



Risk factors for chronic hydrocephalus in patients with intracerebral hemorrhage complicated by coma after emergency hematoma removal

Hai-Tao Yuan¹, Jun Feng², Qian Wang³

¹Department of Neurosurgery, People's Hospital of Dongxihu District, Wuhan, China; ²Department of Neurosurgery, Union Hospital Tongji Medical College Huazhong University of Science and Technology, Wuhan, China; ³Department of Hospital Administration, The Third People's Hospital of Gansu Province, Lanzhou, China

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Correspondence to: Jun Feng. Department of Neurosurgery, Union Hospital Tongji Medical College Huazhong University of Science and Technology, Wuhan 430022, China. Email: lfengjun@sina.com; Qian Wang. Department of Hospital Administration, The Third People's Hospital of Gansu Province, No. 763, Jiatan Road, Chengguan District, Lanzhou 730020, China. Email: wangqian_2021@sina.com.

Background: The cerebrospinal fluid circulation of patients with intracerebral hemorrhage (ICH) can be blocked by blood clots, resulting in acute hydrocephalus. However, current research on chronic hydrocephalus (CH) is lacking.

Methods: A total of 253 patients with ICH combined with coma treated at The Third People's Hospital of Gansu Province after emergency hematoma removal from January 2018 to January 2020 were included. Patients were divided into the CH group (n=48) and the control group (n=205) depending on whether hydrocephalus occurred or not within 3–12 months after operation. The main clinical characteristics of the two groups were compared, and the risk factors for CH were analyzed. Counting data of the two groups were expressed as “n (%)”, and multivariate logistic regression analysis was used to explore the risk factors for CH.

Results: Compared with the control group, the proportion of patients with modified Graeb score ≥ 5 points in the CH group increased significantly (52.08% vs. 21.95%, $P=0.000$). The proportion of patients with preoperative cerebral hernia increased significantly (37.5% vs. 19.51%, $P=0.008$). The proportion of patients with preoperative obstructive hydrocephalus increased (43.75% vs. 24.39%, $P=0.007$). The proportion of patients with postoperative subdural effusion increased (41.67% vs. 13.66%, $P=0.000$). Multivariate logistic regression analysis showed that a modified Graeb score ≥ 5 points and postoperative subdural effusion were risk factors for the formation of CH in patients with ICH complicated by coma after emergency hematoma removal ($P<0.05$). The modified Graeb score has diagnostic value for the formation of CH in patients with ICH combined with coma after emergency hematoma removal, and the area under the curve was 0.653 [$P=0.001$, 95% confidence interval (CI): 0.561–0.744]. There was no significant difference in preoperative neurological deficit score between the control group and the CH group (19.75 ± 3.03 vs. 19.86 ± 3.01 , $P=0.113$). Compared with the control group, the neurological deficit score at 12 months after operation in the CH group was significantly higher (12.73 ± 2.99 vs. 10.64 ± 2.82 , $P=0.000$).

Conclusions: A modified Graeb score > 5 points and postoperative subdural effusion are risk factors for the formation of CH in patients with ICH combined with coma after emergency hematoma removal. The formation of CH affects postoperative neurological rehabilitation.

Keywords: Intracerebral hemorrhage (ICH); hematoma removal; chronic hydrocephalus (CH); risk factors

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Introduction

Intracerebral hemorrhage (ICH) is a common cardiovascular and cerebrovascular disease among middle-aged people and the elderly. ICH is an important risk factor for death (1-3). In recent years, as the incidence of hypertension, diabetes, and hyperlipidemia increases, so does the incidence of ICH. Some patients with large amounts of bleeding need emergency hematoma removal. For such patients, hydrocephalus is often complicated after operation, which seriously affects neurological recovery (4,5). Postoperative hydrocephalus can be divided into acute hydrocephalus and chronic hydrocephalus (CH). Acute hydrocephalus usually occurs within 3 days after operation, caused by sudden disturbance of cerebrospinal fluid circulation. Without active treatment, it may gradually develop into CH. The most of the reasons of Acute hydrocephalus are due to the obstruction of some parts of cerebrospinal fluid circulation pathway. CH is common and has complex etiologies, but the pathogenic factors affect cerebrospinal fluid circulation slowly. Some patients can develop CH without obvious ventricular system obstruction, which mostly occurs during 3–12 months after operation. Clinically, it can be manifested as the expansion of the whole ventricular system with blunt frontal angle, resulting in cognitive dysfunction, abnormal gait, incontinence, epilepsy, and visual impairment. If the CH is not treated in time, it can lead to irreversible neurological impairment (6,7). Current study had evaluated the risk factors of CH in patients with aneurysmal subarachnoid hemorrhage (8). However, it did not focus on patients with ICH complicated by coma after emergency hematoma removal. Current research mainly focuses on acute hydrocephalus, so there are limited studies on the formation of CH in patients with ICH combined with coma after emergency hematoma removal. Therefore, the aim of the present study was to explore the risk factors for CH in patients with ICH combined with coma after emergency hematoma removal, to provide evidence for reducing the incidence of CH.

We present the following article in accordance with the STARD reporting checklist (available at <https://atm.amegroups.com/article/view/10.21037/atm-22-128/rc>).

Methods

General data

A total of 253 patients with ICH combined with coma treated at The Third People's Hospital of Gansu Province

after emergency hematoma removal from January 2018 to January 2020 were included. Patients were divided into the CH group (n=48) and the control group (n=205) depending on whether hydrocephalus occurred or not within 3–12 months after operation.

The inclusion criteria were as follows: (I) spontaneous ICH; (II) coma; (III) new intracranial hemorrhage confirmed by brain computed tomography (CT); and (IV) complete clinical data. The exclusion criteria were as follows: (I) cerebral hemorrhage caused by craniocerebral trauma or aneurysm rupture; (II) intracranial infection, including encephalitis, meningitis, and ventriculitis; (III) patients with epidural hematoma, subdural hematoma, and arachnoid cyst; (IV) patients aged <18 years; and (V) survival time and follow-up time <1 year.

All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of The Third People's Hospital of Gansu Province (No. 2020-178). Individual consent for this retrospective analysis was waived.

Diagnostic criteria

For CH, patients with ICH combined with coma after emergency hematoma removal were followed up in the outpatient department. Patients underwent intracranial CT plain scan within 3–12 months after onset of ICH. If the following criteria were met, the patient was diagnosed as CH: (I) ventricular enlargement with blunt frontal angle; (II) bilateral frontal angle diameter or cranial diameter (Evans' index) >0.33; (III) blurred ventricular margin; and (IV) paraventricular low-density halo ring.

Observational indicators

The observational indicators were as follows: (I) general information, including age, sex, body mass index (BMI), hypertension, diabetes mellitus, and hyperlipidemia; (II) bleeding site, amount of bleeding, Glasgow Coma Scale, modified Graeb score, preoperative cerebral hernia, preoperative obstructive hydrocephalus, preoperative subarachnoid hemorrhage, postoperative subdural effusion, and operation method; and (III) neurological deficit score.

Evaluation criteria

The evaluation criteria were as follows: (I) Glasgow Coma

Table 1 Comparison of general data between the two groups

Category	Age (≥ 65 years old)	Sex (male)	BMI (≥ 30 kg/m ²)	Hypertension	Diabetes	Hyperlipidemia
CH group (n=48)	28 (58.33)	31 (64.58)	12 (25.00)	38 (79.17)	24 (50.00)	42 (87.50)
Control group (n=205)	112 (54.63)	132 (64.39)	59 (28.78)	148 (72.20)	105 (51.22)	176 (85.85)
χ^2 value	0.215	0.001	0.275	0.971	0.023	0.088
P value	0.643	0.980	0.600	0.324	0.879	0.766

Data were expressed as n (%). BMI, body mass index; CH, chronic hydrocephalus.

Scale: the patient's consciousness at admission was evaluated according to the Glasgow Coma Scale, with a maximum of 15 points and a minimum of 3 points. The lower the score, the more serious the condition is; (II) modified Graeb score: according to the modified Graeb score, the amount of intraventricular hemorrhage, the number of hemorrhagic ventricles, and the degree of ventricular dilatation were semi-quantitatively evaluated by brain CT at admission. The highest score is 32 points. The higher the score, the more serious the condition; and (III) neurological deficit score: the neurological deficit score was evaluated at admission and 12 months after operation to evaluate the state of neurological deficit and the impact of CH on neurological deficit.

Statistical analysis

SPSS version 26.0 (IBM, Armonk/Chicago, USA) was used for the data analysis. Counting data of the two groups were expressed as "n (%)", and multivariate logistic regression analysis was used to explore the risk factors for CH. $P < 0.05$ indicated a statistically significant difference.

Results

Comparison of general data between the two groups

There was no significant difference in terms of age, sex, BMI, hypertension, diabetes, and hyperlipidemia between the control group and the CH group ($P > 0.05$) (Table 1).

Comparison of disease severity between the two groups

Compared with the control group, the proportion of patients with modified Graeb score ≥ 5 points in the CH group increased significantly (52.08% vs. 21.95%, $P = 0.000$). The proportion of patients with preoperative cerebral hernia increased significantly (37.50% vs. 19.51%, $P = 0.008$).

The proportion of patients with preoperative obstructive hydrocephalus increased (43.75% vs. 24.39%, $P = 0.007$). The proportion of patients with postoperative subdural effusion increased (41.67% vs. 13.66%, $P = 0.000$) (Table 2).

Risk factors for CH in patients with ICH combined with coma after emergency hematoma removal

Multivariate logistic regression analysis showed that a modified Graeb score ≥ 5 points and postoperative subdural effusion were risk factors for the formation of CH in patients with ICH complicated by coma after emergency hematoma removal [$P = 0.014$, 95% confidence interval (CI): 1.419–23.732 and $P = 0.014$, 95% CI: 1.496–36.358] (Tables 3,4).

Diagnostic value of modified Graeb score for CH in patients with ICH combined with coma after emergency hematoma removal

The modified Graeb score has certain diagnostic value for the formation of CH in patients with ICH combined with coma after emergency hematoma removal, and the area under the curve was 0.653 ($P = 0.001$, 95% CI: 0.561–0.744) (Figure 1).

Effect of CH on neurological function in patients with ICH combined with coma after emergency hematoma removal

There was no significant difference in preoperative neurological deficit score between the control group and the CH group (19.75 ± 3.03 vs. 19.86 ± 3.01 , $P = 0.113$). Compared with the control group, the neurological deficit score at 12 months after operation in the CH group was significantly higher (12.73 ± 2.99 vs. 10.64 ± 2.82 , $P = 0.000$) (Table 5).

Discussion

CH is a common complication after acute ICH (9,10), and

Table 2 Comparison of disease severity between the two groups

Category	CH group (n=48)	Control group (n=205)	χ^2 value	P value
Bleeding site			0.005	0.941
Superficial supratentorial brain	11 (22.92)	48 (23.41)		
Supratentorial deep brain	37 (77.08)	157 (76.59)		
Amount of bleeding (mL)			1.110	0.292
≥ 50	27 (56.25)	98 (47.80)		
< 50	21 (43.75)	107 (52.20)		
Glasgow Coma Scale			1.258	0.262
< 8 points	22 (45.83)	76 (37.07)		
≥ 8 points	26 (54.17)	129 (62.93)		
Modified Graeb score			17.645	0.000
≥ 5 points	25 (52.08)	45 (21.95)		
< 5 points	23 (47.92)	160 (78.05)		
Preoperative cerebral hernia			7.122	0.008
Yes	18 (37.50)	40 (19.51)		
No	30 (62.50)	165 (80.49)		
Preoperative obstructive hydrocephalus			7.221	0.007
Yes	21 (43.75)	50 (24.39)		
No	27 (56.25)	155 (75.61)		
Preoperative subarachnoid hemorrhage			0.033	0.857
Yes	8 (16.67)	32 (15.61)		
No	40 (83.33)	173 (84.39)		
Postoperative subdural effusion			19.847	0.000
Yes	20 (41.67)	28 (13.66)		
No	28 (58.33)	177 (86.34)		
Operation method			0.275	0.600
Trepanation and drainage	17 (35.42)	81 (39.51)		
Traditional craniotomy	31 (64.58)	124 (60.49)		

Data were expressed as n (%). CH, chronic hydrocephalus.

Table 3 Evaluation of risk factors for CH

Factor	Evaluation 1	Evaluation 2
Modified Graeb score	≥ 5 points	< 5 points
Preoperative cerebral hernia	Yes	No
Preoperative obstructive hydrocephalus	Yes	No
Postoperative subdural effusion	Yes	No

CH, chronic hydrocephalus.

is more common in patients with secondary ventricular hemorrhage. CH seriously affects the neurological rehabilitation of patients, and can lead to death in severe cases. At present, there is no effective treatment for CH, so it is particularly important to prevent it. Identifying the risk factors for CH is the basis of prevention. In the present study, we explored the risk factors for the formation of CH in patients with ICH combined with

Table 4 Risk factors for CH in patients with ICH combined with coma after emergency hematoma removal

Factor	B value	Standard error	Wald value	P value	95% CI
Modified Graeb score ≥ 5 points	1.758	0.719	5.985	0.014	1.419–23.732
Preoperative cerebral hernia	-1.425	0.822	3.003	0.083	0.048–1.205
Preoperative obstructive hydrocephalus	-0.801	0.690	1.349	0.245	0.116–1.734
Postoperative subdural effusion	1.998	0.814	6.025	0.014	1.496–36.358

CH, chronic hydrocephalus; ICH, intracerebral hemorrhage; CI, confidence interval.

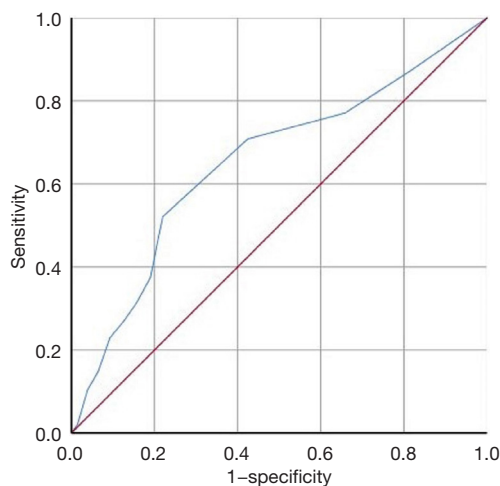


Figure 1 Diagnostic value of modified Graeb score for CH in patients with ICH combined with coma after emergency hematoma removal. CH, chronic hydrocephalus; ICH, intracerebral hemorrhage.

Table 5 Effect of CH on neurological function in patients with ICH combined with coma after emergency hematoma removal

Category	Preoperative neurological deficit score	Neurological deficit score at 12 months after operation
CH group (n=48)	19.75 \pm 3.03	12.73 \pm 2.99
Control group (n=205)	19.86 \pm 3.01	10.64 \pm 2.82
t value	0.815	4.566
P value	0.113	0.000

CH, chronic hydrocephalus; ICH, intracerebral hemorrhage.

coma after emergency hematoma removal. The results showed that a modified Graeb score ≥ 5 points and postoperative subdural effusion were risk factors for the formation of CH in patients with ICH combined with

coma after emergency hematoma removal. The formation of CH affected neurological recovery.

CH seriously affects the neurological function of patients (11,12), which is manifested as the following symptoms: (I) chronic intracranial hypertension syndrome: headache, nausea, and vomiting are not as severe as they are with acute hydrocephalus; fundus edema is often accompanied by secondary atrophy; (II) bilateral abduction paralysis; (III) mental and behavioral disorders or abnormalities, and memory loss; (IV) spastic quadriplegia is characterized by severe symptoms of the lower limbs and mild symptoms of the upper limbs; (V) endocrine abnormalities, such as obesity, sexual reproductive degeneration, or precocious puberty; and (VI) bilateral temporal hemianopia and cerebellar sign are rare. The findings of the present study also showed that the neurological deficit score of patients with CH increased significantly 12 months after operation, indicating that CH affected the recovery of neurological function.

Currently, many studies show that intraventricular hemorrhage is an independent risk factor for CH. The modified Graeb score was revised by Morgan *et al.* based on the original Graeb score in 2013 (13). The modified Graeb score allows a detailed evaluation of the amount of intraventricular hemorrhage, and can semi-quantitatively evaluate the number of intraventricular hemorrhages, which better reflects the degree of ventricular dilatation (14,15). In their study, Czorlich *et al.* analyzed 171 patients with subarachnoid hemorrhage with a survival time of more than 30 days. The results showed that the increase in Graeb score was a risk factor for the formation of CH in patients with subarachnoid hemorrhage (16), which supports the findings of the present study. Our study showed that a modified Graeb score ≥ 5 points was a risk factor for the formation of CH in patients with ICH complicated by coma after emergency hematoma removal ($P=0.014$, 95% CI: 1.419–23.732). The modified Graeb score has certain value in the diagnosis of CH in patients with ICH combined with coma after emergency hematoma removal.

In addition, the findings of the present study indicated that postoperative subdural effusion was a risk factor for CH in patients with ICH complicated by coma after emergency hematoma removal. Subdural effusion is defined as the accumulation of low-density liquid under the dura mater with a maximum depth of more than 0.5 cm from the surface of the cerebral cortex to the inner side of the scalp or skull (17,18). Subdural effusion is caused by a hole between the dura mater and the arachnoid wall, and the venous reflux is blocked under high intracranial pressure, resulting in the redistribution of cerebrospinal fluid. As reported in previously published studies, subdural effusion is not only a serious complication affecting the prognosis of patients but also a risk factor for the formation of hydrocephalus (19-22). These findings support the findings of the present study.

Finally, hematoma volume may be related to CH. But in our study, the amount of intracranial hemorrhage was not significantly related to the formation of CH.

Limitations

Previously published studies have shown that plasma osteopontin concentration and cerebrospinal fluid output are risk factors for CH after ICH (23,24). However, the present study was a retrospective clinical study, and we failed to study the plasma osteopontin concentration. Moreover, the immune response and blood-brain barrier injury may be risk factors for CH as well, but we also failed to study these.

Conclusions

A modified Graeb score >5 points and postoperative subdural effusion are risk factors for the formation of CH in patients with ICH combined with coma after emergency hematoma removal. The formation of CH affects postoperative neurological rehabilitation.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at <https://atm.amegroups.com/article/view/10.21037/atm-22-128/rc>

Data Sharing Statement: Available at <https://atm.amegroups.com/article/view/10.21037/atm-22-128/dss>

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://atm.amegroups.com/article/view/10.21037/atm-22-128/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of The Third People's Hospital of Gansu Province (No. 2020-178). Individual consent for this retrospective analysis was waived.

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