Blunt Cervical Vessel Injury

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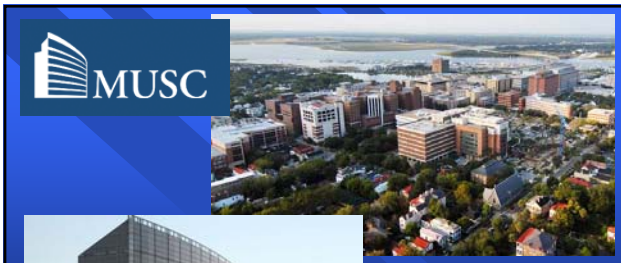
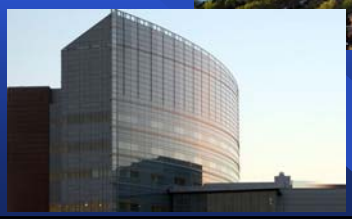
MUSC





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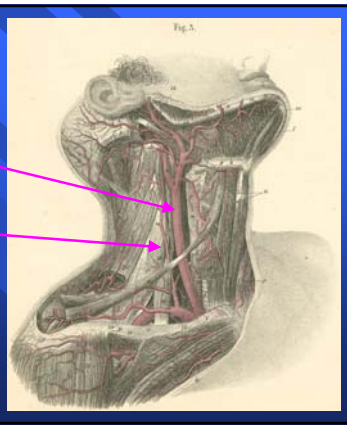
Anatomy

Carotid Artery

Vertebral Artery



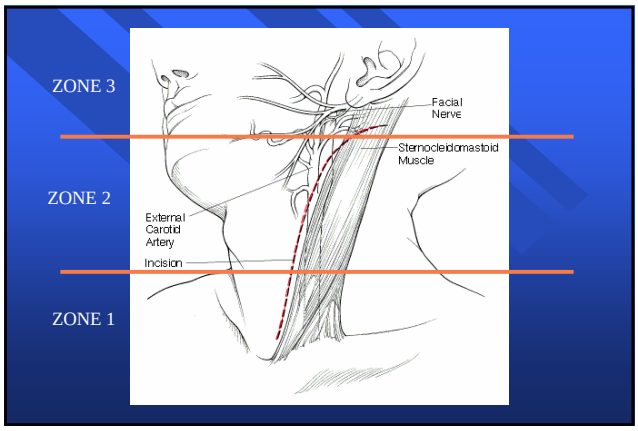
HISTORY

- Ambroise Pare ligated the carotid artery and the jugular vein of a soldier wounded in a duel in 1552
- Patient survived but developed aphasia and hemiplegia
- In 1803, Fleming ligated the lacerated common carotid artery of a suicidal sailor and the outcome was reportedly favorable
- In World War I, standard approach to neck injury was non-operative with a mortality of up to 16%

HISTORY

- In World War II, more aggressive neck exploration resulted in lowered mortality
- In 1956, Fogelman and Stewart reported on a series of 100 patients with penetrating neck trauma and noted a lower mortality with immediate exploration (6%) than with delayed exploration (35%)

  Am J Surg 91:581, 1956
- Current mortality rates in civilian injuries: 3-6%



BLUNT INJURY

- Blunt cervical vessel injury (BCVI) involving the carotid or vertebral arteries is relatively uncommon (< 10% of patients)
- Only 130 cases reported up until 1980
  - Mortality 23%
  - Morbidity 48%

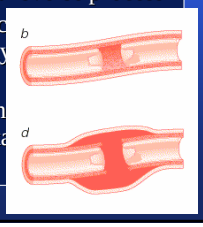
Krajewski LP and Hertzner NR. Ann Surg, 1980;191(3):341-6.
Perry MO, Snyder WH, and Thal ER. Ann Surg. 1980 Jul;192(1):74-7.

BLUNT NECK INJURIES

- May result in significant neurologic abnormality
- Early diagnosis may allow treatment and prevent progression
- Associated with cervical fractures
- Patients who present with a neurologic deficit and a normal head CT scan should have immediate radiologic evaluation (CTA or angiography)
- Current literature suggests that angiography superior to CTA or MRA for diagnosis

MECHANISM OF INJURY

- Direct trauma to the vessel
- Vessel injury by bone fragments
- Extreme hyperextension +/- rotation: vertebral arteries can be stretched over the transverse process
- Since the intima is much less elastic or adventitia, intimal disruption may in dissection
- Transection of the entire wall (all th results in acute hemorrhage. If conta pseudoaneurysm may form



PROGRESS

- Prior to 1980: little recognition of BCVI
- 1980s: multiple reports and some increased awareness
- 1990s: screening with conventional angiography (CA)
- 2000s: introduction of screening with CT angiography (CTA)
- 2010s: refining diagnostic tools and therapy

Early Experience

- IN the 1980s, we and others reported early experience with Blunt Cervical Vessel Injury (BCVI) before the era of screening and noted that:
  - Diagnosis is usually delayed until symptoms appear
  - Angiography is the gold standard diagnostic tool and may allow for treatment in some cases
  - Anticoagulation/antithrombotic therapy may ameliorate the severity of complications after BCVI

Yamada S Kindt GW, Youmans JR . J Trauma 1967;7: 333-42.
Perry MO, Snyder WH, Thal ER. Ann Surg 1980;192:74-7.
Krajewski LP, Hertzer NR. 1980;191:341-346.
Fakhry SM, Jaques PF, Proctor HJ. J Vasc Surg. 1988;8:501-508.
Richardson JD, Simpson C, Miller FB. Surgery. 1988;104:673-680.

CURRENT STATUS

- BCVI is an uncommon but potentially serious injury and is difficult to diagnose
- Screening criteria generally identify high risk patients
- Conventional angiography (CA) is the gold standard diagnostic tool but its routine use for screening is limited by issues of accessibility, complications and cost
- Computed Tomographic Angiography (CTA) has become widely accepted as a screening tool for BCVI

PRESENTATION

- Carotid Artery Injuries:
  Contralateral sensory or motor deficit which may progress to a full stroke
- Vertebral Artery Injuries
  - Ataxia
  - Vertigo
  - Emesis
  - Possible visual field defects
- Co-existing TBI may mask signs and symptoms of BCVI

Prior to Era of Screening (1990s)

- Majority of patients asymptomatic
- Variable time from injury to symptoms
  - 1 hour to several weeks
- Diagnosis frequently delayed
- Neither GCS or neurologic exam correlated with subsequent development of symptoms
- Relatively limited awareness of the injury by clinicians

Cobgill TH, Moore EE, Meissner M, et al. J trauma 1994;37(3): 473-9.
Davis JW, Holbrook TL, Hoyt DB, et al. J Trauma 1990;30(12):1514-7.
Perry MO, Snyder WH, Thal ER. Ann Surg 1980;192(1):74-7.

Mechanism of Injury

Motor Vehicle Collision	41 – 70 %
Direct Cervical Blow	10 – 20 %
Pedestrian Struck	12 – 18%
Fall from Height	5 – 15%
Hanging	5%

Associated Injuries

- Traumatic brain injuries: 50 – 65%
- Facial fractures: 60%
- Thoracic injuries: 40 – 51%
- Nearly *half* of all patients will have cervical spine fractures at the time of diagnosis

Risk Factors

	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 L 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

Even minor fractures count !!

Table III. Indication for screening angiography in patients proven to have BCVI with only minor cervical spine fractures

Type of fracture	*Associated injuries*	*Indication for angiography*	*BCVI*
C7 3-column body	SDH, SAH, neurogenic shock	Presumed subluxation with neurogenic shock	CAI
C6/7 spinous process	DAI, mandible fx	DAI	CAI
C4,5,7	DAI	DAI	VAI
C3-9 spinous process	Scapular fx, multiple rib fx, pulmonary contusion unstable pelvis	Mechanism	VAI
C6 spinous process	SAH, DAI, ? neurogenic shock	DAI	VAI
C7 body	SAH, mandible fx	Mechanism	VAI
C6 body		Mechanism	VAI
C7 spinous process		Mechanism	VAI

BCVI, Blunt cerebrovascular injury; *CAI*, carotid artery injury; *DAI*, diffuse axonal injury; *fx*, fracture; *SAH*, subarachnoid hemorrhage; *SDH*, subdural hemorrhage; *VAI*, vertebral artery injury.

Cothren CC, Moore EE, Ray CE, et al. Surgery. 2007; 141(77):76-82

Treat *before* symptoms…

- Prior to initiation of screening protocols, Berne et al. found that the median time to diagnosis was 12.5 hours for survivors and 19.5 hours for non-survivors

This suggested there was a *window of opportunity* for diagnosis and treatment

Berne JD, Norwood SH, McAuley CE, et al. J Am Coll Surg 2001;192(3):314-21.

1990's

- Attempts made to identify patients in the asymptomatic latent period
- Screening protocols initiated
- No consensus on the ideal screening protocol
- Some discussion of optimal therapy

Denver Screening Criteria

- Arterial hemorrhage or expanding hematoma
- Cervical bruit
- Focal neurologic deficit
- Neuro exam inconsistent with CT findings
- Stroke on CT scan

Risk factors: LeForte II or III, C spine fracture, basilar skull fracture, DAI with GCS<6, Near hanging with anoxic brain injury

Biffl WL, Moore EE, Ryu RK et al. Ann Surg 1998;228 (4):462-70.

BCVI Grading Scale

- Grade I—intimal irregularity with <25% narrowing;
- Grade II—dissection or intramural hematoma with >25% narrowing;
- Grade III—pseudoaneurysm;
- Grade IV—occlusion; and
- Grade V—transection with extravasation.

Prognostic Value of Grading Scale

	Stroke Risk	Mortality
Grade I	**3%**	**11%**
Grade II	**11%**	**11%**
Grade III	**33%**	**11%**
Grade IV	**44%**	**22%**
Grade V	**100%**	**100%**

Stroke risk of blunt injury to the vertebral arteries is 20% irrespective of grade in this study

Biffl WL, Moore EE, Elliott JP, et al. Ann Surg 2000;231 (5) 672-81

Memphis Screening Criteria

- Cervical spine fracture
- Horner's syndrome
- Neuro exam not explained by CT findings
- LeForte II or III fracture pattern
- Basilar skull fracture with involvement of carotid canal
- Neck soft tissue injury
  - Seat belt sign
  - Hanging
  - hematoma

Miller PR, Fabian TC, Crose MA, et al. Ann Surg 2002; 236(3): 386-93.

Memphis Screening Criteria

- Overall incidence 1.03%
- 3.5% of all blunt trauma patients met screening criteria
- 29% of those screened had an injury

Miller PR, Fabian TC, Crose MA, et al. Ann Surg 2002;236(3):386-93.

Comparison of Screening Protocols

	Denver Criteria	Memphis Criteria
Incidence	0.86%	1.03%
% Screened	4.8%	3.5%
Yield	18%	29%

Both screening regimens mandated 4 vessel angiography if the patient met at least one of the screening criteria

How to screen?
The most hotly debated question…

- Conventional Angiography
- Duplex Ultrasound
- CT Angiography (CTA)
- MRA/MRI

or

- Combination?

Why not Angiography?

- It IS the gold standard
- Invasive !
- Technical limitations
- Risk profile
  - Complication rates up to 4%
  - Iatrogenic stroke up to 1%
- Large economic and workload burden
  - Some institutions cannot support this demand

Biffl WI, Ray CE, Moore EE, et al. J Trauma. 2002:53:850-856
Cintron SJ, Wallace RC, Lewis CA, et al. J Vasc Interv Radiol. 2003;14:257-262.
Rommel O, Niedeggen A, Tegenthoff M, et al. Cerebrovasc Dis. 1999;9:202-209.

Duplex Screening

- Initially of interest
  - Costs less - $1200 less than angiography[1]
  - Less invasive
- Limitations[2,3,4]
  - Does not identify small tears or non occlusive dissections
  - Cannot visualize ICA at base of the skull
  - Evaluation of the vertebral arteries is limited
  - Technician dependent

Fry WR, Dort JA, Smith RS, etal. Am J Surg 1994; 168(6):693-5.
Biffl WL, Ray CE, Moore EE, et al. J Trauma. 2002;53: 850-856.
Biffl WL, Moore EE, Elliott JP, et al. Ann Surg. 2000;231:672-681.
Miller PR, Fabian TC, Crose MA, etal. Ann Surg. 2002;236:386-395.

Magnetic Resonance Angiography

- Non invasive modality
- Infinite number of projections of the vessel
- Ability to assess the intracranial architecture for signs of stroke

but…

Not adequately sensitive

Availability issues

Time requirements for image acquisition

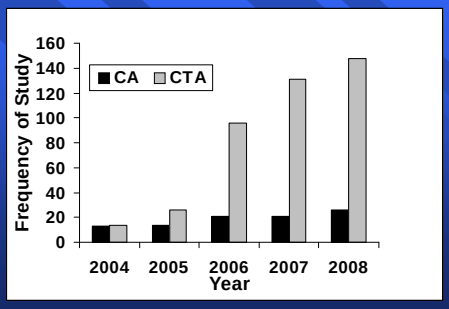
Impractical for use in trauma patients

CT Angiography

- Easy to obtain during initial workup
  - Adds 60 seconds/scan
  - Additional 100cm^3 of contrast burden
  - Little additional radiation exposure
- Sensitivity of 95%
- Specificity of 93%
- Widely available and can be incorporated in to trauma "panscan"

Berg M, Zhang Z, Ikonen A, et al. Am J of Neuroradiology 2005;26(5):1022-34.

Increasing CTA Use



Fakhry SF, Aldaghlas TA, Seoudi H, et al. AAST, 2009.

ROLE OF CTA

- Early experience with older CT scan technology suggested that CTA was not acceptable as a screening tool (sufficiently low false negative rates)
- There were also concerns regarding its ability to accurately detect injuries (sufficiently low false positive rates)
- As CT technology improved and multi-detector scanners became available, results improved
- With the advent of 16 detector scanners, CTA became accepted as a screening test for BCVI by many centers

FALSE NEGATIVE and FALSE POSITIVE RATES IN RECENT STUDIES USING 16 DETECTOR CTA

	# CTA/#CA	False Neg	False Pos
Berne et al. J Trauma, 2004	486/48	0%	62.5%
Eastman, et al. J Trauma, 2006	162/146	0.7%	0%
Biffl et al. J Trauma, 2006	331/17	0%	1.2%
Utter et al. J Am Coll Surg, 2006	372/111	8.6%	-
Malhotra et al. Ann Surg, 2007	119/92	10%	35%

EXAMPLE OF STUDY USING 8 DETECTOR CTA

Schneidereit et al. J Trauma 2006 *	170/23	-	42%

Computed Tomographic Angiography: False Positives in the Diagnosis of Blunt Cervical Vessel Injury

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*** Department of Surgery, Medical University of South Carolina, Charleston, South Carolina**

PURPOSE

- The purpose of this study was to assess the false positive rates of 16/64 slice multi-detector computerized tomographic angiography as compared to the "gold standard" conventional angiography in the evaluation of blunt cervical vessel injury

METHODS

- Our trauma team adopted a policy of screening for BCVI using established criteria
- Initial screening was done using Computerized Tomographic Angiography (CTA) with 16 and 64 slice machines
- Patients who screened positive and were eligible for anticoagulation underwent conventional angiography (CA)

METHODS

- Adult trauma patients who had undergone CTA and/or CA of the neck vessels were selected from the trauma registry and the radiology database our Level 1Trauma Center
- January 2004 through December 2008

INCLUSION CRITERIA

- Admitted between January 2004 and December 2008
- Blunt injury mechanism
- Trauma activation patient or consultation from the Emergency Department for trauma
- Neck CTA and/or conventional angiography

SCREENING CRITERIA

- Cervical spine fracture
- Basilar skull fracture
- Multiple facial fractures
- Traumatic Brain Injury (TBI) with GCS < 9
- Lateralizing neurologic signs in the absence of corresponding TBI on head CT scan
- Neck hematoma, bruit or thrill
- Clinical suspicion

RESULTS

- 11,476 blunt trauma patients were seen during the study period
- 448 patients (3.9%) underwent evaluation for BCVI:
  - Mean age was 43.0 years
  - 67.9 % were male
  - 50.1 % were motor vehicle crashes
  - Mean ISS was 19.5
  - Mortality was 8.7%

CTA and CA

- 62 patients had both CTA and CA performed
- 48 patients had a positive CTA and 17 of them had a negative CA:
  - False Positive rate of 35.4%*
- 14 patients had a negative CTA and 3 of them had a positive CA:
  - False Negative rate of 21.4%*

* Approximate since the entire population was not evaluated with a "gold standard" test

COMPARISON OF CTA AND CA

	CA positive	CA negative	Total
CTA positive	31 (65%)	17 (35%)	48
CTA negative	3 (21%)	11 (79%)	14
Total	34	28	62

FALSE NEGATIVE and FALSE POSITIVE RATES IN RECENT STUDIES USING 16 DETECTOR CTA

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Utter et al. J Am Coll Surg, 2006	372/111	8.6%	-
Malhotra et al. Ann Surg, 2007	119/92	10%	35%
Fakhry et al, 2009	415/95	21%	35%

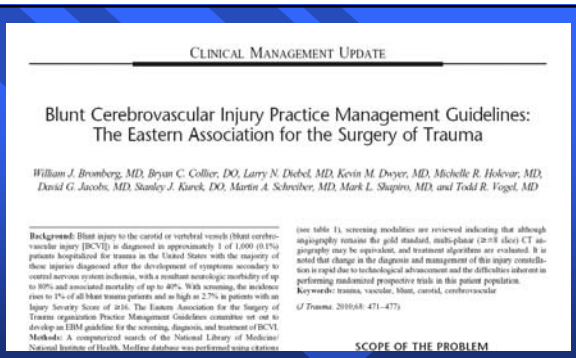
	Total blunt patients	Months of study	Number screened (% of total)	BCVI incidence (all patients)	BCVI incidence in screened pts
Berne et al. 2004	2023	34	435 (21.5)	1.2%	5.5%
Eastman, et al. 2006	4216	11	162 (3.8)	1.25%	28.4%
Biffl et al. 2006	2727	11	331 (12)	0.66%	5.4%
Utter et al. 2006	NA	8	372 (NA)	NA	16%
Malhotra et al. 2007	7000	40	119 (1.7)	0.3%	22%
Fakhry et al. 2009	11,476	48	448 (3.9)	0.41%	10.7%

CONCLUSIONS

- CTA use has increased dramatically and is the preferred screening tool for BCVI
- In this study:
  - CTA had a false positive rate of 35%
  - CTA had a false negative rate of 21%
- Majority of BCVI (60%) are to the vertebral arteries
- Given the relatively high false positive rate of screening CTA, CA is indicated prior to the initiation of anti-thrombotic therapy

RECOMMENDATION

- A large, rigorous, multi-institutional study is needed to determine whether CTA is an appropriate screening test (with an acceptable low false negative rate – high sensitivity) and a reliable diagnostic test (with an acceptable low false positive rate – high specificity)



CLINICAL MANAGEMENT UPDATE

Blunt Cerebrovascular Injury Practice Management Guidelines: The Eastern Association for the Surgery of Trauma

William J. Bromberg, MD, Bryan C. Collier, DO, Larry N. Diebel, MD, Kevin M. Dwyer, MD, Michelle R. Holevar, MD, David G. Jacobs, MD, Stanley J. Kurek, DO, Martin A. Schreiber, MD, Mark L. Shapiro, MD, and Todd R. Vogel, MD

Addressed the issue of screening and noted that the current literature does not yet support a departure from conventional angiography

EAST GUIDELINES FOR THERAPY

Barring contraindications, Grade I and II injuries should be treated with antithrombotic agents such as aspirin or heparin.

Either heparin or antiplatelet therapy can be used with seemingly equivalent results. A number of authors still recommend heparinization if there is no contraindication, reserving anti-platelet agents for those patients with relative contraindications to heparinization.

If heparin is selected for treatment, the infusion should be started without a bolus and titrated to an aPTT of 50-60 sec.

In patients in whom anticoagulant therapy is chosen conversion to warfarin titrated to a PT INR of 2-3 for 3-6 months is recommended.

EAST GUIDELINES FOR THERAPY

Grade III injuries (pseudoaneurysm) rarely resolve with observation or heparinization and invasive therapy (surgery or angio-interventional) should be considered.

Carotid stents placed without subsequent anti-platelet therapy have been noted to have a high rate of thrombosis in this population

In patients with an early neurologic deficit and an accessible carotid lesion, operative or interventional repair should be considered to restore flow.

Grade IV injuries (occlusion) antithrombotic as tolerated
Grade V injuries (transection with extravasation) surgery/IR

Treatment Outcomes

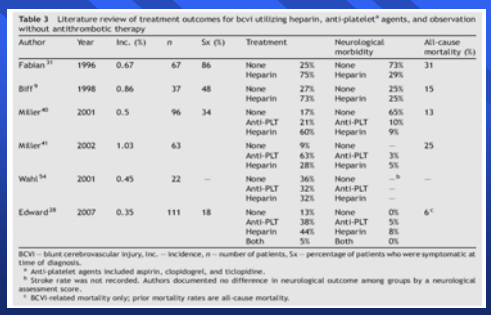


Table 3 Literature review of treatment outcomes for bcvi utilizing heparin, anti-platelet[a] agents, and observation without antithrombotic therapy

Author	Year	Inc. (%)	n	Sx (%)	Treatment		Neurological morbidity		All-cause mortality (%)
Fabian[31]	1996	0.67	67	86	None	25%	None	73%	31
					Heparin	75%	Heparin	29%	
Biff[9]	1998	0.86	37	48	None	27%	None	25%	15
					Heparin	73%	Heparin	25%	
Miller[40]	2001	0.5	96	34	None	17%	None	65%	13
					Anti-PLT	21%	Anti-PLT	10%	
					Heparin	60%	Heparin	9%	
Miller[41]	2002	1.03	63		None	9%	None	–	25
					Anti-PLT	63%	Anti-PLT	3%	
					Heparin	28%	Heparin	5%	
Wahl[54]	2001	0.45	22	–	None	36%	None	–[b]	–
					Anti-PLT	32%	Anti-PLT	–	
					Heparin	32%	Heparin	–	
Edward[38]	2007	0.35	111	18	None	13%	None	0%	6[c]
					Anti-PLT	38%	Anti-PLT	5%	
					Heparin	44%	Heparin	8%	
					Both	5%	Both	0%	

BCVI = blunt cerebrovascular injury, Inc. = incidence, n = number of patients, Sx = percentage of patients who were symptomatic at time of diagnosis.
[a] Anti-platelet agents included aspirin, clopidogrel, and ticlopidine.
[b] Stroke rate was not recorded. Authors documented no difference in neurological outcome among groups by a neurological assessment score.
[c] BCVI-related mortality only; prior mortality rates are all-cause mortality.

Arthurs ZM and Starnes BW. Injury, Int J Care Injuured. 2008. (39), 1232-1241.

Treatment Outcomes

- Grade I : 72 % completely healed
- Grade II: 33% improved, 33% stable, 33% progress to pseudoaneurysms
- Grade III: 50% remain unchanged, 40% enlarged
- Grade IV: universally did not improve

Edwards NM, Fabian TC, Claridge JA, et al. J Am Coll Surg 2007;204(5): 1007- 13.

Anticoagulation: Complications

- Affect 25 to 54% in trauma population[1]
  - Intracranial hemorrhage
  - Gastrointestinal bleeds
  - Retroperitoneal hematoma
  - Re-bleeding from blunt solid organs that were injured
  - Bleeding from surgical wounds
- Few trauma patients were able to receive heparin therapy at time of diagnosis → 14% [2]
  - Complication rate of 16% of those receiving heparin

Biffl, Moore, Ryu, et al. Ann Surg 1998;228 (4): 462-70.
Eachempati SR, Vaslef SN, Sebastian MW, et al. J trauma 1998; 45 (6) : 997-1004.

Follow-up

- No clear consensus
- Grade I –II
  - Repeat imaging at 7-10 days prior to D/C
  - May be able to discontinue anticoagulation
- Grade III
  - Treat for 4-8 weeks
  - Repeat angiography (intervention vs observation)
- Grade IV
  - Do not resolve and therefore do not need repeat imaging
- Repeat Angio +/- intervention on all patients who become symptomatic on anticoagulation

Thank you!

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