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Original Article

Use of our Protocol of Multimodality Tools to Aid in the Safe Microsurgical Clipping of Unruptured Anterior Circulation Aneurysms

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Abstract

Objectives: The aim of this study is to analyze the effectiveness of our protocol of the use of multimodality tools, namely indocyanine green-dual image video angiography, neuroendoscope, neuromonitoring with motor-evoked potential, micro-Doppler in the microsurgical clipping of unruptured anterior circulation aneurysms, operated at our institute from January 2016 to December 2018. **Materials and Methods:** We performed a retrospective analysis of all cases of unruptured anterior circulation aneurysms, operated at Fujita Health University Banbuntane-Hotokukai Hospital, Japan, from January 2016 to December 2018. We assessed outcome at immediate postoperative, at discharge, and at 3 months follow-up by defining permanent morbidity as drop in Modified Rankin Scale (MRS) by 1 at 3 months follow-up and transient morbidity as temporary deficit that improved at discharge or follow-up. Postoperative events, namely seizures, infection that did not affect/change. Preoperative MRS and discharge timing were excluded. We concluded poor outcome as MRS ≥3 and good outcome as MRS <3 (0–2). All patients had a minimum of 3 months follow-up before outcome conclusion. **Results:** In 2016, a total of 98 cases were operated with no mortality or permanent morbidity (i.e., change in preoperative MRS), only transient morbidity was seen in (two cases) 2.04%. In 2017, a total of 119 cases were operated with no mortality or morbidity. In 2018, a total of 130 cases were operated with no mortality or permanent morbidity, only transient morbidity 0.7%. Summarizing from January 2016 to December 2018, a total of 347 cases of anterior circulation aneurysms were operated. Mostly, in the female sex (73.3%), the most common was middle cerebral artery aneurysm (39.1%). The mean size was 5.3 mm with no mortality or permanent morbidity with only transient morbidity in 0.9%. No poor outcome (MRS ≥3) was seen in our series. **Conclusion:** In our center for most unruptured anterior circulation aneurysms, microsurgical clipping is the treatment of choice. We believe our protocol of the intra-operative usage of multimodality tools have aided in the safe microsurgical clipping and have consistently resulted in good operative outcomes. Hence, we recommend and continue to use our Fujita-Bantane Protocol in all cases of micro-surgical clipping of aneurysms to consistently achieve good operative outcomes.

Keywords: *Anterior circulation aneurysms, dual image video angiography, incidental aneurysms, indo-cyanine green, motor-evoked potentials, neuro-endoscope, neuro-monitoring, safe clipping, surgical outcome, unruptured aneurysms*

Introduction

Advances in neuro-imaging and its widespread use for screening has led to an increase in the rate of diagnosis of un-ruptured intracranial aneurysms (UIAs) commonly known as Incidental Aneurysms. Although incidental cerebral aneurysms are common, the management is controversial.[1,2] As reports from large-scale retrospective and prospective cohort studies have concluded that the risk of rupture associated with small UIAs is extremely low.[2] These studies included data primarily from the Caucasian populations in North America and Europe, but the incidence of rupture is higher in Japan and Finland than in other regions.[3-5] This difference in the rupture risk might be induced by differences in racial or genetic backgrounds.[5]

The overall prevalence of UIAs in the Japanese population was 3.2%. The prevalence in women was higher than that in men (4.4% vs. 2.5%). The prevalence increased with age in both genders.[6] Although the prevalence of intracranial aneurysms is low, aneurysmal rupture causing subarachnoid hemorrhage (SAH) can be devastating, with morbidity and mortality rates around 25% and 40%,

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respectively.[3,4,7] The Un-ruptured Cerebral Aneurysm Study (UCAS) showed that the natural course of unruptured cerebral aneurysms varies according to the size, location, and shape of the aneurysm. The risk for rupture was significantly higher for aneurysms that were 7 mm or larger, aneurysms of the anterior communicating artery (A-Com A) and the internal carotid (IC)-posterior communicating artery (P-ComA), aneurysms with a daughter sac as independent factors.[8] The International Study of UIAs trial and the UCAS stratified the risk of rupture for UIAs according to aneurysm size, with higher risk for aneurysms that were 7 mm or larger.

In this study, we analyze the effectiveness of our protocol of the usage of multimodality tools, namely indo-cyanine green-dual image video angiography (ICG-DIVA), neuroendoscope, neuromonitoring (motor-evoked potential [MEP]), micro-Doppler in the safe micro-surgical clipping of anterior circulation aneurysms, performed at our institute from 2016 to 2018.

Materials and Methods

We performed a retrospective analysis of all cases of unruptured anterior circulation aneurysms operated at Fujita Health University Banbuntane-Hotokukai Hospital, Japan, from January 2016 to December 2018 [Table 1]. Along with the UCAS recommendations, cases that showed aneurysmal growth on serial imaging was taken up for surgical treatment.

Preoperative imaging included two-dimensional and three-dimensional (3D) computed tomography angiography, computational fluid dynamics study demonstrating wall pressure, wall shear stress suggesting impending rupture. Magnetic resonance imaging & 3D digital subtraction angiography if indicated. We classified Permanent Morbidity as drop in Modified Rankin Scale (MRS) by 1 at 3 months follow-up and Transient Morbidity-as temporary deficit that improved at discharge or follow-up. Postoperative events, namely seizures, infection that did not affect/change discharge timing were excluded. We concluded poor outcome as MRS ≥3, good outcome as MRS <3 (0–2). In our hospital, all neurovascular surgeries are performed with OPMI Pentero Microscope (Carl Zeiss, Oberkochen, Germany) with infrared 800 camera for ICG-VA. The MINIRC-2000K (Mizuho Co., Ltd., Nagoya, Japan) NIR camera mounted on the microscope for DIVA. Right angled rigid endoscope (Machida, Japan) for endoscopic evaluation. Micro-Doppler ultrasound (DVM 4300, Hadeco, Japan). All surgeries were performed under general anesthesia for induction, followed by propofol sedation. No muscle relaxant agents were used after induction to facilitate MEP monitoring.

Intra-operative protocol as depicted in Flowchart 1.

Data analysis

In 2016, a total of 98 cases of anterior circulation aneurysms were operated with majority being females (72.4%). Most common was middle cerebral artery (MCA) aneurysm 41.8%, followed by IC-P-Com aneurysm. Mean size was 4.8 mm with no mortality or permanent morbidity, only transient morbidity was seen in (2 cases) 2.04% [Table 2].

In 2017, a total of 119 cases of anterior circulation aneurysms were operated with majority being females (73.1%). Most common was MCA aneurysm 41.1%, followed by IC-P-Com aneurysm. Mean size was 6 mm approximately with no mortality or morbidity [Table 2].

In 2018, a total of 130 cases of anterior circulation aneurysms were operated with majority being females (74.6%). The most common was MCA aneurysm 34.6%, followed by A-Com aneurysm. The mean size was 5.1 mm approximately with no mortality or permanent morbidity, only transient morbidity 0.7% [Table 2].

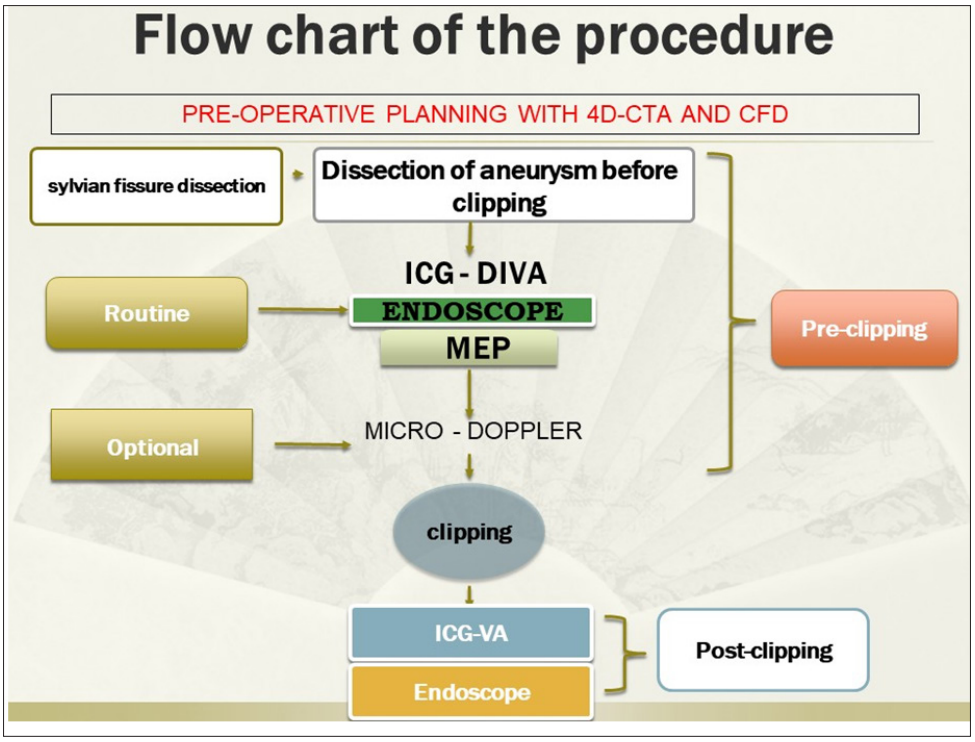
Results

Summarizing from January 2016 to December 2018, a total of 347 cases of anterior circulation aneurysms were operated with majority being females (73.3%), most common was MCA aneurysm 39.1%. The mean size was 5.3 mm with no mortality or permanent morbidity, and transient morbidity in 0.9%. No poor outcome (MRS ≥3) was seen in our series [Table 3].

During the initial part of the study, MEP monitoring was done on a selective basis mostly for MCA, IC-P-Com, IC-Acho aneurysms, etc. AS the protocol evolved, we have used it for almost all the cases as mentioned above. Now it has become a routine for all cases. Suture removal was done on the 7th postoperative day, the average in-hospital stay was 12–14 days.

Discussion

Although the estimated 3% prevalence of intracranial aneurysms is low, aneurysm rupture causing SAH can be devastating, with morbidity and mortality rates around 25% and 40%, respectively.[3,6,7] Despite recent improvements in surgical and medical management of aneurysmal SAH, the overall mortality rate produced by this disease is still high (approximately 40%–50%). The high mortality and morbidity rates are attributed mainly to brain damage caused by a severe initial hemorrhage, early re-bleeding, and delayed cerebral ischemia related to vasospasm.[9,10] During the last two decades, detection of UIAs has increased because of new and improving diagnostic technology and its routine and increased use in screening. The overall prevalence of UIAs in the Japanese population was 3.2%. The prevalence in women was



Flowchart 1: Fujita-Bantane Protocol

higher than that in men (4.4% vs. 2.5%). Female sex is an independent risk factor for the growth of UIAs in elderly patients.[6,11,12] The prevalence increased with age in both genders.[11-13] The size is considered to be an independent risk factor.[1,2,7,8,12-14] The management of unruptured aneurysms is controversial, currently there are no randomized controlled trials to decide on the management of UIAs. The PHASES score and the UIA treatment score (UIATS) score are currently used in decision making. The PHASES score is a 5-year rupture rate estimation model based on 8283 patients diagnosed with UIAs and 29166 patient years of follow-up and the UIATS score is a consensus-based scoring system.[15,16] Neither scoring system has been satisfactorily validated on an independent large cohort and there is a conflicting reports about such scoring systems leading to over treatment and questions about their reliability on stable UIAs, growing UIAs.[17,18]

Hence, the management of UIAs should take into consideration patient characteristics such as age, sex, ethnic background, comorbidities and aneurysm characteristics such as size, shape, location, and aspect ratio.[3-5,7,11-13,15-20] The management of aneurysms at high volume centers by experienced neurosurgical and endovascular teams has excellent results, most experts agree that micro-surgical clipping should be the first line of treatment.[7,21]

In our center, micro-surgical clipping is the first line of treatment for most unruptured anterior circulation aneurysms. We have been using the Fujita-Bantane Protocol (FB Protocol) in all our cases. After sylvian dissection and exposure of the aneurysm.

Step 1 involves preclipping ICG-DIVA. Although standard ICG-VA (ICG alone) clearly highlights vascular structures from nonvascular structures as white and black images respectively, other structures cannot be observed.[22-26] ICG-DIVA provides real-time simultaneous visualization of the aneurysm, vessels and surrounding structures including brain, nerves with far better depth perception thereby facilitating better anatomical correlation. This helps in quicker and more effective decision making during surgery.[27,28] DIVA images giving better anatomical correlation clearly depicted here in Figure 1.

Step 2 involves preclipping neuro-endoscopic evaluation. The neuro-endoscope, with its better illumination, higher magnification, extended viewing angles can provide real-time assessment about the hidden perforators, key neurovascular structures which are not visible under the dead angles of the microscope.[29-32] Additional technological advancements have made the neuro-endoscope not only as an diagnostic tool but also capable of assisting angiographic evaluation and guiding clipping procedure as shown in Figure 2.[33-37]

The Step 1 and Step 2 are repeated as per requirements. Continuous transcranial MEP monitoring is done during the procedure; initially, MEP monitoring was done on a case-to-case basis. Now has become a routine in all cases. Direct (cortical) MEP is sensitive in detecting ischemic stress to descending motor pathways during aneurysm surgery. Recently, increased use of combined trans-cranial and direct MEP monitoring is being practiced with better sensitivity and specificity as a part of multimodality monitoring during

Figure 1: Illustrative case of internal carotid artery aneurysm with (a-c) depicting pre-clipping microscopic, indo-cyanine green, dual image video angiography images respectively. (d-f) Depicting post clipping microscopic, indo-cyanine green, dual image video angiography images respectively. Dual image video angiography images giving better anatomical correlation clearly depicted here. (g-i) Depicting post 2nd-clipping microscopic, indo-cyanine green, dual image video angiography images respectively

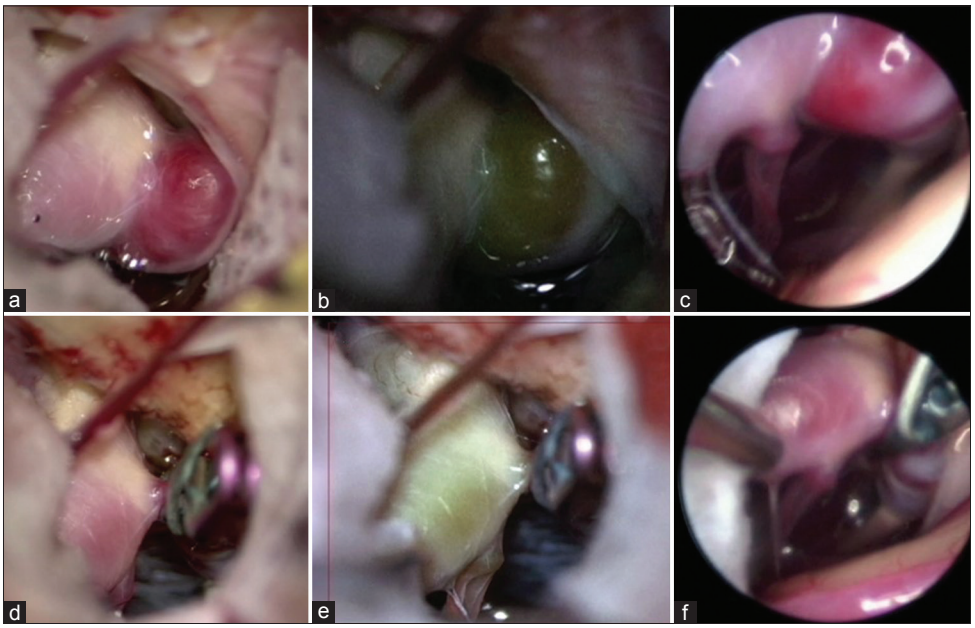


Figure 2: Illustrative case of internal carotid-posterior communicating aneurysm (a and b) depicting preclipping microscopic, dual image video angiography images respectively. (c) Is endoscopic view depicting posterior communicating and perforators, not seen in microscopic view. (d and e) Depicting post-clipping microscopic, dual image video angiography images respectively. (f) Is endoscopic view showing posterior communicating preserved and complete obliteration of the aneurysm

Table 1: Demographic data

Years	Aneurysm								
	ACOM	A2-3/DACA	MCA	IC-PC	IC-OPH	IC-ACHO	IC-TOP	IC-CAVERNOUS	C2-C3
2016	14	3	41	17		8	3		12
2017	20	8	49	22	13	5	2		
2018	24	7	45	22	22	7	2	1	
Total	58	18	135	61	35	20	7	1	12

ACOM – Anterior communicating artery aneurysm; A2-3/DACA – Distal Anterior Cerebral Artery aneurysm; MCA – Middle cerebral artery aneurysm; IC-PC – Internal cerebral artery - posterior communicating artery aneurysm; IC-OPH – Internal cerebral artery - ophthalmic artery aneurysm; IC-ACHO – Internal cerebral artery – anterior choroidal artery aneurysm; IC-TOP – Internal cerebral artery - bifurcation aneurysm; IC-CAVERNOUS – Internal cerebral artery - cavernous segment aneurysm; C2-C3 – Ophthalmic-clinoidal segment

Table 2: Year wise data

Type of aneurysm	Total number	Male	Female	Size (mm) R; M	MEP	Morbidity
				2016		
ACOM	14	8	6	2.5-12; 4.5	2	Seizures - 1 case
A2-3/DACA	3	-	3	4-6; 4.7		
MCA	41	10	31	2-9; 4.7	13	Drop in MEP in 1 case - no symptoms
IC-PC	17	6	11	3-10; 4.4	11	Drop in MEP in 1 case-transient hemiparesis transient 3rd nerve palsy - 1 case
IC-ACHO	8	1	7	3-8; 5	6	
IC-TOP	3		3	4-8; 5.7	3	
C2-C3	12	2	10	3-7; 4.8	2	
Total	98	27	71	4.8		
				2017		
ACOM	20	8	12	3-20; 7.8	5	
A2-3/DACA	8	2	6	3-15; 7.3	1	
MCA	49	16	33	3-20; 5.9	24	
IC-PC	22	3	19	2.5-20; 6.6	16	
IC-OPH	13	1	12	2-7; 4.4	2	
IC-ACHO	5	-	5	3-10; 5.2	1	
IC-TOP	2	2	-	3-6; 4.5	1	
Total	119	32	87	6		
				2018		
ACOM	24	8	16	2-10; 4.6	23	Seizures - 1
A2-3/DACA	7	4	3	3-6; 4.7	4	
MCA	45	13	32	1.5-10; 5	42	Seizures - 2
IC-PC	22	6	16	2-14; 4.8	17	
IC-OPH	22	-	22	2.5-15; 5.7	14	
IC-ACHO	7	2	5	2-6; 4.1	7	
IC-TOP	2	-	2	3-10; 6.5	2	Transient aphasia - 1
IC-CAVERNOUS	1	-	1			
Total	130	33	97	5.1		

ACOM – Anterior communicating artery aneurysm; A2-3/DACA – Distal Anterior Cerebral Artery aneurysm; MCA – Middle cerebral artery aneurysm; IC-PC – Internal cerebral artery - posterior communicating artery aneurysm; IC-ACHO – Internal cerebral artery - anterior choroidal artery aneurysm; IC-TOP – Internal cerebral artery - bifurcation aneurysm; C2-C3 – Ophthalmic-clinoidal segment; MEP – Motor-evoked potential; IC-OPH – Internal cerebral artery - ophthalmic artery aneurysm; IC-CAVERNOUS – Internal cerebral artery - cavernous segment aneurysm

Table 3: Year wise summary

Years	Number of cases	Transient morbidity (%)	Permanent morbidity	Mortality
2016	98	2.04	Nil	Nil
2017	119	Nil	Nil	Nil
2018	130	0.7	Nil	Nil
Total	347	0.9	0 (nil)	0 (nil)

aneurysm surgery.[38-41] Micro-Doppler is used as an optional modality on a case-to-case basis, if additional information is required about the patency of the parent vessel or perforators.

The goal of aneurysm surgery is to achieve satisfactory clipping such that there is no residual filling of the aneurysm, distal branch and perforator occlusion, or parent vessel stenosis. As aneurysm remnants have potential for re-growth

and hemorrhage, whereas clip occlusion of a parent artery or small hidden perforators can lead to permanent neurological deficits and is a devastating complication. Thus, preserving blood flow in the branches and perforators of a parent artery is very important for successful surgery.[42]

We believe our protocol, which has evolved over a short period of time provides all the vital information to the operating surgeon, thereby aiding in quicker and better decision making to make microsurgical clipping safe. Thus, consistently resulting in satisfactory operative outcomes and achieving the goal of aneurysm surgery.

Conclusion

In the current era of neuro-vascular surgery, most randomized controlled trials are nearing a consensus that both open micro surgical clipping and endovascular treatment are equally efficient and viable treatment options in experienced hands.[43,44] Although open micro surgical clipping is the gold standard treatment in terms of aneurysm obliteration rates and rebleeding rates, it is being constantly challenged by recent technological advancements and continuously evolving endovascular treatment modalities.[45-49] Most experts agree that management of aneurysms done at high volume centers by experienced neurosurgical and endovascular teams has excellent results. In most centers micro-surgical clipping is the first line of treatment for unruptured aneurysms.[50,51]

In our center for most unruptured anterior circulation aneurysms micro-surgical clipping is the treatment of choice. We believe our protocol of the intra-operative usage of multimodality tools have aided in the safe micro-surgical clipping and have consistently resulted in good operative outcomes. Hence, we recommend and continue to use our FB Protocol in all cases of micro-surgical clipping of aneurysms to consistently achieve good operative outcomes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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