Anatomical relationships between the $V_2$ segment of the vertebral artery and the cervical nerve roots

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Object. During surgical procedures focused on the cervical nerve roots, the surgeon works in proximity to the $V_2$ segment of the vertebral artery (VA). Depending on the specific surgical approach, it may be necessary to identify, expose, or mobilize the artery. In most cases, the artery may be left undisturbed. To reduce the risk of iatrogenic injury to the $V_2$ segment during anterior and anterolateral approaches to the cervical spine, the authors analyzed the relationship between the $V_2$ segment and the proximal segment of the C3–6 nerve roots.

Methods. Six cadaveric cervical spines (12 sides) were fixed with formalin, injected with red and blue latex, and investigated intraoperatively using different magnifications ($\times 3$–40). The VA rested on the anteromedial surface of the cervical nerve roots at the level of each intertransverse space. The exiting nerve roots intersected the VA at a distance ranging from 4.5 to 8.1 mm (mean 6.3 ± 1.06 mm) from the dural sac. The distance was slightly shorter at cephalad levels, suggesting that the artery is more posteriorly and medially situated at those levels. Arterial pedicles anchored the VA to the cervical nerve roots at various levels. These arteries gave rise to purely radicular, ligamentous, and medullary branches without a predictable pattern. After reaching the nerve roots on their lower margin, the nonligamentous branches pierced the radicular dural sheath within the neural foramen at a distance of 2 to 4 mm from the VA.

Conclusions. Proximal-to-distal dissection of a cervical nerve root may proceed with relative safety for at least 4 mm. The $V_2$ segment of the VA gives rise to at least one radicular arterial pedicle between C-4 and C-6. These trunks give rise to purely radicular, ligamentous, and medullary branches in an unpredictable pattern.

Key Words • cervical spine • spinal nerve root • vertebral artery • spinal surgery

The VA is traditionally divided into four portions. The $V_2$ segment extends from the VA entry into the C-6 foramen to the transverse foramen of C-2. It is the longest segment of the VA and is, for the most part, embedded within its own osseous canal, in close relationship with the exiting cervical nerve roots. The $V_2$ segment itself is rarely the target of a surgical approach. However, in a number of commonly performed procedures such as cervical corpectomy, cervical foraminotomy, and anterior discectomy, the surgeon works very close to the $V_2$ segment. Although rare, direct injury of this portion of the VA during cervical surgery is a well-known complication. Several investigators have detailed the basic anatomy of the VA. However, little attention has been given to the mutual relationships between the VA and the exiting cervical roots. In this study, we investigated the specific features of the neurovascular complex formed by the second segment of the VA and the related cervical nerve roots.

Abbreviations used in this paper: VA = vertebral artery; VB = vertebral body.

Materials and Methods

Six cadaveric cervical columns (12 sides) were fixed with formalin, kept in a 60% alcohol solution, and then injected with red and blue latex. The $V_2$ segment of the VA was investigated under different magnifications ($\times 3$–40). The artery was exposed in a stepwise fashion, within its own canal, from an anterolateral direction. The dural sac and the cervical nerve roots were uncovered by a progressive, radical drilling of the VBs and of the transverse processes, while the VA was left in situ. The distance between the nerve root axilla and the point where the VA intersects the root itself was recorded, and the relationships between the nerve roots and the collateral branches of the $V_2$ segment were described.

Results

The VA was found to have a close relationship with the cervical nerve roots. At the level of each intertransverse space, the posterior surface of the artery rested on the anteromedial aspect of the nerve roots (Fig. 1A). The nerve roots exiting at C3–6 intersected the $V_2$ segment at a distance ranging from 4.5 to 8.1 mm (mean 6.3 ± 1.06 mm) from the dural sac, as measured on the side of the nerve axilla (Fig. 1B). The distance was slightly shorter at cephal-
alad levels (Table 1). The exiting roots at each level were surrounded by extensive venous plexuses (Fig. 1B). These venous channels were uniformly distributed along the entire length of the exiting nerve root, forming a direct communication between the epidural venous plexus and the venous plexus surrounding the VA.

Collateral branches arose from the medial and posterior sides of the VA. The medial branches were directed to the anterior longitudinal ligament and the VBs. These tiny vessels were observed in 21 (58%) of the 36 examined levels and were normally covered with the bellies of the longus colli and longus capitis muscles. Radiculart branches arose from the posterior surface of the VA between C-4 and C-6 in 14 (39%) of the 36 levels examined. These medially directed branches left the VA at the inferior margin of the corresponding nerve root, entered the neural foramen with an ascend ing course, and followed the nerve root with variable branching patterns. In each specimen, these radicular branches supplied the corresponding nerve root. In six of 14 cases, the radicular trunk sent a collateral branch into the virtual space between the posterior longitudinal ligament and the VB. In nine of 14 cases, the radicular trunk concluded at the spinal cord as a contributor of the anterior or the posterolateral medullary axes (Fig. 1C). In each case, the radicular branches pierced the dural sheath of the corresponding nerve root within the neural foramen at a distance ranging from 2 to 4 mm from the VA trunk.

At the C-3 level, the V$_2$ segment of the VA consistently gave rise to a collateral branch in the retroodontoid arterial arch and a lateral branch that crossed the extraforaminal portion of the cervical nerve roots and united with the ascending cervical artery (Fig. 1A). No medullary branches were observed at this level.

**Discussion**

Vertebral artery injury is a potential complication of a number of commonly performed surgical procedures involving the cervical spine. The likelihood of injury is particularly high in the late phase of these procedures, during the attempt to accomplish thorough decompression of a nerve root or removal of the most lateral portion of a normal or diseased VB. Smith, et al., in a review of 5 years
A thorough lateral
cutaneous and medially located at those levels.

Moreover, depending on the specific case, the landmarks
within the surgeon’s view during a lateral decompression.
Moreover, depending on the specific case, the landmarks
themselves might have been removed or displaced in an
early stage of the surgical procedure. In our opinion, one
of the best guides for understanding the position of the VA
during decompression of a cervical nerve root is the nerve
root itself. Therefore, we measured the length of the seg-
ment of each nerve root between the dural sac and the VA.

The cervical nerve roots intersect the VA at a variable
distance from their origin. Overall, dissection of a nerve
root in a proximal to distal direction can proceed with rel-
ative safety for at least 4 mm. In all specimens examined,
at least one radicular arterial pedicle was present between
C-4 and C-6. These trunks give rise to purely radicular,
ligamentous, and medullary branches in an unpredictable
pattern. This information is useful in minimizing the risk
of vascular complications during cervical spine surgery.

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TABLE 1
Length of cervical nerve roots measured from the dural sac
to the medial border of the second segment of the VA
in 12 cadaveric specimens*

<table>
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<th>C-5</th>
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<td>6.3</td>
<td>6.3</td>
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* The mean length was 6.3 ± 1.06 mm (± standard deviation).