Preoperative Cardiac Evaluation

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Goals

- Patient and procedure-related risk factors
- Revised cardiac risk index (RCRI)
- NSQIP surgical risk calculator
- Updated 2014 AHA/ACC guideline
- Role for perioperative beta-blockers?
- Role of perioperative statins
- Disappointing results for perioperative ASA
- Preoperative revascularization
- Postop biomarker surveillance
Approach to Cardiac Risk Stratification

• Low risk
  – No further evaluation required

• High risk
  – Employ risk reduction strategies
  – No benefit from further evaluation
  – Negative test results likely to be false negative

• Intermediate risk
  – Most likely to benefit from additional testing to stratify risk
Patient-Related Risk Factors

- Coronary artery disease
- Recent MI
- Congestive heart failure
- Cerebrovascular disease
- Renal insufficiency
- Diabetes mellitus
- Advanced age
- Poor functional capacity
- Aortic stenosis
Coronary Artery Disease

- Any evidence of CAD confers risk
  - Any previous MI
  - MI within past 6 months particularly high risk
  - Q waves on ECG
  - Positive ETT
  - Symptoms consistent with angina
Patient-Related Risk Factors

• Congestive heart failure:
  – Any prior h/o CHF
  – Physical examination c/w CHF including rales, S3, or jugular venous distension
  – Chest x-ray findings c/w CHF

• Cerebrovascular disease
  – Any prior h/o stroke or TIA
  – Asymptomatic bruit does not clearly increase risk
Patient-Related Risk Factors

- Renal insufficiency
  - Relative risk even greater (3.0) than for known CAD (2.4)
  - Creatinine > 2.0 mg/dl
- Diabetes
  - Risk only for insulin treated patients
Impact of Age on Perioperative Risk

• Minor predictor for cardiac complications after controlling for comorbidities more common with age
• Does not appear in commonly used tools to predict cardiac complications (RCRI, ACC/AHA, etc)
• In contrast:
  – VTE risk increases with age
  – One of the most important patient-related risk factors for postop pulmonary complications
• Therefore: Consider age when evaluating overall medical risk of surgery, but not when predicting risk for cardiac complications
Procedure-Related Risk Factors

- High risk surgery (relative risk 2.8)
  - Abdominal surgery
  - Chest surgery
  - Major intra-abdominal vascular surgery
- Emergency surgery
- General anesthesia
- Prolonged surgery
Revised Cardiac Risk Index

- 4315 patients aged > 50 years
- Derivation and validation cohorts
- Nonemergent, noncardiac surgery
- High risk surgery = aortic, intraperitoneal, intrathoracic
- Outperformed previous indices including original Goldman index, Detsky index and ASA class
- Limitation: Unable to stratify risk for patients undergoing AAA repair

Circulation 1999;100:1043
## Revised Cardiac Risk Index: Significant Factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Adjusted OR (derivation cohort)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High-risk surgery</td>
<td>2.8</td>
</tr>
<tr>
<td>2. Ischemic heart disease</td>
<td>2.4</td>
</tr>
<tr>
<td>3. History of CHF</td>
<td>1.9</td>
</tr>
<tr>
<td>4. Cerebrovascular disease</td>
<td>3.2</td>
</tr>
<tr>
<td>5. Insulin treated diabetes</td>
<td>3.0</td>
</tr>
<tr>
<td>6. Creatinine &gt; 2.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Event Rates Stratified by RCRI Class: RCRI Predicts Risk

Event Rate (%)

<table>
<thead>
<tr>
<th>Class</th>
<th># Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>3-6</td>
</tr>
</tbody>
</table>

Class 1: Factors
Class 2: 1 Factor
Class 3: 2 Factors
Class 4: 3-6 Factors
Universal ACS NSQIP Surgical Risk Calculator: A Decision Aid

- Patient level data from 393 NSQIP hospitals
- N=1.4 million patients
- Evaluated risk factors for 30 day postop outcomes
- Risk factors based on prespecified NSQIP variables
- Developed risk predictor calculators for mortality, overall morbidity, and 6 specific outcomes
- Option for surgeon adjustment of risk

J Am Coll Cardiol 2013;217:833
Surgical Risk Calculator

Enter Patient and Surgical Information

Procedure

Are there other potential appropriate treatment options?  
- Other Surgical Options
- Other Non-operative options
- None

Age Group  Under 65 years
Sex  Female
Functional status  Independent
Emergency case  No
ASA class  I - Healthy patient
Wound class  Clean
Steroid use for chronic condition  No
Ascites within 30 days prior to surgery  No
Systemic sepsis within 48 hours prior to surgery  None
Ventilator dependent  No
Disseminated cancer  No
Diabetes  None
Hypertension requiring medication  No
Previous cardiac event  No
Congestive heart failure in 30 days prior to surgery  No
Dyspnea  None
Current smoker within 1 year  No
History of severe COPD  No
Dialysis  No
Acute Renal Failure  No
BMI Calculation
- Height (in)
- Weight (lbs)

Please enter as much of the following information as you can to receive the best risk estimates. A rough estimate will still be generated if you cannot provide all of the information below.

http://riskcalculator.facs.org
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Estimated Risk</th>
<th>Chance of Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>1%</td>
<td>Above Average</td>
</tr>
<tr>
<td>Serious Complication</td>
<td>10%</td>
<td>Below Average</td>
</tr>
<tr>
<td>Any Complication</td>
<td>19%</td>
<td>Above Average</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>2%</td>
<td>Average</td>
</tr>
<tr>
<td>Cardiac Complication</td>
<td>1%</td>
<td>Above Average</td>
</tr>
<tr>
<td>Surgical Site Infection</td>
<td>10%</td>
<td>Above Average</td>
</tr>
<tr>
<td>Urinary Tract Infection</td>
<td>2%</td>
<td>Above Average</td>
</tr>
<tr>
<td>Venous Thromboembolism</td>
<td>1%</td>
<td>Below Average</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>1%</td>
<td>Above Average</td>
</tr>
<tr>
<td>Return to OR</td>
<td>4%</td>
<td>Average</td>
</tr>
</tbody>
</table>

**Predicted Length of Hospital Stay:** 3.0 days
ACC/AHA 2014: First Consider High and Low Risk Scenarios

1. Emergency surgery?
   - Yes: Proceed to OR
   - No

2. Acute coronary Syndrome?
   - Yes: Rx as per Guidelines
   - No

3. Estimate risk based on patient and surgical risks
   - Yes: Proceed to OR
   - No or Unknown – to Step 6

4. Low Risk
   - Yes: Proceed to OR
   - No or Unknown – to Step 6

5. Elevated Risk
   - Yes: Proceed to OR
   - No or Unknown – to Step 6

Moderate or greater functional capacity ≥ 4 METs?
ACC/AHA Functional Capacity

Good = ≥ 4 METs

**Functional Capacity**

1 MET
- Can you... Take care of yourself? Eat, dress, or use the toilet?
- Walk indoors around the house?
- Walk 100 m on level ground at 3 to 5 km per h?

4 METs
- Can you...
  - Climb two flights of stairs or walk uphill?
  - Run a short distance?
  - Do heavy work around the house like scrubbing floors or lifting or moving heavy furniture?
  - Participate in strenuous sports like swimming, singles tennis, football, basketball, or skiing?

4 METs

Greater than 10 METs
Step 6: Poor (< 4 METs) or Unknown Functional Capacity

Will further testing impact decision making or care?

Yes

Pharmacologic stress test

Abnormal

Revascularize as per guidelines

Normal

No

Proceed to surgery or alternative lower risk Rx or palliation
ACC/AHA: Other Recommendations

• To estimate risk of MACE (step 3), either
  – RCRI
  – NSQIP surgical risk calculator

• Consider echo if unexplained dyspnea

• Noninvasive testing, either:
  – Dobutamine echo
  – Pharmacologic myocardial perfusion

• Clinically significant valvular disease:
  – Echo if none in past year
  – Intervention based on standard indications

• Choice of anesthetic agent does not impact MACE risk
Patient Level Meta-Analysis: Preop BNP Levels to Predict MACE After Vascular Surgery

Unadjusted ORs for a Preop BNP Above the Optimal Cut Point (116 pg/ml)

<table>
<thead>
<tr>
<th>Study</th>
<th>BNP above cut point</th>
<th>BNP below cut point</th>
<th>OR (random) 95%CI</th>
<th>Weight %</th>
<th>OR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibson</td>
<td>22/33</td>
<td>2/96</td>
<td></td>
<td>20.40</td>
<td>94.0 (19.43, 454.78)</td>
</tr>
<tr>
<td>Cuthbertson</td>
<td>2/57</td>
<td>0/13</td>
<td></td>
<td>10.14</td>
<td>1.22 (0.06, 26.84)</td>
</tr>
<tr>
<td>Mahla</td>
<td>14/85</td>
<td>5/133</td>
<td></td>
<td>25.31</td>
<td>5.05 (1.75, 14.59)</td>
</tr>
<tr>
<td>Bolliger</td>
<td>2/38</td>
<td>2/95</td>
<td></td>
<td>16.79</td>
<td>2.58 (0.35, 19.04)</td>
</tr>
<tr>
<td>Biccard</td>
<td>13/53</td>
<td>13/244</td>
<td></td>
<td>27.36</td>
<td>5.78 (2.50, 13.36)</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>266</td>
<td>581</td>
<td></td>
<td>100.00</td>
<td>7.36 (2.23, 24.31)</td>
</tr>
</tbody>
</table>

Total events: 53 (BNP above cut point) 22 (BNP below cut point)
Test for heterogeneity, Chi²=13.37, df=4 (P=0.001), I²=70.1 %
Test for overall effect: Z=3.27 (P=0.001)
POISE: Perioperative Beta Blockers

- 8351 patients > 45 y.o.
- Expected stay of > 1 day
- **At least one of:**
  - CAD
  - PVD
  - Stroke
  - CHF admit within < 3 yrs
  - Major vascular surgery

- **OR at least 3 of:**
  - High risk surgery
  - CHF
  - DM on meds
  - Creat > 2.0
  - Age > 70
  - H/o TIA
  - Urgent surgery

Metoprolol XL 100 mg vs placebo
2-4 hrs before surgery and 6 hrs after surgery
Metoprolol XL 200 mg qd vs placebo for 30 days after surgery
POISE: Higher Mortality and Stroke Rates with Fixed High Dose Metoprolol

Lancet 2008;371:1839
Does Beta Blocker Choice Matter? Strongest Evidence for Bisoprolol

Eur Heart J 2009;30:2769
ACC/AHA: Key Findings from Literature

1. Preoperative beta blockers reduce cardiac events
2. Benefit on mortality unproven
3. Beta blockers increase risk for stroke
4. Beta blockers increase potential for bradycardia
5. If started < 1 day before surgery, increased stroke, death, hypotension
6. Findings hold true even if exclude DECREASE or POISE trials
## ACC/AHA 2014 Beta Blocker Recommendations

<table>
<thead>
<tr>
<th>Class</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (recommend)</td>
<td>Continue if taking chronically</td>
</tr>
<tr>
<td>IIa (reasonable)</td>
<td>Use after surgery guided by clinical circumstances</td>
</tr>
<tr>
<td>IIb (consider)</td>
<td>Positive preop noninvasive test (at least moderate ischemia)</td>
</tr>
<tr>
<td></td>
<td>(\geq 3) RCRI risk factors (of 6 total)</td>
</tr>
<tr>
<td></td>
<td>Begin long enough before surgery to assess safety, preferably at least 1 day before surgery</td>
</tr>
</tbody>
</table>

Circulation 2014 Aug (epub ahead of press)
Do Statins Decrease Risk? Meta-Analysis of 15 Cohort Studies: Perioperative Death or Acute Coronary Syndrome

Pooled OR 0.70 (0.57-0.87)

Favors Treatment

Favors Control
### Cohort Studies: Perioperative Death

<table>
<thead>
<tr>
<th>Statins</th>
<th>No statistics</th>
<th>Odds ratio (random) (95% CI)</th>
<th>Weight (%)</th>
<th>Odds ratio (random) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/640</td>
<td>26/756</td>
<td>0.58 (0.48 to 0.72)</td>
<td>7.31</td>
<td>0.54 (0.27 to 1.07)</td>
</tr>
<tr>
<td>1/62</td>
<td>6/440</td>
<td>1.19 (0.14 to 10.02)</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>2/94</td>
<td>3/95</td>
<td>0.67 (0.11 to 4.08)</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>0/31</td>
<td>2/100</td>
<td>0.69 (0.66 to 0.73)</td>
<td>42.08</td>
<td></td>
</tr>
<tr>
<td>7/1480</td>
<td>21/1803</td>
<td>0.63 (0.03 to 13.37)</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>2/657</td>
<td>19/909</td>
<td>0.40 (0.17 to 0.95)</td>
<td>5.08</td>
<td></td>
</tr>
<tr>
<td>6/526</td>
<td>5/367</td>
<td>0.14 (0.03 to 0.62)</td>
<td>1.69</td>
<td></td>
</tr>
<tr>
<td>5/226</td>
<td>30/755</td>
<td>0.44 (0.44 to 4.81)</td>
<td>2.77</td>
<td></td>
</tr>
<tr>
<td>2/72</td>
<td>9/374</td>
<td>0.21 (0.14 to 0.43)</td>
<td>4.15</td>
<td></td>
</tr>
<tr>
<td>80,870</td>
<td>709,378</td>
<td>0.55 (0.25 to 5.48)</td>
<td>1.68</td>
<td>1.16 (0.25 to 5.48)</td>
</tr>
</tbody>
</table>

**Pooled OR 0.58 (0.48-0.72)**

- **Favors Treatment**
- **Favors Control**
Perioperative Statins: Conclusions

- Statins probably reduce perioperative CV morbidity and mortality
- Effect may be due to anti-inflammatory effect but mechanism speculative
- Optimal dose, agent, and duration unknown
- Early d/c of statins after surgery increases risk
- AHA/ACC 2014:
  - Continue if taking chronically
  - Reasonable (IIa) in vascular surgery
  - Begin (IIb) if standard clinical indications and planning elevated risk surgery
POISE-2: Does Perioperative ASA Reduce CV Risk?

- N=10,010 patients, noncardiac surgery
- Aspirin 200 mg qd vs. placebo
- First dose immediately before surgery
- Rx for 30 days if new start for ASA
- Rx for 7 days if already on ASA, then resume usual dose
- Outcome = composite of death or nonfatal MI at 30 days
- More major bleeding in ASA group: 4.6% vs. 3.8%

Aspirin Does Not Reduce Composite CV Outcome

Hazard ratio, 0.99 (95% CI, 0.86–1.15); P=0.92

No. at Risk

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>Aspirin</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5012</td>
<td>4998</td>
</tr>
<tr>
<td>5</td>
<td>4724</td>
<td>4713</td>
</tr>
<tr>
<td>10</td>
<td>4696</td>
<td>4678</td>
</tr>
<tr>
<td>15</td>
<td>4680</td>
<td>4665</td>
</tr>
<tr>
<td>20</td>
<td>4669</td>
<td>4660</td>
</tr>
<tr>
<td>25</td>
<td>4662</td>
<td>4653</td>
</tr>
<tr>
<td>30</td>
<td>4652</td>
<td>4643</td>
</tr>
</tbody>
</table>
Subgroup Analysis: No Benefit from Aspirin in Any Subgroup

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value for Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.99 (0.86–1.15)</td>
<td>0.96</td>
</tr>
<tr>
<td>Aspirin strata</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiation stratum</td>
<td>0.99 (0.81–1.21)</td>
<td></td>
</tr>
<tr>
<td>Continuation stratum</td>
<td>1.00 (0.81–1.23)</td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td>Nonvascular</td>
<td>0.95 (0.81–1.11)</td>
<td></td>
</tr>
<tr>
<td>Vascular</td>
<td>1.31 (0.84–2.02)</td>
<td></td>
</tr>
<tr>
<td>Revised Cardiac Risk Index</td>
<td></td>
<td>0.89</td>
</tr>
<tr>
<td>0</td>
<td>0.94 (0.69–1.29)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.99 (0.78–1.25)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.14 (0.86–1.51)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.74 (0.43–1.26)</td>
<td></td>
</tr>
<tr>
<td>≥4</td>
<td>0.88 (0.32–2.38)</td>
<td></td>
</tr>
<tr>
<td>Vascular disease</td>
<td></td>
<td>0.92</td>
</tr>
<tr>
<td>No</td>
<td>0.99 (0.81–1.20)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1.00 (0.80–1.26)</td>
<td></td>
</tr>
</tbody>
</table>
Does Coronary Revascularization Reduce Risk?
CARP Trial: RCT of Coronary Revascularization Before Major Vascular Surgery

- 510 patients
- Major vascular surgery
- Randomly assigned to revascularization or no revascularization
- Excluded patients with left main disease or LVEF <20%
- Revascularization group:
  - PCI 59%
  - CABG 41%
- All patients received usual care
- No difference in beta blocker or statin use

*NEJM* 2004;351:2795
Revascularization Does not Reduce 30 Day Mortality and Morbidity

<table>
<thead>
<tr>
<th>Outcome</th>
<th>CABG or PCI</th>
<th>Usual Care</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>3.1%</td>
<td>3.4%</td>
<td>0.37</td>
</tr>
<tr>
<td>MI by ECG and enzymes</td>
<td>8.4%</td>
<td>8.4%</td>
<td>0.99</td>
</tr>
<tr>
<td>MI by enzymes</td>
<td>11.6%</td>
<td>14.3%</td>
<td>0.37</td>
</tr>
<tr>
<td>LOS</td>
<td>6.5</td>
<td>7.0</td>
<td>0.29</td>
</tr>
</tbody>
</table>
ESC: Timing of Noncardiac Surgery After PCI

Risk of MI if antiplatelet agents stopped too soon after PCI
### ACC/AHA 2014: Timing of Noncardiac Surgery if Previous PCI

<table>
<thead>
<tr>
<th>Type of PCI</th>
<th>Delay after PCI before noncardiac surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTCA (balloon)</td>
<td>14 days</td>
</tr>
<tr>
<td>Bare metal stent</td>
<td>30 days</td>
</tr>
<tr>
<td>DES</td>
<td>365 days</td>
</tr>
<tr>
<td>Consider after 180 days if risk of delay &gt; risk of stent thrombosis</td>
<td></td>
</tr>
</tbody>
</table>
ACC/AHA: Management of Antiplatelet Agents

- Stent implantation ≤4-6 wk: Yes → Elective surgery → Yes → Delay surgery until after optimal period (BMS: 30 d and DES: 365 d) (Class I)
- Stent implantation ≤4-6 wk: No → Yes → Delay surgery until after optimal period (BMS: 30 d and DES: 365 d) (Class I)
- Risk of surgical delay is greater than risk of DES thrombosis: Yes → Proceed to surgery after 180 d (Class IIb)
- Risk of surgical delay is greater than risk of DES thrombosis: No → DES ≥30 d, but ≤365 d*: Yes → Continue DAPT unless risk of bleeding is greater than risk of stent thrombosis (Class I)
- Risk of surgical delay is greater than risk of DES thrombosis: No → DES ≥30 d, but ≤365 d*: No → Delay surgery until after optimal period (BMS: 30 d and DES: 365 d) (Class I)
- Does surgery demand discontinuation of P2Y<sub>12</sub> inhibitors??: No → No → Continue current DAPT regimen
- Does surgery demand discontinuation of P2Y<sub>12</sub> inhibitors??: Yes → Yes → Continue ASA and restart P2Y<sub>12</sub> ASAP (Class I)
### Who to Revascularize Before Noncardiac Surgery?

<table>
<thead>
<tr>
<th>PCI or CABG do not reduce risk of noncardiac surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI increases risk of subsequent noncardiac surgery if interval too brief</td>
</tr>
<tr>
<td>AHA/ACC 2014: Indications are same as for patients not facing noncardiac surgery</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revascularize for survival benefit (class I):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable angina or MI</td>
</tr>
<tr>
<td>Left main disease</td>
</tr>
<tr>
<td>3 vessel CAD with impaired LV function</td>
</tr>
<tr>
<td>2 vessel CAD with proximal LAD and impaired LV function</td>
</tr>
</tbody>
</table>
Don’t Revascularize Unless You Would Anyway!
Routine Postoperative Surveillance: Most Myocardial Injury is Asymptomatic

POISE Substudy

Study Patients With Events ($n = 8351$), %

- Isolated Cardiac Biomarker or Enzyme Level Elevation
- Asymptomatic MI
- Symptomatic MI

Time After Surgery, $d$
Mortality Similar for Symptomatic and Asymptomatic MI’s

- Symptomatic MI: 12.5%
- Asymptomatic MI: 9.7%
- Isolated Cardiac Biomarker or Enzyme Level Elevation: 2.2%
2/3 of perioperative MI’s are asymptomatic
Mortality does not differ based on ischemic symptoms or not
Most MI’s occur during first 48 hours
ACC/AHA
- Obtain troponins and EKG if signs or symptoms of ischemia
- Value of surveillance troponins and EKG if high risk but no symptoms unknown
- Routine surveillance not recommended
Historical Summary

“The heart… is the only one of the viscera, and indeed the only part of the body, that is unable to tolerate any serious injury.”

Aristotle (384-322 BC)
Summary: Patient-Related Risks

- Coronary artery disease
- Congestive heart failure
- Cerebrovascular disease
- Renal insufficiency
- Diabetes mellitus requiring insulin
- Advanced age is a minor factor after controlling for other comorbidities
- Poor functional capacity
Summary: Procedure-Related Risks

• High risk surgical site
  – Abdominal surgery
  – Chest surgery
  – Major intra-abdominal vascular surgery
• Emergency surgery
• Prolonged surgery
Summary: Interventions

• Beta blockers
  – Positive noninvasive test
  – ≥ 3 RCRI risk factors
• Statins
  – All patients undergoing vascular surgery
  – Clinical indication for long term Rx and elevated risk surgery
• Aspirin:
  – No benefit, more major bleeding
• Revascularize only if would do so anyway…