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The Spine Journal 16 (2016) 1055–1061

THE SPINE JOURNAL

Clinical Study

Risk factor analysis and decision-making of surgical strategy for V3 segment anomaly: significance of preoperative CT angiography for posterior C1 instrumentation

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Received 6 January 2016; revised 21 March 2016; accepted 27 April 2016

Abstract

BACKGROUND CONTEXT: Awareness of vascular anomalies is crucial to avoid iatrogenic injuries during surgical procedure. Although V3 segment anomaly has been well described, the incidence of V3 segment anomaly has been rather variable in the literature, and there are few reports regarding the adequate surgical strategy for each type of V3 segment anomaly.

PURPOSE: This study aimed to analyze the incidence of V3 segment anomaly and demonstrate the importance of recognizing vertebral artery (VA) anomaly in deciding the surgical strategy for C1 screw placement.

STUDY DESIGN: A retrospective cohort study was carried out.

PATIENT SAMPLE: The sample included 147 patients who underwent C1 posterior instrumentation and preoperative three-dimensional computed tomography angiography (3D CTA).

OUTCOME MEASURES: The primary outcome of this study was the incidence of V3 segment anomaly using preoperative CTA, and the secondary outcome was the risk factor analysis of the V3 segment anomaly.

METHODS: There were 147 patients who underwent C1 posterior instrumentation to treat various kinds of upper cervical disease. The 3D CTA of the patients were assessed preoperatively to identify the anomaly of the VA. Each surgical technique of C1 posterior instrumentation was decided upon the shape and the course of the VA around the atlas.

RESULTS: During the study period, 11 cases of V3 segment anomaly (7.5%) were found on 3D CTA. Persistent intersegmental artery was found in nine cases and was the most common variant of VA anomaly. Early branch of posterior inferior cerebellar artery was found in three cases. Most of V3 segment anomaly was found unilaterally, but there were two cases with bilateral V3 anomaly. Seven cases (63.6%) were associated with congenital bony abnormality around craniovertebral junction (CVJ), such as occipital assimilation, Klippel-Feil syndrome, and os odontoideum. V3 segment anomaly was significantly common in the cases with bony abnormality (29.2% (7/24) vs. 3.6% (4/123), p<.05). Compared with patient without bony abnormality, the odds ratio was 10.78 (95% CI: 2.88–40.37) for those with congenital bony abnormalities. Rheumatoid arthritis was not a risk factor of V3 segment anomaly (p=.391).

CONCLUSIONS: The course of the VA is heterogenous, and the V3 segment anomaly of the VA is more common in the cases with congenital bony abnormalities around CVJ. Therefore, preoperative radiological studies should be performed to identify V3 segment variations and reduce the risk of VA injury. To avoid significant morbidities associated with VA, surgical technique of C1 posterior instrumentation should be decided depending upon the V3 segment anomaly. A more optimal entry point and trajectory for C1 fixation can be selected.

Keywords: Anatomic variation; Atlas; Risk factor; Screw fixation; V3 segment; Vertebral artery

FDA device/drug status: Not applicable.

Author disclosures: ***JTH:*** Nothing to disclose. ***ISK:*** Nothing to disclose. ***JuYK:*** Nothing to disclose. ***HJL:*** Nothing to disclose. ***JaYK:*** Nothing to disclose. ***MSK:*** Nothing to disclose. ***JHS:*** Nothing to disclose.

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http://dx.doi.org/10.1016/j.spinee.2016.04.019

Introduction

Vertebral artery injury (VAI) during posterior cervical spine surgery is a rare but potentially disastrous complication. Misplacement of screws is the most common cause of VAI; however, aberrant anatomy may be a potential cause of inadvertent injury and also be related with VAI during screw placement. Awareness of vascular anomalies is crucial to avoid iatrogenic injuries during surgical procedure. The presence of vertebral artery (VA) anomalies at the craniovertebral junction (CVJ) may prevent safe placement of C1 lateral mass screws and therefore influence the treatment options for CVJ pathologies [1,2].

The anatomical variations involving the VA between C1 and C2 have been well described [1–4]. There could be three types of V3 segment anomaly. In the first type of anomaly (persistent intersegmental artery), the VA courses abnormally below the C1 arch after leaving the transverse foramen of the C2 and enters the spinal canal not passing through the C1 transverse foramen (Fig. 1A). In the second type (fenestrated VA), the VA is fenestrated at the atlas level; one courses as usual, whereas the other enters spinal canal below the C1 arch and joins the former above the C1 arch (Fig. 1B). In the third type, the VA course is normal, but the posterior inferior cerebellar artery (PICA) originates from the VA between C1 and C2 and enters the spinal canal from the caudal side of C1 (Fig. 1C, D). The incidence of these three types of anomaly has been reported quite variably. Although studies from Asian population reported that V3 segment anomaly is not uncommon and the incidence of the V3 segment anomaly was as high as 10%, US data showed that V3 segment is quite rare and below 0.5% [5].

Thus, the purpose of this case series is to demonstrate the real incidence of the V3 segment anomaly in the clinical setting for patients who need C1 posterior instrumentation and discuss the various surgical strategies for C1 screw placement in the cases of V3 segment anomaly. Furthermore, we wanted to find out the risk factors that are related to V3 segment anomaly. To the best of our knowledge, this is the first clinical case series of C1 posterior instrumentation about V3 segment anomaly in the literature.

Materials and methods

Patient demographics and surgical indications

There were 147 patients who underwent C1 posterior instrumentation and preoperative three-dimensional computed

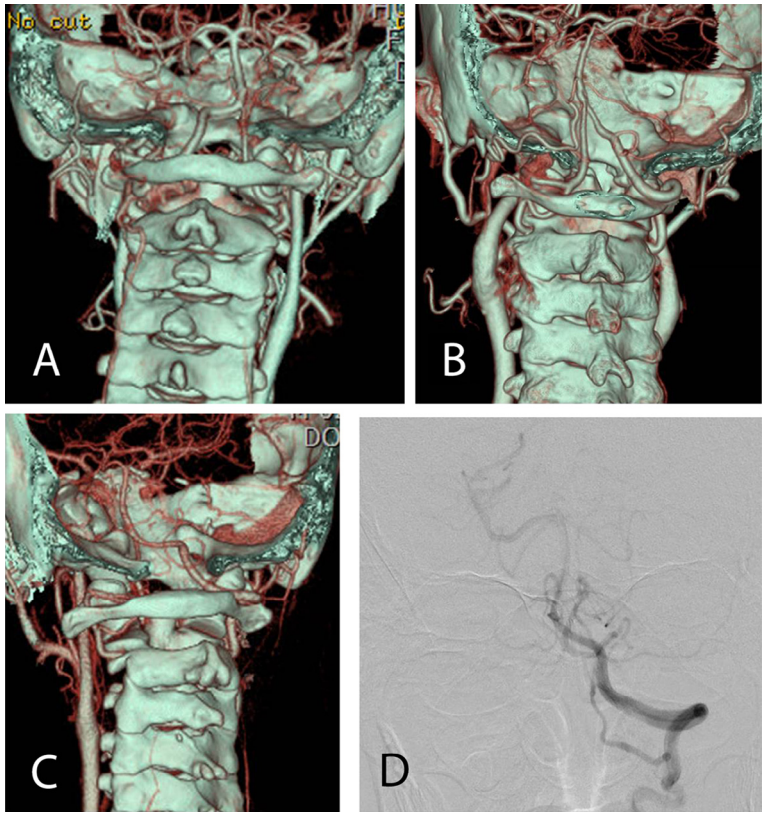

Fig. 1. (A) Three-dimensional computed tomography angiography (3D CTA) demonstrates the persistent intersegmental artery on the right side; the vertebral artery (VA) courses abnormally below the C1 arch after leaving the transverse foramen of the C2 and enters the spinal canal not passing through the C1 transverse foramen. Left side of V3 segment is fenestrated. (B) 3D CTA shows the fenestrated VA on the left side; one courses as usual, whereas the other enters the spinal canal below the C1 arch and joins the former above the C1 arch. (C) In the third type, the VA course is normal, but the posterior inferior cerebellar artery (PICA) originates from the VA between C1 and C2. (D) Digital subtraction angiography shows the course of the PICA originates from the caudal side of C1 and enters the spinal canal.