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Twist-drill craniostomy with pressure-controlled fibrinolytic irrigation therapy for the evacuation of bilateral acute traumatic subdural hematoma: illustrative case

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BACKGROUND Bilateral acute subdural hematomas (aSDHs) present a significant challenge for neurosurgeons, particularly due to the risk of contralateral hematoma enlargement following unilateral evacuation and subsequent volume shifts. This complexity is further compounded in elderly patients with preexisting health conditions.

OBSERVATIONS This case report presents a novel minimally invasive approach for managing bilateral aSDHs in a 76-year-old female. The patient developed bilateral aSDHs following head trauma and was considered high risk for general anesthesia and bilateral craniotomies. A minimally invasive technique was utilized, involving twist-drill craniostomy under local anesthesia combined with pressure-controlled fibrinolytic therapy using the IRRAflow and LiquoGuard 7 systems. The patient was treated with continuous pressure–controlled irrigation therapy using an electrolyte solution containing 200,000 IU/l of urokinase infused at a rate of 100 ml/hr. The patient showed significant improvement, with complete resolution of the hematomas and no residual neurological deficits.

LESSONS This case demonstrates the effectiveness of minimally invasive techniques that avoid the risks associated with general anesthesia and craniotomies. While these findings are promising, they should be interpreted with caution and require prospective confirmation in a larger cohort of patients. Nonetheless, they align with the recent literature that supports minimally invasive approaches for aSDHs.

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KEYWORDS acute subdural hematoma; minimally invasive; fibrinolytic irrigation therapy

Acute subdural hematomas (aSDHs) are critical neurosurgical emergencies characterized by the accumulation of blood between the dura mater and the arachnoid membrane.[1] Traditionally, symptomatic aSDHs are managed through open craniotomy, a procedure that, while effective, carries significant risks including prolonged recovery, surgical trauma, and high morbidity and mortality rates.[2] These risks are particularly severe in patients 60 years or older with preexisting health conditions, who are at increased risk of adverse outcomes.[3] The management of bilateral aSDHs further complicates the surgical approach, as there are limited published experience and a lack of established guidelines.[4] Current evidence from case reports suggests that removing the hematoma on one side can lead to a volume shift, potentially causing enlargement of the contralateral hematoma and further neurological impairment.[4] Recent advancements in minimally invasive neurosurgical techniques can provide promising alternatives for the treatment of aSDHs.[5] This case report highlights a novel minimally invasive approach performed bedside for managing bilateral aSDHs in a high-risk patient. The approach utilized advanced pressure-controlled drainage systems combined with continuous fibrinolytic irrigation, offering a less invasive option that aims to reduce surgical trauma and improve patient outcomes.

Illustrative Case

Presentation

A 76-year-old female with a complex medical history, including hypertension, atrial fibrillation, cardiomyopathy, diabetes, and a history of oral anticoagulation with rivaroxaban, presented to the emergency department following head trauma. On initial evaluation, her Glasgow Coma Scale score was 13, and she exhibited significant behavioral changes indicative of neurological impairment. Computed tomography (CT) scans confirmed bilateral aSDHs. Given the patient's substantial comorbidities, including an American Society of Anesthesiologists class of IV, and the high risks associated with traditional surgical

ABBREVIATIONS aSDH = acute subdural hematoma; CT = computed tomography; ICP = intracranial pressure; TDC = twist-drill craniostomy.
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approaches, coupled with the absence of an immediate need for craniotomy and the elevated anesthetic risk, we opted for a novel minimally invasive approach. Preoperatively, 3500 IU of prothrombin complex concentrate was administered to normalize blood coagulation.

Surgical Technique

The awake patient was positioned in the right lateral decubitus position for management of the left-sided hematomas and subsequently in the left lateral decubitus position for the right-sided hematomas. The precise puncture sites were determined using CT imaging, targeting the frontal eminence on both sides. After shaving the hair and administering 5 ml of 2% Scandicain (AspenPharma) as local anesthesia, a 4.5-mm tangential twist-drill craniostomy (TDC) was performed at the planned sites. For the left-sided hematoma, the IRRAflow double-lumen catheter system (9 Fr, IRRAS AB) was utilized. For the right-sided hematomas, two single-lumen drains (7 Fr) were inserted. Continuous pressure–controlled irrigation was administered using the IRRAflow and LiquoGuard 7 (Möller Medical GmbH) systems. The rationale for using two different irrigation/drainage systems (IRRAflow and LiquoGuard) was that we only had one unit of each system available for use.

Pressure-Controlled Subdural Fibrinolytic Therapy

The IRRAflow single catheter system was employed on the right side of the patient. This system features a dual-lumen design that integrates automated irrigation, controlled drainage, and intracranial pressure (ICP) monitoring into a single device. It consists of an Intelligent Digital Cassette, an IRRAflow catheter, and a control unit. The system functions cyclically, alternating between irrigation, monitoring, and drainage phases. It is equipped with ICP alarms to prevent excessive irrigation or overdrainage and includes built-in safety mechanisms to maintain irrigation and drainage within predefined ICP thresholds. If the ICP exceeds the upper limit, the system automatically halts irrigation and switches to a drainage-only mode for 2 minutes while alerting the user. Conversely, if the ICP drops below the lower threshold, the system stops both irrigation and drainage and issues an alert.

The LiquoGuard 7 system was utilized with two catheters inserted through a 4.5-mm burr hole. Similar to the IRRAflow system, the LiquoGuard 7 system features high and low ICP alarms to prevent excessive irrigation or overdrainage. The LiquoGuard 7 cerebrospinal fluid management system facilitates continuous irrigation in parallel with passive drainage (Fig. 1).

Postoperative Management

Following craniostomy and catheter insertion, the patient was managed with continuous pressure–controlled irrigation therapy utilizing an electrolyte solution containing 200,000 IU/l of urokinase, infused at a rate of 100 ml/hr on both sides. This fibrinolytic therapy was maintained for a duration of 5 days. The infusion facilitated gradual dissolution of the hematomas, with ICP being monitored continuously through the pressure-controlled catheter systems. Further imaging was conducted on day 5, when the irrigation fluid was observed to be clear. Passive drainage was continued until the outflow ceased and the hematomas were radiologically confirmed to be resolved.

Outcome

The postoperative course was notably positive. By the 1st postoperative day, the patient demonstrated substantial improvement and exhibited no residual neurological deficits. She was discharged in a self-sufficient condition after 8 days. At the 4-week follow-up, imaging confirmed the complete resolution of both subdural hematomas (Fig. 2). No significant difference in hematoma evacuation was observed between the IRRAflow and LiquoGuard 7 systems. The patient continued to show a favorable recovery without any signs of neurological impairment or complications.

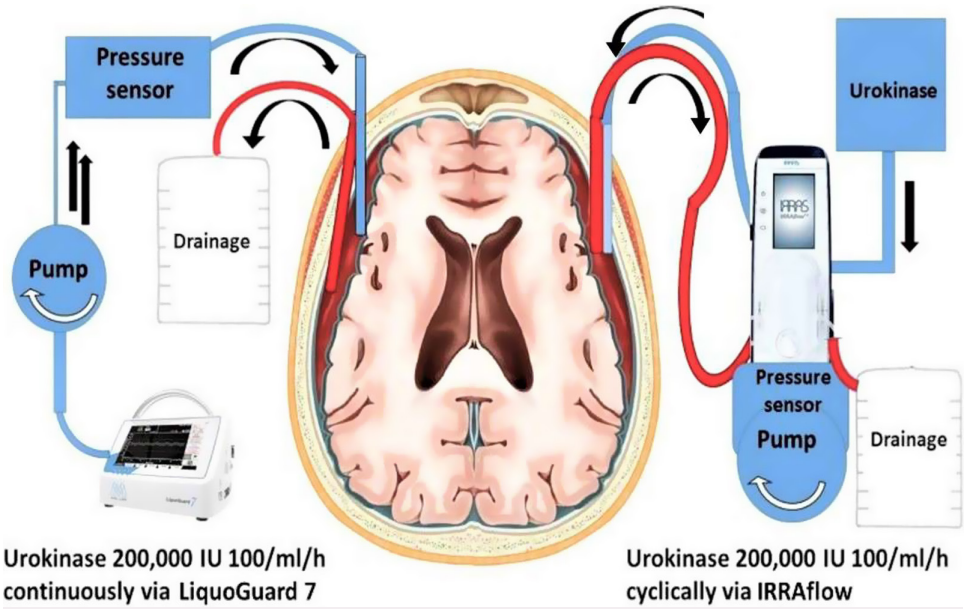

FIG. 1. Schematic of the two systems for controlled subdural irrigation and lysis therapy. The IRRAflow system operates cyclically, alternating between irrigation, pressure monitoring, and drainage via a double-lumen catheter. The LiquoGuard 7 system, on the other hand, allows for continuous irrigation and pressure monitoring through two catheters. In both systems, drainage is passive.

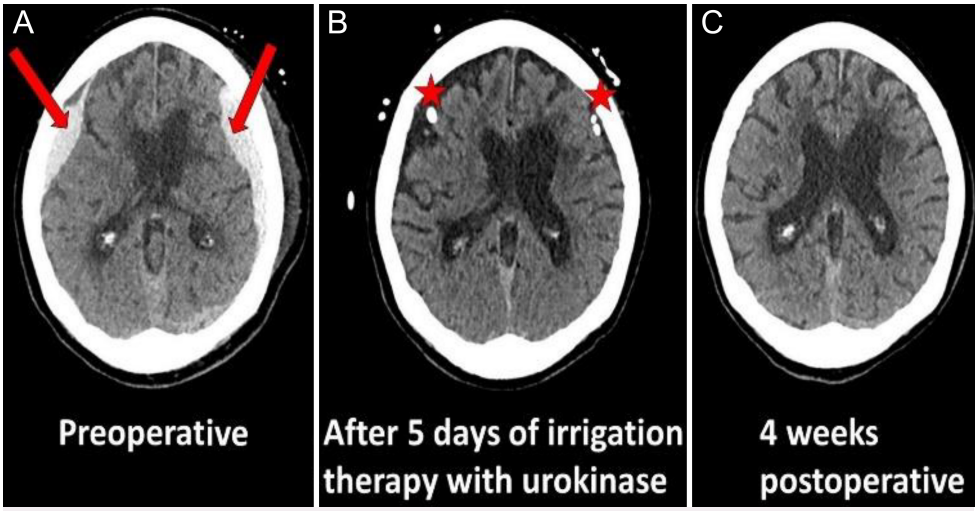

FIG. 2. CT images showing preoperative bilateral aSDHs (*red arrows*, **A**), 5 days after irrigation therapy (**B**), and 4 weeks postoperatively (**C**). The double-lumen catheter on the right side (IRRAflow) and the two catheters on the left side (LiquoGuard 7) are marked with *red stars*. The bilateral hematomas have nearly completely regressed after 5 days of irrigation and lysis therapy.

Informed Consent

The necessary informed consent was not obtained in this study, as treatment was administered on an emergency basis.

Discussion

Observations

In the case presented, a novel minimally invasive surgical technique for bilateral aSDHs was employed. This approach combined bilateral TDC performed under local anesthesia with pressure-controlled fibrinolytic therapy using the IRRAflow and LiquoGuard 7 systems. This dual strategy not only eliminated the need for general anesthesia, thereby significantly reducing perioperative risks, but also mitigated the risk of contralateral hematoma enlargement since hematoma evacuation is gradual and no sudden volume shifts occur. Furthermore, with successful hematoma resolution observed on both sides, we noted that the two systems can potentially be used interchangeably. To the best of our knowledge, this is the first documented case of a patient being treated using this specific surgical technique.

The approach utilized in this case aligns with recent literature that highlights the benefits of minimally invasive techniques for managing aSDHs in elderly patients with elevated surgical risks. Because of the patient's clinical presentation, an individual, deliberate assessment led to the decision not to proceed with craniotomy.[3,6] A comparative study assessing the impact of craniotomy size on functional outcomes in elderly patients with aSDHs categorized patients into three groups: small, medium, and large craniotomies.[3] The study found that craniotomy size did not significantly influence functional outcomes, as measured by the Glasgow Outcome Scale score. Importantly, patients who underwent small craniotomies achieved comparable functional outcomes to those with larger craniotomies while also benefiting from shorter operative times and more effective hematoma evacuation. Conversely, patients with larger craniotomies exhibited greater midline shifts and more pronounced clinical signs, indicating that smaller craniotomies can be a more efficient and less invasive option without compromising outcomes.[3]

Supporting this, Yokosuka et al. reported favorable neurological outcomes in a cohort of 11 patients with aSDH who were treated via endoscopic evacuation under local anesthesia.[6] This technique, which utilized a 4-mm rigid endoscope and a malleable irrigation suction cannula, demonstrated effective hematoma evacuation and was associated with a good recovery profile, underscoring the efficacy of minimally invasive approaches in high-risk patient populations.

Additionally, Ryu et al. described a novel minimally invasive technique for managing aSDHs that incorporated subdural fibrinolysis.[7] This method involved a 3-cm incision and 1-cm burr hole craniostomy performed under local anesthesia, through which a 10.5-Fr external ventricular drainage catheter was inserted into the hematoma. Fibrinolytic therapy was administered using recombinant tissue plasminogen activator mixed with saline, followed by saline flushing to ensure complete delivery. Postoperative management included passive drainage for 12–24 hours and frequent follow-up brain CT scans to monitor hematoma resolution and evaluate patient recovery. The mean evacuation rate of the subdural hematoma after drainage was 83.6%, with no rebleeding or operation-related infection observed during the aspiration procedure. The median midline shift correction after the procedure was 7 mm, further demonstrating the efficacy and safety of this minimally invasive technique.

Lessons

This case report suggests that minimally invasive techniques, including TDC with pressure-controlled fibrinolytic therapy, might emerge as viable and effective alternatives for managing bilateral aSDHs in elderly and frail patients. These approaches not only minimize surgical trauma but may also improve functional outcomes, providing a valuable treatment option for high-risk populations. It is important to recognize the potential risks and limitations associated with these techniques. The safety and efficacy of continuous irrigation and fibrinolysis have not yet been fully established, as these methods are not considered standard practice. The initial patients were closely monitored in the intensive care unit, but further research

involving larger patient cohorts and prospective data is necessary before these approaches can be widely recommended. Given the current limited patient numbers and incomplete data, caution is warranted. Additionally, patient selection is critical, as this method might not be suitable for those with larger aSDHs and significant mass effect, poor neurological status, rapid symptom progression, or a high risk of elevated ICP. Further research is warranted to validate these initial findings and explore the broader applicability of these methods in diverse clinical settings.

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Disclosures

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

Conception and design: Bissolo, Doria-Medina, Beck, Roelz. Acquisition of data: Bissolo, Doria-Medina, Roelz. Analysis and interpretation of data: Bissolo, Doria-Medina, Beck, Roelz. Drafting the article: Bissolo, Doria-Medina, Roelz. Critically revising the article: Doria-Medina, Shah, Beck, Roelz. Reviewed submitted version of manuscript: Bissolo, Doria-Medina, Beck. Approved the final version of the manuscript on behalf of all authors: Bissolo. Statistical analysis: Doria-Medina. Administrative/ technical/material support: Doria-Medina, Shah. Study supervision: Beck, Roelz.

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