



Anterior cervical spine blood supply: a cadaveric study

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Abstract

Purpose To describe the origin of the vessels supplying the anterior sub-axial cervical vertebrae (C3–C7) to further understand their potential influence on anterior bone loss after anterior cervical spinal surgery.

Method Cadaveric dissection was performed on ten adult human necks after latex perfusion of their subclavian, common carotid and vertebral arteries. The nutrient vessels of the sub-axial cervical spine were identified and traced to their origin. The course and distribution of these vessels and their nutrient foraminae are described.

Results In all cases the anterior nutrient vessels were derived from the thyro-cervical trunk with branches that passed over the longus coli muscles forming a leash of vessels in the pre-vertebral fascia which subsequently extended in a frond-like pattern to pass onto the anterior aspect of vertebrae. The more cranial the cervical level the fewer the number of nutrient vessels and foraminae. The distribution of the foraminae on the anterior vertebral body followed the oblique supero-medial course of the nutrient vessels.

Conclusion Nutrient vessels perforate the cervical vertebrae on their anterior surface. These are derived from a leash of vessels that lie within the pre-vertebral fascia overlying the longus coli muscles. The origin of these vessels is the ascending cervical artery with a variable contribution from the transverse cervical artery.

Keywords Cervical · Blood supply · Nutrient · Bone loss

Introduction

Surgery on the anterior cervical spine is common and typically involves a surgical approach between the pre-tracheal fascia and carotid sheath to gain access to the pre-vertebral fascia [4, 5]. The pre-vertebral fascia is then incised to expose the anterior longitudinal ligament (ALL) and subsequently the vertebral body and intervertebral disc (IVD) between the longus coli muscles [4, 9].

The most common procedures performed are anterior cervical discectomy and fusion (ACDF) and cervical disc arthroplasty (CDA). These procedures typically offer satisfactory outcomes. However, not all patients benefit equally. One complication that affects both procedures is anterior bone loss, which in the severe form can result in subchondral collapse and implant subsidence [10, 11]. The aetiology of this condition remains unproven, with authors proposing a biomechanical or avascular cause [3, 10–12].

The major blood supply to the anterior aspect of the cervical vertebrae is poorly understood. The vertebral arteries give off spinal branches that enter the spinal canal on the

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ventral surface of the associated nerve roots [2, 8]. In the intervertebral foramen three main branches are formed; a medial branch supplying the cord, a branch supplying the laminae and a branch to the dorsal arterial plexus [8]. It is commonly thought that branches of the dorsal arterial plexus supply the entire vertebra via two vessels. The first traverses around the vertebra to the front of the body. The other, crosses deep to the posterior longitudinal ligament (PLL) to anastomose with its counterpart from the other side before penetrating the vertebral body through the basi-vertebral foramen [8].

However, an earlier text by Harris and Jones and a report by Crock and Yoshizawa suggested that the anterior cervical blood supply is contributed to by both the vertebral arteries and the thyro-cervical and costo-cervical trunks of the subclavian artery [6, 8], in line with previous work published on the newborn [1, 13]. To our knowledge, these are the only publications of anatomical works assessing the blood supply of the anterior cervical spines.

Considering the potential for avascularity of the anterior vertebra being a cause for anterior bone loss, endplate collapse and implant subsidence, an accurate understanding of the anatomy is important. In this cadaveric study we aim to describe the origin of the vessels supplying the anterior sub-axial cervical vertebrae (C3–C7) to further understand their potential influence on anterior bone loss after anterior cervical spinal surgery.

Methods

Local ethical committee approval was obtained (IRB 408/17-ek). The sub-axial spine (C3–C7) of seven modified Thiel embalmed cadaveric specimens and three fresh specimens was investigated [7] (mean age 81.3 years, age range 73–95 years). Cadaveric specimens were excluded if they were not over the age of 18 years or if they had any evidence of previous neck surgery or trauma.

The great vessels were left intact and the origins of the anterior cervical vessels were exposed and then perfused with different coloured latex-based resins. These vessels were closed by sutures at the aortic arch and the branching of the internal carotid artery. The subclavian arteries were perfused with blue, vertebral arteries with green and the common carotid arteries with red resin, respectively. Cadaveric specimens were excluded if their vessels were too calcified to all latex perfusion.

Following the curing of the latex, the cadavers were disarticulated through the occipito-cervical and upper thoracic regions, maintaining the upper ribs and great vessels with the specimen. The soft tissues anterior to the cervical vertebrae were dissected and the skin, platysma, sternocleidomastoid, strap muscles, trachea and oesophagus were removed.

Further dissection of the pre-vertebral fascia and the anterior nutrient vessels was then performed under $2.5\times$ loupe magnification and followed to their origins to determine the source of the anterior nutrient vessels of the anterior cervical vertebrae. Incision of the nutrient vessels allowed the coloured resin to be determined. Following this dissection, the longus coli was progressively elevated off the cervical vertebrae to identify more lateral nutrient vessels. This was extended to the posterior vertebra and intervertebral foramen. Specific dissection of the posterior plexus was not performed. The anterior longitudinal ligament and periosteum was then removed to identify the nutrient foraminae. Finally, the vertebrae were removed and sectioned in the axial plane to describe the intraosseous supply.

Statistical analysis

All statistical comparisons were done using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and SPSS version 24 (IBM, Armonk, VA, USA). Cramér's ϕ correlations were determined following the Chi-square test to assess the association between the level of the cervical spine and the number of vessels or foraminae.

Results

All seven samples were included. In one specimen there was leak of resin which compromised the assessment of the perfusing vessels from the left side of the specimen. Consequently, this side of the specimen was excluded from analysis.

In all cases the anterior nutrient vessels were derived from vessels that passed over the longus coli muscles forming a leash of vessels in the pre-vertebral fascia (Fig. 1). The leash then formed a number of feeding vessels that extended



Fig. 1 Vessels passing over longus coli and forming a leash of vessel with frond-like projections

in a frond-like pattern to pass onto the anterior aspect of vertebrae. From here the vessels penetrated the vertebrae often through multiple anterior nutrient foramina.

We found that the source of the anterior cervical spine blood supply was dependent on the cervical level, but always from branches of the thyro-cervical trunk (Fig. 2). In the upper sub-axial spine (C3–C5) the anterior nutrient vessel was exclusively supplied by the ascending cervical artery. In the lower sub-axial cervical spine (C6–C7) the nutrient vessels were predominantly derived from the ascending cervical artery, but in addition, a variable contribution from the transverse cervical artery was observed (3/20 C6 or C7 levels).

In all vertebrae, except C7, more lateral nutrient vessels below the longus colli were identified and these were derived from branches of the vertebral arteries passing deep to this muscle. No vessels arising from the carotid arteries contributed to the anterior blood supply of the sub-axial cervical vertebrae.

All vessels terminated in nutrient foraminae. Most nutrient foraminae were located in the cranial third of the vertebra and because of the supero-medial orientation of the ascending cervical artery, most foraminae were seen along an oblique orientation from infero-lateral to supero-medial (Fig. 3).

The more caudal vertebrae had a greater number of feeding vessels than their more cranial counterparts (Fig. 4).

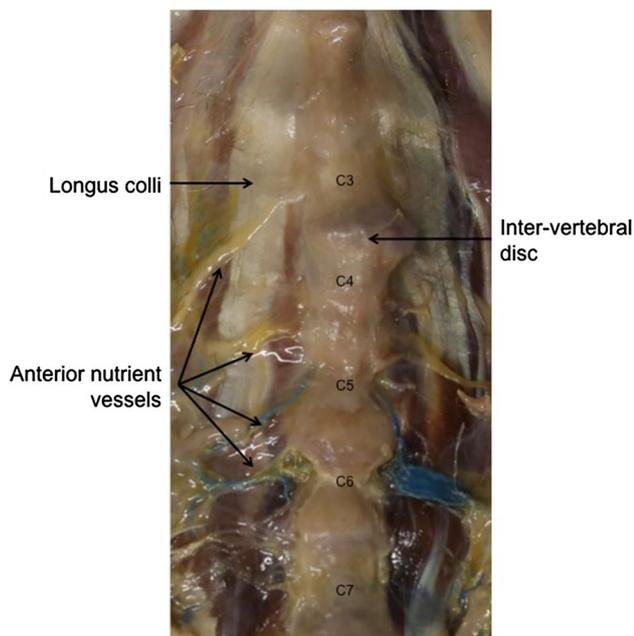


Fig. 2 Anterior view of the dissected specimen, with dissection carried out under 2.5×loupe magnification. This demonstrates perfusion to the anterior cervical vertebrae from branches supplied by the thyro-cervical trunk of the subclavian artery (blue). Note the incomplete resin penetration of the cranial vessels in this sample (colour figure online)

	Lateral	Para-central	Central	Para-central	Lateral
Cranial	12	10	28	4	11
Midline	6	6	5	5	4
Caudal	5			2	4

Fig. 3 Diagrammatic representation of the location of anterior nutrient foraminae. The values represent the percentage of all nutrient foraminae found in each section. The shading illustrates the direction of the branches of the ascending cervical vertebrae. Note this diagram does not include the lateral portion of the vertebral body and therefore the nutrient foraminae from the vertebral artery are not included

Similarly, the number of anterior nutrient foramina reduced more cranially and in one specimen no anterior nutrient foramen was identified at the C3 and C4 levels. Tables 1 and 2 illustrate the number of vessels and number of nutrient foraminae according to cervical level.

The maximal diameter of a nutrient foramen was 2 mm, but most nutrient foraminae were less than 1 mm in diameter. Secondary to these small dimensions, intra-osseous perfusion of resin was not achieved (Fig. 5).

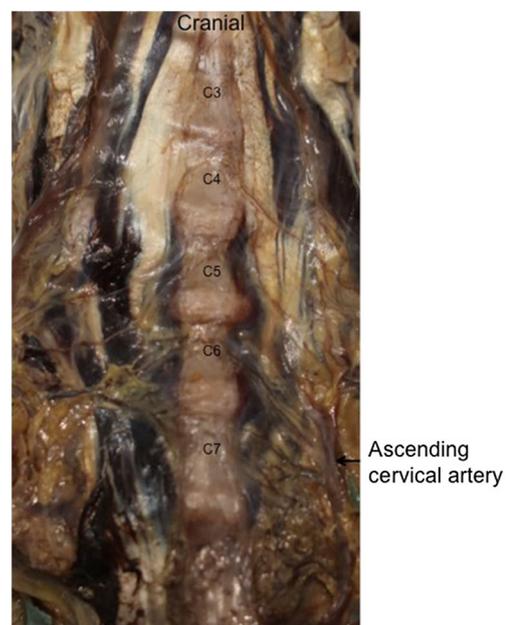


Fig. 4 Representative photograph illustrating the cranial to caudal difference in the number of nutrient vessels

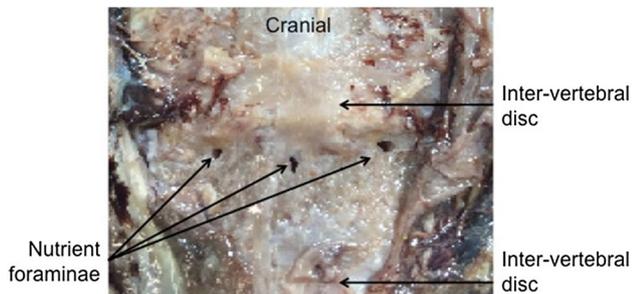
Table 1 Comparison of the number of feeding vessels according to cervical vertebral level

Level	Mean	<i>p</i> value			
		C4	C5	C6	C7
C3	0.8	0.004	0.338	0.885	0.154
C4	0.9		0.461	0.027	0.231
C5	1.3			0.632	0.621
C6	1.6				0.021
C7	1.5				

Bold denotes *p* value < 0.05

Table 2 Comparison of the number of nutrient foraminae according to cervical vertebral level

Level	Mean	<i>p</i> value			
		C4	C5	C6	C7
C3	2.2	0.301	0.484	0.446	0.334
C4	2.3		0.193	0.469	0.122
C5	2.8			0.062	0.321
C6	3.3				0.35
C7	4.7				

**Fig. 5** Representative photograph illustrating the nutrient foramen penetrating the anterior vertebra just below the superior end plate

Discussion

Our study has found variability in the anterior nutrient vessels of the cervical vertebra. We have consistently shown that these vessels arise from a leash of vessels within the pre-vertebral fascia rather than the dorsal arterial plexus. Furthermore, in all levels this leash is derived from the ascending cervical artery, with the lower cervical vertebra having an additional, but variable, contribution from the transverse cervical artery.

These results are consistent with the early publications of Anseroff as well as Harris and Crock [1, 6, 8]. The findings of Menck and Lierse proposing that the cervical

vertebral bodies were mainly supplied by the vertebral artery could not be confirmed with our given sample, though it needs to be considered that these authors have investigated samples from newborns [13]. Anseroff in his work found that the pattern of blood supply to the vertebral bodies forms a general principle; however, both anterior–posterior anastomoses and contributions and posterior supply are less dominant at the cervical levels [1]. Moreover, the Anseroff in his work found that the calibre of the arterial feeders to the cervical spine does not increase with age at the same ratio as the vertebral bodies grow, resulting in an increasing undersupply of the cervical compared to the thoracic and lumbar vertebral bodies starting at the age of 3–5 years [1]. Given that the origin of the nutrient vessels is from the subclavian artery and the branches of these vessels pass over longus coli within the pre-vertebral fascia, careful dissection anterior to the muscle and during incision of the pre-vertebral fascia prior to exposure of the ALL should be considered. Thus, avoiding inadvertent damage to the anterior blood supply of the vertebra.

Furthermore, because the nutrient vessels are not consistent within the midline and because they are often independently derived from both a right and left branch that do not anastomose, a midline incision of the pre-vertebral fascia may avoid damage to these vessels. Surgeons should also recognise that the nutrient vessels often penetrate the bone adjacent to the superior endplate and therefore extensive stripping of the anterior vertebra in this area should be avoided to prevent direct trauma of the nutrient vessel.

Similarly, surgeons should recognise that the small nutrient vessels on the lateral borders of the vertebral body are derived from the vertebral artery. Thus, subperiosteal stripping beneath longus coli may damage these vessels.

This study is limited by its inability to determine the amount of vertebral body supplied by the nutrient vessels and the clinical significance of damage to this vessel. Furthermore the posterior plexus was not dissected to determine the size of the nutrient vessel entering the basi-vertebral foramen. Despite these limitations this study advances our knowledge of the blood supply of the anterior vertebra and confirms that nutrient vessels to the anterior vertebrae are at risk of damage during anterior cervical procedures, thus supporting the hypothesis that anterior bone loss after anterior cervical procedures could be the result of avascular necrosis.

Conclusion

Nutrient vessels perforate the cervical vertebrae on their anterior surface. These are derived from a leash of vessels that lie within the pre-vertebral fascia overlying the longus coli muscles. The origin of these vessels is the ascending

cervical artery with a variable contribution from the transverse cervical artery.

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Compliance with ethical standards

Conflict of interest None declared related to this study.

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