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Author

Original Research PaperNeurosurgeryRETROSPECTIVE ANALYSIS OF SUBARACHANOID HEMORRHAGE (SAH) AND
RUPTURED CEREBRAL ANEURYSM ON DIGITAL SUBSTRACTION
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ABSTRACT

Objective: To review the epidemiology and characteristics of subarachnoid haemorrhage (SAH) and

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sporadic ruptured cerebral aneurysm in eastern Indian population.

Method: This is a retrospective study of consecutive 206 East Indian patients between January 2012 and February 2014, who were admitted to Bangur Institute of Neurosciences (BIN), IPGMER and SSKM hospital, Kolkata, India, for spontaneous SAH with or without rupture of cerebral artery aneurysm. DSA was performed and analysed in detail. The gender and age characteristics were determined. Patient with aneurysm were classified in two broad groups i.e. single aneurysm and multiple aneurysm group and analysed.

Results: In total SAHs, there were 118 females and 88 males, whereas in aneurysmal SAH, there were 72 females and 40 males. For males aneurysm rupture was most common during 5^{th} decade whereas in females its 6^{th} decade. Ruptured aneurysms were mostly of 2-5 mm in size (59%). The mean ruptured aneurysm size was 7.13 mm for males, and 5.98 mm for females which was not significant statistically. Ruptured single cerebral aneurysm occurred in anterior circulation in 91% of the cases. Ruptured aneurysm most commonly occurred at anterior communicating artery (30.4%) . 23 cases (21% of all aneurysm patients) had multiple aneurysm which was common in females .

Conclusion: This study can be used as an effective tool for predicting and planning treatment of aneurysmal SAH in East Indian patients or by large, Indian patients as detailed characteristics of each arterial segmental aneurysm has been studied.

KEYWORDS : SAH, DSA, Aneurysm

INTRODUCTION

Ruptured cerebral aneurysm is the most common cause of subarachnoid hemorrhage (SAH), causing significant morbidity and mortality. The overall incidence of aneurysmal SAH is approximately 9-10.5/100,000 population/year.^{10,49} Finland and Japan have the highest incidence of SAH in the world, with rates between 15.1 and 29.8 per 100,000 population per year, 10,20,37,68 whereas the rates have been documented to be as low as 2.2 per 100,000 population/year in Dijon, France,²² and about 2 per 100,000 population/ year in China.³⁷ The incidence of SAH in India has not been evaluated by population-based studies in detail, although it had been reported to be lower around 3-4 per 100,000 from hospitalbased data.⁵ Unlike Caucasian and Japanese populations⁸⁻¹⁹, few studies describing the epidemiology of cerebral aneurysm in the Indian population have been published⁵. The purpose of this study is to review the epidemiology of sporadic ruptured cerebral aneurysm, in terms of size, location, the prevalence of multiple cerebral aneurysms, and cerebral aneurysm's gender difference in east Indian population. Reliable knowledge about the risks of cerebral aneurysm will help in planning, screening and prevention strategies and in predicting the prognosis of the general population and of the individual patients.

MATERIAL AND METHODS:

This is a retrospective study of consecutive 206 east Indian patients with SAH who underwent DSA between January 2012 and March 2014, who were admitted to the Bangur institute of Neurosciences and SSKM and IPGMER, Kolkata, which is a tertiary referral center of neurological diseases in eastern India. The data used in this study was retreated from the medical records of the hospital. The ethical board of the IPGMER and SSKM Hospital of WBUHS approved this retrospective analysis, and informed consent was waived. The patients included 88 males and 118 females, with mean age of 47.23 (53.85) yrs (SD: 11.56 yrs, range: 16–76 yr). SAH was initially diagnosed by brain computed tomography, and digital subtraction angiography (DSA) was followed and SAH was confirmed to be due to cerebral aneurysm. In all the patients, the size of the aneurysms was measured by a neurosurgeon and neuroradiologist at the time of diagnosis, and we used the measurement as reported. The measurement of the dome, neck and height of the aneurysm was done using 3D images acquired in the system (Philips Xper CT 20:20) and dome diameter is being considered for size comparisons of all aneurysms. Patient with ruptured cerebral aneurysms were divided in two broad groups i.e. single aneurysm group and multiple aneurysm group and each group was analysed separately. 5 male and 18 female patients had multiple aneurysms present, and the specific aneurysm responsible for the rupture could not be reliably determined.

RESULTS:

1. Gender characteristics in ruptured cerebral aneurysm patients

The total 206 patients of SAH had 88 males and 118 females, with a male ratio of 0.74:1, indicating overall females had a higher SAH rate and 109 patients out of all SAH patients had aneurysms with 37 male and 72 female patients with ratio of 0.51:1 (p<0.0001, Table 1.) The male/female ratio was 0.82:! for patients younger than 40 yrs, and increases to 1.25:1 for patients younger than 35 yrs (p<0.05), indicating in younger patients males had a higher cerebral aneurysm rupture incidence than females (Table 1).

Table	1. Female	male	ratio	in	ruptured	cerebral	aneury	sm
patie	nts							

		SA	Η		ANEURYSMS				
	MALE	FEMA	RATIO	Р	MALE	FEMA	RATIO	Р	
		LE	(M:F)			LE	(M:F)		
TOTAL PATIENTS	88	118	0.74:1	<0.05	37	72	0.55:1	< 0.05	

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								-
PATIENTS	24	32	0.75:1	>0.05	14	17	0.82:1	>0.05
< 41								
YEARS								
PATIENTS	11	7	1.57:1	>0.05	10	7	1.25:1	>0.05
< 35								
YEARS								

2. Age characteristics in ruptured cerebral aneurysm patients

The age distribution of the total 206 patients is shown in Figure 1. For males, aneurysm rupture was most common in the age group of 41–50 yrs i.e. 5th decade whereas in females it was in the age group of 51 – 60 years i.e. 6th decade. There were subjects who suffered ruptured aneurysm before the age of 30 yrs (n = 8) and before the age of 20 yrs (n = 2). The mean age of male patients was significantly lower than that of female patients (42.91±10.9 yrs vs 48.45±10.8 yrs, p < 0.013). (Figure 1)



Figure 1. Age characteristics in the ruptured cerebral aneurysm patients. A: age distribution for all 206 patients; B: age distribution for 37 male patients; C: age distribution for 72 female patients.

3. Size characteristics in ruptured *single* cerebral aneurysm patients

The size distribution of ruptured single cerebral aneurysm patients (group 1, total = 86) was: >25 mm: 0 aneurysms (0%); >20 mm: 1 aneurysms (1.16%); >10 mm: 10 aneurysms (11.62%); >5mm: 28 aneurysms (32.55%); >2 mm: 45 aneurysms (52.32%); and ≤ 2 mm: 2 aneurysms (2.32%). The mean ruptured aneurysm size was 6.40 mm, with 7.13 mm (median 5.15 mm) for males, and 5.98 mm (median 4.96 mm) for females. There was no significant difference in ruptured aneurysm size between males and females (p > 0.05). Ruptured aneurysms were most likely in the region of 2 mm-5 mm (53.73%), followed by 5 mm-10 mm (31.34%).

No patient in this study had ruptured cerebral aneurysm sized less than 2 mm. The trend that males had a larger aneurysm size than females was seen in younger subjects. In female subjects, a trend of smaller ruptured aneurysm in younger subjects was seen, while this trend was not observed in males. (Table 2)

Table 2. Size of ruptured single cerebral aneurysm for male and female patients at different age groups

MEAN AVERAGE ALL PATIENT 6.40 Median 4.81 SD 4.2									
Mean size	(median, DS)	Mean size	Р						
Male total	Mean 7.13,	Female total	Mean 5.98	0.21					
(n=32)	(n=32) (Median 5.15,		(Median 4.96						
	SD 5.32)		SD 3.03)						
$Male \le 41$	Mean 7.93,	Female ≤ 41	Mean 5.61	0.26					
years	(Median 5.03	years (n=12)	(Median 4.56						
(n=12)	SD 6.61)		SD 2.43)						
$Male \le 35$	Mean 8.47	Female ≤ 35	Mean 5.45	0.23					
years	(Median 5.03	years (n=7)	(Median 4.92						
(n=10)	SD 7.14)		SD 1.96)						

4. Location of ruptured single cerebral aneurysms The analysis of location of ruptured cerebral aneurysms included all patients (n = 112). Ruptured single cerebral aneurysm occurred in anterior circulation in 91.3% of the cases, while 8.7% occurred in posterior circulation . Ruptured aneurysms most commonly occurred in anterior communicating artery (ACOMA, 30.4%) and internal carotid artery (ICA, 24%). There were more cases of AcoA aneurysm rupture before the age of 50 than PcoA aneurysm rupture (23:4), while there were more cases of PcoA aneurysm rupture after the age of 50 than AcoA aneurysm rupture (15:9). (Table 3)

Anterior ICA		ACA	MC	CA	ACOM	PCO	M	DAG	CA	Subtot
circulation										αl
< 41	6	5	2		7	1		1		22
41 – 50	5	3	9		11	1		1		30
51-60	7	2	3		4	7		0		23
61 – 70	1	0	1		1	0		0		3
> 71	0	0	0		1	0		0		1
Subtotal	19	10	15		24	9		2		79
Posterior	Basilar	Vertebral	PCA		PICA	Subtotal				
circulation A		A								
Subtotal	Subtotal 4		0		3	7				86
Posterior	Ba	silar A	V	er	tebral	A PC	{ PI	CA	Su	ıbtotal
circulation	(trunk	and top))							
< 41		1		0		0		1		2
41 - 50	2			0		0		1		3
51-60		1			0	0		0		1
61 – 70		0		0		0		1		1
> 71		0		0		0		0		0
Subtotal		4			0	0		3		7

Table 3. Location of ruptured *single* cerebral aneurysms.

The mean dome size of ruptured single cerebral aneurysm at different arteries is shown in Table 4. The aneurysms at DACA tended to have a smaller size, followed by aneurysms at anterior cerebral artery (Table 4).

Table 4. Size of ruptured single intracranial aneurysm at different arteries.

ANTERIOR	ICA	ACA	MCA	ACOM	PCOM	DACA
CIRCULATION						
MEAN SIZE	7.49	4.02	8.34	5.02	7.66	4.17
(±SD) MM	(±5.74)	(±1.36)	(±4.68)	(± 2.01)	(± 4.21)	(±1.17)
POSTERIOR	BASILAR	VERTEBR	PCA	PICA		
CIRCULATION		AL				
MEAN SIZE	4.05	0	0	3.9		
(±SD) MM	(± 2.84)			(± 0.34)		

4. Characteristics of multiple cerebral aneurysms

In the total 109 patients, 23 cases (21.1%) had multiple aneurysms, with 5 (5/40, 12.5%) in male patients and 18 (18/72, 25%) in female patients. There was a significant difference of multiple aneurysms prevalence in males and females (p <0.05). In these 23 patients, 18 patients (78.26%) had two aneurysms; the remaining 5 patients (21.73%) had more than two aneurysms. The mean age of single aneurysm patients (mean age = 45.47 ±11.30) was slightly younger and statistically significant than those with multiple aneurysms (mean age = 50.86±10.01, p= 0.040). The site of incidence of multiple aneurysms is shown in Table 5. Multiple aneurysms occurred in anterior circulation in 94% cases, and in posterior circulation in 6% cases. Multiple aneurysm most commonly occurred in AcoA (32%), followed by internal carotid artery (24%) and medial cerebral artery (22%).**(Table 5)**

Table 5. Location of multiple aneurysms.

Tuble 0. Decution of multiple uncur ysins.										
ANTERIOR	ICA	ACA	MCA	AC	PC	DĀ	SUBTO			
CIRCULATION				OM	OM	CA	TAL			
MALES	4	1	0	5	0	0	10			
FEMALES	8	1	11	11	5	1	37			

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SUBTOTAL	12	2	11	16	5	1	47
POSTERIOR	BASILA	VERTE	PCA	PICA			
CIRCULATION	R	BRAL					
MALES	1	0	0	0			1
FEMALES	1	0	1	0			2
SUBTOTAL	2	0	1	0			3
MIRRORED	ICA	MCA	ACA	AC	PC	PCA	
ANEURYSM				OMA	OMA		
MALES							
FEMALES	1 54YR	1 73YR		1 56YR	1 66YR		
SUBTOTAL							

Of the multiple aneurysm cases, 4 cases had mirror aneurysms (17.39% out of the 23 cases with multiple aneurysms, and 1.9% out of the total 206 cases), where aneurysms distributed both on the right side and left side in a mirrored manner ¹⁶⁻¹⁸. With the cases of mirrored aneurysms, ICA, MCA, anterior communicating segment and posterior communicating artery each had one mirror aneurysm. There was a significant difference of incidence rate for mirror aneurysm as all cases were females (p < 0.05).

5. Location wise Characteristics of aneurysms 5.1. Internal Carotid artery (ICA) aneurysms:

22% of all aneurysms were seen in ICA. Among ICA aneurysms ophthalmic segment aneurysm (54%) was most common in our study. Among ophthalmic segment aneurysms left side and dorsal variant was most common. Among paraclinoid segment aneurysms right side and antero-lateral variant was common. Postero-superior directed aneurysm was commonest in distal carotid bifurcation segment. Females being common except at carotid bifurcation region.

5.2. Anterior cerebral artery (ACA) aneurysms:

11% of all aneurysms. A1-A2 junction being the common site with slightly male preponderance. 17% associated with multiple aneurysms. Superior orientation was found to be commonest.

5.3. Anterior communicating artery (AcoA) aneurysms:

28% of all aneurysms. M:F ratio 1:4. Anterior and superior orientations were found commonly. 39% were lobulated.

5.4. Middle cerebral artery (MCA) aneurysms:

20% of all aneurysms. Right side being commonly involved (72%) with M1 and M1 bifurcation being the commonest site. 33% were lobulated with superior and lateral orientations being the commonest.

5.5. Posterior cerebral artery (PCA) aneurysms:

Only 1 PCA aneurysm was seen in this study in a female patient on left side. P3 segment was involved and it was a fusiform aneurysm.

5.6. Posterior communicating artery (PcoA) aneurysm:

10% of all aneurysms. M:F ratio 1:4 posterorly and inferiorly directed aneurysms were common. 30% of PcoA aneurysms were found to be lobulated.

5.7. Basilar artery aneurysms:

4% of all aneurysms. Male being commonly affected. Basilar top aneurysm with superior orientation was commonest. Dysmorphic basilar top was seen in three patients.

5.8. Posterior inferior cerebellar artery (PICA) aneurysm and Vertebral artery aneurysm:

DISCUSSION

To our knowledge, this is the only study on the epidemiology of ruptured cerebral aneurysms in the eastern Indian population with SAH. No such comparable study in Indian population is being done but it can be compared to the Hong Kong study of

267 Chinese patients with SAH from ruptured cerebral aneurysms ²² and Chinese study 1256 Cases of Sporadic Ruptured Cerebral Aneurysm ³⁸. The patients in our series ranged in age from 16 to 76 yrs with a mean age of 47.23 (53.9) yrs, which is slightly younger than the mean age of 59 yrs reported by the Hong Kong study ²² , and 53.9 yrs for Chinese study [31] while older than the mean age of ruptured cerebral aneurysms (46 yrs) for Caucasian patients 26, 27. Weir et al reported that in a database of 945 patients, the average age of patients with ruptured aneurysms was 46 yrs ²⁶. In Aarhus et al's study, the median patient age was 50.9 yrs $^{\scriptscriptstyle 27}$. The same as the Hong Kong study 22, males presented with ruptured cerebral aneurysms at a younger mean age (51.6 yrs) than females (55.2 yrs). This observation has also been reported in Western literature. Aarhus et al 27 reported male patients were younger than female patients [48.2 yrs vs. 53.8 yrs]. A female predominance of patients with ruptured cerebral aneurysms has been reported in studies from the West¹⁵ [female to male ratio: 2.86:1], Japan²⁸ [female to male ratio: 1.46:1], and Taiwan²¹ [female to male ratio 1.47:1]. With the total 206 patients in our series, the female to male ratio was 1.8:1. However, our results showed with younger patients (\leq 30 yrs), there was a male predominance (Table 1). The Hong Kong study demonstrated a trend of larger ruptured aneurysms in men (mean size, 6.3 mm) than in women (mean size, 5.6 mm), however, statistical significance was not achieved.

This study demonstrated that males also had a slight larger aneurysm size (mean size, 7.13 mm) than females (mean size, 5.98 mm), again statistical significance was not achieved. Males had a larger aneurysm size than females in younger subjects without statistical significance (p>0.05 for subjects less than 35 year, Table 2).

Many series, including this study, demonstrated that the majority of ruptured aneurysms are less than 10 mm in diameter. In this series, 87.2% (75/86) of the patients had ruptured aneurysms sized ≤ 10 mm. 54.65% (47/86) of the patients in our series had ruptured aneurysms sized ≤ 5 mm. Previous study in the Chinese population demonstrated a proportion of 64% had aneurysms of size 5 mm or less²². This is different from the results in western and Japanese populations, where it was reported a lower proportion of ruptured caneurysms had a size of 5 mm or less^{13, 28-32}. Kassel and Torner analyzed 1092 patients with SAH and reported that 71% of the aneurysms were less than 10 mm in diameter and 13% were less than 5 mm in diameter, respectively³². For female subjects, trend of smaller ruptured aneurysms in younger subjects is seen in this study (Table 2).

While some studies classified PcoA as part of the posterior circulation³³, the PcoA connects the posterior and anterior cerebral circulations and almost all of the aneurysms that affect it arise at the anterior circulation end and such is usually considered part of the anterior circulation³⁴. In our study, we classified PcoA as part of the anterior circulation. A high proportion of ruptured aneurysms located in the AcoA and ICA, which is different to the pattern reported in western and Japanese populations where AcoA and PcoA are commonly involved^{13, 26, 28}. Such findings are also consistent with previous literatures from Hong Kong and Taiwan²⁰⁻²². Our data showed there were more cases of AcoA aneurysm rupture before the age of 50 than PcoA aneurysm rupture, while there were more cases of PcoA aneurysm rupture after the age of 50 than AcoA aneurysm rupture (Table 3).

The prevalence of multiple aneurysms in our series was 20.5314.57%. This is broadly similar to the previous report of 17% in Hong Kong population, 15% in Japanese population and 14.57% in Chinese population.^{22, 35, 31} Whilst some literature describing western populations reported this figure to be 30–40% ^{24, 36-38}. Some reports listed the risk factors of multiple

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aneurysms, including smoking, hypertension, and family history of cerebrovascular diseases 37, 38. In the Hong Kong series²², there was no significant difference in the incidence of multiple aneurysms between men and women, which is contrary to the general finding that female gender is a risk factor for multiple aneurysms^{36, 38}. The current study also showed more females had multiple aneurysms than males (Table 5), which was statistically significant. 'Mirror-like' aneurysm, which are located bilaterally on corresponding arteries, has been reported to constitute less than 5% of overall aneurysm 24 . 25 . In this series of ruptured cerebral aneurysms, 3.66% (4/109) had mirrored aneurysms and ICA, MCA, ACOMA and PcomA each had one mirror aneurys. This result is different from Meissner et al's report that the most common distribution for mirror aneurysms was the middle cerebral artery followed by noncavernous internal carotid artery23. It has been reported that the presence of a mirror aneurysm is not an independent predictor of future SAHs²³. The prevalence of giant aneurysms (sized >25 mm) in our series was not seen which is less than previous reports on Hong Kong Chinese (1%) and the Japanese population (1%)²² ²⁸, and substantially less than the figure of approximately 4% published in literature from the West¹³.

CONCLUSIONS:

This study indicates that in the eastern Indian population younger males has a higher cerebral aneurysm rupture incidence than females. Aneurysm rupture is most common during the age of 50-59 yr in the total population, and the mean age of male patients is younger than that of female patients. A high proportion of the ruptured aneurysms in our series have a size less than 5 mm.

Ruptured aneurysms most commonly occur in AcoA and PcoA. About fifteen percent of patients in our series have multiple aneurysms.

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