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Possible compression of the atlantal segment of the vertebral artery in occipitalisation

J. Skrzat, J. Walocha, G. Goncerz

Department of Anatomy, Collegium Medicum, Jagiellonian University, Krakow, Poland

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The current study evaluates the passage of the atlantal segment of the vertebral artery through the atlas to the cranial cavity in the case of occipitalisation, and searches for potential bony obstacles that constrict the lumen of the vertebral artery.

Morphometric analysis was performed of the ossified atlanto-occipital articulation of the dry adult male skull, particularly in the region of the posterior arch of the atlas.

The distance between the floor of the right groove for the vertebral artery and the occipital bone was measured using a digital sliding caliper. On the left side, measurements of the diameters of the inlet and outlet of the canal for the vertebral artery were performed using the same technique.

Fusion of the left portion of the posterior arch of the atlas with the occipital bone caused significant narrowing of the space around the normally existing groove for the vertebral artery, and converted it into the canal. The size of the intracranial opening of the canal for the vertebral artery was measured as 3.8 mm × 4.7 mm, whereas the inlet to the canal was 5.4 mm × 7.0 mm. The diameter of the canal decreases, particularly at the entrance into the cranial cavity; therefore, compression of the vertebral artery within the canal seems to be possible. (Folia Morphol 2011; 70, 4: 287–290)

Key words: assimilation of atlas, vertebral artery, basicranium

INTRODUCTION

Occipitalisation is a cranial anomaly that occurs when the first cervical vertebra (the atlas) fuses with the occipital bone. There is a partial or complete fusion between the atlas and the base of the occiput. The assimilation usually involves the anterior arch of the atlas, the lateral masses or the entire atlas [1, 10]. This condition may significantly disturb the haemodynamic function of the vertebral artery while it passes through the craniovertebral junction. The vertebral artery is divided into four segments, but only the atlantoaxial and intracranial segments can be modified by occipitalisation because they are in close relation to the atlantooccipital synostosis [5].

Normally, the vertebral artery lies in a groove located on the superior surface of the posterior arch of the atlas, behind the superior articular facet. The groove (*sulcus arteriae vertebralis*) is sometimes converted into a foramen by a delicate bony spicule, which arches backward from the posterior end of the superior articular facet [3].

The aim of this study is to evaluate the morphological alteration of the osseous structures around the atlantal segment of the vertebral artery in respect to the case of severe occipitalisation. Hence,

Address for correspondence: Dr hab. n. biol. J. Skrzat, Department of Anatomy, *Collegium Medicum*, Jagiellonian University, ul. Kopernika 12, 31–034 Kraków, Poland, tel: +48 12 422 95 11, e-mail: jskrzat@poczta.onet.pl

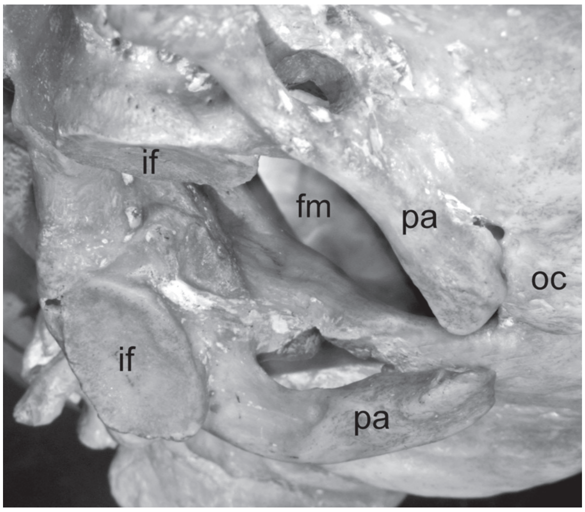

Figure 1. Inferior aspect of the basicranium with assimilated atlas to the occipital bone; if — inferior articular facet of the atlas; pa — posterior arch of the atlas; fm — foramen magnum; oc — occipital bone.

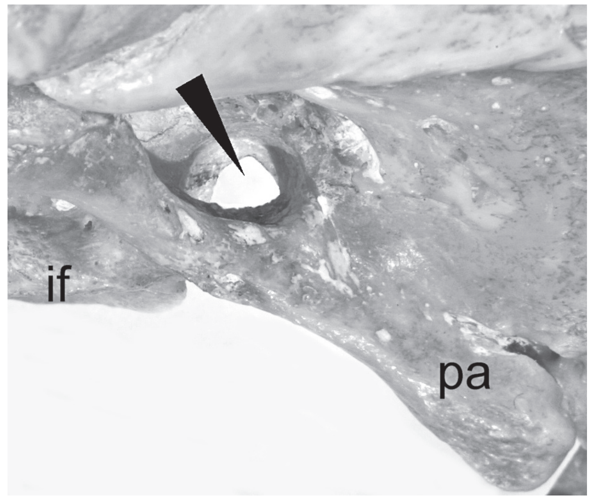

Figure 2. Lateral view of the outer aspect of the basicranium demonstrating the inlet to the canal for left vertebral artery (indicated by arrow); if — inferior facet of the atlas; pa — posterior arch of the atlas.

we try to conclude whether evidence derived from morphological and metrical analyses performed on a dry skull are sufficient to deduce potential perturbations of the blood flow in the vertebral artery.

MATERIAL AND METHODS

A skull belonging to the cranial collection housed in the Department of Anatomy of the Medical College of the Jagiellonian University manifests a case of severe occipitalisation. The skull is well preserved and does not show any traits of craniofacial deformities. Its morphological characters and the degree of cranial suture obliteration indicate that it belonged to an adult individual of the male sex, about 45 to 50 years old.

Occipitalisation of the analysed skull is primarily expressed by: complete assimilation of the right and left superior facets of the atlas with the occipital condyles, fusion of the anterior arch of atlas with the basilar part of the occipital bone, and partial fusion of the posterior arch (Fig. 1).

The anatomy of the osseous components that accompany the vertebral artery in the cranio-vertebral junction was evaluated by visual inspection and adequate measurements. The distance between the floor of the right groove for the vertebral artery and the occipital bone was measured using a digital sliding caliper. On the left side, measurements of the diameters of the inlet and outlet of the canal for the vertebral artery were also performed by the same technique.

RESULTS

Fusion of the left portion of the posterior arch of the atlas with the occipital bone caused significant narrowing of the space around the normally existing groove for the vertebral artery. Instead there is a canal which transmitted the left vertebral artery towards the cranial cavity. The vertical distance between the right groove for the vertebral artery and the occipital bone was measured to be 6.5 mm. On the left side the distance between the left groove for the vertebral artery and the occipital bone was found to be 7.0 mm but further diminished to 5.4 mm at the inlet to the vertebral canal. The size of the intracranial opening of the canal for the vertebral artery was measured as: 3.8 mm × 4.7 mm. The canal for the vertebral artery of the atlas has a conical shape with a top of pyramidal lumen directed towards the posterior cranial fossa (Fig. 2). The shape of the canal seems to reflect a localised decrease in the diameter of the vertebral artery at the entrance into the posterior cranial fossa (Fig. 3). The internal opening of this canal is posterior to the internal aspect of the hypoglossal canal.

DISCUSSION

The vertebral artery is vulnerable to compression caused by external factors such as osseous exostosis or vertebral distortion. In the atlas vertebra, bony bridges may change normal route of the vertebral artery and cause external pressure as it

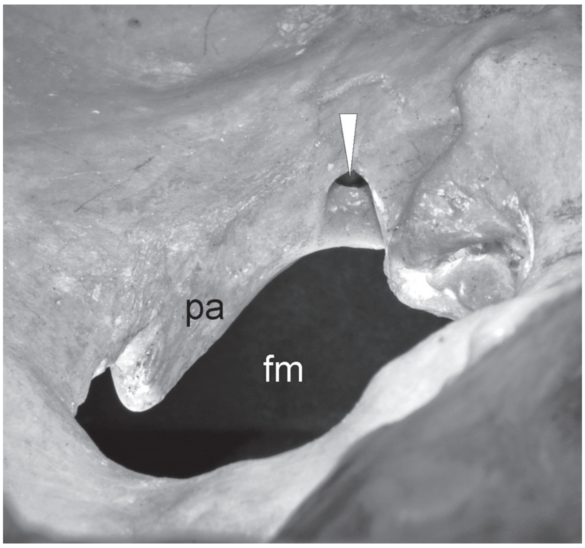

Figure 3. A site for compression of the vertebral artery indicated by arrow; fm — foramen magnum; pa — posterior arch of the atlas.

passes from the transverse foramen to the cranium *via* the foramen magnum. According to Tubbs et al. [11], the abnormal pathway through which the vertebral artery enters the crania involves an osseous foramen created between the fused atlas and occipital bone. Furthermore, Wang et al. [12] reported four different anomalous pathways of the vertebral artery in the craniovertebral junction with occipitalisation.

The presence of accessory osseous structures may also reduce the cross-sectional area of the vertebral artery, compromising its blood flow [6]. Bernini et al. [2] deduced that modification of the calibre of the vertebral artery is quite frequent in malformation of the occipito-cervical joint, and coexists with morphologic and functional changes of the vessel. In such a case, hypoplasia or dysgenesis of the vertebral artery may occur.

The degree to which the vertebral artery is compressed depends on the ratio between the artery diameter and the size of the canal. The diameter of the vertebral artery ranges from 2.3 mm to 7.4 mm [3] or from 0.5 mm to 5.5 mm [4]. According to these studies, one may conclude that the diameter of the vertebral artery fluctuates considerably between different individuals. In turn, the superoinferior diameter of the canal for the vertebral artery ranges from 4.6 mm to 6.1 mm, while the anteroposterior diameter ranges from 5.6 mm to 7.2 mm on the right side [9].

Comparing the potential diameters of the vertebral artery to the normal diameters of the canal transmitting this artery, we presume that the coincidence of a large calibre of the vertebral artery and a canal of small diameter may play a crucial role in compression. Nevertheless, it is still a subject of controversy whether bony bridges cause compression of the vertebral artery located inferiorly. According to Cacciola et al. [3], the vertebral artery occupies 42% to 71% of the groove on the posterior arch of the atlas, although it can be also occupied completely. Thus, the relationship between the artery diameter and the size of the osseous groove can be a condition influencing on the potential compression of the blood vessel.

In our case the abnormal pathway through which the left vertebral artery entered the posterior cranial fossa involved an osseous foramen created between the fused atlas and the occipital bone. Based on measurements of the canal for the vertebral artery in our specimen, and by comparing its diameters to the range of variation of the vertebral artery, we concluded that the intracranial opening of the canal could not provide adequate space for normal transmission of the vertebral artery. This view can be supported by a considerable disproportion between the sizes of the inlet and outlet of the canal. A wide inlet to the canal may suggest a large calibre of the vertebral artery which had to decrease to pass through the relatively small opening to the cranium. Disproportion between the diameters of the inlet and outlet of the canal for the vertebral artery may also suggest that the vertebral artery was thicker in the vertebral column than in the cranial cavity. Thus, we presume that vasoconstriction could occur as a result of local bony obstacles. The vertebral artery may be either intermittently or permanently compressed by different bony structures during head movement [7, 8].

The fusion of the posterior arch of the atlas could cause a compression of the arterial wall and narrowing of its lumen. In fact, blood flow velocities in the vertebral artery might have been significantly decreased. Nevertheless, it is not sufficient to judge objectively from the morphology of the dry skull whether abnormal transition and narrowing of the vertebral artery caused clinical symptoms. We can only hypothesize that in the studied case that the reduced space available for the passage of the left vertebral artery could restrict blood flow in the vessel.

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