

# Blunt Cerebrovascular Injury: Are We Over-Screening Low Mechanism Trauma?

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# Background and Purpose

- Blunt Cerebrovascular Injury (BCVI) is a rare but recognized injury to the carotid or vertebral arteries which may lead to ischemic stroke in trauma patients
  - Estimated to occur in 0.2-3% of blunt trauma cases
  - Most often asymptomatic
- Large percent of asymptomatic cases and prevention of morbidity and mortality make appropriate screening for BCVI a critical component of trauma evaluation
  - CTA is widely accepted as preferred modality
  - DSA is gold standard (not performed on majority of patients due to increased risk and cost)
- Criteria rely on risk factors (e.g. soft tissue injuries to neck, neurological symptoms, imaging risk factors)
- Because expanded Denver criteria and Memphis criteria miss 15-20% of BCVIs, more inclusive approaches have been taken
- At our institution, a liberal approach to screening was implemented in 2010 with all patients with “above the clavicle” injuries

# Background

- Blunt Cerebrovascular Injury (BCVI) is a traumatic injury to the cervical carotid or vertebral arteries which occurs in **0.2-3%** of blunt trauma cases
- Screening is important because:
  - Many cases are initially asymptomatic
  - Treatment has been shown to reduce risk of ischemic stroke
- CTA is widely accepted as preferred screening modality
- Screening criteria rely on clinical and imaging risk factors
- Existing criteria including the Expanded Denver Criteria may miss **15-20%** of BCVIs, leading some to advocate universal screening
- However, increased screening increases the risk of false positive studies and unnecessary treatment and cost
- At our institution, a liberal approach to screening was implemented in 2010 including all patients with “above the clavicle” injuries

Expanded Denver Criteria	
<u>Signs/Symptoms</u>	<u>Risk Factors</u>
<ul style="list-style-type: none"><li>• Potential arterial hemorrhage from face or neck</li><li>• Cervical bruit in patient &lt; 50 yrs old</li><li>• Expanding cervical hematoma</li><li>• Neurologic deficit inconsistent with head CT</li><li>• Stroke on CT or MRI</li></ul>	<p>High-energy trauma mechanism with:</p> <ul style="list-style-type: none"><li>• LeFort II or III facial fracture</li><li>• Mandible fracture</li><li>• Complex skull or skull base fracture</li><li>• Severe Traumatic Brain Injury (TBI) with GCS &lt; 6</li><li>• Cervical spine fracture, <u>subluxation</u> or ligamentous injury at any level</li><li>• Near hanging with anoxic brain injury</li><li>• Clothesline type injury or seat belt abrasion with significant swelling, pain, or altered mental <u>status</u></li><li>• TBI with thoracic injuries</li><li>• Scalp degloving</li><li>• Thoracic vascular injury</li><li>• Blunt cardiac rupture</li><li>• Upper rib fractures</li></ul>

# Purpose

We hypothesized that a subset of low-mechanism trauma patients with “above the clavicle” injuries could be safely excluded from BCVI screening.

# Methods

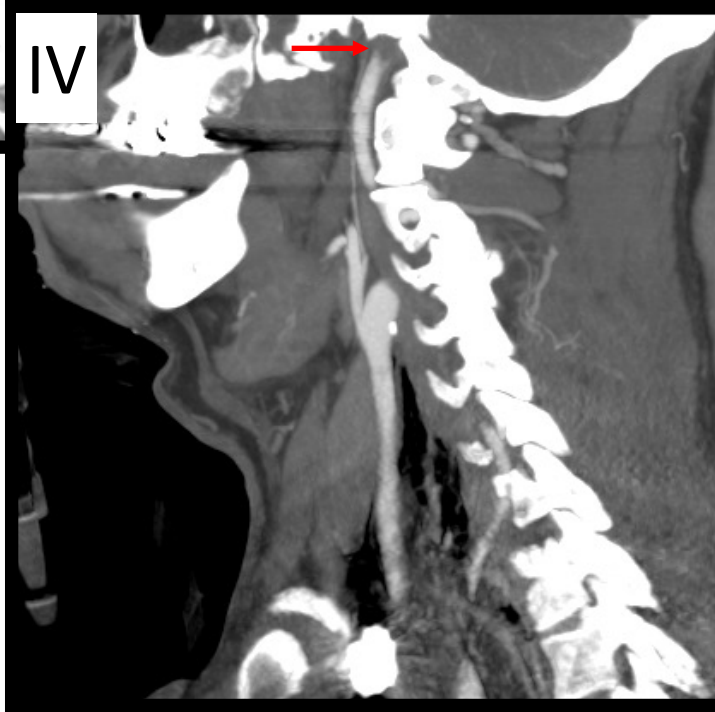
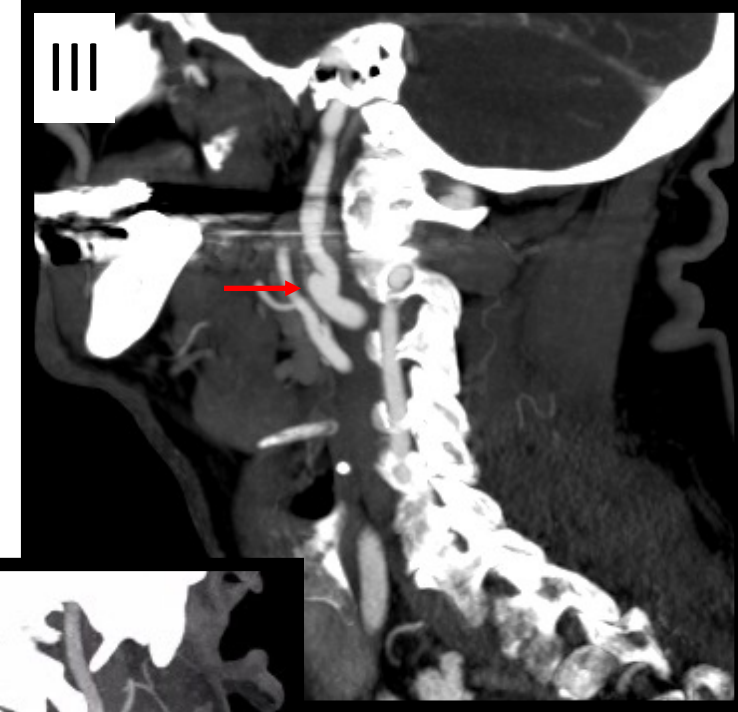
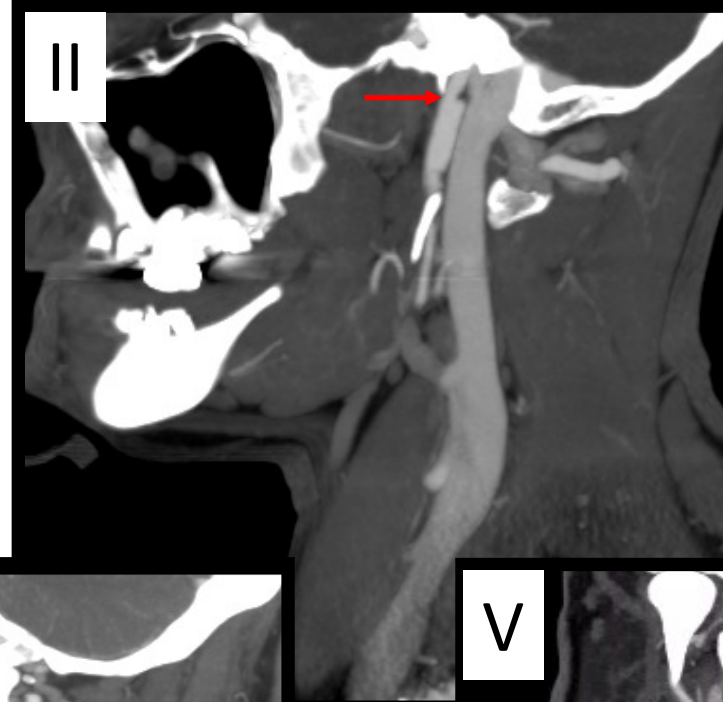
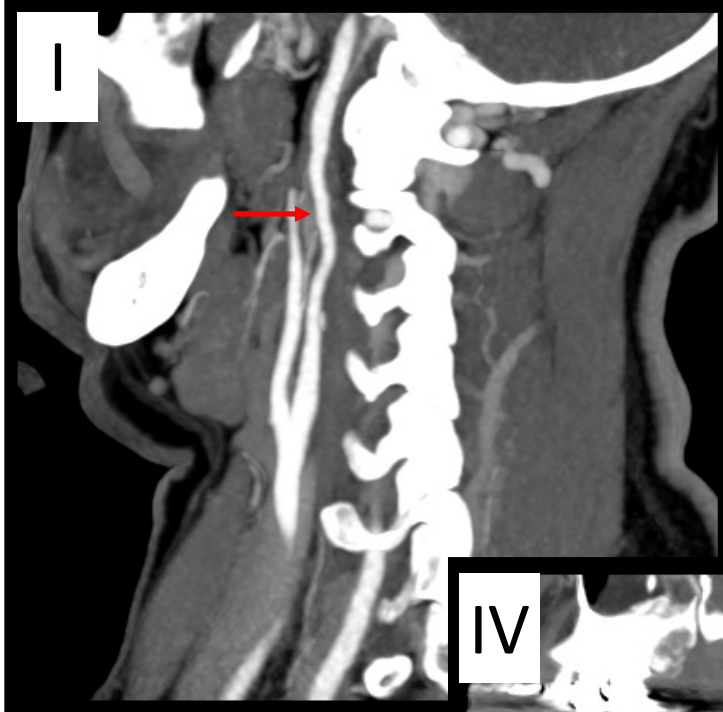
- Retrospective review of all BCVI screening neck CTAs performed on adult emergency department patients in 2019
- Recorded:
  - Trauma mechanism and mechanism-specific risk factors
  - Initial physical exam
  - Results from imaging studies
  - Antiplatelet/anticoagulant treatment
  - Outcome measures (including ischemic stroke, death, and bleeding on therapy)
- Each initial CTA was classified as **negative**, **indeterminate**, or **positive**
- Indeterminates were further classified as false positives or true positives based on follow up imaging and clinical decision making

# Methods

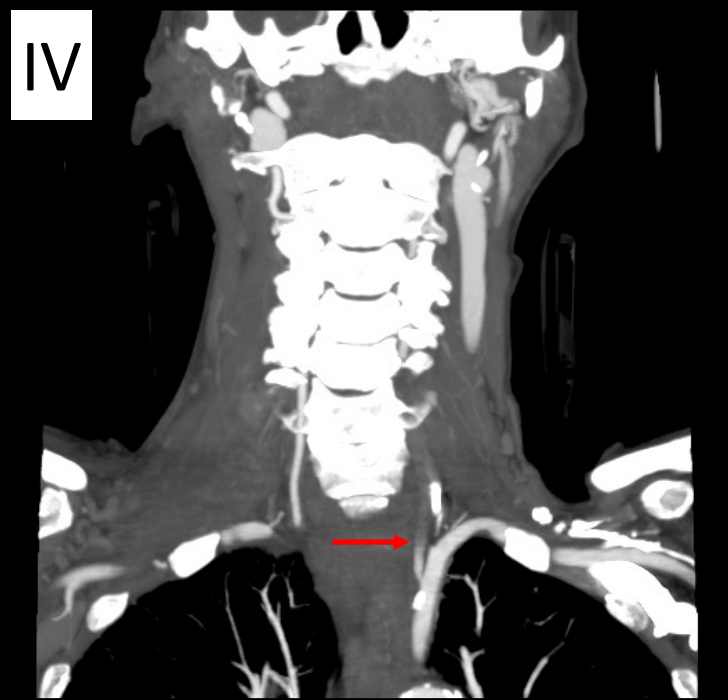
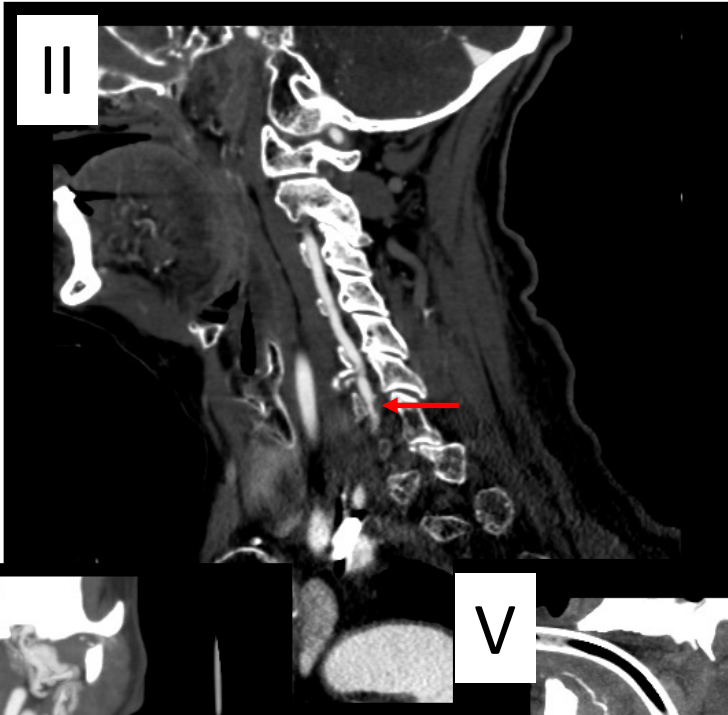
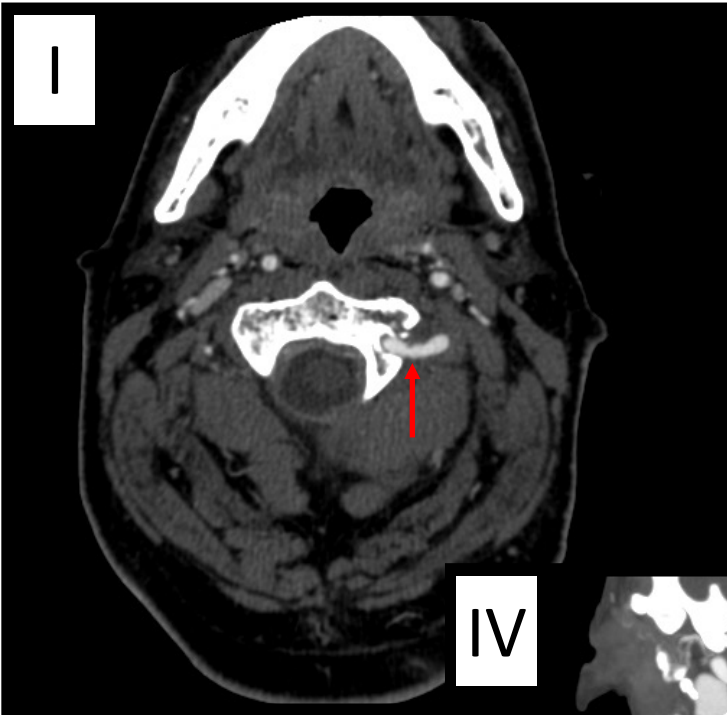
- Statistical analysis was conducted using the JMP software with pairwise data mean comparison performed using student's t-test
- Statistical significance was defined as  $p < 0.05$



# Examples of **Internal Carotid Artery** Biffl Grade I-V Injuries

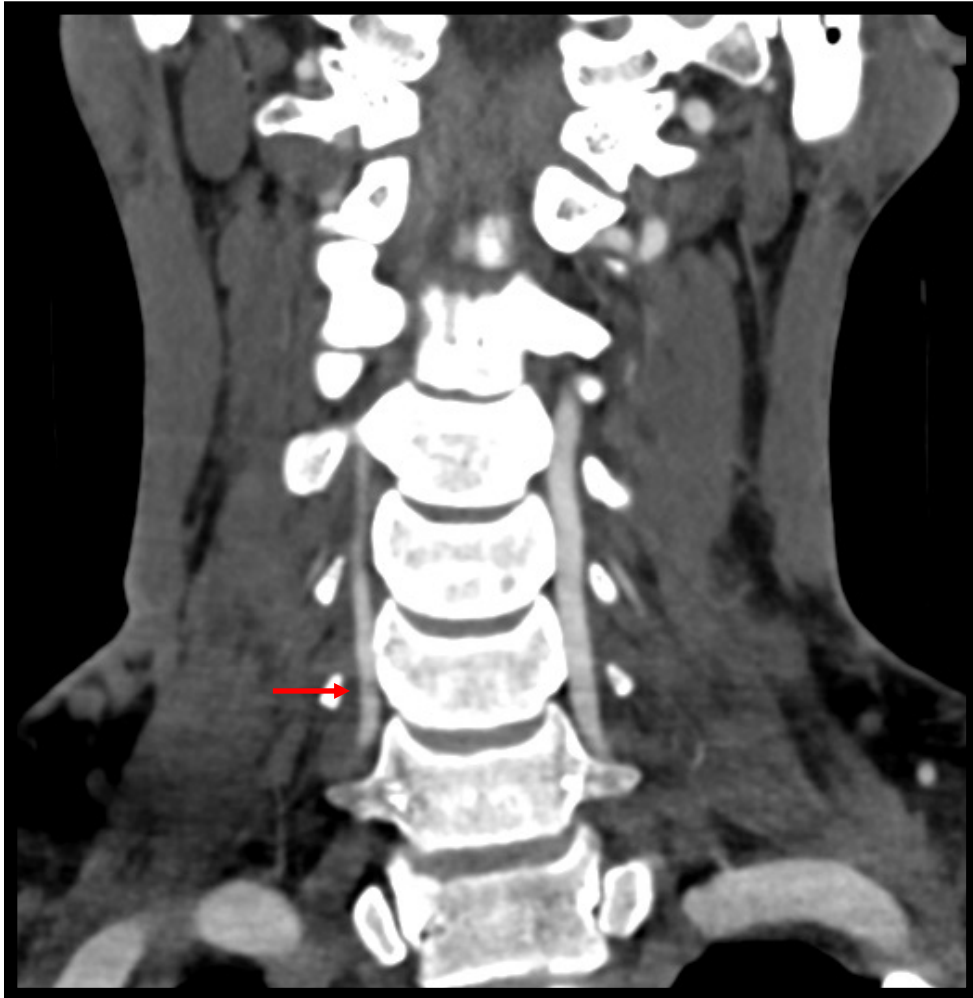


# Examples of **Vertebral Artery** Biffl Grade I-V Injuries

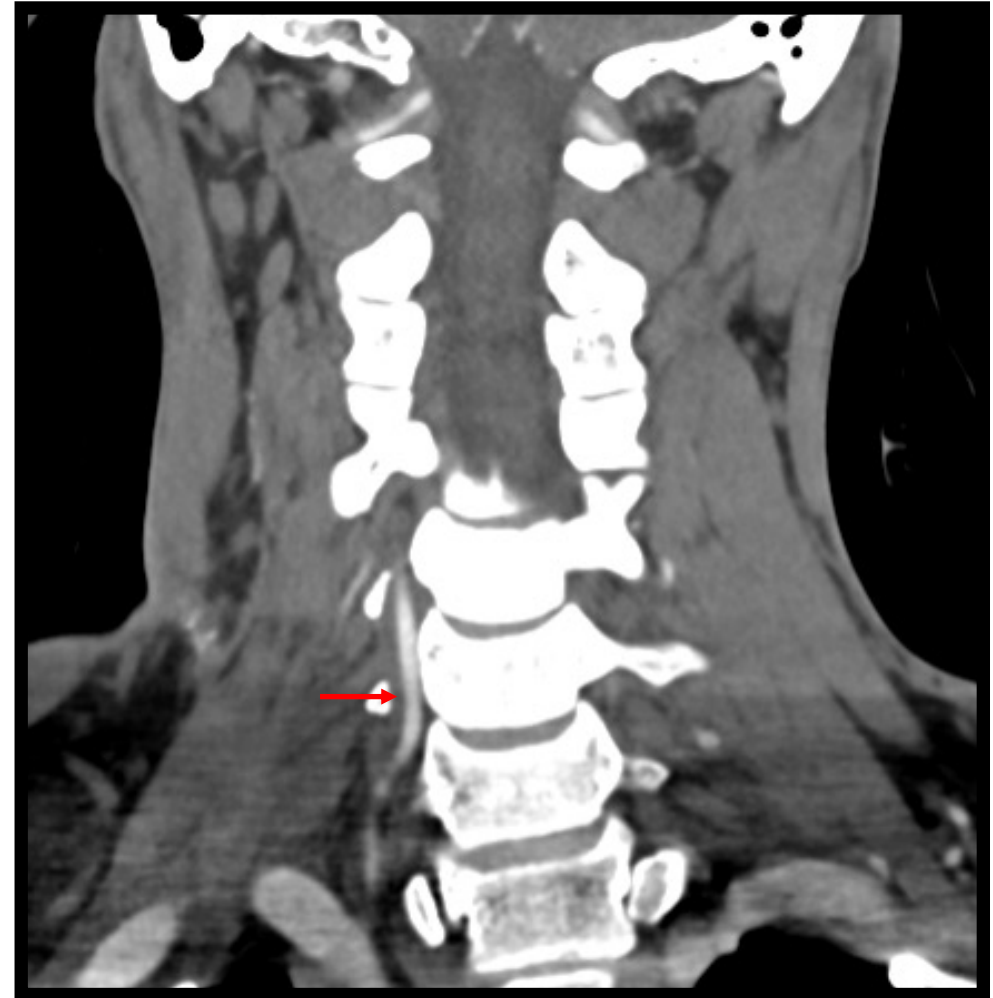




# Example of a False Positive Indeterminate Injury | **Artifact**

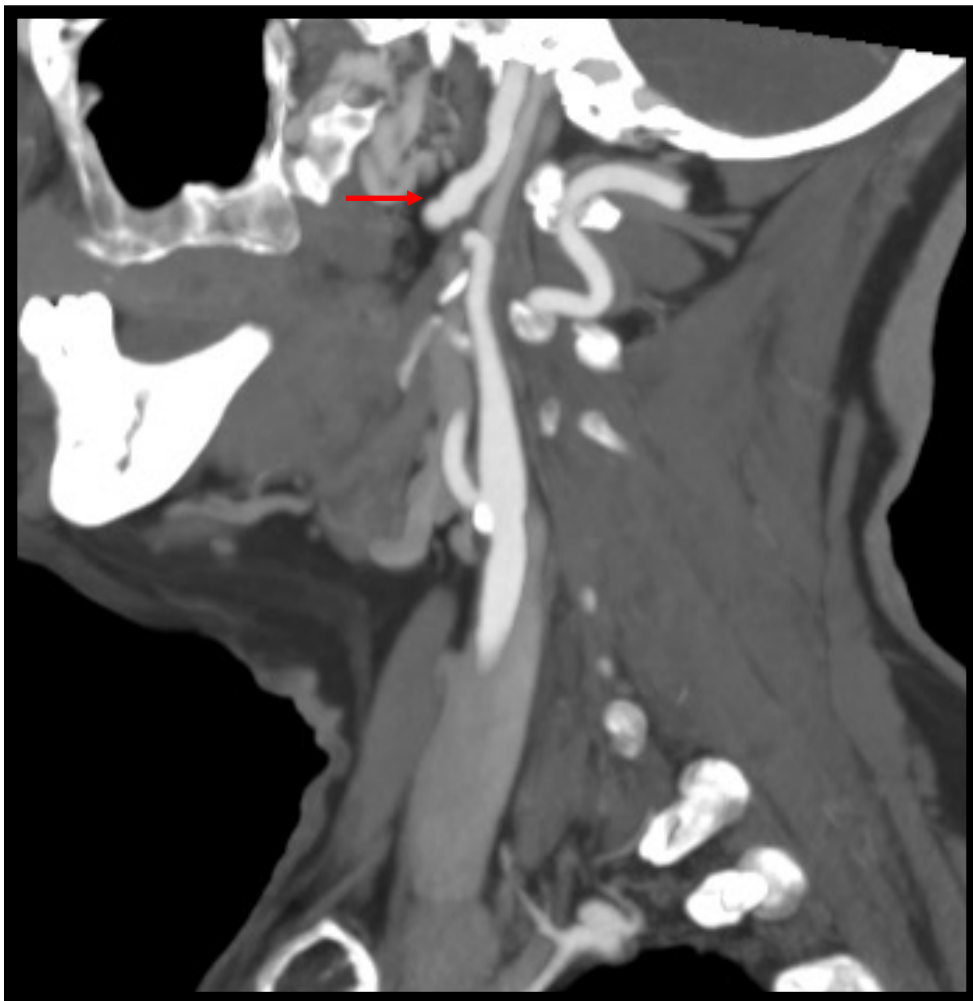


Initial Study

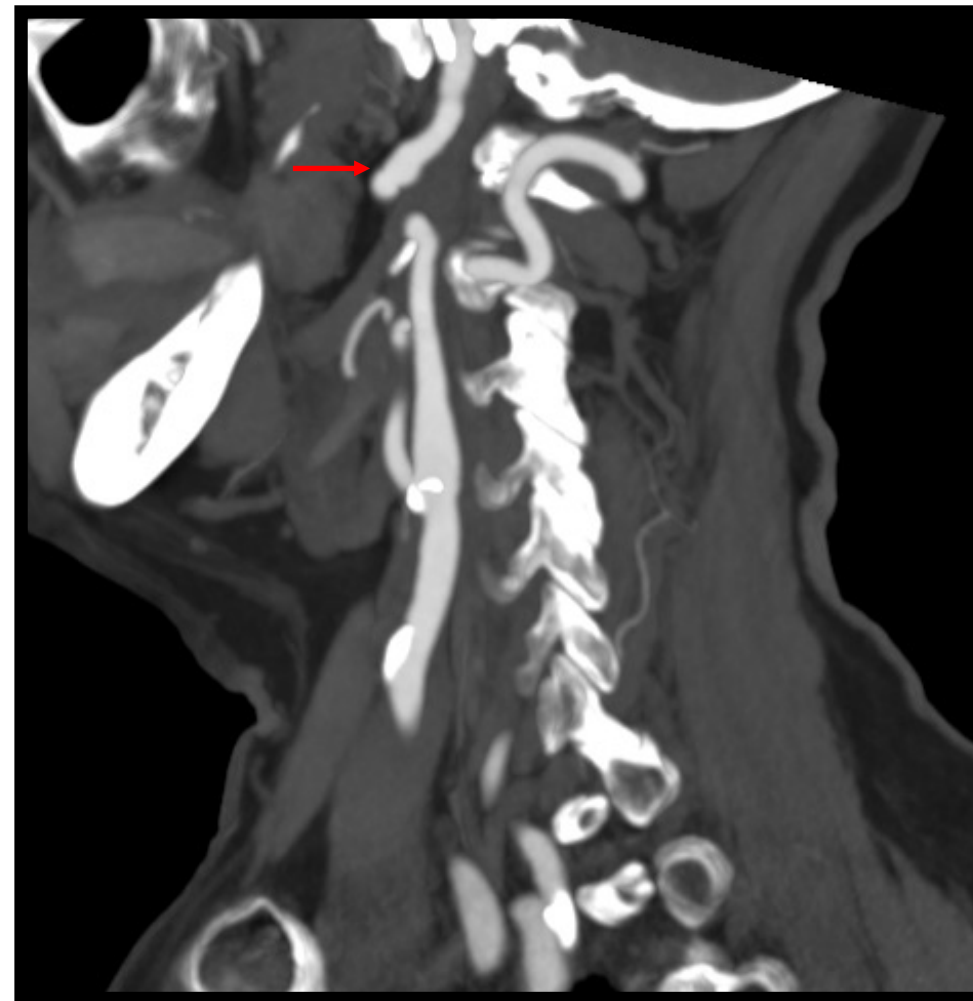


48-hour followup study (resolved)

Example of a False Positive Indeterminate Injury | **Fibromuscular dysplasia**



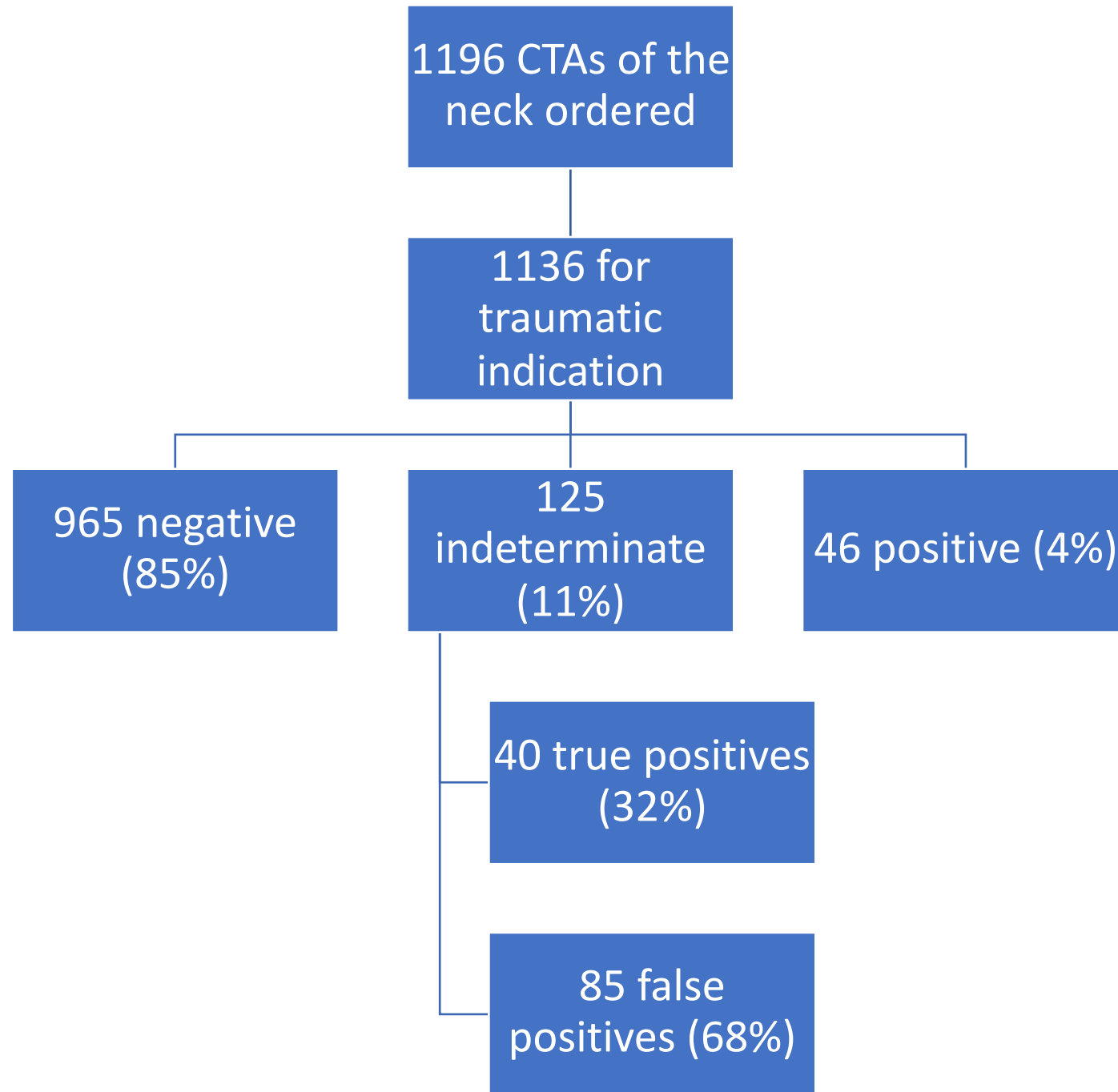
Initial Study



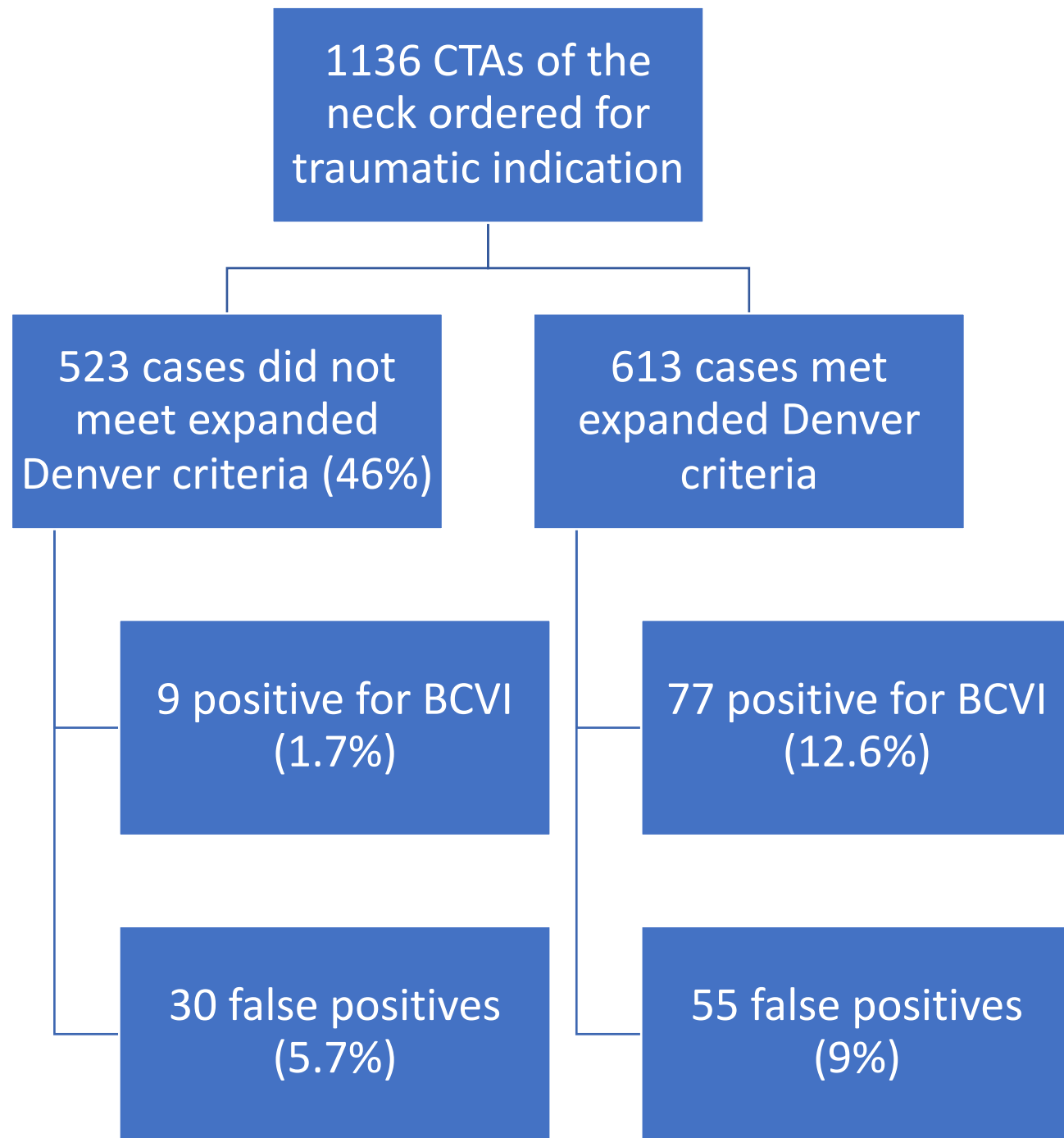
48-hour followup study (unchanged)

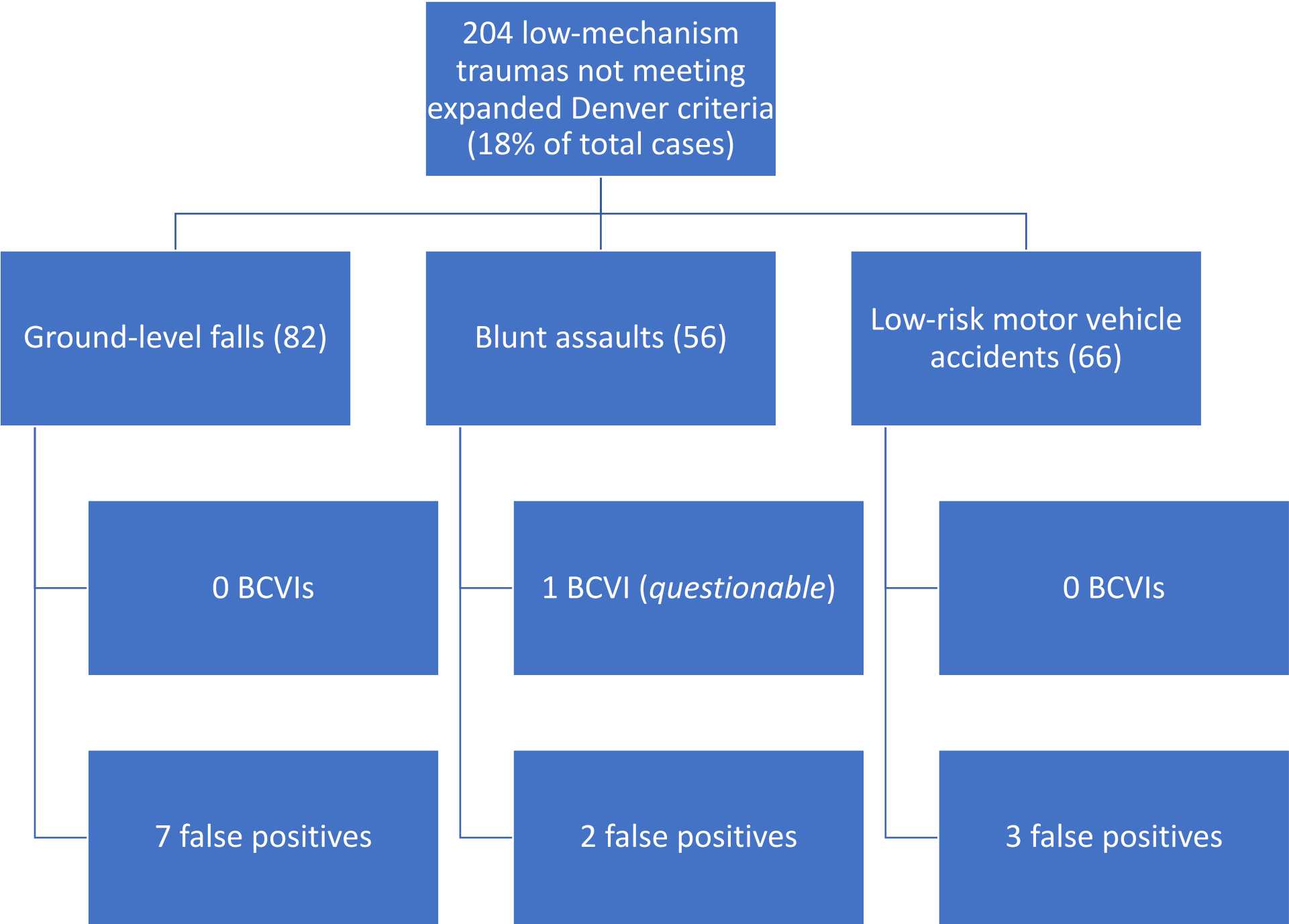
# Results

- 1196 neck CTAs performed, 1136 (95%) were for traumatic indication
- Most common mechanism was motor vehicle collision followed by ground level fall
- 965 (85%) neck CTAs were interpreted as negative, 125 (11%) as indeterminate and 46 (4%) as positive
- Of the indeterminate studies, 40 (32%) were classified as true positives and 85 (68%) were classified as false positives
- Within 171 positive and indeterminate cases, an internal carotid injury was reported in 114 (66.7%) and a vertebral artery injury in 82 (48%)
- 64 of the internal carotid injuries (56.1%) and 29 of the vertebral injuries (35.4%) were subsequently classified as false positives
- 204 out of the 1136 cases (18%) or 29% of the cases not meeting expanded Denver criteria could have been excluded from screening neck CTA with only 1 questionable injury missed and 12 indeterminate false positives prevented









# Results

- At least one follow up CTA was performed for 130 out of 171 positive and indeterminate studies (76%)
- 79 (60.8%) showed improvement, 49 (37.7%) showed no change, and 2 (1.5%) showed progression
- DSA was performed in 13 cases (7.6%), with stenting performed in 4, angioplasty in 1, and vessel sacrifice in 2
- In the 86 positive and true positive cases, ischemic stroke occurred 3 times (3.5%) compared to 0 times in 85 false positive cases ( $p=0.08$ )
- Death occurred in 18 of the of positive/TP cases (20.9%) and in 3 of the FP cases (3.5%,  $p<0.005$ )
- Worsening intracranial hemorrhage in 5 of the positive/TP cases (5.8%) and 2 of the FP cases (2.4%  $p=0.26$ )

Trauma mechanism	N	%
Motor vehicle collision	443	39.0
Ground-level fall	149	13.1
Fall down stairs	101	8.9
Blunt assault	93	8.2
Motorcycle accident	88	7.8
Fall from higher than ground-level	61	5.4
Penetrating injury	52	4.6
Pedestrian struck by motor vehicle	50	4.4
All-terrain vehicle or dirt bike	22	1.9
Hanging	8	0.7
Other	69	6.1

Group	I	II	III	IV	V
Positive studies	9	16	10	8	3
Indeterminate studies	114	6	1	3	0
TP	36	3	0	1	0
FP	78	3	1	2	0
Positive + TP	45	19	10	9	3



	N	Positive	<u>Indeterminate</u>			Negative	Positive +	Negative +
			Total	TP	FP		TP	FP
<b>Entire dataset</b>	<b>1136</b>	<b>46</b>	<b>125</b>	<b>40</b>	<b>85</b>	<b>965</b>	<b>86 (7.6%)</b>	<b>1050 (92.4%)</b>
<b>eDenver+</b>	<b>613</b>	<b>42</b>	<b>90</b>	<b>35</b>	<b>55</b>	<b>481</b>	<b>77 (12.6%)</b>	<b>536 (87.4%)</b>
GLF+	67	4	7	4	3	56	8 (11.9%)	59 (88.1%)
BA+	37	0	2	1	1	35	1 (2.7%)	36 (97.3%)
MVC+	240	27	41	17	24	172	44 (18.3%)	196 (81.7%)
<b>eDenver-</b>	<b>523</b>	<b>4</b>	<b>35</b>	<b>5</b>	<b>30</b>	<b>484</b>	<b>9 (1.7%)</b>	<b>514 (98.3%)</b>
GLF-	82	0	7	0	7	75	0 (0%)	82 (100%)
BA-	56	0	3	1*	2	53	1 (1.8%)	55 (98.2%)
MVC-	203	1	11	3	8	191	4 (2.0%)	199 (98.0%)
MVC <sub>low</sub>	66	0	3	0	3	63	0 (0%)	66 (100%)
<b>GLF-, BA-, MVC<sub>low</sub></b>	<b>204</b>	<b>0</b>	<b>13</b>	<b>1*</b>	<b>12</b>	<b>191</b>	<b>1 (0.5%)</b>	<b>203 (99.5%)</b>

# Discussion

- 204 cases of **low mechanism** trauma **not meeting expanded Denver criteria** (18% of our dataset) could have been excluded with only 1 questionably true positive case missed
  - 12 false positives would have been avoided
- The cost savings would have been **\$51,571.20** (at calculated institution-specific price of \$252.80 per CTA neck), though true savings are likely greater with consideration of potential cost of further work up

# Discussion

- Indeterminate neck CTAs are common but are largely ignored in the existing literature
- 68% of CTA studies interpreted as indeterminate in our study were determined to be false positives
- Among interpreting neuroradiologists, there was a three-fold variability in rates of reporting cases positive for BCVI (2-7.4%) and indeterminate (6.2-18.5%)
- None of the indeterminate cases demonstrated progression on follow up imaging studies

# Conclusions

- We advocate reservation of BCVI screening for low-mechanism trauma patients (ground-level falls, blunt assaults, and low-impact motor vehicle collisions) to those meeting expanded Denver criteria.
- Neck CTA should not be routinely added to initial trauma imaging bundle in these patients.
- More research is needed to understand the progression of indeterminate injuries and to establish designations for true and false positives.