural empyema, or that underwent previous surgery for evacuation of cSDH (recurrent cSDH) were excluded from this study. All patients gave their informed consent to the procedure and to the use of clinical data. Patients were informed that the surgical procedure represented a first minimally invasive attempt that do not preclude standard burr hole procedure which could be further be accomplished if needed.

2.1. Twist drill craniostomy

2.1.1. Standard technique

Tabaddor and Shulmon [9] reported for the first time an alternative technique for cSDH evacuation. TDC is a percutaneous approach that can be performed at bedside, under local anesthesia. A handheld drill is used and a small burr hole < 10 mm is performed, after that a subdural drain can be placed connecting a suction pump drain or a transosseous bolt [7]. In Tabaddor and Shulmon description the cranial opening is performed by a drill oriented 45° to the skull to reduce the risk of brain injury. The dura mater and the parietal membrane of the hematoma can be opened during drilling or with a needle/ surgical knife. Then, a cannula is inserted in the subdural space and connected to an external drainage system.

The main indication for TDC is relative to fragile elderly patients with multiple comorbidities in which general anesthesia presents elevated risks [10,11]. The technique has been modified widely, in order to improve safety and reduce infectious risks, and one of the most important improvements is represented by the “subdural evacuating port system” [12,13]. Another modification of the technique is characterized using a bolt at the level of the parietal eminence allowing the introduction of gas such O_2 with the aim to ease the hematoma evacuation [14,15].

2.1.2. Modified technique

We presented a modified twist drill craniostomy based on the introduction of a new tool. In particular, the most important innovation is the use of a subdural catheter that presents a mushroom shape, allowing to anchor the catheter and to avoid clots that may obstruct the drainage. (Subdural catheter kit complete, INTEGRA^{TM}, NEUROSCIENCES IMPLANTS S.A., Plainsboro, New Jersey, US)

We modified the standard technique, commonly used worldwide, transforming the approach in a real percutaneous technique (Table 1, Video 1). After local anesthesia administration using a solution of mepivacaine and adrenaline, a very small skin incision (< 5mm) is performed (Fig. 1A). The association with electric drill further speeds up the procedure, but also a handled drill can be used. (Fig. 1B) The dural opening can be made with an ophthalmic knife or during drilling (the thickness of the hematoma protects brain parenchyma). The catheter is inserted in the subdural space with percutaneous technique after forging and lengthening the catheter by pulling on the mandrel. (Fig. 1C) Then, the catheter is connected to Jackson Pratt suction bulb. The catheter is not tunneled but comes straight out of the wound and the skin closure is limited to one or two stitches with the catheter in the middle that comes straight out of the wound. In our modified technique the following steps are avoided: linear incision, self-retractor positioning, exposure of the skull, tunneling of the catheter. Also, the catheter removal is simplified (Fig. 1D), consisting of pulling away the catheter, without the need of reopening the wound nor anesthesia and consequent skin re-hemostasis and reclosure (Table 2). The overall positioning procedure time is of < 2 min. The overall removal procedure time consists of the few seconds needed to pull away the catheter at the bedside, like surgical drainage removal during common medication used after most of the surgical procedures. To reduce infectious risks, we prefer to perform the positioning procedure in the operating theatre.

3. Results

A total of 37 patients were included in this study. 27 females (72.9%) and 10 males (27.1%) with a female/male ratio of 2.7: 1. Patients’ age ranged from 47 to 93 years with a mean age of 70 years. 8 out of 37 patients (21.6%) presented bilateral hematomas and 29 out of 37 patients (78.3%) were in treatment with antiplatelets. All patients presented typical surgical radiologic findings: midline shift, and a preoperative average maximum thickness of 18.81 mm. (Table 3) All patients presented cSDH with membrane type D laminar and type G trabecular according to Nakaguchi et al. classification [8]. After surgery the average maximum thickness of the common postoperative liquoral subdural collection was 6.21 mm. We documented one acute subdural hematoma (2.7%), asymptomatic and not treated, and one recurrence of the cSDH (2.7%) after 2 months that needed re-intervention with single burr hole. All procedures were performed in the operating room, in local anesthesia, with a modified TDC. Antiplatelet therapy seems to not correlate to the risk of recurrence after TDC. None of patients developed hypertensive pneumocephalus. Clinical outcome was negatively influenced by dementia and bilateral hematoma. All patient recovered after surgery. A postoperative head computed tomography (CT) scan after 72 h and one month was performed in all patients, with a mean follow-up of 11 months (range 6–24 months).

3.1. Case illustration

We present an 87-year-old male patient with history of head trauma 2 months before, in treatment with antiplatelets. The patient was referred to our hospital because he presented aphasia and progressive weakness in right upper and lower limbs. Head CT scan showed a left hemispheric cSDH with type G membrane. (Fig. 2A) A percutaneous minimally invasive cSDH evacuation was performed. 72-hours postoperative CT scan revealed an optimal hematoma’s drainage. (Fig. 2B) The postoperative period was uneventful, and the patient was discharged on postoperative day 5. No recurrence was observed at 1-year follow-up.

4. Discussion

In this paper we presented our pilot experience with the use of a modified mushroom TDC technique in patients affected by cSDH. In our series, antiplatelets and the presence of type D and G membrane did not

Table 1
Steps required in standard versus modified twist drill craniostomy procedure.

Steps required	Standard procedure	Modified procedure
Anesthesia	Yes	Yes (local)
Linear incision to expose the skull surface (use of self-retractor)	Yes	No, incision < 5 mm without skull visualization
Burr hole (5 mm)	Yes (manual)	Yes (manual or electric drill)
Dural opening with electrocautery	Yes	Yes (dural opening can be also performed with ophthalmic knife or during drilling)
Catheter insertion with the mandrel in the subdural space	Yes	Yes (percutaneous)
Tunneling of the catheter	Yes	No (catheter comes straight out of the wound)

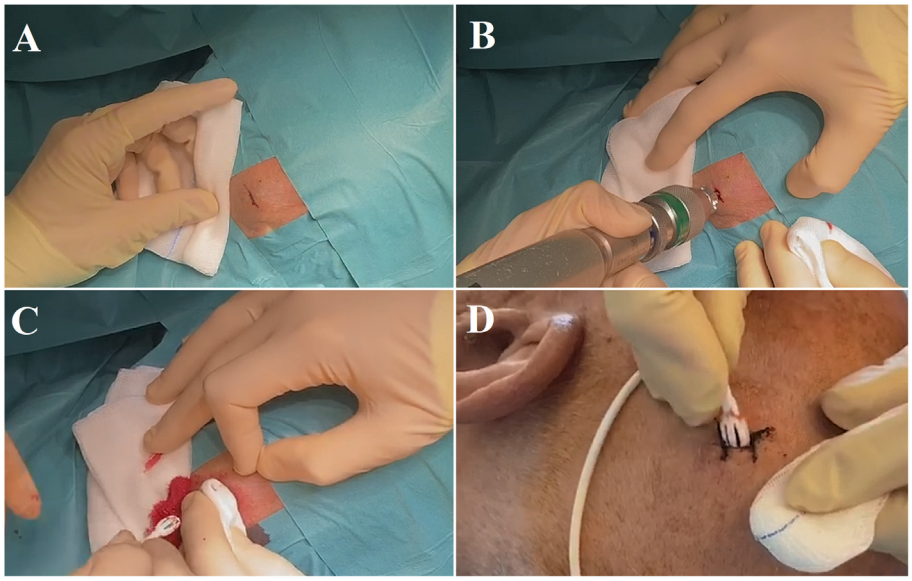

Fig. 1. Detailed illustration of the various stages of the surgical procedure and catheter removal. A ≤ 5 mm skin incision is performed (A) as well as a burr hole with the aim of a high-speed electric or handled surgical drill (B). Then, a catheter is inserted in the subdural space with percutaneous technique (C). The catheter is removed without the need of reopening the wound on anesthesia, consequently skin re-hemostasis and reclosure are not required. (D).

Table 2
Steps required in standard versus modified catheter removal procedure.

Steps required	Standard procedure	Modified procedure
Anesthesia	Yes	No
Reopening the wound	Yes	No (pull away the catheter through the wound, without reopening)
Catheter removal from the tunneling to the burr hole site	Yes	No
Complete catheter removal from the subdural space	Yes	No
Hemostasis with electrocautery	Yes	No
Wound reclosure	Yes	No

affect the efficacy of the drainage. In the present report a modified mushroom TDC technique was described, with optimization of procedure time, further reduction of invasiveness and improvement of risk infection and cosmetic results by reducing the scar length. In our opinion this modified technique can be considered as a first line treatment even in presence of membrane or antiplatelet therapy. In the literature, authors reported a series of patients treated with standard mushroom TDC technique, but they did not specify about the presence of membrane [16]. Buchanan et al. [7] stated that there is no consensus regarding first-line management for chronic subdural hematomas.

cSDH is a complex and unpredictable pathology [17] given the high risk of recurrence (18–33%), death (56–10%) [18] that often affects fragile elderly patients which present multiple comorbidities. Thus, minimally invasive approaches should be considered. The satisfying radiological results after evacuation with TDC can be related to intermembrane direct communication or permeability, that allow to the hematoma to be drained and to the CSF to replace it in the subdural space. The development of new devices and materials must be encouraged with the aim to overcome the current technical limits. The introduction of the mushroom catheter showed interesting advantages, reducing the risk of catheter obstruction and helping to perform minimally invasive percutaneous approach, but need further investigation. It can be argued that further technical innovations can improve safety and efficacy in the treatment of cSDH.

5. Conclusions

We presented a modified twist drill technique, characterized by the introduction of new device and tool application, that optimize both surgical results, clinical outcome and surgical procedure time. The presence of membrane type D and G does not affect the efficacy of drainage, that is negatively linked to the presence of clots or acute hematoma. This modified technique is safe, fast and effective, representing a valid first line treatment of a complex and unpredictable

Table 3
Table summarizing the characteristics of the patients and the outcomes.

Males number	10 males (27.1%)
Females number	27 females (72.9%)
Age (years)	mean age 70 years (range from 47 to 93 years)
Unilateral	29 (78.3%)
Bilateral	8 (21.6%)
Type (Nakaguchi classification)	26 type D (70.2%) 11 type G (29.7%)
Symptoms	29 (78.3%) hemiparesis of which 12 (32.4%) + aphasia, 8 (21.6%) severe consciousness impairment, 8 (21,6%) gait disturbances and consciousness impairment.All patients presented a range GCS score from 8 to 15/15.
Outcome	- 1 (2.7%) acute subdural hematoma, asymptomatic and not treated - 1 (2.7%) cSDH recurrence after 2 months, treated with burr hole - 35 (94.6%) showed deficits improvement, no recurrence at 1-year follow-up
Antiplatelets/anticoagulants	29 (78.3%)
Drainage removal	After 72 h

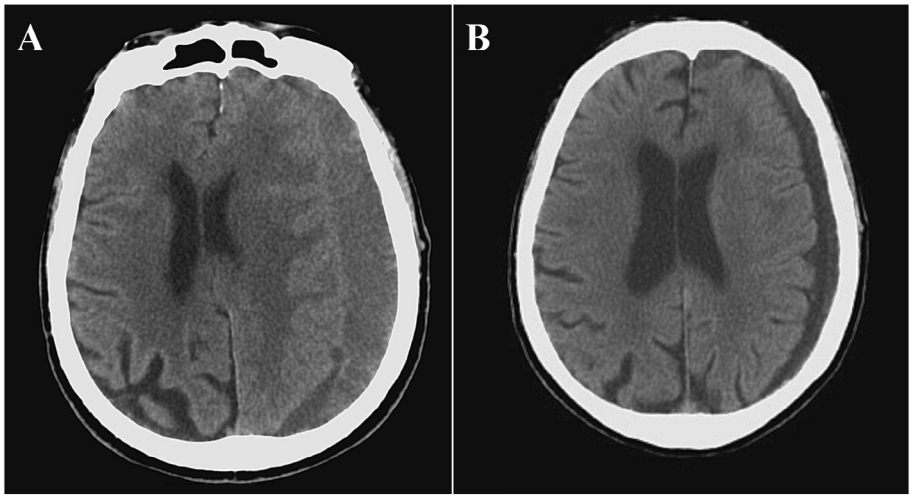

Fig. 2. Pre- and post-operative head CT scan showing a left hemispheric cSDH with type G membrane (A) and an optimal hematoma's drainage with brain re-expansion (B).

pathology such as cSDH, especially in elderly patients with comorbidities. We suggest performing such technique on a larger patients' cohort to further validate its effectiveness.

6. Funding support and sponsorship

this research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

7. Patient consent

an informed written consent was obtained from the patient of the illustrative case.

8. Ethics approval

there is no ethical issue in this paper. The described technique does not present important variations from the classical one and does not involve additional risks for the patient.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

none

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inat.2020.100736.

References

[1] A.G. Kolias, A. Chari, T. Santarius, et al., Chronic subdural haematoma: modern management and emerging therapies, Nat Rev Neurol 10 (10) (2014) 570–578.
[2] T. Rust, N. Kiemer, A. Erasmus, Chronic subdural haematomas and anticoagulation or anti-thrombotic therapy, J Clin Neurosci 13 (8) (2006) 823–827.
[3] A.F. Ducruet, B.T. Grobelny, B.E. Zacharia, et al., The surgical management of chronic subdural hema- toma, Neurosurg Rev 35 (2) (2012) pp. 155–69 [discussion: 169].
[4] G. Filippini, Epidemiology of primary central nervous system tumors, Handb Clin Neurol 104 (2012) 3–22.
[5] I.T. Gavrilovic, J.B. Posner, Brain metastases: epidemiology and pathophysiology, J Neurooncol 75 (1) (2005) 5–14.
[6] L.B. Miranda, E. Braxton, J. Hobbs, et al., Chronic subdural hematoma in the elderly: not a benign disease, J Neurosurg 114 (1) (2011) 72–76.
[7] I.A. Buchanan, W.J. Mack, Minimally Invasive Surgical Approaches for Chronic Subdural Hematomas, Neurosurg Clin N Am. 28 (2) (2017) 219–227.
[8] H. Nakaguchi, T. Tanishima, N. Yoshimasu, Factors in the natural history of chronic subdural hematomas that influence their postoperative recurrence, J Neurosurg. 95 (2001) 256–262.
[9] K. Tabaddor, K. Shulmon, Definitive treatment of chronic subdural hematoma by twist-drill cranios- tomy and closed-system drainage, J Neurosurg 46 (2) (1977) 220–226.
[10] O.R. Hubschmann, Twist drill craniostomy in the treat- ment of chronic and subacute subdural hematomas in severely ill and elderly patients, Neurosurgery 6 (3) (1980) 233–236.
[11] R. Ramnarayan, B. Arulmurugan, P.M. Wilson, et al., Twist drill craniostomy with closed drainage for chronic subdural haematoma in the elderly: an effective method, Clin Neurol Neurosurg 110 (8) (2008) 774–778.
[12] N. Emonds, W.E. Hassler, New device to treat chronic subdural hematoma–hollow screw, Neurol Res 21 (1) (1999) 77–78.
[13] A.I. Rughani, C. Lin, T.M. Dumont, et al., A case-comparison study of the subdural evacuating port sys- tem in treating chronic subdural hematomas, J Neurosurg 113 (3) (2010) 609–614.
[14] N. Takeda, K. Sasaki, A. Oikawa, et al., A new simple therapeutic method for chronic subdural hematoma without irrigation and drainage, Acta Neurochir (Wien) 148 (5) (2006) 541–546.
[15] S. Kubo, H. Takimoto, H. Nakata, et al., Carbon dioxide insufflation for chronic subdural haematoma: a simple addition to burr-hole irrigation and closed- system drainage, Br J Neurosurg 17 (6) (2003) 547–550.
[16] Harjyot Toor, Ira Bowen, Bailey Zampella, Gohar Majeed, Christopher Elia, James A Berry, Shokry Lawandy, Rosalinda Menoni, Dan E. Efficacy of Trauma Catheter and Mushroom Tip Catheter in Evacuation of Chronic Subdural Hematoma and Complications of Drain Placement. Cureus. 2019; 11 (7), e5123.
[17] Chronic Subdural Hematoma in Elderly Patients, Is This Disease Benign? Neurol Med Chir (Tokyo). 57 (8) (2017) 402–409.
[18] C. Smely, A. Madlinger, R. Scheremet, Chronic subdural haematoma–a comparison of two different treatment modalities, Acta Neurochir. 139 (9) (1997) 818–825.