Update on Cardiac Anesthesia

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No conflicts of interest

Why the fuss? Nonsurg Candidates @ 1 yr
Leon MB, NEJM 2010;1597-1607

<table>
<thead>
<tr>
<th></th>
<th>TAVI</th>
<th>Med Mgmt</th>
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<tbody>
<tr>
<td>Mortality</td>
<td>31%</td>
<td>50%*</td>
</tr>
<tr>
<td>Vascular Cx (Major)</td>
<td>30%</td>
<td>4%*</td>
</tr>
<tr>
<td>3-4+ Paravalvular Al</td>
<td>10.5%</td>
<td>NA</td>
</tr>
<tr>
<td>Stroke</td>
<td>10%</td>
<td>5%*</td>
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Edwards SAPIEN Valve
Huffmeyer J, Semin CT Vasc Anes 2012;16:25

Medtronic CoreValve
Huffmeyer J, Semin CT Vasc Anes 2012;16:25

Transapical Approach
Fassl J, J Cardiothorac Vasc Anes 2010;24:496

TAVI Access
Percutaneous (>90% in most series)
- Predominantly transfemoral
- Trans-subclavian also possible
Surgical
- Predominantly transapical
- Trans-aortic also possible: abdominal or thoracic
Gravlee, Glenn, MD
Update on Cardiac Anesthesia

Growth of TAVI
Binder RK, Heart 2012;98:i30

- Europe: 4500 in 2009, 16000 in 2011 (Ger >40%)
- Oct 2012: FDA approved TAVI for high-risk surgical candidates who are eligible for surgery
- Off-label: Failing surgical bioprostheses

TAVI: Better than surgical AVR? Meta-anal
Takagi H, Int J Cardiol 2011;153:207

- But only PARTNER was prospective, others observational with propensity matching
- Argues that Euroscore overestimates surgical mortality - STS score not so much

Transfemoral TAVI
Anesthetic Considerations

- GA or sedation (TEE, technical precision tip us to GA)
- All report anesthesiologist presence
- HYBRID OPERATING ROOM RECOMMENDED
- If GA, ETT rather than LMA (risk of hemodynamic deterioration, pulm edema, use of TEE)
- A-line, CVP (less often PAC), temp, Foley
- Fassl J, JCTVA 2010;24:691

Transfemoral TAVI
Progression
Huffnemen J, Semin CT Vasc Anes 2012;16:25

Sedation for Percutaneous TAVI
(Survey: Bufton KA, JCTVA 2013;27:46)

| Anesthetic Practices for Transfemoral TAVR Procedures in North America and Europe |
|------------------------------------------|----------|----------|
| Anesthetic Approach | North America | Europe |
| GA | 69* | 61 |
| Sedation with transesophageal echocardiography | 1 | 2 |
| Sedation without transesophageal echocardiography | 2 | 10 |
| No sedation with local anes/gi | 0 | 1 |
| Anesthesiologist present | 0 | 1 |
| Total | 62 | 20 |

*Six North American institutions switched to GA from sedation after experiencing complications. Three other centers using GA had plans to try sedation in light of the European experience.
†Two European centers using GA recently had switched from using predominant sedation after a series of emergent intubations. A total
Incidence and Predictors of Early and Late Mortality After Transcatheter Aortic Valve Implantation in 663 Patients With Severe Aortic Stenosis

Corrado Tamburino, MD, PhD; Davide Capodanno, MD; Angelo Ramonino, MD;

• Registry “Real world” – more than just nonsurgical candidates
• 663 consecutive patients, all with Medtronic CoreValve, 14 centers in Italy
• Anesthesia and procedural mortality
  – Died: GA 37%, “local” 63%
  – Overall population: GA 28%, “local” 72%
  – P=0.02
  – Dropped out in stepwise regression
  – Intraprocedural stroke was biggest risk factor (HR 15.7)

Transapical TAVI Anesthetic Considerations
Fassl J, JCTVA 2010;24;691

• GA for sure
  – Lung isolation? (Optional)
• Hybrid OR
• A-line, CVP or PAC, Temp, Foley
• Various anesthetic techniques reported:
  – Usually des or sevo with muscle relaxant
  – Often remifentanil
  – 1 case report of pure thoracic epidural

TAVI Anesthesia: Wake-up

• Assuming GA, typically extubate at end of procedure
• Hypertension/tachycardia avoidance important – be ready to treat either
• Immediate extubation: Lower likelihood with the usual suspects:
  – Low pre-op LVEF
  – High comorbidity (renal, pulmonary)
  – Slow recovery after rapid pacing
  – Need for inotropes

What is the rescue plan?

• If a life-threatening complication occurs that can only be salvaged with surgery, is that the plan?
• Does the patient agree?
• Does the surgeon agree?
• Are you prepared to proceed quickly?
  – hybrid OR, surgeon and perfusionist present
**TAVI Peri-procedural Complications**
Stortecky S, Heart 2012;98,iv52

- Aortic insufficiency (>50% in most)
- Acute kidney injury (12-28%)
- Vascular access/bleeding/dissection
- Stroke (5%+)
- Sluggish recovery from rapid vent pacing/deployment (undefined)
- Conduction disturbance/LBBB
- Valve misplacement (MI/ischemia, LVOT obstruction) or embolization (!)

**Reducing AI with TAVI**

- Biggest valve possible
  - Trend: Annular sizing via CT reconstruction because TTE and TEE tend to underestimate
- Avoid TAVI with bulky eccentric valve calcium
- Postimplant dilation (another RVP run)
  - 40% incidence in some centers
  - Trade-off? Central vs paravalvular AI
  - Immediate valve-in-valve also possible

**TAVI Vascular Complications**
Stortecky S, Heart 2012;98,iv52

- Injury eligibility: Fem access site to aortic valve
- Mortality doubles to triples
- Bleeding: Occult or obvious
- Rupture, dissection, retroperitoneal hemorrhage, hemothorax, AV fistula, pseudoaneurysm, local access bleeding
- Index of suspicion: Unexpected hypotension during technical access difficulty
- Response: Crystalloid bolus up to transfuse/open abdomen or chest
  - Covered stent may suffice
  - (Suggest another day for the TAVI)

**TAVI and (new) AI**

- Box 1 Causes of postprocedure aortic regurgitation
  - Paravalvular
    - Valve placement too low
    - Valve placement too high
    - Annular-valve ‘discongruence’ – valve too small
    - Incomplete stent expansion
    - Bulky, eccentric calcification
  - Transvalvular
    - Leaflet damage
    - Leaflet stuck open
    - Incomplete stent expansion causing leaflet malcoaptation
    - Calcium overhang of stent preventing back pressure for closing

**TAVI Vascular Complications**
Stortecky S, Heart 2012;98,iv52

- Reported incidence 0-31%
- Size matters

**New LBBB is common after TAVI**

Houthuizen P, Circulation 2012;126: 720

Figure 4. Incidence of transcatheter aortic valve implantation (TAVI-induced) left bundle-branch block (LBBB) according to valve type. The percentages of patients who developed a TAVI-induced LBBB are shown for both the Medtronic CoreValve system (MCS) and the Edwards SAPIEN (ES) device. Patients...
**TAVI future possibilities**

In addition to lower risk with primary AS:
- Combined with coronary stent
- Deploy inside malfunctioning existing bioprosthetic aortic (or mitral) valve
- Highly selected AI patients (intrinsic leaflet pathology)
- Also: Several different valves under development

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**TAVI Summary**

- Expanding rapidly: Typically octogenarians with predicted operative mortality >10%
- Transfemoral>transapical by substantial margin
- GA or sedation (transfem), A-line and CVP – TEE integral to procedure
- Be prepared for major Cx: bleeding (may be occult: dissection), heart block, new AI, coronary ostial obstruction

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**Prohemostatic Drugs in Cardiac Surgery**

- Not much new info: rVIIa, DDAVP, antifibrinolytics
- New but unimpressive: F XIII concentrate

**New and promising: Fibrinogen concentrates:**
- Increasing use in Europe, available in US
  - FDA-approved for congenital fibrinogen deficiency
  - Off-label use hasn’t discouraged us in the past: IV nitroglycerin, DDAVP, FVIIa, aminocaproic acid

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**Some facts about fibrinogen**

- Critical importance to plasma->“cell-based” clotting process
- Several studies show [fib] is first to diminish in consumptive processes (others say Va)
- FFP: 300-400 mg/U @ 2 mg/mL
- Cryo: 2.5-4 gm/10 bags (2-300 mL)
- Fibrinogen concentrate (Riastap, Behring, Marburg, Ger): About 1 gm/50 mL vial

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**rVIIa vs Fibrinogen**

<table>
<thead>
<tr>
<th>rVIIa</th>
<th>Fibrinogen</th>
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<tbody>
<tr>
<td>Genetically engineered</td>
<td>Pooled human product</td>
</tr>
<tr>
<td>Fluid phase</td>
<td>Lyophilized: reconstitute</td>
</tr>
<tr>
<td>Exorbitant (platinum)</td>
<td>Expensive (silver)</td>
</tr>
<tr>
<td>Generates thrombin</td>
<td>Requires thrombin</td>
</tr>
<tr>
<td>Procoagulant</td>
<td>Supports clotting only?</td>
</tr>
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*Levy JH Anesth Analg 2012;114:261*
Is “normal” fibrinogen too low?
Biome M, Thromb Haemost 2005;93:1101
- Low normal fibrinogen was a strong post-CPB (T2) predictor of highest blood loss group (Group 3)
- Plt count and aPTT also were quite good

Bollinger D, BJA 2009;102:793
- Hemodilution effect

Fibrinogen: Sufficient by itself in hemodilution?
- Conventional recommendations suggest 75-100 mg/dL as intervention threshold
- In vitro study on hemodiluted WB: Bollinger D, BJA 2009;102:793
- 80% dilution:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group 1</th>
<th>Group 3</th>
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<tbody>
<tr>
<td>Fibrinogen (mg dl⁻¹)</td>
<td>384 (75)</td>
<td>70 (11)*</td>
</tr>
<tr>
<td>Antithrombin III (%)</td>
<td>106 (14)</td>
<td>18 (2)*</td>
</tr>
<tr>
<td>Factor II (%)</td>
<td>115 (17)</td>
<td>25 (1)*</td>
</tr>
<tr>
<td>Factor VII (%)</td>
<td>107 (25)</td>
<td>16 (4)*</td>
</tr>
<tr>
<td>Factor IX (%)</td>
<td>90 (18)</td>
<td>23 (5)*</td>
</tr>
<tr>
<td>Factor X (%)</td>
<td>113 (16)</td>
<td>19 (4)*</td>
</tr>
</tbody>
</table>

Bollinger D, BJA 2009;102:793
- Authors suggest 200 mg/dL as target (2 g/L)
- Note that ONLY fibrinogen was replenished
  - Surprising and instructive that this would work

YET: Seems likely that 100-150 mg/dL would suffice if FFP/Plts also replenished
**Fibrinogen: Selected Studies in CT Surg**

  - Prophylactic fibrinogen 2 gms p-CPB in CABG decreases 12-hr blood loss 20% despite ND in (normal) coag tests

  ![Graph showing fibrinogen levels](image1)

- Rahe-Meyer N, BJA 2009;102:785 (N=15, SMALL)
  - In post-CPB coagulopathy (clinical Dx, AVRs & Type I aneurysms), fibrinogen (mean 5.7 gm, N=10) as a first intervention reduced the need for RBCs, Plts, & FFP and decreased blood loss
  - Induced high-normal fibrinogen concentrations (360±6 mg/dL) in Pts who had low-normal post-CPB fibrinogen (210±3 mg/dL)
  - FFP: minimal effect
  - 1-day post-op: All Pts had high-normal fibrinogen (>400 mg/dL) regardless of fib/FFP administration
  - Similar findings with Thoraco-abdominal aneurysms
    - Rahe-Meyer N, JTCVS 2009;138:694

**Fibrinogen: Recent Studies in CT Surg**

- Fibrinogen concentrate as 1st intervention associated with much lower transfusion of other components
- Not randomized, ND in blood loss

Bilecen S, JCTVA 2013;27:12
  - In database of 1075 CPB Pts, 264 received fibrinogen concentrate 2 gms: ND in blood loss, transfusion, or other outcomes
  - Speculate that dose was too low, but study clearly was very uncontrolled

**Fibrinogen Recommendations**

- For higher risk Pts (e.g., long CPB time, pre-op clopidogrel, circ arrest, redo), include [fibrinogen] in late CPB or post-protamine screening tests
  - Can substitute ROTEM FIBTEM or maybe TEG α-angle
- If [fib] < 200 mg/dL (roughly FIBTEM<15) and bleeding after heparin neutralization, strongly consider fibrinogen concentrate 4(+) gms or cryoprecipitate 10 bags as first intervention

**Fibrinogen conc: Recent Editorial**

Manucci R, JTCVA 2013;27:1-4

- Hot topic: Std of care (vs cryoppt) for fibrinogen in several European countries
- Prolonged CPB: Lower [fib] approaching critical levels
- Dose-finding study needed, but improved outcomes to date associated with ≥6 gms
  - Would require over 20 u FFP
- 5 prospective studies in progress

**Lariat Procedure**
Lariat Procedure

www.mymethodist.net

Transvenous, transforaminal, Echo-guided

Percutaneous, subxiphoid

Lariat Indications: Atrial fibrillation

With contraindication to/ intolerance of anticoagulants

Other factors supporting procedure

• Low tolerance to or success with antiarrhythmics
• Failed atrial fib ablation and/or cardioversions
Touted as 95% successful: Randomized studies?
• Rapidly spreading

Lariat: Anesthetic Considerations

• TEE typically done real-time with live 3D
• General anesthesia is the norm
• Atrial fibrillation – assess pre-procedure rate control
• Potential for rupture/tamponade
  – Solid IV access
  – Arterial catheter seems wise
  – We are using perfusion/CT surgeon back-up at present, but typically not a hybrid OR

Other Nonsurgical LAA closure approaches: WATCHMAN Device

Other LAA Space Occupiers

Nonsurgical LAA Closure Devices

• Lariat Complications: Too soon to say
• “Space occupying” devices: Acute complication rates (mainly rupture/pericardial effusion) 4-8%
  – Improves with experience
  – Sedation/MAC feasible? Our cardiologists want GA
  – vs Lariat: Must continue anticoagulation
Comparative Effectiveness of Revascularization Strategies

William S. Weintraub, M.D., Maria Y. Grau-Sepulveda, M.D., M.P.H., Jacolyn M. Weiss, Ph.D., M.P.H.,

- Medicare Pts (≥ 65 y/o)
- 2- or 3-vessel CAD without MI
- 86,000 CABG; 104,000 PCI
- Data: CathPCI registry, STS Database
- Median follow-up 2.67 years
- Propensity scores and inverse probability weighting for risk adjustment

Comeback for CABG (vs PCI)?

Weintraub WS, NEJM 2012;366:1467

Components of the SYNTAX Score

SYNTAX Score Implications

The raw SYNTAX score is a good predictor of MACCE

- PCI patients with lower raw SYNTAX scores have similar 12-month MACCE rates to CABG patients
- 12-month MACCE rates in CABG patients are comparable between patients with high or low SYNTAX scores
- Increasing SYNTAX scores (and lesion complexity) are related to increased adverse outcomes in PCI, whereas outcomes of CABG are independent of SYNTAX score

MACCE = Major Adverse Cardiac and Cerebrovascular Event

Diabetics With Multivessel Disease

Farkouh ME, NEJM 2012;367:2375

Prospective, randomized Drug-eluting stents predominantly

Death, MACE, or Stroke (%)
Compelling Evidence for Coronary-Bypass Surgery in Patients with Diabetes

Mark A. Hlatky, M.D. (noninterventional cardiologist)

- Consistent with multiple previous trials, yet PCI continues to grow vs CABG: Why?
- “many cardiologists simply have dismissed the results of earlier randomized studies as outdated...This is a catch-22, since long-term studies are needed...but evidence from long-term studies may be ignored if therapies are evolving.”
- “the comparative effectiveness of CABG and PCI...remains similar whether PCI is performed without stents, with bare-metal stents, or with drug-eluting stents...Mortality has been consistently reduced by CABG...The controversy should finally be settled.”

Will ACOs address issues like CABG vs PCI with objectivity (and teeth)?

Time will tell...
Other countries do

Hlatky MA, NEJM 2012;367:2437

Many PCIs today are ad hoc procedures, performed at the time of diagnostic coronary angiography, with the same physician making the diagnosis, recommending the treatment, and performing the procedure. There is little time for informed discussion about alternative treatment options, either medical therapy on the one hand or CABG on the other. Well-informed patients

Fast-tracking in Cardiac Anesthesia

- Several different approaches and definitions
- Trend toward extubation on OR table?
- Advantages of fast-tracking: depends on definition. If extubation within 6-12 hrs
  - Not a determinant for hospital or ICU LOS unless ICU LOS is defined to exclude a step-down unit
  - Respiratory or cardiac Cx: No convincing data
  - So why extubate in OR? You CAN do it in stable, lower risk Pts

Fast-tracking in Cardiac Anesthesia

If defined as extubation within 6 hours, consider it for
- Off-pump cases, pump times < 120 min, hypothermia minimum temp ≥ 32 °C, no or low-dose inotropes
- Age: Go with “physiologic” age, but if > 75 they should look REALLY good
- Minimal co-morbidity outside CV system (COPD, hepatic, renal, neurologic)

Recent study looking at 3 sufentanil targeted-infusion rates

El Tahan MR, JTCVA 2013;27:63-70
- Valve surgery, 3 groups of 16 Pts each
- Low risk: mean age high 30s, normal LVEF, Mean EuroSCORE low 4’s, mean weight 70 kg, MS>AS>MR=AI>double valve
- Surgical Duration 4-5 hrs, CPB 2 hrs, Crossclamp usually < 1 hr, “standardized hypothermic CPB”
Anesthesia Protocol
El Tahan MR, JTCVA 2013;27:63-70

• TIVA with targeted infusions of sufentanil and propofol - cisatracurium bolus + infusion thru CPB
• Sufentanil target effect-site concentrations @ 0.2, 0.3, and 0.4 ng/mL
  – My (crude) calculation: doses approximately 0.33, 0.50, and 0.55 ug/kg/hr
  – D/C infusion @ sternal closure
• Propofol titrated to state entropy < 50, response entropy minus state entropy < 10
  – Same crude calc: doses approx 140, 82, and 75 ug/kg/min
  – D/C at skin closure

Sufentanil Targeted Infusion Results
El Tahan MR, JTCVA 2013;27:63-70

• No diffs in hemodynamics, rescue vasoactive drugs (underpowered perhaps)
• Eye opening time range 25±8 to 86±10
• Extubation time 112±17 to 271±27
• ND in ICU or hospital LOS (standardized, common in fast-track studies)

Thoughts on El Tahan study

• Higher-risk, older Pts would need lower doses
• Sufentanil and cardiac fast-tracking in US: Probably underutilized
  – Dosing of 0.2-0.4 ug/kg/hr D/C’d at sternal closure is compatible with extubation within 2 hours
• Why not a volatile agent rather than propofol?
• BIS or other CNS monitor rather than entropy should be OK (none if volatile > 0.5 MAC)

CNS Autoregulation: Lower Limit

• Classically thought to be 50 mmHg
• Now recognized as likely higher and quite variable
• Age may increase it, poorly controlled hypertension clearly does, severe CVD regionally does so (Circle of Willis is overrated)
• And yet, CPB has some unique aspects
  – Flow is controlled
  – Hemodilution “left shifts” flow-pressure relationship

Predicting the Limits of Cerebral Autoregulation During Cardiopulmonary Bypass
Briem, Joshi, MD, * Masahiro Ono, MD, † Charles Brown, MD, * Kenneth Brady, MD, † R. Blaine Easley, MD, ‡ Gayane Yenokyan, PhD, ‡ Rebecca F. Gottesman, MD, PhD, † and Charles W. Hogue, MD *

232 CABG or Valve Pts monitored with TCD and NIRS during CPB, LLA using TCD vs MAP relationship: Observational

Demographics:
• Age 66±11, Males 78.9%, Substantial incidence of comorbidity: HTN 67%, Prev MI 31%, and pre-existing Carotid Dz (>50% narrowing) in over 80%

Anesth Analg 2012;114:503-10

TCD/MAP Lower Limit of Autoreg
Joshi B, Anesth Analg 2012;114:503-10

CRASH 2013
Other Findings
Joshi B, Anesth Analg 2012;114:503-10

- Only associations found with LLA were pre-op SBP (if < 160) and avg cbr oximetry index >0.5
- Efforts to construct a Receiver Operant Curve at various MAP decrements from baseline failed to find a “sweet spot” optimizing sensitivity and specificity
- No relationship between stroke and either LLA or time below LLA

Comments about Joshi et al. LLA study
Anesth Analg 2012;114:503-10

Observational: Varying ongoing conditions with possible confounders: [iso],[Hgb],Flow (2-2.4 index), PaCO₂, possibly drugs (vasodilators not recorded), TCD use assumes constant MCA diameter
- Hgb especially concerning: Mgmt not controlled, data not given

- Promising, impact on outcomes unclear
- Emboli vs hypoperfusion as stroke etiology (impacting CBF mgmt “philosophy”)
- Brain as the index organ: Defining LLA based on CNS may miss gut, kidney LLAs

MAP during CPB

- Multiple observational studies are inconclusive
- Appears likely that MAPs should be higher with age > 70, DM, poorly controlled HT, CVD, and severe aortic atherosclerosis
  - How high? Realistically, > 60 mmHg (witness Gold’s experience)