Blunt CerebroVascular Injury

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BCVI

- Disease in evolution
- Treatment and diagnosis last 10-20 years
- Screening last 10 years
- Many institutions not having a screening program
- Many present with CNS ischaemia
- Emphasis on detecting and managing lesions prior to CNS sequelae.

BCVI

"Can we, through early detection and timely treatment(s), prevent the complications of this injury?"

- Modern imaging and screening paradigms
- Natural history of disease
- Level of data
- Treatment regimes
- Controversy
- Cases
- Summary

BCVI

- Guidleines
  - EAST
  - WST
  - Local
  - Others?

- Screening
  - Denver
  - Modified Denver
  - Local
  - Others?

Incidence

- BCVI diagnosed in 1 per 1000 trauma in US
  - Not with a screening program
  - Majority Dx when symptoms of CNS ischaemia
    - Neurological morbidity 80%
    - Mortality 40%

- Screening program
  - Incidence rises to 1 in 100 (2.7% if ISS>15)

Mechanisms

- Complex
  - Direct blow
  - Hyperextension with contralateral rotation
  - Laceration arteries by adjacent fractures
- Carotid arteries
  - Hyperextension (stretching artery over lateral masses)
- Vertebral arteries
  - Foramen transversarium fractures
  - Hyperextension/ tethering within lateral masses

EAST Guidelines

LEVEL I – Recommendations convincingly justifiable based on available scientific information alone.

No studies

LEVEL II – recommendation is reasonably justifiable by scientific evidence and strongly supported by expert opinion.

7 studies

LEVEL III – recommendation supported by available data, but scientific evidence lacking.

9 studies

Screening – who

BCVI in asymptomatics is controversial

+ve Many BCVI's present hours to days before neurological symptoms. Failure to identify and treat can result in morbidity and mortality

-ve Small yield in screening and majority already impaired.

Many cannot be anticoagulated hyperacutely

'Mayberry et al, 35,000 patients with 17 BCVI diagnosed & 11 symptomatic (only 2 asymptomatic > 2 hours)

= majority of data supports screening (EAST)

Factors/ aetiology

- Neurological abnormality unexplained by diagnosed injury (II)
- Blunt trauma with arterial epistaxis(II)
- Level III
  - GCS<9
  - Petrous temporal bone #
  - DAI
  - Cervical spine # (C1 – C3, f.tranversarium, sublux)
  - Facial fractures

Risk Factors

Biffl et al,

"Optimizing screening for BCVI" AmJ Surg 1999

249 patients (linear regression analysis)

4 factors for blunt carotid injury

- GCS< 6
- Petrous fracture
- Diffuse axonal injury
- LeFort II or III

1 of above = 41% risk BCAI

4 of above = 93% risk BCAI

Risk Factors

Biffl et al,

"Optimizing screening for BCVI" AmJ Surg 1999

249 patients (linear regression analysis)

1 factors for blunt vertebral injury

- Cervical spine fracture

20% diagnosed with BCVI did not have the independent risk factors.

"broad selection criteria are required to prevent missed injuries"

"Cervical seatbelt bruising not an indicator BCVI in both Biffl and Cothren studies"

TABLE 2. Denver Modification of Screening Criteria for BCVI Adapted From Cothren et al[51] (With Permission)

Denver Modification of Screening Criteria
Signs/symptoms of BCVI
Arterial hemorrhage
Cervical bruit
Expanding cervical hematoma
Focal neurological deficit
Neurologic examination incongruous with CAT scan findings
Ischemic stroke on secondary CAT scan
Risk factors for BCVI
High-energy transfer mechanism with
Lefort II or III fracture
Cervical spine fracture patterns: subluxation, fractures extending into the transverse foramen, fractures of C1–C3
Basilar skull fracture with carotid canal involvement
Diffuse axonal injury with Glasgow Coma Scale score ≤6
Near hanging with anoxic brain injury

CRITERIA

Clinical

- Seat belt abrasion of neck
- Cervical haematoma increasing in size
- Arterial haemorrhage from wound / mouth / nose / ears
- Unexplained neurological deficit including GCS ≤ 8
- Horner's syndrome and TIAs associated with blunt trauma
- Stabbing injury to neck (specifically looking at blunt injury component)

Imaging

- Any cervical spine, mandibular, Le Fort II & III fractu
- Fracture through foramen transversarium
- Base of skull fracture involving carotid canal
- Infarction on CT brain
- Closed head injury with diffuse axonal injury

Trauma
Radiology
Neurosurgery
Stroke

Order
CTA
Neck & Circle of Willis

INDETERMINATE

POSITIVE
Determine Grading (I – V)

Order
MRI/MRA
Brain & Neck

NEGATIVE

Refer to Neurosurgery

Grade I

Grade II – V
Determine suitability for catheter angiogram & stent

Catheter Angiogram
Contra-indicated

Catheter Angiogram
Not contra-indicated

Refer to Stroke Unit

CATHETER ANGIOGRAM

Berne et al, "A multivariate logistic regression analysis of risk factors for blunt cerebrovascular injury" JVS 2010

"We wished to simplify the protocol in order to make it workable"

Table XII. Multivariate logistic regression model for BCVI

	Odds ratio	*95% CI*	P
Cervical spine injury	7.46	4.87-11.44	<.001
Mandible Fx	2.59	1.30-5.15	.007
Basilar skull Fx	1.76	1.02-3.01	.041
Thoracic or lumbar spine Fx	1.29	0.82-2.03	.28
Any facial injury	1.16	0.73-1.86	.53
Injury severity score	1.05	1.04-1.07	<.001
Le Fort Fx	0.97	0.50-1.86	.92
ED GCS	0.93	0.89-0.97	.001

BCVI, Blunt cerebrovascular injury; *CI*, confidence interval; *ED GCS*, emergency department Glasgow Coma Scale.
Area under ROC: 0.90.

Berne et al, "A multivariate logistic regression analysis of risk factors for blunt cerebrovascular injury" JVS 2010

"We wished to simplify the protocol in order to make it workable"

- Appropriate mechanism + 1 of = screening CTA
  - CSI
  - Basilar skull #
  - Mandibular fracture

- Appropriate mechanisms + combination below = CTA
  - ICH
  - Facial fractures
  - Non cervical spine fractures
  - GCS
  - ISS

Screening – how

- Image those that make screening criteria
  - 4VCA gold standard
  - CTA
  - Ultrasound
  - MRA

Screening – how

- Image those that make screening criteria
  - 4VCA gold standard
  - CTA (8 slice or greater similar to 4V angiography)
  - Ultrasound not sensitive
  - MRA not sensitive

CTA

- 4 Slice or less not sensitive
  - Biffl et al 2002 – single slice Sen=68% Spec=67%
  - Miller et al 2002 – 4 slice CTA v 4VCA
    - CAI sensitivity = 47%
    - VAI sensitivity = 53%
- 16 slice- Eastman et al 2006
  - 162 CTAs v 146 4VCA
  - Sensitivity = 97.7%
  - Specificity = 100%

Case CTA

- Young girl
- Fall horse
- Right subclavain injury noted on chest CT
- CTA supraortic vessels 2 hours later
- Call Sunday 4 am :

  “will you come in and stent this?”

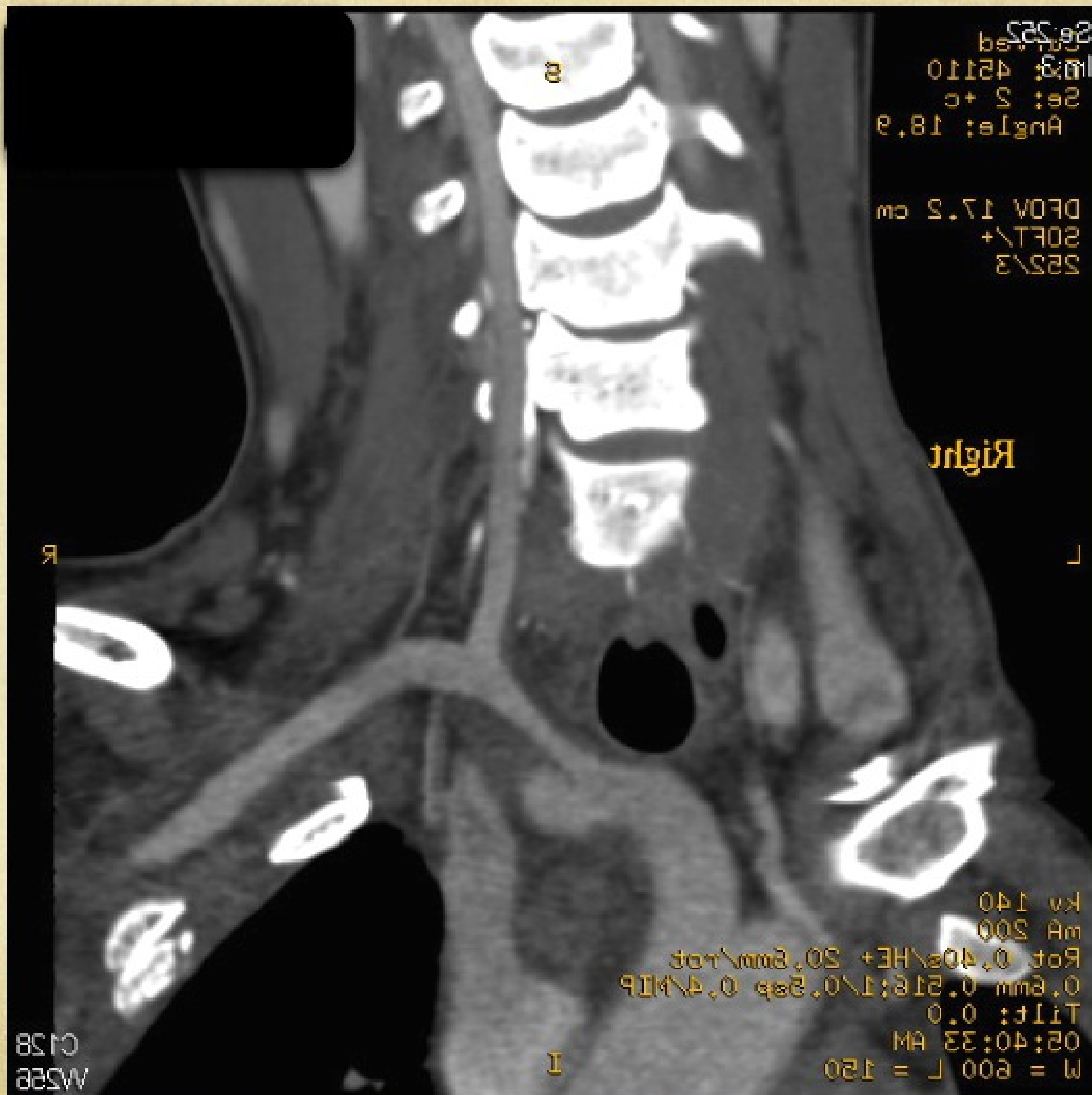
Case CTA

"No"

- Phone discussion no images
- Small localised dissection between right common carotid and right vertebral. Dilated vessel but minor.
- No symptoms

"Can she go on clexane?"

"will review at vascular 8am meeting Monday"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- Begins at carotid origin and terminates at vertebral
- 150% diameter
  - IR " wait and see"
  - VS "wait and see"
- Wait and See approach


DFOV 11.8 cm
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Presentation


Angle: 94.7
Right Subclavian A.
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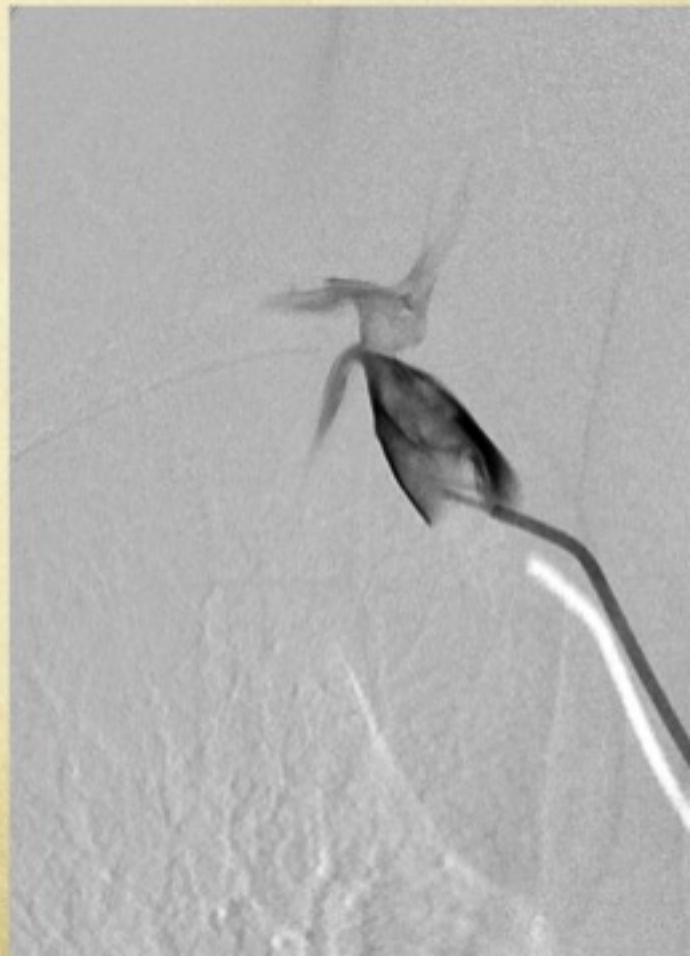


CTA

- 8 CTs
- 1 angiogram
- + extras with view to more

"Have expertly (multidisciplinary) used cutting edge technologies to decide to do follow up for a period to almost certainly not treat"

- Ultrasound no good as screening (data)
- MRA no good as screening (data)
- As follow up – no data
- ??????????

Radiation

Trauma series (CXR/PXR/T&L Spine)	= 3 mSv
CXR x 3	= 0.06 mSv
CTA Carotid x 5	= 25 mSv
CT Thoracic Aorta	= 19 mSv
CT external	= 8 mSv
Angiography DSA	= 2 mSv
Miscellaneous	= 0.002 Msv

Total = 57 mSv

Estimated risk of fatal radiation induced cancer 20 yo female = 0.5% (1 in 220)

Thanks Dr Zoe Brady – Radiation medical Physicist Alfred hospital

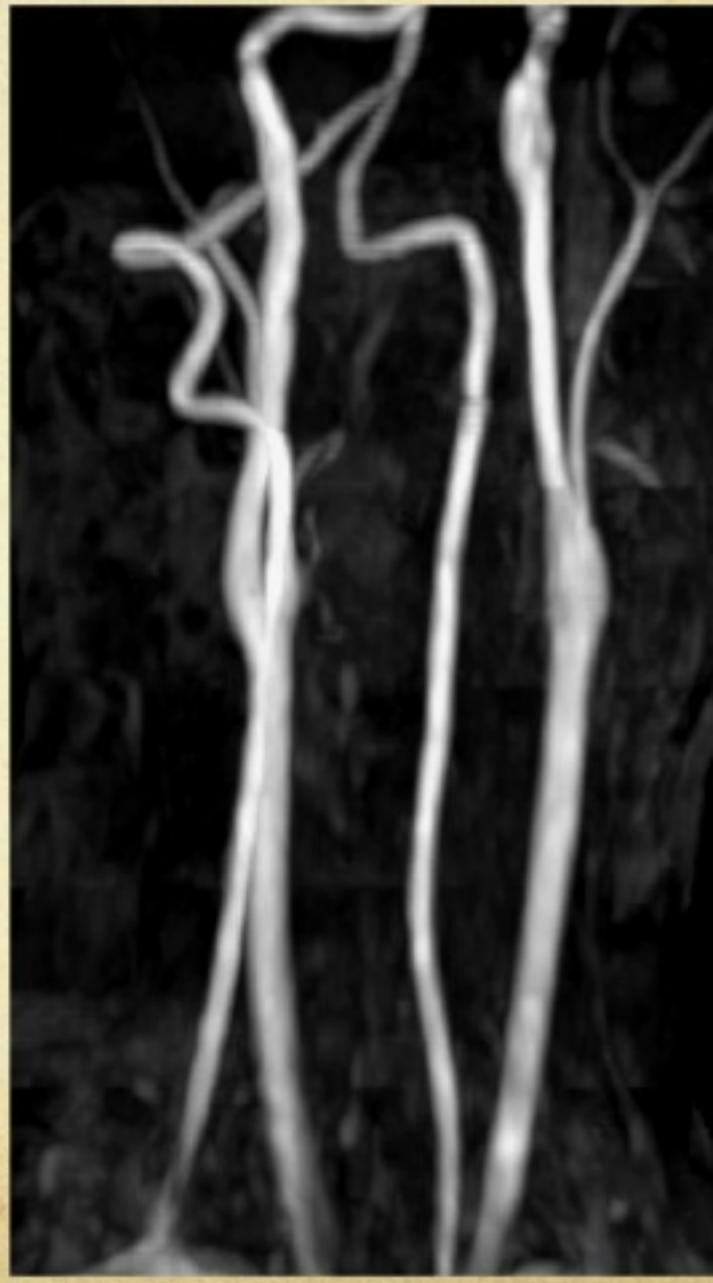
US

- Sensitivity varies 38% to 86%
- Latter for carotid injuries alone
- Majority of CAI near skull base

Distal ?????????

MR

- Big advantage – no radiation
- Few studies
- Miller et al 2002
  - Sensitivity = 50%
  - Specificity = 47%
- Regardless, spatial resolution poor
- Probable role in follow up
- Desperate need of a modern study



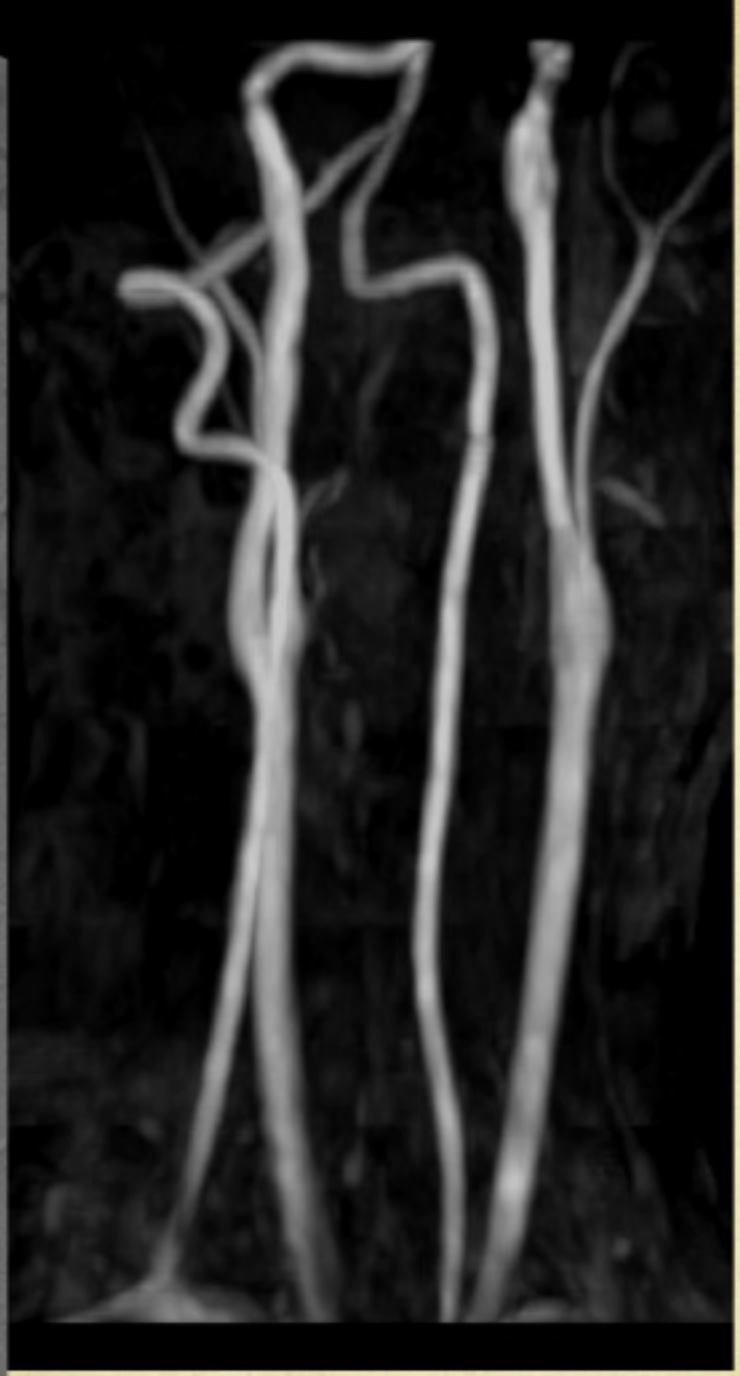
Grading scale – Biffl et al

- Grade I – intimal irreg, <25% lumen narrowing
- Grade II- dissection/ intramural hematoma, >25% narrowing
- Grade III- pseudoaneurysm
- Grade IV- occlusion
- Grade V- transection/ extravasation

Stroke rate by injury grade

	Grade of injury	Stroke rate
Carotid artery injuries	I	3%
	II	14%
	III	26%
	IV	50%
	V	100%
Vertebral artery injuries	I	6%
	II	38%
	III	27%
	IV	28%
	V	100%

Cothren CC, Clinics 2005;60(6):489-496



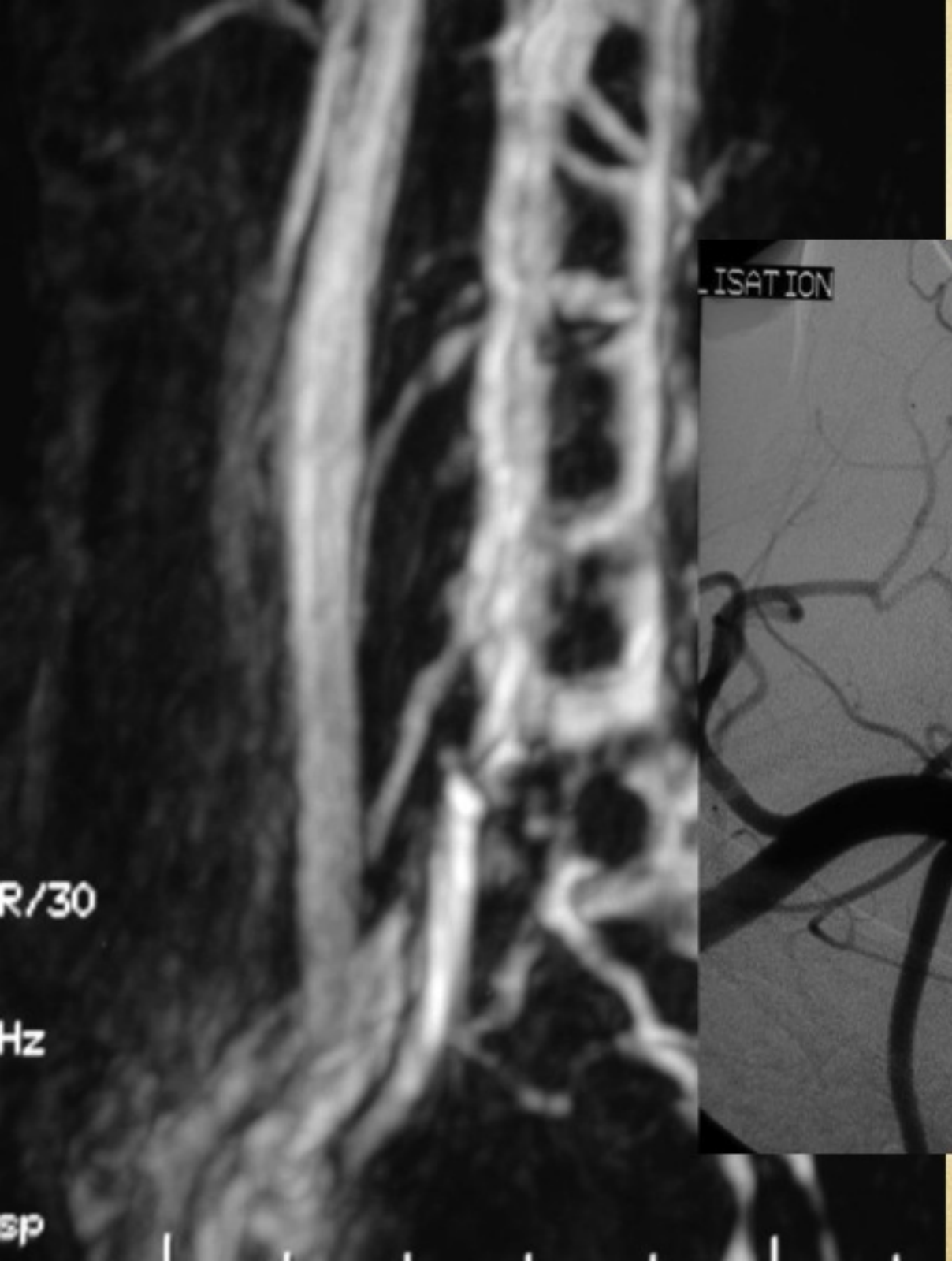
Grade 1

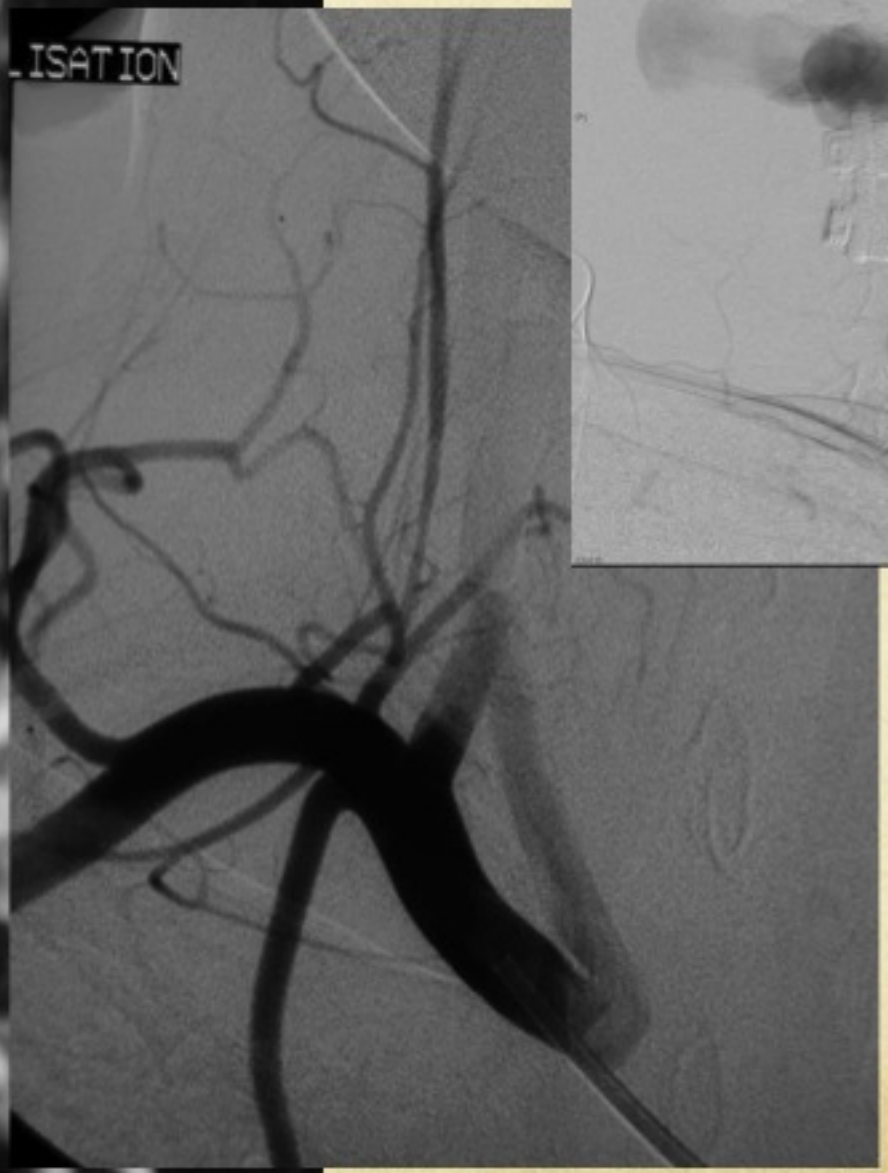
Grade 2

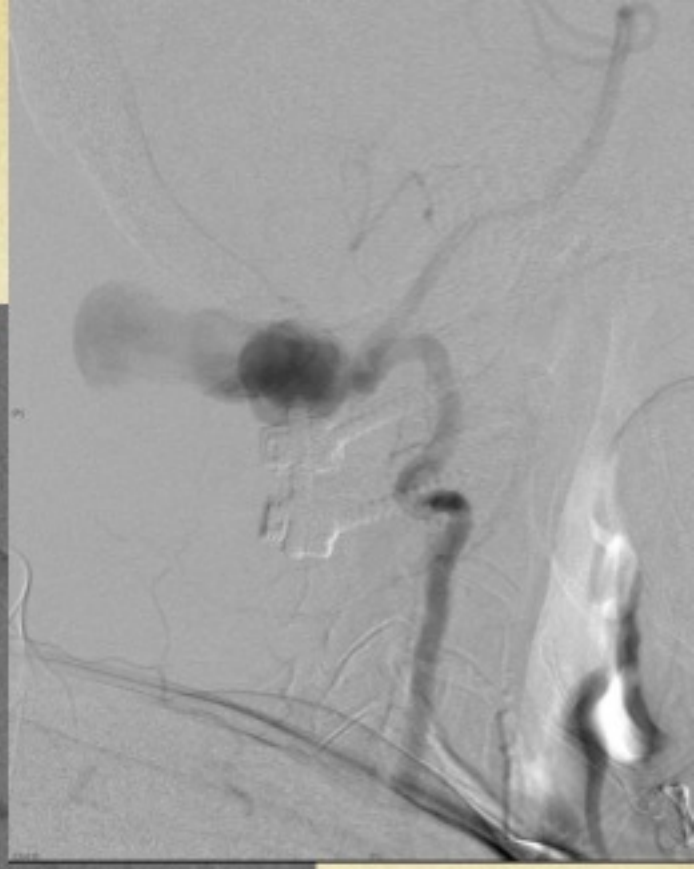
LEFT CA

Grade 3

Grade 4







Grade V

management

- Grades I & II – treated with anticoagulants (II)
  - Heparin or antiplatelets
  - Warfarin to 6 months
- Pseudoaneurysm (GdIII) rarely resolves. Consider surgery or intervention (III). High occlusion rates if not on antiplatelets.
- Early neurological deficit – Surgery or IR (III)

Majority of injuries occur in surgically inaccesible sites

Cothren CC, Clinics 2005

Anticoagulants

- Cothren et al, Am J Surg 2005190;845-849
  - 4VCA on all patients meeting Denver criteria
  - BCVI identified Heparin infusion
    - Antiplatelet
    - Subcut heparin
  - Estimation stroke risk calculated for successfully treated

- Cothren et al, Am J Surg 2005190;845-849
  - 244 asymptomatic patients
  - 187 Rx antithrombotics = stroke rate 0.5%
  - 48 inadequate Rx = stroke rate 21%
  - 1 patient catheter realted stroke (0.1%)

"neurological events averted in 32 patients, this is basis of cost effectiveness (although statistically not significant)"

Unconscious at scene
Chest injuries
Right C6 and C7 transverse process fractures
CT brain normal
Anticoagulated (clexane)

Day 2 drop in GCS
Not moving right side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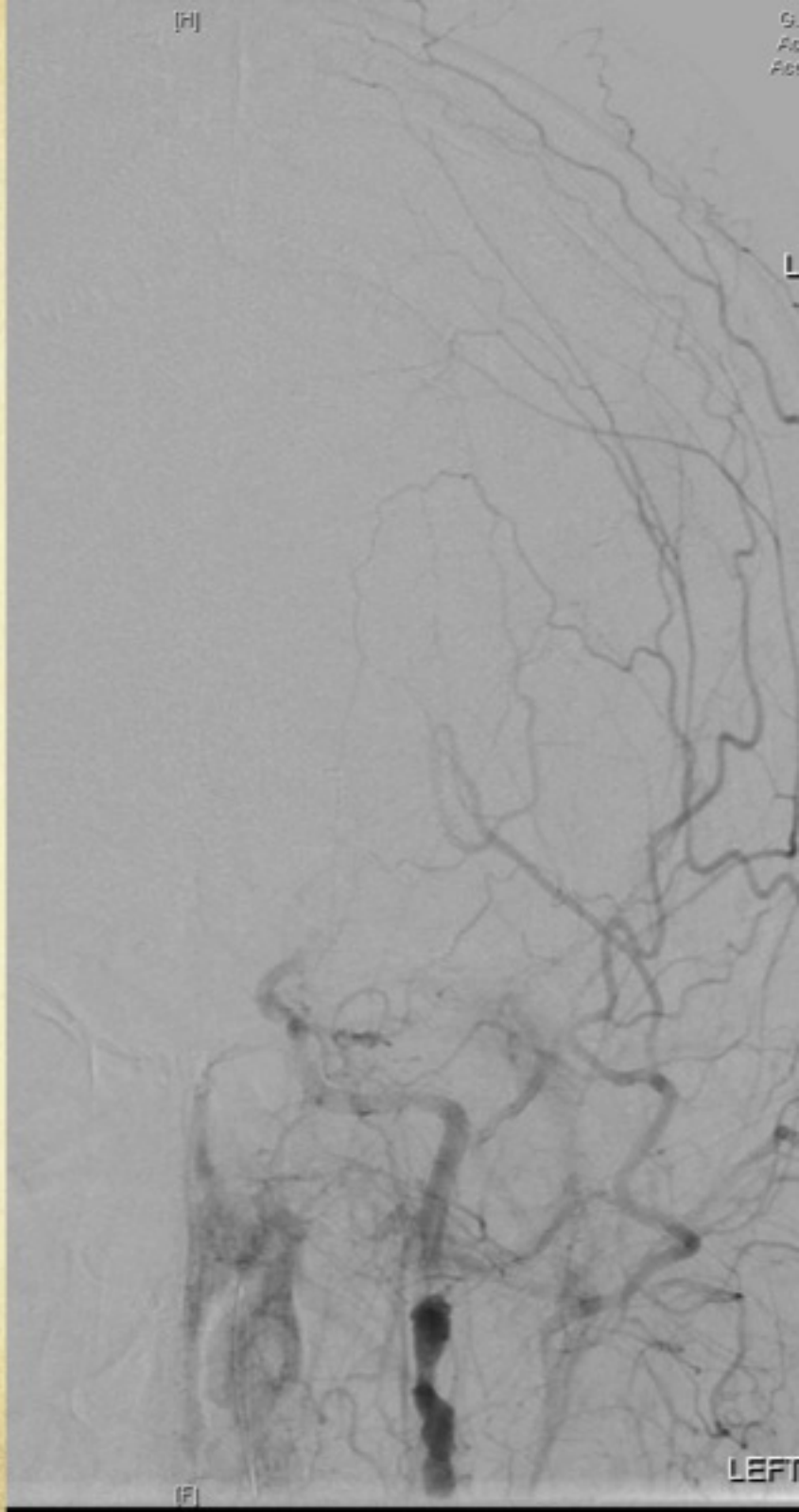
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After nimodipine
AFTER STENT INSERTION
(F)
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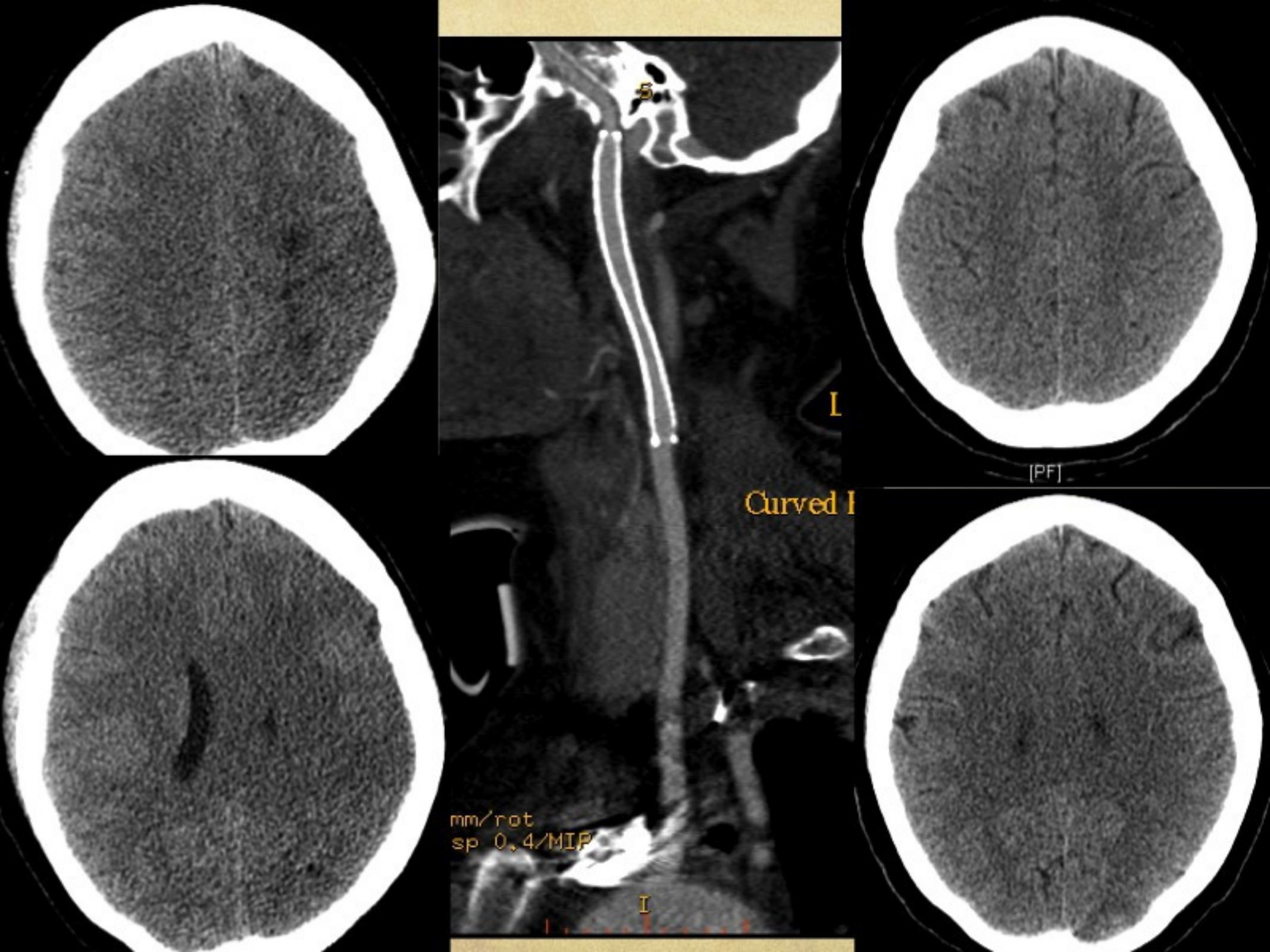
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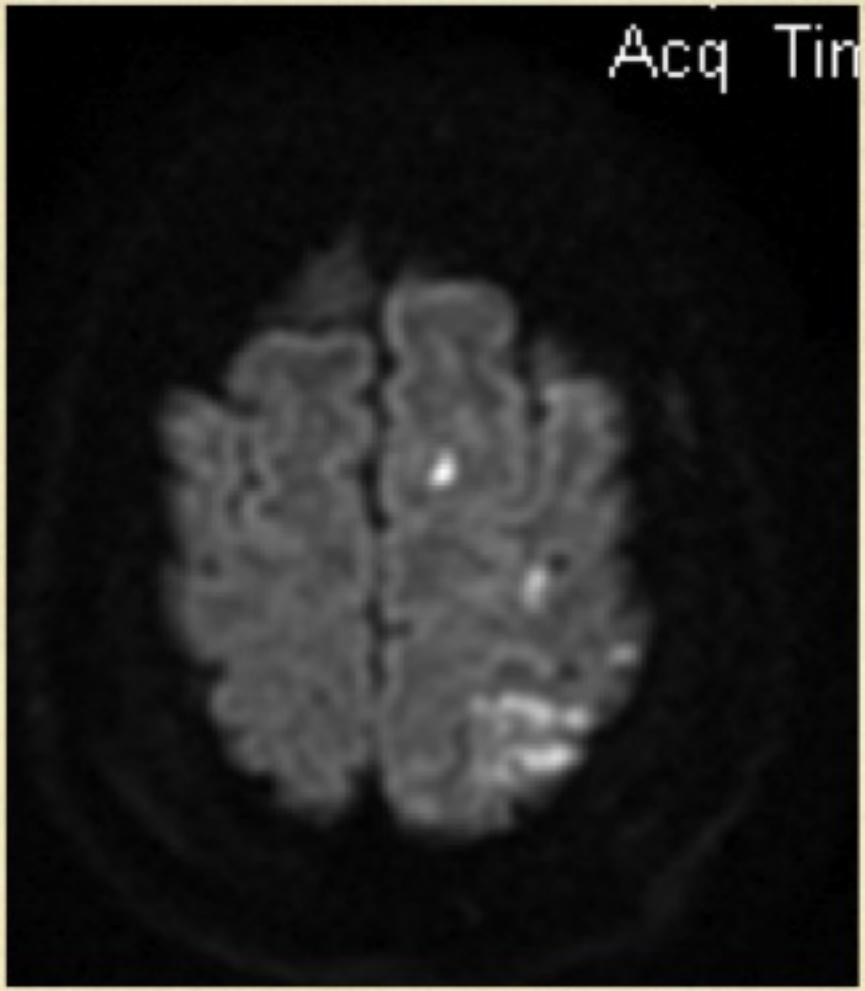
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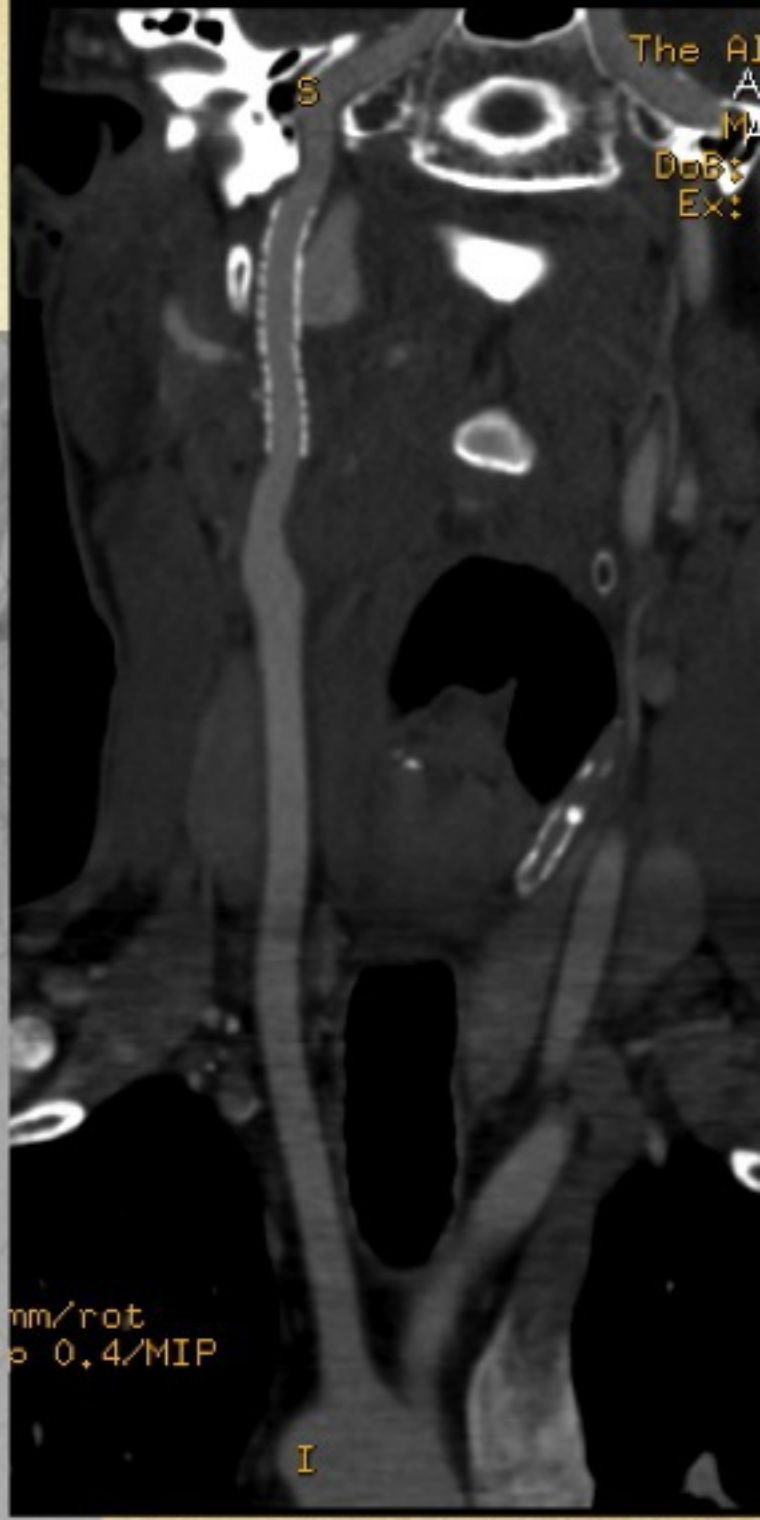
Pseudoaneurysm

Pseudoaneurysm



Pseudoaneurysm

Follow up

- No consensus
- Image with what shows pathology best in that patient
- Be wary of radiation
- Stented patients?????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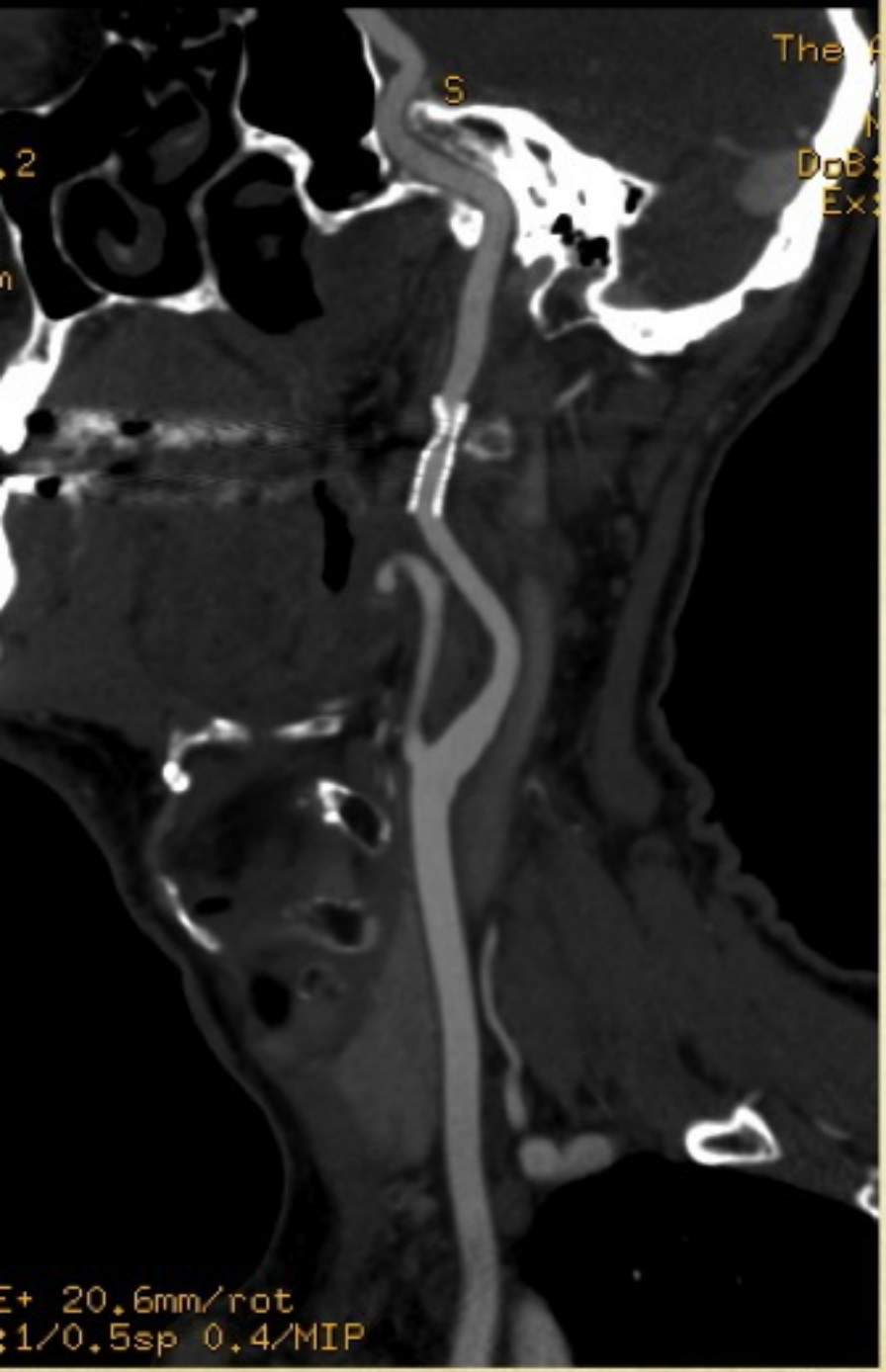
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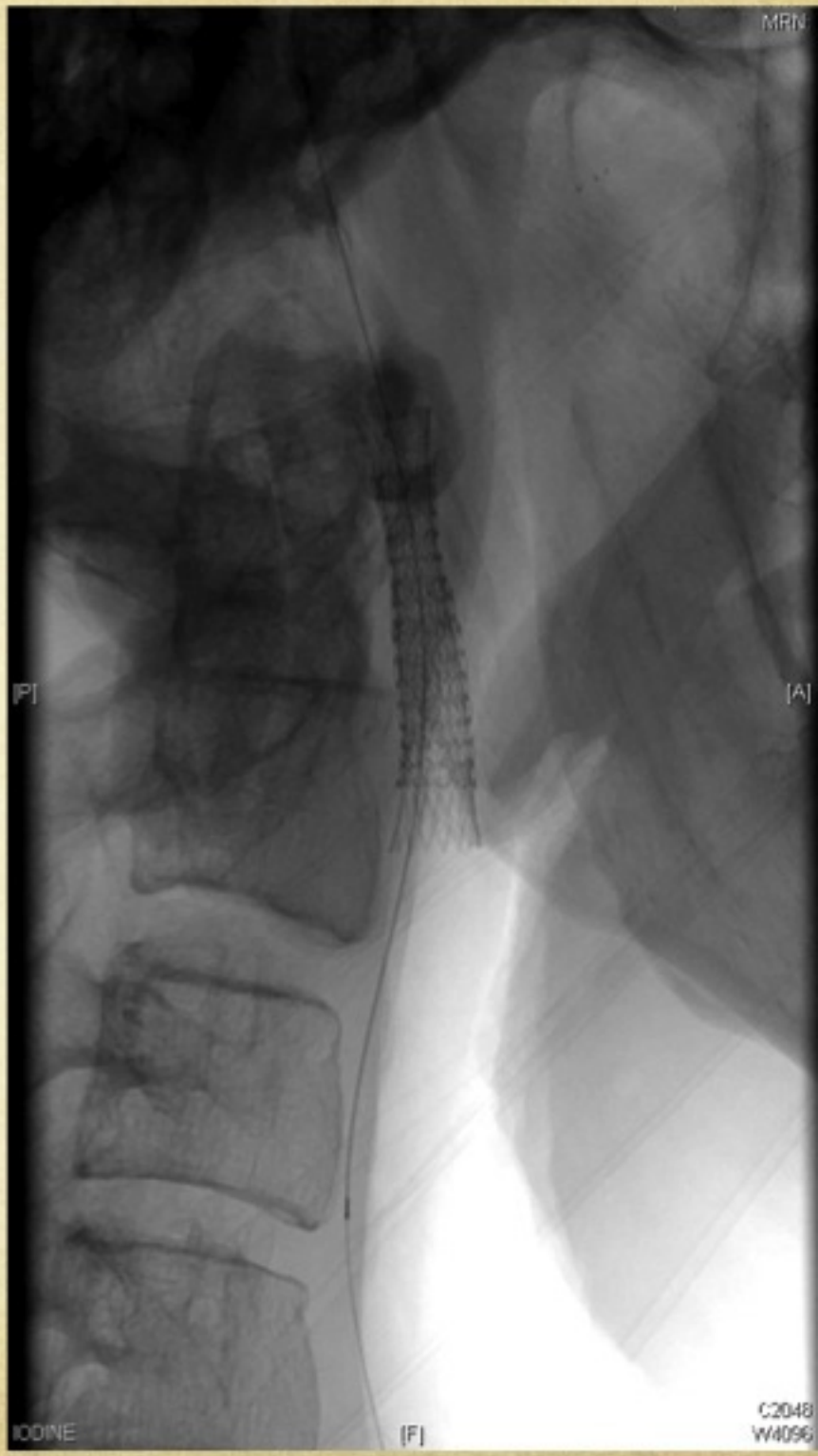
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Cothren et al, "Carotid Artery Stents for Blunt Cerebrovascular Injury" Arch Surg 2005

All stents for pseudoaneurysm failing to resolve at 7-10 days

23 in stent group and 23 in anticoagulant alone

Heterogeneous anticoagulation within each group.

Table 1. Treatment Stratification and Complications of Patients With Blunt Grade III Carotid Artery Injuries

Treatment	Patient Status Before Angiography	Type of Anticoagulation Therapy Received	Periprocedural and Postprocedural Complications
Stent (n = 23)	Asymptomatic (n = 19)	Heparin sulfate (n = 14), antiplatelet agents (n = 2), and none (n = 3)	CVA (n = 3) and subclavian dissection (n = 1)
	Symptomatic (n = 4)	Heparin (n = 4)	None
No stent (n = 23)	Asymptomatic (n = 19)	Heparin (n = 12), none (n = 4), antiplatelet agents (n = 2), and low-molecular-weight heparin (n = 1)	CVA (n = 1) (none who received anticoagulation therapy)
	Symptomatic (n = 4)	Heparin (n = 2), low-molecular-weight heparin (n = 1), and none (n = 1)	None

Endovascular treatment

Cothren et al, "Carotid Artery Stents for Blunt Cerebrovascular Injury" Arch Surg 2005

All stents for pseudoaneurysm failing to resolve at 7-10 days

45% carotid occlusion rates **stent group**

3 strokes and 1 dissection

5% carotid occlusion rates **anticoagulation only group**

1 stroke (not on AC)

Endovascular Treatment

Edwards et al, "Antithrombotic therapy and endovascular stents are effective treatment for blunt carotid injuries: results from longterm followup."; J Am Coll Surg. 2007 May;204(5):1007-13

- 22 endovascular stents
  - 18 psuedoaneurysm
  - 4 dissection
  - No periprocedural complications
  - 1 stroke
  - Mean follow up 29.7(3-94 months)

" Carotid stents are safe and effective"

Endovascular Treatment

- Problems
  - Data
  - Natural history
  - Stent technologies for this
- Recommendations
  - Only stent if need to
  - Be careful with PTFE
  - antiplatelets

Summary

- Evolving area with guidelines only
- Primary imaging with 16++ slice CT as soon as practicable
- DSA for those who remain high risk despite CTA or secondary stroke
- 20% BCVI outside modified Denver criteria
- BCVI can occur with trivial trauma

Summary

- Treat all grades except Gd V with antithrombotics
- IR and/ or surgery reserved for
  - Grade V
  - Early neurological defecit
  - ?Grade II and III failing to heal?
- Follow up
  - ?? Tailored
  - Stents would seem to do badly without antiplatelets
- Await more data (possibly best served with large registry data)