Angioarchitecture of Brain Arteriovenous Malformations and the Risk of Bleeding: An Analysis of Patients in Northeastern Malaysia

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Abstract

Background: Central nervous system arteriovenous malformation (AVM) is a vascular malformation of the brain and involves entanglement of veins and arteries without an intervening capillary bed. Affecting predominantly young male patients, AVM presents with different clinical manifestations namely headache, seizures, neurological deficit and intracranial haemorrhage. The patients who present acutely with intracranial bleeding have a significant morbidity and mortality. The aim is to study the angioarchitecture of brain AVM (BAVM) and determine the risk factors for intracranial bleeding. Ultimately, the goal of the study is to look for the association between volume of haematoma and architecture of BAVM.

Methods: A cross-sectional study of 58 patients was conducted at the Hospital Universiti Sains Malaysia. Data were collected over a period of seven years (2000 to 2007) to look for the association between the angioarchitecture of brain arteriovenous malformations (BAVM), haemodynamics and the natural history and risk of intracranial haemorrhage.

Results: BAVM was predominantly found in young male patients in 65.5%. Small nidal size (P-value=0.004), deep location (P-value=0.003) and deep venous drainage (P-value=0.006) were found to be significant factors contributing to intracranial haemorrhage. All patients with coexisting intranidal or prenidal aneurysms presented with intracranial haematoma.

Conclusion: The angioarchitecture of BAVM like nidal size, deep location and deep venous drainage can predict the risk of intracranial bleeding and can help in the management of high risk patients without any delay. Small sized and deep seated lesions have a diffuse type of intracranial bleed which eventually need more attention to the managing team as diffuse haematoma indicates more insult to brain.

Keywords: angioarchitecture, brain arteriovenous malformation, intracranial haemorrhage, stroke, neurosciences, neuroradiology

Introduction

Brain arteriovenous malformation (BAVM) is a vascular malformation in the supratentorial and infratentorial compartments of the brain (1). It consists of a tangle of veins and arteries without an intervening capillary bed. It predominantly affects young male patients and presents with different clinical manifestations, such as headaches, seizures, neurological deficits and intracranial haemorrhage. The patients who present acutely with intracranial bleeding have significant morbidity and mortality (2). The purpose of this study was to identify the risk factors for intracranial bleeding associated with BAVM in patients referred for angiography and management from the Hospital in the North and North East of Malaysia. This study also enabled us to examine the association between the haematoma volume and the angiographic architecture of brain arteriovenous malformations.

Materials and Methods

This was a cross-sectional study of in-patients at the Department of Radiology, Hospital Universiti Sains Malaysia (HUSM), collected from the year 2000 to 2007. A total of 58 patients were included, after excluding patients with vein of Galen malformation, dural arteriovenous fistula and brain haemangiomas. The demographic

features and the first clinical manifestations that brought patients to the hospital were evaluated by patient interviews or were recorded from case notes.

Intraarterial digital subtraction angiography (IADSA) was performed via femoral artery puncture and selective four- or six-vessel cerebral catheterisation. The imaging system used was manufactured by Advantage GE Medical Systems. Routine views were taken, including: a) AP and lateral views for the internal carotid artery run; b) Towne's and lateral views for the vertebral artery run; and c) additional views such as oblique and cross compression, whenever necessary. Non-contrast computed tomography (CT) scanning was performed with a helical multislice scanner (Lightspeed, GE Medical systems) with a slice thickness of 3.5 mm from the base of the skull through the posterior fossa, followed by 7.5 mm contiguous axial sections to the vertex, with a KVP of 120 and an MA of 200. Pre-treatment CT scans and MR images were used.

The nidal size of the lesion was measured on a cerebral angiogram in both the antero-posterior and lateral views, but the maximum linear diameter in any plane was considered for this study. When the calibration was not marked on the images, the diameter of the genu of the petrous portion of the internal carotid artery (5 mm) was used as a reference for sizing a nidus, either using callipers or a customised scale on paper (2–3). Venous drainage, feeding-artery aneurysms and location were further evaluated using cerebral angiograms and CT scans or magnetic resonance imaging (MRI). Nidal size was classified per Spetzler Martin's grade (4).

Arterial feeders were divided into two categories: superficial supply and deep supply. The superficial supply categorisation included cortical branches of the anterior, middle, and posterior cerebral arteries (ACA, MCA and PCA). The deep supply categorisation included perforating branches, choroidal arteries, and posterior fossa arteries. Mixed supply from both the superficial and deep arteries was considered to be deep supply. The location was grouped under two main categories: superficial and deep. The superficial areas were the temporal, frontal, parietal and occipital lobes. Deep-seated BAVM was a lesion that was situated at the basal ganglia, corpus callosum, thalamus or cerebellum.

Venous drainage was divided into two subgroups: superficial and deep. Superficial drainage was considered present if all the drainage from the BAVM was through the cortical venous system and the cerebellar hemispheric veins. The venous pattern was considered deep if any or all of the drainage was through the deep cerebral veins, such as the internal cerebral vein, the basal veins, the precentral cerebral vein or in the venous sinuses. Aneurysms were categorised as either present or absent.

The patients who solely presented with intracranial haemorrhage were analysed and the type and pattern of haemorrhage was recorded from the CT scan images. Patterns of haemorrhage were further divided into focal and diffuse where focal meant intraparenchymal haematoma (IPH) only, whereas diffuse included intraventricular (IVH), subarachnoid or intraparenchymal haematomas. Patients who presented with solely subarachnoid haemorrhage (SAH) were further graded according to the Fisher score (5), and any association between the angioarchitecture of BAVM was analysed using McNemar's test.

Statistical analysis was performed using SPSS for Windows (version 12.01) software. The association between the angioarchitecture of BAVM and intracranial haemorrhage was analysed using multiple logistic regression (backward model). The objective was to evaluate the association between the angioarchitecture of BAVM and patterns of haematoma using Pearson's chi-square and Fisher's exact tests.

Results

Patient ages ranged from 5 to 61 years. The mean age and standard deviation were 26.7 years (SD ± 12.96). The median age was 23.50 years. A preponderance of males was noted in this study; the sample population consisted of 38 (65.5%) males and 20 (34.5%) females. Additionally, out of the 40 (69%) patients who presented with intracranial haemorrhage, 27 (67.5%) were males and 13 (32.5%) were females. Among the 58 patients, 82.8% were Malays, 8.6% were Chinese, 5.2% were Indians and 3.4% were Siamese. Sixty-nine percent of the patients arrived at the emergency department with a clinical presentation of intracranial haemorrhage and were investigated using non-contrasted CT scanning. Nineteen percent of the patients presented with seizures, and these patients were evaluated by contrasted CT or MRI or both.

In total, 8.6% of patients presented with headache and 3.4% with neurological deficit. These patients were also evaluated using contrasted CT, MRI or both. The BAVM patients, who presented with intracranial haematomas, had different types of bleeding: a total of 29.3% presented with no bleeding; 18 patients (31%) arrived with solely intraparenchymal haemorrhage; 17 patients (29.3%) had intraparenchymal bleeding and, at the same time, intraventricular bleeding;

three patients (5.2%) had both subarachnoid and intraventricular bleeding; two patients (3.4%) had subarachnoid and intraparenchymal haemorrhage; and one patient (1.7%) had all three types of bleeding: intraparenchymal, intraventricular and subarachnoid haematomas. A total of six patients who presented with subarachnoid haemorrhage were further graded based on their CT Fisher scores, and all were found to have a score of four, which suggests that SAH was extended either intraparenchymally, intraventricularly, or both.

A multivariate model was constructed using multiple logistic regression to further test for significance (Table 1). Small size of nidus (P-value=0.004) and deep lesions (P-value=0.003) were significant predictors of intracranial bleed. Venous drainage failed to show any significance in the multivariate model, even though was significant at the univariate level (P-value=0.858), in relation to intracranial haemorrhage. No association between angioarchitectural factors and patterns of haematoma were found at the univariate level. Six patients presented solely with subarachnoid haemorrhage, and all of them had a score of four. No significant relationship was found between size of nidus and the other angioarchitectural factors (venous drainage, site of lesion, and draining veins) in the Fisher scores of four patients, using McNemar's test.

Discussion

This study revealed that in the sample population, haemorrhage was the main clinical event and accounted for 69.0% cases at the initial presentation. This observation may indicate that acute onsets of symptoms are quite easily diagnosed as cases of BAVM, but unfortunately other clinical manifestations, such as seizures and headaches, may be missed or misdiagnosed. The remaining 31% presented with other clinical manifestations. For the 58 patients, the age range was 3 to 61 years and the mean age was 26.67 (SD ± 12.96) years; this shows that the population harbouring BAVM was relatively young, compared to Western populations (6). We also observed a higher preponderance of male patients than female patients, with a ratio of 1.9:1. Malays (82.8%) were found to be at the highest risk, however, this result is biased because the population consists more of Malays. There are a variety of haemorrhage types represented; solely intraparenchymal bleed (31%) followed by a combination of intraventricular bleeding and intraparenchymal haematoma (29.3%). No patients presented with only subarachnoid haemorrhage, but many presented with a combination with either intraparenchymal or intraventricular bleeding. Six patients had subarachnoid haemorrhages, and all had Fisher scores of four. Only one patient had diffuse bleed with subarachnoid, intraparenchymal haematoma and intraventricular bleeding at the same time

Small nidal size was found to be an independent predictor for intracranial haemorrhage in both univariate (P-value=0.000) and multivariate models (OR=19.8, P-value=0.004, 95 %CI=2.7–142.9). Additionally, 64.9% of patients had nidal size of less than or equal to 3 cm, of which 86.5% presented with intracranial bleed. This association of small size with intracranial bleeding is in accordance with many studies. The risk factors for intracranial bleeding have been researched as early as 1980 by Guidetti and Delitala followed by Graf et al. in 1983, Crawford et al. in 1986, and Stapf et al. in 2006 (7–10).

Table 1: Results of a multivariate analysis to determine the association between the angioarchitecture of BAVM and intracranial bleeding

Variable	n	OR (95% Cl)	P-value	Adjusted OR (95% Cl)	P-value
Size of nidus					
<3 cm	20	0.08	0.000	19.8	0.004
3-6 cm	37	(0.0-0.3)		(2.7-142.9)	
Venous drainage					
Superficial	26	5.40	0.007	0.79	0.858
Deep	32	(1.6-18.4)		(0.06-10.3)	
Location					
Superficial	28	18.7	0.000	0.01	0.003
Deep	30	(3.7-94.1)		(0.0-0.2)	

Deep venous drainage was a significant factor at the univariate level in relation to intracranial haemorrhage (P-value=0.007); however, it failed to show any significance at the multivariate level. This goes against most of the studies in which venous drainage was an independent factor in causing intracranial haemorrhage (9–11). This may be due to the small number of patients in our study.

The morphologies of the draining veins were not assessed in detail, because they have been recorded in two previous studies carried out by Miyasaka in 1992 and Nataf et al. in 1997 (12,13). The morphology of the venous drainage is a very important factor in determining intracranial haemorrhage because it contributes to the haemodynamics of the lesion.

Deep location was an independent risk factor for intracranial haemorrhage in both the univariate and multivariate models (OR=0.01, P-value<0.05, 95% CI=0.0–0.2) in our study. Overall, 51.7% of BAVM had a deep location, of which 93.3% had a haemorrhagic presentation, which is consistent with major studies (6,11). We found that feeding arteries were not a significant factor for intracranial bleeding, (P-value>0.05, OR 0.01, 95% CI) which was consistent with the results of Stefani et al. in 2000 (12).

In this study, 70.8% of patients with superficial and 67.6% of patients with deep supply presented with intracranial bleeding. Most of the lesions had a mixed supply from both the superficial and deep arteries, and, as mentioned above, they were considered to be deep supply arterial feeders. Therefore, we can postulate that mixed arterial supply can reduce the intranidal pressure within the lesion and, subsequently, these lesions have less of a tendency to bleed (14).

All patients who had aneurysm coexisting with brain arteriovenous malformation had intracranial haematoma, which is significant clinically. However, due to a small sample size of six patients harbouring aneurysms, it was not found to be a statistically significant predictor of intracranial haemorrhage. This result is different than those of most other studies (15,16). However, the presence of aneurysms was clinically significant, as 100% of BAVM cases with aneurysm had intracranial haemorrhage. The prevalence of coexisting aneurysms was 8.6%. Only five patients out of 58 had aneurysms; all of them presented with haemorrhage. Four patients had intranidal and one patient had prenidal aneurysmal dilatation. The size of the nidus, location, venous drainage, arterial feeders and the presence of aneurysms were not significant factors (P-value>0.05) influencing the patterns of intracranial haematoma.

The patients presenting with subarachnoid haemorrhage had a Fisher score of four. They were analysed using McNemar's test to examine the association between size and other angioarchitectural factors such as venous drainage, location of the lesion and arterial feeders, but no factors were found to be significant, with a P-value>0.05.

Conclusion

From our study, we can conclude that young male patients with a mean age of 26.6 years were found to be more prone to BAVM. Most patients (69 %) presented with intracranial haemorrhage, followed by seizures (19%), headaches (8.6%), and neurological deficits (3.4%). The patients who presented with intracranial haemorrhage and/or intraparenchymal haematoma constituted the most common type of bleeding.

The angioarchitectural factors, namely, small nidal size, deep seated lesions and deep seated venous drainage, are predictive of the risk of intracranial bleeding. Coexisting aneurysms are a clinically significant factor predicting intracranial bleeding. Small nidal size is 2.7-times more likely to be related to bleeding than large nidal size, and deeply located BAVM is 0.2 times more likely to involve bleeding.

Radiologists or neuroradiologists who diagnose BAVM must note that certain angioarchitectural factors, such as small nidal size, deep seating lesions and deep venous drainage, increase the risk of intracranial haemorrhage. These patients will need to be referred either to neurointerventional radiologists, neurosurgeons, neurologists or radiosurgeons, as a multidisciplinary approach is required for appropriate management.

Author s contributions

SK and MSA contributed equally to the conception and design, data collection, analysis and interpretation, drafting of the article and revision. Statistical expertise: NNN

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