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Perioperative Nursing Influence on Cerebrospinal Fluid Biochemical Markers in Cerebral Hemorrhage Patients Undergoing Minimally Invasive Intracranial Hematoma Removal Surgery

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Abstract

Background: Cerebral hemorrhage refers to a hemorrhagic disease caused by primary non-traumatic rupture of blood vessels in the brain parenchyma. It is a common acute cerebrovascular disease in the elderly.
Objectives: To observe the effect of perioperative nursing on minimally invasive intracranial hematoma removal surgery in patients with cerebral hemorrhage.
Methods: This randomized controlled trial study was conducted on 106 patients undergoing treatment for minimally invasive internal hematoma (MIRIH) at the First Hospital of Jilin University, Jilin, China, between January and December 2022. These patients were randomly divided into two groups, namely the control and observation groups (n=53 each). The observation group received perioperative care in addition to routine care. Differences between groups were compared using t-tests and Chi-square tests.
Results: On the first day, there were no significant differences in the baseline characteristics between the groups. However, on the 7th and 14th days of admission, the observation group showed an increase in potassium ions and a decrease in chloride ions, lactate dehydrogenase, trace microalbumin, and the National Institutes of Health Stroke Scale (NIHSS) scores, compared to the control group ($P<0.05$). The observation group also had a lower incidence of postoperative complications, including pneumonia, lower limb vein thrombosis, and cerebral hernia, compared to the control group ($P<0.05$). NIHSS scores on days 7 and 14 were significantly lower in the observation group than in the control group (day 7: 9.60±4.11 vs 12.02±2.83, $P<0.05$; day 14: 6.77±3.47 vs 9.19±2.86, $P<0.05$).
Conclusion: Perioperative nursing leads to improvement in electrolyte/metabolic levels, neurological recovery, and reduction in post-MIRIH surgical complications.

Keywords: Cerebral Hemorrhage, Cerebrovascular Disorders, L-Lactate Dehydrogenase, Perioperative Care, Perioperative Nursing

1. Background

Cerebral hemorrhage (CH) is a hemorrhagic disease caused by primary non-traumatic rupture of blood vessels in the brain parenchyma. It is a common acute cerebrovascular disease in the elderly (1, 2). Cerebral hemorrhage is identified by mild indications, an abrupt start, and swift advancement. People may experience a sudden headache, weakness, paralysis, vision loss, vomiting, seizures, and unconsciousness (3, 4). This disease can lead to hydrocephalus, vasospasm, seizures, coma, and cognitive and motor impairments (5, 6). Without timely intervention, the occupying effect of CH can trigger the shifting of the brain's centerline and herniation, potentially causing sudden fatality (7).

Cerebrovascular disease ranks second in global mortality according to the Global Burden of Disease Report (8). Cerebral hemorrhage accounts for 10-20% of strokes (9, 10), and with an annual incidence of 60/100,000 with a severe acute mortality rate of 30-40% is a significant threat to human safety and health (8). The primary causes of CH include hypertension, cerebral amyloid angiopathy, and hypertensive arteriopathy (11). In young adults, the most common locations of CH are the basal ganglia (45.89%), lobar (41.55%), thalamus (10.63%), brainstem (8.7%), cerebellum (4.83%), and other regions (3.86%) (12).

When the tight junction structure and function of endothelial cells in the blood-brain barrier (BBB) are abnormal, various neurotoxic substances and white blood cells in the peripheral blood enter the brain through damaged BBB. This can lead to changes in the composition and flow of cerebrospinal fluid (CF), accompanied by electrolyte disorders, among which, hyponatremia and hypokalemia are the most common. In research, early hypokalemia is mainly caused by thalamic damage due to brain tissue lesions in stroke patients, leading intracellular potassium ions to enter the cells. Similarly, the potassium ion level in CF is also at a low level. Therefore, CF can be applied to evaluate the prognosis of CH (13, 14).

Cerebral hemorrhage diagnosis involves a physical exam, medical history, computed tomography (CT) scans, and magnetic resonance imaging (MRI) to locate bleeding in the brain (15, 16). Approaches to treating CH can be categorized into medical and surgical methods. Medical strategies encompass regulating blood pressure, managing coagulopathy, and managing such complications as infections and seizures. Surgical interventions may be considered in certain cases, such as when there is a large hematoma causing a significant mass effect or when the hemorrhage is accessible and causes neurological deterioration. The focus of ongoing research and development is on less invasive surgical techniques (10). With technology advancements, minimally invasive internal hematoma (MIRIH) removal is essential to CH treatment. This surgical method has minimal trauma and can improve a patient's neurological function and quality of life (17). Therefore, it is required to implement corresponding nursing measures during the perioperative period for patients with CH MIRIH to consolidate the surgical effects and prevent postoperative complications (18, 19).

2. Objectives

The results of a study by Lotte Sondag et al. (2023) demonstrated that minimally invasive surgery may be beneficial, especially when performed early in the onset of symptoms (20). The findings of a study by Anjun Song et al. (2022) also confirm the usefulness of minimally invasive surgery (21).

While there is limited direct evidence on the impact of perioperative nursing (PN) on patient outcomes during minimally invasive intracranial hematoma removal surgery, the available literature suggests that minimally invasive techniques can lead to better outcomes compared to traditional craniotomy. Therefore, it was necessary to conduct the present study to investigate the effect of intraoperative nursing on minimally invasive intracranial hematoma removal surgery in patients with cerebral hemorrhage.

3. Methods

3.1. General Information

In the present randomized controlled trial study, CH patients who received MIRIH treatment at the First Hospital of Jilin University Jilin, China, from January 2022 to December 2022, were selected as samples. The sample size was calculated using the following formula:

$$n1=n2=2[(\mu\alpha+\mu\beta)\sigma/\delta]2$$

where σ is the population standard deviation, and δ is the mean difference between the two samples. n1=n2 are the sample sizes for the control group (CG) and observation group (OG), respectively. If $\alpha=0.05$, $\beta=0.10$, then $\mu\alpha=1.96$, $\mu\beta= 1.28$. In reference (22), $\sigma=4.0$, $\delta=3.2$, and the calculated sample sizes are n1=n2=45. 20% loss of follow-up rate was considered, so the required sample size is at least (42+42)/(1-20%)≈106. Finally, it is determined that n1=n2=53. The study obtained patient and family consent and Ethics Committee approval. The diagnosis of CH was based on specific criteria (severe headache, nausea and vomiting, altered consciousness, seizures, and focal neurological deficits) (23, 24), and confirmed by clinical imaging (including CT and MRI). Inclusion criteria comprised meeting diagnostic standards, receiving MIRIH treatment, having a hypertension history, Glasgow Coma Scale (GCS) score of ≥ 6, and bleeding volume of 30-50 ml. Exclusion criteria included traumatic CH, severe lesions in other organs, coagulation disorders, and certain cerebrovascular conditions. A computer random generator assigned 106 patients into control (CG) and observation (OG) groups with balanced baseline data.

3.2. Methods

Both groups received MIRIH: Brain CT was used to locate intracerebral hematoma and determine the maximum CT slice distance of the hematoma. The distance between the hematoma and the surface of the skull was delineated using a parallel section line of OM." to "The virtual straight line between the occipital bone and the midline is determined as the distance between the hematoma and the surface of the skull body. The distance between the hematoma site and the center of the forehead scalp was measured, and the puncture points were taken as the skull surface layer line and surface line foot pad. Local anesthesia was performed with lidocaine (manufacturer: China National Pharmaceutical Group Rongsheng Pharmaceutical Co., Ltd., National Pharmaceutical Approval No.: H20023544). Routine disinfection was performed on the puncture point. An intracranial hematoma puncture needle (manufacturer: Beijing Wantefu Technology Co., Ltd., model: YL-1) was used for vertical injection into the skull. After passing through the skull dura mater, a blunt plastic needle core needed to be replaced and slowly pushed into the hematoma cavity. After the plastic needle core was pulled out, liquid hematoma fluid was aspirated through a side-hole drainage tube. After suction, a hematoma crusher was used to crush the hematoma. A volume of 5 ml of heparin sodium (produced by Qingdao Jiulong Biopharmaceutical Co., Ltd., with national drug approval number H32023290) and a physiological saline mixture were used for flushing. After cleaning the hematoma, 20,000 to 40,000 units of urokinase (manufacturer: Nanjing Nanda Pharmaceutical Co., Ltd., National Pharmaceutical Approval No.: H32023290) and physiological saline were injected, and the hematoma crusher was removed. The surgery was completed. After sterile dressing, the drainage tube was continuously drained for 3-4 h twice a day. After the hematoma was cleared by more than 80%, the drainage tube was removed.

Routine care was implemented in CG: (1) Upon admission, the patient and their family were introduced to the hospital environment, and the basic information of CH and MIRIH treatment was explained. The patients were blessed with absolute bed rest and unobstructed bowel movements. They needed to maintain emotional stability. Patients were provided with strategies for self-emotional regulation. These included mindfulness exercises, deep breathing techniques, and cognitive reframing strategies. They were encouraged to practice these strategies regularly to manage their emotional responses effectively and reduce stress related to their medical condition and treatment. Targeted counseling should be provided to patients with psychological problems to help them maintain a relaxed state (2). After patients were transferred to the ward post-surgery, it was necessary to enhance monitoring during periods when the effects of anesthesia were still present. During the experiment, various vital signs of the patient were closely monitored. Protective barriers were set up to prevent patients from falling off the bed. Patients should not rest on pillows, sleep, or consume water (3). After waking up, patients who were able to answer questions correctly, had clear consciousness, and had normal swallowing function could eat water. Those without vomiting could continue to eat. Patients needed the transition from a dilute to a viscous diet when eating. In bed, active and passive training was done, including elbow flexion and extension, knee flexion and extension, ankle pump exercise, and fist grip training. Each movement was trained for 10 s 15-20 times per hour.

Preoperative nursing was implemented in OG as follows: (1) Preoperative care: ① Psychological care: Nurses explained the purpose of MIRIH surgery to patients and their families; this included an explanation about the characteristics of minimal trauma and mild brain tissue damage. The nurse explained the advantages and disadvantages of the surgery, as well as possible situations during and after the surgery. ② Preoperative preparation: Nurses cooperated with doctors to conduct hematological and cranial CT preoperative examinations, and indwelling catheterization was achieved before the surgery. For calm and restless individuals, sedatives were given according to medical advice. The nurse assisted the doctor in locating the bleeding site on the scalp. (2) Postoperative care: ① Drainage tube care: The drainage tube needs to be clamped for 2-4 h after the surgery. Patients with consciousness disorders, restlessness, slow breathing, and irregular breathing should immediately open and close the drainage tube. For patients with stable conditions, 1-5 U of urokinase was injected into the drainage tube as instructed by the doctor 1-2 times a day. After the postoperative CT examination of the head confirmed that all or most of the hematoma had been cleared, the hematoma cavity drainage tube was removed. During the experiment, the blood color of the drainage bag was observed. If colorless liquid appeared, CF outflow was considered. The patient was assisted in adopting a supine position, and the drainage tube was placed at the head of the bed, which should be below the level of the hematoma. It needed an immediate report to the doctor. ② Oral care: Dobey's solution/5% sodium bicarbonate solution was used to clean the mouth 1-2 times a day, and lipstick or paraffin oil was applied to dry lips. ③ Skincare: The bed unit was kept dry and clean, and the patient rolled over once every 2 hours. Family members were instructed to massage the compressed area with Sefu Moisturizer. ④ Hypertension control: 24-hour dynamic monitoring of blood pressure was conducted. If blood pressure was too high, it had to be reduced according to medical advice, and it had to be controlled between 140-160/80-90 mmHg. Intravenous administration speed, concentration, and dosage should also be controlled. Patients with poor blood pressure control were given 40 mg of nitroglycerin+40 ml of 0.9% physiological saline solution for micropump injection. ⑤ Brain edema control: It was necessary to pay attention to monitoring the patient for prodromal symptoms of cerebral hernia. After reporting to the doctor, dehydration agents, such as rapid intravenous infusion of mannitol, intravenous infusion of furosemide, and intravenous infusion of human blood albumin, were given as instructed to reduce intracranial pressure. ⑥ Respiratory management: Conscious patients were encouraged to cough and expectorate, turn over and tap the back, and administer nebulized inhalation of viscous sputum,1-6 times a day. Patients who were in a coma and had a tracheotomy needed regular aspirated sputum and had to undergo regular sputum culture. Medical advice was followed to administer antibiotics to prevent lung infections.

3.3. Observation Index

The patient's CF specimen was collected on the 1st, 7th, and 14th days of admission and examined using a Beckmann AU5400 biochemical analyzer and a Johnson & Johnson 4600 dry chemical electrolyte analyzer. Matching wet biochemical reagents (produced by Ningbo Meikang Biotechnology Co., Ltd.) were used to detect potassium ions (K^+), chloride ions (Cl^-), lactate dehydrogenase (LDH), and trace albumin (mALB) levels.

Neurological function recovery status: The National Institutes of Health Stroke Scale (NIHSS) was used for evaluation. The scale mainly includes consciousness level, visual field, eye movement, facial paralysis, upper limb movement, lower limb movement, sensation, limb ataxia, articulation, language, and attention (25). The total score range is obtained at 0-42 points, with a score of 0-1 indicating normal or close to normal neurological function, 1-4 points representing mild defects, 5-14 demonstrating moderate neurological impairment, 15-20 points showing moderate to severe neurological deficits, and 21-42 being classified as severe neurological deficit.

Incidence rate of complications: the incidence of postoperative rebleeding, hypostatic pneumonia, lower limb vein thrombosis, and cerebral hernia in the two groups were statistically analyzed.

3.4. In regards to blinding

The participants were randomized into either the CG or OG using a computer random generator. Both the patients and the healthcare providers were blind to the group allocations. The data analysts were also blinded, ensuring an unbiased interpretation of the results.

3.5. Statistical methods

EpiData software was used to establish a database, ensuring the accuracy of data input through parallel input by two individuals. The collected data were analyzed using SPSS 26.0 software. The measurement data was represented by $x\pm s$, and a sample t-test was used for intergroup comparison. Randomized block univariate variance analysis was applied to compare different times within groups. The quantitative data were expressed as frequency or percentage, using a χ^2-test. P-values of < 0.05 were considered statistically different.

3.6. Ethical considerations

This study obtained the consent of patients and their families and was approved by the Ethics Committee of the First Hospital of Jilin University (No. FHJLU2022019).

4. Results

4.1. Baseline characteristics

Table 1 presents a comparison of baseline characteristics between the CG and OG. The CG comprised 29 males (54.72%) and 24 females (45.28%), while the OG consisted of 33 males (62.26%) and 20 females (37.74%). The mean age was similar between groups, 64.36±8.05 years in the CG and 63.25±11.46 years in the OG (P=0.565). In terms of the bleeding site in the CG, 21 (39.63%) cases had basal ganglia hemorrhage, 9 (16.98%) thalamic hemorrhage, 12 (22.64%) lobar intracerebral hemorrhage, and 11 (20.75%) cerebellar hemorrhage. The OG had a similar distribution with 17 (32.08%) basal ganglia, 10 (18.87%) thalamic, 15 (28.30%) lobar, and 11 (20.75%) cerebellar hemorrhages. The differences in bleeding site distribution were not statistically significant between the two groups (P=0.848). For the GCS score, the CG had a mean of 9.85±1.34 points while the OG had 9.55±1.35 points (P=0.254). Finally, the mean preoperative bleeding volume was 40.17±4.83 ml in the CG and 39.15±5.40 ml in the OG (P=0.308).

Table 1. Comparison of baseline data

Group	Gender (%)		Age (year)	Bleeding site				GCS score (point)	Preoperative bleeding volume (ml)
	Male	Female		Basal ganglia hemorrhage	Thalamic hemorrhage	Lobar intracerebral hemorrhage	Cerebellar hemorrhage		
CG (n=53)	29 (54.72)	24 (45.28)	64.36±8.05	21 (39.63)	9 (16.98)	12 (22.64)	11 (20.75)	9.85±1.34	40.17±4.83
OG (n=53)	33 (62.26)	20 (37.74)	63.25±11.46	17 (32.08)	10 (18.87)	15 (28.30)	11 (20.75)	9.55±1.35	39.15±5.40
t/x^2	0.622		0.577	0.807				1.149	1.025
P	0.430		0.565	0.848				0.254	0.308

CG: Control group; OG: Observation group; GCS: Glasgow Coma Scale

4.2. Comparison of cerebrospinal fluid index

Upon admission, there were no differences in the levels of K^+, Cl^-, LDH, and mALB between the two groups (P>0.05). On the 7th and 14th days of admission, K^+ increased in the OG and was higher than that in the CG during the same period. However, Cl^-, LDH, and mALB decreased in the OG and were all lower than those in the CG during the same period (P<0.05). The repeated analysis of variance results showed that there were group, time, and interaction effects between the two groups (P<0.05) (Table 2). In both groups, patients' K^+ levels demonstrated an upward trend, while Cl^-, LDH, and mALB levels exhibited a gradual decline (Figure 1).

4.3. Comparison of NIHSS scores

Table 3 compares NIHSS scores between the CG (n=53) and OG (n=53) at 1, 7, and 14 days after admission. On day 1, the scores were similar between the groups (14.87±3.32 vs 14.55±4.97, P=0.698). By days 7 and 14, the observation group had significantly lower NIHSS scores compared to the control group (day 7: 9.60±4.11 vs 12.02±2.83, P<0.001; day 14: 6.77±3.47 vs 9.19±2.86, P<0.001). The NIHSS scores of patients in both groups showed a gradual downward trend (Figure 2).

Table 2. Comparison of K^+, Cl^-, LDH, and mALB (x±s)

Group	K⁺ (mmol/L)			F	P
	1st day of admission	7th day of admission	14th day of admission		
CG (n=53)	1.87±0.34	2.23±0.30	2.49±0.35	F_{group}=17.741	P_{group}<0.001
OG (n=53)	1.88±0.39	2.49±0.39	2.84±0.39	F_{time}=140.822	P_{time}<0.001
t	0.141	3.847	4.863	$F_{interaction}$=7.162	$P_{interaction}$=0.001
P	0.888	<0.001	<0.001		
Group	Cl^- (mmol/L)			F	P
	Before	7th day of treatment	14th day of treatment		
CG (n=53)	40.22±5.16	36.96±3.11	33.97±3.64	F_{group}=13.761	P_{group}<0.001
OG (n=53)	39.83±4.71	34.32±4.32	29.18±4.51	F_{time}=126.127	P_{time}<0.001
t	0.406	3.611	6.107	$F_{interaction}$=13.050	$P_{interaction}$<0.001
P	0.685	<0.001	<0.001		
Group	LDH (U/L)			F	P
	Before	7th day of treatment	14th day of treatment		
CG (n=53)	136.72±14.68	125.62±12.06	117.28±15.84	F_{group}=12.432	P_{group}=0.001
OG (n=53)	135.59±13.57	117.65±12.00	106.24±13.45	F_{time}=92.366	P_{time}<0.001
t	0.412	3.411	3.868	$F_{interaction}$=4.379	$P_{interaction}$=0.015
P	0.682	<0.001	<0.001		
Group	mALB (mg/L)			F	P
	Before	7th day of treatment	14th day of treatment		
CG (n=53)	53.97±5.72	50.32±5.18	45.20±3.92	F_{group}=9.727	P_{group}=0.002
OG (n=53)	53.50±4.64	47.22±4.41	41.24±4.87	F_{time}=219.321	P_{time}<0.001
t	0.465	3.317	4.612	$F_{interaction}$=8.077	$P_{interaction}$=0.001
P	0.643	0.001	<0.001		

CG: Control group; OG: Observation group; LDH: Lactate dehydrogenase; mALB: trace albumin

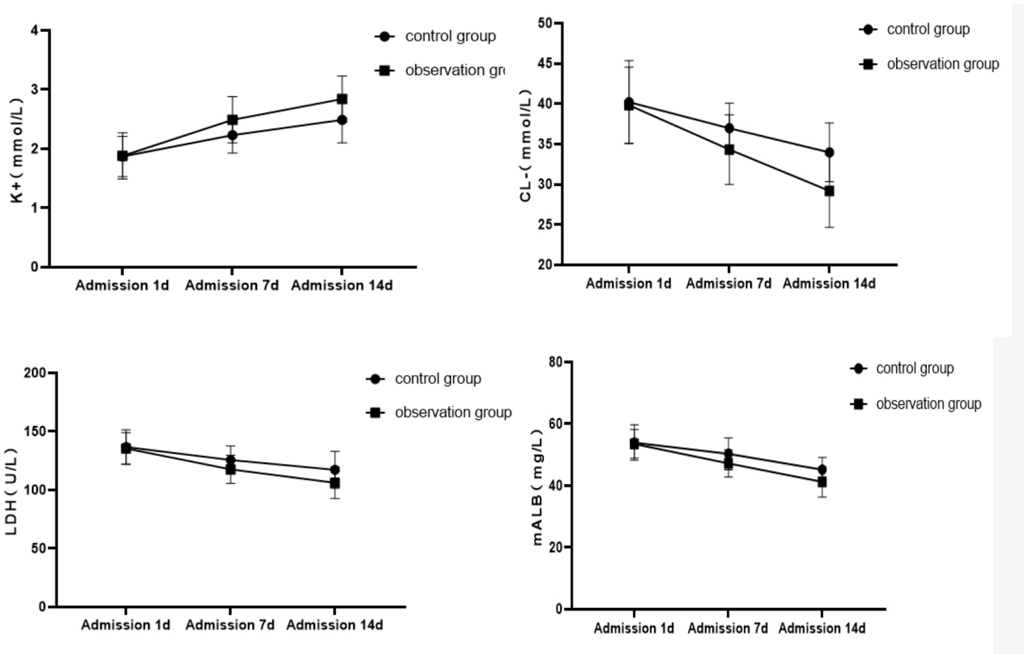

Figure 1. Changes of K^+, Cl^-, LDH, and mALB

Table 3. Comparison of NIHSS scores between two groups (x±s)

Group	NIHSS (point)			F	P
	1st day of admission	7th day of admission	14th day of admission		
CG (n=53)	14.87±3.32	12.02±2.83	9.19±2.86	F_{group}=7.361	P_{group}=0.008
OG (n=53)	14.55±4.97	9.60±4.11	6.77±3.47	F_{time}=204.163	P_{time}<0.001
t	0.390	3.531	3.918	$F_{interaction}$=10.039	$P_{interaction}$<0.001
P	0.698	<0.001	<0.001		

CG: Control group; OG: Observation group

4.4. Comparison of complications incidence

Table 4 compares the incidence of postoperative complications between CG and OG (n=53 each). The complications examined were postoperative rebleeding, hypostatic pneumonia, venous thrombosis of the lower limb, and cerebral hernia. No cases of postoperative rebleeding occurred in either group. The incidence of hypostatic pneumonia was 5.66% (n=3) in the CG and 0% in the OG. Venous thrombosis of the lower limb occurred at an incidence rate of 5.66% (n=3) in the CG and 1.89% (n=1) in the OG. The cerebral hernia occurred in 3.77% (n=2) and 0% of the patients in the CG and OG, respectively. The total incidence of all complications was 15.09% (n=8) in the CG compared to 1.89% (n=1) in the OG. Statistical analysis using the X^2 test yielded a value of 4.371 (P=0.037), indicating a significant difference in the overall incidence of postoperative complications between the two groups.

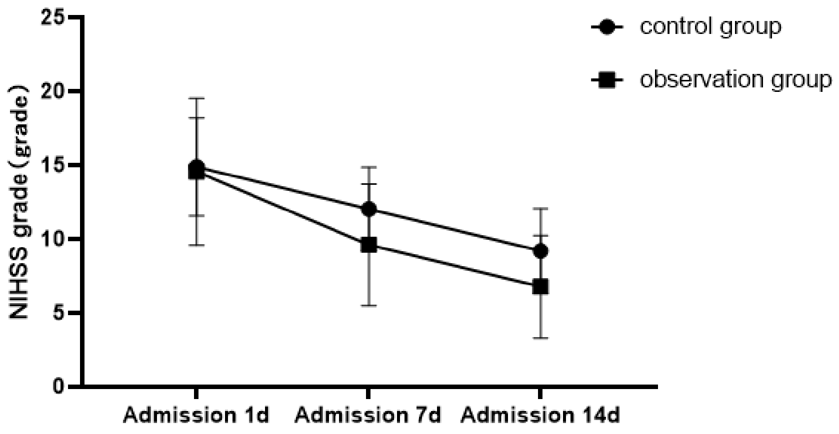

Figure 2. Comparison of NIHSS scores

Table 4. Comparison of complications incidence (n, %)

Group	Postoperative rebleeding	Hypostatic pneumonia	Venous thrombosis of the lower limb	Cerebral hernia	Total incidence
CG (n=53)	0	3 (5.66)	3 (5.66)	2 (3.77)	8 (15.09)
OG (n=53)	0	0	1 (1.89)	0	1 (1.89)
X^2	-	-	-	-	4.371
P	-	-	-	-	0.037

CG: Control group; OG: Observation group

5. Discussion

The present research designed a randomized controlled trial to elucidate the impact of PN on patients with cerebral hemorrhage undergoing minimally invasive intracranial hematoma removal surgery. The study divided participants into two groups, namely the CG and OG (n=53 each). The OG, in addition to the standard care, received perioperative care. The results showed a significant improvement in the OG compared to the CG. Notably, the OG experienced a rise in K^+ and a decrease in Cl^-, LDH, mALB, and NIHSS scores on the 7th and 14th days of admission. Moreover, the OG exhibited a lower incidence of postoperative complications, including pneumonia, lower limb vein thrombosis, and cerebral hernia, in comparison to the CG. The baseline characteristics, such as gender distribution, mean age, bleeding site, GCS score, and preoperative bleeding volume, were similar between the groups, indicating a well-balanced sample.

The CH refers to the rupture of cerebral blood vessels that causes blood to enter the brain parenchyma, causing compression and ultimately leading to dizziness, headache, and even coma in patients. When a hematoma is large and intracranial pressure is high in severe conditions, it can damage the brainstem and endanger the patient's life safety (26). Compared with conventional surgery, MIRIH only requires local anesthesia at the puncture point, which greatly reduces the risk of anesthesia and facilitates rapid postoperative recovery for patients. This method can also relieve the edema-occupying effect, reduce intracranial pressure, inhibit the continuous release of toxic substances, and help patients recover their neurological function (27, 28). At present, clinical prognostic indicators for CH mainly focus on imaging and serological examinations. However, routine imaging examinations cannot evaluate the development, changes, and prognosis of the disease. In addition, there are various factors interfering with the body in serological testing, which has certain limitations. The results of a study by Song et al. (2022) showed that during CH, BBB was disrupted, and the tight junctions between endothelial cells in capillaries were opened, resulting in a decrease in BBB hindrance (29). This causes neurotransmitters in the peripheral blood to enter the central nervous system through BBB, leading to changes in the flow, pressure, and composition of CF. Therefore, checking CF biochemical indicators can reflect the prognosis of CH (30).

There was a significant decrease in the levels of Cl^-

, LDH, and mALB in the OG; elevated levels of these biochemical markers are usually associated with poor prognosis in patients with cerebral hemorrhage (31, 32). Additionally, in our study, a significant increase was observed in K^+ levels in the OG. Potassium is an essential electrolyte for maintaining cell function, and its deficiency can exacerbate neurological conditions (33, 34). Therefore, our results suggested that perioperative care might have a protective effect on the brain's biochemical environment, thereby improving the prognosis of patients.

The cause analysis showed that after CH, due to the rupture of red blood cells, intracellular K^+ rapidly transferred to extracellular space, with low blood potassium and low blood sodium being the most common. LDH is an important myocardial enzyme in the body, mainly present in brain tissue and myocardial cells. After CH, blood circulation in the brain is disrupted, resulting in necrosis of nerve cells due to hypoxia and ischemia. Moreover, after BBB is damaged, a large amount of LDH is released from brain cells and enters the bloodstream (35). In addition, after CH, it leads to brain tissue hematoma, resulting in sympathetic adrenal hyperfunction. This causes the body to be in a state of stress and can also result in an increase in LDH levels in the blood. mALB is a vascular reactive change signal. It can not only reflect early brain tissue diseases but also indicate the severity of vascular endothelial dysfunction. The abnormal expression conjecture of mALB can reflect the prognosis after CH surgery (36).

The NIHSS scores were significantly lower in the OG on days 7 and 14 compared to the CG. This suggests that the neurological function of the patients in the OG improved more significantly. A similar study conducted by Zheng et al. (2021) supports these findings, demonstrating that a comprehensive nursing rehabilitation intervention contributes to enhancing neurological performance post-surgery and improving physical function in patients with intracerebral hemorrhage (37). Furthermore, in the current study, implementing PN following MIRIH yielded favorable outcomes for CH patients, as evidenced by zero cases of pneumonia, one case of lower limb venous thrombosis, and zero cases of cerebral herniation within the OG. In a study by Musa et al. (2022), compared with routine nursing interventions, PN was found to be more effective in restoring neurological function in MIRIH patients than in CG. It was also revealed that complications were reduced, which is consistent with the results of the current study. PN can promote patient recovery while reducing the risk of complications (38). The findings of another study by Liuyuan Wei et al. (2021) on gallstone patients demonstrated that comprehensive high-quality nursing care during the perioperative period led to a significantly lower number of postoperative complications and lower pain scores in the experimental group compared to the control group (39). These studies suggest that PN can be effective in promoting patient recovery and reducing the risk of complications across various surgical contexts.

6. Conclusion

The findings of the present study indicated that PN care could significantly improve the biochemical profile of cerebrospinal fluid and neurological function as well as reduce the risk of postoperative complications in patients with cerebral hemorrhage undergoing minimally invasive intracranial hematoma removal.

Acknowledgments

None.

Footnotes

Conflicts of Interest: None to declare.
Author's contributions: S. Liu was responsible for developing and designing the study, overseeing the collection and analysis of the data, and providing critical feedback during the manuscript review process. L. Wang played a key role in collecting the data, performing the statistical analysis, and drafting the manuscript. Together, both authors worked collaboratively to refine the manuscript and ensure its accuracy and quality. Ultimately, both authors approved the final version of the manuscript for submission.
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