

**12th Nordic Course in Trauma  
Radiology**

Stockholm, Sweden

11 June 2024, 1040-1100

# Blunt Cerebrovascular Injuries

**Clint W. Sliker, MD, FACR, FASR**

Associate Head of Trauma Radiology  
Department of Diagnostic Radiology & Nuclear Medicine  
University of Maryland School of Medicine  
R Adams Cowley Shock Trauma Center  
University of Maryland Medical Center



UNIVERSITY of MARYLAND  
SCHOOL OF MEDICINE



I have no conflicts of interest to disclose.



# Overview

- Review various appearances of blunt cerebrovascular injuries (BCVI).
- Review injury grading BCVI with Denver/Biffi injury scale.
- Discuss injury features that may affect patient outcomes.
- Discuss BCVI screening.

# Blunt Cerebrovascular Injuries

- 1.1%-1.6% incidence
  - 0.03%-0.3% pediatric
- Mortality high if untreated
  - Common or internal carotid artery 25%-40%
  - Vertebral artery 10%-15%
- Treatment greatly improves outcomes
  - Asymptomatic and symptomatic

# Mechanism of Injury

## Stretch Injury

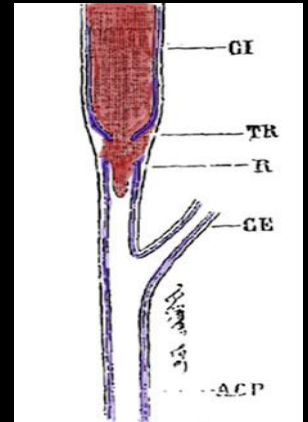
- Main mechanism
  - Especially ICA's
- Causes
  - Hyperextension
  - Hyperextension-rotation
  - Distraction

## Crush Injury

- Direct blow
- Fracture fragments
  - Carotid canal
  - Cervical spine
- Between normal structures
  - Mandible and spine (ICA's)
  - Basiocciput & C1 (vertebral arteries)

# Pathophysiology

- Complete or partial mural disruption
  - Intimal tear
  - Thrombogenic
- Platelet aggregation
  - Distal embolization
  - Hemodynamically significant lesion
    - Stenosis
    - Occlusion



ACP, artère carotide primitive; CE, carotide externe; CI, carotide interne; R, rupture des deux tuniques internes; TR, ces tuniques refoulées vers l'axe du vaisseau.

Adapted from –  
Verneuil M. *Contusions multiples deire violent hemiplegie droite signes de compression cerebrale*. Paris: Bull Acad Natl Med; 1872

# Imaging Diagnosis

- DSA is diagnostic reference
- MDCT primary modality most centers
  - Readily available
    - Neck CTA
    - Whole body CT – IV contrast neck through pelvis
    - Include COW through aortic arch.
- Accuracy of MDCT
  - Sensitivity ~64%
  - Specificity 95%
  - Neck CTA and whole body CT comparable

# MDCT Findings

- Minimal intimal injury
- Intramural hematoma
- Intimal flap
- Intraluminal thrombus
- Pseudoaneurysm
- Occlusion
- Transection with active bleeding
- Arteriovenous fistula



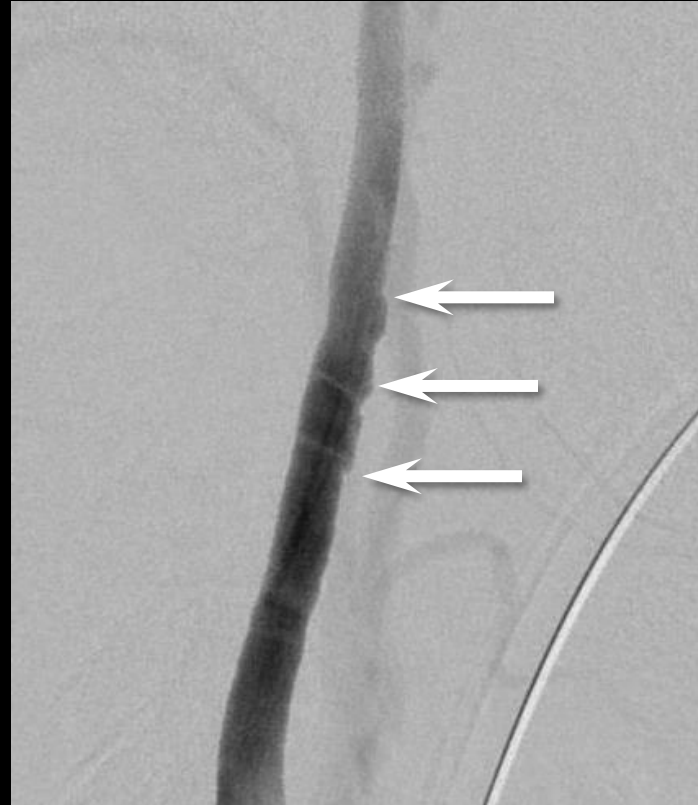
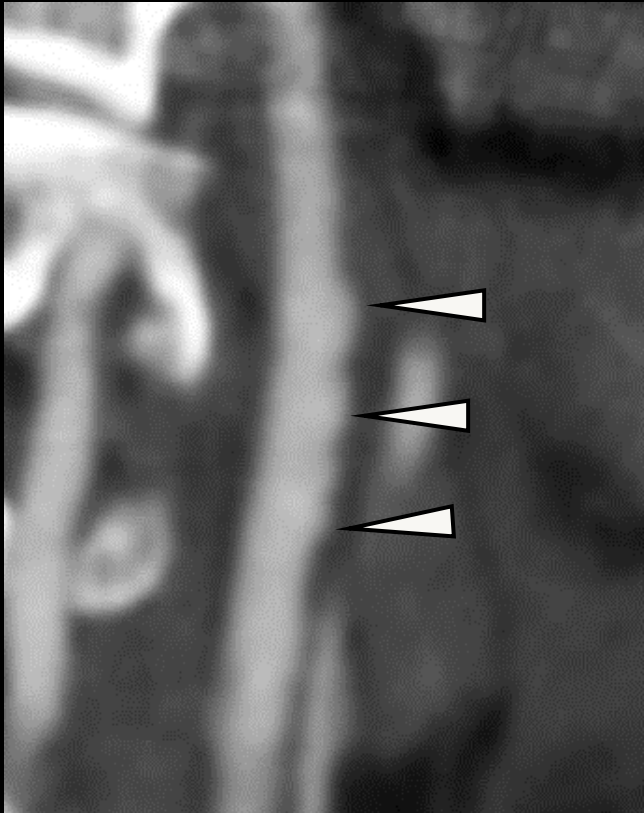
# Injury Grade

- Denver or Biffi scale
  - Widely used
  - Grades I-V
  - Initially only BCI
- Standardize reporting
- Prognostic information
  - Not linear

Grade	Description
I	Minimal intimal irregularity, Intramural hematoma with < 25% luminal stenosis
II	Raised intimal flap, Intramural hematoma with $\geq$ 25% luminal stenosis, Intraluminal thrombus
III	Pseudoaneurysm
IV	Occlusion
V	Transection with active hemorrhage

**AVF – Not consistently assigned a grade,  
report as distinct finding**

# Grade I



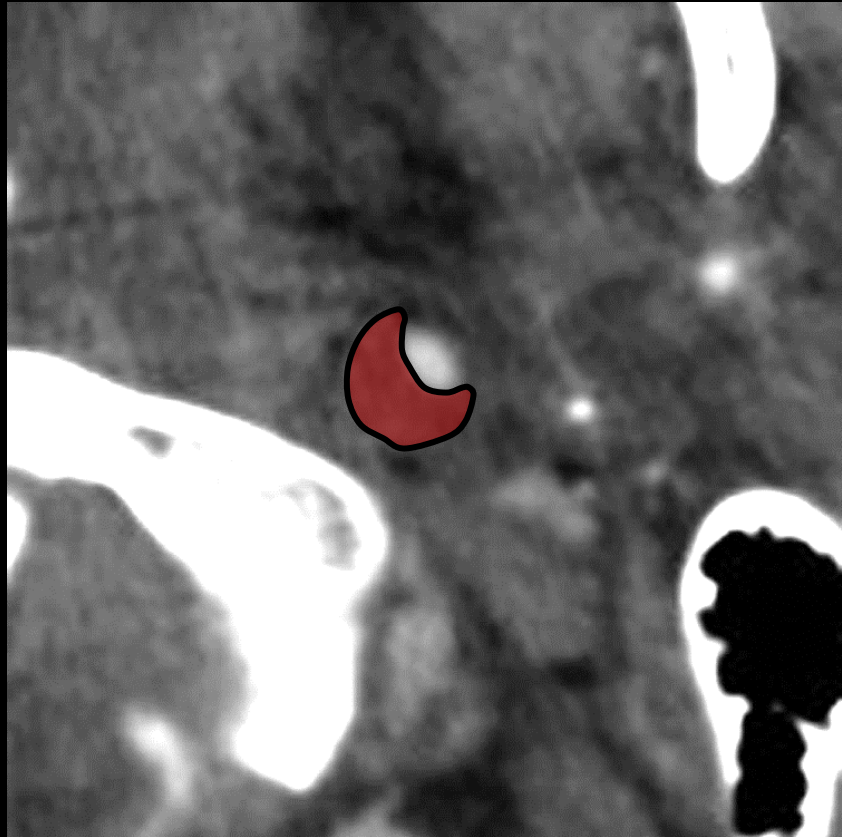
**Minimal intimal injury**

# Grade I



**IMH < 25% luminal narrowing**

# Grade II



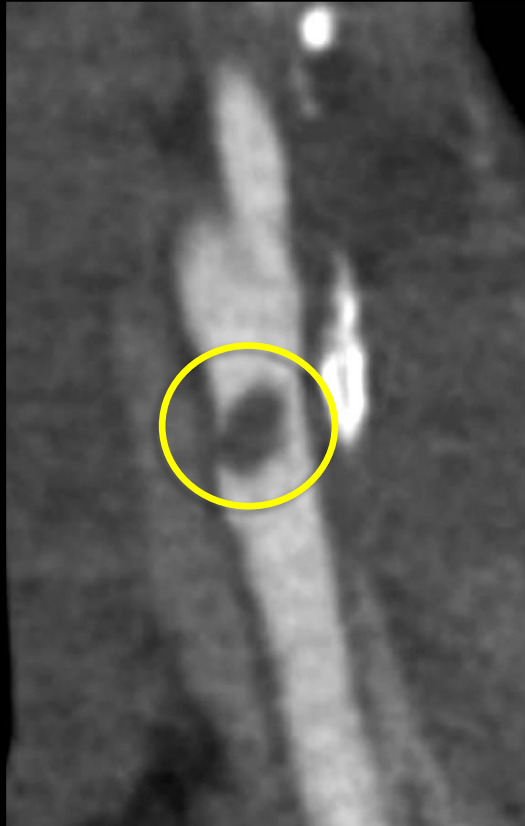
**IMH  $\geq$  25% luminal narrowing**

# Grade II



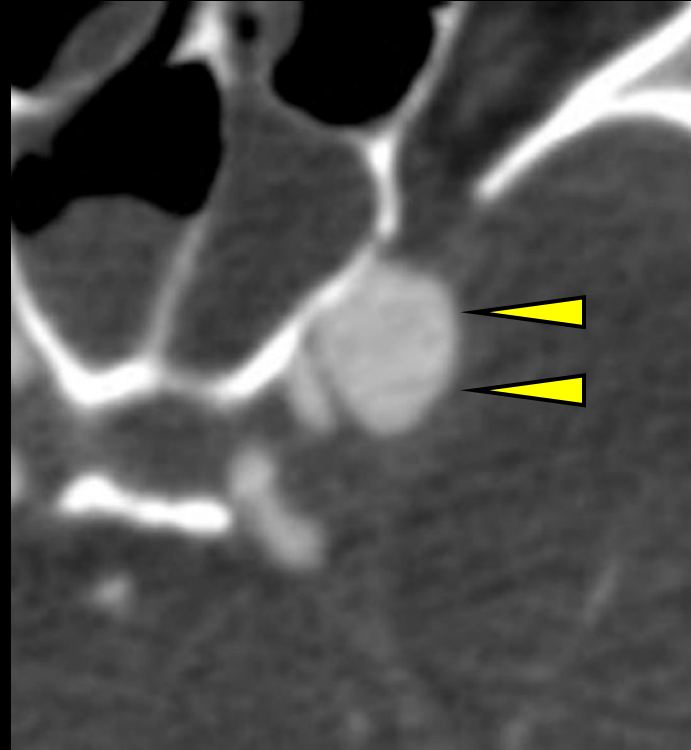
**Intimal Flap**

# Grade II



**Intraluminal Thrombus**

# Grade III



**Pseudoaneurysm**

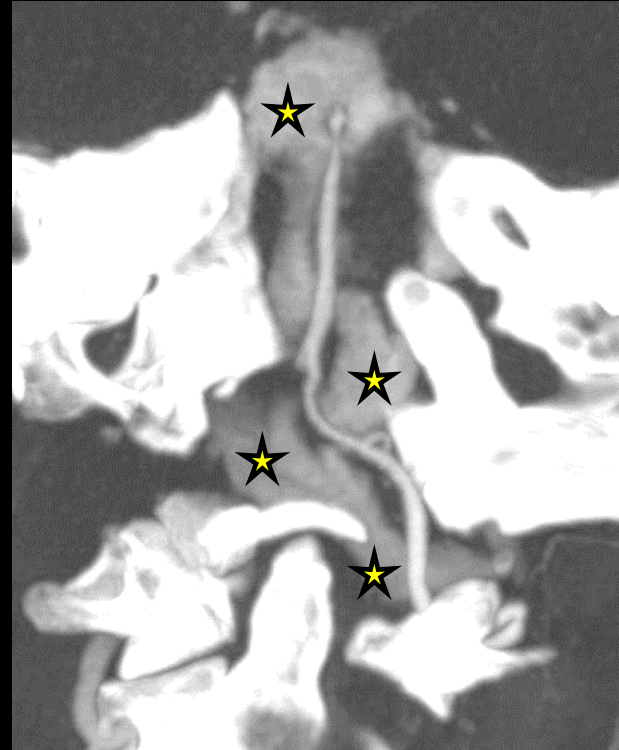
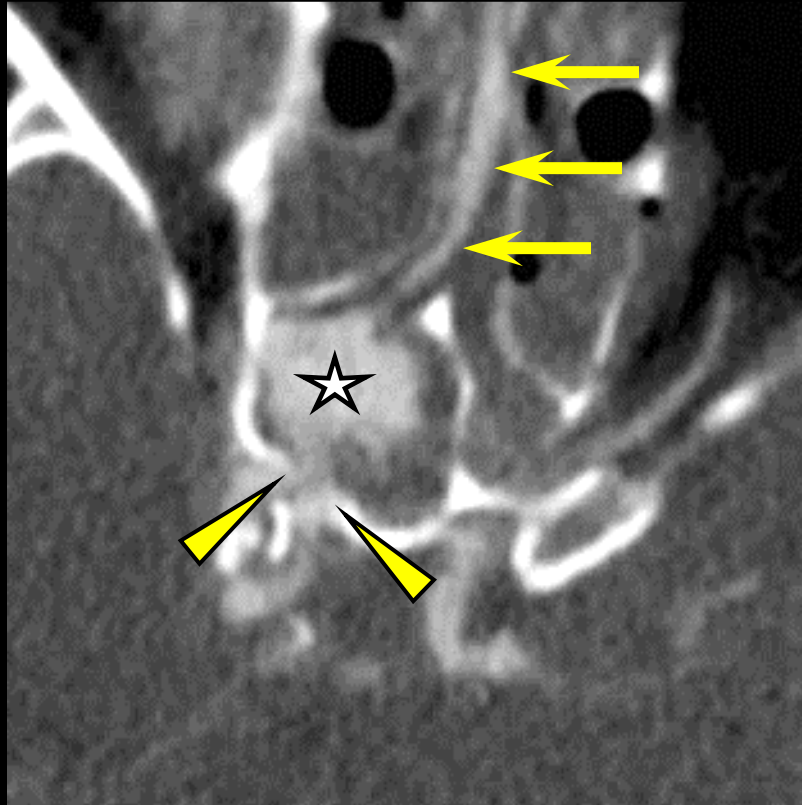
# Grade IV



**Occlusion**



# Grade V

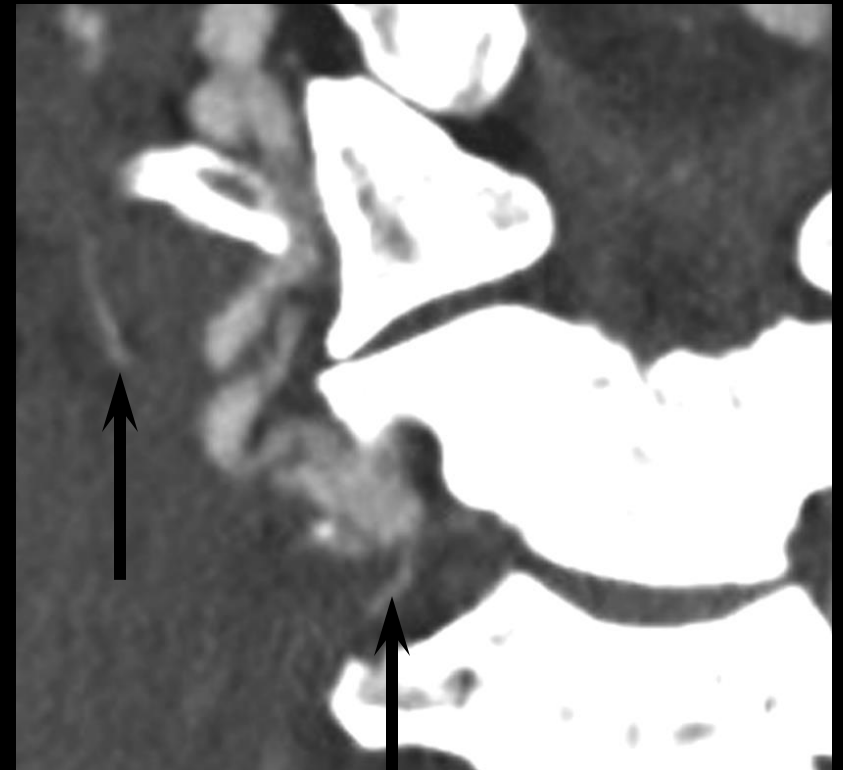
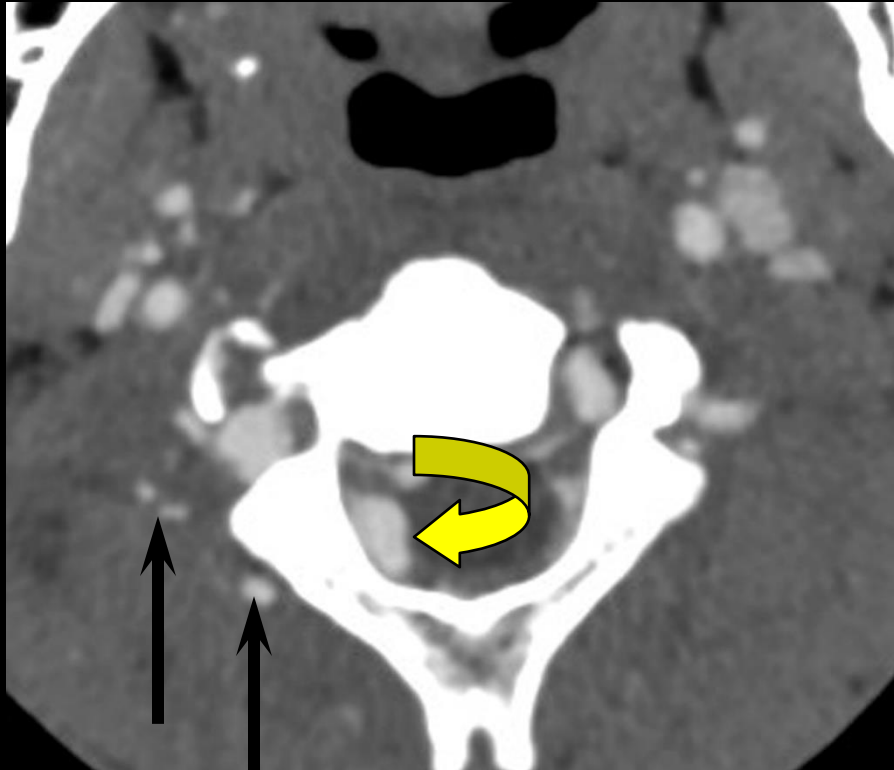


**Active Bleeding**

# Arteriovenous Fistula

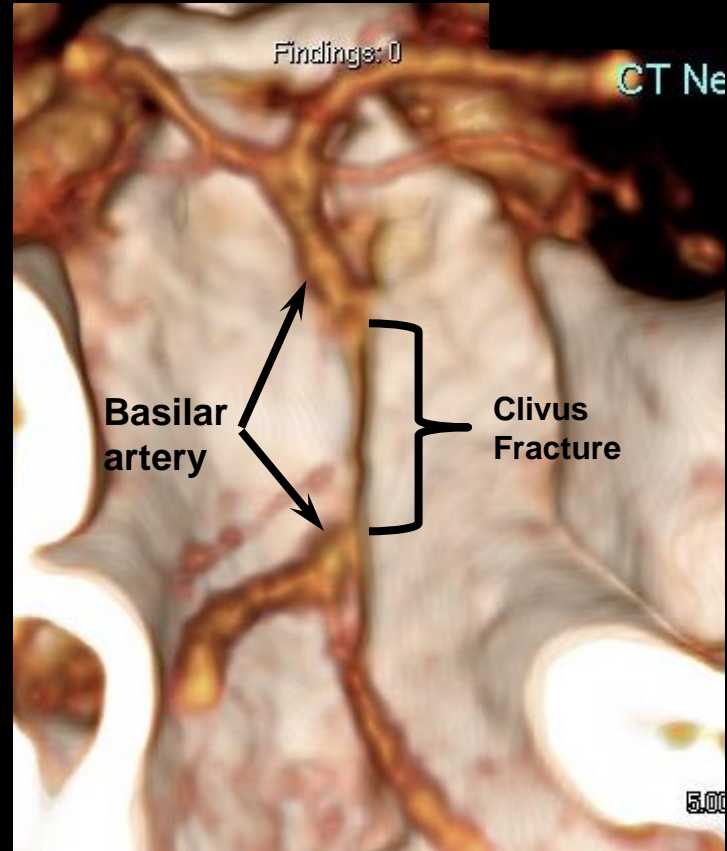


# Arteriovenous Fistula



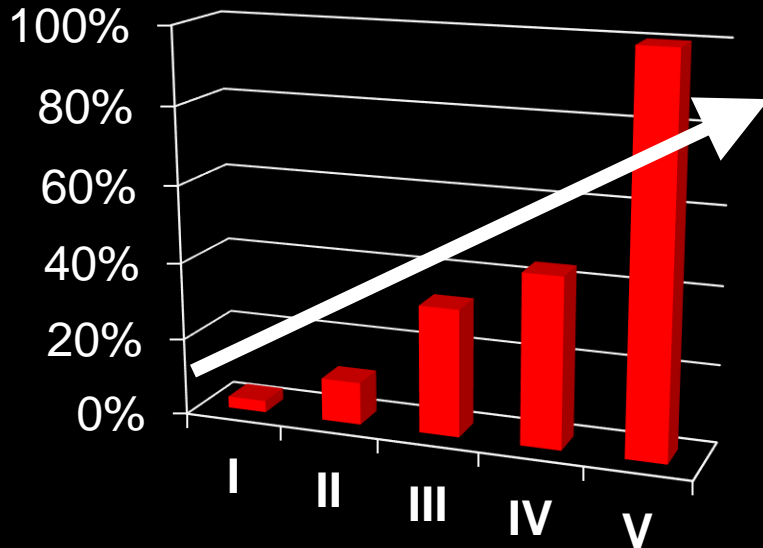


# Other Cerebrovascular Injuries

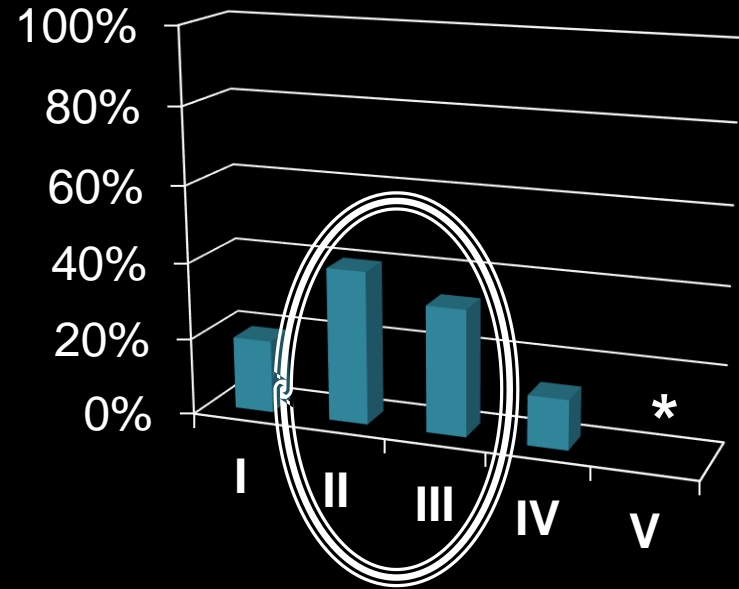


# Grade & Stroke Rate: Denver

## Carotid Artery



## Vertebral Artery

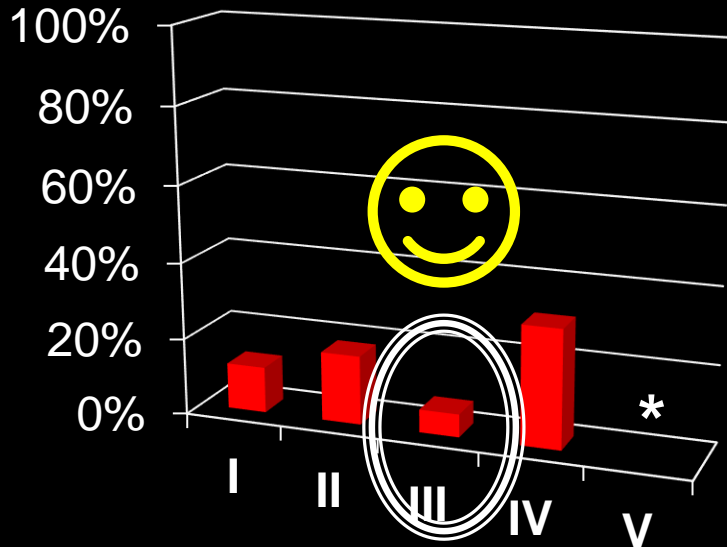


Biffi et al. 2001

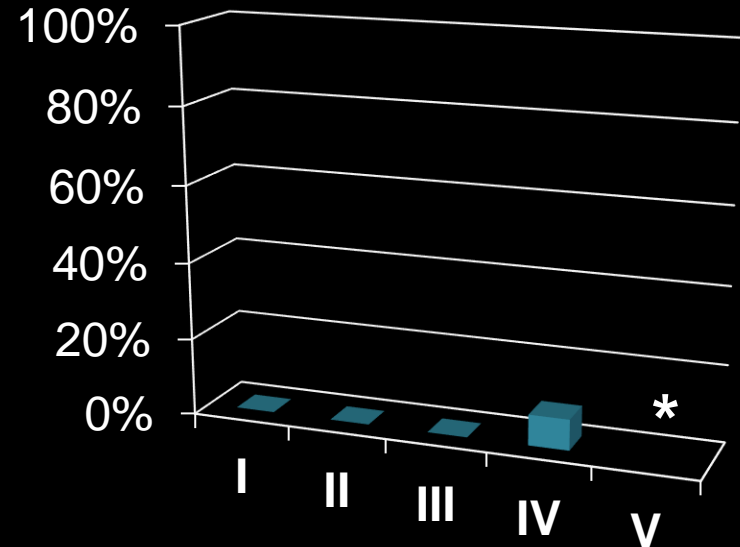
\*No grade V vertebral artery injuries

# Grade & Stroke Rate: Maryland

## Carotid Artery



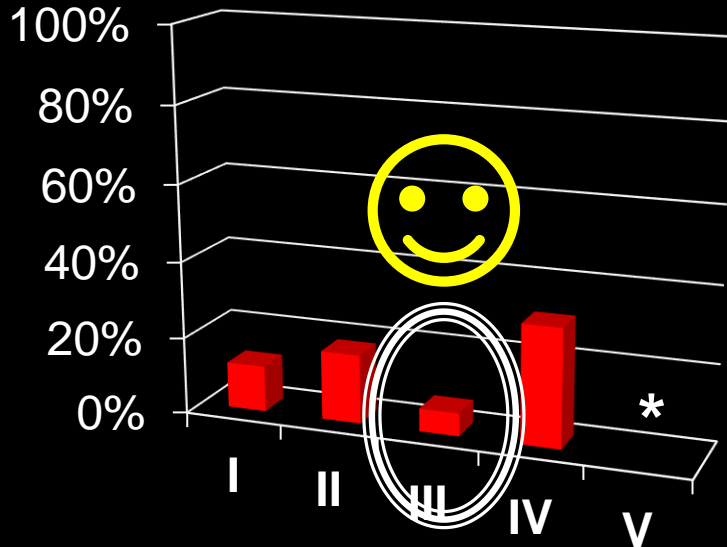
## Vertebral Artery



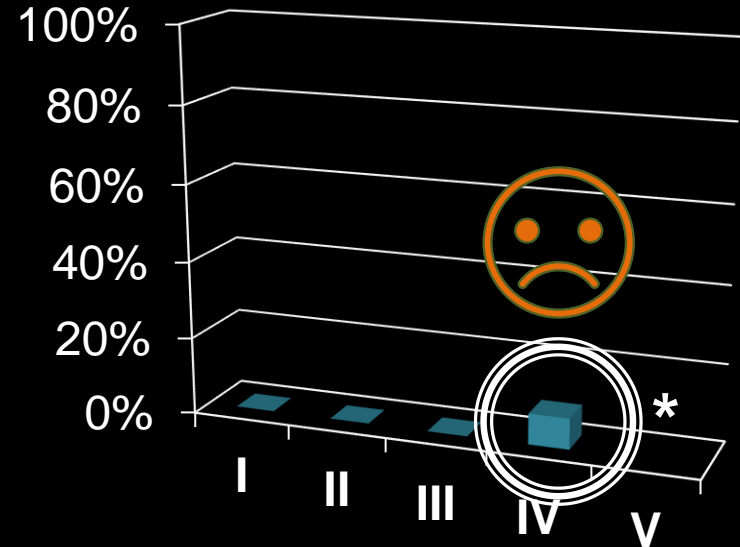
\* Grade V injuries excluded

# Grade & Stroke Rate: Maryland

## Carotid Artery



## Vertebral Artery



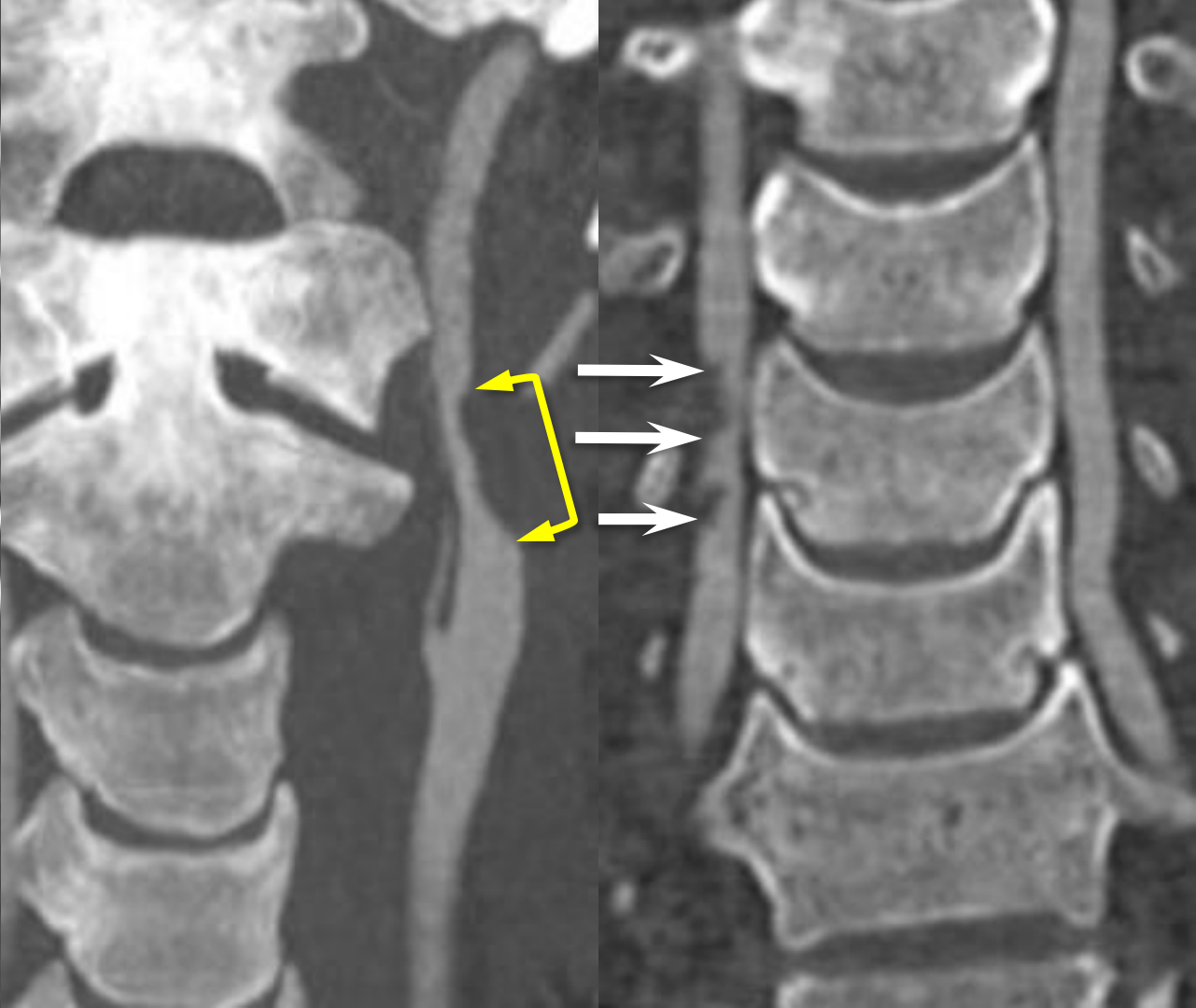
\* Grade V injuries excluded



# Stroke Rates

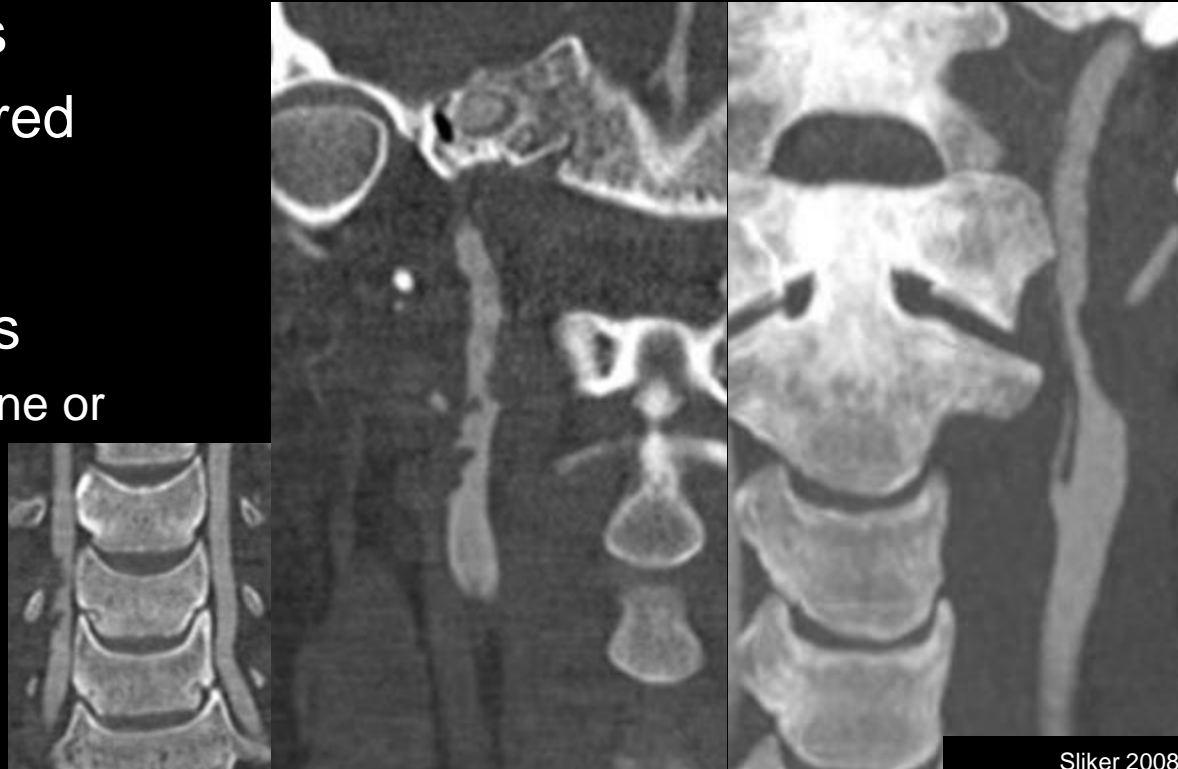
- Disease course altered since early 2000's
- Increased awareness since 1990's and early 2000's
- Screening
  - Preclinical, asymptomatic
  - MDCT
- Treatment

**Antiplatelet, Anticoagulation, Endovascular**



# Multivessel Injury

- 18%-38% of patients
- Both CA and VA injured
  - 2X stroke than either alone
- 3 or 4 injured vessels
  - 2X stroke rate than one or two injured vessels



# Screening

- High injury mechanism
- Injury severity score  $\geq 16$
- Specific injury patterns
  - Head
  - Neck
  - Chest

# Screening Criteria

- Denver Criteria
- Memphis Criteria
- Western Trauma Association (WTA) Guidelines
- Eastern Association for the Surgery of Trauma (EAST) Guidelines
- “Expanded” Denver Criteria
- Utah Score (pediatric trauma)
- McGovern Score (pediatric trauma)
- American College of Surgeons - TQIP
- Virginia Commonwealth University (VCU) Criteria
  - “Expansion” of Expanded Denver Criteria

# Screening Criteria

- Denver Criteria
- Memphis Criteria
- Western Trauma Association (WTA) Guidelines
- Eastern Association for the Surgery of Trauma (EAST) Guidelines
- **“Expanded” Denver Criteria**
- Utah Score (pediatric trauma)
- McGovern Score (pediatric trauma)
- American College of Surgeons - TQIP
- Virginia Commonwealth University (VCU) Criteria
  - “Expansion” of Expanded Denver Criteria

**You will still miss injuries a  
considerable number of injuries!**

# Risk Factor Negative BCVI

Study	Modality	Criteria	No risk factors
Bonatti et al. 2013	WBCT	Memphis	38%
Bruns et al. 2014	WBCT	EAST	30%
Jacobson et al. 2015	Neck CTA	Expanded Denver	38%
Leicthle et al. 2020	Neck CTA	a. ACS-TQIP b. VCU	28% 17%
Müther et al. 2020	Neck CTA	EAST	35%
Schmidt et al. 2023	Neck CTA	Denver, Expanded Denver	30%

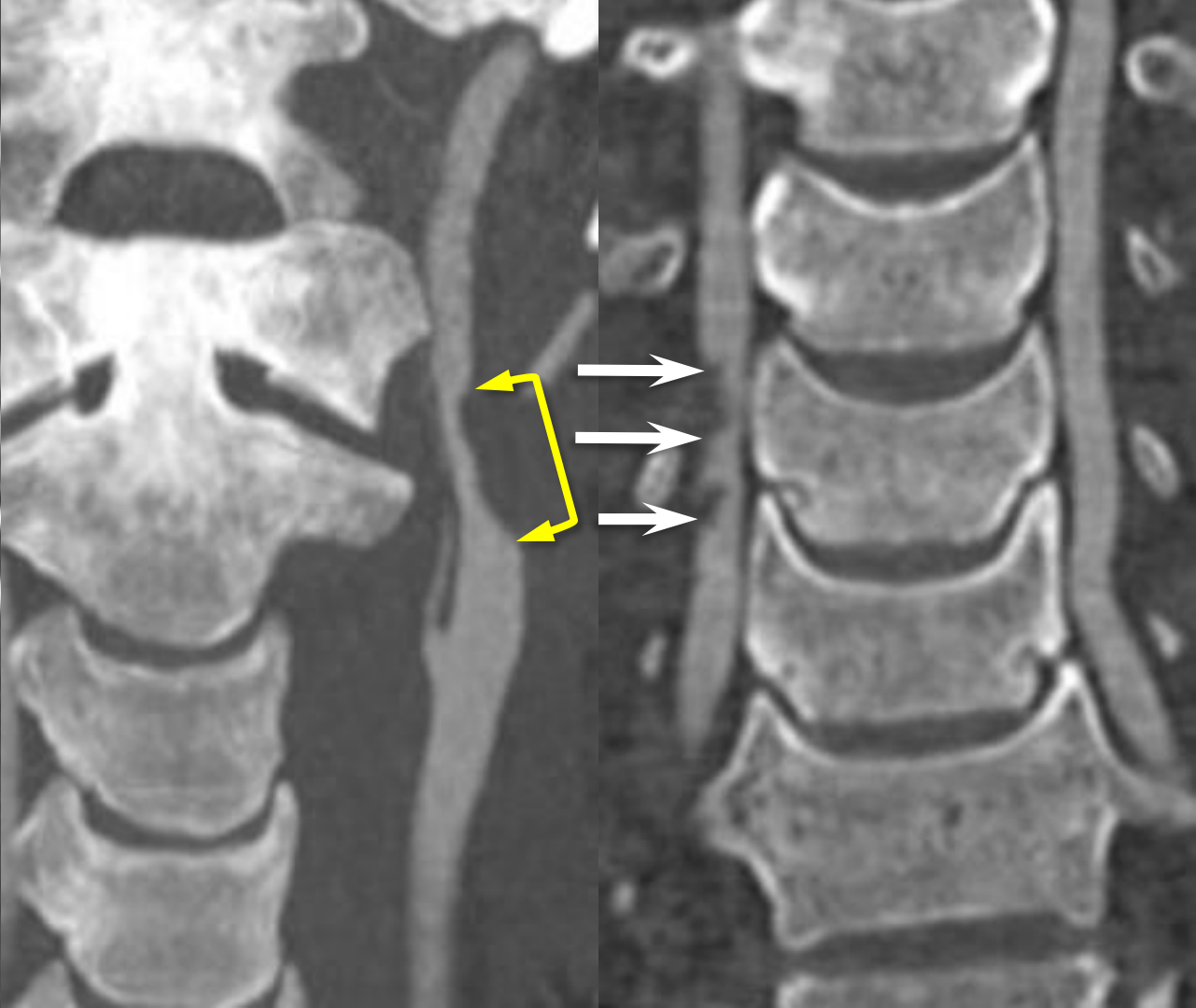
**WBCT – Whole body CT with contrast-enhanced c-spine CT**  
**Neck CTA substituted for dry c-spine CT**

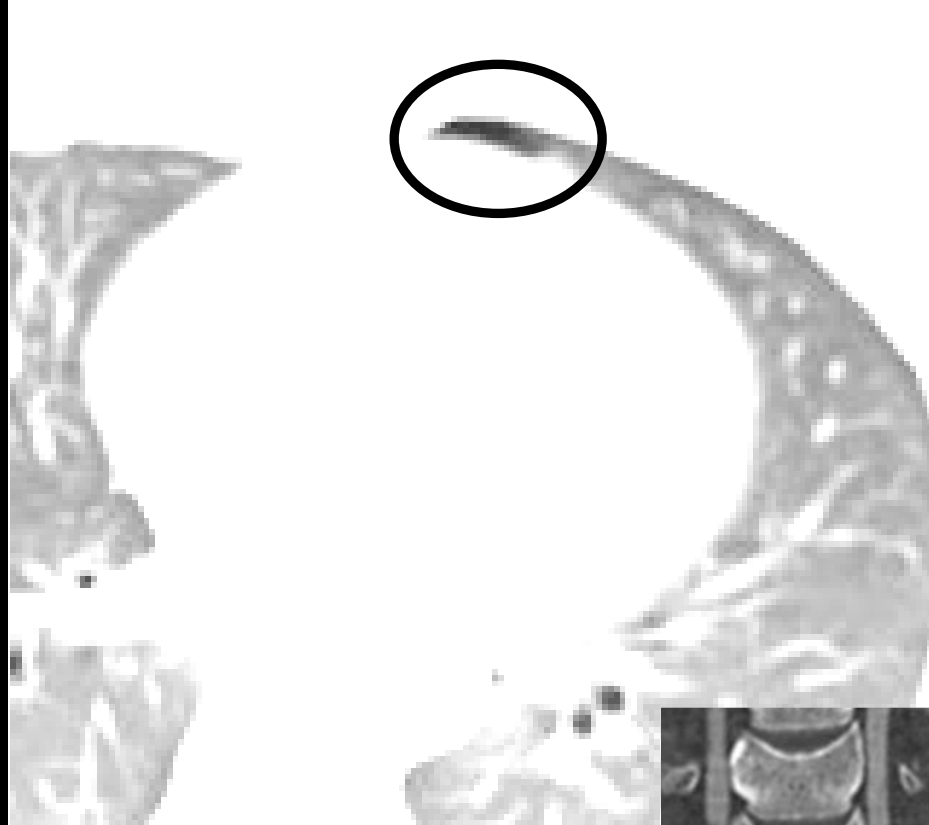


# Risk Factor Negative BCVI

Study	Modality	Criteria	No risk factors
Bonatti et al. 2013	WBCT	Memphis	38%
Bruns et al. 2014	WBCT	EAST	30%
Jacobson et al. 2015	Neck CTA	Expanded Denver	38%
Leicthle et al. 2020	Neck CTA	a. ACS-TQIP	28%
		b. VCU	17%
Müther et al. 2020	Neck CTA	EAST	35%
Schmidt et al. 2023	Neck CTA	Denver, Expanded Denver	30%

**WBCT – Whole body CT with contrast-enhanced c-spine CT**  
**Neck CTA substituted for dry c-spine CT**





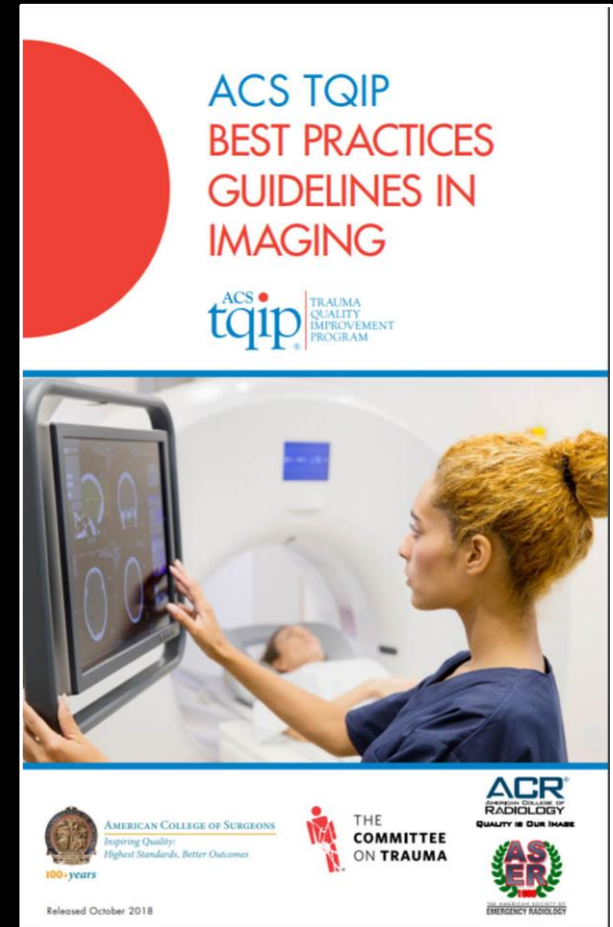
Minimal pneumothorax



# Whole-body MDCT

- Diagnose most BCVI at Shock Trauma since 2006
- ACS TQIP – Best Practices in Imaging (2018)
  - WBCT with arterial contrast in neck.
  - Best practice for diagnosing BCVI.
    - Input from ASER and ACR

TQIP – Trauma Quality Improvement Program  
ACS – American College of Surgeons  
ASER – American Society of Emergency Radiology  
ACR – American College of Radiology



# Summary

- BCVI are morphologically heterogeneous.
- Grading standardizes reporting but is not consistently prognostic.
- Multi-vessel injuries associated with increased risk of stroke.

# Summary

- Screening can decrease BCVI-related stroke rates.
- Risk factor-based screening may miss many injuries.
- ACS considers WBCT best practice for diagnosing BCVI.



Thank you for your attention.