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Case study

Vertebral artery injury in patients with isolated transverse process fractures

Phillip A. Bonney [a], Joshua D. Burks [a], Andrew K. Conner [a], Chad A. Glenn [a], Cordell M. Baker [a,*], Ahmed A. Cheema [a], Jacob B. Archer [a], Bryan E. Buster [a], Roxie M. Albrecht [b], Bradley N. Bohnstedt [a]

[a] Department of Neurological Surgery, University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA
[b] Department of Surgery, University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA

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ABSTRACT

We sought to assess the rate of CTA-diagnosed vertebral artery injury in patients with isolated transverse process fractures, with and without extension into the transverse foramen, in the blunt-trauma population served by our hospital. We queried our universities trauma registry between January 2009 and July 2014 for ICD-9 codes pertaining to cervical spine fractures. Of 330 patients identified, 45 patients had fractures limited to the transverse process and were selected for the study population. For each patient identified, demographics, injury mechanism, imaging reports, angiography findings, and treatments were recorded. In total, 69 fractures were identified in 45 patients. Of the 45 patients, 15 (33%) had transverse process fractures at multiple cervical levels. 23/45 (51%) patients had at least one fracture extending into TF. Four patients with transverse process fractures and one patient without transverse process fractures were diagnosed with vertebral artery injury by CT angiogram (17.4% vs. 4.5%, $p = 0.35$). The number of transverse process fractures in patients with VAI was greater than those without VAI (3.0 vs. 1.4, $p < 0.001$). None of the 30 patients with any one-level TPF (with or without extension into TF) was diagnosed with VAI ($p = 0.003$). None of 17 patients with isolated C7-level TPFs were diagnosed with VAI ($p = 0.15$). The incidence of cervical VAI was greater in patients with multiple-level TPFs than in patients with single-level TPFs. While patients with a single, isolated TPF have a low probability of VAI, patients with numerous TPF fractures may benefit from CTA.

1. Introduction

Blunt vertebral arterial injuries (BVIs) are an important cause of stroke in trauma patients. Though well established, the rates of such injuries are fairly low using modern screening and treatment modalities [1–3]. Evaluation of patients with fractures of the cervical spine often includes CT angiogram (CTA) to assess for arterial injury. In particular, the intimate relationship of the vertebral artery with the transverse foramina of the cervical spine requires close attention to transverse process fractures extending into the transverse foramina.

While CTA is a valuable tool in evaluating traumatic neurovascular pathology, it requires a contrast load and exposes the patient to radiation. Our institution, a Level I Trauma Center, has routinely obtained CTA for all patients with cervical spine fractures according to the Modified Denver Screening Criteria for blunt cerebrovascular injury, fitting with standard practices [4]. In the current climate of maximizing medical resources to reduce the number of unnecessary procedures and address the unsustainable increase in healthcare expenditures, both in neurosurgery and in medicine generally, we reviewed our protocol for evaluation of trauma patients with cervical spine injuries. We aim to better understand which types of cervical spine fractures warrant evaluation with CTA.

To better define which patients are likely to benefit from CTA, we sought to quantify the risk of VAI in patients with isolated transverse process fractures (ITPFs). In our analysis, we considered the location and number of fractures, and whether the fracture extended into the transverse foramen. Here we present the results of this study within the context of recent literature.

* Corresponding author at: Department of Neurosurgery, 1000 N. Lincoln Blvd., Suite 4000, Oklahoma City, OK 73104, USA. Fax: +1 (405) 271 3091.
E-mail addresses: phil.alan.bonney@gmail.com (P.A. Bonney), joshua-burks@ouhsc.edu (J.D. Burks), Andrew-conner@ouhsc.edu (A.K. Conner), chad-glenn@ouhsc.edu (C.A. Glenn), cordell-baker@ouhsc.edu (C.M. Baker), ahmed-cheema@ouhsc.edu (A.A. Cheema), bryan-buster@ouhsc.edu (B.E. Buster), roxie-albrecht@ouhsc.edu (R.M. Albrecht), Bradley-bohnstedt@ouhsc.edu (B.N. Bohnstedt).

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2. Methods

2.1. Patients

This study was approved by our institutional review board (IRB # 4842). The University of Oklahoma Medical Center trauma registry, a prospectively-collected database of all trauma patients, was queried from January 2009 to July 2014 to identify patients with cervical spine fractures who received CT angiograms during work up. Data obtained included patient demographics, injury mechanism, imaging reports, angiography findings, and treatments related to the cervical spine injury. For the purposes of the study, the diagnoses of cervical spine fractures were made by an attending radiologist. Vertebral artery injury was graded according to the system described by Biffl et al. [5].

Our query retrieved 330 patients. Of these, 45 patients had fractures limited in the cervical spine to the transverse process of one or multiple vertebrae. These 45 patients formed the studied cohort.

2.2. Statistical analysis

Descriptive statistics were used to summarize patient data. Continuous variables were analyzed using unpaired *t*-test after evidencing normality of data. Non-parametric continuous data were compared using Mann Whitney *U* test. Categorical variables were analyzed using Fisher's exact test. Cochran-Mantel-Haenszel test was used to assess categorical variables when influence by other covariates was expected.

3. Results

Demographics of patients with isolated C-spine transverse process fractures (ITPFs) and patients with at least one non-TPF in the cervical spine are displayed in Table 1. Most patients with ITPFs were male (68%). The mean age was 46.5 (range 19–88). The most common mechanism of injury was motor vehicle collision (MVC, 71.1%) followed by motorcycle collision (MCC, 13.3%). The majority of patients (80%) had a GCS of 14 or 15 on arrival to the emergency department. In comparing ITPF patients to all others, we ascertained no obvious differences in the two groups.

A total of 69 transverse process fractures were identified in the 45 patients with ITPFs. Fifteen patients (33%) had fractures at multiple cervical levels. Twenty-eight patients (62%) had C7 fractures; 14 patients (31%) had C6 fractures. In 22 patients, no cervical spine fracture extended into the transverse foramen (TF), while in 23, at least one fracture extended into TF (TPF-TF). An example of TPF-TF apparent on CTA is given in Fig. 1. Characteristics of fractures in these two groups are displayed in Table 2. There were a total of 27 fractures in the 22 patients who had no TPF-TFs, and 42 fractures in the 23 patients who had at least one TPF-TF. The difference in mean number of fractures was not statistically significance (1.23 vs. 1.83, $p = 0.06$). Compared with other cervical levels, fractures at C5 were more likely to occur in patients with at least one TPF-TF ($p = 0.01$). Conversely, fractures at C7 were more likely to occur in patients without any TPF-TF ($p = 0.01$).

Of the 45 patients with isolated transverse process fractures, 5 were diagnosed with vertebral artery injuries (VAIs) on CTA (11.1%). The injuries are described in Table 3. In all 5 cases, fractures occurred at multiple cervical levels. In four cases, there was at least one TPF-TF. In one case, VAI occurred without TF involvement. Four patients were further evaluated with catheter angiography, which confirmed injuries in all cases. Due to extensive other injuries, the fifth patient did not undergo catheter angiography.

Analysis of factors associated with VAIs revealed that age was not significantly different in patients with and without VAI. The total number of fractures was greater in VAI patients (3.0 vs. 1.4, $p < 0.001$). Further, no patients with one ITPF (with or without involvement of TF) experienced VAI, while 5 patients with multiple fractures experienced VAI (0% vs. 33%, relative risk = 1.5, $p = 0.002$). The number of fractures extending into TF in patients was also greater in patients with VAI (2.0 vs. 0.63, $p < 0.01$). Using Cochran-Mantel-Haenszel test to compare the strength of the associations of number of TPFs and number of TPF-TFs, number of TPFs was found to be a more powerful association ($p = 0.01$). The analysis of factors associated with VAIs is illustrated in Table 4.

4. Discussion

This study was performed to clarify risk factors for vertebral artery injury [6] in patients with isolated cervical transverse process fractures (ITPFs) at our center. We found a total of 5 injuries in 45 patients, an injury rate of 11.1%. Previous literature suggests a rate of 9.5% [7]. All patients with VAI had at least two fractures, with an average of 3.0 fractures. The number of transverse process fractures in patients with VAI was greater than those without VAI (3.0 vs. 1.4, $p < 0.001$). Further, those with single-level ITPFs were unlikely to have VAI. In light of this, multiple-level ITPF may be useful in predicting a need for further diagnostic testing similar to TPF-TF. Multiple-level ITPF informs likelihood of VAI, whereas single-level fractures suggest VAI is unlikely.

Early recognition of VAI is critical as devastating outcomes may await patients not diagnosed and treated early. Overall mortality of

Table 1
Patient demographics.

Characteristic	Isolated C-spine TP fracture patients	All other C-spine fracture patients	*p*-Value
Patients	45	285	
Female	11 (24%)	94 (33%)	0.30
Male	34 (76%)	191 (67%)	
Age			
Mean ± SD	46.5 ± 17.5	42.6 ± 19.1	0.20
Range	19–88	11–91	
Mechanism			
MVC	32 (71.1%)	204 (71.6%)	1.00
MCC	6 (13.3%)	25 (8.8%)	0.41
Fall	3 (6.7%)	36 (12.6%)	0.33
Pedestrian	1 (2.2%)	6 (2.1%)	1.00
ATV	1 (2.2%)	3 (1.1%)	0.45
Other blunt	2 (4.4%)	11 (3.9%)	0.69
GCS Admission			
3	6 (13.3%)	54 (18.9%)	0.41
4–13	3 (6.7%)	38 (13.3%)	0.33
14–15	36 (80.0%)	193 (67.7%)	0.12

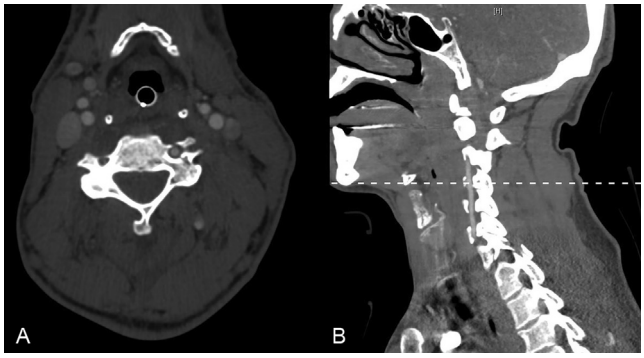

Fig. 1. A: Axial view, computed tomography with angiography (CTA) at the C4 vertebra showing a transverse process fracture extending through the transverse foramina and into the adjacent C4 pedicle. B: CTA sagittal view demonstrating the level of the fracture (line).