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CASE REPORT

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Fenestration of the vertebrobasilar junction detected with multidetector computed tomography angiography

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The complex embryonic origin of the vertebrobasilar system may result in a wide range of anatomical variations. It has been hypothesized that the formation of fenestrations are likely to occur due to the failure of regression of the bridging arteries that connect the longitudinal neural arteries during embryogenesis. Fenestration of the vertebrobasilar system is a rare anatomical variation that involves a luminal division of the artery, that has a single origin into two separate and parallel channels which are rejoined distally. Fenestrations are important anatomical variants in patients undergoing endovascular and invasive intracranial interventions. Vascular fenestration has been associated with aneurysms, arteriovenous malformations, neuralgia, and vertebrobasilar ischaemia. We report on 3 cases of fenestration at the vertebrobasilar junction in 1 female and 2 male patients, respectively, using multidetector computed tomography angiography. The length of the fenestrated segment of the artery measured 4.41 mm, 3.90 mm, and 5.90 mm, respectively in the patients. Our report is clinically important as the presence of this anatomical variation may influence the management of cervical and intracranial pathologies. Increased awareness of the prevalence of anatomic variations contributes to the advancement of noninvasive imaging capabilities. (Folia Morphol 2022; 81, 2: 510–514)

Key words: morphological variation, vertebral artery, basilar artery

INTRODUCTION

The vertebrobasilar system is the combination of the two vertebral arteries (VAs) together with the basilar artery. The vertebrobasilar junction (VBJ) is the point of union of the bilateral VAs, mostly at the lower border of the pons [19] to form the basilar artery. The vertebrobasilar system provides the blood supply to vital structures like the cervical spinal cord, brainstem, thalamus, cerebellum, and occipital lobes [18]. Therefore, a morphological variation of either of the VA or basilar trunk can influence vascular supply to the afore mentioned structures. Anatomically, VAs are divided into four segments: prevertebral (V1), vertebral (V2), atlantoaxial (V3), and intracranial (V4) segments [1]. Pre-

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Table 1. Incidence of vertebrobasilar junction (VBJ) fenestration in different population groups

Author (year)	Country	Type of study	Number of cases	Sex: male/female	Segment of vertebral arteries
Campos et al. (1987) [2]	Canada	DSA	21	7/14	VBJ
Yoon et al. (2004) [24]	South Korea	CTA	4	2/2	VBJ
Consoli et al. (2013) [3]	Italy	DSA	2	Female	VBJ
Kan et al. (2013) [9]	United States	DSA	1	Female	VBJ
Gupta et al. (2013) [7]	India	CTA, DSA	4	3/1	VBJ
Trivelato et al. (2016) [22]	Brazil	DSA	5	1/4	VBJ
Zhu et al. (2016) [25]	China	DSA	10	6/4	VBJ
Present study	South Africa	CTA	3	1/2	VBJ

CTA — computed tomography angiography; DSA — digital subtraction angiography

vious studies regarding the morphology of the VA have shown the existence of variation in its course [5, 6, 11].

Fenestration is an uncommon anatomical variation that involves a luminal division of an artery that has a common origin into two separate and parallel channels anywhere along its course to rejoin distally. Fenestration is sometimes mistaken for duplication, but should, however, be differentiated. Duplication normally involves double vascular origin which later fuse during the course of the artery [8].

Fenestration of the VBJ has been reported to be a predisposing factor to other vascular malformations like aneurysms [24], arteriovenous malformations [12], and neuralgia [10]. Furthermore, fenestration has been associated with epidermoid cysts and vertebrobasilar ischaemia [13, 23]. A thorough understanding of the anatomy and knowledge of anatomical variations of the vertebrobasilar artery is essential for assessing neurologic syndromes and preoperative neurosurgical planning. In this report, we describe three cases of VBJ fenestration using multidetector computed tomography angiography.

Fenestration of the VBJ is a morphological variation that has been previously reported in the international population, for example in China, United States, Canada and Brazil (Table 1). In this report, we present 3 cases of fenestration of the VBJ in 2 White and 1 Indian South Africans.

CASE REPORT

Our study is retrospective in nature, therefore, written informed consent was not obtained. However, the design of this study was approved by our Institutional Review Board/Ethics Committee (Biomedical Research Ethics Committee of the University of KwaZulu-Natal with ethical No: BE 148/19). No identifying patient information is present in this paper.

Case 1

Computed tomography angiography (CTA) scan of intracranial vessels of a 34-year-old Indian South African female at Lenmed Ethekwini Hospital and Heart Centre illustrated fenestration at the VBJ (Fig. 1A). The length of the fenestrated segment at the VBJ was 4.41 mm with the two limbs having a similar diameter. Clinical examination showed extensive aneurysmal subarachnoid haemorrhage in the right Sylvian fissure with intracerebral extension into the adjacent peri-lenticular parenchyma. Ruptured right middle cerebral artery saccular aneurysm, and further multilobulated anterior cerebral artery aneurysm was noted with the incorporation of large left A3 segment.

Case 2

A 79-year-old male White South African presented to Lenmed Ethekwini Hospital and Heart Centre for the history of vertebrobasilar transient ischaemic attack (TIA) and acute unsteadiness. CTA scan revealed fenestration at the VBJ (Fig. 1B). The length of the fenestrated segment at the VBJ was 3.90 mm with the two limbs having a similar diameter. The posterior communicating artery was hypoplastic on the right when compared to the left and no intracranial aneurysm was demonstrated.

Case 3

An 83-year-old male White South African presented to Lenmed Ethekwini Hospital and Heart Centre for a clinical history of collapse, recurrent TIA, ataxia, and diplopia. CTA showed fenestration at the VBJ

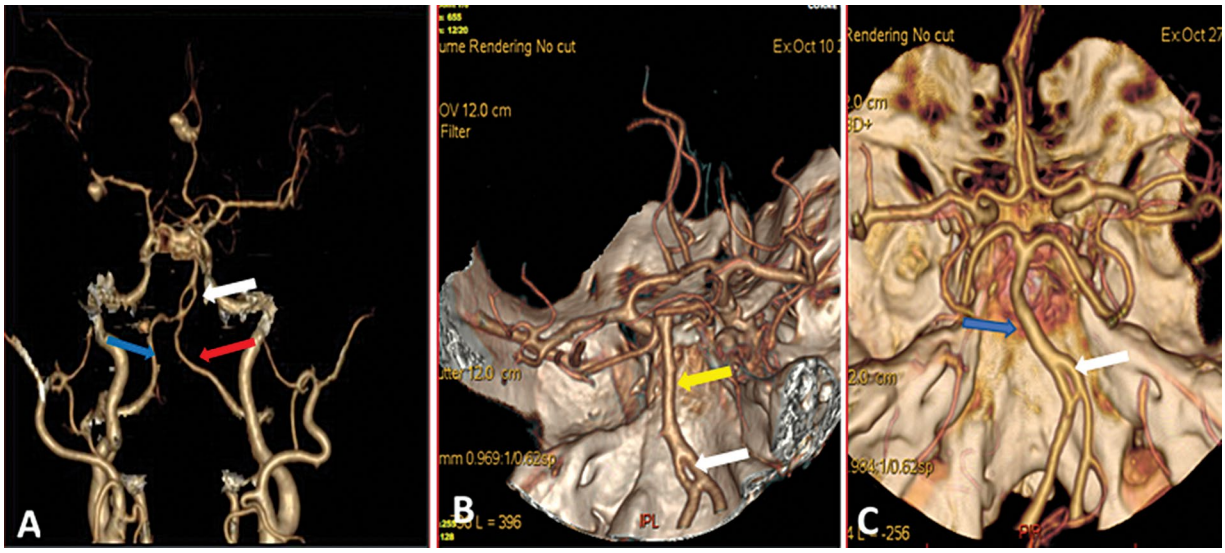

Figure 1. Computed tomography angiography images of case 1 (**A**), case 2 (**B**) and case 3 (**C**); **A.** Three-dimensional reconstructed image shows vessels of anterior and posterior circulation. Blue arrow shows intracranial segment of right vertebral artery (VA) while the red arrow shows intracranial segment of the left VA. The white arrow shows fenestration at the vertebrobasilar junction (VBJ) between the confluence of bilateral VAs and proximal part of the basilar artery; **B.** Three-dimensional reconstructed image shows the intracranial VA, bending basilar artery and the circle of Willis. The white arrow shows fenestration at the VBJ while the yellow arrow shows the basilar artery; **C.** Three-dimensional reconstructed image shows the intracranial VA, bending basilar artery and the circle of Willis. The white arrow shows fenestration at the VBJ while the blue arrow shows the basilar artery.

(Fig. 1C). The length of the fenestrated segment at the VBJ was 5.90 mm with the two limbs having a similar diameter. The basilar artery was minimally ecstatic involving the medial and lateral margin at its bifurcation.

DISCUSSION

Anatomical variation in the origin of the VA is the most reported morphological variation. This has also been reported in the South African population [4, 15]. However, reports on fenestration at the VBJ are scarce and are mostly reported internationally (Table 1). Previous studies regarding the morphology of the VA have shown the existence of variation with demographic and ethnic/racial differences [5, 6, 11]. Complex embryogenesis of the vertebrobasilar system results in vascular fenestration and it is frequently reported at the extracranial portion of the VA [12]. In contrast, the three cases we report showed fenestration at the VBJ.

Embryologically, the VA is formed during the 32nd to 40th days by the development of longitudinal anastomosis between the seven adjacent cervical intersegmental arteries that are formed from the primitive dorsal aorta [17]. Later, however, the first six cervical intersegmental arteries regress, while the seventh persists to form the proximal part of the subclavian artery and the point of origin of the adult VA. The basilar trunk is formed from the fusion of primitive embryonic longitudinal neural arteries by approximately the fifth foetal week [14]. Generally, fenestration at any of the segments of the VA (V1–V4) is due to the absence of obliterations of two intersegmental vessels which fuse, or by segmental arteries which become short or disappear while a portion of the dorsal aorta remains against the VA [1]. Basilar artery fenestration occurs as a result of partial failure or incomplete fusion of the longitudinal neural arteries and regression of the bridging arteries connecting the longitudinal arteries [25]. Although fenestration at the VBJ is formed between the confluence of the bilateral distal VA and proximal part of the basilar artery, researchers agree that the best explanation for this morphological variation is the persistence or incomplete fusion of one of the temporary bridging arteries between the embryologic bilateral longitudinal neural arteries that form the basilar artery [7, 25]. This could occur as a result of some genetic or environmental factors [25]. In the cases we observed, fenestration was found at the VBJ in 3 patients (Figs. 1A–C).

The macroscopic examination of the fenestrated segment revealed a unique fusiform thickened vessel [1]. Furthermore, microscopic and histopathological examination of the limbs has shown irregularities in the lateral and medial wall structure [1, 13]. These

irregularities may alter the haemodynamics of blood flow at the proximal and distal end of the fenestrated segment causing TIA as reported in two of our patients (cases 2 and 3).

Vertebral artery dominance and bending of the basilar artery have also been reported as risk factors for brainstem infarction and TIA [16]. Morphologically, the VBJ is subjected to the greatest stresses of flow and turbulence from the bilateral VA below. This complex geometry of the VBJ, in addition to fenestration and basilar bends (Fig. 1A–C), may also contribute to the clinical history of TIA in cases 2 and 3.

Some authors suggest that fenestration of the VA is an incidental finding and has no pathological and clinical importance [20], while others hypothesized that its occurrence increases the prevalence of aneurysms (most especially at the VBJ) [2, 24]. Fenestration has also been associated with the brain, spinal cord, and spinal column abnormalities in addition to other vascular disorders [21]. In case 1, there is a middle cerebral artery and anterior cerebral artery aneurysm, which is not associated with the fenestration. According to the report by Campos et al. [2] and review of literature (Table 1), fenestration at the VBJ is more common in female subjects while VA fenestration is considered to be more frequent in male subject [12]. This may not be comparable due to different embryological processes in the formation of the basilar artery as opposed to the vertebral arteries. Also, our report is a small series with only 3 subjects comprising 2 males and 1 female.

CONCLUSIONS

The authors presented 3 cases of fenestration at the VBJ in 2 White males and 1 female Indian South African patients. The presence of this morphological variation can increase the incidence of an aneurysm. Since most intracranial vascular disorders such as aneurysm are treated using endovascular procedures, a knowledge of the presence of fenestrations may influence the endovascular strategy. Therefore, knowledge of this anatomical variation will help in the preoperative workup and contribute to the correct interpretation of preoperative images. This report will also contribute to the demography of the South African population.

Conflict of interest: None declared

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