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ICA Bifurcation Aneurysms: Clinical Features and Surgical Outcome in a Tertiary Referral Center in South India

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ABSTRACT

AIM: To study the clinical profile, imaging features, intra-operative findings, post-operative outcome at discharge and at 6 months in patients with internal carotid artery (ICA) bifurcation aneurysm.

MATERIAL and METHODS: Present study is a retrospective analysis of data of patients who underwent surgery for ICA bifurcation aneurysm between the period of 1st January 2011 to 31st December 2015 at our institute. Demographic variable, clinical grade, radiological finding was assessed. Outcome was measured using modified Rankin score (mRs) at discharge and at 6 months follow up. All ICA bifurcation aneurysms were clipped using a standard pterional craniotomy.

RESULTS: A total of 28 patients were included in the study out of which 4 had bilateral ICA bifurcation aneurysms. Mean age was 44.15 (age range 14-65) years, with 43.75% of patient were <40yrs. Multiple aneurysms were seen in 11 (39.28%) patients, with superior projection being the most common in 53.12%. Vasospasm was seen in 12 (42.85%) with 4 patients undergoing chemical angioplasty. At discharge good outcome (mRs <3) was seen in 4/5 (80%) patients in the un-bled category, whereas 18/23 (78.2%) in bled category. At 6 months follow up, mRs <3 was seen 4 (100%) patients in unbled category, and 84.21% (16 of 19) patients in bled group.

CONCLUSION: The findings of the present study have shown an increased incidence of bilaterality and multiplicity for ICA bifurcation aneurysms. The direction of the dome of aneurysm and temporary clipping do not affect the treatment outcomes. These aneurysms have excellent outcomes following surgery.

KEYWORDS: Intracranial aneurysm, Internal carotid artery, ICA bifurcation, Outcome, Surgery, Vasospasm

INTRODUCTION

Aneurysms of the internal carotid artery (ICA) bifurcation are not very common. The incidence among adults accounts up-to 5% of all intracranial aneurysms. (1,5,25). ICA bifurcation aneurysms accounts for almost 40% of all intracranial aneurysms in patients <20 years (11), and also have an increased tendency to bleed (14). These aneurysms tend to be more common in males in comparison to the other aneurysms of the ICA (2). The micro-neurosurgical exposure and clipping of ICA bifurcation aneurysms can be demanding due toneed for deep retraction to achieve good exposure (17), high position of the aneurysm with respect to the skull base, attachment of the dome to the surrounding brain parenchyma, and large number of perforators surrounding the base and/or the dome. The orientation of the aneurysm dome affects the clipping, with the posterior orientation being the most difficult. Precise dissection in the 3D anatomy of ICA bifurcation and the surrounding perforators requires not only experience and microsurgical skill but also the patience to work on the aneurysm base under the repeated protection of temporary and pilot clips (15). We present our experience with 32 ICA bifurcation aneurysms.

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The objective of the present research is to evaluate the clinical profile, imaging features, intra-operative findings, post-operative outcome at discharge and at 6 months in patients who underwent surgery for ICA bifurcation aneurysm.

MATERIAL and METHODS

The present study is a retrospective analysis of data of patients who underwent surgery for ICA bifurcation aneurysmal (bleed or unbleed) between the period of 1st January 2011 to 31st December 2015 at our institute. Demographic variable, symptoms, clinical grade [World Federation of Neurosurgical Socities (WFNS) grade], radiological findings like Fischer's grade, projection of the dome, size of the aneurysm, intraoperative findings like temporary clipping, intra-operative rupture were all considered. Outcome was measured using modified Rankin score (mRs) at discharge and at 6 months follow up. All ICA bifurcation aneurysms were clipped using a standard pterional craniotomy.

RESULTS

A total of 28 patients were included in the study out of which 4 had bilateral ICA bifurcation aneurysms (total of 32 aneurysms), of which 20 (62.5%) were present on the left side. 23 (82.1%) aneurysms presented as a ruptured aneurysm of which 22 (95.6%) were WFNS grade I. Twenty nine aneurysms were surgically managed. In 3 aneurysms no active intervention was done during the study period. No patients suffered re-bleed before surgery. Mean age was 44.15 (age range 14-65) years, with 43.75% of patients less than 40 years and 15 patients (53.57%) were male. All patient presented with headache. The other initial presentations include altered sensorium in 13 patients (46.4%), limb weakness in 2 patients (7.1%), memory loss in 2 (7.1%) patients (Table I).

Most common modified Fisher's grade was grade II, seen in 9/23 (39.1%) patients. Intraparenchymal bleed was present in 5/23 (21.7%) patients, and hydrocephalous was seen in 8/28 (28.5%) patients. Multiple aneurysms were seen in 11 (39.28%) patients. Of the total no of aneurysms, based on size aneurysms,43.75% were small (<5 mm), 46.87% medium (5-15 mm), 3.1% large (15-25 mm) and giant (>25 mm) aneurysms were seen in 6.2%, and with regard to projection, most common projection of the dome was superior (Figure 1) in 17 (53.12%) followed by anterior (Figure 2) in 10 (31.2%), and posterior (Figure 3) in 5 (15.62%) (Table II). Twenty four (75%) aneurysms were clipped, whereas in 5 (15.62%) aneurysms, clipping along with wrapping was done. Six patients had intra-operative rupture, and 16 patients underwent temporary clipping with mean duration of 3 minutes and 2 seconds.

Vasospasm was seen in 12 (42.85%) patients, with motor deficit in 7 (25%) of patients, among which 4 (33.33%) patients underwent chemical angioplasty, 1 patient underwent decompressive hemicraniectomy for post-operative infract, and another one underwent re-exploration and mastoid waxing for CSF rhinorrhoea,1 (3.5%) patient died (Table III).

Good outcome (mRs≤3) was seen in 4/5 (80%) patients in unbleed category, whereas 18/23 (78.3%) in bleed category. Five (83.3%) out of 6 patients in grade III, 3 (50%) out of 6 patients in grade IV had good outcome. However, these differences were not statistically significant (p=0.312) (Table IV). Favourable outcome was seen 7 of 11 (63.6%) of patient

Table I: Demographic Variables

Variable		n (%)
Age (years)	10-19	1 (3.5)
	20-29	3 (10.7)
	30-39	9 (32.1)
	40-49	6 (21.4)
	50-59	3 (10.7)
	>60	6 (21.4)
Sex	Male	15 (53.5)
	Female	13 (46.4)
Clinical grade (n=23)	WFNS Gr I	22 (95.6)
	WFNS Gr II	-
	WFNS Gr III	1 (4.3)
	WFNS Gr IV	-
TOB (n=23)	< 3 days	9 (39.1)
	> 3 days	14 (60.8)

***TOB:** Time of bleed, **WFNS:** World Federation of Neurosurgical Socities.*

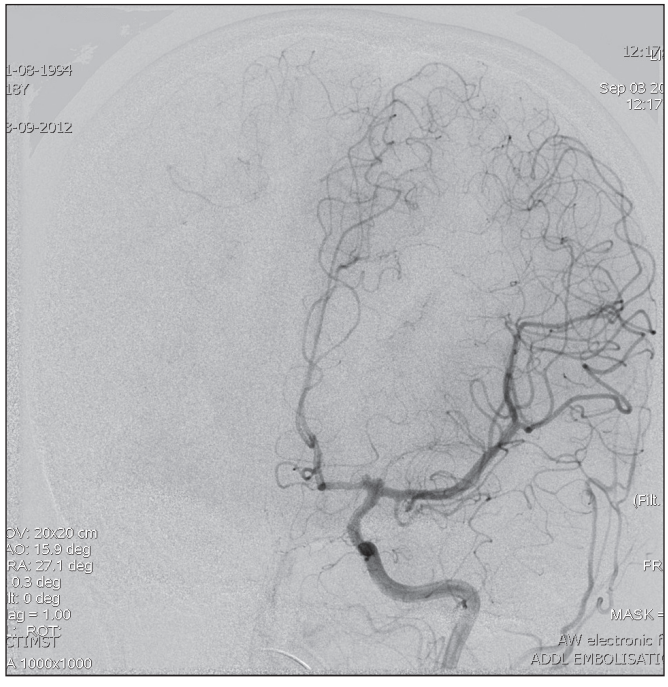

Figure 1: Digital subtraction angiography of left internal carotid artery shows a small bilobuled superiorly directed ICA bifurcation aneurysm.

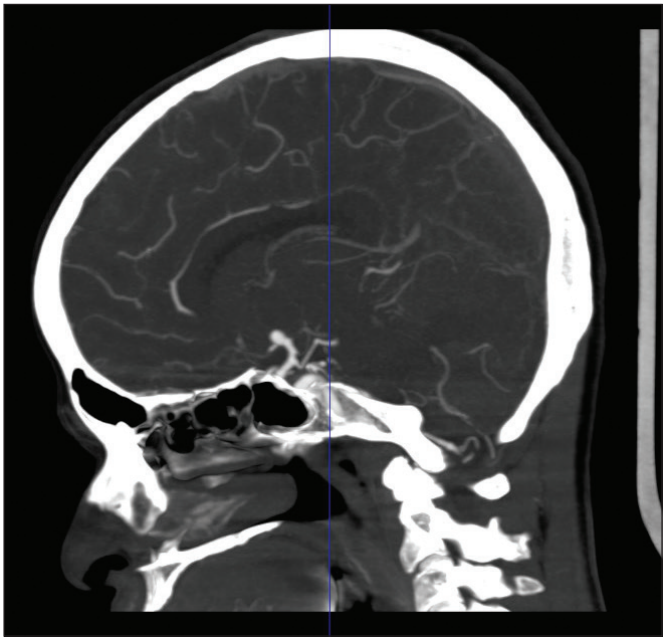

Figure 2: Computed tomographic angiography shows a small saccular aneurysm with the dome directed anteriorly.

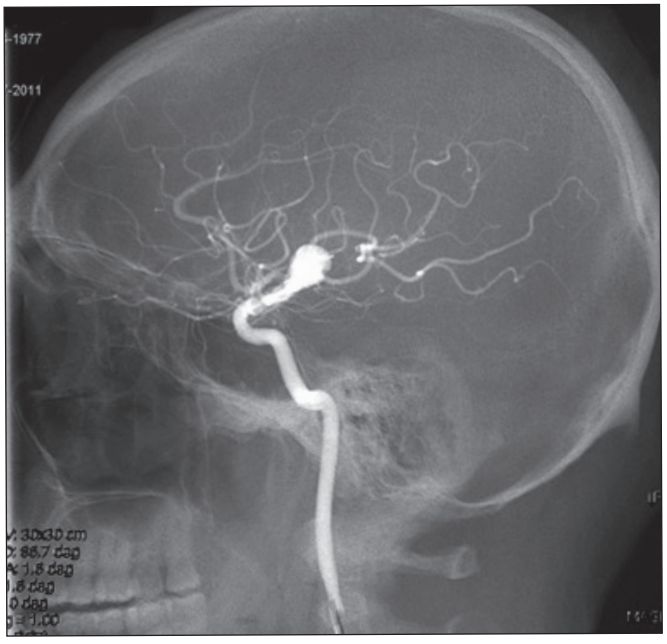

Figure 3: Digital subtraction angiography of the internal carotid artery shows a saccular ICA bifurcation aneurysm with the dome directed posteriorly.

Table II: Radiological Findings

Variable		n (%)
Aneurysmal Hemorrhage	Yes	23 (82.14)
	No	5 (17.8)
Modified Fischer's Grade (n=23)	I	2 (8.6)
	II	9 (39.1)
	III	6 (26)
	IV	6 (26)
Hydrocephalous	Yes	8 (28.57)
Multiple aneurysms	Yes	11 (39.28)
Fundus direction (n=32)	Superior	17 (53.12)
	Anterior	10 (31.2)
	Posterior	5 (15.62)
Size (n=32)	Small	14 (43.7)
	Medium	15 (46.87)
	Large	1 (3.1)
	Giant	2 (6.2)

Table III: Outcome of the Patients with ICA Bifurcation Aneurysms

	Discharge n (%) (n=28)	At 6 months follow-up n (%) (n=23)
Vasospasm	6/23 (26)	-
Good outcome (mRs ≤3)	Unbleed	4/5 (80)
	Bleed	18/23 (78.3)
mRs Grade		
0	14 (50)	20 (86.9)
I	4 (14.2)	-
II	3 (10.7)	-
III	1 (3.5)	-
IV	4 (12.5)	3 (13)
V	1 (3.5)	-
VI	1 (3.5)	-
Lost to follow up	-	4

with multiple aneurysms, and 11 (64.7%) out of 17 patients with superior projection, these findings were also not statistically significant (p=0.10) (Table V). Poor outcome was seen in 1 (100%) and 1 of 2 (50%) patients with large and giant aneurysms respectively, and this finding was statistically significant (p<0.05) (Table VI).

At six months 4 patients were lost to follow up (3 in bled and 1 in un-bled group). Good outcome was seenin 4 (100%) patients in un-bled category, and 89.47% (17 of 19) patients in bled group. The outcome at discharge in the present study was not statistically significant with regard to Fischer's grade, direction of the dome of the aneurysm (p=0.10), multiple aneurysm (p= 0.57), temporary clipping (p=1.0), or intra-operative rupture of aneurysm (p=0.59). Only statistically significant finding was the size of the aneurysm and outcome at discharge and at 6 month follow-up time point (Table VI).

Table IV: Association Between Fisher's Grade and Outcome

Modified Fisher's Grade	mRS at discharge (n=23)		Fisher-Freeman-Halton Exact Test	mRS at 6 months (n=19)		Fisher-Freeman-Halton Exact Test
	≤3	>3	p-value	≤3	>3	p
I	2	0		2	0	
II	8	1		8	1	
III	5	1	0.312	4	1	0.814
IV	3	3		2	1	
Total	18	5		16	3	

Table V: Association Between Direction of Dome of Aneurysm and Outcome

Direction of dome of aneurysm	mRS at discharge (n=28)		Fisher-Freeman-Halton Exact Test	mRS at 6 months (n=23)		Fisher-Freeman-Halton Exact Test
	≤3	>3	p-value	≤3	>3	p
Anterior	6	0		4	0	
Posterior	5	0	0.10	5	0	0.537
Superior	11	6		11	3	
Total	22	6		20	3	

mRs: *Modified Rankin score.*

Table VI: Association Between Size of the Aneurysm and Outcome

Size of the aneurysm	mRS at discharge (n=28)		Fisher-Freeman-Halton Exact Test	mRS at 6 months (n=23)		Fisher-Freeman-Halton Exact Test
	≤3	>3	p	≤3	>3	p
<5mm	7	3		6	2	
5-15mm	14	1		13	0	
15-25mm	0	1	0.051	0	1	**0.043**
>25mm	1	1		1	0	
Total	22	6		20	3	

mRs: *Modified Rankin score.*

DISCUSSION

Since Dott first successfully operated an ICA bifurcation aneurysm, by wrapping a muscle patch in a 53-year-old male patient in 1933 (3), ICA bifurcation aneurysms have been treated by many. More than forty series have been reported since1933 (17).

In the present study the age range of the patients were between 14 – 65, and the mean age of patients was 43.075 years. 12 (43.7%) patients were aged <40 years, out of which 6 (21.42%) patients were less than 30 years of age. As per the literature the mean age of presentation of patient with ruptured ICA bifurcation aneurysm is 41 years (9,12,22). Average age of 31.5 was observed in the manuscript published by Gupta et al. (7), and ascending trend was seen in other studies (6,17). In our study, male to female to ratio was almost equal [1:1.05], and this finding is similar to Miyazawa et al. (17). Some studies in the literature have reported male dominance (2,8,10,19), while some reported female dominance (6,7,12).

The incidence of bilateral aneurysm in the present study was seen in 14.28%, whereas multiple aneurysm in 39.28% of patients. Miyazawa et al. reported 3 of 25 cases with bilateral ICA bifurcation aneurysms (12%), almost same to the results of the present study, whereas Gupta et al. published the incidence of only 2.9% (7). As per the literature, the incidence of the multiple aneurysms in the case of ICA bifurcation aneurysm is 30%, which is higher compared to other site of the aneurysms (17). Compared to our study, similar incidence of multiple aneurysms was seen in other studies (9,17). In contrast, Suzuki reported no multiple aneurysms in their ICA bifurcation aneurysm series (23), and lower incidence was reported in few studies (2,7,13), and higher incidence 53% was reported by Kwon et al (12).

Multiple classifications are given in the literature for ICA bifurcation aneurysms (2,8,19,20). In the present study, we classified ICA bifurcation aneurysms based on the classification followed by Miyazawa et al. – superior projection (projecting upward), anterior, and posterior (projecting downward backward) (17). In present series, superiorly projecting aneurysm was most common, followed by anteriorly projecting aneurysms whereas the least common was posteriorly projecting aneurysm. As per the literature, also superior projecting aneurysms are most common at 54.4%, and the least common is anteriorly projected aneurysm (only 5.3%) (2,8,10,14,21,22). Gupta et al. reported 67.3% superiorly and 20% anteriorly projecting ICA bifurcation aneurysms (7), whereas Miyazawa et al. demonstrated 48% superiorly and 28% anteriorly projecting aneursysms (17). In the present study, the rate of anterior projection was higher when compared to previous studies. From the surgical strategy point to know the projection of the aneurysm prior to surgery is important (2,13,18). Posteriorly projecting aneurysm are of utmost challenging ICA bifurcation aneurysms. The perforator density is high, hence there is an increased risk for perforator injury. Dome of the aneurysm is partially obstructed by the ICA, which obstructs the proper visualization of the perforators. While clipping, an aneurysm remnant may be easily missed at the dead angle behind the ICA trunk.

In the present study, 6 (21.4%) patients had intra-operative rupture, and in 16 (57.14%) patients, temporary clip was applied during aneurysm dissection. There was no significant difference in the outcome between the two groups where temporary clip was used and not used (p=1.000). Miyazawa et al. did not find any statistical significance between the outcomes of the patients and the application of temporary clip (17). In Kwon et al.'s study, intraoperative aneurysmal rupture occurred in 5.8% of cases, and temporary clipping was used in 41.17% of cases (12), whereas all patients underwent temporary clipping with mean duration of 5.4 minutes without intraoperative complications in another study (6). The above two authors did not evaluate the relation between the temporary clipping and outcome. Temporary clipping is applied in cases of premature rupture and difficult aneurysmal dissection. Da Pian et al. considered that there was no need to place temporary clips on the parent vessel under deep hypotension (2), and Reynier et al. commented that hypotension was useful even for large aneurysms with no need for temporary clipping (21). In our series deep hypotension was not used for any patients.

The incidence of vasospasm in present study was 42.85% (12 patients) among which 4 patients underwent chemical angioplasty. Gupta et al. reported vasospasm in 24 patients (43.6%), and there was no statistically significant correlation between the vasospasm and outcome (7). Main causative factor for unfavourable outcomes is considered to be vasospasm (2,6,8,21), but perforator damage can also cause poor outcome (8,13). Kodama et al. reported post-operative deterioration and poor outcome in four cases (13%), due to vasospasm and concluded that since the incidence of pre- and post-operative vasospasm exceeded 60%, control of vasospasm is imperative for the management of these aneurysms (10). In contrast, Yasargil et al. in his study found no correlation between vasospasm, neurological deficit, and the surgical results (27), and the outcome in patients was related to the clinical grade (26). In our series, unfavourable outcomes were due to poor clinical grade, size and vasospasm.

In the present study, modified Fisher's grade IV was seen in 26% of patients (6/23 patients), among which 3 patient had poor outcome, with vegetative state and mortality in 3.5% each (1 patient). The modified Fisher's grade was not found to be statistically significant with regard to outcome. Da Pian et al. reported mortality in 1 (4.76%) patient, due to vasospasm and good recovery in one (4.76%) patient in Grade IV (2). Yasargil demostrated good outcome in patients with clinical Grades III and IV, and only two (3.6%) mortalities within the same group (26). Kodama et al. and Ohno et al. also reported good results in patients with clinical grade IV (10,18). Kashiwagi et al. reported poor outcome in three (17.64%) patients with clinical Grade IV among their 17 patients (8). Miyazawa et al. series of 25 patients, 71.1% (five) patient among the poor clinical grade (grade IV) had unfavourable outcomes, with a significant difference in favourable outcomes between patients in Grades I and II, and those in Grades III and IV. High clinical grade is a factor of unfavourable outcome (17).

Mortality was seen in one patient (3.5%) in our series, was probably due to poor clinical grade and primary brain injury due to SAH. As per the literature mortality rate for carotid ligation was 41%, and that of conservative therapy was 43% (16). Until 1968, the treatment of choice was carotid ligation for ICA bifurcation aneurysms, although further bleeding following the carotid ligation was observed and the mortality remained high (4,16,20,24). Before microsurgery was introduced, mean mortality rate was 26.7% (17), in few studies, reaching as high as 30-40% (16,19), but since then mortality rate has been around 3-5% (2,10,26). Contrary to the literature, Gupta et al. reported a mortality rate of 11.4% (7).

The present study is a retrospective study and is limited by its inherent drawbacks. Another drawback of the study is the small sample size. Overall we are comfortable with the reliability of the information that we were able to extract from the medical records, and took care to note when specific data were insufficient. Probably there was also an element of referral bias. Only large prospective studies can overcome these weaknesses.

CONCLUSION

Bilateral and multiple aneurysms are more commonly associated with ICA bifurcation aneurysms. ICA bifurcation aneurysms are technically difficult. Direction of the dome of aneurysm and temporary clipping do not affect the outcome. They have excellent outcome even after rupture and in incidentally detected aneurysms with microsurgical technique and aggressive management of vasospasm.

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