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Original Article

Effect of minimally invasive surgery combined with intracranial pressure monitoring on neurological function recovery and quality of life in patients with hypertensive cerebral hemorrhage

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Abstract: Objective: To explore the influence of minimally invasive surgery (MIS) combined with postoperative intracranial pressure (ICP) monitoring on Glasgow Outcome Scale (GOS) score and postoperative complications of hypertensive intracerebral hemorrhage (HICH). Methods: From January 2018 to January 2020, 106 patients with HICH admitted to Qingdao Municipal Hospital were divided into two groups according to different treatment methods. Among them, 56 cases in the research group received neuroendoscopy minimally invasive surgery (MIS) combined with ICP monitoring, while 50 cases in the control group received only neuroendoscopy MIS. Perioperative indexes, complication rate within 6 months after operation, GOS scores, and GOS grades 6 months after operation, Activities of Daily Living (ADL) scores before and 6 months after operation, and National Institute of Health stroke scale (NIHSS) scores before and 14 days after operation were compared between the two groups, and the quality of life of patients was evaluated in the two groups 6 months after operation. Results: Compared with the control group, the patients in the research group had notably better indexes of operation time, length of hospital stay, hematoma absorption time, intra-operative blood loss, and hematoma clearance rate, and notably lower incidence of postoperative complications. Moreover, the patients in the research group had markedly higher GOS and ADL scores at 6 months after operation, as well as markedly higher NIHSS score at 14 days after operation. Conclusion: MIS combined with postoperative ICP monitoring can improve the prognosis of patients with HICH, reduce postoperative complications, and improve postoperative activities and quality of life.

Keywords: Minimally invasive surgery, postoperative intracranial pressure monitoring, hypertensive intracerebral hemorrhage, GOS score, postoperative complications

Introduction

Hypertensive cerebral hemorrhage (HICH) is a common cerebrovascular disease in the clinic, and a frequently-occurring neurologic disorder that causes death and seriously affects people's health and quality of life [1]. Among many cerebrovascular diseases, the mortality caused by HICH is as high as 40% [2]. Patients aged 50-70 years have a high prevalence of HICH. The incidence of HICH is higher in males than in females and is influenced by the season, with the highest incidence in the cold winter and spring. The change in people's lifestyle and increased aging of the population are leading to an increasing incidence rate [3]. Because of its high morbidity, mortality and disability rate, HICH has seriously affected people's quality of life, and has become a major public health problem [4]. Medical conservative treatment is the most basic clinical treatment for cerebral hemorrhage, and surgery remains the main clinical treatment for HICH [5]. Currently, there are several clinical surgical treatments, but no clear standard has been established [6].

In recent years, with the development of science and technology and the constant updating of medical devices, the concept of minimally invasive surgery (MIS) has been gradually recognized by the public, and MIS has been widely used [7]. It is also widely accepted in the clinical treatment of cerebral hemorrhage [8]. At present, MIS in the clinical treatment of cerebral hemorrhage is mainly represented by neuroendoscopic hematoma removal and minimally invasive hematoma puncture drainage [9]. Neuroendoscopy MIS can be used to treat the entire nervous system, providing a better view of the operation, removing deep structures and hematoma corners, and rapidly stopping bleeding [10]. Regardless of the surgical treatment, the patient may still develop severe edema secondary to the removal of the hematoma, leading to increased intracranial pressure (ICP) [11]. ICP is an important reference index in the diagnosis and treatment of clinical neurosurgical diseases, and it is valuable for the diagnosis of intracranial diseases and the determination of medical conditions [12]. ICP monitoring can display ICP continuously, dynamically, accurately and intuitively, which has important guiding significance for the treatment of diseases that may be complicated by intracranial hypertension. It has been widely used in the treatment of severe craniocerebral trauma in clinic, but it is rarely used in cerebral hemorrhage at present [13].

In this study, we carry out neuroendoscopy evacuation of hematoma and monitor ICP in patients with HICH, so as to explore the influence of this surgery program on postoperative GOS score and postoperative complications.

Materials and methods

General data

From January 2018 to January 2020, 106 patients with HICH admitted to Qingdao Municipal Hospital were divided into two groups according to different treatment methods. Among them, 56 cases in the research group received neuroendoscopy minimally invasive surgery (MIS) combined with ICP monitoring, while 50 cases in the control group received only neuroendoscopy MIS. The research group consisted of 32 males and 24 females, with an average age of (58.54±4.38) years, ranging from 45 to 70 years old. In the control group, there were 31 males and 19 females, with an average age of (58.86±4.42) years, ranging from 50 to 72 years.

Inclusion and exclusion criteria

Inclusion criteria were as follows: (1) Patients met the diagnostic criteria of HICH [14]; (2) Patients were all new-onset patients who were admitted to the hospital within 24 hours after onset, and they had obvious surgical indications. (3) This study was conducted with the approval of the ethics committee of Qingdao Municipal Hospital, and all the subjects and their families were informed and signed a fully informed consent form.

Exclusion criteria were as follows: (1) Patients with contraindications to surgery; (2) Patients with rapid increase in bleeding at admission, aggravation of consciousness disorder, or even deep coma; (3) Patients whose intracerebral hemorrhage caused by craniocerebral trauma, intracranial aneurysm, vascular malformation, or complicated by severe organ dysfunction.

Surgical methods

Patients in the control group received only neuroendoscopy evacuation of hematoma. All patients were anesthetized with endotracheal intubation, after which they were placed in a supine position with their heads slightly raised. After routine disinfection and towel laying, a 3.5 cm straight incision was made near the midline of hairline in the forehead, which was about 5 cm in depth. Scalp was cut in layers subcutaneously to the skull. Bipolar coagulation was applied to stop bleeding. A retractor was applied to expose the skull. A hole was drilled with an electric drill, and the diameter of bone flap was about 3 cm, which was made by milling cutter. Bone wax was adopted for hemostasis. Suspension could be performed on patients with dura mater hemorrhage. If the tension of dura mater was high, a cruciform incision was made to perform middle frontal gyrus fistulization. The hematoma was first punctured with a cerebral needle in the direction of the hematoma to determine the location of the hematoma, and then an endoscopic channel was inserted into the hematoma cavity in the direction of the puncture. The hematoma was probed and removed in all directions with the assistance of a 0-degree observation scope. The medical staff should avoid damage to normal brain tissue during operation. Compression hemostasis was conducted by fluid gelatin, surgicel, or gelatin sponge if there was no obvious bleeding part during operation. If a bleeding artery was found, bipolar coagulation was used to stop bleeding, and monopolar coagulation was adopted if necessary. After the removal of hematoma, the dura mater was repaired and sutured, the bone flap was fixed, and the scalp was sutured in layers. After the operation, the patient was transferred to the ICU and given infusion therapy of anti-inflammatory, hemostasis, dehydration, and ICP reduction. The changes in pupils, consciousness, and limb activity were closely observed. The patients underwent brain CT reexamination regularly to clarify the postoperative situation. Patients in the control group only received routine monitoring, including ECG monitoring, brain CT monitoring, and maintenance of water-electrolyte and acid-base balance.

Patients in the research group received neuroendoscopic hematoma removal combined with ICP monitoring. Based on the operation method of the control group, the Cadman ICP EXPRESS ICP monitor produced by Johnson & Johnson of the United States was used for ICP monitoring. First, the ICP monitoring probe was placed in the ventricle or brain parenchyma, and the probe was immediately connected to the ICP monitor. The measured pressure was recorded as the initial ICP. Then, the ICP probe was fixed, and hematoma localization puncture was performed. During and after operation, the change of ICP of patients was dynamically monitored, and the alarm value of high ICP (generally 20 mmHg) was set. When the ICP monitor showing an ICP of patients higher than 20 mmHg, the patients were given step-up therapy of ICP immediately according to the ICP monitor, to reduce the ICP.

Outcome measures

(1) In the two groups, the perioperative indicators were observed, including operation time, intra-operative blood loss, length of hospital stay, hematoma absorption time, and hematoma clearance rate.

(2) The incidence of complications within 6 months after operation was observed in the two groups, including electrolyte disturbance, pulmonary infection, intracranial infection, renal insufficiency, and rebleeding.

(3) The GOS scores and grades of the two groups were compared after operation for 6 months: GOS [15] was used to evaluate the prognosis of the patients, including five grades. Grade I represents death, scoring 1 point; Grade II represents persistent vegetative state with eye activity and sleep cycle, scoring 2 points; Grade III represents severe disability, unable to live independently in daily life, with the need of care, scoring 3 points; Grade IV represents moderate disability, able to live independently and work under protection, scoring 4 points; Grade V represents good recovery and back to normal life, scoring 5 points. The higher the score, the better the prognosis.

(4) The Activities of Daily Living (ADL) scores of the two groups were compared before and after operation for 6 months: ADL [16] was used to evaluate the patients' ability of daily activities, including 10 items of defecation, urination, grooming, toileting, eating, mobility, activity, dressing, ascending and descending stairs and bathing. The scale has a full score of 100 points. Patients scoring <20 points are considered to have extremely serious functional defects, and they cannot take care of themselves; A score of 20 to 40 indicates that the patient needs a lot of help in life; A score of 40 to 60 indicates that the patient needs help in life; A score of >60 points indicates that the patient lives on his own. The higher the score, the stronger the ability of daily living.

(5) National Institute of Health stroke scale (NIHSS) score of the two groups was compared before and after operation for 14 days: NIHSS score [17] was applied to evaluate patients' recovery of neurological function. There are 15 options in all, with scores of 0, 1, 2, 3 and 4, respectively, with a total score of 34. The higher the score, the more serious the neurological defect and the worse the illness.

(6) Quality of life of score 6 months after surgery was compared between the two groups: Shot Form 36 Health Survey (SF-36) was applied to evaluate the quality of life of the two groups after surgery. The scale includes eight items: general health, physiological function, body pain, vitality, social function, emotional function and mental health. Each item has a score of 0-100. The higher the score, the better the quality of life.

Statistical methods

SPSS24.0 (IBM Corp, Armonk, NY, USA) was utilized for statistical analysis, and GraphPad

Table 1. Comparison of general data of patients between the two groups [n (%)] (x ± sd)

Classification	Research group (n=56)	Control group (n=50)	t/χ^2 value	*P* value
Gender			0.258	0.611
Male	32 (57.14)	31 (62.00)		
Female	24 (42.86)	19 (38.00)		
Age (years)	58.54±4.38	58.86±4.42	0.373	0.709
BMI (kg/m^2)	23.18±3.06	22.96±3.10	0.367	0.714
Bleeding location			0.395	0.982
Basal ganglia region	28 (50.00)	27 (54.00)		
Thalamus	12 (21.43)	11 (22.00)		
Lobe	10 (17.86)	7 (14.00)		
Brainstem	4 (7.14)	3 (6.00)		
Cerebellum	2 (3.57)	2 (4.00)		
Marital status			0.135	0.713
Married	30 (53.57)	25 (50.00)		
Unmarried	26 (46.43)	25 (50.00)		
Place of residence			0.105	0.745
City	32 (57.14)	27 (54.00)		
Countryside	24 (42.86)	23 (46.00)		
Education background			0.440	0.507
≥ high school	20 (35.71)	21 (42.00)		
< high school	36 (64.29)	29 (58.00)		
Smoking history			0.709	0.399
Present	38 (67.86)	30 (60.00)		
Absent	18 (32.14)	20 (40.00)		
Diabetes history			0.051	0.819
Present	29 (51.79)	27 (54.00)		
Absent	27 (48.21)	23 (46.00)		

Prism 7 for image rendering. The counting data were expressed by [n (%)]. Chi-square test was used to compare the counted data between groups. When the theoretical frequency in Chi-square test was less than 5, continuity correction Chi-square test was applied. Measured data were expressed in the form of ($\overline{x}$ ± sd). Independent sample t test was used for comparison of measured data between groups, and paired t test was used for comparison before and after nursing. When P<0.05, the difference was statistically significant.

Results

General data

There was no considerable difference in general clinical baseline data such as gender, age, body mass index (BMI), bleeding part, marital status, education background, smoking history and diabetes history between the two groups (*P*> 0.05). as shown in **Table 1**.

Comparison of perioperative indexes between the two groups

The operation time, length of hospital stay, hematoma absorption time, intra-operative blood loss and hematoma clearance rate in the research group were considerably better than those in the control group (P<0.001), as shown in **Table 2**.

Comparison of incidence of postoperative complications between the two groups

The incidence of postoperative complications was 8.93% in the research group, which was notably lower than that in the control group (28.00%) (P<0.05), as shown in **Table 3**.

Comparison of GOS, ADL, and NIHSS scores between the two groups

GOS score in the research group was considerably higher than that in the control group at 6 months after surgery. No considerable difference could be found in ADL and NIHSS scores between the two groups before operation. Six months after surgery, the ADL scores were increased in both groups, and were notably higher in the research group than the control group. After surgery for 14 days, the NIHSS scores decreased in both groups, and were notably lower in the research group than the control group (P<0.001), as shown in **Figure 1**.

Comparison of GOS grading between the two groups

Six months after operation, the research group had much higher numbers of patients with good prognosis, and lower numbers of patients with poor prognosis than the control group (P<0.05), as shown in **Table 4**.

Table 2. Comparison of perioperative indexes between the two groups

Group	Operation time (min)	Length of hospital stay (d)	Hematoma absorption time (d)	Intra-operative blood loss (ml)	Hematoma clearance rate (%)
Research group (n=56)	102.15±10.57	10.42±1.15	8.04±1.07	40.07±4.12	91.88±8.61
Control group (n=50)	148.82±13.45	15.34±1.64	12.54±1.65	198.66±19.57	80.65±8.24
t	19.970	18.030	16.830	59.220	6.840
P	<0.001	<0.001	<0.001	<0.001	<0.001

Table 3. Comparison of incidence of postoperative complications between the two groups [n (%)]

Group	Electrolyte disturbance	Pulmonary infection	Intracranial infection	Renal insufficiency	Re-bleeding	Total incidence
Research group (n=56)	2 (3.57)	2 (3.57)	0 (0.00)	1 (1.79)	0 (0.00)	5 (8.93)
Control group (n=50)	5 (10.00)	4 (8.00)	1 (2.00)	2 (4.00)	2 (4.00)	14 (28.00)
χ^2	-	-	-	-	-	6.531
P	-	-	-	-	-	0.010

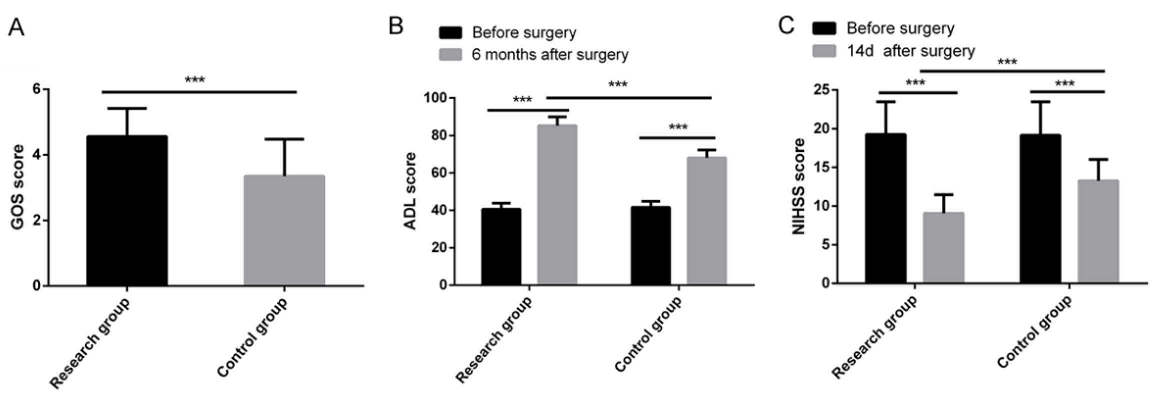

Figure 1. Comparison of GOS, ADL, and NIHSS scores between the two groups. A: The GOS score in the research group was considerably higher than that in the control group at 6 months after surgery. B: Six months after surgery, the ADL scores were higher in both groups than those before, and the scores were higher in the research group than the control group. C: After surgery for 14 days, the NIHSS scores were lower in both groups than those before, and the score was lower in the research group than the control group. Note: ***P<0.001.

Table 4. Comparison of GOS grading between the two groups [n (%)]

Group	Grade I	Grade II	Grade III	Grade IV	Grade V
Research group (n=56)	0 (0.00)	4 (7.14)	7 (12.50)	20 (35.71)	35 (62.50)
Control group (n=50)	0 (0.00)	19 (38.00)	11 (22.00)	8 (16.00)	12 (24.00)
χ^2	-	14.800	1.691	5.282	15.860
P	-	<0.001	0.193	0.021	<0.001

Comparison of quality of life score between the two groups

Patients in the research group scored considerably higher than the control group on all quality of life scores, including general health, physiologic functioning, role-physical, bodily pain, vitality, social functioning, role-emotional, and mental health. Details are shown in **Figure 2**.

Discussion

HICH is one of the most serious complications of hypertension. The key to its treatment lies

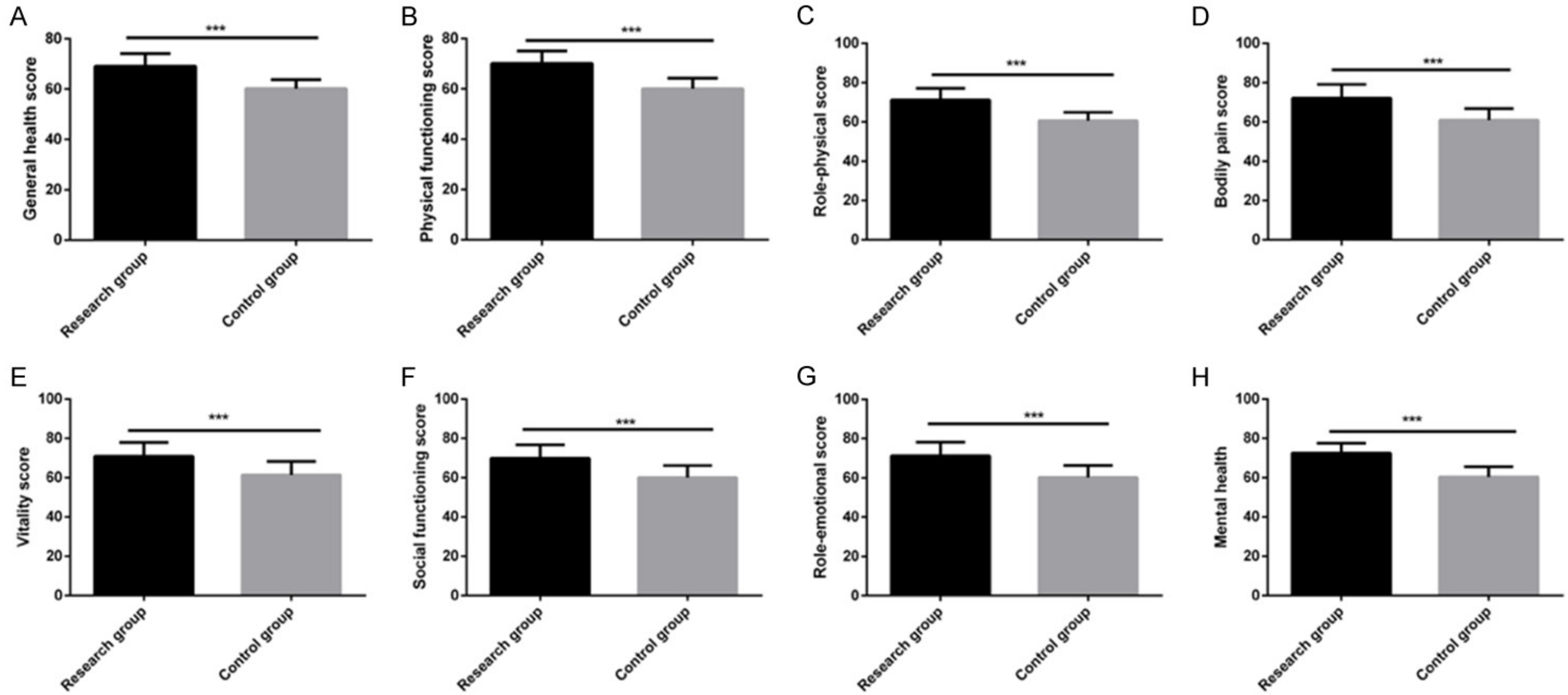

Figure 2. Comparison of quality of life between the two groups. Patients in the research group had notably higher scores of general health (A), physiological functioning (B), role-physical (C), bodily pain (D), vitality (E), social functioning (F), role-emotional (G), and mental health (H) than the control group. Note: ***P<0.001.

in the clearance of intracerebral hematoma, reduction of ICP, and relief or prevention of the formation of cerebral hernia in time, thus reducing the damage of neurological function caused by brain edema, and creating favorable conditions for the recovery of function of damaged brain tissue [19, 20]. Monitoring ICP in patients with HICH is valuable for determining the presence of new intracranial bleeding, the development of cerebral edema, and the adjustment of treatment options [21]. At present, there is no uniform standard for surgical treatment of HICH [22]. In this study, we applied neuroendoscopy MIS combined with ICP monitoring to treat HICH patients, hoping to provide a valuable surgical scheme for clinical treatment of HICH.

In the study of Men et al. [23], HICH patients treated by microscope combined with ICP monitoring after operation showed much less intraoperative blood loss, evidently shorter operation time, and notably higher hematoma clearance rate, which effectively reduced postoperative complications and improved clinical efficacy. Here, compared with the control group, the operation time, length of hospital stay and hematoma absorption time in the research group were notably shorter, the intra-operative blood loss was less, the hematoma clearance rate was higher, and the incidence of complications within 6 months after operation was lower, indicating that MIS under neuroendoscopy combined with ICP monitoring can effectively shorten the operation time and length of hospital stay, reduce the amount of intraoperative bleeding and the incidence of complications, improve the hematoma clearance rate, and promote the postoperative recovery process. This is similar to the results of Men et al. The team of Ren [24] has disclosed that ICP monitoring can considerably increase the incidence of good outcomes of patients with hypertension-related spontaneous intracerebral hemorrhage, bringing notably better GOS grade, thus improving their prognosis. Patients undergoing surgery were followed up for 6 months, and GOS prognosis score was performed. The results showed that the research group had notably higher overall GOS score, markedly higher proportion of good prognosis, and markedly lower proportion of poor prognosis than the control group, suggesting that MIS under neuroendoscopy combined with ICP monitoring can effectively improve the GOS prognosis index, and improve the prognosis of patients after surgery. This is similar to the research results of Ren. Tang et al. have shown that MIS can significantly reduce the mortality, rebleeding rate, infection and other complications, and improve the GOS prognosis and quality of life of patients with HICH [25], which is similar to our research results. NIHSS score, a powerful tool for evaluating neurological dysfunction in patients with cerebral hemorrhage, was also applied in this study. The results revealed that patients in the research group had notably lower NIHSS score than the control group 14 days after surgery, indicating the obvious advantages of MIS under neuroendoscopy combined with ICP monitoring in postoperative neurological function recovery. Che et al. [26] have found that ICP monitoring after MIS can effectively shorten the postoperative hospital stay, reduce the mortality, and improve the functional recovery and prognosis of HICH patients 6 months after surgery, which is similar to our research results. In addition, the ADL scores of patients were also compared before and 6 months after operation, and we found significantly higher scores in the research group. The evaluation of SF-36 scores also exhibited a higher score in the research group. Such results indicated that MIS under neuroendoscopy combined with ICP monitoring showed obvious advantages in improving daily living ability and quality of life after operation. It is suggested that post-operative ICP monitoring can markedly improve the ADL score and quality of life of patients with HICH after operation for 6 months [27]. Xu et al. [28] have revealed that endoscopic MIS can considerably reduce the mortality and improve the quality of life of patients with HICH after surgery for 6 months. Both results are similar to ours.

To sun up, MIS combined with postoperative ICP monitoring can improve the prognosis of patients with HICH, reduce postoperative complications, and improve postoperative activities and quality of life. However, there are some shortcomings to this study. For example, we should analyze and evaluate the risk factors that affect the prognosis of patients, so as to improve the clinical efficacy. Moreover, we can study the treatment compliance to improve prognosis. In the future, we will conduct research along these lines.

Disclosure of conflict of interest

None.

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