Variations Involving The Distal Vertebral Artery

Jin HUA¹, Sun ZE-LIN², Yang LI-ZHUANG³

¹Department of Neurosurgery, The third affiliated hospital of Harbin Medical University, HaPing Road, Harbin, Heilongjiang, China ²Department of Neurosurgery, Hebei United University affiliated hospital, 57 JianSheNan Road, Tangshan, HeBei province, P. R. China ³Department of Neurosurgery, The second affiliated hospital, Harbin Medical University, Harbin, Heilongjiang, China

Summary

Objectives: To investigate the variations in distal VA, from the viewpoint of angiography and microsurgical anatomy.

Methods: Variations involving the distal VA in digital subtraction angiography (DSA) were reported together with findings during cadaver study.

Results: Twenty-two variations were found in 21 patients, including 8 C-2 vertebral origins of the PICA, 10 duplicated (from 9 patients) and 4 aberrant distal VAs, respectively. Another aberrant distal VA was observed in one cadaver specimen. All the variants involved only the part of lateral spinal artery (LSA). Two aberrant distal VAs were indicated by DSA and another one was verified by anatomical study as extradural location, respectively.

Conclusions: Variants of distal VA included the C-2 vertebral origin of the PICA, duplicated and aberrant distal VA.

Key words: Lateral spinal artery, Posterior inferior cerebellar artery, Distal vertebral artery, Variation

Distal Vertebral Arteri Kapsayan Varyasyonlar

Özet

Amaç: Anjiografi ve mikrocerrahi anatomi açılarından distal vertebral arter (VA) varyasyonlarının araştırılması.

Yöntemler: Kadavra çalışmaları sırasında bulgular ile digital subtraksiyon anjiografi (DSA) esnansındaki distal VA varyasyonları.

Sonuçlar: Sırasıyla 8 C2 vertebral orijinli PICA, 10 çift çıkışı (9 hastada) ve 4 aberan distal VA olmak üzere 21 hastada 22 varyasyon tespit edildi. Bir kadavra örneğinde bir başka aberan distal VA gözlemdi. Tüm varyasyonlar sadece bir bölüm lateral spinal arteri (LSA) kapsıyordu. İki aberan distal VA DSA ile gösterildi ve bir başka varyant ise anatomik çalışmada ekstradural olarak saptandı.

Yargı: Distal VA varyasyonları PICA’nın C2 vertebral orijini, duplike ve aberan distal VA’ı içerir.

Anahtar Kelimeler: Lateral spinal arter, Posterior inferior cerebellar arter, Distal vertebral arter, Varyasyon
INTRODUCTION

Some typical variations in distal VA, including the C-2 vertebral origin of the posterior inferior cerebellar artery (PICA), duplicated and aberrant distal VA have also been discussed, but little attention has been paid to the significant role of the LSA in these variations from the viewpoint of microsurgical anatomy. In the present article, we focus on the aforementioned variations in distal VA related to the LSA (Figure 1).

MATERIAL AND METHODS

Twenty-two variations involving the distal VA were found by DSA in 21 patients. These variations were recruited and described in this study, documented and analyzed together with findings in cadaver study. A left aberrant distal VA in one cadaver specimen was present to documented the DSA demonstration.

RESULTS

1. DSA studies

Twenty-two variations involving the distal VA, together with its LSA, were demonstrated by DSA in 21 patients. These variants involved only the part of lateral spinal artery (LSA) (Figure. 2-5). C-2 vertebral origin of the PICA from the distal VA as the continuation of the LSA (Figure. 2) was observed in 8 patients. Six of them arise from the right, whereas another 2 arise from the left VA, respectively.

Hyperplastic LSA joining the distal VA segment at the level of C1, which resulted in the duplicated distal VA (or defined as the duplication of the distal VA of the LSA type (Figure. 3)(6)) was found in 10 case from 9 patients. Six of them arise from the left, whereas another 4 arise from the right VA, respectively. The diameter of the VA was equivalent to the variant of distal VA (Figure. 3A and B) in 6 patients, was larger than the variant (Figure. 3C and D) in 1, and was hypoplastic and smaller than the variant (Figure. 3E and F) in another 3 patients, respectively. In 4 patients, an aberrant distal VA(5,6) was showed to

Figure 1: Anatomy of suboccipital segment of the right distal VA. 1-distal VA; 2-distal VA; 3-Radicular artery; 4-the LSA; 5-Muscular branch; 6-C-2 ganglion; 7-Anterior ramus of the C-2 nerve; 8-Posterior ramus of the C-2 nerve; 9-Transverse process of atlas.
course medially between C2 and C1, instead of passing the transverse foramen of C1. As it reached the spinal canal, this aberrant distal VA turned rostrally and entered the cranial cavity (Figure. 4). 3 of them arose from the right, whereas another from the left, respectively. The course of the aberrant distal VA comprised both the hyperplastic LSA in all of 4 cases. One aberrant distal VA was found to give rise to the muscular branch of VA (Figure. 4C and D). Extradural origin of PICA\(^{(2,6)}\) was found in 2 of the aberrant distal VAs (Figure. 4C and D). One of them also gave rise to a muscular branch (Figure. 4C and D) that usually arises extradurally\(^{(7)}\) below the Foramen magnum (dash line) immediately near the dural penetration of VA. All the information indicated that the 2 aberrant distal VAs took an extradural\(^{(4)}\) but no intradural\(^{(6)}\) course between C2 and C1.

2. Cadaver study

A left aberrant distal VA taking a similar course as the 4 aberrant distal VAs demonstrated by DSA, was observed in one cadaver specimen. It coursed extradurally rather than intradurally in the spinal canal, covered with suboccipital venous plexus (Figure. 5A). As one of the aberrant distal VAs demonstrated by DSA, this one comprised both the hyperplastic LSA. The muscular branch of VA that accompanied the posterior ramus of the C-2 nerve (Figure. 5A and B) remained recognizable. Moreover, this aberrant distal VA also gave rise to both the muscular branch that usually arises from distal VA and the posterior meningeal artery at the level of C1, prior to piercing the dura mater to enter the cranial cavity (Figure. 5B).

**Figure 2:** A, DSA, left VA, anteroposterior view, showing a left C-2 vertebral origin of the PICA from the distal VA(arrows). B, DSA, left VA, lateral view, showing a left C-2 vertebral origin of the PICA from the distal VA as the continuation of the LSA. 1-Radicular artery; 2- LSA; 3-Muscular branch; 4-PICA; 5-LSA.
**Figure 3:** A, DSA, left VA, anteroposterior view, showing a duplicated distal VA. The diameter of the real VA was equivalent to the variant of distal VA; B, DSA, left VA, lateral view, showing the same duplicated distal VA in A; C, DSA, right VA, anteroposterior view, showing a duplicated of distal VA. The diameter of the VA was larger than the variant of distal VA. The variant involves only the part of LSA (arrows); D, DSA, right VA, lateral view, showing the same duplicated distal VA in C; E, DSA, left VA, anteroposterior view, showing a duplicated distal VA. The diameter of the real VA was diminutive and apparently smaller than the variant of distal VA. The variant involves only the part of LSA (arrows); F, DSA, left VA, lateral view, showing the same duplicated distal VA in E. 1-VA; 2-distal VA; 3-Variant of distal VA; 4-LSA; 5,6-Muscular branch of distal VA.

**Figure 4:** A, DSA, right VA, anteroposterior view, showing an aberrant distal VA, which coursed medially below the level of C1 (dash line), without passing the transverse foramen of C1, and then turned rostrally in the spinal canal and entered the cranial cavity; B, DSA, right VA, lateral view, showing the same aberrant distal VA in A; C, DSA, right VA, anteroposterior view, showing another similar aberrant distal VA as demonstrated in A and B. It gave rise to both a C1 extradural origin of PICA, and the muscular branch that usually arises at the level inferior to the Foramen magnum; D, DSA, right VA, lateral view, showing the same aberrant distal VA in C. It gave rise to both a C1 extradural origin of PICA, and the muscular branch that usually arises extradurally below the Foramen magnum immediately near the dural penetration of VA (dash line). 1-distal VA; 2-Aberrant distal VA; 3-Transverse process of atlas; 4-Posterior tubercle of atlas; 5-Muscular branch of VA from the level of C1; 6-Muscular branch of distal VA; 7-C1 extradural origin of PICA.
DISCUSSION

Lasjaunias and colleagues (5) reported that anatomic variants such as the C1 and C2 origins of the PICA, the duplicated and aberrant distal VA are related to variations in size and connection of the LSA. Siclari et al (6) classified this series of variations into LSA type and posterior spinal artery (PSA) type. If a hyperplastic variant from C-2 vertebral origin of the PICA further involve the PSA via ascending branch of the PSA that anastomoses with the PICA, it is classified as the PSA type; (6) Otherwise, it is classified as the LSA type of C-2 vertebral origin of the PICA. (5,6)

As the variants in this series incorporate only the section of LSA and the more proximal section of LSA remain uninvolved (Figure. 2 and 3), duplicated and aberrant distal VA, respectively. Not for the sake of terminology, but for the clinical significance of the VA and its LSA branch which is often encountered during several suboccipital approaches (a lateral, far-lateral, suboccipital midline or upper cervical approach). (2,7)

All 8 C-2 vertebral origins of the PICA recruited in the present series were LSA type and none of them was the PSA type. Both types, however, are originated from the radicular artery. The real distal VA remained recognizable (Figure 3) in all 10 cases of duplicated distal VA showed by DSA in this series, although 3 of them were hypoplastic (Figure. 3E and F). Four aberrant distal VAs showed by DSA in this series entered the spinal canal between C2 and C1 in stead of passing the transverse foramen of C1 (Figure 4). We agree that an aberrant distal VA like this, corresponds to the part of prominent LSA, whereas the real distal VA may be diminutive (Figure. 3E and F) or absent (as the 4 cases in this series) (Figure 4). In an aberrant distal VA demonstrated by DSA and another aberrant distal VA observed in our cadaver specimen, the muscular branch of VA accompanying the posterior ramus of the C-2 nerve (1) was found to arise from the aberrant distal VA. It is reasonable to reach the conclusion that aberrant distal VA was correspondent to a hyperplastic LSA. Contrary to previously reported an intradural course of distal VA (3,6), the aberrant distal VA in one of our cadaver specimen was found to enter the intradural
space more distally at the level of C1, resulting in an extradural\(^4\) course of distal VA between C2 and C1 (Figure. 5). We cast doubt on some reported intradural course of distal VA within the spinal canal based merely on DAS,\(^3,6\) lacking of information from either intraoperative findings or anatomical dissection. Moreover, 2 aberrant distal VAs demonstrated by DSA in this series, were found to give rise to both a C1 extradural origin of PICAs.\(^2,6\)

One of them was also found to give rise to a muscular branch that usually arises extradurally immediately before the dural penetration of VA (Figure. 4C and D).Such information indicates that the segment of the 2 aberrant distal VAs between the level of C2 and C1 should be extradurally located within the spinal canal.

Whether an extradural course of distal VA may also occur to a variant of a duplicated distal VA or even a C-2 vertebral origin of the PICA? No information has ever been offered by DSA in this series. Further study is therefore, required. An extradural variant is more liable to inadvertent injury during 9 surgeries, because it lacks of protection by dura mater. In addition, it may not always be distinguished from an intradural one by DSA. A probable extradural course of distal VA should be kept in mind when a duplicated, an aberrant distal VA, or even a C-2 vertebral origin of the PICA is showed by DSA, to avoid intraoperative iatrogenic injury to these variants.

**CONCLUSION**

Variants of distal VA included the C-2 vertebral origin of the PICA, duplicated and aberrant distal VA. It is the LSA that really account for the C-2 vertebral origin of the PICA, duplicated and aberrant distal VA. Exist of extradural course of an aberrant distal VA has been not only indicated by DSA, but also verified by cadaver dissection. Preoperative DSA should be advocated to find variations involving the distal VA.

**Abbreviations:** LSA=Lateral spinal artery; PICA=Posterior inferior cerebellar artery; VA=Vertebral artery; LSA=Lateral spinal artery; VA=Vertebral artery.

**Correspondence to:**
Yang Li-Zhuang
E-mail: lizhuangyang@sohu.com

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