Blunt Cerebrovascular Injuries

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Disclosures

- None
- I did not turn my presentation in on time for the AV team to check…all AV troubles are my own fault!

BCVI: Objectives

- What (what is the injury)
- Who (who is at risk to develop)
- When (do they occur)
- Why (should we care)
- How (to treat)

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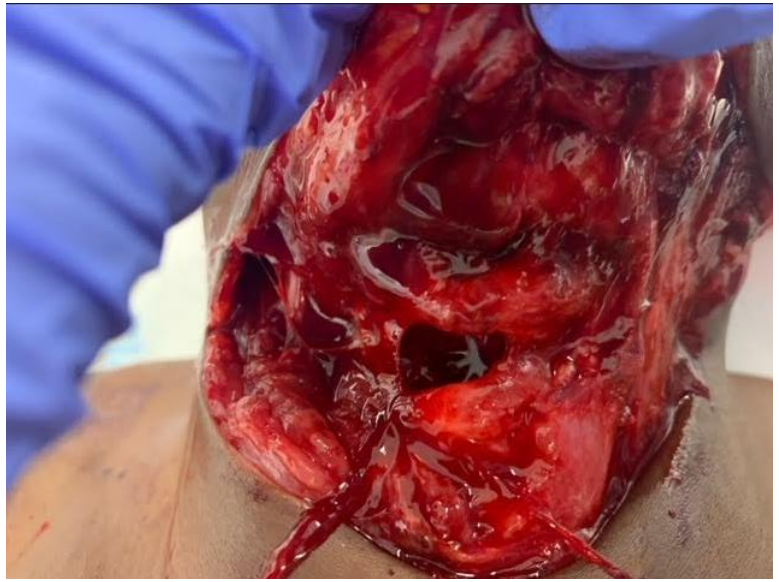
“Why have I never heard of this?”



“Why have I never heard of this?”

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BCVI in the news

Katie May

Alexander Orekhov

Brittanie Cecil

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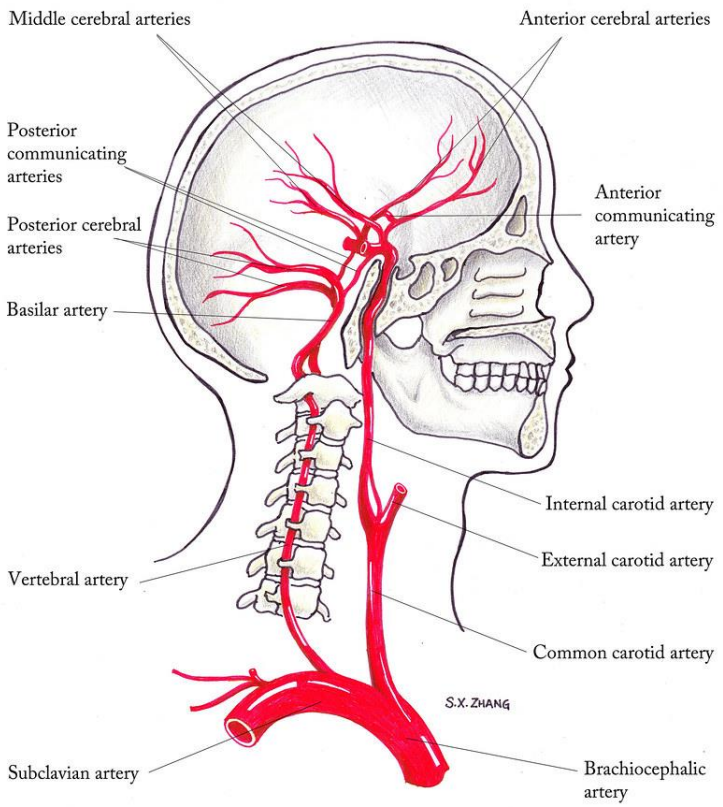
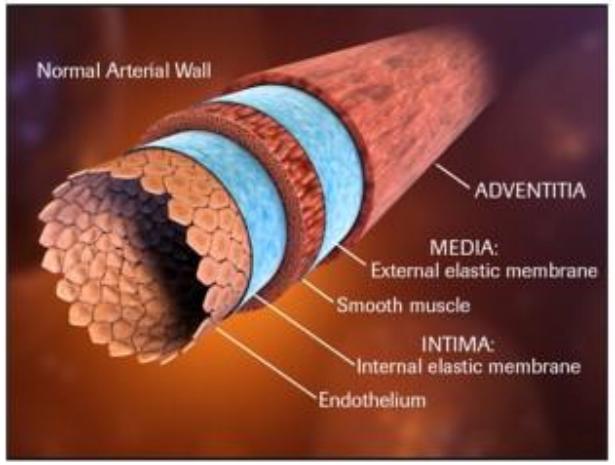
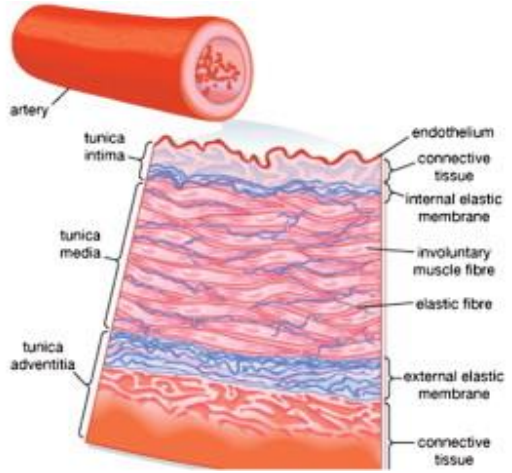
What is a blunt cerebrovascular injury







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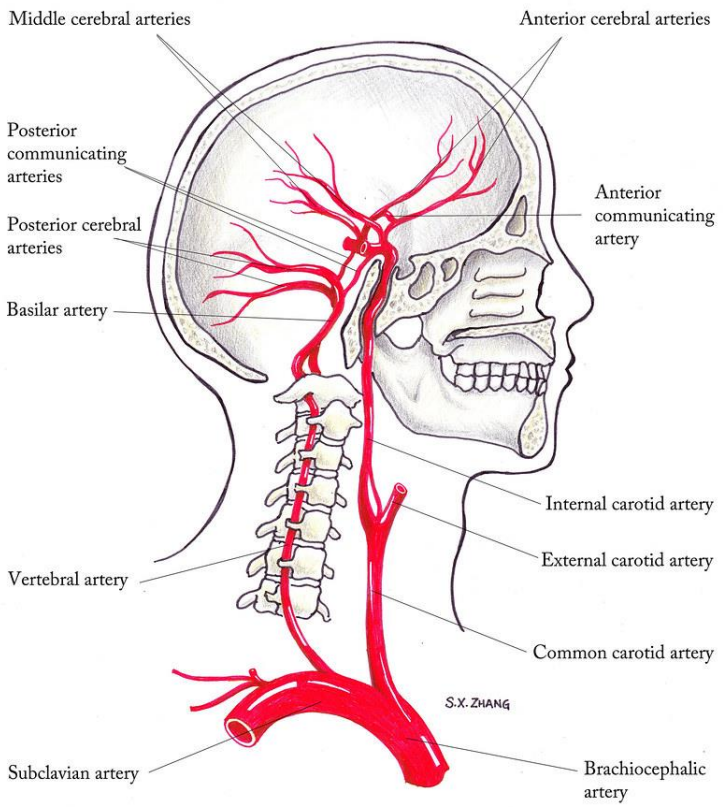
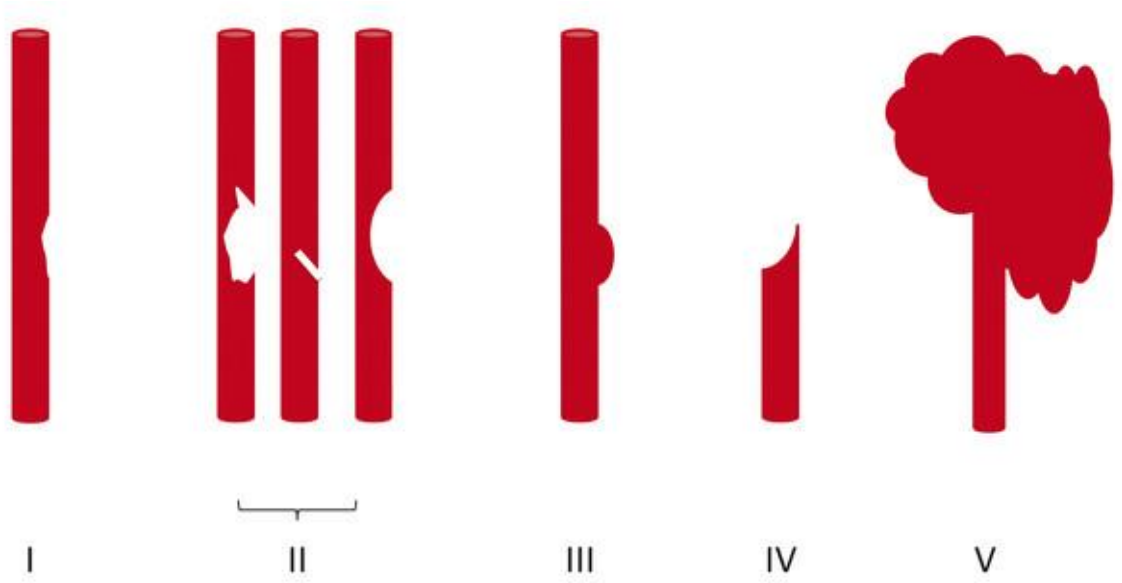
What is a blunt cerebrovascular injury

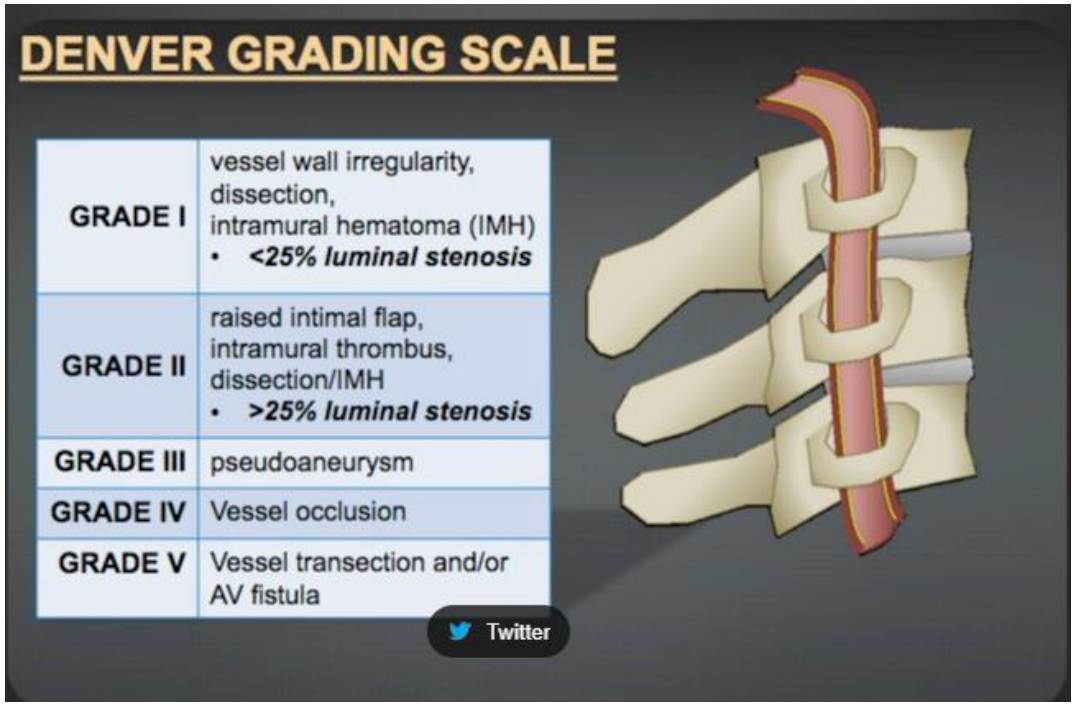


- Initial estimates: 0.5-3.3% patients admitted for blunt trauma
- True incidence hard to estimate
- The more you look the more you find!

Miller Ann Surg 2002
Black J Trauma Acute Care Surg 2020

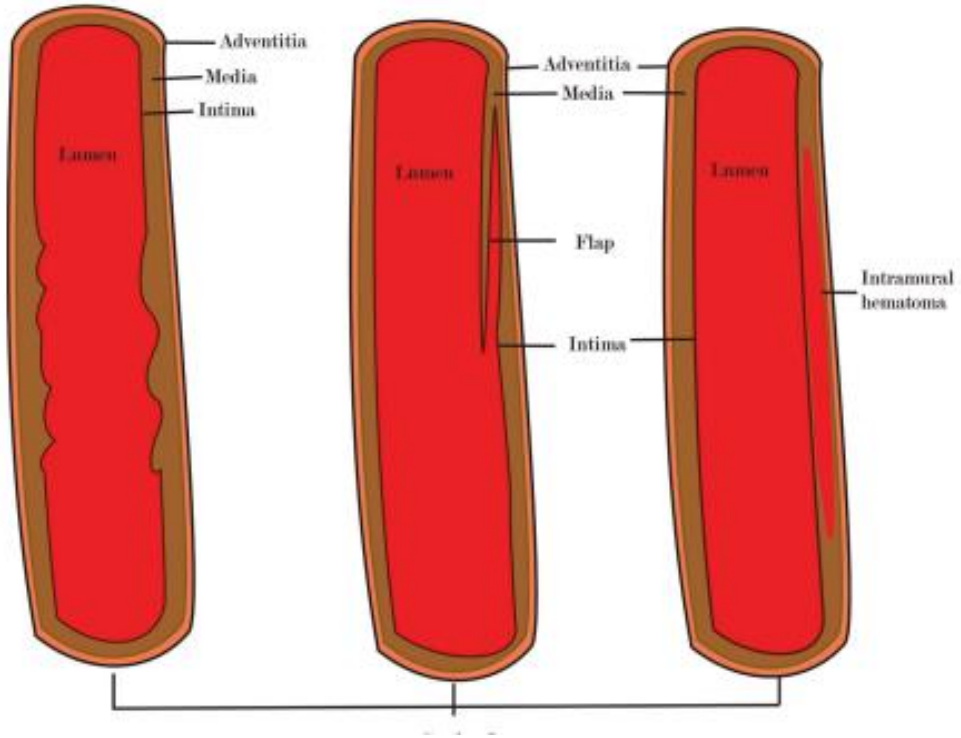
What is a blunt cerebrovascular injury



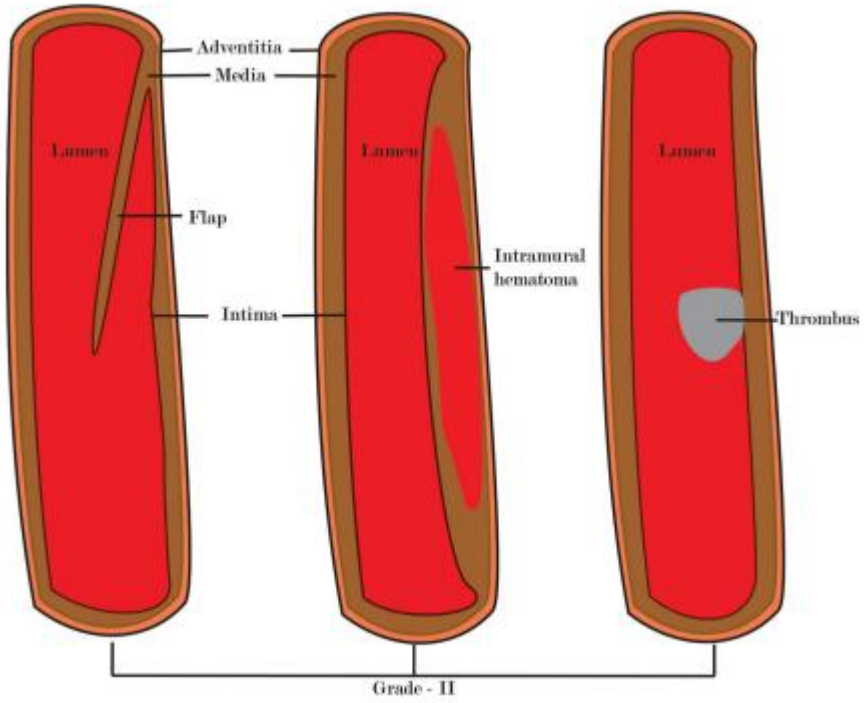


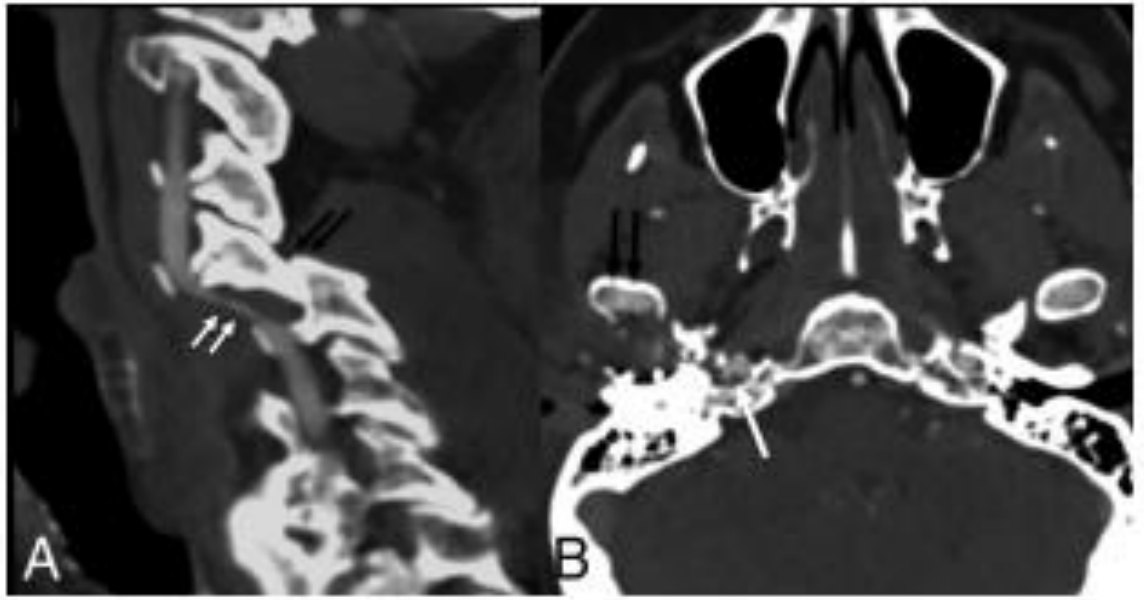
Biffl J Trauma 1999

Grade 1 Injury

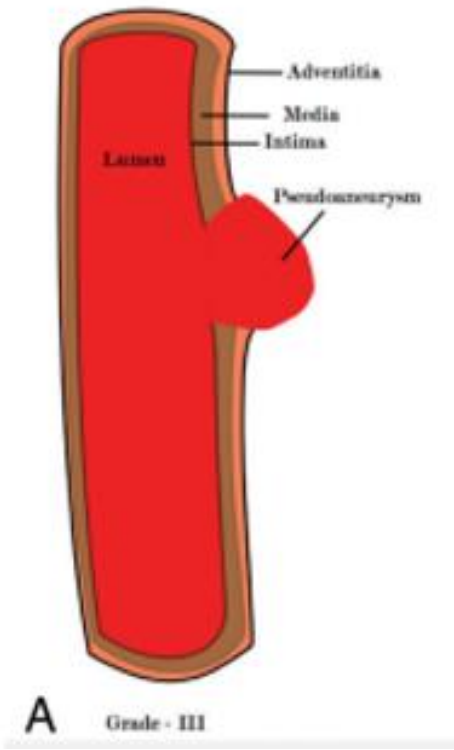


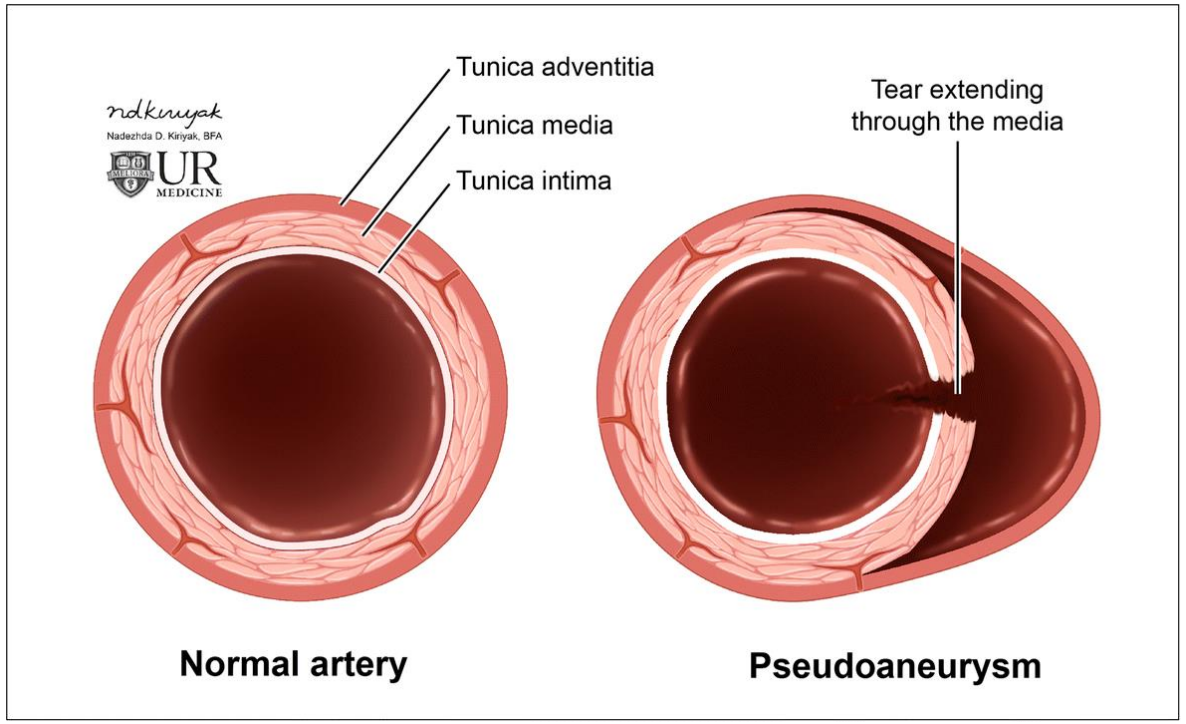
Grade 2 Injury

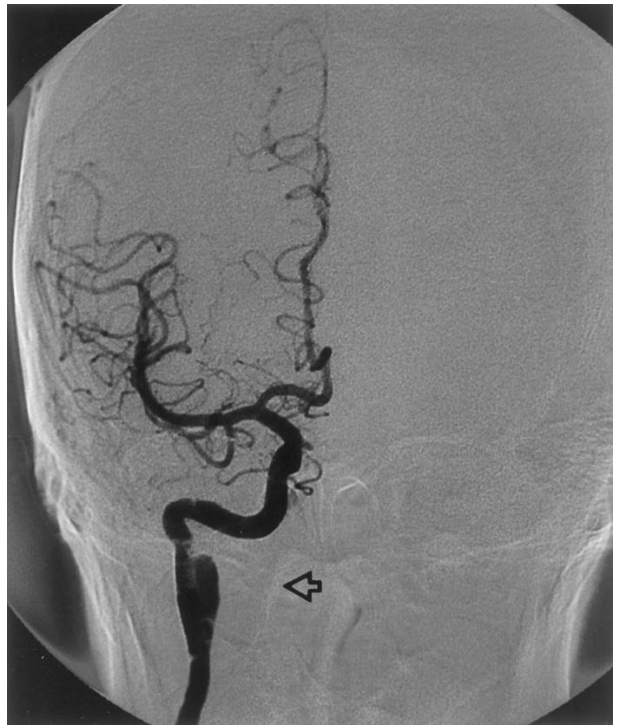




Grade 3 Injury







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Grade 4 Injury

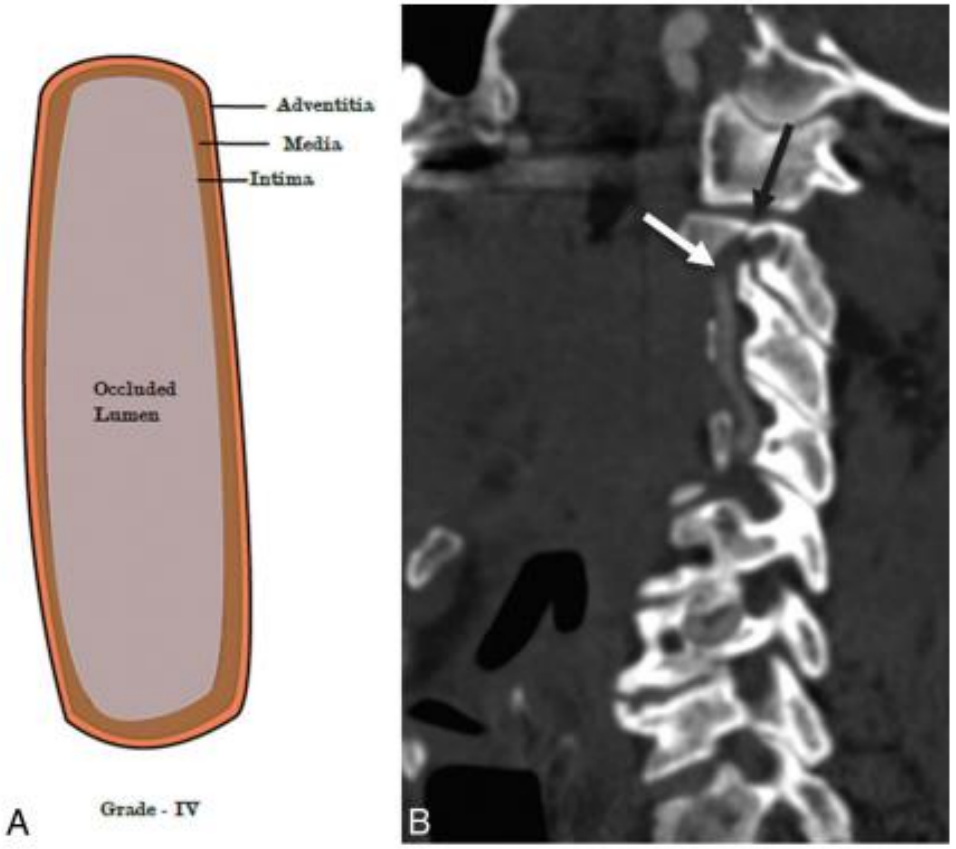

FIG 6. A 64-year-old man with blunt trauma to the neck. An illustrative diagram (*A*) shows grade IV injury. CTA sagittal image (*B*) shows a fracture of the C2 transverse foramina (*black arrow*) with abrupt occlusion of the right vertebral artery (*white arrow*), grade IV injury.

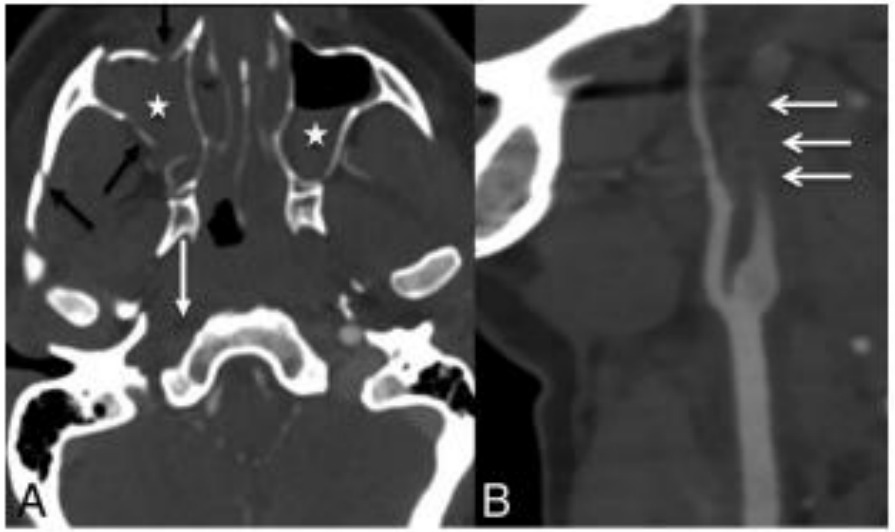

FIG 7. A 3
fractures.
zygomatic
tapered oc

with facial
ures of the
(*stars*) and
V injury.

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Grade 5 Injury

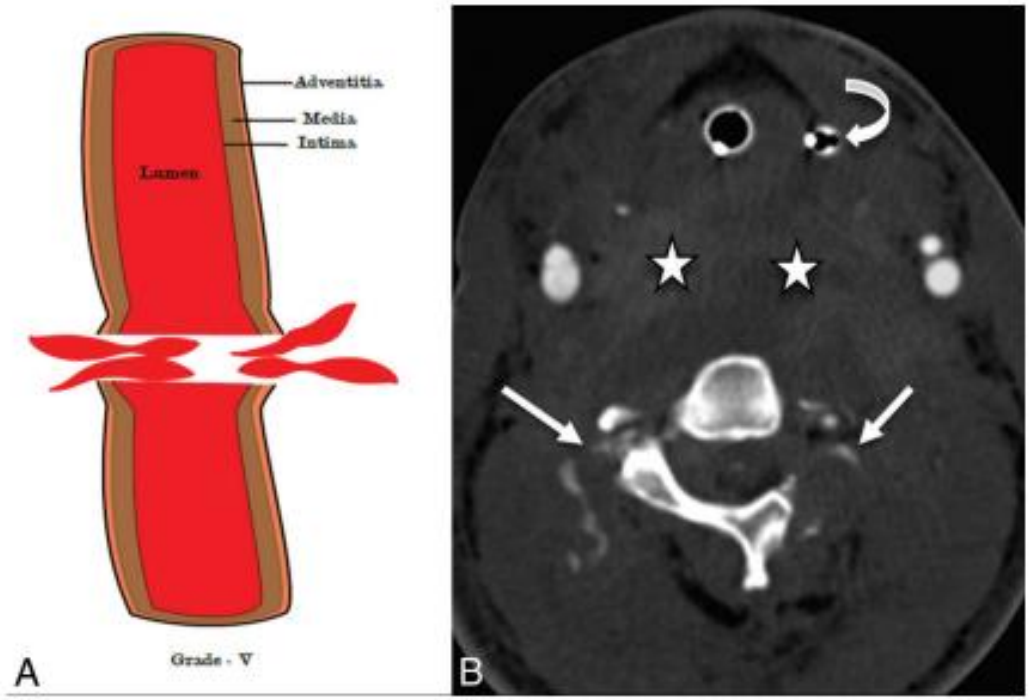

FIG 8. A 28-year-old man after a motor vehicle collision. An illustrative diagram (*A*) shows a grade V injury. CTA axial image (*B*) shows transection of the bilateral vertebral arteries with active contrast extravasation (*white arrows*), grade V injury. Also, note the large prevertebral neck hematoma (*stars*) displacing the orogastric tube (*curved arrow*) anteriorly. The patient also sustained C1 and C2 fractures (not shown).

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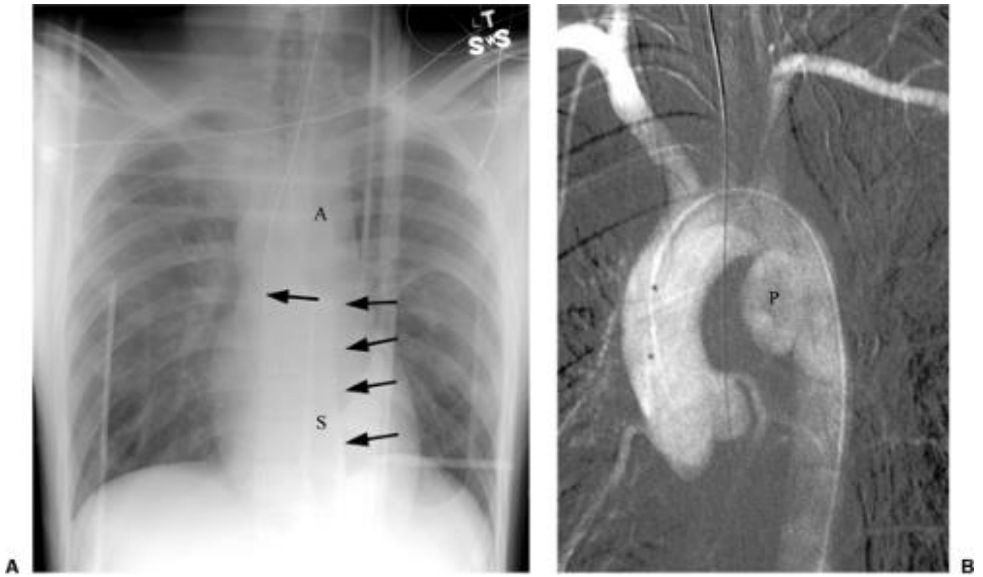
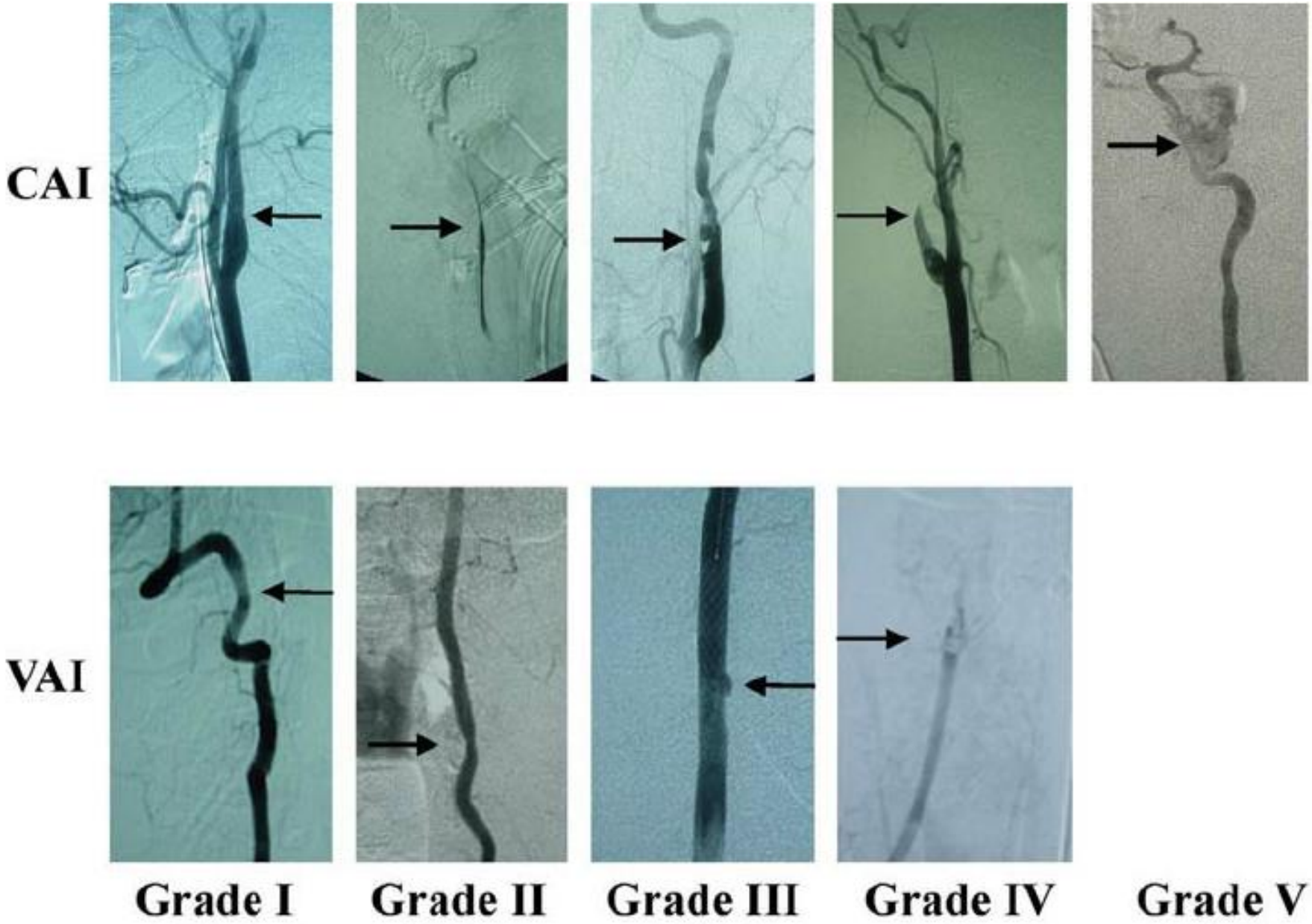
Historical Perspective

Timothy Fabian MD

Walt Biffl MD





Historical Perspective: Prevent Stroke

Timothy Fabian MD

Walt Biffl MD

Table 8. STROKE INCIDENCE BY INJURY GRADE FOR BCI AND BVI (1999)

	BCI		BVI	
Worst Injury Grade	Total	Stroke	Total	Stroke
I	50	4 (8%)	33	2 (6%)
II	14	2 (14%)	13	5 (38%)
III	35	9 (26%)	15	4 (27%)
IV	8	4 (50%)	18	5 (28%)
V	7	7 (100%)	—	—

BCI, blunt carotid artery injury; BVI, blunt vertebral artery injury.

- Internal carotid artery: stroke rates ranging 26 to 41 percent (2022)
- Vertebral injuries: stroke is 14 to 24 percent (2022)

- Carotid artery: stroke rates increase with increasing injury grade
- Vertebral artery: stroke rate independent of injury grade

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Biffl J Trauma 1999
UptoDate 2022

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Who gets screened?

Literature review in 1980—only 96 patients found

Were only screening symptomatic patients

1988….significant uptick in publications

1998--Biffl “The unrecognized epidemic of blunt carotid arterial injuries: early diagnosis improves neurologic outcomes.”

Who gets screened? Before 1996

Symptomatic patients

- Hemorrhage of presumed carotid origin
- cervical bruits
- signs or history of external cervical trauma with altered mental status
- lateralizing neurologic deficits including hemiparesis, transient ischemic attacks, amaurosis fugax, or Horner's syndrome
- neurologic deficits incongruous with computed tomography (CT) scan findings
- evidence of cerebral infarction on CT

- → underwent four-vessel cerebral angiography for diagnosis

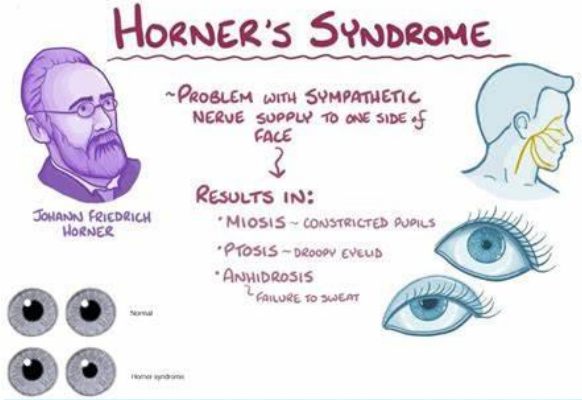
Who gets screened? After 1996

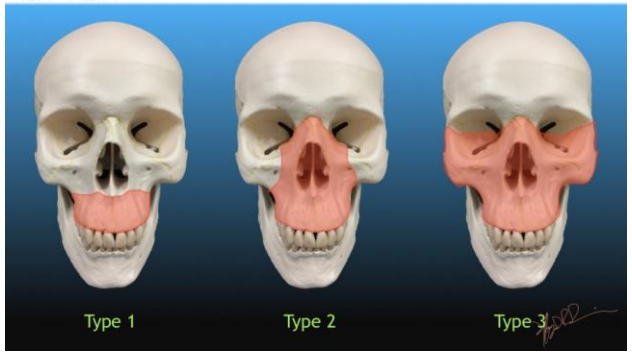
Symptomatic and asymptomatic

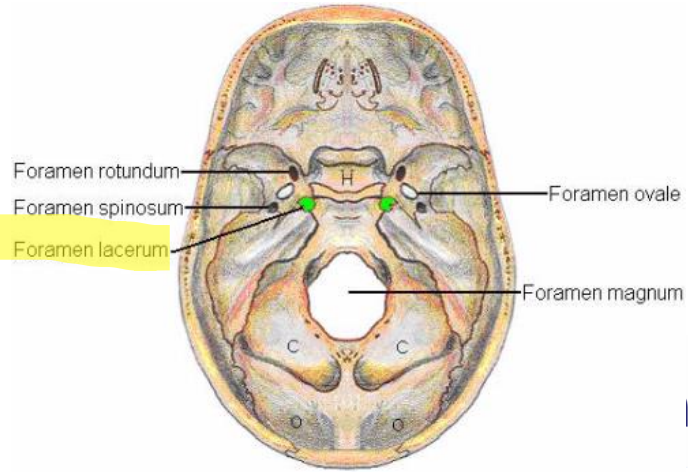
- screen patients who were asymptomatic for BCVI
  - injury mechanism compatible with severe hyperextension or flexion and rotation of the neck
  - significant soft-tissue injury of the anterior neck
  - cervical spine fracture
  - displaced midface fracture or mandibular fracture associated with a major injury mechanism
  - basilar skull fracture involving the sphenoid, mastoid, petrous, or foramen lacerum.

Who gets screened? An evolution

Denver Criteria (1999)	Memphis Criteria (2002)
Carotid artery hemorrhage	Cervical spine fracture
Cervical bruit	Neurologic exam not explained by CT head
Cervical trauma plus AMS	Horner's syndrome
Lateralizing neurologic deficit (hemiparesis, TIA, amaurosis fugax, Horner's syndrome)	Lefort II/III facial fractures
Cerebral infarction on CT head	Skull base fractures involving foramen lacerum
Severe cervical hyperextension injury	Neck soft tissue injury (e.g. seatbelt injury, hanging)
Severe cervical flexion and rotation injury	
Significant cervical soft tissue injury	
Cervical spine fracture	
Displaced midface fracture	
Mandible fracture	
Basilar skull fracture involving sphenoid, mastoid, petrous or foramen lacerum	





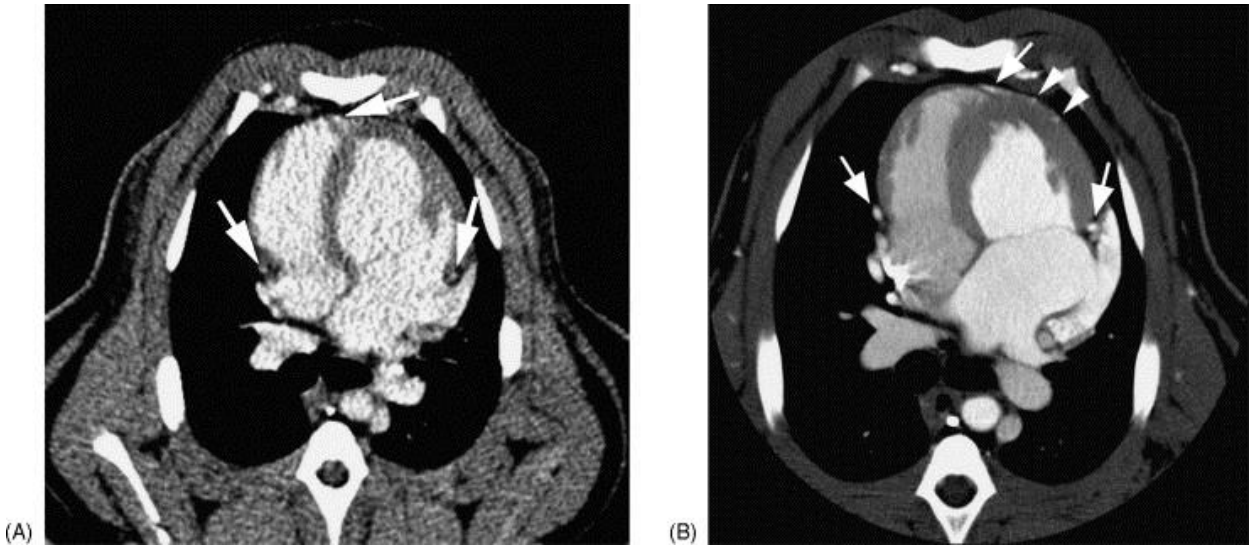


Who gets screened? An evolution

20% of patients with BCVI did not meet screening criteria

The more we scan, the higher the incidence of injury

CT scans are getting better



Burlew et al J Trauma Acute Care Surg 2012
Emmett J Trauma Acute Care Surg 2011

Who gets screened? An evolution

EXPANDED Denver Criteria (2012)	MODIFIED Memphis Criteria (2011)
Potential arterial hemorrhage from nose/neck/mouth	Cervical spine fracture
Cervical bruit **<50yo**	Neurologic exam not explained by CT head
Expanding cervical hematoma	Horner's syndrome
Focal neurologic deficit: TIA, hemiparesis, vertebrobasilar symptoms, Horner's syndrome	Lefort II/III facial fractures
Cerebral infarction on CT head **or MRI** **Neurologic exam inconsistent with CT head**	**Basilar skull fracture**
Severe cervical hyperextension injury	Neck soft tissue injury (e.g. seatbelt injury, hanging)
Severe cervical flexion and rotation injury	**Potential head or skull injury**
Significant cervical soft tissue injury	**Loss of consciousness, AMS, periorbital ecchymosis, supramastoid ecchymosis**
Cervical subluxation or ligamentous injury, transverse foramen fracture, any body fracture, and fracture C1-C3	**Potential cervical spine fracture, or soft tissue injury (paralysis with cspine level, cervical step off, soft tissue seatbelt mark)**
Displaced midface fracture **(LeFort II/III)**	**Potential LeFort facial fracture (midface instability, marked external deformity)**
Mandible fracture	
Complex skull fracture, basilar skull fracture, occipital condyle fracture	
Closed head injury with Diffuse Axonal Injury and GCS <6	
Clothesline/seatbelt type injury with significant swelling/pain or AMS	
Traumatic brain injury with thoracic injuries	
Scalp degloving	
Thoracic vascular injuries/blunt cardiac rupture	

Who gets screened? An evolution

Selective screening → Universal screening
can we know the true incidence?

- Incidence 7.6% (Birmingham)
- Incidence 2.7% (Virginia)
- Up to 1/3 missed using modified/extended criteria
- The more we scan, the higher the incidence of injury
- Who can remember all the criteria?

Black J Trauma Acute Care Surg 2020
Leichtle J Trauma Acute Care Surg 2020

Who gets screened? (Still) An evolution

Advocate for BCVI Screening if getting whole body scan

- Likely to detect some clinically less significant injuries (Grade 1)
- Progression: 10-30% of injuries

- **Contrast Nephropathy?**
  - Can be protocolized to use same contrast bolus or small increase in volume
  - Incidence not increased in retrospective studies
  - ACR suggest risk of nephropathy overstated

- **Cost?**
  - CT cspine cost included in CTA neck
  - 7% increased cost for exam including CTA

Black J Trauma Acute Care Surg 2020
Leichtle J Trauma Acute Care Surg 2020

Who gets screened? Mechanism

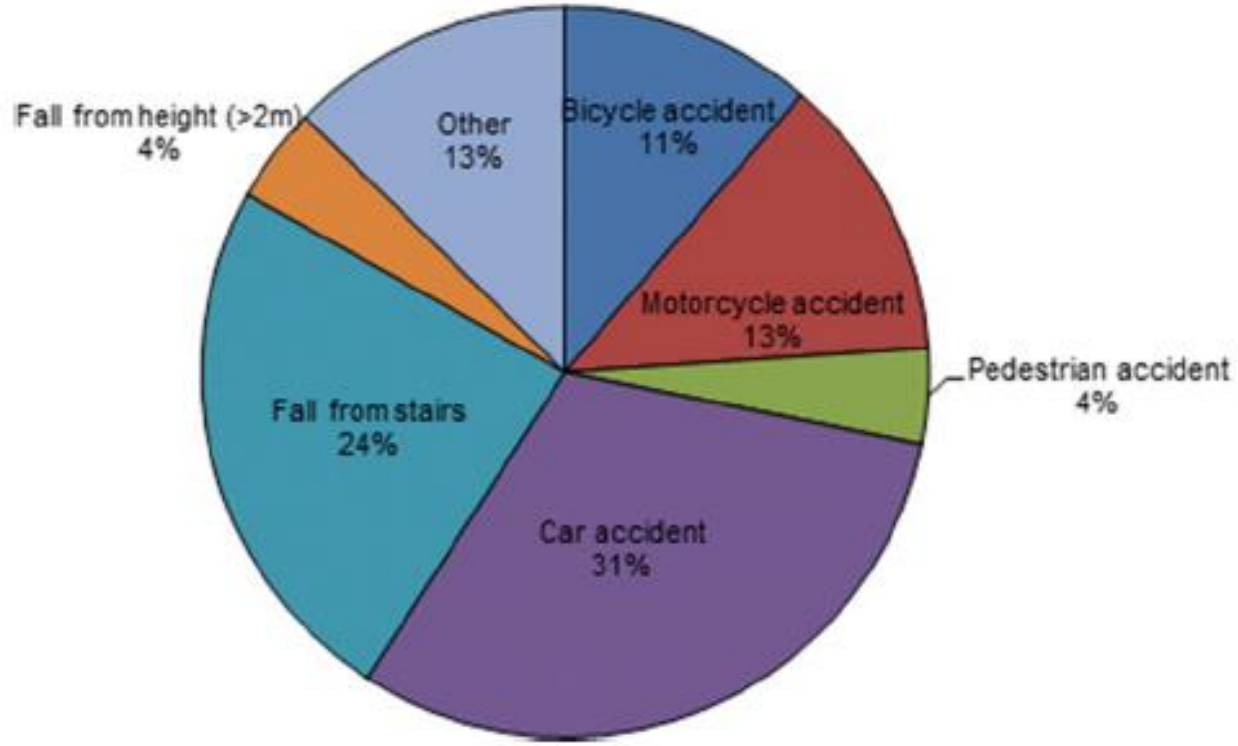


Fig. 1 Pie chart displaying the mechanism of trauma of all BCVI patients

Hundersmarck European J Trauma 2021

What about everyone's favorite trauma?

Geriatric Falls and BCVI

Table 1 Incidence of BCVI based upon ICD-9 code from the NTDB (2007–2014), stratified by age (18–64, 65+) and injury mechanism

	All blunt injuries	≥ 1 risk factor for BCVI	*p*
18–64 non-ground-level fall	0.70% (14497)	2.8% (10758)	< 0.001
18–64 ground-level fall	0.20% (715)	1.1% (388)	< 0.001
Elderly non-ground level fall	0.59% (2330)*	2.49% (1810)*	< 0.001
Elderly ground level fall	0.15% (1168)† ‡	0.86% (652)† ‡	< 0.001

All data are presented as incidence (number of patients with BCVI)
*Statistically significant difference relative to 18–64 non-ground-level fall group ($p < 0.05$)
†Statistically significant difference relative to elderly non-ground-level fall group ($p < 0.05$)
‡Statistically significant difference relative to 18–64 ground-level fall group ($p < 0.05$)

Less likely to get BCVI Screening
Two centers: 39%, 44% of elderly GLF meeting criteria screened

Flashburg J Trauma Acute Care Surg 2019
Anto World J Emerg Surg 2018

Incidence and Distribution(2020)

TABLE 2. Distribution of Injuries, by Biffl Grade, All Injuries (n = 614)

Biffl Grade		Carotid Artery Injuries n (%)	Vertebral Artery Injuries n (%)
1	Luminal irregularity or dissection <25% luminal narrowing	174 (54.9)	133 (44.8)
2	Dissection or intramural hematoma ≥25% luminal narrowing	92 (29.0)	79 (26.6)
3	Pseudoaneurysm	38 (12.0)	13 (4.4)
4	Vessel occlusion	13 (4.1)	71 (23.9)
5	Transection with free extravasation	0 (0.0)	1 (0.3)
All		317	297

Black J Trauma Acute Care Surg 2020

Time to Stroke

- Estimated: 20% untreated injuries → stroke
- 2018: 37 trauma centers, retrospective 10 yr review
  - 492 BCVI related strokes
    - 182 (37%) –stroke on admission

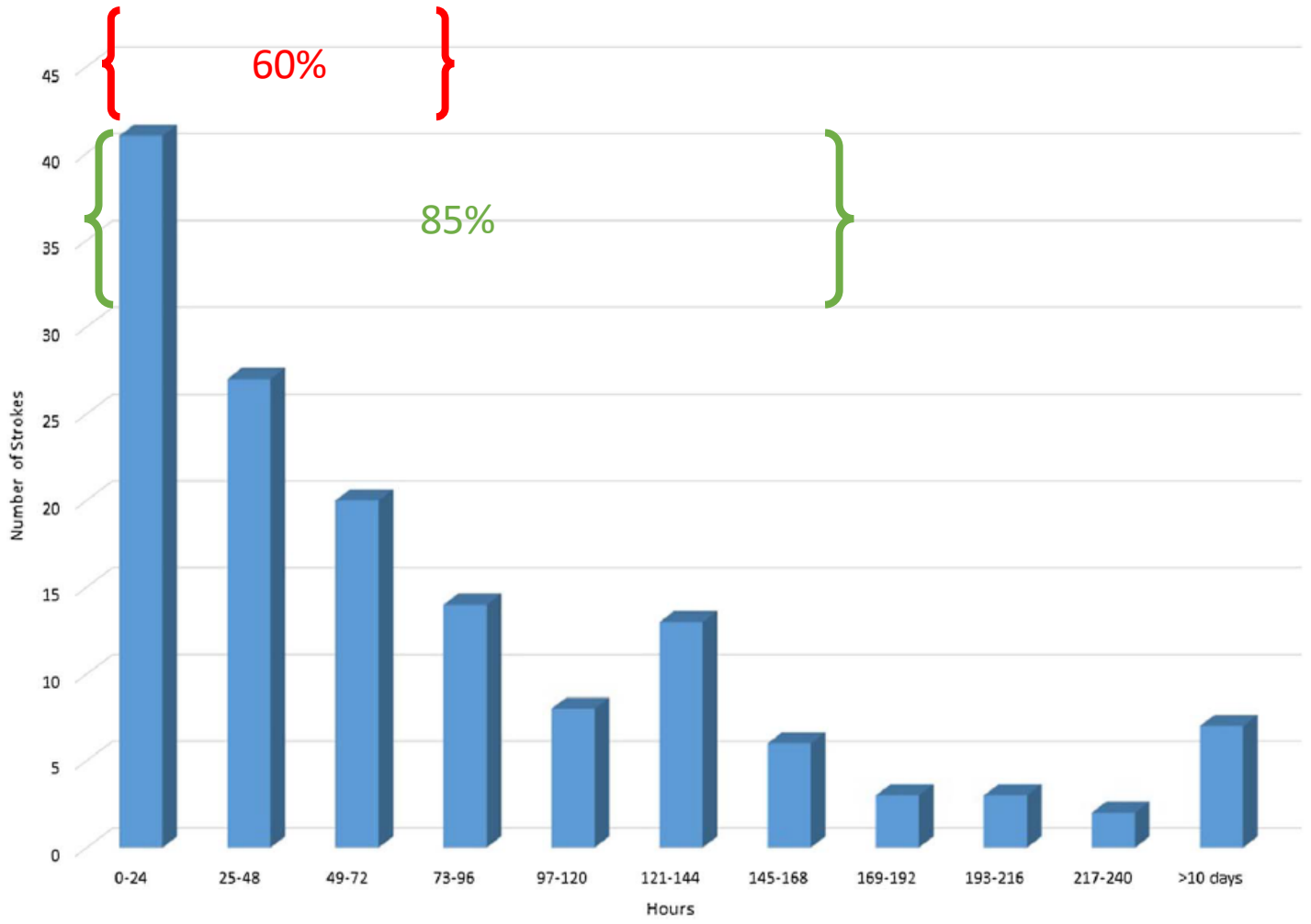
Biffl Grade	Carotid (n=118, 65%)	Vertebral (n=61, 34%)
I	14	6
II	31	21
III	16	3
IV	50	32
V	6	2

  - Mortality = 32% (half of which were attributed to the stroke)

Time to Stroke

- 304 without stroke on admission that developed stroke:
  - Median time to stroke: 48 hours*
    - New Neurologic symptoms: median 54 hours
    - No new symptoms: median 42 hours
- Of patients who stroked after admission:
  - 72% were not on antithrombotic therapy
    - No therapy median time to stroke: 38 hours
  - 22% on therapy when stroke occurred
    - Varying therapies (heparin, aspirin, Plavix)
    - Median time to stroke 81 hours

Time to Stroke (pts with neurologic sx)



Burlew J Trauma Acute Care Surg 2018

Treatment

Table 4. Injury Outcome Stratified by Treatment Modality

	No. of BCVI (N=422)	No. (%) With Stroke
Treatment for Asymptomatic Injuries (n=282)		
Treatment		
Heparin sodium	192	1 (0.5)
Aspirin	67	0
Aspirin/clopidogrel	23	0
No Initial Treatment (n=140)		
Reason for no treatment		
Contraindication/subtherapeutic	107	23 (21)
Stroke at presentation	26	26 (100)
Primary embolization/stent	7	7 (100)

Abbreviation: BCVI, blunt cerebrovascular injuries.

Cothren Arch Surg 2009

Treatment Results: All grades BCVI @7-10 days

HEALING

ASPIRIN AND/OR PLAVIX	ASA ONLY	HEPARIN
46%	63%	39%

PROGRESSION

ASPIRIN AND/OR PLAVIX	ASA ONLY	HEPARIN
15%	10%	12%

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Cothren Arch Surg 2009

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Bleeding Risk?

- Retrospective including TBI patients, SCI patients
- Therapy started (ASA 46%, Heparin 50% Combo 4%)
  - Median day 3
  - 86% prior to day 7
- Hemorrhagic TBI worsened:
  - 6.25% non treated group
  - 5.1% treated group (both recovered for rehab)
- No SCI patients worsened

No definitive answer to when is safe: still individualized; suggests earlier may be safe.

Pediatric BCVI

- Even less data…a work in progress
- Attempts at scoring systems misidentify >40%
- What we have suggests: “not small adults”
- Age likely has a factor
- Risk factors: skull base fractures, cervical spine fractures, mandible fracture ?MVC/autoped?
- Screening bias?

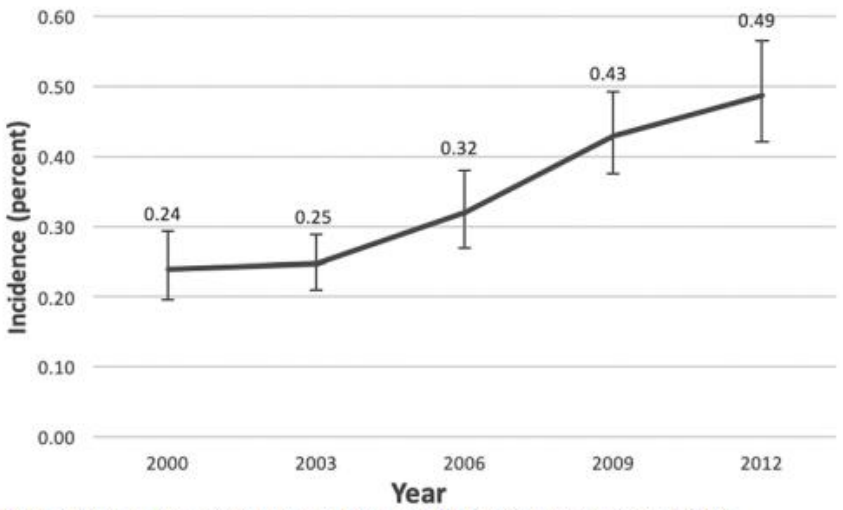

FIG. 1. Incidence of BCVIs among pediatric trauma patients from 2000 to 2012. *Error bars* denote 95% CIs.

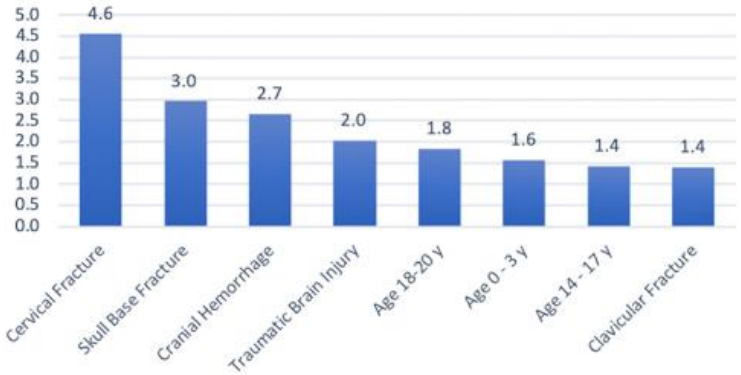

FIG. 2. Adjusted ORs of factors associated with increased risk of BCVI in the multivariate analysis. All listed factors were statistically significant. Figure is available in color online only.

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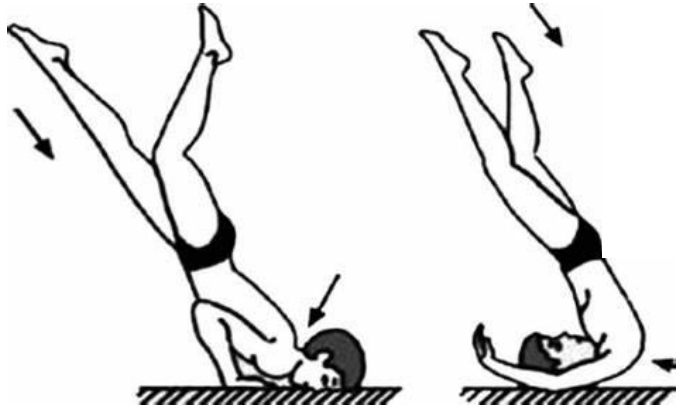
So….what can we do: First responders

- Look for signs of hyperflexion/extension injuries
- Any lateralizing signs



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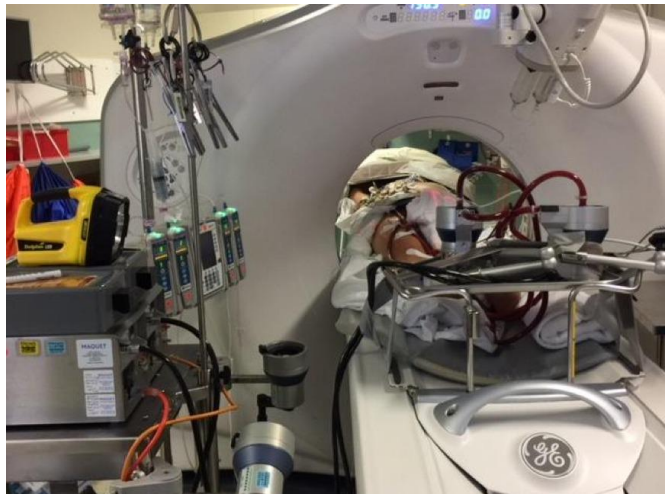
So….what can we do: Nursing

- Forgive us when the patient needs another road trip to CT scan!
- Any lateralizing signs?
  - Stroke
  - BCVI
  - Spine



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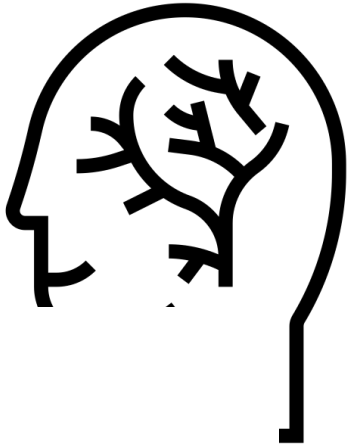
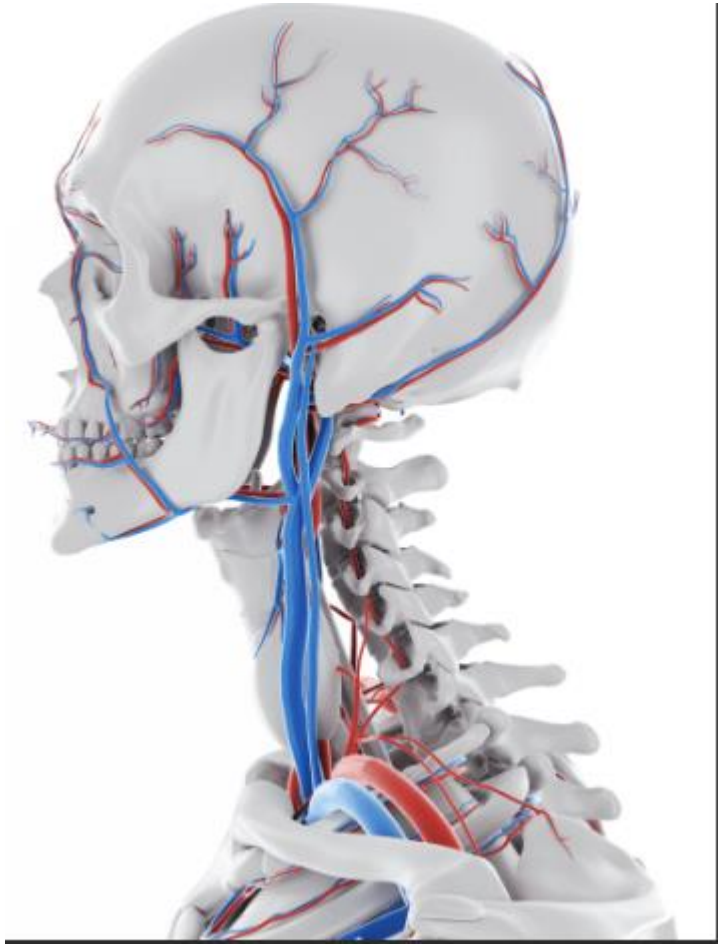
So….what can we do: Providers

- Remember screening criteria
- Severe flexion/extension injury
- Don’t exclude young/old
- Daily risk/benefit assessment for starting therapy
- Spread the word!



Blunt Cerebrovascular Injuries: Take Home

- **Early screening and treatment protocols decrease stroke rates**
  - The more you look, the more you find
- **More common in high energy mechanism**, but not insignificant in low energy
- **Pediatrics**—most centers screen like adults—new data coming
- **Antiplatelet medications equivalent** healing to heparin infusion (and much easier)
  - Which antiplatelet? Which dose?
- **Most strokes occur within 72 hours**, some are present on admission
- When is **a safe time to start therapy** in polytrauma/TBI?



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THANK YOU
FOR LISTENING

ANY QUESTIONS ?

NO?
GREAT!

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