Original Article

Detection of Predictors of Hemorrhage in Patients with Cerebral Arteriovenous Malformation by Digital Subtraction Angiography

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Abstract:

Background: *Cerebral arteriovenous malformation (AVM) is a complex tangled of dilated blood vessels in which arteries flow directly into veins without capillaries. The main cause of death in patients with cerebral AVM is intraparenchymal hemorrhage. There are multiple imaging tools that can detect the predictors of hemorrhage in cerebralarteriovenous malformation. But nowadays digital subtraction angiography (DSA) is playing a wonderful role to detect these predictors.*

Objectives: *To detect the common predicting factors of hemorrhage from in brain by DSA.*

Methodology:This observational cross-sectional study was carried out in the department of Neurosurgery, Dhaka Medical College Hospital and study period was from October, 2014 to March, 2016. 76 patients of hemorrhagic stroke with clinical and radiological (CT scan) suspicion of ruptured cerebral AVM were selected by non-probability purposive sampling technique. After that enrolled patients were scrutinized according to selection criteria. Finally selected 50 patients who underwent DSA and were positive for AVM were included in this study. All the included patients' demographic, clinical and DSA profile were recorded in pre-structured data collection sheet. All the data were compiled, edited and plotted in tabular and figure forms. Data analysis was done by chi-square test. P value was determined significant when it was <0.05.

Results: *In angiographic presentation, maximum cases were found deep seated (72%), small sized (<3 cm) (70%), having compact type of nidus (58%), having superficial arterial feeder (62%), having high flow draining vein (70%), having deep venous drainage (56%) and single draining vein (78%). Associated aneurysm and venous ectasia were 12% and 4% respectively. The statistically significant predictors were deep location (P=0.036) and superficial arterial feeder (P=0.03) between male and female subjects.*

Conclusion: *Our results showed that small sized, deep-seated Cerebral arteriovenous malformation, having high flow draining vein, having deep venous drainage and single number of draining vein are the possible causes of hemorrhage. Lesions that have associated aneurysms have a risk of bleeding.*

Key Words: *Predictors of Hemorrhage, Cerebral Arteriovenous Malformation, Digital Subtraction Angiography.*

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Introduction:

Cerebaralarteriovenous malformation (AVM) is complex tangled, dilated blood vessels in which arteries flow directly into veins without capillaries. AVM occurs most often at the junction of cerebral arteries, usually within the parenchyma of the frontal-parietal region, frontal lobe, temporal lobe, lateral cerebellum or overlying occipital lobe. AVM can bleed or directly compress brain tissue; seizures or ischemia may result. The main cause of death in patients with cerebral AVM is intraparenchymal hemorrhage[1].This clinical event represents the first symptom in about 30-55% of reported cases, with an annual incidence of 2-3 %. AVM causes about 2% of all hemorrhagic strokes each year[2]. But in our country we do not have any statistical data about cerebral AVM. Despite this small proportion, AVM is gaining more attention because of the more frequent use of noninvasive imaging methods, like brain MRI, which is uncovering an increasing number of such malformations, bleed

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and unbleed[3]. Population based studies reveal that about 35% to 50% of patients with AVM initially present with hemorrhage, and the annual risk of further hemorrhage may vary from 1% to 18%[4]. Future hemorrhage in the natural course of disease appears to be related to initial presentation of hemorrhage[5]. Therefore identification of a set of morphological and physiological risk factors that can predict a hemorrhagic clinical presentation has been the subject of previous report. However, because not all authors have reported that initial hemorrhage[6]predisposes to subsequent hemorrhage, the precise nature of natural AVM history remains controversial.Modern invasive treatment methods have been developed with the aim at eliminating this source of hemorrhage, comprising microsurgical resection, endovascular embolization, radiotherapy, alone or in combination[7]. However, the risk of invasive therapy needs to be weighed against the natural history hazard of untreated AVM. Although intracranial hemorrhage is generally considered to constitute a possibly devastating event, prior series suggest that AVM hemorrhage may be more benign than previously assumed[8]. AVM may be diagnosed with the help of multidimensional imaging tools. Computed tomography (CT) of head without contrast has a low sensitivity but calcification and hypodensity may be noted; enhancement is seen after contrast administration[9].Magnetic resonance imaging (MRI) is very sensitive. Showing an inhomogeneous signal void on T1 and T2 weighted sequences, commonly with hemosiderin suggesting prior hemorrhage[10].At present the most effective diagnostic tool is intra-arterial digital subtraction angiography (DSA) which shows the origin, orientation and course of feeding arteries and draining veins and the location, size and morphology of nidus and eloquence of the adjacent brain region. DSA not only helps the proper diagnosis of cerebral AVM but also helps in embolization and other treatment procedure. Even DSA can help to detect small sized micro AVM which is not possible to detect by conventional other methods.

Materials and Methods:

This observational cross-sectional type of study was carried out from October, 2014 to March, 2016 in the department of Neurosurgery, Dhaka Medical College & Hospital, Dhaka. All patients admitted with hemorrhagic stroke with clinical and CT suspicious of ruptured AVM underwent DSA after taking proper informed written consent. Angiography was performed as intra-arterial (IA) DSA via femoral arterial approach by an interventional neurosurgeon. The DSA of every patient was reviewed. Fifty (50) patients from them who underwent DSA and were positive for AVM was included in this study. The following information for each AVM was recorded: location, size, source of feeder, flow dynamics (high flow versus low flow), and morphology of nidus (compact versus diffuse), associated aneurysms (proximal or intranidal versus none), venous drainage (superficial versus deep versus both), number of draining veins, presence of ectasia (yes versus no) and venous out flow obstruction. Each patient was evaluated immediately and 6 hours after DSA for any post procedural complications. All the included patients' demographic, clinical and DSA profile were recorded in pre-structured data collection sheet.Statistical analysis was performed by using SPSS version 16.0. Data were defined as means (±SD), frequency distribution and percentages. Chi-square test was done in relevant field.

Results:

Table-I

Distribution of the respondents by age (n=50)

Age (in years)	No of patients (n=50)		Total (%)
	Male(n=36)	Female(n=14)	
11 – 20	6(16.67%)	1(7.14%))	7(14%)
21 – 30	9(25%)	3(21.42%)	12(24%)
31 – 40	12(33.33%)	5(35.71%)	17(34%)
41 – 50	7(19.44%)	3(21.42%)	10(20%)
>50	2(5.55%)	2(14.28%)	4(8%)
Total	36(72%)	14(28%)	50(100%)
Mean age (in years)	31.26±11.13	30.36±12.11	29.25±11.16
Age range (in years)	17 – 63	19 – 59	17 – 63

Table-I shows that the highest numbers of patients were from 31-40 years age group (34%) followed by 21-30 years age group (24%). The overall mean age was 29.25±11.16. The age range was 17 – 63 years.

Table-II

Distribution of the respondents by sex (n=50)

Sl. No.	Sex	Total no.	Percentage (%)
1.	Male	36	72%
2.	Female	14	28%

Table-III

Distribution of the respondents according to presenting symptoms

Clinical presentation	Male(n=36)	Female(n=14)	Total (%)	P-value
Hemorrhagic	36(100%)	14(100%)	50(100%)	0.508^{NS}
Seizure	15(41.67%)	5(35.71%)	20(40%)	
Others	9(25%)	2(14.28%)	11(22%)	

Statistics was calculated by chi-square testNS: Not significant P value <0.05 is significant

Table-IV

Distribution of the respondents regarding the pattern of hemorrhage (n=50)

Pattern of hemorrhage	Male (n=36)	Female (n=14)	Total (n=50)	p value
Intraparenchymal	26(72.22%)	9(64.28%)	35 (70%)	0.04^{S}
Intraventricular	5(13.88%)	3(21.14%)	8(16%)	>0.05^{NS}
Both	5(13.88%)	2(14.28%)	7(14%)	>0.05^{NS}
Subarachnoid hemorrhage	0(0%)	0(0%)	0(0%)	
Subdural / Extradural	0(0%)	0(0%)	0(0%)	

Statistics was calculated by chi-square testNS: Not significantS: SignificantP value <0.05 is significant

Table-V

Distribution of the respondents according to AVM characteristics (n=50)

Angiographic presentation	Male(n=36)	Female (n=14)	Total (%)	P-value
AVM location				
Superficial	10	4	14(28%)	0.036^{S}
Deep	26	10	36(72%)	
Size of AVM				
<3cm	25	10	35(70%)	>0.05^{NS}
>3cm	11	4	15(30)	
Morphology of AVM				
Diffuse	16	5	21(42%)	>0.05^{NS}
Compact	20	9	29(58%)	

Statistics was calculated by chi-square testNS: Not significantS: Significant P value <0.05 is significant

Table-VI

Distribution of the respondents according to AVM characteristics (n=50)

Angiographic presentation	Male(n=36)	Female(n=14)	Total (%)	P-value
Arterial feeder				
Superficial	19	12	31(62%)	0.03^{S}
Deep	17	2	19(38%)	
Flow dynamics				
High flow	27	8	35(70%)	>0.05^{NS}
Low flow	9	6	15(30%)	
Aneurysm				
None	31	13	44(88%)	>0.05^{NS}
Intranidal	3	1	4(8%)	
Remote	1	0	1(2%)	
Prenidal	1	0	1(2%)	

Statistics was calculated by chi-square testNS: Not significantS: Significant P value <0.05 is significant

Table-VII

Distribution of the respondents according to AVM characteristics (n=50)

Angiographic presentation	Male(n=36)	Female(n=14)	Total (%)	P-value
Venous drainage				
Superficial	13	9	22(44%)	>0.05^{NS}
Deep	23	5	28(56%)	
No of draining vein				
One	33	6	39(78%)	>0.05^{NS}
Two	2	6	8(16%)	
>Two	1	2	3(6%)	
Venous ectasia				
Yes	2	0	2(4%)	>0.05^{NS}
No	34	14	48(96%)	
Venous outflow obstruction				
Yes	0	0	0(0%)	>0.05^{NS}
No	36	14	50(100%)	

Statistics was calculated by chi-square testNS: Not significantS: Significant P value <0.05 is significant

Table-II Shows that among 50 patients male were 36 (72%) and female were 14 (28%).

Table-III shows that all patients (100%) presented with hemorrhage among whom 40% presented with seizure and 22% patients presented with other symptoms. Here other symptoms denote neurological deficit (due to mass effect and venous hypertension) and headache.

Table-IV shows that Intraparenchymal hemorrhage was the highest (70%) in number where male to female incidence showed statistically significant difference.

Table-V shows the distribution of different baseline characteristics of arteriovenous malformations. Here in maximum cases the possible causes of hemorrhage were found small size of AVM, deep location of AVM and compact type of AVM. AVM location showed the statistically significant difference between male and female subjects.

Table-VI shows the distribution of different baseline characteristics of arteriovenous malformations. Here in maximum cases the possible causes of hemorrhage were found high flow of draining vein. AVM arterial feeder showed the statistically significant difference between male and female subjects.

Table-VI shows the distribution of different baseline characteristics of arteriovenous malformations. Here in maximum cases the possible causes of hemorrhage were found deep venous drainage and single draining vein.

Discussion:

The devastating and potentially fatal complications of cerebral arteriovenous malformation usually happen through intracranial hemorrhage. The radical advancement of radiological tools plays a helpful role to detect the predictors of hemorrhage from cerebral AVM. DSA has become very popular nowadays both for diagnosis and prediction of risk factors of hemorrhage. There are different established predictors of hemorrhage from cerebral AVM like age, gender, location, size, feeding arteries, associated aneurysm, morphology of nidus, flow dynamics and venous drainage pattern. Among them there are some anatomical factors for which detection by DSA is more preferred than CTA. Because CTA can not show the actual details of intranidal or feeding artery aneurysm, venous drainage patterns and subtle AVMnidusangioarchitecture.The main goal of the treatment of cerebral arteriovenous malformation is to preserve neurological function mainly by preventing intracranial hemorrhage and its consequences. Therefore, understanding the natural history ofcerebral arteriovenous malformation, especially related to risk of future hemorrhage, is crucial.Cerebral arteriovenous malformation shows symptoms usually between 20 to 40 years of age[11]. In this study, the highest number of patients were from 31-40 years age group (34%) followed by 21-30 years age group (24%) and the overall mean age

was 29.25±11.16 that matches with previous study. It is evident that cerebral arteriovenous malformation represents a heterogeneous group of lesions with different clinical presentations and most likely different outcomes. Some arteriovenousmalformation are extensive andprogressive having the potential life threatening hemorrhage, thrombosis[12]. AVM produces neurological dysfunction through hemorrhage in the subarachnoid space, intra-ventricular space or most commonly in the brain parenchyma. In this study, 100% patients presented with hemorrhage among which 70% showed brain parenchymal hemorrhage, 16% showed intra-ventricular hemorrhage and rest 14% showed both. Among the 50 patients of this study, the small sized AVM (<3 cm) was found in 70% cases which was similar to 68% findings of population based study of Toronto group but does not match with same type of study on Berlin group and Paris group (23% to 32%) and nearer to 67% (284 of 424) for the combined Berlin/Paris/New York/Toronto Database[11]. It was found that deep-seated AVM bleed more[13]. The risk of hemorrhage can vary widely depending on the presence and number of risk factors that included age, deep location, and deep venous drainage. In our study[14], 72% lesions were deep-seated and 28% lesions were superficial. A number of anatomic AVM characteristics have been reported to predispose AVM patients to bleeding. In our study, we found 42% diffuse type and 58% of compact type of AVM. It is well known to us that compact type AVM most commonly occurs in adults who are fairly reflected in our study as 90% patients belonged to adult group.The reported rate of aneurysms associated with cerebral AVM vary widely (2.7%-58%) in the different literatures, depending on the definition of what would represent an associated aneurysm, the type of angiography utilized and referral patterns[13]. In this study, the aneurysm was observed in 12% cases that were within the range of previously mentioned literature. The venous drainage system as a factor in AVM hemorrhage and found three variables associated with hemorrhage: a single draining vein, deep venous drainage and impaired venous drainage alone[15]. In this study, maximum cases of bleeding were found having single draining vein (78%) and deep venous drainage (56%) which was similar to previous study.Some studies showed venous ectasia did not demonstrate any association with hemorrhage but those were descriptive reports that did not have follow-up analyses[16,17]. In our descriptive study, venous ectasia found only 4% cases which was similar to previous studies.This may suggest that the risk of hemorrhage in these complex lesions is not only the summation of the risk of each separated lesion, but also each angioarchitectural characteristics is actually a marker of a more severe intracranial vasculopathy and therefore a condition more prone to hemorrhage.

Conclusion:

Our results showed that small sized, deep-seated arteriovenousmalformation, having high flow draining vein, deep venous drainage and single number of draining vein are the possible causes of hemorrhage. Lesions that have associated aneurysms have a risk of bleeding. Arteriovenous malformation location and arterial feeder showed the statistically significant difference between male and female respondents. This information should be taken into consideration while deciding among therapeutic options for cerebral arteriovenous malformation

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