Perioperative Assessment and Management of Cardiovascular Risk in Patients Undergoing Non-Cardiac Surgery

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August 3, 2005
Outline

• Illustrative Case Examples
• Review of Clinical Guidelines and Algorithms pertaining to cases
• The Revascularization Question:
  – What is the evidence and what should we do in 2005?
• Perioperative adjunctive care:
  – ICU management, PA lines
• Perioperative beta blockade and other medical therapy
• Conclusions
Case 1

- 72 year old female
- Asked to consult pre-op Total Hip replacement
- PMHX:
  - CAD: STEMI Inferior MI 1995; NSTEMI 1996
  - Cath: 1996: Single vessel disease: RCA 85%; Rx angioplasty and stenting RCA
  - Type 2 DM: 10 years on oral agents
  - HTN
  - Ex-smoker, quit 1995
Case 1

• Meds:
  – ASA 81 od
  – Atenolol 50 mg od
  – Pioglitazone 4 mg od
  – Amlodipine 10 mg od
  – Atorvastatin 20 mg od

• ALL/ADR: nil
Case 1

- Able to walk for 15-20 minutes on level ground w/o limitation
- Mild exertional dyspnea climbing 2 flights of stairs. NYHA FC II
- No orthopnea or PND
- No anginal symptoms
Case 1

- PX: BP: 145/75, P: 70 reg R: 18/min
- RESP: clear lung fields bilat
- CVS: JVP: 4 cm ASA, S1 soft, S2 normal
  - Grade 3/6 holosystolic apical murmur
  - DP/PT present bilaterally; No peripheral edema
- Nil else contributory
Case 1

- **ECG:**
  - Normal sinus rhythm, Old inferior infarct
  - No acute changes

- **CXR:**
  - No evidence cardiac chamber enlargement or CHF
What further risk stratification testing needs to be done in this case?

What is perioperative risk of major cardiac events (Death, MI, Heart failure)?

What interventions, if any, should be recommended in the perioperative setting?
Answers: Case 1

• Risk Stratification:
  – Obtain 2D echocardiogram to assess severity of mitral regurgitation
    • Moderate 3+/4+ MR
    • Posterobasal and Inferior WMAs:
      – LVEF 45%
  – Operating Room
    • Risk of perioperative cardiac death: 1% (Goldman)
    • Risk of perioperative MI/HF/VT: 3% (Goldman)
  – Perioperative Beta blockade:
    • Target HR 60-70/min
  – ?CVP line to monitor fluid status perioperatively
Case 2

- 61 year old male:
  - Consult preoperatively for elective AAA repair
- PMHX:
    - Cardiac Cath 2001:
      - 70% Cx: stented
      - 85% LAD: stented
      - Non-stenotic disease in RCA
      - LV function: LVEF 40% by echo 2003
        » No significant valvular disease
Case 2

• PMHx (continued):
  – Peripheral vascular disease:
    • ABI 0.60
    • Bilateral claudication at 4 blocks
  – HTN: 10 years
  – Renal Insufficiency: Cr baseline 155
  – Type 2 DM: on oral agents
Case 2

• Meds:
  – ASA 81 mg od
  – Ramipril 10 mg od
  – Bisoprolol 5 mg od
  – HCTZ 25 od
  – Simvastatin 40 mg od

• ALL/ADR: NIL
Case 2

- Limited to 4 blocks on level by claudication
- No exertional dyspnea with stair climbing 1 flight
- No anginal symptoms
- No orthopnea or PND
Case 2

- PX: BP: 125/70 P: 70 reg R: 16 o2 sat: 96% r/a
- RESP: clear
- CVS: JVP: 3 cm ASA, S1, 2 normal. No S3/4
  - No murmurs. Femoral pulse diminished R>L. Faint PT palpable bilaterally.
  - No edema
- Nil else contributory
Case 2

• ECG:
• CXR: Mild LV chamber enlargement. Clear lung zones bilaterally
What further risk stratification needs to be done in this case?

What is perioperative risk of major cardiac events?

What (if any) interventions should be done pre-operatively or perioperatively?
Case 2: Answers

- Risk stratification:
  - Consider non-invasive testing:
    - Dobutamine echocardiography
    - Persantine sestamibi
  - If results are “high risk” ie. 3 vessel CAD:
    - What to do?
- Perioperative Risk (Goldman):
  - Cardiac Death: 1%
  - Perioperative MI/CHF/VT: 3%
- PA line monitoring? ICU care? What is the evidence behind these recommendations?
Case 3

• 59 year old man
• Asked to see pre-operatively for urgent AAA repair
• PMHX:
  – Peripheral vascular disease:
    • Bilateral intermittent claudication at 3 blocks
  – AAA: 6.5 cm
  – CAD: CCS Class III exertional angina, recent onset.
    • High risk exercise sestamibi study:
      – Large reversible defects basal, mid and apical anterior wall and basal, mid inferior wall
Case 3

- PMHx (continued):
  - HTN: 10 years
  - Ex-smoker quit 10 years ago; prior 20 pack year history
  - Hyperlipidemia on therapy
  - Type 2 Diabetes: on oral agents
Case 3

• Meds:
  – ASA 81 od
  – NTG spray 0.4 mg prn
  – Atenolol 100 mg od
  – Amlodipine 10 mg od
  – Ramipril 10 mg od
  – Atorvastatin 40 mg od

• ALL/ADR: Nil
Case 3

- PX: BP: 130/60, P: 60 reg  R: 16  o2 sat 98%
- CV: Diminished PT pulses bilaterally otherwise normal examination
- RESP: clear
- ABD: large palpable AAA in epigastrium
Case 3

- **ECG:**
  - Normal sinus rhythm
  - Non-specific ST-T changes anterolaterally and inferiorly

- **CXR:**
  - Normal
What further investigations should be ordered pre-operatively?

What is the benefit (if any) to pre-operative revascularization?

What other interventions (if any) should be used perioperatively?
Case 3: Answers

- Risk stratification:
  - *Done! HIGH RISK*

- Delay surgery until coronaries and LV function fully assessed

- Do we proceed with revascularization pre-operatively?

- ICU Care post op +/- PA line monitoring?

- Perioperative beta blockade
Review of ACC Clinical Guidelines
## Clinical Predictors

### Major
- Unstable coronary syndromes
  - Recent myocardial infarction* with evidence of important ischemic risk by clinical symptoms or noninvasive study
  - Unstable or severe† angina (Canadian class III or IV)†
- Decompensated congestive heart failure
- Significant arrhythmias
  - High-grade atrioventricular block
  - Symptomatic ventricular arrhythmias in the presence of underlying heart disease
  - Supraventricular arrhythmias with uncontrolled ventricular rate
- Severe valvular disease

### Intermediate
- Mild angina pectoris (Canadian class I or II)
- Prior myocardial infarction by history or pathological Q waves
- Compensated or prior congestive heart failure
- Diabetes mellitus
- Chronic renal insufficiency

### Minor
- Advanced age
- Abnormal electrocardiogram (left ventricular hypertrophy, left bundle branch block, ST-T abnormalities)
- Rhythm other than sinus (e.g., atrial fibrillation)
- Low functional capacity (e.g., inability to climb one flight of stairs with a bag of groceries)
- History of stroke
- Uncontrolled systemic hypertension
# Cardiac Risk Stratified by Procedure

<table>
<thead>
<tr>
<th>High (Reported Cardiac Risk Often &gt;5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent major operations, particularly in elderly people</td>
</tr>
<tr>
<td>Aortic and other major vascular</td>
</tr>
<tr>
<td>Peripheral vascular</td>
</tr>
<tr>
<td>Anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intermediate (Reported Cardiac Risk Generally &lt;5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carotid endarterectomy</td>
</tr>
<tr>
<td>Head and neck</td>
</tr>
<tr>
<td>Intraperitoneal and intrathoracic</td>
</tr>
<tr>
<td>Orthopedic</td>
</tr>
<tr>
<td>Prostate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low† (Reported Cardiac Risk Generally &lt;1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endoscopic procedures</td>
</tr>
<tr>
<td>Superficial procedure</td>
</tr>
<tr>
<td>Cataract</td>
</tr>
<tr>
<td>Breast</td>
</tr>
</tbody>
</table>

*Combined incidence of cardiac death and nonfatal myocardial infarction.
†Do not generally require further preoperative cardiac testing.

ACC Guidelines Step 6 and 8

Step 6
- Clinical predictors
  - Functional capacity
    - Poor (< 4 METs)
    - Moderate or excellent (> 4 METs)
      - High surgical risk procedure
      - Intermediate surgical risk procedure
      - Low surgical risk procedure

Step 8
- Noninvasive testing
  - Low risk
    - Operating room
      - Postoperative risk stratification and risk factor reduction

- Invasive testing
  - Consider coronary angiography
    - Subsequent care* dictated by findings and treatment results

Intermediate clinical predictors
- Mild angina pectoris
- Prior MI
- Compensated or prior CHF
- Diabetes mellitus
- Renal insufficiency

Braunwald Heart Disease 7th edition
ACC Guidelines: Steps 7 and 8

Step 7
- Clinical predictors
  - Functional capacity
  - Surgical risk

Step 8
- Noninvasive testing
  - High risk
    - Consider coronary angiography
  - Low risk
    - Operating room
      - Postoperative risk stratification and risk factor reduction

Minor clinical predictors
- Advanced age
- Abnormal ECG
- Rhythm other than sinus
- Low functional capacity
- History of stroke
- Uncontrolled systemic hypertension

Subsequent care* dictated by findings and treatment results
A Word on Functional Capacity

Reilly et al. 1999:

- Outpatients referred for non-cardiac surgery
- Self-reported exercise tolerance:
  - Estimate number of blocks walked or stairs climbed without development of cardiac symptoms
  - Less than 4 blocks or less than 2 flights:
    - Doubled amount of perioperative complications
Post Operative Intensive Care

• Patients cared for in ICU’s staffed by dedicated intensivists have improved outcomes:
  • “High intensity” staffing associated with:
    – lower in-hospital mortality (RR=0.71)
    – Lower ICU mortality (RR=0.61)
    – Shorter length of stay in both ICU and hospital
Post Operative Pain Management

- Post operative tachycardia and catecholamine surges → myocardial ischemia or coronary plaque rupture
- Post operative pain associated with tachycardia and increased catecholamines
- Effective postoperative analgesia may reduce cardiac complications: NO RCT’s available
- May also MASK cardiac complications by increasing angina threshold
Surveillance and Implications of Perioperative Cardiac Complications

- Detecting perioperative MI: troponin T and I
  - Troponin I: specificity 99%
  - CK MB: specificity 81%
- Lee et al. 1996:
  - 1175 pts undergoing non-cardiac surgery
  - Troponin T:
    - 99% specific for MI and better predicts major cardiac complications post-operatively
Surveillance and Implications of Perioperative Cardiac Complications

• Post-op MI:
  – Timing:
    • Data using TnI suggests most periop. MI’s occur days 1 or 2 (Badner et al. 1998)
  – Mortality:
    • 1980’s: 30-50% short term/in hospital
    • 1990’s-2000’s: Less than 20%
      – ?reflective of increased sensitivity to detect smaller NSTEMIs or better Rx
Surveillance and Implications of Perioperative Cardiac Complications

• Post-op MI:
  – Long-term outcomes:
    • Lope-Jimenez et al. 1997:
      – Abnormal CTnT associated with increased incidence CV complications within 6 months of surgery.
    • Kim et al. 2002: TnI in 229 vascular pts
      – 6 month follow-up
        » 6 fold increase in mortality
        » 27 fold increase in future MI
Strategies to Reduce Perioperative Cardiac Risk in Non-Cardiac Surgery
CABG

- CASS registry: (Retrospective)
  - Operative mortality of patients with prior CABG = 0.9%
  - Without prior CABG = 2.4% (2.3 fold inc. risk)
  - 1.4% mortality of CABG procedure
CABG

• Eagle et. al. 1997:
  – Retrospective review of 3368 non-cardiac surgical procedures on pts in CASS registry
  – Medical treatment of CAD compared with CABG over >10 year follow-up period
  – Rate of MI and death stratified by type of surgical procedure:
    • Low risk= skin, breast, urological or minor orthopedic procedures
      – MI and death less than 1%
      – unaffected by revascularization
CABG

• Eagle et. al. 1997 (condt)
  – Intermediate risk: abdominal, thoracic, or carotid endarterectomy
    • Combined morbidity/mortality: 1-5%
      – Small, but significant improvement in outcomes in pts with prior CABG
  – High Risk: Major vascular surgery
    • Mortality reduced by 2/3 in pts with prior CABG
CABG and PCI

  - Randomized controlled clinical trial of 510 patients undergoing either AAA repair or peripheral vascular surgery on elective basis
  - Revascularization arm:
    - 59% PCI; 41% CABG
    - Median time from randomization to vascular surgery: 54 days (vs. 18 days)
  - Primary Outcome:
    - Long term mortality, 2.7 years follow-up
  - Secondary Outcomes:
    - MI, stroke, limb loss, and need for dialysis
Long-Term Survival among Patients Assigned to Undergo Coronary-Artery Revascularization or No Coronary-Artery Revascularization before Elective Major Vascular Surgery

Influence of Coronary-Artery Revascularization on Long-Term Survival among High-Risk Subgroups of Patients Scheduled for Vascular Surgery

<table>
<thead>
<tr>
<th>High-Risk Variable</th>
<th>Patients (N=510)</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angina</td>
<td>198 (38.8)</td>
<td>1.45 (0.79–2.64)</td>
<td>0.23</td>
</tr>
<tr>
<td>Positive stress imaging test†</td>
<td>226 (44.3)</td>
<td>1.26 (0.77–2.06)</td>
<td>0.35</td>
</tr>
<tr>
<td>Fulfillment of criteria of Eagle and colleagues‡</td>
<td>142 (27.8)</td>
<td>0.90 (0.51–1.62)</td>
<td>0.73</td>
</tr>
<tr>
<td>With large stress-induced defect</td>
<td>37 (7.3)</td>
<td>3.96 (0.82–19.11)</td>
<td>0.09</td>
</tr>
<tr>
<td>Category of revised Cardiac Risk Index§</td>
<td>248 (48.6)</td>
<td>1.20 (0.76–1.89)</td>
<td>0.44</td>
</tr>
<tr>
<td>With large stress-induced defect</td>
<td>50 (9.8)</td>
<td>1.65 (0.64–4.25)</td>
<td>0.30</td>
</tr>
<tr>
<td>Prior CABG</td>
<td>77 (15.1)</td>
<td>1.81 (0.81–4.05)</td>
<td>0.15</td>
</tr>
<tr>
<td>Three-vessel disease and left ventricular dysfunction</td>
<td>74 (14.5)</td>
<td>1.29 (0.62–2.65)</td>
<td>0.50</td>
</tr>
<tr>
<td>Pain at rest and tissue breakdown</td>
<td>152 (29.8)</td>
<td>0.76 (0.43–1.34)</td>
<td>0.34</td>
</tr>
</tbody>
</table>

McFalls, E. O. et al.  
N Engl J Med 2004
CARP Study: Conclusion:

“…amongst patients with stable coronary artery disease revascularization does not improve survival.”
Long-Term Use of Medical Therapy in the Revascularization and No-Revascularization Groups at 24 Months after Randomization

• Hassan et al. 2001:
  – Effects of multivessel angioplasty on subsequent non-cardiac surgery in BARI cohort
    • 501 patients underwent NCS median 29 months after most recent revascularization
    • Mortality same (1.6%) in PCI vs. CABG
• Kaluza et al. 2000:
  – 40 patients undergoing PCI prophylactically 6 weeks prior to NCS
  – 7 MIs, 11 major bleeding episodes, and 8 deaths
  – All deaths and MIs plus 8/11 bleeding episodes occurred in patients who had surgery within 14 days of stenting
PCI

- Wilson et. al (2003):
  - 207 patients who underwent NCS within 2 months of stent placement
  - 8 patients (3.9%) died or had MI (ALL in cohort that had surgery within 6 weeks of stenting)
  - No events in patients who underwent PCI/stenting 7-9 weeks prior to surgery
**Recommendations: PCI and CABG**

- No revascularization indicated if patients have stable symptoms and no prognostically significant disease at cardiac catheterization.
- If PCI/stenting performed, optimally delay non-cardiac surgery for 6 weeks to avoid stent-related complications.
- PCI alone (without stenting) if non-cardiac surgery is urgent.
Pharmacologic Interventions: Beta Blockers

- Mangano et al. NEJM 1996
  - 200 patients undergoing high risk NCS
  - Atenolol vs. placebo on AM of surgery and continued for 7 days post-operatively
  - Reduction in perioperative ischemia but not MI
  - Improvement in survival at 6 months in atenolol group which persisted for 2 years
Overall Survival in the Two Years after Noncardiac Surgery among 192 Patients in the Atenolol and Placebo Groups Who Survived to Hospital Discharge

Beta Blockers

- Poldermans et al. NEJM 1999
  - Bisoprolol vs placebo initiated 7 days pre-operatively, titrated to resting HR < 60/min, and continued for 30 days
  - Elective major vascular surgery with one clinical marker of cardiac risk and inducible ischemia on dobutamine stress echocardiography
  - Bisoprolol reduced perioperative MI by 80%
Kaplan-Meier Estimates of the Cumulative Percentages of Patients Who Died of Cardiac Causes or Had a Nonfatal Myocardial Infarction during the Perioperative Period

No. At Risk

<table>
<thead>
<tr>
<th></th>
<th>Standard care</th>
<th>Bisoprolol</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. At Risk</td>
<td>53</td>
<td>59</td>
</tr>
<tr>
<td>Days after Surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>53</td>
<td>59</td>
</tr>
<tr>
<td>7</td>
<td>38</td>
<td>58</td>
</tr>
<tr>
<td>14</td>
<td>37</td>
<td>57</td>
</tr>
<tr>
<td>21</td>
<td>37</td>
<td>57</td>
</tr>
<tr>
<td>28</td>
<td>35</td>
<td>57</td>
</tr>
</tbody>
</table>

P < 0.001
Mean Heart Rates of Randomized Patients at Base Line and One, Three, and Seven Days Postoperatively

<table>
<thead>
<tr>
<th>TIME OF MEASUREMENT</th>
<th>BISOPROLOL GROUP (N=59)</th>
<th>STANDARD-CARE GROUP (N=53)</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>beats/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean</td>
<td>66</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>58–78</td>
<td>72–82</td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean</td>
<td>71</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>62–80</td>
<td>76–88</td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean</td>
<td>71</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>65–80</td>
<td>76–88</td>
<td></td>
</tr>
<tr>
<td>Day 7</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean</td>
<td>69</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>63–74</td>
<td>69–82</td>
<td></td>
</tr>
</tbody>
</table>

*The mean heart rate was measured in the morning before the next dose of beta-blocker was administered.*
**Beta Blockers: Who Benefits?**

Determine Risk Score
Assign 1 point for each of the following characteristics:
- age ≥ 70 years
- current angina
- prior myocardial infarction
- congestive heart failure
- prior cerebrovascular event
- diabetes mellitus
- and renal failure.

Score = 0 (28%)
0 < score < 3 (55%)
Score ≥ 3 (17%)

Dobutamine stress echocardiography (DSE)

- No new wall-motion abnormalities (11%)
- New wall-motion abnormalities in 1-4 segments (4%)
- New wall-motion abnormalities in ≥ 5 segments (2%)

Cardiac complications (%)

<table>
<thead>
<tr>
<th>Score</th>
<th>Non-β-blocker user</th>
<th>β-blocker user</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td>0.9</td>
<td>3.0</td>
<td>0.9</td>
</tr>
<tr>
<td>2.0</td>
<td>5.8</td>
<td>2.0</td>
</tr>
<tr>
<td>2.8</td>
<td>33</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Pharmacologic Interventions: Others

- Alpha agonists
  - Meta-analysis of perioperative clonidine
  - Underpowered to show reduction in cardiac morbidity
- Nitroglycerin:
  - May reduce ischemia but not consistent effect in all studies
  - No evidence for reduced clinical endpoints
Non-Pharmacological Interventions: Temperature

• Frank and colleagues:
  – 300 high risk patients undergoing vascular surgery
    • Randomized to normothermia vs. usual care
  – Normothermia reduced incidence of perioperative cardiac morbidity and mortality within 24 hours of surgery
Perioperative Monitoring

• ST segment monitoring:
  – No completed studies on efficacy

• TEE monitoring:
  – Better sensitivity for detecting intraoperative ischemia compared to ECG
  – Can assess wall motion and volume status continuously
  – No large database to show either clear benefit or risk

• Pulmonary Artery (PA) catheters:
  – Sandham et. al. NEJM 2003
  – High risk elective or urgent major NCS
  – 1994 patient randomized to goal-directed therapy with PA catheter vs. standard care without PA catheter
Kaplan-Meier Survival Curves to One Year

<table>
<thead>
<tr>
<th>Months</th>
<th>Standard care</th>
<th>Pulmonary-artery catheter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>997</td>
<td>997</td>
</tr>
<tr>
<td>2</td>
<td>885</td>
<td>842</td>
</tr>
<tr>
<td>4</td>
<td>861</td>
<td>826</td>
</tr>
<tr>
<td>6</td>
<td>844</td>
<td>808</td>
</tr>
<tr>
<td>8</td>
<td>803</td>
<td>773</td>
</tr>
<tr>
<td>10</td>
<td>794</td>
<td>761</td>
</tr>
<tr>
<td>12</td>
<td>786</td>
<td>747</td>
</tr>
</tbody>
</table>

Proportion Surviving

Perioperative Morbidity and Mortality

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard-Care Group</th>
<th>Catheter Group</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay — days</td>
<td>Median</td>
<td>10</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Interquartile range</td>
<td>7–15</td>
<td></td>
</tr>
<tr>
<td>In-hospital mortality — no. (%)</td>
<td>77 (7.7)</td>
<td>78 (7.8)</td>
<td>0.93</td>
</tr>
<tr>
<td>Myocardial infarction — no. (%)</td>
<td>33 (3.4)</td>
<td>40 (4.3)</td>
<td>0.41</td>
</tr>
<tr>
<td>Congestive heart failure — no. (%)</td>
<td>108 (11.2)</td>
<td>119 (12.6)</td>
<td>0.36</td>
</tr>
<tr>
<td>Supraventricular tachycardia — no. (%)</td>
<td>88 (9.1)</td>
<td>84 (8.9)</td>
<td>0.95</td>
</tr>
<tr>
<td>Ventricular tachycardia — no. (%)</td>
<td>2 (0.2)</td>
<td>2 (0.2)</td>
<td>1.00</td>
</tr>
<tr>
<td>Pulmonary embolism — no. (%)</td>
<td>0</td>
<td>8 (0.9)</td>
<td>0.004</td>
</tr>
<tr>
<td>Renal insufficiency — no. (%)</td>
<td>95 (9.8)</td>
<td>70 (7.4)</td>
<td>0.07</td>
</tr>
<tr>
<td>Hepatic insufficiency — no. (%)</td>
<td>26 (2.7)</td>
<td>23 (2.4)</td>
<td>0.84</td>
</tr>
<tr>
<td>Sepsis from central venous catheter or pulmonary-artery catheter — no. (%)</td>
<td>13 (1.3)</td>
<td>12 (1.3)</td>
<td>0.95</td>
</tr>
<tr>
<td>Wound infection — no. (%)</td>
<td>83 (8.6)</td>
<td>66 (7.0)</td>
<td>0.23</td>
</tr>
<tr>
<td>Pneumonia — no. (%)</td>
<td>70 (7.3)</td>
<td>63 (6.7)</td>
<td>0.70</td>
</tr>
<tr>
<td>Adverse events due to pulmonary-artery catheters or central venous catheters — no. (%)</td>
<td>0</td>
<td>1 (0.1)</td>
<td>1.00</td>
</tr>
<tr>
<td>Pulmonary infarction</td>
<td>0</td>
<td>1 (0.1)</td>
<td>1.00</td>
</tr>
<tr>
<td>Hemothorax</td>
<td>0</td>
<td>2 (0.2)</td>
<td>0.24</td>
</tr>
<tr>
<td>Pulmonary hemorrhage</td>
<td>0</td>
<td>3 (0.3)</td>
<td>0.12</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>4 (0.4)</td>
<td>8 (0.9)</td>
<td>0.36</td>
</tr>
<tr>
<td>Arterial puncture</td>
<td>1 (0.1)</td>
<td>3 (0.3)</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Sandham et al.
NEJM 2003
Transfusion Threshold

- No RCTs to evaluate optimal threshold
- Small cohort studies:
  - Hematocrit range 27-29% may be important threshold to reduce ischemia
Conclusions

- Establish urgency and classify risk of procedure
- Assess clinical predictors by history and physical examination
- Precisely assess functional capacity to guide investigative approach
- Judiciously use non-invasive and invasive testing
Conclusions

• No current evidence for “prophylactic” revascularization
• ICU care likely effective in high risk surgery
• No current evidence for PA line monitoring to improve outcomes
• Beta blockers likely effective in high risk patients to reduce events
<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary artery disease</td>
<td></td>
</tr>
<tr>
<td>Myocardial infarction &lt;6 months earlier</td>
<td>10</td>
</tr>
<tr>
<td>Myocardial infarction &gt;6 months earlier</td>
<td>5</td>
</tr>
<tr>
<td>Canadian Cardiovascular Society angina classification</td>
<td></td>
</tr>
<tr>
<td>Class III</td>
<td>10</td>
</tr>
<tr>
<td>Class IV</td>
<td>20</td>
</tr>
<tr>
<td>Alveolar pulmonary edema</td>
<td></td>
</tr>
<tr>
<td>Within 1 week</td>
<td>10</td>
</tr>
<tr>
<td>Ever</td>
<td>5</td>
</tr>
<tr>
<td>Suspected critical aortic stenosis</td>
<td>20</td>
</tr>
</tbody>
</table>
Detsky Revised Cardiac Risk Index

• Risk Levels:
  – High: >15%
  – Intermediate: >3 but <15%
  – Low: <3%
Classes of Risk: Detsky (Death, Major Complications)

- Class I (0-5 pts): 1.3%
- Class II (6-12 pts): 4.7%
- Class III (13-25 pts): 15%
- Class IV (>25 pts): 56%
Goldman Revised Cardiac Risk Index: 6 Factors

- High Risk Type of Surgery (Suprainguinal vascular, intraperitoneal, intrathoracic)
- History of ischemic heart disease
- History of heart failure
- History of cerebrovascular disease
- History of pre-operative treatment with insulin
- Pre-operative serum creatinine > 177
Revised Cardiac Risk Index Score and Risk of Major Complications (%)

- Score:
  - 0 .................................. 0.4%
  - 1 ................................. 0.9%
  - 2 ................................. 7%
  - 3 or more ...................... 11%
Detsky Revised Cardiac Risk Index-2

Arrhythmias

- Rhythm other than sinus or sinus plus atrial
  premature beats on electrocardiogram  5
- >5 premature ventricular contractions on electrocardiogram  5

Poor general medical status, defined as any of the following:

- PO$_2$ <60 mm Hg, PCO$_2$ >50 mm Hg, K$^+$ level <3 mmol/L,  5
- blood urea nitrogen level >50 mmol/L, creatinine level >260  
  µmol/L, bedridden

- Age >70 years  5

- Emergency surgery  5