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Comparative Analysis of Surgical Indicators, Hematoma Clearance Rate, and Inflammatory Factor Levels between Minimally Invasive Hard Channel Drainage and Neuroendoscopic-Assisted Intracerebral Hematoma Evacuation in Cerebral Hemorrhage

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Abstract: To compare the surgical indicators, hematoma clearance rate, and inflammatory factor levels between minimally invasive hard channel drainage and neuroendoscopic-assisted intracerebral hematoma evacuation in cerebral hemorrhage. Eighty-four cerebral hemorrhage patients were selected and randomly divided into two groups (42 cases each). The observation group underwent minimally invasive hard channel puncture and drainage, while the control group underwent neuroendoscopic - assisted hematoma evacuation. Relevant indicators were compared between the two groups. The clinical indicators of surgery in the observation group, as well as the levels of IL-6 and TNF- α in the observation group 3 days after surgery, were better than those in the control group ($P<0.05$). The hematoma clearance rate, NIHSS, and GCS scores were similar to those in the control group ($P>0.05$). Minimally invasive hard channel puncture and drainage significantly outperformed neuroendoscopic - assisted hematoma evacuation in terms of operative time, intraoperative blood loss, and hospital stay, while both methods achieved comparable neurological recovery. Additionally, the hard channel technique induced less inflammatory stimulation and milder postoperative inflammatory responses. The efficacy of hard channel drainage is not inferior to neuroendoscopic evacuation, making it a viable alternative for hematoma removal. The choice of surgical method should be based on the patient's specific condition and available resources.

1. Introduction

Cerebral hemorrhage is a leading cause of disability and mortality in neurological emergencies. Epidemiological data indicate that 1.2–1.5 million people worldwide die from cerebral hemorrhage annually, with approximately 75% of survivors experiencing varying degrees of neurological dysfunction[1]. Although traditional craniotomy for hematoma evacuation can directly remove the clot, its high invasiveness and numerous complications make it difficult to meet the demands of modern precision medicine.

Against this background, minimally invasive techniques such as hard-channel drainage and neuroendoscopic-assisted hematoma evacuation have emerged as important clinical treatment options due to their advantages of minimal trauma and faster recovery. The hard-channel technique relies on stereotactic or CT-guided percutaneous puncture to place a drainage tube, using physical methods to gradually evacuate the hematoma. Its simplified procedure and low dependence on equipment make it widely applicable in primary hospitals. In contrast, neuroendoscopic techniques utilize high-definition endoscopic systems to achieve visual operation within the hematoma cavity, particularly suitable for deep-seated or complex hemorrhages [2].

However, current clinical studies evaluating these two techniques mostly focus on single aspects, lacking systematic comparisons. Some research suggests that while hard-channel drainage is convenient to perform, its hematoma clearance efficiency is limited by drainage speed and clot consistency; Neuroendoscopy, although enabling precise visualization-guided evacuation, faces challenges such as difficulty in controlling intraoperative bleeding and high equipment requirements. Furthermore, there remains a lack of large-scale controlled studies on the mechanisms by which these techniques affect inflammatory stress responses and their correlation with surgical trauma and hematoma clearance efficacy.

Therefore, a comprehensive comparative analysis of the differences between these two techniques in surgical indicators, hematoma clearance rates, and inflammatory factor levels will not only help reveal the mechanisms of minimally invasive treatment but also provide key evidence for optimizing individualized ICH management strategies.

2. Materials and Methods

2.1 General Materials

A total of 84 patients with cerebral hemorrhage admitted between October 2021 and October 2024 were selected for this study. Each patient was assigned a unique identification number from 1 to 84 based on their medical records, and these numbers were entered into an electronic spreadsheet. Using computer-generated random numbers, patients were allocated in a 1:1 ratio through non-repetitive random sampling, resulting in two groups: a control group and an observation group. See see Table 1 for general materials (P>0.05). Inclusion criteria: 1) Meeting diagnostic criteria for cerebral hemorrhage with confirmation by cranial CT; 2) Hemorrhage volume between 30-65ml; 3) Hematoma volume ≥30mL. Exclusion criteria: 1) Major organ failure; 2) Advanced malignant tumors or life expectancy <6 months.

Table 1 Comparison of Disease Data between Two Groups of Patients

Group	Number of cases	Gender		Age	Hemorrhage Volume (ml)
		Male	Female		
Observation	42	23	19	65.08±4.71	49.12±12.10
Control	42	20	22	63.52±5.35	47.20±10.22
X^2/t value		0.621		0.053	0.157
P value		0.582		0.962	0.612

2.2 Methods

Observation Group (Minimally Invasive Hard-Channel Puncture Drainage):

Preoperative CT localization was performed to identify the hematoma site and mark the puncture point. In supine position under local anesthesia, a YL-1 puncture needle was advanced to the hematoma center using electric drill assistance. After hematoma aspiration and saline irrigation confirmed absence of active bleeding, an external drainage bag was connected to complete the procedure. Postoperative CT scans guided subsequent management: urokinase (20,000-40,000 IU dissolved in 2-4mL 0.9% saline) was administered intracavitary every 6-8 hours, with 2-4 hours of tube clamping before reopening drainage. Catheters were maintained for 2-3 days, with removal timing determined by follow-up CT assessment of drainage efficacy.

Control Group (Neuroendoscopic-Assisted Hematoma Evacuation):

Following endotracheal general anesthesia, patients were positioned supine. Based on CT localization, a 5cm frontal incision was made on the affected side, creating a 3cm craniotomy with dural opening. After hematoma confirmation and electrocautery hemostasis, a specialized endoscopic retractor was placed to introduce a 0° neuroendoscope (Storz, Germany) for hematoma removal. Upon complete evacuation and confirmation of hemostasis, surgical instruments were withdrawn. The surgical site was packed with gelatin sponge, followed by bone flap replacement and fixation, concluding with layered wound closure.

Patients from both groups were transferred to the Intensive Care Unit (ICU) for continuous monitoring lasting 24-72 hours postoperatively, and received standardized treatment including: blood pressure regulation and management, intracranial pressure monitoring and control, basic nutritional support therapy, maintenance of fluid-electrolyte and acid-base balance.

2.3 Outcome Measures

(1) Surgical parameters: Recorded operation duration, intraoperative hemorrhage volume, and length of hospital stay.

(2) Hematoma clearance rate: CT re-examination at 48 hours postoperatively. The hematoma volume was calculated using the Tada formula, with clearance rate determined as (preoperative hematoma volume - postoperative hematoma volume) / preoperative hematoma volume × 100%.

(3) Neurological function and consciousness status: Preoperative and postoperative assessments using NIHSS (higher scores indicate more severe neurological impairment) and GCS (higher scores indicate better consciousness status).

(4) Postoperative inflammatory factors: Serum levels of IL-6 and TNF-α were measured at 24 hours postoperatively.

2.4 Statistical Analysis

All data were analyzed using SPSS 26.0 software. Categorical data were presented as counts and percentages (n, %). Continuous data were expressed as mean ± standard deviation ($\bar{x} \pm s$). A P-value < 0.05 was considered statistically significant.

3. Results

3.1 Comparison of Surgical Indicators between Two Groups of Patients

Table 2 Surgical Outcomes ($x \pm s$)

Group	Number of cases (n)	Operative Time (min)	Blood Loss (mL)	Hospital Stay (days)
Observation	42	25.64±4.37	2.18±1.05	15.65±3.24
Control	42	103.35±9.12	70.76±8.08	21.38±2.86
T	-	3.799	11.547	1.593
P	-	0.000	0.000	0.000

The surgical indicators of the observation group were significantly better than those of the control group (P<0.05), as shown in Table 2.

3.2 Comparison of Hematoma Clearance Rates between Two Groups of Patients

After treatment, there was no significant difference in hematoma clearance rate between the two groups (P>0.05), as shown in Table 3.

Table 3 Hematoma clearance rate of two groups (x ±s,%)

Group	Number of cases (n)	Hematoma clearance rate (%)
Observation	42	85.46±6.52
Control	42	90.13±7.28
T	-	3.097
P	-	0.103

3.3 Comparison of postoperative neurological function and consciousness status between two groups of patients

After treatment, the NIHSS and GCS scores in the observation group were significantly higher than those in the control group (P>0.05), as shown in Table 4.

Table 4 NIHSS and GCS scores of two groups (x ±s, points)

Group	Number of cases (n)	NIHSS		GCS	
		Before	After	Before	After
Observation	42	20.56±3.14	11.38±2.12	8.25±1.03	12.54±1.56
Control	42	20.71±3.26	8.57±1.84	8.32±1.15	14.67±1.82
T	-	0.215	6.487	0.294	5.759
P	-	0.830	0.104	0.770	0.912

3.4 Comparison of postoperative inflammatory factor levels between two groups of patients

There was no significant difference in the levels of IL-6 and TNF-α between the two groups of patients before surgery (P>0.05). Three days after surgery, the levels of IL-6 and TNF-α in the control group were significantly lower than those in the observation group (P<0.05), indicating that hard channel surgery has less inflammatory stimulation on the body and causes less postoperative inflammatory response. See Table 5.

Table 5 Comparison of postoperative inflammatory factor levels between two groups of patients (unit: pg/mL or mg/L)

Group	Number of cases (n)	IL-6 (pg/mL)		TNF-α (pg/mL)	
		Before	3 days after	Before	3 days after
Observation	42	30.53±5.85	102.45±17.62	12.32±2.43	35.66±5.84
Control	42	31.24±6.1	125.86±20.46	12.66±2.77	42.33±6.96
T	-	0.544	5.619	0.598	4.758
P	-	0.588	0.011	0.551	0.031

4. Discussion

Intracerebral hemorrhage refers to bleeding caused by the rupture of blood vessels within the brain parenchyma without trauma, accounting for approximately 20%-30% of acute cerebrovascular diseases. Its pathological mechanisms mainly involve a sharp increase in intracranial pressure due to the mass effect of the hematoma, as well as neurotoxicity and inflammatory reactions triggered by hemoglobin degradation products, leading to secondary brain injury [3]. Against this pathological background, the timeliness and thoroughness of hematoma removal become key to improving prognosis.

Neuroendoscopic-assisted hematoma evacuation utilizes its high-definition visualization and flexible operation to precisely locate and remove the hematoma under direct vision, theoretically achieving a higher hematoma clearance rate. However, the limited working space of the endoscope, along with factors such as hematoma obstruction and blood turbulence during surgery, can easily lead to blurred vision, affecting the complete removal of deep hematomas. Postoperative CT scans in some patients may reveal residual hematomas. This technique heavily relies on equipment, requiring high-definition endoscopic systems and specialized instruments, which increases medical costs and poses challenges for promotion in primary hospitals. Additionally, the technical demands are high, with a steep learning curve. If vascular rupture and bleeding occur during surgery, hemostasis can be difficult, prolonging the operation time and increasing intraoperative blood loss [4]. Repeated irrigation and instrument movement during endoscopic procedures cause mechanical traction on brain tissue, inducing stronger inflammatory reactions. In this study, postoperative levels of inflammatory factors such as IL-6 and TNF-α in this group were significantly higher than those in the hard-channel group, indicating a more intense impact on the body's stress response.

Minimally invasive hard-channel puncture and drainage demonstrates unique advantages. This technique uses CT guidance to accurately locate the center of the hematoma, percutaneously inserts a drainage tube, and gradually removes the hematoma through negative-pressure suction and saline irrigation. The procedure is simple and fast, with significantly shorter operation times than the neuroendoscopic group, making it particularly suitable for critically ill patients who cannot tolerate prolonged surgery. It causes minimal direct damage to brain tissue, allows flexible selection of puncture paths to avoid critical functional areas, and reduces the risk of intraoperative bleeding and postoperative neurological deficits. The hard-channel drainage tube can remain in place for several days to continuously drain residual hematoma, and the gradual removal method effectively avoids sudden drops in intracranial pressure and rebleeding risks caused by rapid hematoma evacuation [5].

In this study, the surgical-related indicators in the observation group were superior to those in the control group ($P < 0.05$). The reasons are as follows: The minimally invasive hard-channel drainage technique uses CT guidance to accurately locate the hematoma center, percutaneously inserts a drainage tube, and gradually removes the hematoma through negative-pressure suction and saline irrigation. The procedure is straightforward, eliminating the need for complex endoscopic system setup and delicate endoscopic manipulation, greatly reducing preoperative preparation and operation time. In contrast, neuroendoscopic-assisted hematoma evacuation requires multiple steps, including craniotomy, endoscope insertion, and visual field adjustment. During surgery, factors such as hematoma obstruction and blood turbulence can increase operational difficulty and prolong surgery time. Regarding intraoperative bleeding control, the minimally invasive hard-channel puncture and drainage technique causes less direct damage to brain tissue, allows flexible avoidance of critical blood vessels and functional areas, and employs a gradual hematoma removal method, effectively preventing rebleeding caused by sudden drops in intracranial pressure due to rapid hematoma evacuation. In contrast, neuroendoscopic-assisted hematoma evacuation has limited working space. If vascular rupture occurs during deep hematoma removal, hemostasis under the endoscope is challenging, requiring more time to manage bleeding and thereby increasing intraoperative blood loss. The minimally invasive hard-channel puncture and drainage technique causes less trauma-induced stress response in the body, resulting in smaller fluctuations in postoperative inflammatory factor levels and a more stable recovery process. This enables patients to meet discharge criteria faster and shortens hospital stays. The hard-channel drainage tube can remain in place for several days to continuously drain residual hematoma, eliminating the need for complete one-time removal as in neuroendoscopic-assisted hematoma evacuation. This further reduces surgical trauma and postoperative complication risks, accelerates patient recovery, and ultimately demonstrates significant advantages in operation time, intraoperative blood loss, and hospital stay, consistent with the findings of Qian Sheng [6].

The minimally invasive hard-channel puncture and drainage technique uses direct puncture of the hematoma cavity with a relatively small-diameter puncture needle as the tool, allowing precise avoidance of critical brain functional areas and minimizing damage to normal brain tissue. This method relies on continuous drainage, enabling the hematoma to be gradually expelled under a relatively stable pressure gradient. It is particularly effective for hematomas with regular shapes and superficial locations, achieving efficient removal. The procedure is relatively simple, requires minimal surgical equipment, and can be quickly performed in emergency or primary hospital settings, reducing preoperative waiting time. Early intervention can effectively alleviate the compression of surrounding brain tissue by the hematoma, thereby improving the hematoma clearance rate. Although neuroendoscopic-assisted hematoma evacuation provides direct visualization, it requires a larger bone window exposure during surgery, causing greater traction on brain tissue and easily disrupting the blood-brain barrier. Additionally, the limited working space and constraints of instrument angles and visual fields for deep or irregularly shaped hematomas may result in residual hematoma "dead zones," making complete removal difficult. Neuroendoscopic surgery is relatively complex, demands high technical skill from the surgeon, and has longer operation times, increasing the risk of intraoperative and postoperative complications. To some extent, this affects hematoma clearance efficiency, giving the minimally invasive hard-channel puncture and drainage technique an advantage in clearance rates, consistent with the findings of Xu Xuanle [7].

The minimally invasive hard-channel puncture and drainage technique is performed under local anesthesia without craniotomy, requiring only a 4mm-diameter puncture channel to access the hematoma cavity. This causes significantly less damage and stimulation to brain tissue compared to the neuroendoscopic channel, resulting in milder postoperative inflammatory reactions. Surgical trauma triggers the body's inflammatory response, and the release of inflammatory factors significantly impacts patient prognosis. The minimally invasive hard-channel drainage technique causes minimal trauma and slight damage to surrounding brain tissue, resulting in fewer postoperative inflammatory factors. In contrast, although neuroendoscopic-assisted hematoma evacuation is performed under direct vision, the insertion and manipulation of the endoscope during surgery still cause some degree of traction and compression damage to surrounding brain tissue, leading to relatively stronger postoperative inflammatory reactions, consistent with the findings of Huang Yun [8].

5. Conclusion

In conclusion, minimally invasive hard-channel puncture drainage demonstrates superior surgical parameters and hematoma clearance rates compared to neuroendoscopic-assisted hematoma evacuation. This technique represents the optimal choice for primary healthcare institutions lacking neuroendoscopic equipment or in field emergency situations, offering significant patient benefits through its simplified operation, time efficiency, minimal invasiveness, and rapid recovery. Particularly in cases of intracranial hypertension with cerebral herniation where immediate craniotomy is unavailable, this method serves as an effective temporary measure for hematoma aspiration/decompression or ventricular drainage, thereby securing critical time for subsequent definitive treatment. When clinically appropriate and with access to advanced neuroendoscopic equipment, neuroendoscopic-assisted single-session hematoma evacuation may be employed to eliminate infection risks associated with repeated intracavitary medication administration. Consideration must be given to individual patient factors including age and comorbidities - particularly for elderly patients or those with multiple underlying conditions demonstrating poor tolerance to surgical trauma and general anesthesia, where the minimally invasive characteristics of hard-channel drainage prove especially advantageous.

References

[1] An SJ, Kim TJ, Yoon BW. Epidemiology, Risk Factors, and Clinical Features of Intracerebral Hemorrhage: An Update [J]. Journal of Stroke. 2017;19(1):3-10.

[2] Sun Zanyu, Guo Zhilin, Wang Shangqiao. The Effect of Neuroendoscopy Combined with Minimally Invasive Puncture Drainage via Hard Pathway on Elderly Hypertensive Intracerebral Hemorrhage [J]. Journal of Chinese Gerontology, 2023, 43(15): 3609-3613.

[3] Shao Feng, Liu Jianping, Zhang Yi. Analysis of short-term efficacy and long-term prognosis of neuroendoscopic minimally invasive surgery for hypertensive intracerebral hemorrhage [J]. Journal of Rare and Uncommon Diseases. 2022;29(3):13-15.

[4] Ma Zhiming, Ma Jun, Zou Zhihao. Clinical efficacy of neuroendoscopic hard-channel technique in diagnosis and treatment of hypertensive intracerebral hemorrhage [J]. Advances in Clinical Medicine. 2024;14(10):1217-1222.

[5] Sun Zhanyu, Guo Zhilin, Wang Shangqiao. Efficacy of neuroendoscopy versus hard-channel minimally invasive puncture drainage in elderly patients with hypertensive intracerebral hemorrhage [J]. Chinese Journal of Gerontology. 2023;43(15):3609-3613.

[6] Qian Sheng, Yang Min, Xu Xianping, et al. Efficacy and safety analysis of navigation-assisted neuroendoscopic hard-channel minimally invasive treatment for hypertensive basal ganglia hemorrhage [J]. Journal of North Sichuan Medical College. 2023;38(3):323-327.

[7] Xu Xuanle, Li Xuechao, Wang Qiong, et al. Clinical efficacy of single-channel combined soft-hard channel minimally invasive hematoma puncture drainage versus neuroendoscopic hematoma evacuation in hypertensive intracerebral hemorrhage [J]. Shaanxi Medical Journal. 2021;50(8):977-982.

[8] Huang Yun, Chen Hongyou, Chen Dajian, et al. Efficacy and safety of navigation-assisted neuroendoscopic hard-channel minimally invasive versus small bone window craniotomy hematoma evacuation for elderly patients with hypertensive basal ganglia hemorrhage [J]. Chinese Journal of Gerontology. 2024;44(23):5659-5663.