2019 Winter Anesthesia Conference

EVAR, TEVAR, and C-ARMS: Making Sense of Endovascular Aortic Surgery

J. Matthew Aldrich, MD
Associate Professor
Medical Director, Critical Care Medicine
UCSF Department of Anesthesia & Perioperative Care

Disclosures

SCCM, ICU Liberation: Committee member, past Co-Chair

NIH, R01 HL128679: Co-investigator

Learning objectives

At the completion of the lecture, the participant should be able to:

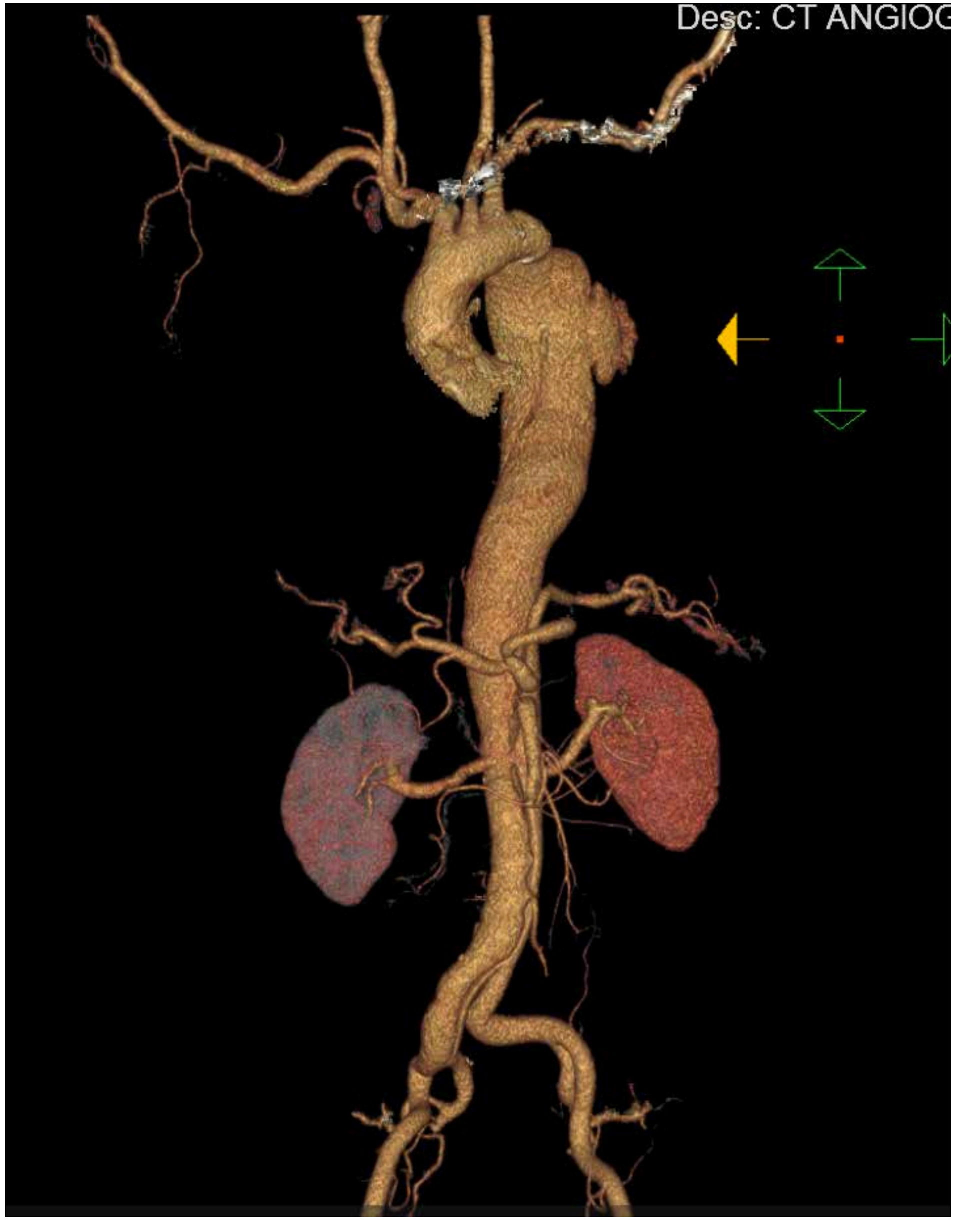
- Describe the risks for cardiac, pulmonary, renal and spinal cord complications
- Formulate an anesthetic plan for an endovascular thoraco-abdominal aortic repair

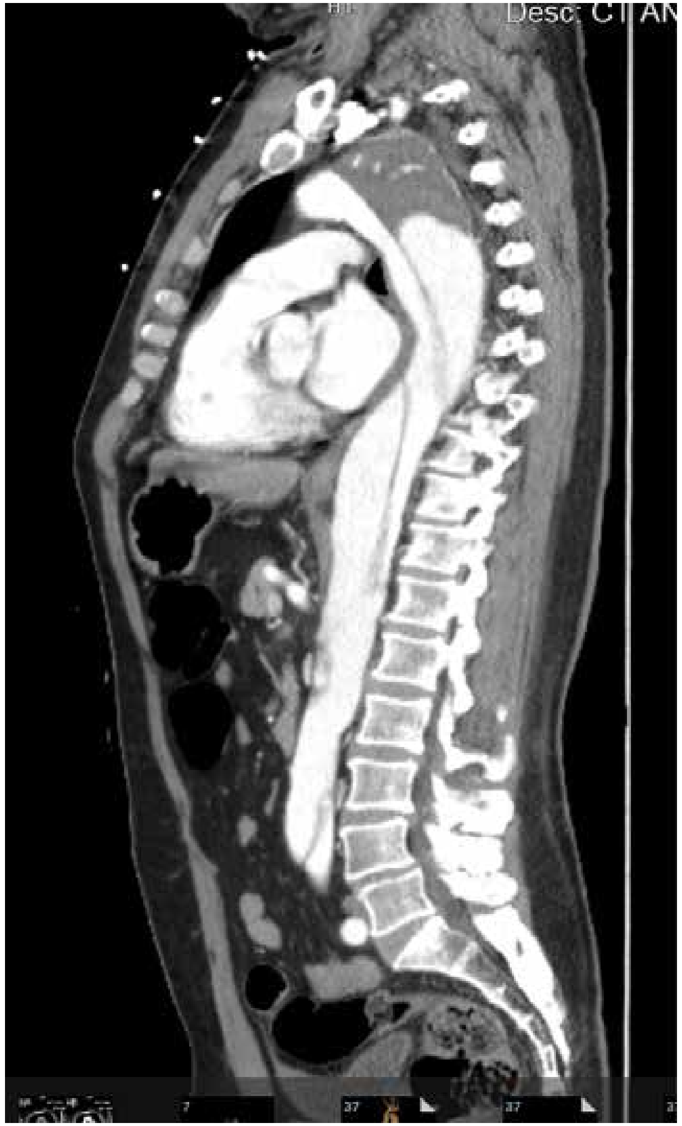
Case

- 53 yo man with known type B aortic dissection (dx 2010) and aneurysm
- Presents to UCSF from an OSH with acute chest pain, increase in size of aneurysm, and new saccular dissection component
- PMH:
  - prolonged hospitalization with respiratory failure @ time of initial aortic dissection
  - HTN (uncontrolled), HLD, chronic LBP
- PSH: tracheostomy, PEG

Case

- Medications: esmolol gtt, MS Contin, oxycodone, fentanyl, Plavix (last dose 2 days ago)
- ROS: + CP, + LBP
- PEx:
  - BP 120s-140s/70s-90s, HR 70s, RR 16-20s, 98% on RA
  - Well-healed tracheostomy and PEG incisions, pulse exam normal
- Studies:
  - TTE with normal LV, dilated thoracic Ao
  - Cr 0.78
  - CTA


Desc: CT ANGIOG


Desc: CT AN

Case

§ Operative plan:

- L carotid to L SCA bypass
- TEVAR with overlapping C-TAG stents (15 cm & 20 cm) treating the thoracic aorta from L carotid artery to just superior to celiac artery.

§ Anesthetic plan:

- GA
- R radial arterial line and R IJ MAC introducer
- TEE
- Spinal cord protection: lumbar drain

Case

- Successful TEVAR
- Neurologically intact
- CSF drainage for 3 days post-op, then removed
- Normal renal function
- BP management with benazepril, amlodopine, hydrochlorothiazide
- Discharged home on POD 5

Endovascular aortic repair (EVAR): overview

- First described in late 1980s for AAA
- Thoracic aneurysm first treated with stent in 1994
- FDA approved thoracic endovascular aneurysm repair (TEVAR) in 2005
- FDA approved fenestrated grafts for juxta- and supra-renal AAA in 2012, often referred to as multibranched endovascular aneurysm repair (MBEVAR)

Vasquez et al., *Int Anes Clinics 2016*; 54 (2): 52-75

Outcomes: EVAR

- Multiple RCTs of EVAR vs. open repair:
  - UK EVAR 1[1], DREAM[2], USA OVER[3], ACE[4]
  - Improved short-term but not long-term mortality
  - Decreased LOS
  - Higher rates of re-intervention in EVAR groups
- Pooled Cochrane analysis of five trials[5]
  - Short term mortality 1.4% vs. 4.2%
  - No difference in intermediate and long term mortality
  - Higher re-intervention rate

[1]UK EVAR Trial Investigators. *NEJM* 2010; 362: 1863-1871
[2]De Bruin et al. *NEJM* 2010; 362: 1881-1889
[3]Lederle et al. *JAMA* 2009; 302:1535–1542
[4]Becqueminet al. *J Vasc Surg* 2011; 53: 1167-1173
[5]Paravastu et al., *Cochrane Database of Syst Rev* 2014

Outcomes: TEVAR for desc thoracic aortic disease

§No RCTs

§Meta-analysis[1] of 42 observational studies of ~ 6000 patients undergoing open repair vs. TEVAR

- Reduced short term mortality & complications
- Decreased LOS
- No mortality benefit beyond 1 year

§Retrospective review[2] of 352 ER, 372 SR

- ER patients older and sicker
- No difference in mortality or SCI

[1]Cheng et al. *J Am Coll Cardiol*. 2010;55(10):986-1001
[2]Greeenberg et al. *Circulation* 2008 Aug 19;118(8):808-17

UCSF's experience with MBEVAR

Prospective study of 153 patients who underwent elective endovascular repair of TAAA and PRAA using multibranched stent grafts

§ 44% with prior aortic surgery

§ Mean age 73; 74% men

§ Outcomes:

- 3% peri-operative death; 5% late post-op aneurysm-related death
- 5% AKI requiring dialysis
- 6% paraplegia
- K-M estimated 5 year freedom from aneurysm-related mortality was 90% and freedom from overall mortality was 48%

Kaushik et al. *J Vasc Surg* 2018;68:325-30

Perioperative risk

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Long-Term Outcomes of Abdominal Aortic Aneurysm in the Medicare Population

Marc L. Schermerhorn, M.D., Dominique B. Buck, M.D.,
A. James O'Malley, Ph.D., Thomas Curran, M.D., John C. McCallum, M.D.,
Jeremy Darling, B.A., and Bruce E. Landon, M.D., M.B.A.

ABSTRACT

NEJM 2015;373:328-38.

- Perioperative mortality: 1.6% vs. 5.2%
- MI: 2.5% vs. 5.2%
- Pneumonia: 3.8% vs. 12.9%
- Acute renal failure: 4.3% vs. 11.3%

Management of aortic aneurysms: when and how to treat?

- AAA[1]
  - Fusiform when > 5.4 cm; consider repair in women with AAA 5.0-5.4 cm
  - Saccular less common but higher risk, repair at smaller diameter
  - No clear recommendation on approach
- TAA[2]
  - Degenerative or traumatic aneurysms > 5.5 cm, strongly consider endovascular approach
  - Guidelines acknowledge lack of RCT data and need for shared decision-making

[1]Chaikof et al. *J Vasc Surg* 2018
[2]Hiratzka et al. *Circulation*. 2010;121:e266-e369

Preoperative assessment

- High risk vascular surgery population
- Common co-morbidities include CAD, CHF, DM, PVD, CKD, COPD
- Requires careful preoperative evaluation
  - Cardiac: ECG at baseline, other studies based on patient condition
  - Renal function; risk for CIN
  - Medications:
    - recent use of anticoagulants or antiplatelet medications
    - BB, clonidine, statin use; avoid abrupt discontinuation

Cardiovascular evaluation

- What's the risk of the procedure?
  - Both EVAR and TEVAR are generally *elevated risk* procedures
- Emergent, urgent, or elective?
- Evaluate for CAD risk factors
- Testing
  - Preoperative ECG (Class IIa, LOE B)
  - TTE (IIa vs. IIb vs. III depending on circumstance)
  - Pharmacologic stress testing: reasonable for patients with elevated risk and poor functional capacity (Class IIa, LOE B) *if it will change management*

Fleisher et al. J Am Coll Cardiol 2014;64:e77–137.

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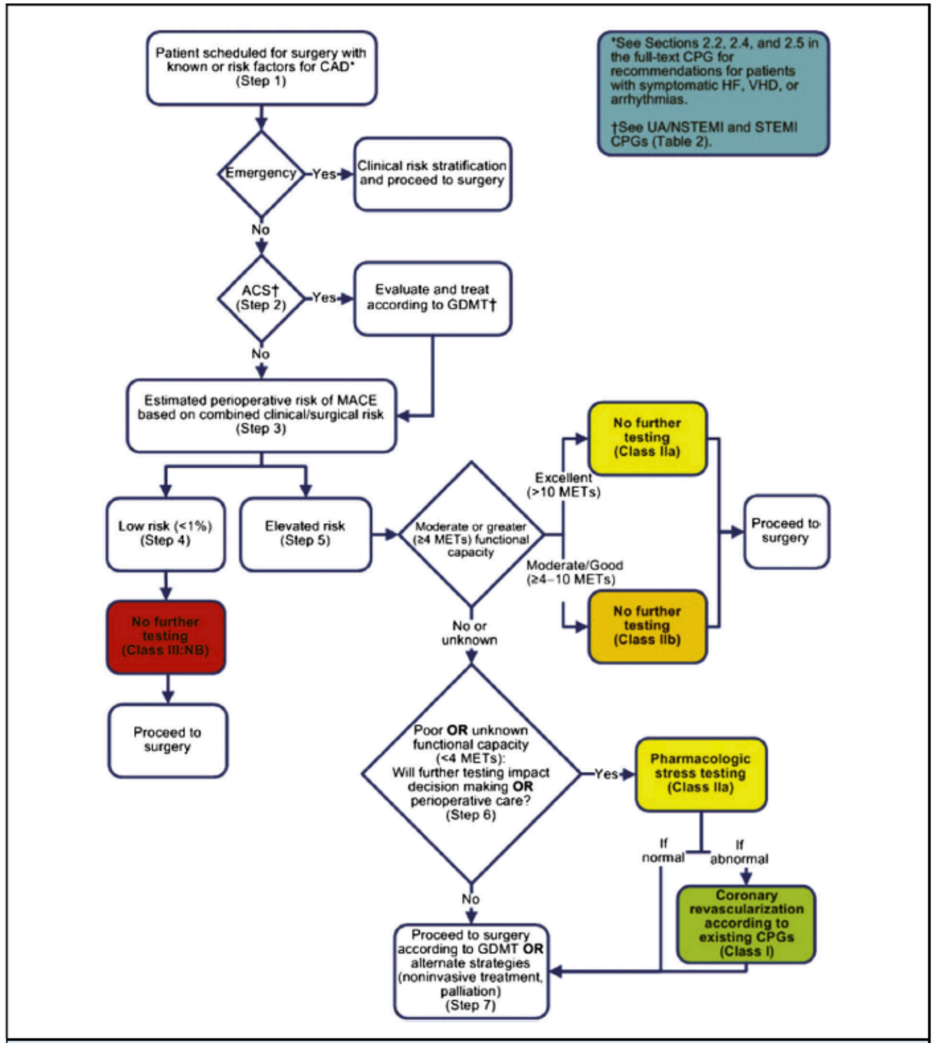
2014 ACC/AHA algorithm



Anesthetic Plan

What’s the best approach for EVAR & TEVAR?

§General anesthesia?

§Neuro-axial technique?

§MAC with local anesthetic?

NSQIP database: increased risk from GA

- ~ 6000 elective EVAR procedures from 2005-2008
- > 4800 under GA
- General anesthesia:
  - Increased pulmonary morbidity (vs. spinal and local/MAC)
  - Increased LOS (vs. spinal and local/MAC)
  - No difference in mortality
  - No differences observed when compared to epidural techniques

Edwards et al. *J Vasc Surg* 2011;54:1273-82

Increased cardiac risk with GA

Contents lists available at SciVerse ScienceDirect

European Journal of Vascular and Endovascular Surgery

journal homepage: www.ejves.com

General Anaesthesia is Associated with Adverse Cardiac Outcome after Endovascular Aneurysm Repair

E.J. Bakker[a,b], K.M. van de Luijtgaarden[a], F. van Lier[b], T.M. Valentijn[b], S.E. Hoeks[b], M. Klimek[b], H.J.M. Verhagen[a,*], R.J. Stolker[b]

[a] Department of Vascular Surgery, Erasmus Medical Center, Rotterdam, The Netherlands
[b] Department of Anaesthesiology, Erasmus Medical Center, Rotterdam, The Netherlands

- Retrospective cohort study
- 302 patients undergoing infrarenal EVAR, 2002-2011
- 173 under GA; 129 with locoregional
- GA demonstrated OR of 3.8 (3.8; C.I. 1.1-12.9; P = 0.03) for 30 day cardiac event

Locoregional anesthesia for endovascular aneurysm repair

Alan Karthikesalingam, MSc, MA, MRCS, Sri G. Thrumurthy, MRCS, Emily L. Young, MBBS,
Rob J. Hinchliffe, MD, FRCS, Peter J. E. Holt, PhD, FRCS, and
Matt M. Thompson, MD, FRCS, *London, United Kingdom*

Bakker et al. *EJVES* 2012; 44:121-125

- Systematic review and meta-analysis
- 10 studies, > 13,000 patients
- Poor quality of included studies
- No difference in mortality comparing LA, RA, & GA
- LA & RA improved post-operative outcomes vs. GA but *limited clinical significance*

TEVAR: limited evidence for best anesthetic technique

§One single-center prospective registry of 400 patients did show GA was a risk factor for mortality (HR 1.59; CI 1.02-2.50)

- GA used early in practice
- Regional techniques now used as primary approach (continuous spinal)
- Median survival of all patients: 48.8 months

Lee et al; *Circulation* 2011;123:2938-2945

So, what’s the best approach?

§No RCTs

§Observational data subject to selection bias

§My recommendation:

- Most EVARs can be done under local/MAC or regional
- Most TEVAR procedures should be conducted under GA based on anticipated length and complexity of case

Intraoperative anesthetic management

- Induction
  - Short-acting opioid plus low dose propofol
  - Short acting vasopressors and anti-hypertensives need to be immediately available
- Maintenance
  - Inhaled agent or TIVA (if MEPs/SSEPs)
- Potential issues
  - Monitor for sudden hypotension c/f rupture
  - Elevated lactate can indicate bowel ischemia in TAAA cases
  - Bleeding
  - Hypothermia

Monitoring

Hemodynamics

§Invasive arterial monitoring (pre-induction)

§Central venous catheter

- Beneficial if anticipated need for vasopressor or anti-hypertensive infusions
- Limited benefit to continuous CVP monitoring
- Helpful if need to convert to open procedure (rare)
- UCSF experience: CVC placed in RIJ for TEVAR

Monitoring: TEE

§Several series and reports describe benefit and advocate for use with TEVAR[1-3]

§Most helpful for:

- Dissection cases; locating wire/catheters in true lumen
- Positioning of proximal portion of stent
- Detection and repair of endoleaks
- Detection of retrograde dissection requiring emergent repair

[1]Swaminathan et al. *Anesth Analg* 2003;97:1566 –72
[2]Rapezzi et al. *Am J Cardiol*. 2001;87:315–319
[3]Rocchi et al. *J Vasc Surg*. 2004;40:880–885

Complications

AKI

Eur J Vasc Endovasc Surg (2015) 49, 534—540

Incidence of Acute Kidney Injury (AKI) after Endovascular Abdominal Aortic Aneurysm Repair (EVAR) and Impact on Outcome

A. Saratzis [a,b,*], N. Melas [b], A. Mahmood [a], P. Sarafidis [c]

[a] Department of Surgery, University Hospitals Coventry and Warwickshire, Coventry, UK
[b] Department of General and Vascular Surgery, Papageorgiou General Hospital, Aristotle University, Thessaloniki, Greece
[c] Department of Nephrology, Hippokration Hospital, Aristotle University of Thessaloniki, Greece

- Single center, prospective registry of 149 patients undergoing infrarenal EVAR
- 28 (18.8%) developed AKI; none required dialysis
- AKI independently associated with all cause mortality and cardiovascular morbidity

AKI-prevention

- Mechanism of injury primarily due to contrast induced nephropathy or mechanical injury (stent-related, emboli, etc)
- Preventive measures:
  - Limit contrast exposure
  - IV isotonic saline or sodium bicarbonate hydration
    - Pre-admit with hydration initiated with 1 ml/kg x 12 hours preop + 12 hours post-contrast vs. standard protocol of 3 ml/kg 1 hour, then 1 ml/kg until 6 hours post-contrast
  - N-acetylcysteine: conflicting data but reasonable to consider[2-4]

[1]Weisbord et al. *Clin J Am Soc Nephrol*. 2008;3(1):273.
[2]Marenzi et al. *NEJM* 2006;354(26):2773.
[3]ACT investigators. *Circulation*. 2011 Sep;124(11):1250-9
[4]Trivedi et al. *Am J Med.* 2009;122(9):874.e9

Spinal cord injury (SCI)

- Feared complication of both open and endovascular thoracic and thoraco-abdominal repairs
- <u>Incidence</u>: meta-analysis of 46 TEVAR series reported pooled incidence rate of SCI of <u>3.88</u>% (95% CI, 2.95%-4.95%)
- Rare incidence of SCI with EVAR

[1]Wong et al. *J Vasc Surg* 2012;56:1438-47

UCSF data on SCI

- Prospective trial of 116 patients treated with MBEVAR from 2005-2013
- 112/116 with preop placement of lumbar drain for CSF drainage
- Outcomes:
  - Lower extremity weakness developed in 24/116 patients (21%)
  - 9 patients with persistent LEW; 6 with paraplegia
  - Only 5 emerged from anesthesia with LEW
  - 5 developed weakness > 72 h post-op
- RFs: baseline GFR < 30, fluoro time > 190 minutes, sustained hypotension

Sobel et al. *J Vasc Surg* 2015;61:623-9

SCI risk factors with TEVAR

§Extent of endovascular stent coverage of the thoracic aorta

§Acute dissection with malperfusion of segmental arteries

§Degree of urgency

§Previous abdominal aortic aneurysm repair

§Hypotension

§Occlusion of L SC or hypogastric arteries

Sinha & Cheung, *Current Opinion in Anesthesiology* 2010; 23:95–102
Acher & Wynn, *J Vasc Surg* 2009;49:1117-24
Fedorow et al. *Anesth Analg* 2010;111:46 –58

Mechanisms of SC ischemia & injury

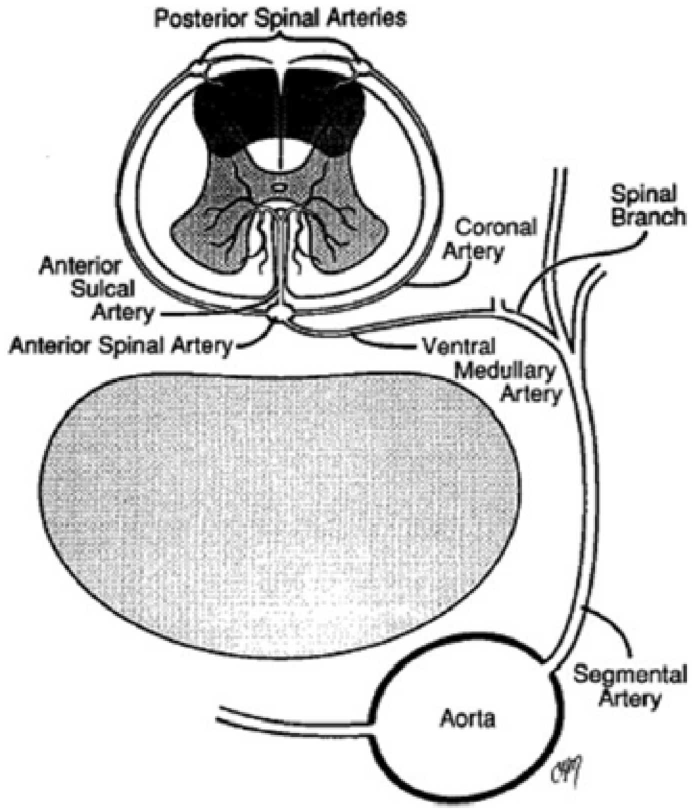
- TEVAR impacts flow
  - L SCA
  - intercostal & lumbar SA
  - hypogastric and sacral arteries
- Prior distal aortic surgery
  - loss of hypogastric artery inflow to collateral circulation
- Severe peripheral disease
  - loss of hypogastric artery perfusion
- Hypotension
- Aortic atheromatous disease

Etz et al. *Eur J Cardiothorac Surg* 2015;47:943–57

UCSF

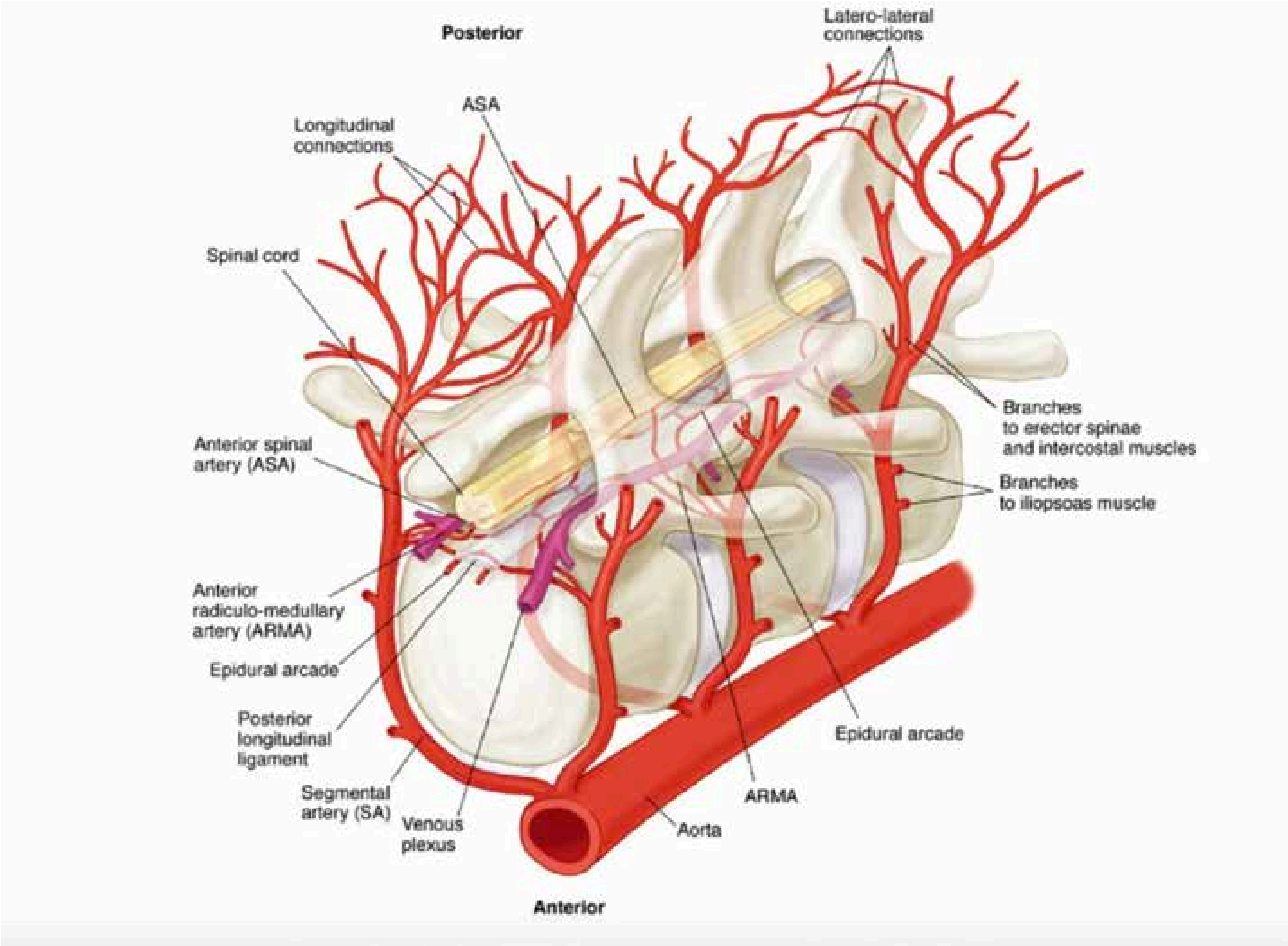
SC blood supply

- One anterior spinal artery (ASA)
- Two posterior spinal arteries (PSA)
- Both originate from vertebral arteries
- Contributions to ASA from SA, epidural arterial network, small paraspinuous vessels; all have anastomoses with subclavian & hypogastric arteries



Fedorow et al., *Anesth Analg* 2010;111:46 –58

Rich collateral network



Griepp et al. *Ann Cardiothorac Surg* 2012;1(3):350-357

Why is the rate of SCI lower with TEVAR than open repair?

§Thoracic aorta is covered; unable to re-vascularize SA during procedure

§Shouldn’t this result in higher incidence of SCI?

§Yet…

- Less impact on hemodynamics
- Avoidance of aortic x-clamp and loss of distal perfusion

Spinal cord protection

§Minimize ischemic time

- More relevant to open repair
- Left heart bypass

§Improve tolerance of ischemia

- Hypothermia: systemic and epidural
- Nalaxone
- Steroids

§Augment perfusion

- CSF drainage: prophylactic or rescue
- Deliberate or permissive HTN

CSF drainage

Physiologic rationale:

SCPP = MAP – lumbar CSF P (or CVP)

Support for CSF drainage

Two RCTs from open TAAA repair support CSF drainage[1,2]

§ **Hnath et al. *J Vasc Surg* 2008; 48:836-40**

- 121 patients undergoing TEVAR; 46% with preop CSF drain
- No patients with preop CSF drain developed SCI; 5 (8%) without CSF drain developed SCI (3/5 rescued with post-op drainage)

§ **Keith et al. *J Vasc Surg* 2012;55:1-9.**

- 16 (6%) of 239 patients developed SCI within 30 days post-op
- 10 treated with selective CSF drainage; 3 with complete and 4 with partial resolution of SCI
- All 7 patients without compete resolution died within one year

[1]Svensson et al. *Ann Thorac Surg*. 1998;66:132–138
[2]Coselli et al. *J Vasc Surg*. 2002;35:631–639

Selective drain placement

§ 381 patients at Duke from 2002-2012

§ Selective drain placement for high risk patients

- Prior aortic repair plus planned long thoracic segment coverage
- Hybrid TAAA repairs

§ 81 high risk patients (21%) received preop drain: 14.8% developed SCI

§ 300 low risk patients: 4.3% with SCI (0.3% permanent)

§ Drain-related complications: 11.1% (all minor)

Hanna et al. *Ann Thorac Surg* 2013;95:1968–75

Systematic review and meta-analysis

- 46 studies
- 4936 patients
- SCI incidence:
  - Routine prophylactic drain (3 studies): 3.2%
  - No prophylactic drainage (8 studies): 3.47%
  - Selective prophylactic drainage (15 studies): 5.6%
- Authors' conclusion: limited evidence to support routine prophylactic drainage for TEVAR

Wong et al. *J Vasc Surg* 2012;56:1438-47

Complications of CSF drainage

- Direct injury to spinal cord or nerve root
- Neuraxial hematoma
- PDPH
- ICH
  - 0.5-5.5 % of patients with symptomatic ICH[1]
- Catheter fracture
- Mortality
  - 0.2-6% in three largest series[1,2,3]

[1]Fedorow et al *Anesth Analg*. 2010;111:46–58
[2]Wynn et al. *J Vasc Surg* 2009;49:29–35
[3]Estrera et al. *Ann Thorac Surg* 2009;88:9–15
[4]Youngblood et al. *J Thorac Cardiovasc Surg* 2013

CSF drainage protocols

- Significant variability
- Epidural catheters vs larger dedicated lumbar drains
- L3-4 or L4-5 placement, awake or under GA
- Usually drain to CSFP < 10 or 12 mm Hg
- Drain ≤ 10 ml/hr but may increase to 20 ml/hr transiently in the event of paralysis
- Drainage collection should occur in sterile, sealed chamber with volume limit
- CSF drainage for 24-48 hours post-op

Fedorow et al *Anesth Analg*. 2010;111:46–58
Vasquez et al., *Int Anes Clinics 2016;* 54 (2): 52-75

Guidelines/Recommendations

§ Vascular domain of the European Association for Cardio-Thoracic Surgery[1]

- *Consider* prophylactic CSF drainage in patients undergoing TEVAR at high risk for SCI (IIaC)
- If SCI develops, treat with CSF drainage, MAP elevation to ≥ 80, and target hgb > 10 (IIaC)

§ 2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM guidelines[2]

- CSF drainage in high risk patients (1b)
  – Coverage of most of descending aorta or previous AA r*epair*

[1]Etz et al. European Journal of Cardio-Thoracic Surgery 47 (2015) 943–957
[2]Hiratzka et al. *Circulation*. 2010;121:e266-e369

Should you monitor this patient with SSEPs or MEPs?

Limited evidence for use of MEPs/SSEPs in reducing SCI

- Reasonable physiologic rationale but only one small case series (21 patients) described its use with TEVAR[1]
- Decrease in signals do not always correlate with spinal cord ischemia
- SCI often presents post-op
- Impacts anesthetic management
- European Association for Cardio-Thoracic Surgery recommends MEPs/SSEPs "may be considered" (IIbC)[2]

[1]Weigang et al. Eur J Cardiothorac Surg 2006;29:392–6
[2]Etz et al. *European Journal of Cardio-Thoracic Surgery* 47 (2015) 943–957

UCSF

Conclusions

- Better short term outcomes with endovascular aortic repair
- Avoid GA if possible for EVAR
- SCI remains a serious concern
- SCI prevention centers on maintaining adequate blood pressure and CSF drainage
- Unclear if CSF drainage should be performed as routine prevention, selectively for high risk cases, or as rescue