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ANATOMIC VARIATIONS

C3 segmental vertebral artery diagnosed by computed tomography angiography

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Abstract
Extremely rarely, the vertebral artery (VA) enters the subarachnoid space via the intervertebral space of the C2–3 vertebrae. We have identified three cases with this anomalous VA in the literature. We report here another case involving aberrant VA penetration of the dura at the C2–3 vertebral level diagnosed by computed tomography (CT) angiography. A 71-year-old-woman with memory disturbance underwent brain CT and CT angiography. The right VA was aberrant and penetrated the dura at the C1–2 vertebral level. On the left side, the VA penetrated the dura at the C2–3 vertebral level. To our knowledge, this anomalous VA is the first case of C3 segmental VA diagnosed by CT angiography. To prevent VA injury, it is important to identify this variation before performing a posterior fusion of the cervical vertebrae.

Keywords Vertebral artery · Computed tomography angiography · Anatomic variation · Spinal fusion

Introduction

Normally, the V3 segment of vertebral artery (VA) enters the subarachnoid space via the atlanto-occipital space. However, the VA sometimes enters the subarachnoid space at the C1–2 intervertebral level, a variation regarded as a C2 segmental type of VA [11, 18] or aberrant VA with an intradural course at the C1–2 vertebral level [5]. The prevalence of the C2 segmental type of VA has been reported as 3.2% identified by magnetic resonance angiography [16] and as 3.3% identified by computed tomography (CT) angiography [6].

Extremely rarely, the VA enters the subarachnoid space at the C2–3 intervertebral level. We have identified three similar cases in the literature [7, 15]. Two cases were diagnosed by magnetic resonance angiography [15]. Lasjaunias et al. [7] reported another case diagnosed by vertebral angiography (Fig. 3.64 in the textbook [7]). We have encountered one case involving an aberrant VA with an intradural course at the C2–3 vertebral level diagnosed by CT angiography.

In this paper, we review the development of the aberrant VA with an intradural course at the C2–3 vertebral level and evaluate the clinical significance of this anomalous artery for cervical spinal posterior fusion. Especially, we will discuss posterior spinal fusion in left side of the atlas, axis, and 3rd cervical vertebra adjacent to C3 segmental type of VA.

Case report

A 71-year-old-woman with memory disturbance and headache underwent brain CT and CT angiography for evaluation of her vascular condition. CT angiography showed anomalous courses of both VAs. The right VA was aberrant and took an intradural course at the C1–2 vertebral level. On the left side, the VA entered the subarachnoid space at the C2–3 vertebral level (Figs. 1, 2). And both posterior inferior cerebellar arteries were originated from both distal intradural VAs. An axial image of the atlas showed poorly developed vertebral foramens on both sides. And we did not identify any bony abnormality in the cervical vertebra and cervico-occipital joint. Conservative treatment improved her memory disturbance and headache.

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Fig. 1 Reconstructed computed tomography angiography demonstrates anomalous courses of both vertebral arteries (VAs). The right VA (white arrowhead) enters the subarachnoid space at the C1–2 vertebral level. The left VA (red arrow) enters the subarachnoid space at the C2–3 vertebral level

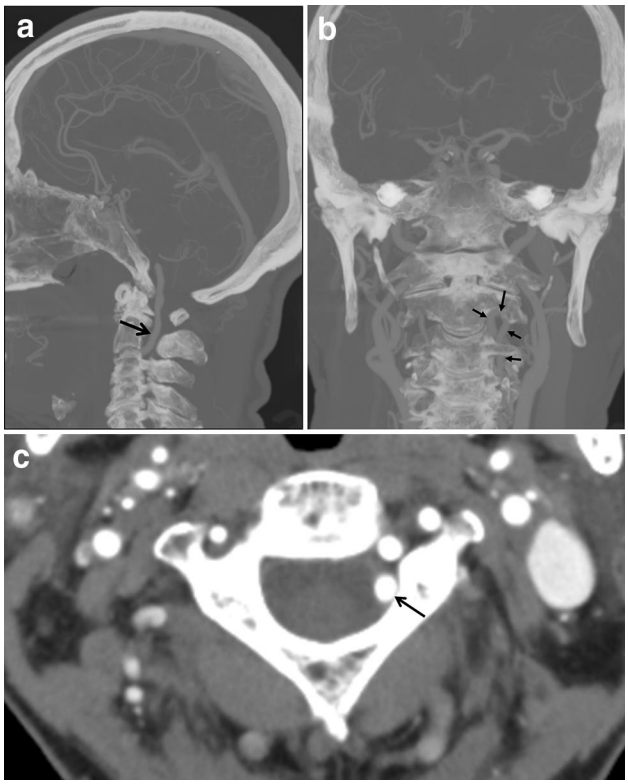

Fig. 2 Computed tomography sagittal image **a** shows the vertebral artery (VA) located in the subarachnoid space at the C2–3 vertebral level over. Computed tomography coronal image **b** demonstrates that the left VA is located in the cervical left third vertebral foramen, and the vertebral arterial loop is located at the C2–3 vertebral level. (Arrow: left VA) Computed tomography axial image **c** at level of axis demonstrates the left VA (arrow) located in intradural space

Discussion

Development of C3 segmental VA

Several mechanisms have been suggested to explain the development of C2 or C3 segmental VA. The first is a persistent cervical intersegmental artery (CIA). Failure of involution in one of the first six CIAs (i.e., a persistent CIA) causes a variety of abnormal origins of the VA. Occurrence of a persistent CIA in the upper (first and/or second) CIAs results in an abnormal origin of the VA from the internal or external carotid artery. Occurrence of a persistent CIA in the lower (third through sixth) CIAs leads to an abnormal origin of the VA from the aortic arch or the common carotid artery [2]. The segment of the VA proximal to a persistent CIA is generally absent [9]. However, we could not identify any abnormal origin of either anomalous VA of our patient. Therefore, persistent CIA does not appear to explain the anomalous VAs described here. An aberrant VA with an intradural course at the C2–3 vertebral level or C3 segmental VA is a more precise term for describing the left VA observed in this patient [5].

The second possible mechanism suggested by Zhu et al. [19] and supported by Siclari et al. [12] states that the distal part of the C2 segmental VA originates from the lateral spinal artery (LSA). However, Zhu et al. [19] suggested that the proximal part of the C2 segmental VA develops from a hyperplastic radiculomuscular artery because of the extradural course of the proximal part of this artery. The LSA originates lateral to the medulla, from either the posterior inferior cerebellar artery or the intradural VA. The LSA courses parallel to the cervical cord and the spinal component of the 11th nerve, anterior to the posterior nerve rootlets, and posterior to the dentate ligament. The LSA typically fuses with the ipsilateral VA or posterior inferior cerebellar artery superiorly and extends inferiorly to the level of C4, where it courses posteriorly and fuse with the posterior spinal arteries (PSAs) [8, 14]. We also agree that the distal part of a C2 or C3 segmental type VA originates from the LSA

or PSA. However, we do not agree with the view of Zhu et al. [19] that the proximal part of the C2 or C3 segmental type of VA develops from a hyperplastic radiculomuscular artery. Several collaterals can be found between the LSA system and the VAs, and these collaterals course through the extradural space. The LSA anastomoses with the extradural arteries arising from the vertebral or occipital arteries.

The third possible mechanism was suggested by Lasjaunias et al. [7], who proposed a schematic representation of different arrangements of the vertebrobasilar system. Siclari et al. [12] later described the detailed developmental anatomy of the LSA or PSA after a thorough analysis of cerebral angiography. These authors suggested that the intradural course of the distal VA at the C1–2 or C2–3 level is related to variations in the size and connection of the LSA or PSA [12]. We agree with the view of Siclari et al. [12].

In our patient, the left C3 segment VA was located at the center of the sagittal CT in Fig. 2a, like the position of the LSA, not the posterior portion of the vertebral column, as in the PSA. In our opinion, the intradural course of the left VA at the C2–3 vertebral level in this patient corresponds to an enlarged LSA.

Clinical significance of a C3 segmental VA for posterior fusion of cervical vertebrae

The three reported cases of a C3 segmental VA have little clinical significance by themselves, but its presence may be dangerous during surgery for spinal posterior fusion. Overall, the risk of VA injury during cervical spine surgery is low. However, in the presence of anomalous VA anatomy, injury can occur even when standard anterior or posterior techniques are used [1, 10]. All preoperative imaging studies should be carefully reviewed. The positions of the VA and its relation to bony and surrounding structures should be noted on the preoperative CT or magnetic resonance imaging scans.

Several posterior arthrodesis techniques for atlantoaxial instability have been proposed. In this patient, atlas lateral mass screw combined with axis lateral mass screw fixation is a safe method for left atlantoaxial fusion. Harms and Melcher [4] mentioned that atlas lateral mass screw combined axis pedicle screw was a reliable technique. But in this patient, pedicle screw fixation for the left side of the axis is dangerous because of left VA running into spinal canal at this level. Another available technique for left atlantoaxial fusion is the transarticular screw fixation.

Pedicle screws can be used in subaxial spinal fusion but involve a risk of VA injury. In the patient reported here, pedicle screw fixation for the left second or third cervical vertebra involved a greater risk of VA injury because of the intradural course of the left C3 segmental VA at this level. A laminar screw method in the second or third cervical spine is feasible because it also provides sufficient spinal rigidity [13]. However, in this patient, the trajectory of laminar screw method for the second or third cervical vertebrae must be aimed parallel to the downslope of the dorsal aspect of the contralateral lamina to prevent screw breakout ventrally into the spinal canal [17]. Another spinal fusion technique using lateral mass screws with the Roy-Camille or Magerl techniques has been used to restore stability of the subaxial spine [3]. Lateral mass screw fixation for the left third cervical vertebra in this patient can be performed with less risk of left VA injury. During posterior fusion of the upper cervical vertebra, the surgeon should pay close attention to the possible presence of this anomalous vessel and select an appropriate surgical technique.

Conclusion

The C3 segmental type of VA is extremely rare, with only three cases having been reported. It is important to identify this unique type of VA before performing cervical spinal surgery. When planning and performing a posterior fusion of upper cervical vertebrae, the surgeon should pay close attention to the possible presence of this anomalous vessel.

Author contributions KMS and MJU have read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors report no conflict of interest concerning the materials and methods used in this study or the findings specified in this report.

References

1. Burke JP, Gerszten PC, Welch WC (2005) Iatrogenic vertebral artery injury during anterior cervical spine surgery. Spine J 5:508–514
2. Chen CJ, Wang LJ, Wong YC (1998) Abnormal origin of the vertebral artery from the common carotid artery. AJNR Am J Neuroradiol 19:1414–1416
3. Deen HG, Birch BD, Wharen RE, Reimer R (2003) Lateral mass screw-rod fixation of the cervical spine: a prospective clinical series with 1-year follow-up. Spine J 3:489–495
4. Harms J, Melcher RP (2001) Posterior C1-C2 fusion with polyaxial screw and rod fixation. Spine (Phila Pa 1976) 26:2467–2471
5. Kim MS (2016) Developmental anomalies of the distal vertebral artery and posterior inferior cerebellar artery: diagnosis by CT angiography and literature review. Surg Radiol Anat 38:997–1006
6. Kim MS (2018) C2 Segmental-Type Vertebral Artery Diagnosed Using Computed Tomographic Angiography. J Korean Neurosurg Soc 61:194–200

7. Lasjaunias P, Berenstein A, Ter Brugge KG (2001) Surgical Neuro-angiography, vol 1 Clinical vascular anatomy and variations, 2nd edn. Springer, Berlin, pp 224–260
8. Lasjaunias P, Vallee B, Person H, Ter Brugge K, Chiu M (1985) The lateral spinal artery of the upper cervical spinal cord. Anatomy, normal variations, and angiographic aspects. J Neurosurg 63:235–241
9. Mayer PL, Kier EL (1993) The ontogenetic and phylogenetic basis of cerebrovascular anomalies and variants. In: Apuzzo ML (ed) Brain surgery complication avoidance and management. Churchill Livingstone, New York, pp 709–760
10. Neo M, Sakamoto T, Fujibayashi S, Nakamura T (2005) A safe screw trajectory for atlantoaxial transarticular fixation achieved using an aiming device. Spine (Phila Pa 1976) 30:E236–E242
11. Sato K, Watanabe T, Yoshimoto T, Kameyama M (1994) Magnetic resonance imaging of C2 segmental type of vertebral artery. Surg Neurol 41:45–51
12. Siclari F, Burger IM, Fasel JH, Gailloud P (2007) Developmental anatomy of the distal vertebral artery in relationship to variants of the posterior and lateral spinal arterial systems. AJNR Am J Neuroradiol 28:1185–1190
13. Tanabe H, Aota Y, Saito T (2016) Laminar screw fixation in the subaxial cervical spine: a report on three cases. World J Orthop 7:695–699
14. Trimble C, Reeves A, Pare L, Tsai F (2013) Vertebral artery anomaly causing C2 suboccipital neuralgia, relieved by neurovascular decompression. J Neuroimaging 23:421–424
15. Uchino A, Saito N, Uemiya N, Sonoda K (2016) Diagnosis of a C3 segmental type of vertebral artery by magnetic resonance angiography: report of two cases. Surg Radiol Anat 38:873–876
16. Uchino A, Saito N, Watadani T, Okada Y, Kozawa E, Nishi N, Mizukoshi W, Inoue K, Nakajima R, Takahashi M (2012) Vertebral artery variations at the C1-2 level diagnosed by magnetic resonance angiography. Neuroradiology 54:19–23
17. Wright NM (2005) Translaminar rigid screw fixation of the axis. Technical note. J Neurosurg Spine 3:409–414
18. Yoshida T, Shiga K, Uraoka M, Yoshikawa K, Owada K, Nakagawa M (2005) C2 segmental type of vertebral artery with recurrent embolic strokes. Cerebrovasc Dis 20:58–61
19. Zhu SW, Yang Y, Liu YG, Cao JW, Li F (2018) Anatomical features and clinical significance of radiculomuscular artery variants involving the suboccipital segment of vertebral artery: angiographic and cadaver studies. Clin Neuroradiol 28:75–80