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Original research

Complications and outcomes after early surgical treatment for poor-grade ruptured intracranial aneurysms: A multicenter retrospective cohort

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HIGHLIGHTS

- Cerebral infarction was the most common neurological complication after early surgery.
- The outcome of patients with WFNS grade V remains poor, and complications may increase the risk of poor outcome.
- Patients with WFNS grade V, intraventricular hemorrhage and brain herniation are more likely to have a poor outcome.

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ABSTRACT

Introduction: Early surgical treatment has been proposed to improve outcomes of selected patients with poor-grade ruptured intracranial aneurysms. We performed a multicenter retrospective analysis to identify complications and outcomes after early surgery.
Methods: We analyzed data from the two cohorts of patients with poor-grade ruptured aneurysms. Poor-grade aneurysm was defined as a World Federation of Neurosurgical Society (WFNS) grade of IV or V after resuscitation. Early surgery was defined as surgery performed within 72 h after poor-grade condition.
Results: Of the 144 patients who underwent surgical treatment for poor-grade aneurysm, 80 underwent early surgery and were included in this report. Forty-one (51%) patients presented with a WFNS grade of IV and 39 (49%) presented with a WFNS grade of V. Cerebral infarction occurred in 17 (21%) patients and was the most common complication except for pneumonia. No patients had a good outcome after postoperative aneurysm rebleeding. At follow-up (mean 12.6 months), 37 (46%) patients had a good outcome after early surgery. Multivariate analysis showed that a WFNS grade of V, presence of intraventricular hemorrhage, brain herniation were independent predictors of poor outcome after early surgery. Patients with WFNS grade V more often had a poor outcome after postoperative cerebral infarction, rebleeding or symptomatic vasospasm.
Conclusions: Patients with a WFNS grade of V, intraventricular hemorrhage, brain herniation were more likely to have a poor outcome after early surgery. Postoperative complications, including rebleeding and cerebral infraction, should be prevented and treated aggressively to maximize the chance of good outcome in poor-grade patients.

1. Introduction

Intracranial aneurysm rupture leads to aneurysmal subarachnoid hemorrhage (aSAH), which is a devastating condition with high morbidity and mortality. Early surgical or endovascular

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treatment for good-grade ruptured aneurysms has been widely adopted in most centers. Historically, poor-grade aneurysms are managed conservatively, and only patients who showed improvement are selected for surgery [1,2]. Most patients without definitive treatment died because of aneurysm rebleeding and vasospasm.

In the past decades, several studies have shown that early surgery improved the outcome in selected patients with poor-grade aneurysms [3–9]. With advances in endovascular technology, endovascular treatment has been used as an available alternative to surgery for ruptured aneurysms. An increasing number of patients with poor-grade aneurysms underwent endovascular treatment [10–15]. The indications and outcomes for surgery may differ from previous studies. [3,4,6–9,16]. However, no studies directly report complications and outcomes of poor-grade aSAH after early surgery in the endovascular era. The purpose of this study was to perform a multicenter retrospective analysis of complications and outcomes in patients with poor-grade aneurysm after early surgery.

2. Material and methods

All patients were treated in a high-volume hospital (more than 150 ruptured aneurysm cases per year) with expertise in surgery and endovascular treatment for aneurysm. From October 2010 and March 2012, 109 patients who presented with World Federation of Neurosurgical Society (WFNS) grades of IV or V underwent surgery at nine centers in a multicenter poor-grade aneurysm study (AMPAS) [17,18]. From March 2012 and April 2014, 289 patients with ruptured aneurysms were treated with surgery and were identified in the database of China National Clinical Research Center for Neurological Diseases (NCRC-ND). In this report, poor-grade patients were included if they were older than 18 years and less than 75 years, presented with WFNS grade IV or V after resuscitation. Patients were excluded if they underwent surgery after 72 h of rupture and if their follow-up was less than 6 months.

From the two cohorts, we collected the following data: patient age; sex; history of smoking and hypertension; Glasgow coma score (GCS); WFNS grade; brain herniation; Fisher grade; intracerebral hematoma (ICH); intraventricular hemorrhage (IVH); aneurysm location, size and number; timing of surgery, surgical reports, decompressive craniectomy (DC), complications during hospitalization and discharge outcomes. Brain herniation was defined as a deterioration of consciousness accompanied by anisocoria or bilateral pupil dilation (excluding oculomotor nerve palsy caused by other diseases). Rebleeding was defined as neurological deterioration with increase in subarachnoid hemorrhage or hematoma on CT scan after surgery.

All patients were initially managed in the emergency room. Management protocol included aggressive resuscitation, early surgery and postoperative intensive care [17]. Patients underwent external ventricular drainage (EVD) if they experienced acute hydrocephalus or large intraventricular hemorrhage (IVH) before or after surgery. DC was performed if intraoperative brain swelling occurred. In cases of multiple aneurysms, the aneurysm responsible for aSAH was clipped and multiple aneurysms were treated if they could be clipped.

Aneurysm rebleeding, cerebral infarction, symptomatic vasospasm, hydrocephalus, intracranial infection and pneumonia were defined as major postoperative complications. Cerebral infarction was defined as a new low-density area on CT scan after surgery. Symptomatic vasospasm was defined as progressive neurological deterioration that could not be explained by other causes (rebleeding, acute or worsening hydrocephalus, electrolyte disturbances, seizures and significant cerebral infarction on CT scan) [19]. Hydrocephalus was defined as ventricular dilatation with enlarged temporal horns ($\geq$2 mm wide) on CT scan, or ventriculoperitoneal shunt placement because of hydrocephalus [20]. These complications were recorded at each center. The outcome was assessed by the modified Rankin Scale (mRS). The mean time to follow-up was 12.6 ± 3.0months (range, 6–28 months). No patients were lost to follow-up. The outcome was dichotomized into good (mRS 0–3) and poor outcome (mRS 4–6).

Continuous data were presented as mean ± SD, and categorical data as numbers (percentage). An independent-samples *t* test or Mantel–Haenszel test was performed for continuous variables. A chi-square test or Fisher test was tested for categorical variables. The univariate analysis was performed to identify the potential risk factors associated with poor outcome in all patients and patients with WFNS grade V. Clinical variables with a P value < 0.10 in the univariate analysis were entered into the multivariate logistic regression model. The backward stepwise (LR) method was used to identify independent predictors of poor outcomes. Receiver operating characteristic (ROC) analysis was performed to test the prognostic model's ability. The adjusted odds ratio (OR) and 95% confidence interval (CI) were calculated. A P value < 0.05 was considered statistically significant. Data collections and statistical analysis were performed using IBM SPSS version 22.0 (IBM SPSS, Armonk, NY, US).

3. Results

In the two cohorts, 144 patients were treated with surgical treatment and were identified, and 96 (67%) underwent early surgery (within 72 h of ictus). Eighty patients were included and 16 patients were excluded because of the neurological deterioration (WFNS grade I–III to grade IV or V) after hospitalization in 14 patients, and follow-up less than 6 months in two patients. Out of the 80 included patients, 41 (51%) presented with WFNS grade IV, and

Table 1
Clinical characteristics of patients with poor-grade ruptured aneurysm.

Characteristics	WFNS grade IV	WFNS grade V	*P* value
No. (men/women)	41(18/23)	39(18/21)	0.840
Age(mean years ± SD)	53.6(±13.9)	53.7(±11.1)	0.955
Smoking, n (%)	12(29)	9(23)	0.529
Hypertension, n (%)	20(49)	23(59)	0.361
GCS(mean ± SD)	8.7(±1.8)	4.8(±1.2)	0.000
Fisher grade, n (%)			0.326
I–II	6(15)	3(8)	
III–IV	35(85)	36(92)	
Brain herniation, n (%)	10(24)	21(54)	0.007
ICH, n (%)	21(51)	25(64)	0.244
IVH, n (%)	15(37)	16(41)	0.684
Multi-aneurysms, n (%)	7(17)	4(10)	0.376
Aneurysm location, n (%)			0.503
MCA	22(54)	16(41)	
ACoA, ACA	9(22)	12(31)	
ICA, PCoA	8(20)	10(26)	
Posterior circulation	1(2)	1(2)	
Missing data[a]	1(2)	0	
Aneurysm size(mean ± SD)	5.8(±3.2)	6.4(±4.6)	0.904
Timing of surgery, n (%)			0.021
$\leq$ 24 h	19(46)	28(72)	
25–72 h	22(54)	11(28)	
DC, n (%)	13(32)	26(67)	0.002
EVD, n (%)	3(7)	4(10)	0.642
In hospital mortality	4(10)	7(18)	0.288
Discharge mRS0–3	13(32)	6(15)	0.099

WFNS, World Federation of Neurological Society; GCS, Glasgow coma scale; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage; MCA, middle cerebral artery; ACoA, anterior communicating artery; ACA, anterior cerebral artery; ICA, internal carotid artery; PCoA, posterior communicating artery; DC, decompressive craniectomy; EVD, external ventricular drainage.

[a] Missing data on location of anterior circulation aneurysm in 1 patient; mRS, modified Rankin Scale.