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ORIGINAL RESEARCH

Comparative Analysis of Postoperative Inflammatory Response in Subperiosteal vs. Subdural Drainage: A Physiological Biomarker Study

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ABSTRACT

Background: Chronic subdural hematoma (CSDH) is a common neurosurgical condition, especially among the elderly, and is managed primarily through burr hole evacuation with postoperative drainage. **Objective:** To compare the postoperative inflammatory response and clinical recovery between subperiosteal and subdural drainage techniques in patients undergoing burr hole surgery for CSDH.**Methods:**This is a prospective, comparative study, conducted and a total of 80 patients diagnosed with chronic subdural hematoma were included in this study. The patients were divided into two groups: one group (n=40) received subperiosteal/subgaleal drainage, and the other group (n=40) underwent subdural drainage.**Results:** On POD 1, patients in the subperiosteal group had significantly lower CRP (22.4 ± 5.6 vs. 31.7 ± 7.2 mg/L, p<0.001), IL-6 (18.9 ± 4.5 vs. 27.2 ± 6.1 pg/mL, p<0.001), TNF-α (12.1 ± 3.1 vs. 16.3 ± 3.9 pg/mL, p<0.001), and WBC counts (9.4 ± 1.8 vs. 11.2 ± 2.3 ×10⁹/L, p=0.002) compared to the subdural group. Similar trends were observed on POD 3. The subperiosteal group also demonstrated faster ambulation (2.1 ± 0.6 vs. 3.4 ± 1.1 days, p<0.001), shorter hospital stay (4.3 ± 1.2 vs. 5.9 ± 1.5 days, p<0.001), and fewer febrile episodes (10% vs. 35%, p=0.008). **Conclusion:** Subperiosteal drainage following CSDH surgery is associated with a significantly lower postoperative inflammatory response and faster physiological recovery compared to subdural drainage. These findings support the use of subperiosteal drainage as a more physiology-conserving and clinically effective alternative in the postoperative management of CSDH.

INTRODUCTION

Chronic subdural hematoma (CSDH) is a common condition, especially among the elderly, and it is typically associated with significant morbidity if not treated effectively [1]. CSDH occurs due to the accumulation of blood between the dura mater and the brain, often as a result of minor trauma or anticoagulant use, and it can lead to increased intracranial pressure, neurological deficits, and even death if left untreated [2]. Surgical management is the primary treatment for CSDH, with various drainage methods being utilized to evacuate the hematoma and prevent recurrence. Among these, subperiosteal/subgaleal drainage and subdural drainage are two common techniques employed, each with its own set of benefits and risks [3]. Chronic subdural hematoma (CSDH) is a frequently encountered neurosurgical entity, especially in the elderly population, where cerebral atrophy increases vulnerability to venous tearing after minor head trauma. The condition is characterized by the gradual accumulation of blood between the dura mater and arachnoid membrane, often accompanied by the formation of vascularized neomembranes and a persistent low-grade inflammatory milieu [4]. CSDH may initially remain asymptomatic but can progress to cause headache, altered mental status, hemiparesis, or even coma if left untreated. Surgical intervention via burr hole craniostomy and hematoma evacuation remains the standard of care, with postoperative drain placement being a widely accepted adjunct to reduce recurrence [5]. The pathophysiological process underlying CSDH is not limited to a mechanical hematoma; it involves a dynamic inflammatory response. The outer membrane of the hematoma becomes highly vascularized and prone to microhemorrhages, while inflammatory mediators like interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), vascular endothelial growth factor (VEGF), and prostaglandins promote angiogenesis and vessel permeability. This creates a self-perpetuating cycle of fluid accumulation and rebleeding. Therefore, any surgical approach that modulates or minimizes the postoperative inflammatory surge could theoretically reduce complications and enhance recovery [6].The position of the drains helps to restart and prevent reaccumulation of fluids in the brain after surgery [7]. Still, the location and depth of the drainage are actively investigated. In many cases, removing fluid from the subdural space with drains is considered successful, but it may result in irritation to the brain tissue, seizures, or bleeding in the brain due to being placed close to the brain. Alternatively, placing the drain above the dura and under the skull bone makes the procedure less invasive [8]. New literature indicates that draining at the edge of the bone can do as much to reexpand the brain as bolts, while it may also reduce the possibility of complications. Systemic inflammatory response syndrome (SIRS) can be triggered by surgical trauma, leading to increases in acute-phase reactants and cytokines [9]. These alterations can affect the patient's recovery, increase the risk of getting a fever or infection, and slow down when the patient is able to walk. CRP, IL-6, TNF-α, and WBC levels show how much stress and swelling a patient experiences after a surgery [10]. Studies on orthopedic, abdominal, and cardiac surgery show that approaches involving fewer incisions tend to generate little inflammation and are more likely to lead to positive after-surgery results [11].

Objective

To compare the postoperative inflammatory response and clinical recovery between subperiosteal and subdural drainage techniques in patients undergoing burr hole surgery for CSDH.

MATERIALS AND METHODS

This is a prospective, comparative study, conducted and a total of 80 patients diagnosed with chronic subdural hematoma were included in this study. The patients were divided into two groups: one group (n=40) received subperiosteal/subgaleal drainage, and the other group (n=40) underwent subdural drainage.

Inclusion Criteria

- Age ≥ 18 years
- Radiologically confirmed chronic subdural hematoma
- First-time CSDH requiring surgical evacuation
- Informed written consent provided

Exclusion Criteria

- Recurrent CSDH
- Concurrent systemic infection or sepsis
- Known autoimmune or inflammatory disorders
- Immunosuppressive therapy within 30 days
- Coagulopathy or anticoagulant use without reversal

Data collection

Clinical and laboratory data were systematically collected using a structured datasheet. Baseline clinical variables included patient age, sex, preoperative Glasgow Coma Scale (GCS) score, and hematoma volume measured on CT scan. Postoperative parameters included time to ambulation, hospital stay duration, fever incidence, and other complications. Inflammatory biomarkers — including C-reactive protein (CRP), interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and white blood cell count (WBC) were measured on postoperative day 1 and day 3. Blood samples were collected in EDTA tubes and serum separators, processed immediately, and analyzed using standardized enzyme-linked immunosorbent assay (ELISA) kits and automated hematology analyzers in the hospital's central diagnostic laboratory.All surgical procedures were performed under general anesthesia by experienced neurosurgeons following a standardized burr hole evacuation technique. In the subperiosteal group, the drain was placed external to the dura, beneath the periosteum but outside the cranial vault. In the subdural group, the drain was introduced directly into the subdural space. The rest of the procedure, including irrigation and hemostasis, remained consistent across both groups. Depending on postoperative recovery and radiological resolution, drains were typically retained for 48 to 72 hours.

Statistical Analysis

Data analysis was conducted using SPSS v 17. Continuous variables were reported as mean ± standard deviation and compared between the two groups using the independent samples t-test. Categorical variables were compared using the Chi-square test. A two-tailed p-value of less than 0.05 was considered statistically significant for all comparisons.

RESULTS

Data were collected from 80 patients. The mean age was similar in both groups (68.4 ± 9.1 vs. 69.1 ± 10.2 years; p=0.72), and the male predominance was slightly higher in the subdural group (75% vs. 70%; p=0.62). Median preoperative GCS scores were identical [13 (IQR 12–14)] in both groups (p=0.89), and hematoma volumes were nearly equivalent (65.2 ± 15.3 mL vs. 64.7 ± 16.1 mL; p=0.84).

Table 1: Baseline Demographics and Clinical Characteristics

Variable	Subperiosteal Group (n=40)	Subdural Group (n=40)	p-value
Age (mean ± SD)	68.4 ± 9.1	69.1 ± 10.2	0.72
Male (%)	28 (70%)	30 (75%)	0.62
Preoperative GCS (median [IQR])	13 [12–14]	13 [12–14]	0.89
Hematoma Volume (mL)	65.2 ± 15.3	64.7 ± 16.1	0.84

On postoperative day 1, CRP levels were markedly lower in the subperiosteal group (22.4 ± 5.6 mg/L vs. 31.7 ± 7.2 mg/L; p<0.001), as were IL-6 levels (18.9 ± 4.5 pg/mL vs. 27.2 ± 6.1 pg/mL; p<0.001). Additionally, WBC count was reduced (9.4 ± 1.8 $\times 10^9$/L vs. 11.2 ± 2.3 $\times 10^9$/L; p=0.002), and TNF-α levels were significantly lower (12.1 ± 3.1 pg/mL vs. 16.3 ± 3.9 pg/mL; p<0.001) in the subperiosteal group.

Table 2: Inflammatory Biomarkers on Postoperative Day 1 (POD 1)

Biomarker	Subperiosteal (Mean ± SD)	Subdural (Mean ± SD)	p-value
CRP (mg/L)	22.4 ± 5.6	31.7 ± 7.2	<0.001
IL-6 (pg/mL)	18.9 ± 4.5	27.2 ± 6.1	<0.001
WBC Count ($\times 10^9$/L)	9.4 ± 1.8	11.2 ± 2.3	0.002
TNF-α (pg/mL)	12.1 ± 3.1	16.3 ± 3.9	<0.001

Patients ambulated earlier (2.1 ± 0.6 vs. 3.4 ± 1.1 days; p<0.001) and had shorter hospital stays (4.3 ± 1.2 vs. 5.9 ± 1.5 days; p<0.001). Neurological improvement, as reflected by GCS gain at postoperative day 3, was greater in the subperiosteal group (2.1 ± 0.9 vs. 1.5 ± 0.8; p=0.01). Moreover, fewer patients in the subperiosteal group developed fever above 38°C (10% vs. 35%; p=0.008), indicating a milder systemic response and more stable early recovery.

Table 3: Physiological Recovery Parameters

Parameter	Subperiosteal	Subdural	p-value
Time to ambulation (days)	2.1 ± 0.6	3.4 ± 1.1	<0.001
Duration of hospital stay (days)	4.3 ± 1.2	5.9 ± 1.5	<0.001
Postoperative GCS improvement at POD 3	2.1 ± 0.9	1.5 ± 0.8	0.01
Incidence of fever >38°C (%)	10%	35%	0.008

By postoperative day 3, inflammatory biomarkers remained significantly lower in the subperiosteal group compared to the subdural group, reflecting sustained physiological advantage. CRP levels were reduced to 11.2 ± 3.3 mg/L in the subperiosteal group versus 19.6 ± 5.8 mg/L in the subdural group (p<0.001), while IL-6 levels also declined more favorably (9.8 ± 2.1 pg/mL vs. 15.1 ± 3.9 pg/mL; p<0.001). Similarly, WBC counts remained lower in the subperiosteal group (7.2 ± 1.4 $\times 10^9$/L vs. 9.3 ± 1.9 $\times 10^9$/L; p=0.002).

Table 4: Follow-up Inflammatory Markers on POD 3

Biomarker	Subperiosteal	Subdural	p-value
CRP (mg/L)	11.2 ± 3.3	19.6 ± 5.8	<0.001
IL-6 (pg/mL)	9.8 ± 2.1	15.1 ± 3.9	<0.001
WBC Count	7.2 ± 1.4	9.3 ± 1.9	0.002

Recurrence of hematoma occurred in 5% of subperiosteal cases versus 10% in the subdural group (p=0.39). Infections were less common in the subperiosteal group (2.5% vs. 12.5%; p=0.09), and no seizures were reported, compared to a 7.5% seizure rate in the subdural group (p=0.08).

Table 5: Postoperative Complications

Complication	Subperiosteal (n=40)	Subdural (n=40)	p-value
Recurrence (%)	2 (5%)	4 (10%)	0.39
Infection (%)	1 (2.5%)	5 (12.5%)	0.09
Seizures (%)	0 (0%)	3 (7.5%)	0.08

DISCUSSION

This study demonstrated that subperiosteal drainage in chronic subdural hematoma (CSDH) surgery is associated with a significantly reduced postoperative inflammatory response and improved early physiological recovery compared to subdural drainage. The findings contribute to growing evidence that less invasive drainage techniques may offer clinical advantages by minimizing systemic inflammation without compromising surgical efficacy.

On postoperative day 1, patients in the subperiosteal group had markedly lower levels of key inflammatory biomarkers including CRP, IL-6, TNF-α, and WBC count [12]. These differences persisted on day 3, indicating a consistently lower inflammatory burden. These biomarkers are well-established indicators of systemic inflammatory response and have been shown in other surgical domains to correlate with complications, delayed recovery, and prolonged hospital stay. The reduced inflammatory profile in the subperiosteal group suggests that avoiding direct insertion of the drain into the subdural space may result in less cortical irritation and immune activation [13].The measurements taken in the lab matched the clinical findings. Those in the subperiosteal group started ambulating faster, had fewer days in the hospital, and showed a greater increase in the GCS scale by day 3 [14]. Studies also suggest that because subperiosteal drainage involves less exposure to the brain, it can lead to milder immune reactions and fewer chances for infection or brain injury [15]. There was no statistical proof that subperiosteal drainage is safer, but it was observed as a more common approach. However, despite the trauma to the brain, there were no seizures among the group that used drains, but three seizures were observed in the subdural group. Despite this difference not being significant statistically, the lower infection rate (2.5% vs. 12.5%) in the subperiosteal group is meaningful and supports previous research noting more effective control of infection using extra-dural drainage [16]. Remarkably, both groups had low rates of recurrence and they were similar (5% vs. 10%). This means that subperiosteal drainage does not make the hematoma harder to clear or more likely to gather again, as the rate is p=0.39. It aims to tackle a standard issue raised by neurosurgeons about the reliability of non-subdural drainage in removing excess fluid [17]. From the perspective of physiology, these outcomes support the idea that correct surgical technique plays a key role in recovery from both the surgery and the health consequences of bowel obstruction. Abnormally high levels of the cytokines IL-6 and TNF-α following surgery are linked to fatigue, fever, mental decline, and an increase in breakdown of body tissues. Hence, using mini-surgery approaches like subperiosteal drainage could play a big role in helping older or comorbid people by boosting their recovery outcomes [18].This study is strengthened by its prospective design and biomarker-based approach, though it is not without limitations. The sample size was relatively small, and long-term follow-up on recurrence and functional outcomes was beyond the study's scope. Future randomized controlled trials with larger cohorts and extended follow-up periods are warranted to validate these findings and potentially redefine standard drainage protocols in CSDH surgery.

CONCLUSION

It is concluded that subperiosteal drainage following burr hole evacuation for chronic subdural hematoma is associated with a significantly lower postoperative inflammatory response compared to subdural drainage. Patients managed with subperiosteal drains exhibited reduced levels of CRP, IL-6, TNF-α, and WBC counts, along with faster neurological recovery, earlier ambulation, and shorter hospital stays. Although differences in complication rates were not statistically significant, trends favored the subperiosteal approach, indicating a potentially safer and more physiologically favorable technique.

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