Identification of Myocardial Ischemia and Infarction in the Perioperative Period

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Scary Stats

- Ischemic heart disease is the number one cause of mortality in the United States
- Of the 230 million adults worldwide who have non-cardiac surgery
  - 30-day mortality is 2% overall and 5% for high-risk patients
  - $50,000 to $90,000 nonfatal perioperative MI, nonfatal cardiac arrest
  - 500,000 to 900,000 nonfatal perioperative MI, nonfatal cardiac arrest
  - > 5% for high-risk patients
- Patients experiencing an MI after non-cardiac surgery have an in-hospital mortality rate of 15%-25%
- Patients suffering a perioperative MI have an increased risk of cardiovascular death and nonfatal MI for 6 months following surgery.
- Perioperative cardiac complications extend the average hospital stay by 11 days and add at least $10,000 onto the hospitalization costs.

Perioperative Myocardial Ischemia

- Study of Perioperative Myocardial Ischemia
  - Preop ST changes in 20%, prep and 41% post-op
  - Post op ischemia 1% risk of in-hospital mortality event
  - Landesberg: ischemia that lasted > 2 hours = 32 x ↑ morbidity cardiac events
  - ↑ # of Predictors = ↑ Risk (22% w/ 0 vs. 77% w/ 4)
  - Perip MI = 20 - 30% ↑ hospital mortality + poor prognosis even after discharge
  - 9 fold ↑ in hospital morbidity events
  - $10 - 20 K additional hospital expenses

The results show that fewer than half the anesthesiology residents nationwide correctly demonstrate the approach considered standard of care for preoperative cardiac evaluation.

The Interpretation of Electrocardiograms: Pretense or a Well-Developed Skill?

J. Willis Hurst, MD, MACP

- Multiple studies show that physicians and nurses are not taught to properly interpret ECGs
- Even when they are taught, unless the skill is utilized on a regular basis, most of the information is forgotten
- Active practitioners tend to be able to identify signs of ischemia even if not formally taught to do so
Objectives for Today

- Understand the basis for and detail the five steps in the 2007/2009 ACC/AHA guidelines on perioperative cardiac evaluation.
- Discuss current terminology and criteria that is used to describe various levels of heart function and myocardial ischemia.
- Detail the evidenced based strategies that minimizes risk of perioperative ischemia and infarction.

Determining: Who is at risk and how high

Cardiac Evaluation and Care Algorithm for Noncardiac Surgery Based on Active Clinical Conditions, Known Cardiovascular Disease, or Cardiac Risk for Patients 50 Years of Age or Greater

1. Emergency?

2. Active Cardiac Condition?

Evaluate and Treat Active Cardiac Conditions

- Major predictors: requires intensive management and may lead to delay in or cancellation of the operative procedure unless emergent

- Unstable Coronary Syndromes
  - Unstable angina
  - Recent MI

- Decompensated Heart Failure (NYHA class IV)

- Significant arrhythmia
  - Sinus tachycardia
  - Sustained VT
  - New atrial flutter or fibrillation

- Severe cardiac disfunction
3. Determine Risk of Surgery

- **High risk >5%**
  - Aortic and other major vascular surgery
  - Peripheral artery surgery
- **Intermediate risk (1-5%)**
  - Carotid endarterectomy
  - Head and neck surgery
  - Intraperitoneal
  - Intrathoracic surgery
  - Orthopedic surgery
  - Prostate surgery
- **Low risk <1%**
  - Ambulatory surgery
  - Endoscopic procedures
  - Superficial procedure
  - Cataract surgery
  - Breast surgery

ACC/AHA guideline summary:
Cardiac risk stratification for noncardiac surgical procedures

Based on Functional Capacity

<table>
<thead>
<tr>
<th>MET</th>
<th>Functional Levels of Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Eating, walking at a computer, dressing</td>
</tr>
<tr>
<td>2</td>
<td>Walking down stairs or in your house, cooking</td>
</tr>
<tr>
<td>3</td>
<td>Walking 1-2 blocks</td>
</tr>
<tr>
<td>4</td>
<td>Rising leaves, gardening</td>
</tr>
<tr>
<td>5</td>
<td>Climbing 1 flight of stairs, dancing, bicycling</td>
</tr>
<tr>
<td>6</td>
<td>Playing golf, carrying clubs</td>
</tr>
<tr>
<td>7</td>
<td>Playing singles tennis</td>
</tr>
<tr>
<td>8</td>
<td>Rapidly climbing stairs, popping chisely</td>
</tr>
<tr>
<td>9</td>
<td>Jumping rope, briskly, moderate cycling</td>
</tr>
<tr>
<td>10</td>
<td>Swimming quickly, running or jogging briskly</td>
</tr>
<tr>
<td>11</td>
<td>Going cross-country skiing, running long distances</td>
</tr>
<tr>
<td>12</td>
<td>Running rapidly for moderate-to-long distances</td>
</tr>
</tbody>
</table>

"In highly functional asymptomatic patients, management will rarely be changed on the basis of results of any further cardiovascular testing...it is therefore appropriate to proceed with the planned surgery."
5a) No risk factors → Proceed with surgery

5b) Consider Noninvasive Testing (if it will change management) or Surgery with HR Control

Goldman Revised Cardiac Risk Index
- History of ischemic heart disease
  - Prior MI (>30 days)
  - Positive treadmill test
  - Use of nitrates
  - Current complaint of chest pain (cardiac in origin)
  - ECG with abnormal Q waves
  - Do not count prior CABG unless one of the other criteria are met
- Compensated or prior CHF
- History of cerebrovascular disease
  - TIA
  - CVA
- Diabetes mellitus requiring insulin
-Creatinine >2.0 mg/dL

Preop ECG?
- Class I
  - 1 or more clinical risk factor who are undergoing vascular surgical procedures
- Class IIa
  - Reasonable for vascular surgery even with no clinical risk factors
- Class IIb
  - Reasonable with 1 or more clinical risk factor who are undergoing intermediate risk surgical procedures
- Class III
  - Preoperative and postoperative resting 12-lead ECGs are not indicated for asymptomatic persons undergoing low-risk surgical procedures
Eagle Study

Clinical Variables:
- Q waves on EKG
- Age greater than 70
- History of angina
- History of ventricular ectopy requiring treatment
- Diabetes mellitus requiring treatment

2007 Guidelines

<table>
<thead>
<tr>
<th>Type of Surgery</th>
<th>Functional Capacity</th>
<th>Number of Clinical Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular Surgery</td>
<td>Good</td>
<td>0</td>
</tr>
<tr>
<td>Intermediate Risk</td>
<td>Good</td>
<td>1</td>
</tr>
<tr>
<td>Low Risk Surgery</td>
<td>Good</td>
<td>2</td>
</tr>
</tbody>
</table>

- Green → No testing
- Orange → Consider testing
- Red → Testing recommended

Rate of cardiac death and nonfatal myocardial infarction, cardiac arrest or ventricular fibrillation, pulmonary edema, and complete heart block according to the number of predictors and the nonuse or use of beta blockers

- No risk factors - 0.4 to 1.0 % vs <1 % with beta blockers
- One to two risk factors - 2.2 to 6.6 % vs 0.8 to 1.6 % with beta blockers
- Three or more risk factors - >9 % vs >3 % with beta blockers

Beta-Blockers

- Beta blockers should be continued in patients undergoing surgery who are receiving beta blockers for treatment
- Beta blockers titrated to heart rate and blood pressure
  - Recommended for high risk patients undergoing vascular surgery
  - Reasonable for intermediate (> 1 clinical risk factor) patients undergoing vascular surgery
  - Reasonable for high or intermediate risk patients undergoing intermediate-risk surgery

J Am Coll Cardiol, 2009; 54:2002-2012
Impact of Heart Rate

Mean heart rate in relation to myocardial ischemia assessed by continuous electrocardiography and troponin T release. Data from Feringa et al. (61). ECG = electrocardiogram.

Beta-Blockers Not Recommended

- Routine administration of high-dose beta blockers in the absence of dose titration is not useful and may be harmful to patients not currently taking beta blockers who are undergoing noncardiac surgery
  - POISE study showed
    - ↓ Rate of MI
    - ↓ Rate of CVA
    - ↓ Rate of death
  - Insufficient evidence in all other situations

Final Recommendations

Consensus definition of MI

Table 1: Clinical classification of different types of myocardial infarction

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clot (ACS)</td>
<td>Microvascular infarction related to thrombus due to a primary coronary event such as platelet adhesion or coronary atherosclerosis</td>
</tr>
<tr>
<td>2. Supply/demand</td>
<td>Microvascular infarction secondary to ischemia due to either increased oxygen demand or decreased supply, e.g., coronary atherosclerosis, vasoconstriction, arrhythmias</td>
</tr>
<tr>
<td>3. Dyssrhythmia</td>
<td>Microvascular infarction associated with ventricular dysrythmias</td>
</tr>
<tr>
<td>4. PCI</td>
<td>Microvascular infarction associated with percutaneous coronary intervention</td>
</tr>
<tr>
<td>5. CABG</td>
<td>Microvascular infarction associated with coronary artery bypass grafting</td>
</tr>
</tbody>
</table>

Perioperative MI (PMI)

- 2 mechanisms
  - Type 1 PMI
    - AKA ACS (acute coronary syndrome)
    - Rupture of plaque
    - Coronary thrombosis ischemia MI
  - Type 2 PMI
    - CAD and prolonged myocardial oxygen supply-demand imbalance ischemia MI

Non-fatal PMI

- Majority of patients do not have high-grade CAD, type 2 PMI may be responsible

Fatal PMI

- Majority of patients have 3 vessel or LMT CAD, type 1 PMI may be responsible
Periop Cardiac Events in Major Noncardiac Surgery

- Cardiac Death: 2.6%
- MI: 2.6%
- Troponin: 2.4%

J Am Coll Cardiol, 2008; 51:1913-24

PMI
- Peaks in the postoperative period - Usually within 48 hours
- Almost always preceded by ST segment depression and tachycardia
- Usually silent and non-Q wave
  - Only 15% have chest pain
  - Only 53% have any clinical symptom

Triggers
- Surgery → Stress response
  - Catecholamines and cortisol increase
  - Vasospasm
  - Hypertension
  - Tachycardia
  - Increases shear stress
  - Inflammation
  - Hypercoagulable state

The Ultimate Stress Test
- Surgery
  - Hemodynamic changes associated with the induction of anesthesia, intubation, surgical stress, pain, volume changes, and blood loss
  - The stress response includes increased levels of catecholamines and cortisol. This leads to hypertension and tachycardia. These not only increase myocardial oxygen demand, they also cause shear stress which leads to plaque rupture
  - Inflammatory and hypercoagulable states are also part of the perioperative physiologic response. Inflammatory substances play a role in plaque fissuring and the hypercoagulable state could then lead to acute coronary thrombosis

Type I MI (ACS)

- Acute coronary thrombosis
  - Plaque rupture
  - Platelet aggregation
  - Fibrin deposition
  - Inflammatory cells
  - Smooth muscle cell proliferation
  - Atherosclerotic lesion

J Am Coll Cardiol, 2008; 51:1913-24
**Type II MI (stable CAD)**

- Reduced ejection fraction
- Troponin elevation
- Improved with revascularization

**Probability of Type 1 and Type 2 MI Based on % of Coronary Stenosis**

**Newer Terminology**

- STEMI/NSTEMI

**ST Depression**

- Types of ST Depression
  - Supraventricular: ≥ 1 mm (0.08 sec after QRS) 30% to 40% error rate
  - Horizontal: ≥ 1 mm (0.08 sec after QRS) Very low error rate
  - Downward: ≥ 1 mm (0.08 sec after QRS) 5% to 10% error rate

**Naming MI’s**

- Q-wave MI
  - Formerly thought to be caused by transmural MI
  - Actually depends on extent and location of damage
  - Q-waves can resolve over time
  - Correlates with improved survival
  - Significant when >4 sec and/or ≥1/3 the height of the total complex
- Non-Q-wave MI
  - Formerly thought to be subendocardial or subepicardial damage

**Newer Terminology**

- Stunned Myocardium
  - ACS
  - Acute vessel occlusion that subsequently reopens and reperfuses
  - Wall motion abnormalities
  - Completely reversible
- Hibernating Myocardium
  - Occurs with chronic, stable plaque
  - Chronic reduction in flow
  - Function is ↓ to match flow
Systolic Dysfunction

- Inotropy (contraction)
- Results in t compliance as the heart dilates to try to maintain CO
- Supply ischemia
- Often expressed as EF
  - <50% - mild
  - 35-50% - moderate
  - <25% - severe

Diastolic Dysfunction

- Lusitropy (relaxation)
- Results in t compliance
- Demand ischemia
- EF can be normal, increased or decreased!

Silent ischemia preop is predictive postop

The Ischemia Cascade

- Conversion from aerobic to anaerobic metabolism
- Diastolic dysfunction
- Systolic dysfunction (Wall Motion Abnormalities)
- Hemodynamic abnormalities
- ECG changes
- Angina

Monitoring Modalities

- Angina: 70-90% is silent
- ECG
  - 25-50% of pt w/ CAD will have normal ECG at rest
  - Additional 25% non interpretable d/t baseline defect
- AECG
  - Silent ischemia preop is predictive postop
  - 30-120 min. ischemia before MI
  - 80% ischemia occurs postop
Monitoring Modalities Effectiveness

- **PAC**
  - ↑ demand → ↑ compliance
  - ↑ V or AC waves on the PAW trace
  - ↑ LVEDP → ↓ CO → pulmonary edema
  - Not specific

- **Echo**
  - Sensitive and specific
  - Expensive and requires extensive training
  - 50% of pts with wall motion abnormalities have normal ECG

- Coronary sinus catheter
- Nuclear imaging techniques
- Thallium scan (myocardial perfusion)
- Tc scan
- Cardiokymography
- Numerical indices

**Pragmatics of Monitoring**

**TABLE 9.1. Sensitivity for Different ECG Lead Combinations**

<table>
<thead>
<tr>
<th>No. of Leads</th>
<th>Sensitivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>II, V₅ 61</td>
</tr>
<tr>
<td></td>
<td>III, V₅ 75</td>
</tr>
<tr>
<td>2</td>
<td>II/V₁, II/V₂, II/V₅ 80</td>
</tr>
<tr>
<td></td>
<td>III/V₁, III/V₂, III/V₅ 82</td>
</tr>
<tr>
<td></td>
<td>V₁/V₅, V₅/V₁ 90</td>
</tr>
<tr>
<td>3</td>
<td>II/V₁, II/V₂, II/V₅ 94</td>
</tr>
<tr>
<td></td>
<td>III/V₁, III/V₂, III/V₅ 96</td>
</tr>
<tr>
<td>4</td>
<td>II/V₁, II/V₂ 100</td>
</tr>
</tbody>
</table>

(Data from London et al. [5])

**Impact of Heart Rate**

- 80% of LV coronary perfusion occurs during diastole
- CPP = DBP – LVEDP
- As HR ↑ → Diastolic Time ↓
HR > 70 is Predictive of Bad Things

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Treatment Algorithm

Suspicious combinations (ischemic/infarction)
- Cardiac arrest / ventricular tachycardia
- Cardiac arrest / ventricular fibrillation
- Complete heart block

Suspected acute coronary syndrome (ACS)
- Chest pain
- Dyspnea
- Syncope
- Headache
- Abdominal pain
- nausea/vomiting
- Diaphoresis
- Wall motion abnormalities on echocardiogram
- Persistent or new ST-segment elevation on ECG

Suspicious for acute myocardial infarction (AMI)
- Sudden cardiac death
- Syncope
- Severe chest pain
- Diaphoresis
- Palpitations

Suspicious for acute coronary syndrome (ACS)
- Unexplained syncope
- Unexplained palpitations
- Unexplained chest pain
- Unexplained shortness of breath
- Unexplained motor weakness

Suspicious for acute myocardial infarction (AMI)
- Unexplained syncope
- Unexplained palpitations
- Unexplained chest pain
- Unexplained shortness of breath
- Unexplained motor weakness