Managing Cardiac & Pulmonary Risk in the Surgical Patient

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Preoperative Evaluation Guidelines

Cardiac:

Pulmonary:
Preoperative Cardiac Evaluation

Is this patient at increased risk for perioperative cardiac complications?

Does the patient need further preoperative medical tests to clarify this risk?

What should be done to reduce the risk of cardiac complications?

Clinical Risk Prediction

What increases this patient’s risk for perioperative cardiac complications?

70-y.o. man with progressive weakness due to cervical myelopathy need spinal decompression & fusion. He needs help with some ADLs and walks slowly with a cane.

He has stable coronary artery disease & HTN
He is an active smoker.
Question 1: What increases this patient’s risk for perioperative cardiac complications?

1. History of coronary disease
2. History of HTN
3. Current smoker
4. Limited functional status
5. All of the above

Identifying Higher Risk Patients

Known cardiovascular disease predicts risk
Atherogenic risk factors (except diabetes) do not

Risk Factor                     | Odds Ratio
--------------------------------|-----------
Ischemic heart disease          | 2.4       
Congestive heart failure        | 1.9       
Diabetes                        | 2.8       
History of Stroke or TIA        | 3.2       
Poor functional status          | 1.8       

# Surgery Specific Risk

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (&gt; 5% risk)</td>
<td>Major aortic or peripheral vascular surgery</td>
</tr>
<tr>
<td></td>
<td>Emergent major surgery</td>
</tr>
<tr>
<td></td>
<td>Long cases w/ large fluid shifts or blood loss</td>
</tr>
<tr>
<td>Intermediate (&lt; 5% risk)</td>
<td>Carotid endarterectomy</td>
</tr>
<tr>
<td></td>
<td>Head &amp; Neck</td>
</tr>
<tr>
<td></td>
<td>Abdominal &amp; Thoracic</td>
</tr>
<tr>
<td></td>
<td>Orthopedic</td>
</tr>
<tr>
<td>Low (&lt; 1% risk)</td>
<td>Endoscopic procedures</td>
</tr>
<tr>
<td></td>
<td>Skin &amp; Breast</td>
</tr>
</tbody>
</table>

# Revised Cardiac Risk Index

**Predictors:**
- Ischemic heart disease
- Congestive heart failure
- Diabetes requiring insulin
- Creatinine > 2 mg/dL
- Stroke or TIA
- “High Risk” operation
  - (intraperitoneal, intrathoracic, or suprainguinal vascular)

<table>
<thead>
<tr>
<th># of RCRI Predictors</th>
<th>Complications</th>
<th>MI &amp; cardiac arrest</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.4%</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2.4%</td>
</tr>
<tr>
<td>≥ 3</td>
<td></td>
<td>5.4%</td>
</tr>
</tbody>
</table>

RCRI > 2 is “Elevated Risk”

NSQIP Cardiac Risk Prediction Tool

Derived from National Surgical Quality Improvement Program (NSQIP) database:
- > 400,000 patients in derivation & validation cohorts
- Wide range of operations
- “Complication” = 30-day incidence of MI & cardiac arrest

<table>
<thead>
<tr>
<th>Independent Predictors</th>
<th>1. Type of surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Age</td>
</tr>
<tr>
<td></td>
<td>3. Serum creatinine &gt; 1.5 mg/dL</td>
</tr>
<tr>
<td></td>
<td>4. Functional status (dependency for ADLs)</td>
</tr>
<tr>
<td></td>
<td>5. American Society of Anesth (ASA) class</td>
</tr>
</tbody>
</table>


ASA Class (a brief digression)

American Society of Anesthesiologists Physical Classification

1. Healthy, normal
2. Mild systemic disease
3. Severe systemic disease
4. Severe systemic disease that is a constant threat to life
5. Moribund patient not expected to survive without surgery
70-y.o. with h/o CAD, now undergoing cervical spine surgery. Needs help with some ADLs.

- Age 70
- Cr < 1.5
- ASA Class 3
- Partially dependent
- Spine surgery

www.qxmd.com/calculate-online/cardiology/gupta-perioperative-cardiac-risk
70-y.o. with h/o CAD, stroke, IDDM undergoing cervical spine surgery for progressive weakness.

Estimated risk of perioperative myocardial infarction or cardiac arrest: 0.72%

www.qxmd.com/calculate-online/cardiology/gupta-perioperative-cardiac-risk

Other findings:
• Excellent performance (AUC = 0.88)

Caveats:
• Doesn't account for all available information

Which Prediction Tool is Better?

<table>
<thead>
<tr>
<th></th>
<th>RCRI</th>
<th>NSQIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>~ 4000</td>
<td>~ 400,000</td>
</tr>
<tr>
<td># of hospitals</td>
<td>1</td>
<td>&gt; 200</td>
</tr>
<tr>
<td>Currency of data</td>
<td>’89 – ’94</td>
<td>’07 – ’08</td>
</tr>
<tr>
<td>Screen for MI?</td>
<td>CK-MB, ECG</td>
<td>No</td>
</tr>
</tbody>
</table>

Which to choose?
• 2014 ACC/AHA guideline endorses both tools
• Personal practice: use NSQIP when quantifying risk
ACC/AHA: When is Risk Excessive?

- Unstable coronary syndromes
  - Recent MI with post-infarct ischemia
  - Class III or IV angina
- Decompensated CHF
- Significant arrhythmia
  - High grade atrioventricular block
  - Symptomatic ventricular arrhythmia
  - Supraventricular arrhythmia with uncontrolled rate
- Severe valve disease (e.g., critical aortic stenosis)

ACC/AHA: When is Risk Excessive?

Severe or unstable cardiac disease that requires urgent evaluation & treatment, regardless of planned surgery
Utility of Stress Testing

Is further preoperative cardiac testing indicated?

A 63 y.o. man will undergo a Whipple procedure for newly diagnosed pancreatic cancer. He had a remote myocardial infarction, diabetes, and HTN. He has not had chest pain in the past year. Fair functional capacity.

Meds: lovastatin, atenolol, glyburide, benazepril, ASA
PEx: BP=115 / 70 HR=60; normal heart & lung exam
ECG: NSR, LVH, otherwise normal

Question 2:

63 y.o. man s/f Whipple procedure. Remote MI, long-standing diabetes & HTN. No chest pain.

Should this patient receive further preoperative tests?
1. No further testing
2. Yes, exercise ECG
3. Yes, nuclear scintigraphy
Noninvasive Stress Testing

Predictive value:
• Mainly studied in vascular surgery patients
• Strong negative predictive value ~ 98% (neg LR = 0.1 - 0.2)
• Weak positive predictive value ~10 - 20% (pos LR = 2 - 3)
• Adds little information to lower risk patients
• More useful for cases with increased risk

Stress Tests: More Useful in Patients at Higher Risk

Pretest Probability = 1% (e.g. TKA)
• Positive Test: Posttest probability = 2 - 3%
• Negative Test: Posttest probability = 0 - 1%

Pretest Probability = 10% (e.g. AAA repair)
• Positive Test: Posttest probability = 18-25%
• Negative Test: Posttest probability = 2%
Revascularization

Should this patient have coronary revascularization?

You diagnose a 63 y.o. man with resectable pancreatic cancer. He has known coronary disease. P-Mibi & angiography last year showed mild inferior reversibility and a 75% RCA lesion and normal LVEF. He did not receive PCI.

Meds: lovastatin, atenolol, benazepril, ASA

PEx: BP=115 / 70 HR=60; normal CV & lung exam
Question 3:

63 y.o. man with CAD undergoing Whipple procedure. His P-Mibi showed mild inferior reversibility. Angiogram showed a 75% RCA lesion and normal LVEF.

1. No, proceed to surgery
2. Consult cardiologist for possible PCI

**CARP Trial: Coronary Artery Revascularization Prophylaxis**

510 patients undergoing vascular surgery
- At least 1 vessel with 70% occlusion
- Excluded left main dz, AS, or LVEF < 20%

Choice of CABG or PCI plus Medical management

Medical management alone

1° Endpoint: Long-term mortality
2° Endpoint: MI, Stroke, Limb loss, Dialysis

McFalls, et al. NEJM, 2004
### CARP: Complications After CABG or PCI

<table>
<thead>
<tr>
<th>Complication</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>1.7%</td>
</tr>
<tr>
<td>MI</td>
<td>5.8%</td>
</tr>
<tr>
<td>Reoperation</td>
<td>2.5%</td>
</tr>
</tbody>
</table>


### CARP: Outcomes After Vascular Surgery

<table>
<thead>
<tr>
<th></th>
<th>Revascularized (n=225)</th>
<th>Med Mgt Only (n=237)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death before surgery</td>
<td>10 (4%)</td>
<td>1</td>
</tr>
<tr>
<td>Death &lt; 30 days post-op</td>
<td>7 (3%)</td>
<td>8 (3%)</td>
</tr>
<tr>
<td>Postoperative MI</td>
<td>26 (12%)</td>
<td>34 (14%)</td>
</tr>
<tr>
<td>Long-term mortality</td>
<td>70 (22%)</td>
<td>67 (23%)</td>
</tr>
<tr>
<td>(2.7 yrs after randomization)</td>
<td></td>
<td></td>
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</tbody>
</table>

p = NS for all comparisons

ACC/AHA Guidelines for PCI

- Indications for PCI are same as for nonsurgical patients
- Avoid PCI if antiplatelet drugs will need to be held prematurely
- Delay elective surgery after elective PCI:
  - Bare metal stent: 30 days
  - Drug eluting stent: 6 months (optimal)
    - 3 months (if harm in delay)
- Continue or restart antiplatelet agents (especially ASA) as soon as possible, unless bleeding risk precludes

Beta-blockers

Should this patient be started on a beta-blocker?

A 75 y.o. woman with diabetes and HTN will undergo revision of an infected knee arthroplasty.
Denies cardiac history or symptoms. Physical examination and ECG are unremarkable.
She is not on a beta-blocker.
Question 4:

75 y.o. woman with stable coronary disease and HTN will undergo hip fracture repair. Not currently on β-blocker.

Should this patient be started on a beta-blocker now?

1. Probably
2. Probably not

Rise & Fall of Beta-blockers

• Early trials showed that starting beta-blockers prevented postoperative MI and reduce mortality

• Subsequent studies less impressive, and some positive studies discredited for fraud

• Largest study found small benefit on MI prevention, but increased overall mortality
POISE: Biggest β-blocker Trial

**Patients:** 8351 pts with s/f major noncardiac surgery
- CAD, CHF, CVA/TIA, CKD, DM, or high-risk surgery
- Not already taking β-blocker

<table>
<thead>
<tr>
<th>Time</th>
<th>1st dose</th>
<th>2nd dose</th>
<th>3rd &amp; daily dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-4 h</td>
<td>Metoprolol XL 100 mg*</td>
<td>Metoprolol XL 100 mg*</td>
<td>Metoprolol XL 200 mg*^</td>
</tr>
<tr>
<td>0-6 h</td>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 h</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

* Study drug held for SBP < 100 or HR < 50
^ Daily dose reduced to 100 mg if persistent bradycardia or hypotension

**Outcome:** 30-day cardiac mortality, nonfatal arrest or MI


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POISE Trial Results

**Placebo**
- 6.9% CV Death
- 5.8% Cardiac Arrest
- 2.3% Total Mortality

**Metoprolol XL**
- Reduced cardiac events (mostly nonfatal MI)
- Increased risk of stroke & total mortality

2014 ACC / AHA Guideline for β-blockers

Definite indications to continue if… (Helps)
- Already using β-blocker to treat angina, HTN, arrhythmia

Reasonable to consider initiation if… (Maybe)
- High clinical risk (RCRI score ≥ 3)
- Ischemia seen on preoperative stress test
- Compelling indication for long-term beta-blockade

Avoid initiation… (Harms)
- On day of surgery

Trial of Perioperative Aspirin (POISE 2)

Before surgery:
- 10,100 patients with cardiac disease or risk factors undergoing major noncardiac surgery
- Aspirin 200 mg or placebo started right before surgery

After surgery:
- Aspirin or placebo given daily x 30 days
- Study drug stopped if major or life-threatening bleed

Devereaux, PJ et al. NEJM 2014; 370:1494-03
POISE 2: Aspirin Results

<table>
<thead>
<tr>
<th></th>
<th>Aspirin</th>
<th>Placebo</th>
<th>Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death or MI</td>
<td>7.0%</td>
<td>7.1%</td>
<td>0.99 (NS)</td>
</tr>
<tr>
<td>Non-fatal MI</td>
<td>6.2%</td>
<td>6.3%</td>
<td>0.98 (NS)</td>
</tr>
<tr>
<td>Major Bleeding</td>
<td>4.6%</td>
<td>3.8%</td>
<td>1.23 (p = 0.04)</td>
</tr>
</tbody>
</table>

Devereaux, PJ et al. NEJM 2014; 370:1494-03

2014 ACC / AHA Guidelines

Aspirin (for patients without stent)

- Not unreasonable to continue ASA in elective surgery if benefits outweigh risks from bleeding
  
  (Class 2b)

- Initiation of ASA does not benefit patients undergoing elective noncardiac surgery
  
  (Class 3)

Trial of Statins in Vascular Surgery

Reduced nonfatal MI
No difference in rates of LFT or CPK elevation

2014 ACC / AHA Guideline (Statins)

Definitely continue if… (Class I)
- Patient is already taking statins chronically

Reasonable to initiate if… (Class 2a)
- Patient is having vascular surgery

Not unreasonable to initiate if… (Class 2b)
- Patient has elevated clinical risk and is undergoing a moderate or high risk operation

Schouten et al. NEJM, 2009; 361:980-9
Take Home Points

Use a validated clinical prediction tool:
• RCRI is easy to use & has become the “new standard”
• NSQIP tool may be more broadly applicable

Reserve stress testing for highest risk patients:
• Elevated risk and poor functional status
• Only do stress test if results will change management (e.g., cancel, delay, or modify surgery)

Take Home Points

Beware perioperative coronary revascularization:
• Indications are the same as for non-surgical patients
• Don’t perform PCI if patient may have upcoming surgery that requires stopping antiplatelet therapy

Beta-blockers:
• Only consider starting in very high risk patients after considering risks, and not immediately before surgery
Preoperative Pulmonary Evaluation

Is this patient at increased risk for perioperative pulmonary complications?

Does the patient need further preoperative medical tests to clarify this risk?

What should be done to reduce the risk of pulmonary complications?
Pulmonary Risk Prediction

What do you recommend for this patient?

A 65 y.o. man is to undergo repair of an abdominal aortic aneurysm. He has COPD and continues to smoke. He denies change in cough, or worsening of his chronic dyspnea when walking uphill.

Exam:
- Resp Rate 20
- O2 sat 95% RA
- Lungs: prolonged expiration, no wheeze

Question 5:

65 y.o. man is s/f repair of an AAA. He has COPD and smokes. No change in cough or usual chronic dyspnea.

Which of the following will be most helpful?

1. Obtain PFTs
2. Quit smoking first before surgery
3. Incentive spirometry after surgery
Pathophysiology of Postoperative Pulmonary Complications

Normal

- Tidal Breathing

Decreased FRC

- Incisional pain
- Anesthesia
- Supine position

Abnormally high Closing Volume

- Age
- COPD
- Smoking

Procedure Related Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurosurgery</td>
<td>2.5</td>
</tr>
<tr>
<td>Head &amp; Neck</td>
<td>2.2</td>
</tr>
<tr>
<td>Aortic</td>
<td>6.9</td>
</tr>
<tr>
<td>Thoracic</td>
<td>4.2</td>
</tr>
<tr>
<td>Abdominal</td>
<td>3.0</td>
</tr>
<tr>
<td>Vascular</td>
<td>2.1</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>2.2</td>
</tr>
<tr>
<td>Prolonged surgery</td>
<td>2.3</td>
</tr>
<tr>
<td>General anesthesia</td>
<td>1.8</td>
</tr>
</tbody>
</table>
### Patient Related Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 60 - 69</td>
<td>2.3</td>
</tr>
<tr>
<td>Age 70 - 79</td>
<td>5.6</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>2.9</td>
</tr>
<tr>
<td>COPD</td>
<td>2.4</td>
</tr>
</tbody>
</table>

ASA Class ≥ II vs. Class I
- Odds ratio = 4.9

ASA Class ≥ III vs. Class I or II
- Odds ratio = 3.1

- Class I: no systemic disease
- Class II: mild systemic disease
- Class III: severe systemic disease
- Class IV: systemic disease that is a constant threat to life

### Respiratory Failure Prediction Tool

- Derived from National Surgical Quality Improvement Program (NSQIP) database:
  - > 400 K patients in derivation & validation cohorts
  - Wide range of operations
  - “Respiratory Failure” = on vent > 48 hrs or reintubation

<table>
<thead>
<tr>
<th>Independent Predictors</th>
<th>1. American Society of Anesth (ASA) class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Functional status (dependency)</td>
</tr>
<tr>
<td></td>
<td>3. Type / location of surgery</td>
</tr>
<tr>
<td></td>
<td>4. Emergency surgery</td>
</tr>
<tr>
<td></td>
<td>5. Preoperative sepsis or SIRS</td>
</tr>
</tbody>
</table>

Estimated risk of postoperative respiratory failure: 6.7 %
Pulmonary Function Tests & Spirometry

PFTs & spirometry add little to risk assessment
  • Usually just tells you what you already know
  • Abnormal chest exam findings more predictive of PPC
  • Can’t use results to identify patients with prohibitively high risk of PPC or mortality
  • Use as diagnostic tool to evaluate unexplained findings

Preoperative Prevention Strategies

Optimize chronic lung disease
  • Treat COPD exacerbation (steroids, antibiotics)

Smoking cessation
  • Limited evidence for benefit for PPC but other benefits
  • May require 8 weeks of cessation for benefit

Respiratory conditioning
  • Education on lung expansion & Inspiratory muscle training
  • Benefit seen in RCTs in cardiac surgery
Preoperative Smoking Cessation Counseling

RCTs of Preoperative Smoking Cessation Counseling:
1. 120 patients undergoing arthroplasty in 6-8 weeks
2. 60 patients undergoing colorectal resection in 2-3 weeks

**Intervention:** Smoking cessation counseling & offer free nicotine replacement products

**Outcomes:** Postop complications, especially wound related (e.g., dehiscence, infection, hematoma)

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Smoking Cessation 6-8 Weeks
Before TKA or THA

![Graph showing comparison between control and intervention groups for quitting smoking, wound complications, and any complications.]

Smoking Cessation 2-3 Weeks Before Colorectal Surgery

![Graph showing comparison of smoking cessation rates between control and intervention groups.](image)


Postoperative Prevention Strategies

Lung expansion maneuvers
- Deep breathing or incentive spirometry recommended, though quality of evidence poor
- Consideration of CPAP for very high risk patients

I COUGH – a multi-intervention strategy to prevent PPC
- Incentive spirometry, Coughing & deep breathing, Oral care, Understanding, Get out of bed tid, Head of bed elevated
- Reduced postop pneumonia and unplanned reintubation

Causes of Postoperative Hypoxemia

Upper airway obstruction
- Early onset - often POD 0 or prior to leaving PACU
- Airway edema, vocal cord injury, laryngospasm, OSA

Atelectasis
- Often onset POD 1-2
- Secretion management: chest therapy, pulmonary toilet
- Positive airway pressure: CPAP, BiPAP, EzPAP

Pulmonary edema
- Often onset by POD 2
- Cardiogenic vs. non-cardiogenic

Pneumonia
- Most common in first 5 days postop (unless on ventilator)
- Think Staph aureus & gram negative rods
- Pseudomonas? Risk with ≥ 5 days hospitalization or prior antibiotic exposure, dialysis, nursing home

Other etiologies:
- Pulmonary embolism
- Bronchospasm
- Effusions – common after abdominal surgery, usually small, exudative and usually don’t require treatment
Take Home Points

Patient related risks:
• Elderly
• COPD
• Severe medical comorbidity
• Functionally dependent or generally debilitated

Procedure related risks:
• Thoracic surgery
• Abdominal surgery
• Emergency surgery
• Prolonged surgery > 3 hrs
• General anesthesia

Take Home Points

Chest x-rays and PFTs:
• Should not be done routinely
• Consider spirometry to evaluate unexplained symptoms

Risk Reduction:
• Patients at increased risk for pulmonary complications should receive lung expansion maneuvers
• Smoking cessation likely beneficial but may require two months lead time to be effective
Thank You

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