

Case Report

Cerebral hernia induced by intracerebral hematoma in patients with poor-grade ruptured intracranial aneurysm: emergent surgical treatment without angiography

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Abstract: Cerebral hernia induced by intracranial haematoma in patients with poor-grade ruptured intracranial aneurysm is a severe disease, which is associated with high mortality rates. This study aims to discuss the treatment principle of cerebral hernia caused by intracranial haematoma due to ruptured intracranial aneurysms-without preoperative angiography. 17 patients of cerebral hernia induced by aneurysmal ICH were treated microsurgically in our department. For serious clinical conditions, all patients received emergent surgical without preoperative angiography. The intracranial aneurysm clipping was successfully completed in 17 cases; direct clipping of the aneurysmal necks was achieved in 7 patients, while reconstructive clipping was performed in 10 patients. 4 cases with Hunt-Hess grade VI-V died after operation, 13 cases were survived, 3 of which had communicating hydrocephalus and were cured by ventriculo-peritoneal shunt. At follow-up, 6 of 13 survivors had favorable outcome (ADL grade I 3; ADL grade II 3), 5 patients had mild disability (ADL grade III), and the rest had severe disability (ADL grade IV). No impaired cognition observed in the survived patients. In patients with poor neurological grade at admission, whose consciousness rapidly deteriorated, because of aneurysmal ICH, urgent ICH removal and aneurysm clipping without the delay for diagnostic angiography may be life saving and a satisfactory outcome can be accomplished.

Keywords: Angiography, cerebral hernia, intracranial aneurysm, intracerebral haematoma

Introduction

Cerebral hernia induced by intracerebral haematoma (ICH) in patients with poor-grade ruptured intracranial aneurysm is a severe disease, which is associated with high mortality rates. Clinical outcome of these patients has little relationship with their initial neurological status, and about 50% of patients with rupture intracranial aneurysm survive functionally [1-9]. However, inadequate surgical treatment may lead to loss of potentially salvageable function or life. Patients diagnosed ruptured intracranial aneurysm, especially complex aneurysm, associated with cerebral hernia due to ICH are often in critical clinical condition and have poor prognosis, so rapid decision making is required to treat this life-threatening condition. Preoperative angiography in some cases may be a waste of time, among which urgent surgical treatment is required.

Adequate surgical strategies should include haematoma evacuation, decompressive craniectomy and intracranial aneurysm clipping. To our knowledge, however, there have not been any large, systematic researches yet. In this study, we describe the anatomical and clinical findings during surgical treatment of these patients, and tailored surgical strategies according to the distribution of ICH. This paper aims at introducing the results and efficacies of emergent surgical intervention to patients with cerebral hernia induced by the aneurysmal ICH in angiographic and clinical follow-up, and discuss the benefits and potential limitations of the technology.

Clinical material and methods

Patients selected in this retrospective study were treated surgically in our department between August 2010 and October 2013.

Poor-grade ruptured intracranial aneurysm

Table 1. Patient characteristics

Case No.	Sex/ Age (yrs)	Aneurysm size (mm)	Side	Pupil abnormality	Bleeding pattern	Hema- toma volume (ml)	Preop- erative Hunt-Hess grade	Surgical time window (hours)	Aneu- rysm location	Prognosis
1	F/32	4	L	unilateral mydriasis	Temporal hematoma	44	III	3	MCA	ADL II
2	M/41	4.5	L	unilateral mydriasis	Frontal hematoma	35	III	5	ACoA	ADL I
3	M/55	3.8	R	unilateral mydriasis	Temporal hematoma; SAH	56	IV	5.5	MCA	ADL III
4	M/66	5.4	R	unilateral mydriasis	Frontotemporal hematoma SAH;	63	IV	2.5	MCA	dead
5	F/52	6	R	bilateral mydriasis	Frontotemporal hematoma; Subdural hematoma	70	V	4	MCA	ADL IV
6	F/45	6.2	R	unilateral mydriasis	Temporal hematoma; SAH	58	IV	6.5	MCA	ADL III
7	M/68	6.1	L	bilateral mydriasis	Frontotemporal hematoma ruptured into the ventricle; SAH; Subdural hematoma	80	V	3.5	ICA-PCoA	dead
8	F/67	5.3	L	unilateral mydriasis	Temporal hematoma; SAH;	46	IV	4.2	MCA	ADL II
9	M/61	4.3	R	unilateral mydriasis	Frontal hematoma; SAH	40	III	3	ACoA	ADL I
10	M/48	7.9	L	unilateral mydriasis	Temporal hematoma; SAH	59	IV	6	MCA	ADL III
11	M/64	9.7	R	bilateral mydriasis	Frontotemporal hematoma; SAH	66	IV	6	MCA	ADL IV
12	M/39	4.2	R	unilateral mydriasis	Frontal hematoma ruptured into the ventricle	39	III	4.5	ACoA	ADL I
13	F/71	5	L	bilateral mydriasis	Frontotemporal hematoma; SAH; Subdural hematoma	72	V	10	MCA	dead
14	F/57	5.9	R	unilateral mydriasis	Temporal hematoma; SAH	42	III	5	MCA	ADL II
15	M/63	6.4	L	unilateral mydriasis	Frontotemporal hematoma; SAH	60	IV	2.6	ICA-PCoA	ADL III
16	M/69	5.1	R	bilateral mydriasis	Frontotemporal hematoma; SAH; Subdural hematoma	74	V	3.6	ICA-PCoA	dead
17	M/54	7.3	R	unilateral mydriasis	Frontal hematoma; SAH	47	IV	5.2	ACoA	ADL III

Patients' data were collected from hospital records, operating records and neuroimaging studies, while follow-up study data were obtained through out-patient records and telephone interview.

The study cohort consisted of 11 men and 6 women aged 32-71 years, with the average of 56 years. All the patients had suffered cerebral hernia caused by aneurysmal ICH, and assigned Hunt-Hess grade (Hunt-Hess grade III-V) according to the clinical manifestation immediately before emergent surgery, the individual characteristics are shown in **Table 1**. And the patients underwent emergent surgical without angiography. The ICH was firstly removed, and then intracranial aneurysm clipping and decompressive craniectomy were performed.

For serious clinical condition, the patients had no time to perform preoperative angiography.

But follow-up angiographic studies included digital subtraction angiography (DSA), computed tomographic angiography (CTA) and magnetic resonance angiography (MRA). We recorded clinical data and assessed 6-month outcome by the activities of daily living (ADL), which was obtained from check-up in the clinic and telephone interview of cognitive status (TICS) when the direct interview was not possible.

Surgical technique

The emergent surgical intervention was performed as soon as the patient underwent CT scanning of the brain. Patients with cerebral hernia induced by aneurysmal ICH with or without subarachnoid hemorrhage were taken immediately to the operating room. A decompressive craniectomy was performed concomitantly to the evacuation of ICH and intracranial aneurysm clipping.

Poor-grade ruptured intracranial aneurysm

All patients had surgery through the extended pterional approach or large question mark-shaped skin incision, and then bone flap was made and dura mater was opened with small straight incision. Under the operating microscope, we firstly evacuated some amount of haematoma in order to release intracranial pressure and to gain easy access proximal control. We advanced with dissection of the sylvian fissure and cisternal, and exposed the internal carotid artery (ICA), anterior cerebral artery (ACA) and middle cerebral artery (MCA). After further dissection, the proximal portion of aneurysm and parent artery were exposed and indentified. Thus, at this point, we considered that it might be possible to perform the aneurysm clipping.

We dissected and exposed the neck of aneurysm cautiously, and saw the aneurysm wall itself was hardly adhesive to cerebral cortex, in order to avoid aneurysm bleeding or rebleeding, we did not fully dissect the aneurysm from the brain. Then the temporary clip was placed on the proximal parent artery of aneurysm to preserve the blood flow to the aneurysm and aneurysm clipping was possible. After the aneurysm was clipped, the remaining haematoma was evacuated. When the brain swelling persisted and high intracranial pressure (ICP) was expected, duraplasty and/or craniectomy with enlargement of the bone flap were performed and the bone flap was not replaced.

Results

Baseline characteristics including age, sex, clinical status, haematoma type and volume are shown in **Table 1**. According to Hunt-Hess Grade classification, five patients were classified as Grade III, eight as Grade IV, and four as Grade V.

All of the patients underwent CT scanning of the brain in the emergency room before admission, which revealed a variety of imaging characteristics. 13 of 17 patients had ICH associated with subarachnoid hemorrhage, two patients had simple ICH, and the rest had ICH ruptured into the ventricular system. The ICH volumes ranged from 35 ml to 80 ml, among which 7 cases were less than 50 ml. In the 4 cases, the ICH was located in the frontal lobe, 5 cases located in the temporal lobe and 8 cases in front-temporal lobe, of which 4 cases were

accompanied with subdural haematoma mainly located in lateral fissure.

All the aneurysms were found on the proximal portion, and ranged in size from 3.8 to 9.7 mm, with an average size of 5.7 mm. In cases of rupture, there were no vascular malformations. No patient had multiple aneurysms. In 10 cases, the aneurysm was located in the MCA (58.82%), 3 cases in the internal carotid artery-posterior communicating artery (ICA-PCoA) (17.65%), and the rest in the ACoA (23.53%). During the operation, 10 cases of complex aneurysms were confirmed.

There were 4 cases of lobar haematoma accompanied with subdural haematoma mainly located in sylvian fissure, In 3 of 4 cases; we evacuated the haematoma from the proximal sylvian fissure to distal sylvian fissure. And after opening the sylvian fissure cistern, we advanced the dissection of the bifurcation of ICA, and exposed M1 and M2 segments of the middle cerebral artery. Finding the carotid neck and dissecting around it, we clipped the aneurysms successfully. 1 patient was treated by distal sylvian fissure approach, that is the haematoma evacuated from the distal sylvian fissure to proximal sylvian fissure, and the aneurysm was found and clipped.

8 cases of aneurysm ruptured again during the operation, among which 4 cases were not serious. With gelatin sponge and brain cotton sheet placed on the rupture position to ensure the operative field clear, quick and careful dissection around the aneurysm and meticulous inspection of perforating arteries were performed, and the carotid aneurysm was found and clipped. For the other four cases, which were bleeding severely, double aspirators were adopted to keep the operative field clear, and then the proximal parent artery of aneurysm was quickly and carefully dissected and clipped by temporary clip, thus finding the aneurysm neck and dissecting around it were relatively easy. As a result, the aneurysms were all successfully clipped in eight cases with rebleeding aneurysms during the operation.

Direct clipping of the aneurysmal neck was achieved in 7 patients, while reconstructive clipping after temporary trapping or a thrombectomy was performed in 10 patients. The intracranial aneurysm clipping was completed

Poor-grade ruptured intracranial aneurysm

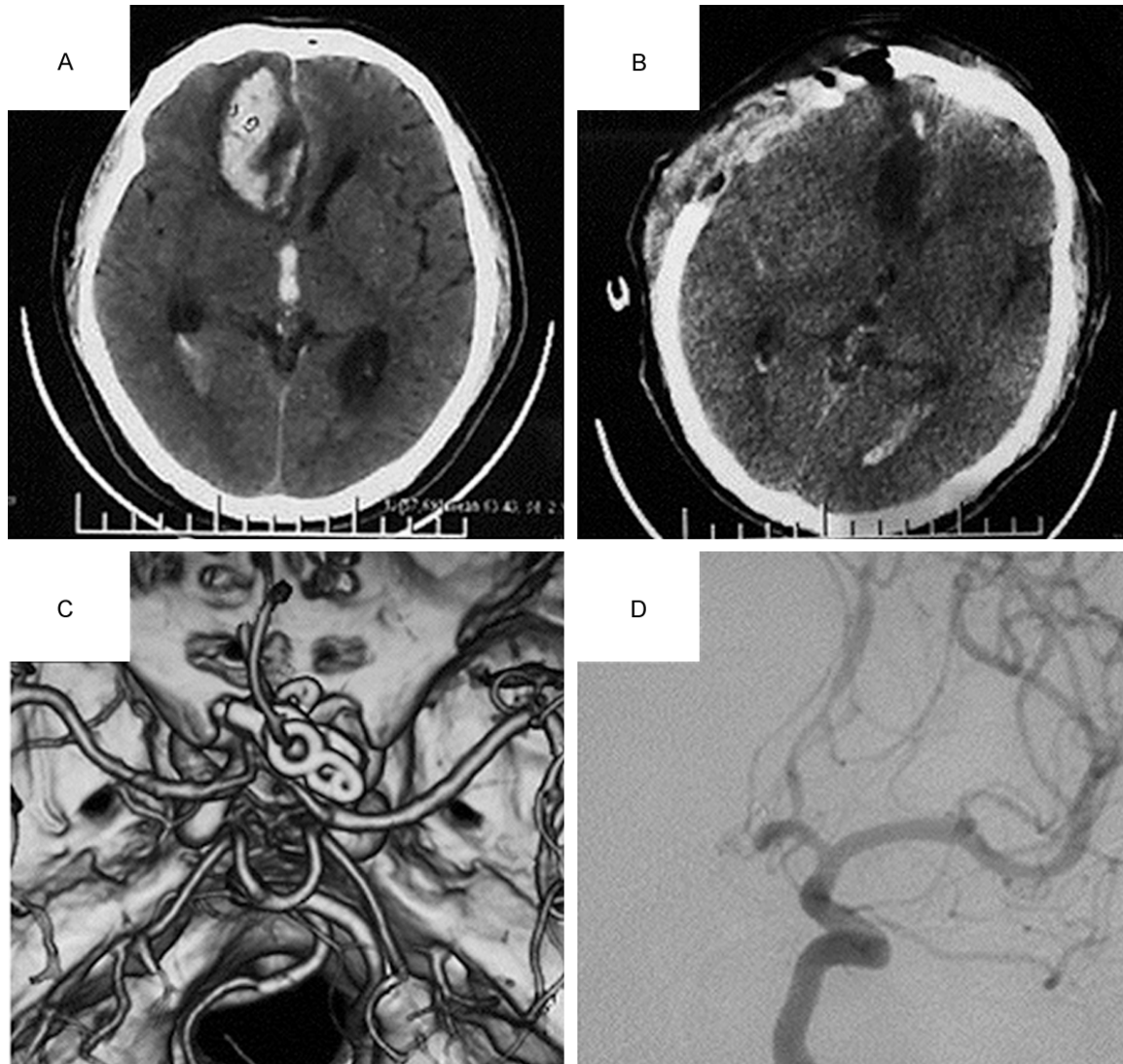


Figure 1. A. Preoperative CT scan showed that the right frontal lobe hemorrhage broken into the ventricular system, midline shift to the left. B. Postoperative CT scan showed the intracerebral haematoma had been evacuated with the bone flap removed. C. Postoperative CTA showed that the aneurysm had been reconstructive clipped successfully, with the parent artery of aneurysm preserved very well. D. A DSA performed at 6-month follow-up appointment demonstrated complete obliteration of the aneurysm, without stenosis or occlusion of the parent artery.

in all 17 cases, among which, 4 (23.5%) cases belonged to Hunt-Hess grade VI-V died after operation: one was in deep coma and had been bed-ridden for a very long time, who finally died of respiratory failure due to lung infection; the other 3 died of massive cerebral infarction caused by postoperative cerebral vasospasm. 13 of 17 (76.5%) cases were survived, 3 of whom had communicating hydrocephalus confirmed by CT scan and were cured by ventriculoperitoneal shunt.

Postoperative CTA was performed on the 7th day and DSA performed at 6-month follow-up

appointment, and complete post-clipping obliteration was found in all of aneurysms (17 of 17 aneurysms). There were no residual necks with postoperative CTA and DSA, with the postoperative CT scan demonstrating that the ICH was completely solved.

In follow-up, 6 of 13 survivors had favorable outcome (ADL grade I3; ADL grade II3), 5 patients with mild disability (ADL grade III) and 2 with severe disability (ADL grade IV). No impaired cognition observed in the survived patients.

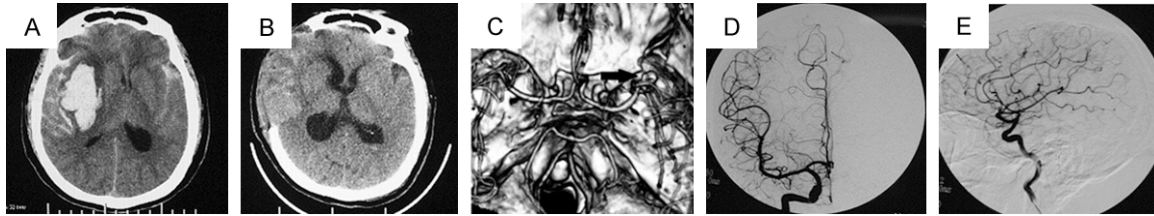


Figure 2. A. Preoperative CT scan showed SAH and a large haematoma in the right frontotemporal lobe. B. Postoperative CT scan showed the intracerebral haematoma had been evacuated with the bone flap removed. C. Postoperative CTA showed that the aneurysm had been clipped successfully (black arrow head), with the parent artery of aneurysm preserved very well. D, E. A DSA performed at follow-up appointment demonstrated complete obliteration of the aneurysm, without stenosis or occlusion of the parent artery.

Illustrative cases

Case 1 (Figure 1)

A 39-year-old man suffered from a sudden severe headache and became unconsciousness 4 h before admission. A physical examination showed a GCS score of 6, and the right pupil was dilated. CT scan revealed a large haematoma in the right frontal lobe ruptured into the ventricle. Because of critical clinical conditions, open surgery was conducted emergently. After evacuating the majority of the haematoma, the aneurysm was exposed. After we confirmed that there were no perforators involved in the neck of the aneurysm, the aneurysm was clipped using a neck reconstruction technique. The patient recovered quickly after surgery. A postoperative CTA demonstrated complete obliteration of the aneurysm.

A DSA performed at 6-month follow-up appointment demonstrated complete obliteration of the aneurysm, with the parent artery of aneurysm preserved very well. The patient recovered without any neurological deficits.

Case 2 (Figure 2)

A 64-year-old man suffered from a sudden severe headache and became unconsciousness 5 h before admission. A physical examination showed a GCS score of 5, and bilateral mydriasis. Because of aspiration, the patient also suffered from acute respiratory distress syndrome (ARDS). CT scan revealed SAH and a large haematoma in the right frontotemporal lobe. Emergent surgery was required, enlargement of the bone flap was performed, after evacuating the majority of the haematoma, the aneurysm was exposed originating from the

M2 segment, and direct clipping was performed. 7 days later, a postoperative CTA demonstrated the aneurysm had been clipped successfully, with the parent artery of aneurysm preserved very well.

The patient suffered from communicating hydrocephalus confirmed by CT scan 2 months later, and were cured by ventriculo-peritoneal shunt. DSA performed at 6-month follow-up appointment demonstrated complete obliteration of the aneurysm.

Discussion

Cerebral hernia induced by acute aneurysmal ICH rarely occurs, but once happen, the patients often in a critical clinical condition and have a poor prognosis, and it is difficult to get reliable clinical guidelines. In this study we have found that:

Patients with cerebral hernia due to aneurysmal ICH always show a critical state. For serious clinical condition, preoperative angiography in some cases may be a waste of time; the patients had no chance to perform preoperative angiography. Emergency haematoma evacuation and aneurysm clipping without the delay for diagnostic angiography may be life saving and achieve a favorable outcome. And we emphasize the adoption of decompression after clipping of aneurysms and haematoma evacuation in the emergent surgical treatment of the patients, who were diagnosed as poor-grade ruptured intracranial aneurysm associated with cerebral hernia induced by ICH. The present research illustrates our experience with a potentially helpful surgical strategy; however, several limitations of this analysis must be considered when interpreting our findings.

Poor-grade ruptured intracranial aneurysm

The study population included only a small number of patients, the inadequacies of the study include small size and lack of comparisons to illustrate the superiority of our emergent surgical treatments.

Previous studies reported that unfavorable outcomes of patients with aneurysm rupture and ICH was 61%-88%, and mortality rates up to 58% because of the more severe clinical grade on admission, severe brain swelling, and high rebleeding rate before aneurysm obliteration [10]. The mortality rate of conservative treatment or haematoma evacuation only without clipping was 75%-80% [8, 11, 12], whereas we achieved favorable functional recovery of 64.71% by the ADL, and mortality rate of 23.53%. So it may be said that our results reduce the mortality rate and have favorable effect to functional recovery.

For patient who is in a coma or whose consciousness is deteriorated quickly, the emergent treatment decisions become difficult. Patients with aneurysmal ICH are characterized by poor outcomes due to the significantly delayed brain edema and ischemic neurological deficit, suggesting that substantial brain damage is more profound than haematomas. Therefore, extensive haematoma evacuation and decompressive craniotomy must be performed to control the delayed brain swelling.

Neuroradiological investigations should at least conclude an emergency CT. However, in severe clinical condition, there is no time for patient to receive preoperative angiography to visualize potential bleeding sources. Emergency treatment to reverse brain herniation should be performed as quickly as possible. The emergent surgical strategy is summarized as follows:

Surgical approach and flap design

To avoid the potential need of returning to operation room several days after the clipping of aneurysms due to the significantly delayed brain edema and increased ICP, planning of craniectomy must be considered as an important part of the initial operation. Enlargement of the bone flap should be performed and the bone flap be left out to alleviate delayed brain swelling, which may induce midline shift. Apart from the above maneuvers, internal decompression can also be performed. In cases with

haematoma in sylvian and temporal lobe or frontal lobe, removal of part of the frontal and temporal lobe may be an option to get further decompression.

Evacuation of ICH

Considering large amount of ICH and increased ICP, the operation field is quite narrow and deep that we often have difficulty with performing surgery in this location. To prevent further injury and create sufficient space for easy access to proximal control, careful haematoma evacuation should be performed. Because of close adhesion between aneurysm and blood clots, too much evacuation of ICH may induce re-rupture of the aneurysm; it is wise to removal part of the haematoma in the distal portion from the aneurysm. Through these operations, we often get sufficient space to work with the ruptured aneurysm. After aneurysm is clipped, the remaining haematoma can be evacuated. Ventricular drainage is not practical in our study due to significant midline shift. In addition, intraoperative medical measures such as mannitol, hyperventilation, and hypothermia can also be adopted to decrease ICP [13-16].

Exploration and clipping aneurysms

Because there is no preoperative angiography, the morphology and location of aneurysm are unknown. There is certain blindness for exploration and clip aneurysm, which may lead to rupture of the aneurysm. However, we can preliminarily conclude where the aneurysm may be present, from the combination of the patient's history, clinical symptoms and preoperative CT scan, which show the characteristics of subarachnoid hemorrhage and haematoma location. Although there is no distinct difference between haematoma volume and rupture point of intracranial aneurysms, there is an interesting feature of the haematoma location according to the rupture point of the intracranial aneurysms. In our study, we find that the haematoma caused by ruptured anterior communicating artery aneurysm often locate at interhemispheric fissure cistern. The haematoma caused by ruptured middle cerebral artery aneurysm is often located at frontal-temporal lobe, or temporal lobe and temporal-parietal lobe and is often associated with ipsilateral subdural haematoma. haematoma in the frontal or temporal lobe near the skull base, may suggest the inter-

nal carotid artery aneurysm or posterior communicating artery aneurysm. We also find that the direction of aneurysm is substantially consistent with the location of haematoma. After part of the haematoma is removed, we could expose the proximal portion more easily, then explore along the parent artery of aneurysm, finally we find and dissect the aneurysm free and clip the aneurysm successfully, if necessary, temporary occlusion of the parent artery proximal could be performed.

Complex intracranial aneurysms include aneurysms that are sizeable (large or giant), broad-necked, fusiform, dissecting or serpentine, which cannot be treated with direct aneurysm neck clipping, especially without preoperative angiography. For saccular aneurysms with a broad neck, we often use low-flow electrocoagulation to shrink the aneurysm wall or to mold the neck after temporary parent artery clipping. For giant aneurysms with severe intraluminal thrombus, a thrombectomy is usually required to facilitate direct clipping. In some cases, however, reconstructive clipping of the aneurysmal neck could lead to a high recurrence rate. Therefore, we adopt aneurysm wrapping to reinforce the reconstructed wall of the parent artery.

Some researchers have noted that it is particularly difficult to get a favorable outcome following surgery in patients with cerebral hernia induced by aneurysmal ICH; furthermore, studies have not used standardized outcome measures to assess patients on presentation and on long-term follow-up. Despite the poor clinical grades of the patients on presentation, our demonstrated outcomes are more favorable than those reported in the literature. For comparison, a previous study [17] showed the mortality of the patients ranged from 41% to 64%. In our study, only 4 patients (23.53%) died of postoperative complications, one of whom entered into a deep coma after operation, had been bed-ridden for a very long time, and finally died of respiratory failure due to lung infection; the other three patients died of massive cerebral infarction caused by postoperative cerebral vasospasm. This may provide further evidence for regarding the benefits of surgery in this patient population.

Although no exact estimates provided at 3- and 5-year time points, it appears that the survival

rates from our current report are markedly higher, possibly representing a trend of improved prognosis.

Conclusions

For patients with poor neurological grade at admission, whose consciousness rapidly deteriorate because of aneurysmal ICH, urgent ICH removal and aneurysm clipping without the delay for diagnostic angiography may be life saving and a satisfactory outcome can be accomplished.

Disclosure of conflict of interest

None.

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