ANATOMICAL STUDY OF THE VERTEBRAL ARTERY PATH IN HUMAN LOWER CERVICAL SPINE

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SUMMARY

The increasing use of new techniques and materials for surgical treatment of lower cervical spine conditions has come along with an increasing concern regarding potential complications that might occur. The transpedicular fixation technique, frequently used in other spine levels, is used on the cervical spine, while providing more stability than other techniques, it may cause serious complications such as vertebral artery injury, nervous root injury, or facet joint injuries. However, the C7 vertebra is considered safer for performing this procedure, since, in the vast majority of people, according to available anatomical studies, does not have a vertebral artery passing through its cross-sectional foramen, because that vessel is inserted into such structure only on C6 vertebra. As there are only imaging studies available today for assessing the path of this artery and its anatomical variables, we conducted this anatomical study by dissecting 40 cadaver's vertebral arteries in order to assess the incidence of anatomical variations. We found 3 cases where the vertebral artery penetrated into cross-sectional foramen at C7 (7.5%), a fact that enhances the risk of an undesired injury with a transpedicular technique at this level. The other remaining specimens showed a usual anatomy.

Keywords: Vertebral artery; Spine/anatomy & histology; Cadaver

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INTRODUCTION

The posterior stabilization of the cervical spine is commonly used when treating an unstable cervical spine resulting from trauma, neoplasia, degenerative conditions or an anterior arthrodesis failure. Such procedure is frequently performed by employing lateral mass screws or inter-spinous or sublaminar ligations. These techniques not always provide enough stability, sometimes they require subsequent additional anterior stabilization procedures [1].

Recently, the transpedicular fixation technique has been introduced in order to provide an alternative to obtain a stable fixation through posterior port without requiring a potential anterior approach [1-4]. Panjabi et al published the first anatomical 3D study in which the ability of human cervical vertebrae's pedicles to enable transpedicular fixation was proven [5,6]. Kotani et al showed, inhuman cadaver-based studies, that transpedicular fixation provides a higher level of stability compared to traditional fixation methods, both anterior and posterior, in cervical injuries affecting two or three columns and in cervical instabilities at multiple levels [5,7].

With the increased popularity of this technique, there was also an increased incidence of complications such as vertebral artery injuries, nervous root and facet joint injuries [1,8].

For a successful insertion of a pedicular screw into the cervical spine, knowledge of pedicle anatomy is required for determining screw insertion axis [5,9-11]. Minimal dislocations from that axis may cause pedicle wall injury, which can result into significant neurological or vascular injury [5,11].

Recent studies show that damages to pedicle's lateral wall are the most frequent accident when introducing a pedicular screw, placing the vertebral artery at risk [1]. With the vertebral artery injury at the cervical region, a patient presenting an inappropriate blood debit by the contralateral artery (e.g., by atherosclerotic occlusion) may experience a lateral spinal cord infarction, and this situation is referred to as Wallenberg's syndrome, which is characterized by pain-sensitive deficit on the ipsilateral surface and contralateral limbs, nystagmus, ataxia, dysmetria on ipsilateral limb, and ipsilateral myosis and ptosis [9].

According to classical anatomical descriptions, the vertebral artery is originated at subclavian artery, ascending anteriorly to the transverse process of the seventh cervical vertebra,

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thus lateral to the transverse foramen at that level, penetrating the transverse foramen of the sixth cervical vertebra, and following an ascending path always through the transverse foramina up to the first cervical vertebra. Then, it runs across the posterior lateral side of the first vertebra, going into the foramen magnum. Cervical vertebrae's transverse foramina are located at vertebral body's lateral side, in front of the lateral mass and just anterior to nervous root [12-14]. Anatomical variations of the artery path at the segment between the second and sixth vertebrae are rare. Upon such anatomy, the use of pedicular screws is safe only when performed at the seventh cervical vertebra [5], in which the vertebral artery is not usually present at the transverse foramen. Nevertheless, in a small portion of people, the vertebral artery is found inside the seventh cervical vertebra's transverse foramen. According to literature surveys, anatomical studies determining the incidence in which a vertebral artery is present inside the C7 transverse foramen in our population are inexistent.

Our study aims to investigate the relationship between vertebral artery and the seventh vertebra's transverse foramen in our environment, intending to collaborate on assessing the risks involving the use of pedicular screws on cervical spine.

MATERIAL AND METHOD

For conducting this study, 40 cervical vertebral arteries of 20 cadavers supplied by the Death Examination Service, randomly selected, were studied. The vertebral artery path was exposed from the first thoracic vertebra to the sixth cervical vertebra, observing the point where it takes position inside the transverse foramen.

The Inclusion Criteria employed here were: skeletal maturity of the specimen, which was regarded as so for cadavers aged above 18 years. The exclusion criteria included the following:

a- bone deformities at cervical segment, visible after positioning the cadaver at ventral decubitus;

b- skin scars at dorsal cervical region suggesting previous spine surgery;

c- vertebral malformations identified during dissection;

d- fractures of transverse processes or other relevant bone protrusions during dissection;

Each cadaver was positioned at ventral decubitus. The access port was performed through skin incision at median posterior cervical region, with 12 cm, followed by dissection at muscular planes next to bone structures, exposing vertebral spine from T1 to C2.

The seventh (C7) and sixth (C6) cervical vertebrae were identified by counting from the first thoracic vertebra (T1), identified by locating the first costal arch. Intending to avoid any failure in detecting C7 and C6 from T1, resulting from the potential existence of a cervical rib, the counting was also performed from the second cervical vertebra (Figure 1).

After the posterior elements of C7 (spinous process and layers) were removed, lateral masses and C7-T1 foramina were bilaterally identified. By paravertebral dissection, the nervous root on C8, at both sides, was detected, which was sectioned to enable vertebral artery visualization. Lateral masses on C7 are, then, carefully opened up to the transverse foramen, where the vertebral artery path was checked. Should the artery could not be seen passing through C7 transverse foramen, the same procedure was performed at C6 for confirming it going into that level (Figure 2).

Figure 1- *Identification of the vertebrae from the first thoracic rib*

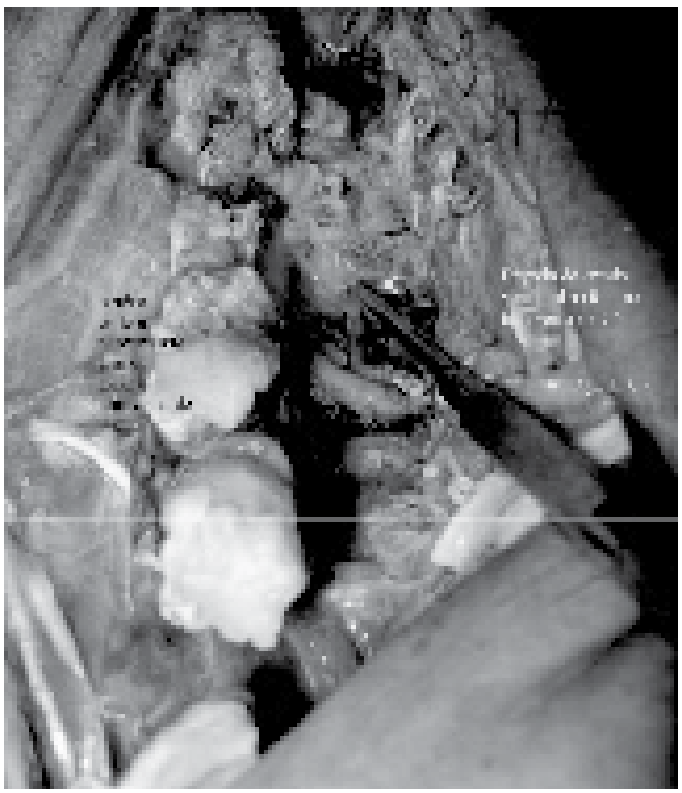

Figure 2 -*Vertebral artery entering into C6 transverse foramen*

RESULTS

As a result of this anatomical study, our series was constituted of 16 male (80%) and 4 female (20%) cadavers, being 18 Caucasians (90%) and 2 black (10%), with heights ranging from 165 cm to 185 cm for males (average = 173.75 cm) and 1.70 cm for all women. The mean age was 57.5 years (32 - 83) and the average weight was 61.15 kg (36 – 96).

From all 40 dissected vertebral arteries, we found 37 of them

entering the transverse foramen of the sixth cervical vertebra (C6 - 92.5%, and three of them through C7 transverse foramen (7,5%).
No anthropometric parameter has shown to be statistically significant as a predictive factor for this anatomical variation.
No anatomical variations were found, such as vertebral arteries entering in other cervical vertebrae. Abnormality was unilateral in 1 cadaver (5%), where the artery penetrated into the left C7 foramen and at right C6 foramen, and bilateral in another cadaver (5%), penetrating into both C& transverse processes (Table 1).

DISCUSSION

In international literature, the incidence of vertebral artery passing through C& transverse foramen is seen in approximately 6-7% of the studied population [9,12]. In a recent study conducted in France [15], 500 vertebral arteries' paths were studied by means of 200 magnetic resonance and 50 computed tomography images with angiographic contrast. With this large case series, the authors found anatomical variations in 7% of the cases studied, similar data to those observed in the present anatomical study. among unusual paths, we found the vertebral artery entering the foramen at C3, C4, C5 or C& in incidences of 0.2%, 1%, 5% and 0.8%, respectively. Thus, one can notice that the introduction into C5 is an anatomical variation more frequently seen than in C7, a fact not corroborated by the present study. Another interesting data, also seen in that French study, was a higher incidence of unilateral abnormality (12.4%) compared to bilateral incidence (0,8%), with the majority located at the left side. This study, however, as some others, cannot provide a correlation between anatomical change and any data enabling the surgeon to act more carefully.
In literature, a correlation exists between the artery entering into the foramen at an unusual level and a variation in its origin from subclavian artery, which has no clinical usefulness as well [16].
The incidence of people with unusual vertebral artery path in its way through low cervical spine is not neglectful, and should be considered when selecting a transpedicular fixation technique at that region. Damage to the pedicle's lateral wall in these people - a potential accident when introducing a pedicular screw - threatens vertebral artery, also at C7. Such injury may cause catastrophic consequences, especially in those patients presenting with inappropriate blood deficit by contralateral artery.
The present study is based on a case series of only 20 cadavers. Nevertheless, it consistently confirms data reported in current literature, by anatomical and imaging studies.

	Ethnicity	*Gender*	*Age (years)*	*Height (cm)*	*Weight (Kg)*	*Vert. artery entry level*
1	*C*	*M*	*34*	*185*	*62*	*C7*
2	*C*	*M*	*51*	*170*	*60*	*C6*
3	*C*	*M*	*65*	*180*	*96*	*C6*
4	*C*	*M*	*83*	*165*	*60*	*C6*
5	*C*	*F*	*39*	*170*	*60*	*C6*
6	*C*	*M*	*62*	*180*	*68*	*C6*
7	*C*	*F*	*41*	*170*	*60*	*C6*
8	*C*	*F*	*80*	*170*	*36*	*C6*
9	*C*	*F*	*61*	*170*	*60*	*C6*
10	*BI*	*M*	*56*	*170*	*60*	*C6*
11	*BI*	*M*	*50*	*170*	*43*	*C6*
12	*C*	*M*	*32*	*180*	*65*	*C6*
13	*C*	*M*	*60*	*180*	*40*	*C6*
14	*C*	*M*	*47*	*170*	*60*	*C6*
15	*C*	*M*	*78*	*170*	*80*	*C6*
16	*C*	*M*	*66*	*180*	*80*	*C6*
17	*C*	*M*	*72*	*170*	*56*	*C6 D/ C7 E*
18	*C*	*M*	*71*	*170*	*57*	*C6*
19	*C*	*M*	*60*	*170*	*60*	*C6*
20	*C*	*M*	*42*	*170*	*60*	*C6*

***C**= Caucasian, **BI**= black, **M**=male, **F**=female, **a.**=artery, **trans.**=transversal, **sp.**=spine*

TABLE 1 - *Cadavers' characteristics*

CONCLUSIONS

The vertebral artery's ascending path, from the upper thoracic region, penetrates the transverse foramina of cervical vertebrae initially at C6 (not passing through C7 foramen) in 92.5% of the cases. In 7.5% of the cases, the artery passes through C7 foramen. We found unilateral abnormality in 5% of the cadavers, in which the artery entered into the left C7 foramen and into the right C6 foramen, and bilateral abnormality in 5% else, penetrating both C7 transverse processes. No anthropometric parameter has shown to be statistically significant as a predictor of this anatomical variation.

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