Neuroradiological Analysis of 23 Cases of Basilar Artery Fenestration Based on 2280 Cases of MR Angiographies

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Summary

Basilar artery (BA) fenestrations are the most frequently observed variant of the cerebral arteries. We examined the magnetic resonance (MR) angiographic incidence, location, characteristic configuration of BA fenestration and associated vascular disease.

From April 2004 to September 2004, a total of 2280 cranial MR angiographies were performed at our institution. Twenty-three BA fenestrations (1.0%) were detected on MRA. There were 13 males and ten females in this group and mean age was 57.6 years old. Three cases of these fenestration group are suffered with atherothrombotic infarction in the territory of vertebro-basilar system. Seven of 23 cases (30%) were associated with intracranial aneurysm. Of those four cases, aneurysms were located at anterior circulation. Of those three cases, the aneurysms were associated with BA fenestration. Since saccular aneurysms are reported to arise frequently at BA fenestration, knowledge and recognition of fenestration are useful and important in the interpretation of cerebral MR angiography.

Introduction

The incidence of basilar artery (BA) fenestration was reported to be 0.6~1.7 % based on angiography^{1,2,3,4}. However, reports of BA fenestration

studied by magnetic resonance (MR) angiography are rare². The purpose of this study is to report the incidence of BA fenestration delineating its configurations and to investigate the associated other vascular disease based on large series of cranial MR angiography.

Material and Methods

Patients

Between April 2004 and September 2004, a total of 2280 cranial MR angiographies were performed at our institution. These 2280 consecutive patients consisted from 1013 females and 1267 males.

The mean age of the patients at the time of examination was 61.8 ± 14.5 (mean $\pm$ standard deviation) years (range 0-95 years). In this series, there were 403 cases of asymptomatic patients for brain check including screening studies, 523 cases presented with headache but no remarkable neuroradiological abnormality, 365 cases with vertigo and/or tinnitus without neuroradiological findings and 859 cases diagnosed as a stroke including asymptomatic lacuna infarction.

MRI and Radiological Findings

All patients were studied with two of 1.5 Tesla units (SIEMENS, Magnetome VISION and GE, Excite) and one of 1.0 Tesla unit (SIE-

MENS, Impact EXPERT). Majority of MR angiography was performed with either the multiple overlapping thin slab or conventional single slab acquisition technique. (TR 32 mm sec. TE 6.9 mm sec. Mean acquisition time: 3 min 20 sec., field of view: 16 x 16 cm) In all cases, vertebrobasilar junction were included within the FOV (field of view). The MRA images were printed and appeared stereoscopically on the conventional film and each of them were layout in order to facilitate us binocular stereoscopic observation. Reading and interpretation of these MRA studies were done by two neuroradiologists and one neurosurgeon. In eight cases, BA fenestrations were also confirmed with 3D-helical CT angiography and three case of them were performed additional catheter cerebral angiography combined with 3D-rotation angiography.

Classification According to the Location of Fenestration

We introduced a classification of BA fenestration according to the location and relation with the origin of AICA and classified these cases to each type. Type I: fenestration locating proximal to AICA (figure 1A), Type II: bilateral AICA symmetrically originating from the fenestrated trunk (figure 1B), Type III: unilateral AICA originating one side of the fenestrated trunk (figure 1C), Type IV: fenestration locating distal to AICA (figure 1D)

Results

Incidence of BA Fenestration

A total of 23 cases of BA fenestrations (1.0%) were detected in this series. Mean age of this group was 57.6 ± 15.5 years (mean $\pm$ S.D.). There were 13 males and 10 females. Mean diameter of these fenestration was 2.4×1.3 mm.

Classification of BA Fenestration

Of those 23 cases, there were 13 cases of Type I, six cases of Type II, three cases of Type III and one case of Type IV (table 1). One case presented with double fenestration (figure 2).

Associated Vascular Diseases: Aneurysm

A total of 39 cases (1.7%) of 2280 cases had intracranial aneurysms. Among these 39 cases, 28 cases had been diagnosed as intracranial aneurysms with the other modalities prior to

this MR angiography. Of the seven cases from these 23 BA fenestration cases (30%), intracranial aneurysms were detected. One of them presented a fusiform aneurysm at V4 portion distal to PICA (figure 3A).

Three of them were detected the lower basilar trunk aneurysms associated with fenestration on MRA and these cases were confirmed with 3D helical CT (figure 3B,C). One case presented with intractable hemifacial spasm due to the invagination of the aneurysm into the brain stem originating from fenestration (figure 3C). This case was performed endovascular treatment with GDCs (Guglielmi detachable coils; Boston Scientific) and the hemifacial spasm was completely cured. In three cases, aneurysms were located in anterior circulation territory that is apart from the BA fenestration.

Ischemia

Three cases of BA fenestration group were suffered with atherothrombotic infarction in the territory of vertebrobasilar system. One case presented Wallenberg syndrome, second case was suffered with AICA territory infarction and third case showed the ipsilateral posterior cerebral cortical artery infarction. The case presented with the AICA territory infarction belonged to Type II.

Associated Vascular Variant

One asymptomatic case of BA fenestration was associated with anterior communicating artery fenestration (A1A2 junction). Another asymptomatic case of BA fenestration was accompanied with persistent primitive trigeminal artery. Among 2280 cases of this population, a total of nine cases (0.39%) were represented the persistent primitive trigeminal artery and four cases (0.18%) were presented with anterior communicating artery fenestration.

Discussion

Basilar Artery Embryology and Fenestration

The word fenestration refers to a localized or segmental duplication equally to an unfused vessel⁵⁻⁹. As well described by Padget, the basilar artery develops from paired primitive longitudinal neural arteries that are formed in the 4-5 mm embryo during its first stage of development⁵. These vessels course longitudinally along the ventral portion of the hindbrain (rhombencephalon) and form focal connections with each

Figure 1 Type I: fenestration locating proximal to AICA, Type II: bilateral AICA symmetrically originating from the fenestrated trunk, Type III: unilateral AICA originating one side of the fenestrated trunk, Type IV: fenestration locating distal to AICA.

other across the midline. During the second stage of development, at five weeks' gestation, fusion of the channels gradually starts to form

the basilar artery. When the paired longitudinal neural arteries fail to fuse, fenestration may occur anywhere along the course of the basilar

Figure 2 Double fenestration.

artery^{5,7,33}. In the literature, the most frequent site of basilar artery fenestration is in the proximal portion⁵⁻¹⁰. The middle or distal part of the basilar artery is rarely affected. These data are well corresponded to our current results.

Relation with Ischemic Disease

Haemodynamic alterations and turbulence may make the fenestrated artery a more likely site for thrombosis than a normal artery. Black SP et Al.²⁵ noted endothelium-lined partial intraluminal septa within the fenestrated artery that can appear as spurs. Such spurs could act as points of turbulence and initial sites for potential thrombosis.

The possibility of thrombosis within a fenestrated artery was postulated by Takahashi et Al.¹, and Berry AD 3rd et Al.²⁶ Haemodynamic disturbances and turbulent blood flow at the

site of fenestration may be the cause of the thrombosis that occurred in this artery.

Frequency of Fenestration

The natural incidence of fenestration of the basilar artery is difficult to define, and the data vary according to type of series and modalities of detection. Pathologic frequency based on autopsy series varies from 1.3% to 5.3%²⁴ while angiographic frequency varies from 0.022% to 1.7%^{1,3,20-23}.

The discrepancy between the autopsy and angiographic frequency can be explained by the fact that in some fenestration its size is very thin and in some projection is angiographically not visible. High resolution MRA and stereoscopic observation can delineate such a small fenestration despite of the complex configuration. Additionally the modern radiological modalities such as 3D helical CT with multi channel detectors and 3D rotational digital subtraction angiography are definitely helpful in accurate understanding of the real morphology as well as the regional anatomy.

Aneurysm Associated with Fenestration

Finlay and Canham²⁷ reported that the lateral walls of the fenestrated artery had a normal intrinsic architecture. The media is absent locally, with discontinuity of elastin at the proximal end of the fenestration. The subendothelium is thickened distally and thinned proximally. This characteristic of the luminal architecture explains the formation of aneurysm associated with fenestration.

In our series, one case showed the aneurysm located distal end of the fenestrated trunk. In the recent literatures, the number of the reports is increasing that endovascular approach may represent a suitable treatment for aneurysms associated with fenestration^{8,14}.

Table 1 **Classification of BA fenestration.**

Type I: Fenestration locating proximal to AICA	13 cases
Type II: Bilateral AICA symmetrically originating from fenestrated trunk	6 cases
Type III: Unilateral AICA originating from one side of fenestration (asymmetrical fenestration)	3 cases
Type IV: Fenestration locating distal to AICA	1 cases
Total	23 cases

Figure 3 A) Fusiform aneurysm at V4 portion. B) Aneurysm associated with fenestration confirmed with 3D helical CT. C) Invagination of the aneurysm into the brain stem originating from fenestration represented with hemifacial spasm.

Conclusions

We report neuroradiological analysis of 23 cases of basilar artery fenestration based on 2280 cases of MR angiographies. The knowledge and recognition of BA fenestration from the point of the developmental anatomy and embryology are useful and important in the interpretation of MR angiography. Our current

study showed that the vertebro-basilar junction should be included in the imaging slices of routine MR angiography, because of its highly association with saccular aneurysms as well as ischemic disease.

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