Prospective factors of temporary arterial occlusion during anterior communicating artery aneurysm repair

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Summary

Introduction: This study was undertaken to determine variables that could predict, in the perioperative period of anterior communicating artery (ACom) aneurysms surgeries, the likelihood of postoperative sequelae and complications, after temporary arterial occlusion (TAO).

Patients and Methods: In a universe of 32 patients submitted to ACom aneurysm repair in the last seven years, 21 needed TAO intraoperatively, and had their data examined retrospectively.

Results: Aneurysms larger than 7mm were more likely to be treated with longer TAO time than small aneurysms, ($p < 0.0001$). There was no statistical correlation between time of occlusion and outcome. Age, Glasgow Coma Scale at initial evaluation, and Fisher scale at 1st CT scanning were independent factors of unfavorable outcome ($p<0.001$). Meanwhile gender, tobacco addiction, obesity, arterial hypertension, dyslipidemia, location of TAO (A1 or A2), intraoperative rupture (IR) and the aneurysm size were not identified as independent prognostic factors.

During follow-up period, two thirds of the patients had a favorable outcome, accomplishing normal daily life activities without major complications. Most patients developed clinical vasospasm (66.6%), with 19% of the patients harboring a severe disease. Delayed ischemic neurological deficit was observed in 28.5%, without any statistical correlation to time of TAO or IR.

Conclusion: TAO during ACom aneurysm repair does not seem to add more morbidities to the procedure, and is not an independent prognostic factor.

Key-words: anterior communicating artery aneurysm, brain aneurysm, vascular neurosurgery.

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Introduction

Anterior communicating artery (AComm) aneurysms are the most common intracranial aneurysms, accounting for approximately 30-37% of intracranial aneurysms [8,17].

AComm aneurysms are also the most complex aneurysms of the anterior circulation due to the angioarchitecture and flow dynamics of the AComm region, frequent anatomical variations, deep interhemispheric location, and danger of severing the perforators with ensuing neurologic deficits [10].

AComm aneurysms are most commonly found at the A1-A2 junction on the dominant side [1]. The angle of the arteries at the bifurcation and the direction of blood flow are factors of hemodynamic stress in the apical region where these aneurysms often develop. They exist at the bifurcation of dominant A1, A2 and AComm and usually point in the direction away from the dominant A1 [1].

Worldwide the endovascular therapy is gaining an increasing role in the treatment of AComm aneurysms [9], but has not yet overwhelmed the microneurosurgical management, and seem to accomplish the same outcome in a long-term follow-up of ruptured cases [4,15]. In everyday clinical practice and decision making, coiling and clipping are to be considered equivalent in the long term [4], but treatment options should be tailored case-to-case.

A variety of operative approaches to the anterior communicating complex for intracranial aneurysms have been described [2,17], but the most commonly used is the pterional approach best described by Yasargil [22].

The advantages of the pterional approach are as followed: neurosurgeons are familiar and comfortable with it; it provides a rapid access to the basal cisterns; it allows exposure to the proximal A1 segment to proximal control, and other common aneurysm locations when multiple ipsilateral aneurysms are present; it provides an anterolateral trajectory to the Acomm region that allows for easier visualization of perforating vessels supplying the septal region and chiasm [17].

However, the pterional approach may present some disadvantages. This is a unilateral approach to a midline structure. Sometimes retraction of the frontal lobe cannot be achieved adequately without widely opening the sylvian fissure, increasing the temporal lobe, insula, draining veins and middle cerebral artery dissection trauma [17]. Bone removal is required to minimize brain retraction and can be cosmetically disfiguring because temporalis muscle atrophy and risk of damage to the frontalis branch of the facial nerve [17].

To prevent some of these previous disadvantages, the anterior subfrontal [13,17,21] and the lateral supraorbital [10,11] approaches for AComm aneurysm clipping were proposed. Up to now there is no optimal approach for AComm aneurysms clipping, and all seem to be feasible, being the choice of the approach an option of the surgeon. Despite its technical nuances the timing of treatment is still a controversial matter.

The ideal timing of clipping after aneurysmal subarachnoid hemorrhage (SAH) was unknown up to the International Subarachnoid Aneurysm Trial, which assessed differences in incidence of delayed cerebral ischemia and clinical outcome between different timings of treatment [7]. The risk for poor

outcome was highest when treatment was performed after day 10; postponing treatment in patients who were eligible for treatment between days 5 to 10 after SAH was not recommended [7].

AComm aneurysms present frequently with SAH at small size [10]. Furthermore, unruptured AComm aneurysm may have increased risk of rupture regardless of size, also as an associated aneurysm, and require treatment. They demonstrate the highest incidence of post-operative morbidity among anterior circulation aneurysms [1].

The aim in microneurosurgical management of an AComm aneurysm is total occlusion of the aneurysm sac with preservation of flow in all branching and perforating arteries [10]. Precise dissection in the anatomy of the AComm complex and perforators requires not only experience and skill but patience to work the dome and base under repeated protection of temporary clips [10].

Elective use of temporary clips (ETC) prevents intraoperative anterior circulation aneurysmal rupture (IAR). Dhandapani et al. [6] have found a 4.5% of IAR in patients who had ETC *vs* 55.3% of IAR without ETC ($p<0.001$). They have also demonstrated that IAR had significant association with unfavorable outcome (38 % vs. 24 %) ($p = 0.02$) [6]. In addition, the use of ETC ($p = 0.027$) and total temporary clipping less than 20 min ($p = 0.049$) were noted to result in significantly better outcome, independent of other factors [6].

In Leipzig et al. [14] study, posteroinferior cerebellar artery and anterior and posterior communicating artery aneurysms were more liable to rupture intraoperatively. The IAR rate was greater in ruptured than unruptured

aneurysms (10.7 versus 1.2%, P < 0.0001). There was a lower rate of IAR in operations using temporary arterial occlusion (3.1 versus 8.6%, P < 0.0001) [14].

According to Salary et al. outcome after aneurysmal SAH is related to the following triad of well-established clinical factors: Hunt and Hess grade, age, and clinical vasospasm [18].

Despite intraoperative aneurysmal rupture been recognized a factor of unfavorable outcome according to Dhandapani et al. [6], up to now there was no multivariate study to validate the use of temporary clipping or other epidemiological data as a independent factor of outcome.

Anesthetic considerations

It is highly advisable the best anesthesiology practicing in neurosurgical treatment of intracranial aneurysms.

Standard American Society of Anesthesiologists monitoring and invasive arterial monitoring is necessary during surgery. Whether central venous pressure or pulmonary artery pressure should be monitored depends on several factors including patient medical history, size and location of the intracranial aneurysms, use of inotropic agents, and the anesthesiologist's discretion [3].

Induction of general anesthesia and intubation should be accomplished in a smooth and controlled manner. Small doses of anxiolytics like midazolam can help to decrease patient anxiety preoperatively, although one should be

aware that this can change neurologic evaluation and create suspicion of deteriorating mental status postoperatively, especially in elderly patients [3].

Pinning the head in a Mayfield surgical frame is associated with a high sympathetic discharge, systemic hypertension, and potential aneurysm rupture. A bolus of opioids, such as sufentanil, or fentanyl, and scalp infiltration with a local anesthetic attenuates the hemodynamic changes during head pinning [3].

The surgical decision to use temporary clipping should prompt the anesthesia team to consider measures for brain protection, because temporary clipping can cause a period of reversible focal cerebral ischemia [3].

Communication between the surgeon and anesthesiologist about timing of application and release of the temporary clip is one of the most important factors in achieving optimal oxygenation and perfusion of the brain during this critical period [3].

If temporary clips are used before placement of the permanent aneurysm clip, the anesthesiologist can decrease the CMRO2 (cerebral metabolic rate for oxygen) by giving a bolus of IV anesthetic while blood pressure is maintained. A moderate decrease in blood pressure can help the surgeon manipulate the artery for placement of the temporary clip. After temporary clip placement, however, a higher blood pressure is needed to promote collateral perfusion to the ischemic area [3].

The Intraoperative Hypothermia For Aneurysm Surgery Trial showed that short-duration intraoperative hypothermia did not improve 3-month neurologic outcome after craniotomy for good-grade patients with aneurysmal subarachnoid hemorrhage [20]. Hypothermia is also associated with

arrhythmias and cardiac ischemia, decreased platelet activity, prolonged coagulation, and increased infection rate [20].

Hyperglycemia also has a deleterious effect on recovery from ischemic brain injury [12,16]. The prophylactic use of calcium antagonists like nimodipine in patients with SAH reduces the risk of brain damage [5]. The efficacy of magnesium in preventing delayed ischemic neurologic deficits in patients with SAH seems to be comparable with nimodipine [19].

Methods

In a universe of 92 patients submitted to AComm aneurysm clipping between 2000 and 2013 by the senior author, 32 were operated in the last seven years. Among these patients, 21 needed temporary arterial occlusion during surgical aneurysm repair, and had their data examined retrospectively.

The admission characteristics of the patients are summarized in Table I. All patients underwent diagnostic cerebral angiography, and had their data regarding the aneurysm morphology summarized in Table II.

The surgical case characteristics and details regarding postoperative course were reviewed and are summarized in Table III. The clinical outcome of the patients was assessed at 1-year follow-up by "Glasgow Outcome Scale - GOS", as defined: GOS 5 - good recovery (resumption of normal life despite deficits); GOS 4 - moderate disability (disabled but independent); GOS 3 - severe disability (conscious but disabled); GOS 2 - persistent vegetative state; and GOS 1 - death.

Results

Aneurysms larger than 7mm were more likely to be treated with longer temporary clipping time than small aneurysms, <7mm (11.3±4.1 *vs* 22±5.7, t-Test, p <0.0001). There was no statistical correlation between time of occlusion and outcome (r=0.92, Pearson, p>0.08). There was also no statistical difference in outcome between patients submitted to intraoperative temporary clipping during more or less than 20 min.

Age, Glasgow Coma Scale (GCS) at initial evaluation, and Fisher scale at 1st CT scanning were independent factors of unfavorable outcome (Glasgow Outcome Scale ≤ 3) (cox-regression, p<0.001). Among variable factors, being older than 50 years, an initial GCS under 13, and a Fisher grade III or IV resulted in worse outcome.

Meanwhile gender, tobacco or alcohol addiction, obesity, arterial hypertension, dyslipidemia, location of temporary occlusion (A1 or A2), intraoperative rupture and the aneurysm size were not identified as independent prognostic factors.

During follow-up period, two thirds of the patients had a favorable outcome (GOS ≥ 4), accomplishing normal daily life activities without major complications. Among nine patients with unruptured aneurysms 100% had a favorable outcome at 1-year follow-up (GOS ≥ 4), meanwhile, among 12 patients with ruptured aneurysms only 41.6% had a favorable outcome.

Fifty-two percent of patients evolved with hydrocephalus, despite of routinely fenestration of the lamina terminalis, performed in 71.4% of procedures. Most patients also developed clinical vasospasm (66.6%), with

29% of the patients harboring a severe disease. Delayed ischemic neurological deficit was observed in 28.5%, secondary to severe vasospasm and without any statistical correlation to time of temporary occlusion or intraoperative aneurysm rupture.

Discussion

Despite Dhandapani et al. [6] findings, we were not able to demonstrate any statistical difference in outcome of patients submitted to ETC, even with time longer than 20 min, neither among whom IAR was observed. It may be explained because we had only 4 cases of ETC longer than 20 min, and just 3 cases of IAR.

Nevertheless we have taken statistically longer time of ETC in aneurysms greater than 7mm, perhaps due some difficult to dissect the dome and base from larger aneurysms, and to locate all perforating branches before permanent closure of the aneurysm.

Our results are quite similar to those obtained by Salary et al. [18], which revealed unfavorable outcome following SAH related to age older than 50 years. Other independent factors of unfavorable outcome were Fisher grade III or IV and Glasgow Coma Scale under 13 at admission.

From all epidemiological comorbidities, such as tobacco or alcohol addiction, obesity, arterial hypertension or dyslipidemia, none has revealed as independent factor of unfavorable outcome.

Despite the severity of the illness, two thirds of patients evolved with favorable outcome (GOS ≥ 4). However, in the group of ruptured cases, only 41.6% patients evolved well.

Conclusion

Temporary clipping during ACom aneurysm repair does not seem to add more morbidities to the procedure, and is not an independent prognostic factor. However, age, initial GCS and Fisher grade are associated to unfavorable outcome.

The authors declare that they have no conflict of interest.

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Table I: Clinical characteristics of patients with AComm aneurysms

Characteristics	
Total number of patients	21
Sex	
Male	6 (29)
Female	15 (71)
Male/Female rate	0.4
Mean Age (years)	52.8 ± 16.5
Range (years)	19-78
Presentation	
Unruptured	9 (43)
Ruptured	12 (57)
Fisher Grade	
1	
2	6 (50)
3	5 (42)
4	1 (8)
Glasgow Coma Scale	
13-15	20 (95)
8-12	1 (5)
<8	0 (0)
Comorbidities	
Hypertension	16 (76)
Smoker	14 (66)
Alcohol	7 (33)
Obesity	8 (38)
Dyslipidemia	8 (38)

*Values represent number of patients, with percentages given in parentheses

Table II: Summary of aneurysm morphological characteristics

Characteristic	
Aneurysm Size	
Small (<10mm)	21 (100)
Large (10-25mm)	0 (0)

*Values represent number of patients, with percentages given in parentheses

Table III: Summary of surgical case characteristics and post-operative course

Characteristic	
Intraoperative aneurysm rupture	3 (14)
Temporary clipping performed	21 (100)
Average clip duration	13.8 ± 6.4
Lamina terminalis opening	15 (71)
Complications	
Vasospasm	14 (66)
Mild	10 (71)
Severe	4 (29)
Delayed ischemic deficit	6 (28)
Hydrocephalus	11 (52)
GOS 1-year follow-up	
GOS 5	8 (38)
GOS 4	6 (28)
GOS 3	2 (9)
GOS 2	3 (14)
GOS 1	2 (9)

*Values represent number of patients, with percentages given in parentheses