INTRAOPERATIVE DUPLEX SONOGRAPHY FOR THE TREATMENT OF LARGE AND GIANT ANEURYSMS. RETROSPECTIVE ANALYSIS OF 13 CASES

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ABSTRACT

Object: The aim of the study was to evaluate the usefulness of intraoperative duplex sonography in the treatment of large (17-24 mm) and giant (>25mm) intracranial aneurysm. **Methods:** A Retrospective clinical review of 13 cases of giant and large aneurysm treated in Tokuda Hospital Sofia, Bulgaria. **Results:** The preoperative location of the aneurysm was as follows: MCA 6 pts (46%), ICA -5 pts (38%), ICA-Ophthalmic 1pt (8%) AcomA – 1pt (8%). Intraoperative Ultrasound (IOUS) used in all of the cases for intraoperative visualization of the aneurysm, adequate clip position. Endoscopy was applied additionally in 4 of the cases (31%). The IOUS visualization of distal blood flow achieved in 4 out of 13 patients (30%). Due to the IOUS image clip reposition was done in 1 pt (8%). In 10 pts (77%), clipping of the aneurysm was performed, and 3 cases (23%) the aneurysms were treated by wrapping. On postoperative CTA controls, complete aneurysm obliteration was observed in all clipped patients. In 3 (23%) patients under IOUS guidance, the aneurysmal walls were reduced in size using bipolar coagulation with the further good presentation of the aneurysmal neck, which allowed adequate clip placement. **Conclusion:** The initial experience with this technique indicates that it is a reliable tool for blood flow evaluation in large and giant aneurysms, as well as the presence intraluminal thrombosis and calcifications in the aneurysm wall. The data from IOUS facilitates a more secure microsurgical dissection and in some situations gives additional data needed for clip repositioning and intraoperative diagnosis. The combination of IOUS and endoscopy provides additional information, which could aid the management of these lesions.

KEYWORDS: intraoperative ultrasonography; intraoperative duplex sonography; giant aneurysm; large aneurysm

Introduction

Large and giant aneurysms are thought to represent about 5-8% of all intracranial aneurysms [11, 14, 35]. Their natural history is often morbid due to their mass effect on the surrounding brain tissue, due to emboli that can dislodge to downstream vascular territory, or due to their higher risk of rupture compared with smaller aneurysms [11, 14, 26, 28, 29, 30, 35].

Giant and large cerebral aneurysms have a higher rate of arterial wall calcifications, atherosclerotic plaque, and intraluminal thrombus. These features often complicate direct microsurgical clip reconstruction and surgical treatment has traditionally been associated with a higher morbidity and mortality rates, because of occlusion of perforators or parent arteries during aneurysm clipping, or prolonged temporary occlusion of main arteries.

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Case	Clinical presentation	Genre	Age	Localization and aneurysmal sac direction	Size	Preoperative diagnostics	Management /outcome/ follow up
1	SAH, H&H II	M	55	ICA upwards and posterior	30 mm	CTA	Clipping GOS 5 /transitional hemiparesis/ 1year
2	H&H IV	F	36	MCA/lateral	16 mm	CTA	Clipping GOS 0
3	H&H I, Intracerebral, hematoma, SAH	F	42	MCA/lateral	15 mm	MRI	Clipping GOS 5/2 years
4	30 days after SAH	F	50	MCA/medial	17 mm	MRI	Clipping GOS 5/3years
5	Headache	F	57	MCA lateral and upwards	27 mm	CTA	Clipping GOS 5/3years
6	Intraparenchimal hemorrhage	F	59	AcomA post downwards and posterior	30 mm	MRI	Wrapping GOS 4/4years
7	SAH, H&H III	F	63	MCA media trifurcation and medial AcomA	16 mm + 6 mm	CTA	Clipping GOS 4/1year
8	SAH, H&H I (Previous SAH 4 years, before the operation)	M	61	ICA/lateral, without good opportunity to enhance, the neck	30 mm	DSA	Wrapping GOS 5/3years
9	Chronic headache	F	40	ICA downward and lateral	16 mm	CTA	Wrapping GOS 5/1 year
10	SAH, H&H II	M	58	ICA/upward and lateral	20 mm	DSA	Clipping GOS 5/3 years
11	Amaurosis, misdiagnosed as tumor on MRI	F	76	Ophthalmic /upward and medial	50 mm	MRI	Clipping GOS 5/3 month
12	Single seizure	M	65	ICA/ upward and anterior covering the main thrunk of the carotid bifurcation	28 mm	MRI	Clipping GOS 5/2 years
13	Seizure, misdiagnosed as tumor lesion	F	39	MCA–M4 segment/ anterior and lateral	18 mm	MRI	Clipping/ transitional leg paresis GOS 4/4years

Table.1. Patient's characteristics, aneurysm localization and management. Patient 1 and Patient 8 had VP shunt implantation due to the development of hydrocephalus.

[1, 11, 15, 20, 28-34].

Abbreviations: CTA – Computed tomography angiography, MRI – Magnetic Resonance imaging, DSA – Digital subtraction angiography, ICA-Internal carotid artery. MCA – Middle cerebral artery, AcomA – anterior communicating artery SAH – subarachnoid hemorrhage GOS – Glasgow outcome scale H&H - Hunt and Hess classification.

The most serious surgical complications related to accidental bleeding and improper clip placement. The latter has been associated with compromised blood flow, and in some cases the subsequent development of aneurysm residual, delayed neurological deficit, stroke, and even death [11, 13, 30].

There are currently available various intraoperative imaging methods for the evaluation of cerebral blood, like for example digital subtraction angiography (DSA), indocyanine green (ICG) video angiography and also microvascular Doppler ultrasonography (MDU) [2, 3, 5, 8, 11, 12, 16, 22].

Intraoperative DSA remains still the gold standard [2, 5, 16], but it is technically demanding and associated with a risk of complications [2, 11, 16]. The non-invasive methods such ICG video angiography, MDU and power Doppler provide useful and non-invasive option for intraoperative evaluation of the cerebral blood flow. Numerous studies point out that the application of these methods on a routine basis assures the success of cerebral aneurysm surgery and can therefore substantially improve the surgical outcome [8, 9, 17, 22, 23, 17].

With this, we present our initial experience with the application of Power Doppler with B-mode in the treatment of large and giant aneurysms. Particular reference is given to the role of assessment of aneurysm's wall thickness, as well as blood flow

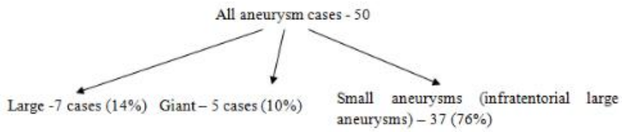


Figure 1: Abbreviation: ICA – Internal carotid artery; MCA –middle cerebral artery, ACA-anterior cerebral artery

before and after the aneurysmal clipping and comparison of this technique to the already routine use of endoscopy inspection in the intraoperative management of aneurysm.

Material and Methods

For the period from June 2007 to May 2010, 13 patients (pts) (9 women, 4 men) diagnosed with anterior circulation large (7 patients with aneurysm size between15-25mm) and giant (5 patients with aneurysm size >25mm) and one case of extreme size of the aneurysm (50 mm) were operated on in the Department of Neurosurgery, Tokuda Hospital Sofia, Bulgaria (Figure 1). Their average age was 53.9 years (SD, 11.8 years; range 36 to 76 years). Preoperatively, all patients underwent computed tomography angiography (CTA), magnetic resonance imaging angiography (MRA), or classical DSA (Table 1).

A contrast-enhanced MRI-based neuronavigation Sonowand-Invite (Sonowand As, Trondheim, Norway) used in 8 cases. MRI Images were T1, T2 and FLAIR modality were loaded to guide the surgeon trough the intervention. For intraoperative duplex sonography, two workstations with similar transducers (working frequency of 4-8-10 Mhz were used - GE LOGIQ5 (5 cases) and SonoWand-Invite (8 cases). LOGiQ-5(GE) has two types of transducers: micro convex and linear T-type. The transducers are with 6-8-10 Mhz and with opportunity for-power-color Doppler. The linear is with working diameter of 35 mm, and the micro convex is with 15mm. In the SonoWand system, the transducer is with 4-8 Mhz, and working diameter of the transducer of 22 mm and also is a duplex-transducer with color Doppler opportunity type FPA.

Intravenous mannitol (1g/kg) prior to incision and CSF withdraw (15-20 ml after dural opening) used for brain relaxation. The patient's head was rotated in 150 to 300 to the contralateral side and slightly extended to facilitate frontal lobe retraction. The preferred surgical approach in the majority of cases was personal (Table 1). In one instance of MCA - M4 segment aneurysm a right parietal approach was chosen; a right front-orbit-zygomatic (FTOZ) approach was selected in one instance of giant ophthalmic aneurysm (Figure 2)

Temporary clips were used when needed for cases 1, 5, 6, 7, 11, 12 (6 out of 13 cases (46%)). Temporary clipping was utilized not more than 4 minutes, with careful planning with the anesthesiology team to ensure optimal brain protection during temporary clipping period. In 10 cases, the aneurysmal neck was clipped, and the aneurysm body and fundus excised. In 3 other cases (23%) the wrapping of the aneurysm was performed.

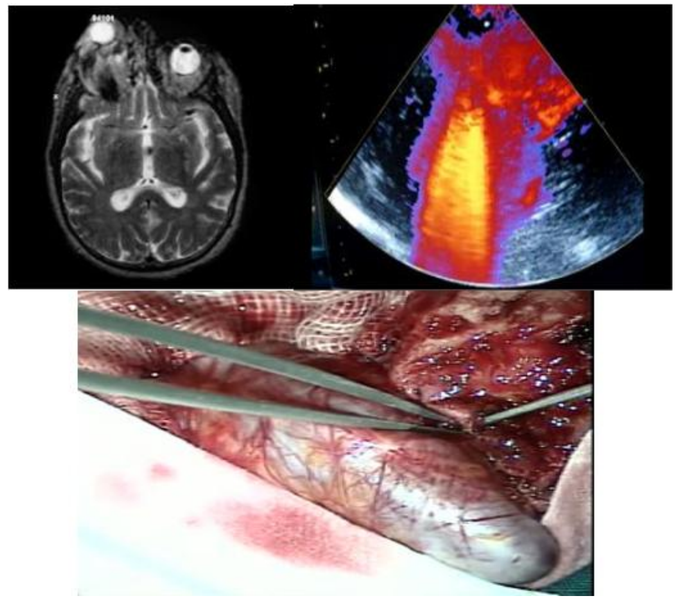


Figure 2: A 76 years old female presented in our department with complains of progressive right eye exophthalmos and visual loss. On the preoperative MRI a diagnosis "hipervascullarised intraocular tumor" was diagnosed and for that reason, no preoperative angiography was performed. The patient was operated on with the right orbitozygomatic approach. However on the routine intraoperative color Doppler ultrasound study a giant aneurysm measured app. 50 mm discovered. Using microsurgical technique, the aneurysm was excised and the parent vessel (right ICA) was reconstructed using 8.0 Prolene (Ethicon, Johnson and Johnson, USA) On the postoperative CTA, however, another aneurysm in the cavernous part of right ICA was diagnosed. Due to the overall patient health condition it was decided not to operate the second aneurysm. The patient discharged with no additional neurological deficit.On the 12 months follow-up no new symptoms from the aneurysm appeared. The patient died 16 months after the operation from myocardial infarction. Abbreviations: ICA –Internal carotid artery; CTA – Computed tomography angiography

Results

Seventy-seven percent of the patients presented with space occupying lesion. Only 2 presented with acute subarachnoid hemorrhage. The initial diagnosis established with CTA (38%), MRI angiography (46%), or DSA (15%).

The exact preoperative location of the aneurysm was as follows: MCA 6 pts (46,4%), ICA -5 pts (38,4%), ICA-Ophthalmic 1pt (7,6%) AcomA – 1pt (7,6%) (Figure 1). In 3 of the 13 pts (23%), the lesion was suspected of a tumor on preoperative MRI and the diagnosis of an aneurysm was established by intraoperative duplex sonography (Figure 2). In 10 pts (77%) a clipping of the aneurysm was performed, wrapping treated the resting three aneurysms (23%). Postoperative CTA control was done in all cases on the third postoperative day. Complete aneurysm obliteration was established in 10 pts. Because incomplete obliteration in the other 3 cases (23%) was due to the complex geometry of the aneurysms sac leading to the presence of the large cerebral vessels involved in the aneurysm. No aneurismal trapping with IC-EC bypass was performed.

Using IOUS the aneurysms were intraoperatively differentiated as follows: One pt. (8%) presented with extensive luminal thrombosis and calcifications. Partial thrombosis identified in 10 pts (69% of cases) with the help of IOUS. The IOUS was particularly useful to evaluate the geometry of the aneurysm sac, clip position and obliteration of the aneurysm (Figure 3). One of the main disadvantages of the technique was the difficulty in the evaluation of flow in smaller vessels. This was due to the diameter of the ultrasound transducers used in the study – between 15-35 mm, which was particularly useful for the evaluation of the aneurysm itself (due to its size) and larger vessels, but not for small diameter vessels. Additional MDU was not used in the present study.

In all three patients, in whom aneurismal wrapping performed, IOUS helped to differentiate the aneurysmal neck and to evaluate the wall thickness and the risk of future rupture. In 3 patients under IOUS guidance, the aneurysmal walls were reduced in size using bipolar coagulation with the further excellent presentation of the aneurysmal neck, which allowed adequate clip placement. The endoscopic inspection used in 4 of the included cases (31%). Information gained by endoscopic inspection helped in reposition of eclipses due to incomplete aneurysm occlusion in one case (7.6%).

Endoscope Inspection was found particularly useful as addition tool for proximal and distal vessels control, clip positioning, and complete neck obliteration small perforator arteries

Outcome of operated patients

GOS of 4-5 points was rated in 9 pts (69%) at eight weeks after surgery. Complications such as temporary ischemia were established in 2 patients (15%). A postoperative hydrocephalus diagnosed in 2 pts (15%), treated with ventricular-peritoneal shunting. Death due to therapeutic resistant vasospasm occurred in 1 case (8%). The long-term follow-up was between 3 months and four years. At the 6-month follow-up examination, GOS 4-5 was established in 90% of patients. One patient died three months after surgical treatment due to pulmonary thromboembolism.

Discussion

At present times, intraoperative neuronavigation and image guidance are an indispensable part of modern neurosurgery with a significant impact on the improved patients outcome [4, 7, 10, 18, 19, 25, 27]. During the last two decades, this combined technique revolutionized neurosurgery, giving neurosurgeons the precision needed in performing state-of-the-art surgery of neurovascular, skull-base, and also neuro-oncological lesions.

The use of IOUS is a well-established method for the treatment of intrinsic brain tumors, metastases and brain arteriovenous malformations [7, 10]. Moreover the integration of 3D ultrasound with neuronavigation technology created an efficient and inexpensive tool for intra-operative imaging in neurosurgery during the last few years [7, 10, 18, 24, 25, 27].

Recent studies have advocated intraoperative angiography both for assessment of vessel patency and for residual aneurysm [1, 2, 5, 16]. Angiography demonstrates unexpected vessel compromise in approximately 10% of cases [2, 5, 16] but has several disadvantages. Despite advances in technique, intraoperative angiography is still an invasive procedure not entirely free of risk with significant morbidity rates ranging from 0.4 to 1.5% [1, 2, 5, 16]. Therefore, intraoperative DSA is restricted to experienced high volume cerebrovascular centers.

In comparison to DSA, ICG Angiography is a technique to visualize blood flow in the cerebral vasculature after intravenous injection of ICG dye. According to the study of Fisher et, al. [8] ICG-Video Angiography (ICG-VA) provides an excellent evaluation of complete aneurysm occlusion, neck remnants and flow in the parent and branching vessels. Moreover, ICG-VA showed particular advantages in the assessment of perforating vessels [6, 21]. However, there are some disadvantages noted in the usage of ICG-VA – the presence of blood clots, intramural thrombi, or calcifications may limit the intraoperative evaluation with ICG-VA [8]. In acute cases with coagulation disorders and constant micro bleeding, dye effusion makes an assessment of the vessels of interest impossible.

In contrast to ICG-VA, according to our findings the use of IOUS was especially useful in assessing the calcifications, intraluminal thrombi and blood flow in the aneurysms. It is consistent with the finding of other authors [12, 22]. In all our cases, IOUS aided in the intraoperative visualization of the aneurysm blood flow within its body, identification of the aneurysm thrombosed part, blood flow within the aneurysm sac before and after clipping. This technique coupled with neuronavigation data provided useful information about aneurysm localization, its wall thickness, blood flow characteristics and facilitated clip application. Power Doppler was used in all cases because its increased sensitivity to flow, where optimal angles with conventional Doppler sonography could not obtain. The use of power Doppler helped differentiate the flow in the aneurysms.

One disadvantage of the method is that IOUS did not provide sufficient data for the proximal and distal blood-flow. In the present series, this was accomplished in 4 out of 13 patients only. It was due to the diameter of the transducers – between 15-35 mm which was sufficient to provide data for the lesion itself (wall thickness, thrombosis, calcification, blood flow before and after clipping). As others have suggested Duplex sonography has limited ability to identify small aneurysms, because it depends on the presence of an echogenic lesion, such as the thick wall of a large aneurysm [22].

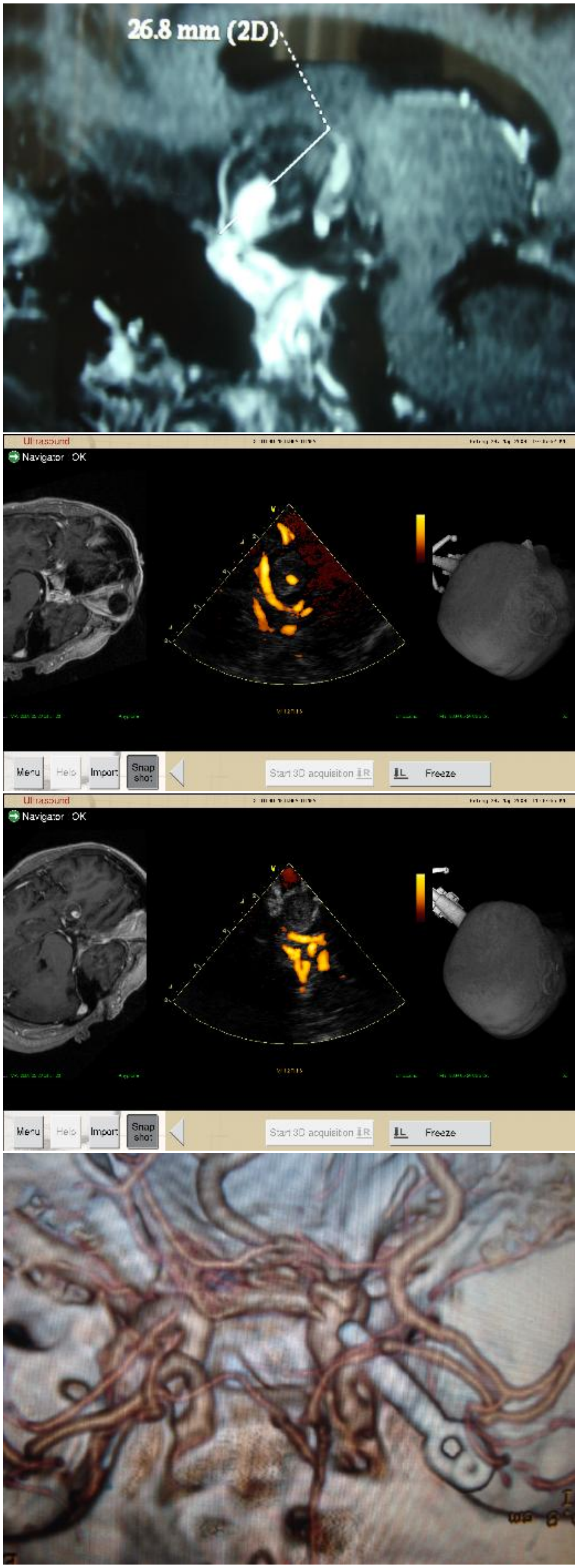
According to the literature, MVD could be especially useful in such situations [8] The endoscopic inspection was found to be a safe and useful technique complementing the information provided by the IOUS.

Endoscopic enhancement of the visual field supplied by the endoscope before, during and after microsurgical aneurysm occlusion was used to gain additional topographic information regarding the perforating vessels, clips position, complete aneurysms occlusion and compromise of involved vessels as noted by other authors [9, 17, 23]

Conclusion

Our results suggest that IOUS is a reliable tool for blood flow evaluation particularly in large and giant aneurysms, as well as presence intraluminal thrombosis and calcifications in the aneurysm wall. This information facilitates a more secure microsurgical dissection around the aneurysmal wall and its neck and in some situations gives additional data for needed for clip repositioning.

Figure.3: A 65 years' old man with aneurysm of the right ICA bifurcation, diagnosed with CTA after a seizure. The intraopera-



tive neuronavigation coupled with duplex sonography showed thick walls on a B- mode and poor filling on color Doppler. Note the aneurysm filling before and after clipping. The aneurysm was clipped and excised. Abbreviations: ICA –internal carotid artery; CT – Computed Tomography Angiography.

In some cases, the utilization of duplex sonography can establish the intraoperative diagnosis of the lesion, which may misdiagnose on the preoperative imaging studies, and could prevent inadvertent intraoperative complications. The combination of MRI neuronavigation coupled with IOUS and endoscopy provides additional information, which could aid in the management of these complex vascular lesions.

Authors' Statements

Competing Interests

The authors declare no conflict of interest.

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