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Impact of Intraoperative Blood Pressure Control and Temporary Parent Artery Blocking on Prognosis in Cerebral Aneurysms Surgery

Min Xu^{1, 2}, Zheng-song Gu³, Cun-zu Wang^{2, 4*}, Xiao-feng Lu²,
Ding-chao Xiang², Zhi-cheng Yuan⁵, Qiao-yu Li⁵,
and Min Wu⁶

¹Department of Neurosurgery, Kunshan Hospital of Traditional Chinese Medicine,
Kunshan Affiliated Hospital of Nanjing University of Chinese Medicine,
Kunshan, Jiangsu 215300, China

²Department of Neurosurgery, Northern Jiangsu People's Hospital,
Yangzhou, Jiangsu 225001, China

³Department of Neurosurgery, Zhenjiang Hospital of Traditional Chinese
Medicine, Zhenjiang, Jiangsu 212001, China

⁴Department of Neurosurgery, Wound Institute of Jiangsu University,
Zhenjiang, Jiangsu 212001, China

⁵Department of Neurosurgery, Zhenjiang First People's Hospital,
Zhenjiang, Jiangsu 212001, China

⁶Department of Neurosurgery, the Affiliated Hospital of Jiangsu University,
Zhenjiang, Jiangsu 212001, China

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Objective In cerebral aneurysm clipping and embolization, blood pressure control and temporary parent artery blocking are common methods to prevent aneurysm rupture. Their influence on the prognosis is uncertain. In this study, we try to find out the association between methods above and prognostic indicators.

Methods We held a retrospective analysis on patients' medical records of cerebral aneurysms surgical clipping and endovascular coiling, and recorded gender, age, diagnosis, Hunt-Hess grade, Glasgow coma scale score, treatment methods, a history of hypertension, preoperative systolic blood pressure, with or

without controlled hypotension, systolic blood pressure difference before and after controlled hypotension, with or without temporary artery blocking, with or without hypertension after treated aneurysm, prognostic indicators including mortality after 1 month, intensive care unit (ICU) stay time of survivors, discharged Glasgow outcome scale (GOS) score. Prognostic indicators were regarded as dependent variable, all the factors were regarded as independent variable, and the strength analysis of influence factors on prognostic indicators was made by binary logistic regression.

Results Total cases were 165, including 68 males and 97 females, with an average age of 56 (12-85) years. The mortality after 1 month was 10.9% (18 cases). The ICU stay time of survivors was 7.35 (0-67) days. GOS score at discharge was 1-3 in 40 (24.2%) patients and 4-5 in 125 (75.8%) patients. Systolic blood pressure difference before and after controlled hypotension was an independent factor influencing mortality ($t=2.273$, $P=0.024$), and the greater the difference was, the higher the mortality would be. Timely hypertension after aneurysm treated was an independent factor affecting ICU stay time of survivors and patients with hypertension had shorter ICU stay time ($\chi^2=10.017$, $P=0.001$). Blood pressure control ($\chi^2=0.088$, $P=0.767$) and temporary blocking ($\chi^2=1.307$, $P=0.253$) did not show significant influence on GOS score at discharge.

Conclusions Timely controlled hypertension after aneurysm clipping and embolization can significantly shorten the stay time in ICU. The degree of controlled hypotension associates with postoperative mortality, the greater systolic blood pressure difference before and after antihypertensive treatment is, the higher the mortality will be.

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IN cerebral aneurysm patients, effects of subarachnoid hemorrhage on cerebral blood flow performed in two aspects. One is vasospasm, which reduces local or even entire cerebral blood flow. The other is the decline of vascular adjustment, which is reduced by vasospasm. During the decrease of blood pressure or temporary clipping of aneurysm, the vascular compensatory capacity decreases compared with normal state.¹ These two situations result in the decrease of cerebral perfusion, ischemia and hypoxia, which are closely associated with poor prognosis. In present, craniotomy clipping and endovascular intervention are two common surgeries in cerebral aneurysms. Intraoperative blood pressure control and temporary parent artery blocking are often adopted to avoid the rupture of aneurysms. However, these hypotheses are still controversial, and the clinical results are inconsistent. In this study, we took prognostic indicators including mortality after 1 month, intensive care unit (ICU) stay time of survivors, discharged Glasgow outcome scale (GOS), analyzing the impact of intraoperative blood pressure control and temporary occlusion on prognosis in cerebral aneurysms surgery to regulate them and improve prognosis.

PATIENTS AND METHODS

Patients and methods

In recent three years (from January 2012 to January

2015), we retrospectively collected 186 hospitalized patients in the Affiliated Hospital of Jiangsu University and Zhenjiang First People's Hospital. Patients more than 12 years of age and undergoing aneurysm clipping and coiling were included. Patients with aneurysm reinforcement or wrapping surgery, ruptured cerebral aneurysms or untreated aneurysms were excluded. Patients' gender, age, diagnosis, Hunt-Hess grade, Glasgow coma scale (GCS), with or without a history of hypertension, preoperative systolic blood pressure (SBP), treatment methods, with or without controlled hypotension, manner, extent, duration, with or without temporary vascular occlusion, with or without intraoperative rupture, the blood pressure before rupture, with or without hypertension after treatment and difference of SBP before and after induced hypotension, and prognostic indicators including ICU stay time, mortality after 1 month, discharged GOS were recorded. At our centers, intraoperative blood pressure control was mainly drug measures conducted by anesthetists including nitroglycerin, labetalol, deepen anesthesia and so on.

GOS score at discharge is divided into 5 grades, and 1 is for death, 2 is for vegetative state, 3 is for severe disability, 4 is for mild disability, and 5 is for fine prognosis. Patients with GOS scores of 1-3 are defined as poor outcome, and with GOS scores of 4-5 are regarded as good outcome.

Statistical analysis

All the variables were analyzed by SPSS 17.0 statistical package. χ^2 test and t test were used in this study. Prognostic indicators were regarded as dependent variable, all the factors were regarded as independent variable, and the strength analysis of influence factors on prognostic indicators was made by binary logistic regression. Continuous data were expressed as mean $\pm$ standard deviation and P -value of less than 0.05 was considered significant.

RESULTS

Characteristics of patients

The remaining 165 patients were 56 (12-85) years old, containing 68 males and 97 females. There were 57 (34.5%) patients with anterior communicating artery aneurysm, 52 (31.5%) with posterior communicating artery aneurysm, 27 (16.4%) with middle cerebral artery aneurysm, 8 (4.8%) with vertebral artery and basilar artery aneurysms, 6 (3.6%) with anterior cerebral artery aneurysm, 2 (1.2%) with tip of the internal carotid artery, 1 (0.6%) with ophthalmic artery aneurysm, and 12 (7.3%) with other unlocated or multiple aneurysms. Hunt-Hess grade after admission in 143 (86.7%) patients ranged 0-3, and 22 (13.3%) patients ranged 4-5. GCS after admission in 25 (15.2%) patients ranged 3-8, 13 (7.8%) patients ranged 9-12, and 127 (77.0%) patients ranged 13-15. The delay between the subarachnoid haemorrhage and the treatment was 39.32 $\pm$ 4.57 (7.5-68.0) hours. Totally, 73 (44.2%) patients were treated with clipping and 92 (55.8%) with coiling. Of them, 104 (63.0%) cases were taken intraoperative blood pressure control, and 61 (37.0%) cases were not. And 45 (27.3%) cases were taken temporary parent artery blocking, and 120 (72.7%) cases were not. After the treatment of aneurysms, 34 (20.6%) cases were required to evaluate blood pressure, and 131 (79.4%) were not. The average ICU stay time was 7.35 (0 to 67) day, and 18 cases (10.9%) died after surgery. GOS score at discharge was 1-3 in 40 (24.2%) patients and 4-5 in 125 (75.8%) patients.

Relationship between mortality after 1 month and intraoperative blood pressure control, temporary parent artery blocking

χ^2 test showed there was a significant relationship between mortality after 1 month and Hunt-Hess grade, GCS score (both $P=0.000$, Table 1). t test revealed that SBP difference before and after induced hypotension of the dead group ($n=18$) was significantly higher than that of the

alive group ($n=147$) (40.83 $\pm$ 32.64 vs. 26.82 $\pm$ 23.62 mm Hg, $t=2.273$, $P=0.024$). However, induced hypotension duration showed no significant difference between the two groups (1.86 $\pm$ 1.61 vs. 1.38 $\pm$ 1.54 hours, $t=1.254$, $P=0.212$).

The above three factors were further analyzed by binary logistic regression. The result showed Hunt-Hess grade was an independent factor for mortality [constant coefficient=3.337, $P=0.020$, and odds ratio (OR)=28.147], which means the higher Hunt-Hess grade was, the higher mortality would be. However, GCS score (constant coefficient=1.796, $P=0.075$, OR=6.028) and the differences of SBP before and after induced hypotension (constant coefficient=0.014, $P=0.231$, OR=1.014) were not significantly associated with mortality.

Relationship between ICU stay length and intraoperative blood pressure control, temporary parent artery blocking

The average ICU stay length of this group was 7.35 $\pm$ 8.60 days. χ^2 test showed there was a significant relationship between stay length of ICU and hypertension, surgical approach (both $P<0.05$, Table 2). t test revealed both SBP difference before and after induced hypotension (24.21 $\pm$ 25.45 vs. 30.31 $\pm$ 24.65 days, $t=1.470$, $P=0.143$) and induced hypotension duration (1.42 $\pm$ 1.87 vs. 1.44 $\pm$ 1.38 hours, $t=0.078$, $P=0.938$) had no significant difference between patients staying ICU more than 7.35 days ($n=53$) and ones less than 7.35 days ($n=111$).

Binary logistic regression analysis showed that timely hypertension led to a shorter ICU stay time (constant coefficient=1.018, $P=0.048$, OR=2.769). While taking hypertension into consideration, other factors including surgical approach (constant coefficient=-0.562, $P=0.115$, OR=0.570) and induced hypotension (constant coefficient=0.401, $P=0.281$, OR=1.493) were not independent factors for ICU stay time.

Relationship between discharged GOS and intraoperative blood pressure control, temporary vascular occlusion

Finally, 125 (75.8%) cases had favourable prognosis. χ^2 test showed there was a significant relationship between GOS score at discharge and Hunt-Hess grade, GCS score (both $P=0.000$, Table 3).

Binary logistic regression revealed Hunt-Hess grade (constant coefficient=-0.746, $P=0.363$, OR=0.474) and GCS score (constant coefficient=0.726, $P=0.352$, OR=2.067) were not independent factors for discharged GOS.

Table 1. Analysis of related factors of the mortality after 1 month

Factors	Case number	Number of death	χ^2	P-value
Hunt-Hess grade				
0-2	124	4		
3	19	4		
4-5	22	10	28.507	0.000
GCS score				
3-8	25	10		
9-12	13	2		
13-15	127	6	20.567	0.000
Hypertension				
Yes	34	2		
No	131	16	1.165	0.369
Induced hypotension				
Yes	104	12		
No	61	6	0.115	0.802
Surgical approach				
Clipping	73	10		
Embolization	92	8	1.048	0.306
Temporary occlusion				
Yes	45	2		
No	120	16	2.661	0.159

GCS: Glasgow coma scale.

Table 2. Analysis of related factors for length of ICU stay

Factors	Case number	Cases staying ICU over 7.35 days (n)	χ^2	P-value
Hunt-Hess grade				
0-2	124	35		
3	19	9		
4-5	22	9	3.668	0.160
GCS				
3-8	25	10		
9-12	13	7		
13-15	127	36	4.138	0.126
Hypertension				
Yes	45	6		
No	120	47	10.017	0.001
Induced hypotension				
Yes	106	28		
No	59	25	4.427	0.035
Surgical approach				
Clipping	73	31		
Embolization	92	22	6.426	0.011
Temporary occlusion				
Yes	45	15		
No	120	38	0.042	0.853

ICU: intensive care unit.

Table 3. Analysis of related factors for Glasgow outcome scale score at discharge

Factors	Case number	Cases achieving good prognosis (n)	χ^2	P-value
Hunt-Hess grade				
0-2	124	110		
3	19	7		
4-5	22	8	41.493	0.000
GCS score				
3-8	25	8		
9-12	13	6		
13-15	127	111	37.300	0.000
Hypertension				
Yes	36	29		
No	129	96	0.577	0.516
Induced hypotension				
Yes	106	78		
No	59	47	0.088	0.767
Surgical approach				
Clipping	73	52		
Embolization	92	73	1.459	0.227
Temporary occlusion				
Yes	40	33		
No	125	92	1.307	0.253

DISCUSSION

Vasospasm is one of the most important complications in cerebral aneurysm patients with subarachnoid hemorrhage, which resulting in a poor prognosis. Once it occurs, the mortality may reach approximately 50%.² Measures of blood pressure control including intraoperative controlled hypotension,³ temporary artery occlusion,^{4, 5} and timely hypertension are vital elements in cerebral aneurysms surgery. Within these measures, controlled hypotension and temporary parent artery blocking both lead to ischemia and hypoxia. During controlled hypotension, mean arterial pressure declines. When intracranial pressure is stable, cerebral perfusion pressure (CPP) inevitably drops. The extreme CPP of cerebral ischemia is 50 mm Hg. Aneurysm patients' vascular function declines due to vasospasm.⁶ Even though higher than 50 mm Hg, the decrease of CPP may aggravate cerebral ischemia due to the lack of effective regulation.⁷ Meanwhile, temporary parent artery blocking is limited in a short time, the ischemia and hypoxia of brain tissues still occur. Therefore, impact of intraoperative blood pressure control on prognosis in cerebral

aneurysms surgery is a well worthy point.

In this study, we chose 7 indicators including with or without a history of hypertension, preoperative SBP, with or without controlled hypotension, SBP difference before and after controlled hypotension, with or without temporary artery blocking, with or without timely hypertension after treated aneurysm and other related indicators including gender, age, diagnosis, Hunt-Hess grade, GCS score, treatment methods and so on were also recorded. The prognostic indicators included the mortality after 1 month, ICU stay time of survivors, and GOS score at discharge. To make it reasonable and reliable, prognostic indicators were treated as dependent variable, all the factors were as independent variable, and the strength analysis of influence factors on prognostic indicators was made by binary logistic regression.

By statistical analysis, in terms of mortality after 1 month, difference of SBP before and after controlled hypotension was non-independent factor to mortality. The higher SBP difference was, the higher mortality would be. And this result was affected by Hunt-Hess grade and GCS score, especially Hunt-Hess grade, which was an independent factor to mortality. These results revealed that, when

taking blood pressure into control in cerebral aneurysm clipping and embolization, difference of SBP before and after surgery should be limited in order to prevent mortality from increasing. And scope of the difference requires further studies. Meanwhile, temporary parent artery blocking was not closely associated with mortality, which indicates a relatively safe measure during surgery.

As for postoperative ICU stay time, timely hypertension after treated aneurysm was an independent indicator. After aneurysm clipping and embolization, timely hypertension, regardless of other indicators, obviously shortened the ICU stay time, and recovered CPP. Triple-H therapy is a common measure to treat cerebral vasospasm.^{8,9} However, the time to start taking hypertension is still controversial. This study showed that timely hypertension after aneurysm clipping and embolization benefited prognosis. There is no doubt that the focus of blood pressure control is vital to cerebral aneurysm surgery.

Theoretically, after intraoperative controlled hypotension, CPP will be lower,^{10, 11} and a poorer prognosis follows. Actually, this study also showed that, in patients with intraoperative controlled hypotension, ICU stay time would be shorter. Controlled hypotension is just a non-independent indicator to ICU stay time, and it is restricted by timely hypotension. Timely hypotension will be taken after aneurysms surgery in most patients. So this phenomenon reflects the positive effect of timely hypotension, instead of controlled hypotension.

However, related indicators about intraoperative blood pressure control and temporary parent artery blocking were all not significantly associated with discharged GOS score. It revealed that they were not effective indicators to reflect patients' condition compared with Hunt-Hess grade and GCS score. Intraoperative blood pressure control and temporary parent artery blocking were both safe measures to long-term efficacy.

In summary, over the retrospective study of 165 cerebral aneurysm cases, it is found that related indicators of blood pressure control including SBP difference before and after controlled hypotension, and timely hypertension after cerebral surgery are closely related with prognosis. These results are very meaningful for the clinical standardization of intraoperative blood pressure control and temporary parent artery blocking in cerebral aneurysms surgery.

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