Which Cervical Fracture Patterns are Associated with Blunt Cerebrovascular Injures when Utilizing Computed Tomographic Angiography?

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INTRODUCTION: Prior studies have demonstrated an association between cervical spine fractures and blunt cerebrovascular injuries (BCVI) due to the intimate anatomic relationship between the cervical spine and the vertebral arteries. Undiagnosed BCVI is a feared complication because of the potentially catastrophic outcomes in a missed posterior circulation stroke. Computed tomography angiography (CTA) is commonly used to screen for BCVI in the trauma setting. However, there is no consensus regarding which fracture patterns mandate screening. Over aggressive screening may lead to unnecessary radiation and unnecessary treatment of patients which can cause patient harm and increased healthcare costs. The aim of this retrospective review is to further elucidate which fracture patterns are associated with BCVI when utilizing CTA and may mandate screening.

METHODS: A retrospective review was performed of patients with blunt cervical injuries who presented to our Level 1 trauma center from January 2018-December 2021. Inclusion criteria included blunt cervical trauma and the use of CTA for BCVI screening. Exclusion criteria included patients under the age of 18, penetrating cervical trauma, and use any imaging modality besides CTA for BCVI screening. For each patient the cervical fracture location, fracture pattern, whether the patient suffered a BCVI, and if the patient suffered a CVA were recorded. Cervical fracture patterns identified were anterior arch, dens, dislocations/subluxations, facet, hangman, Jefferson, lamina, lateral mass, occipital condyle dissociation, occipital condyle, pedicle, posterior arch, spinous process, transverse process, transverse foramen, and vertebral body. If a patient had multiple fracture levels or fracture patterns, each level and pattern was counted as a separate BCVI. Multilevel fractures were defined as any patient with fractures at two distinct cervical levels. Differences between the patients who had a BCVI and those who did not were analyzed using independent sample t-tests for continuous variables and the Chi-Square or Fisher exact test for categorical variables. Odds ratios and 95% confidence intervals were calculated to assess likelihood between patient characteristics/fracture characteristics and BCVI.

RESULTS: A total of 690 patients were identified as having a blunt cervical spine injury. In total, 453 patients (66%) underwent screening for BCVI with CTA. A BCVI was diagnosed in 138 patients (30%). A VAI was diagnosed in 119 patients (26%), CAI was diagnosed in 30 patients (7%), and 11 patients were diagnosed with both a VAI and CAI (2%). There were 9 strokes (2%), all in patients identified with a BCVI. However one of the strokes was believed to be the result of fat emboli from bilateral femoral shaft fractures. No individual cervical level was associated with increased risk of BCVI, but when combined, OC-C3 fractures were associated with an increased risk (OR: 1.4, 95% CI: 1.0-1.9, p-value 0.006). Multilevel fractures were also associated with an increased risk (OR: 1.7, 95% CI: 1.1-2.3, p-value = 0.01). The only fracture pattern associated with increased risk of BCVI were fractures associated with a dislocation/subluxation (OR: 3.8, 95% CI: 1.9-7.8, p-value = 0.0001). Jefferson (OR: 1.7), occipital condyle (OR: 1.7), C2 posterior arch (OR: 2.1), and transverse foramen (OR: 1.3) fractures had increased odds ratios but were not statistically significant.

DISCUSSION AND CONCLUSION: The only fracture pattern associated with an increased risk of BCVI were fractures associated with dislocation/subluxation. This is likely because the translation of the vertebral body places stretch on the vertebral artery. The only fracture levels associated with BCVI were combined OC-C3 and multilevel fractures. The association between upper cervical levels and BCVI is likely due to the unique course of the vertebral artery as it is more exposed proximally. In addition, significant energy is likely required to cause a multilevel fracture which could place the vertebral artery at higher risk. We recommend that any upper cervical fracture (OC-C3), multilevel fracture, or fracture with dislocation/subluxation undergo screening for BCVI.

Table 1

Cervical Fracture Location and Incidence of Blunt Cerebrovascular Injury

Cervical Fracture Location	Total (n = 714)	Total BCVI (n = 233)	VAI (n = 172)	CAI (n = 32)	VAI and CAI (n = 29)	Odds Ratio	95% CI	p-value
OC	24	11	3	4	4	1.8	0.8-4.0	0.16
C1	85	32	24	3	5	1.3	0.8-2.1	0.29
C2	149	53	39	8	6	1.2	0.8-1.7	0.39
C3	35	12	10	1	1	1.1	0.5-2.2	0.83
C4	49	14	12	0	2	0.8	0.4-1.5	0.53
C5	81	24	20	1	3	0.9	0.5-1.4	0.54
C6	137	44	35	6	3	1.0	0.7-1.4	0.89
C7	154	43	29	9	5	0.8	0.5-1.1	0.16
OC-C3	293	108	76	16	16	1.4	1.0-1.9	0.01
C4-C7	421	125	96	16	13	0.7	0.5-1.0	0.04

BCVI indicates blunt cerbrovascular injury; VAI indicates vertebral artery injury, CAI indicates carotid artery injury, CI indicates confidence interval

Table 2

Cervical Fracture Pattern and Incidence of Blunt Cerebrovascular Injury

Cervical Fracture Pattern	Total (n = 734)	Total BCVI (n = 258)	VAI (n = 199)	CAI (n = 33)	VAI and CAI (n = 26)	Odds Ratio	95% CI	p-value
Anterior Arch	17	5	4	0	1	0.8	0.3-2.2	0.62
Dens	79	29	23	4	2	1.1	0.7-1.8	0.75
Dislocation/Subluxation	35	23	21	0	2	3.8	1.9-7.8	0.0001
Facet	91	28	23	3	2	0.8	0.5-1.3	0.35
Hangman	14	3	3	0	0	0.5	0.1-1.8	0.28
Jefferson	21	10	9	1	0	1.7	0.7-4.1	0.22
Lamina	42	14	11	1	2	0.9	0.5-1.8	0.80
Lateral Mass	64	23	13	7	3	1.0	0.6-1.8	0.88
Occipital Condyle Dissociation	1	0	0	0	0	0.0	N/A	0.46
Occipital Condyle Fracture	23	11	3	4	4	1.7	0.8-4.0	0.19
Pedicle	19	6	6	0	0	0.8	0.3-2.3	0.74
Posterior Arch	19	10	7	2	1	2.1	0.8-5.2	0.10
Spinous Process	40	9	8	1	0	0.5	0.2-1.1	0.09
Transverse Process	97	27	18	6	3	0.7	0.4-1.1	0.09
Transverse Foramen	79	32	28	2	2	1.3	0.8-2.1	0.29
Vertebral Body	93	28	22	2	4	0.8	0.5-1.2	0.28

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