Perioperative Care of Our Cath Lab Patients:

Why what happens in the cath lab shouldn’t stay in the cath lab

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Piedmont Heart Institute - Athens
Overview

Pre-Op Evaluation
• Consent
• CIN Prevention

Vascular Access
• Complication prevention and management
• Femoral vs. Radial
Overview

Pre-Op Evaluation

- Consent
- CIN Prevention
### Procedure Related Complications of Cardiac Catheterization

<table>
<thead>
<tr>
<th>Complications (%)</th>
<th>Diagnostic Catheterization-Only Patients Without STEMI (n=1,091,557)</th>
<th>PCI Patients Without STEMI (n=787,980)</th>
<th>PCI Patients With STEMI (n=153,268)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any adverse event</td>
<td>1.35</td>
<td>4.53</td>
<td>12.4</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>0.24</td>
<td>0.47</td>
<td>3.87</td>
</tr>
<tr>
<td>Heart failure</td>
<td>0.38</td>
<td>0.59</td>
<td>3.46</td>
</tr>
<tr>
<td>Pericardial tamponade</td>
<td>0.03</td>
<td>0.07</td>
<td>0.15</td>
</tr>
<tr>
<td>Cerebrovascular accident/stroke</td>
<td>0.17</td>
<td>0.17</td>
<td>0.56</td>
</tr>
<tr>
<td>% of total strokes that are hemorrhagic</td>
<td>9.16</td>
<td>15.6</td>
<td>19.7</td>
</tr>
<tr>
<td>New requirement for dialysis</td>
<td>0.14</td>
<td>0.19</td>
<td>0.63</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk-adjusted (median)</td>
<td></td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>Non-risk-adjusted</td>
<td>0.72</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>Non-risk-adjusted, excluding CABG patients</td>
<td>0.60</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>CABG performed during admission</td>
<td>7.47</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>CABG status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvage/emergency</td>
<td>0.01 / 0.27</td>
<td>0.01 / 0.17</td>
<td>0.05 / 0.87</td>
</tr>
<tr>
<td>Urgent/elective</td>
<td>5.27 / 1.92</td>
<td>0.47 / 0.16</td>
<td>2.08 / 0.43</td>
</tr>
<tr>
<td>CABG indication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI failure without clinical deterioration</td>
<td>0.26</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>PCI complication</td>
<td>0.14</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td><strong>Bleeding Complications (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any bleeding event within 72 hours of procedure</td>
<td>0.49</td>
<td>1.40</td>
<td>3.85</td>
</tr>
<tr>
<td>Any other vascular complication requiring treatment</td>
<td>0.15</td>
<td>0.44</td>
<td>0.62</td>
</tr>
<tr>
<td>Red blood cells/whole blood transfusion</td>
<td>N/A</td>
<td>2.07</td>
<td>5.61</td>
</tr>
</tbody>
</table>
Informed Consent

- Overall risk of serious life threatening complication of death, myocardial infarction, or stroke is $< 0.1\%$.

- Informed Consent
  - Risks, benefits, alternatives
  - Ultimately the responsibility of the operator
  - If PCI is a possible outcome, this should be included in the consent
  - Not required to include all risks
Informed Consent

• Ultimately, it is the responsibility of the operator to ensure this is done.
Contrast Induced Nephropathy

- CIN is a rise in serum Cr ≥ 0.5 mg/dL or 25% increase above baseline.
- Differential includes hypotension, renal atheroemboli, acute interstitial nephritis
- Time course
  - Rise in Cr occurs in 24-48 hours
  - Peaks at 3-5 days
  - Resolves over one week
Contrast Induced Nephropathy

- CIN is associated with adverse outcomes
  - 5 to 20 fold increase risk of early events
    - In-hospital MI
    - Target vessel occlusion
    - Prolonged hospital stay
    - Early mortality
  - Long term adverse associations include 11-fold increase in ESRD, re-hospitalization, and 3-4 times increased risk of mortality

Circulation 2011;123:409-16.
Circulation 2002;105:2259-64.
## Risk factors for Contrast-Induced Nephropathy

<table>
<thead>
<tr>
<th>Patient Factors</th>
<th>Procedural Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic kidney disease</td>
<td>Volume of contrast</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>Use of intra-aortic balloon pump</td>
</tr>
<tr>
<td>Age greater than 70 years old</td>
<td>Urgent or emergent procedure</td>
</tr>
<tr>
<td>Hypotension (at time of procedure)</td>
<td>Repeat contrast exposure within 72 hours</td>
</tr>
<tr>
<td>History of hypertension</td>
<td>Hyperosmolar contrast</td>
</tr>
<tr>
<td>Anemia</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td></td>
</tr>
<tr>
<td>Nephrotoxic medications</td>
<td></td>
</tr>
<tr>
<td>Female gender</td>
<td></td>
</tr>
</tbody>
</table>
# Predictive Model of CIN

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Integer Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotension</td>
<td>5</td>
</tr>
<tr>
<td>IABP</td>
<td>5</td>
</tr>
<tr>
<td>CHF</td>
<td>5</td>
</tr>
<tr>
<td>Age &gt;75 y/o</td>
<td>4</td>
</tr>
<tr>
<td>Anemia</td>
<td>3</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3</td>
</tr>
<tr>
<td>Contrast Media Volume</td>
<td>1 for each 100 cc³</td>
</tr>
<tr>
<td>Serum creatinine &gt;1.5 mg/dl OR eGFR &lt;60 ml/min/1.73 m²</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Add All Scores**

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Risk of CIN</th>
<th>Risk of Dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤5</td>
<td>7.5%</td>
<td>0.04%</td>
</tr>
<tr>
<td>6-10</td>
<td>14%</td>
<td>0.12%</td>
</tr>
<tr>
<td>11-16</td>
<td>26.1%</td>
<td>1.09%</td>
</tr>
<tr>
<td>≥16</td>
<td>57.3%</td>
<td>12.6%</td>
</tr>
</tbody>
</table>

JACC 2004; 44: 1393-9
# Alternative Model of CIN

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creatinine clearance &lt;60 ml/min</td>
<td>2</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>2</td>
</tr>
<tr>
<td>Urgent/emergency procedure</td>
<td>2</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>1</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>1</td>
</tr>
<tr>
<td>Contrast &gt;260 ml</td>
<td>1</td>
</tr>
</tbody>
</table>

## Validation Cohort

![Bar chart showing risk of CIN across different score ranges.]

- **Risk Score**
- **Score Range:** 0-4, 5-6, 7-8, 9-11
- **Risk of CIN**

Am J Cardiol 2004; 93:1515-19
Ann Int Med; 150:170-7
Preventing Contrast-Induced Nephropathy

• Identify risks
  – Higher risk – eGFR < 60 mL/min/1.73m²
  – Diabetes
• Manage medications
  – Hold nephrotoxic drugs (e.g., NSAIDS)
• Management intravascular volume
  – Hydrate with normal saline pre-cath
  – LVEDP guided post cath hydration
• Radiographic contrast
  – Minimize contrast volume
  – Use either low-osmolar or iso-osmolar contrast
• Follow-up: Obtain 48 hour creatinine
Preventing Contrast-Induced Nephropathy

CIN Prevention: Pre-Cath Hydration

sodium chloride 0.9 % bolus 3 mL/kg

3 mL/kg, Intravenous, Administer over 60 Minutes, ONCE, Today at 0900. For 1 dose
Pre-procedural hydration= administer 3ml/kg for ONE HOUR PRIOR to procedure. Intra-procedural hydration=
As approved by interventional cardiologist, use LVEDP-guided hydration for fluid administration throughout procedure Maximum dose = 300 mL
Pre-Procedure(Cath), Sign & Hold
Preventing Contrast-Induced Nephropathy

CIN Prevention: Post-Cath Hydration

** IV Fluids

** FOR LHC/PCI ONLY **

** Contraindicated for ESRD/Dialysis patients **

- ** Post-Procedure fluids not indicated **
  No Post Cath Procedure Fluids

- ** LVEDP less than 13 - 0.9% NaCl at 5 ml/kg/hr for 2 HOURS POST PROCEDURE **
  5 ml/kg/hr, Intravenous, Continuous, for 2 hours, For LVEDP less than 13 Maximum dose = 500 mL/hr based on maximum dosing weight of 100 kg

- ** LVEDP less than 13 - 0.9% NaCl at 5 ml/kg/hr for 4 HOURS POST PROCEDURE **
  5 ml/kg/hr, Intravenous, Continuous, for 4 hours, For LVEDP less than 13 Maximum dose = 500 mL/hr based on maximum dosing weight of 100 kg

- ** LVEDP 13 to 18 - 0.9% NaCl at 3 ml/kg/hr for 2 HOURS POST PROCEDURE **
  3 ml/kg/hr, Intravenous, Continuous, for 2 hours, For LVEDP 13-18 Maximum dose = 300 mL/hr based on maximum dosing weight of 100 kg

- ** LVEDP 13 to 18 - 0.9% NaCl at 3 ml/kg/hr for 4 HOURS POST PROCEDURE **
  3 ml/kg/hr, Intravenous, Continuous, for 4 hours, For LVEDP 13-18 Maximum dose = 300 mL/hr based on maximum dosing weight of 100 kg

- ** LVEDP greater than 18 or LVEDP not obtained - 0.9% NaCl at 1.5 ml/kg/hr for 2 HOURS POST PROCEDURE **
  1.5 ml/kg/hr, Intravenous, Continuous, for 2 hours, For LVEDP greater than 18 or LVEDP not obtained Maximum dose = 150 mL/hr based on maximum dosing weight of 100 kg

- ** LVEDP greater than 18 or LVEDP not obtained - 0.9% NaCl at 1.5 ml/kg/hr for 4 HOURS POST PROCEDURE **
  1.5 ml/kg/hr, Intravenous, Continuous, for 4 hours, For LVEDP greater than 18 or LVEDP not obtained Maximum dose = 150 mL/hr based on maximum dosing weight of 100 kg
Overview

Pre-Op Evaluation
• Consent
• CIN Prevention

Vascular Access
• Complication prevention and management
• Femoral vs. Radial
Preventing Access Complications

• Step 1

Recognize that vascular access is taken for granted, under-investigated, and over-represented in complications.

Image: https://www.researchgate.net/figure/224830285_Fig1_Fig-1-Large-right-groin-and-forearm-hematomas
Local complications of FA access: 2-10%

- Hematoma (1-12%)
- Pseudoaneurysm (1-6%)
- AV fistula (<1%)
- Vessel laceration (<1%)
  - Free bleeding
- Intimal dissection
  - Ante- or retro-grade
- Acute vessel closure (<1%)
  - Thrombosis (small artery lumen)
- Retroperitoneal hemorrhage (0.2 – 0.9%)
- Thickening of the perivascular tissues
- Neural damage
- Infection
- Venous thrombosis
- Pericatheter clot

Complication rate has been persistent over many decades

Most common: hematoma
Most lethal: retroperitoneal hemorrhage
Usual Approach

- Keep poking until you get a gusher
Landmarks Used for Femoral Puncture

- Skin Crease
- Maximum Pulse
- Bony Landmarks

This is NOT Normal Anatomy
Odds Ratio RPH 18:1
Preventing Access Complications

Step 2: Choose a landmark.
Preventing Access Complications

- Step 3

Micropuncture
**Step 3: Preventing Access Complications**

**Micropuncture**

- **Std needle (18g)** = 1.27 mm
- **Micropuncture (21g)** = 0.813 mm

- **↑ In size = 56%**

**5.9 fold ↑ in blood loss**
• Step 4
  
  **Good Closure**

• Hold time
  – 15 minutes diagnostic
  – 30 minutes intervention
  – Bedrest 6 hours

• Hold location
  – Proximal
  – Over palpable pulse
## Preventing Access Complications

### Risk Factors for Bleeding

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;75 vs. &lt;55</td>
<td>2.59</td>
</tr>
<tr>
<td>Heparin use postprocedure</td>
<td>2.46</td>
</tr>
<tr>
<td>Severe renal impairment</td>
<td>2.25</td>
</tr>
<tr>
<td>Age 65–74 vs. &lt;55</td>
<td>2.18</td>
</tr>
<tr>
<td>Female patient</td>
<td>1.64</td>
</tr>
<tr>
<td>Closure device use</td>
<td>1.58</td>
</tr>
<tr>
<td>Sheath size 7F–8 F vs. &lt;6</td>
<td>1.53</td>
</tr>
<tr>
<td>GP IIb/IIIa use</td>
<td>1.39</td>
</tr>
<tr>
<td>Longer procedure duration</td>
<td>1.2</td>
</tr>
</tbody>
</table>


## Preventing Access Complications

<table>
<thead>
<tr>
<th>Access Complication</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudoaneurysm</td>
<td>61.2</td>
</tr>
<tr>
<td>Hematoma</td>
<td>11.2</td>
</tr>
<tr>
<td>Arteriovenous fistula</td>
<td>10.2</td>
</tr>
<tr>
<td>External bleeding</td>
<td>6.1</td>
</tr>
<tr>
<td>Retroperitoneal hematoma</td>
<td>5.1</td>
</tr>
<tr>
<td>Arterial thrombosis</td>
<td>3.1</td>
</tr>
<tr>
<td>Groin abscess</td>
<td>2.0</td>
</tr>
<tr>
<td>Mycotic aneurysm</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Femoral Access Complications Requiring Interventions**

Preventing Access Complications

Pseudoaneurysms

**Procedural Factors**
- Catheterization of both artery and vein
- Cannulation of the superficial femoral or profunda femoris rather than common femoral
- Inadequate compression post procedure
- More anticoagulation used

**Patient Factors**
- Obesity
- Hemodialysis
- Calcified arteries

- Low puncture site
- Inadequate pressure
- Experience of sheath-puller
Preventing Access Complications

• Step 4
  • Patient comfort and convenience
    – Early hemostasis
    – Early ambulation

• Decreased complications?
  – NO!
Meta-analysis of Closure Devices

Dx studies
- OR (95% CI): 1.44 [0.43, 4.82]†
- OR (95% CI): 0.66 [0.18, 2.38]*
- Heterogeneity test P-value: 0.0003

PCI studies
- OR (95% CI): 1.11 [0.94, 1.33]*
- OR (95% CI): 1.35 [0.87, 2.11]*
- Heterogeneity test P-value: 0.15

Both Dx+PCI studies
- OR (95% CI): 1.83 [1.15, 2.90]†
- OR (95% CI): 1.15 [0.67, 1.98]*
- Heterogeneity test P-value: 0.001

All studies
- OR (95% CI): 1.34 [1.01, 1.79]†
- OR (95% CI): 1.30 [0.90, 1.87]*
- Heterogeneity test P-value: <0.0001

Heterogeneity test P-value
- Favors ACD
- Favors Control

ACC/AHA Class III indication to lower complication rates

Preventing Access Complications

1. Don’t take access for granted
2. Access the common femoral over the femoral head
3. Use micropuncture
4. Quality hemostasis/closure
5. GO RADIAL!
Registry Data: Transradial PCI in the UK

**FIGURE 1** Use of Access Site for PCI Between 2007 and 2012

Numbers of procedures using femoral or radial access and indication for percutaneous coronary intervention (PCI) in the United Kingdom between 2007 and 2012. NSTEACS = non-ST-segment elevation acute coronary syndrome; STEACS = ST-segment elevation acute coronary syndrome.
Transradial Use for STEMI in the US

Figure 3  Temporal Trend in Use of TRI for STEMI PCI from 2007 to 2011

Large Associated Benefit

Bleed

- Stable: 0.24 (0.16-0.36) p<0.001
- NSTEACS: 0.35 (0.27-0.44) p<0.001
- STEACS: 0.47 (0.39-0.58) p<0.001

Access site complications

- Stable: 0.21 (0.16-0.27) p<0.001
- NSTEACS: 0.19 (0.15-0.24) p<0.001
- STEACS: 0.16 (0.11-0.23) p<0.001

30-Day Mortality

- Stable: 0.77 (0.61-0.97) p=0.03
- NSTEACS: 0.76 (0.67-0.85) p<0.001
- STEACS: 0.72 (0.65-0.79) p<0.001

MACE

- Stable: 1.08 (0.95-1.23) p=0.25
- NSTEACS: 0.72 (0.65-0.80) p<0.001
- STEACS: 0.70 (0.64-0.77) p<0.001

Katib et al. JACC Intv 2015.
Oximetry + Plethysmography

The clamp sensor is applied to the thumb.

- **Type A**: No damping of pulse tracing immediately after radial artery compression. 
  - 15% of patients

- **Type B**: Damping of pulse tracing.
  - 75% of patients

- **Type C**: Loss of pulse tracing followed by recovery of pulse tracing within 2 minutes.
  - 5% of patients

- **Type D**: Loss of pulse tracing without recovery within 2 minutes.
  - 5% of patients

n=1,010 patients
Arm is very well collateralized

- No correlation to hand ischemia & arterial lines\(^1\)
- Extensive radial CABG experience without ischemia
- Radial harvest with abnormal Allen’s Test is possible\(^2\)

*Theoretical fears from an abnormal Allens Test is a poor excuse for a real risk of groin complications*

1. J Trauma 2006;206:468-70
TR band management


TR band management

- All patients with radial access will have TR band and stabilization device (armboard)
- TR band deflation 1-2 hours after diagnostic cath and 2-4 hours for interventional cath
- Deflate air by 3 ml every 15 minutes until band is deflated
  - If bleeding occurs, re-inflate band in 3 mL increments until bleeding stops
- Armboard for 24 hours or until discharge, whichever first
Hematoma or Swelling on Return to Room?
Hematoma or Swelling on Return to Room?
Managing a Perforation

- Early recognition
- Wrap potential bleeding site
- Wrap forearm swelling not related to hemostasis device at any time
Conclusions

• Consent is a critical part of the procedure
• Think ahead to avoid contrast induced nephropathy
• Access is taken for granted, and is over-represented in complications
• Radial access decreases bleeding, and mortality