Patient Selection, Preparation, Access...

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Associate Professor of Medicine
Catheterization of the Left Side of the Heart in Man

By Henry A. Zimmerman, M.D., Roy W. Scott, M.D., and Norman O. Becker, M.D.

The technic employed in catheterization of the left heart in man is described. A catheter is introduced into the left ulnar artery and passed through the brachial, axillary and subclavian arteries into the arch of the aorta. With the tip of the catheter at the root of the aorta, we have succeeded in entering the left ventricle only in patients with free aortic insufficiency due to syphilis. Failure to pass the aortic valves in normal subjects is discussed.

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Aided by a Grant from the Louis D. Beaumont Foundation.

Radial Access Over the Past 2 Decades

• 1989: TRA for coronary angiography – Campeau
• 1992: TRA for coronary stenting – Kiemeneij
• After initial enthusiasm, interest in TRA is lost, especially in US
  – No industry support?
  – Introduction of vascular closure devices?
• 2000: Bleeding and Transfusions identified as a predictor of death in ACS patients
  – Concept of “Bleeding Avoidance Strategies” is introduced
  – TRA offers potential to reduce access-related bleeding
• Renewed interest in Europe & multiple countries adopting TRA as preferred vascular access
  – US lagging behind with < 2% use in 2007
The use of radial artery access can be useful to decrease access site complications.
ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indications for primary PCI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary PCI is the recommended reperfusion therapy over fibrinolysis if performed by an experienced team within 120 min of FMC.</td>
<td>I</td>
<td>A</td>
<td>69, 99</td>
</tr>
<tr>
<td>Primary PCI is indicated for patients with severe acute heart failure or cardiogenic shock, unless the expected PCI related delay is excessive and the patient presents early after symptom onset.</td>
<td>I</td>
<td>B</td>
<td>100</td>
</tr>
<tr>
<td><strong>Procedural aspects of primary PCI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenting is recommended (over balloon angioplasty alone) for primary PCI.</td>
<td>I</td>
<td>A</td>
<td>101, 102</td>
</tr>
<tr>
<td>Primary PCI should be limited to the culprit vessel with the exception of cardiogenic shock and persistent ischaemia after PCI of the supposed culprit lesion.</td>
<td>IIA</td>
<td>B</td>
<td>75, 103–105</td>
</tr>
<tr>
<td>If performed by an experienced radial operator, radial access should be preferred over femoral access.</td>
<td>IIA</td>
<td>B</td>
<td>78, 79</td>
</tr>
<tr>
<td>If the patient has no contraindications to prolonged DAPT (indications for oral anticoagulation, or estimated high long-term bleeding risk) and is likely to be compliant, DES should be preferred over BMS.</td>
<td>IIA</td>
<td>A</td>
<td>80, 82, 106, 107</td>
</tr>
<tr>
<td>Routine thrombus aspiration should be considered.</td>
<td>IIA</td>
<td>B</td>
<td>83–85</td>
</tr>
<tr>
<td>Routine use of distal protection devices is not recommended.</td>
<td>III</td>
<td>C</td>
<td>86, 108</td>
</tr>
<tr>
<td>Routine use of IABP (in patients without shock) is not recommended.</td>
<td>III</td>
<td>A</td>
<td>97, 98</td>
</tr>
</tbody>
</table>
ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation

If performed by an experienced radial operator, radial access should be preferred over femoral access.

IIa  B  78, 79

Eur Heart J 2012
Consensus document on the radial approach in percutaneous cardiovascular interventions: position paper by the European Association of Percutaneous Cardiovascular Interventions and Working Groups on Acute Cardiac Care** and Thrombosis of the European Society of Cardiology

Martial Hamon**, MD; Christian Pristipino**, MD; Carlo Di Mario†, MD, PhD; James Nolan†, MD; Josef Ludwig†, MD, PhD; Marco Tubaro†, MD; Manel Sabate†, MD, PhD; Josepa Mauri-Ferré†, MD; Kurt Huber§, MD; Kari Niemelä¶, MD; Michael Haude¶, MD; William Wijns¶, MD, PhD; Dariusz Dudek¶, MD; Jean Fajadet¶, MD; Ferdinand Kiemeneij¶, MD, PhD

International experts: Gerald Barbeau**, MD; Shigeru Saito†, MD; Sanjit Jolly†, MD; Yves Louvard†, MD; Tejas Patel**, MD; Sunil V Rao†, MD; Nicolaus Reifart¶, MD; Philippe Gabriel Steg‡, MD; Orazio Valsecchi¶, MD; Yuenjin Yang¶, MD
LEARNING STEPS AND COMPETENCY LEVELS

Level 1:
- Diagnostic procedures in male first and then in female patients with good radial pulse <70 years old

Level 2:
- Planned PCI in selected patients with type A or B lesions, stable clinical setting
- Diagnostic for all stable patients (elderly, bypass graft, short stature)

Level 3:
- PCI for all-comers in stable clinical setting including complex PCI
- NSTE-ACS patients
- STEMI patients
Transradial Arterial Access for Coronary and Peripheral Procedures: Executive Summary by the Transradial Committee of the SCAI

- **Level 1 competency**
  - Simple diagnostic cases on patients with favorable upper limb anatomy (large men).

- **Level 2 competency**
  - Simple diagnostic and interventional procedures on patients with more challenging upper limb anatomy (elective single vessel PCI; bypass grafts, small women, radial and subclavian loops).

- **Level 3 competency**
  - Complex interventional procedures even with challenging limb anatomy (CTOs, multivessel, AMI).

Caputo R et al. CCI 2011; 78:823–839
• Precise puncture & never push (finesse over muscle)
• Prophylactic antispasm medication is needed
  – Verapamil 3 mg / NTG
• Anticoagulate to prevent (reduce) thrombosis
  – Heparin 5000 U (~50 U/Kg in lighter patients)
• Hold on to hard won territory (exchange wire or jet-catheter exchange technique)
• Find a catheter series that works for you (practice makes perfect)
• Remove the sheath at the end of the case
## Anatomical Features & Clinical Consequences

<table>
<thead>
<tr>
<th>Anatomic Features</th>
<th>Clinical Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat bony surface of the radius</td>
<td>Ease of compression</td>
</tr>
<tr>
<td>Collateralization of the radial artery</td>
<td>Absence of Ischemia</td>
</tr>
<tr>
<td>Puncture not over joint</td>
<td>Motion does not increase risk</td>
</tr>
<tr>
<td>No major adjacent nerve</td>
<td>No neurologic sequelae</td>
</tr>
</tbody>
</table>

• Native of Cozad, Nebraska
• Professor of Medicine at the Mayo Clinic, Rochester, MN
• Introduced his “compression test” to diagnose arterial occlusion resulting from thromboangiitis obliterans, or Buerger’s disease
  – American Journal of the Medical Sciences, August 1929
• Pioneer the development of anticoagulants (Vit K antagonists)
• Allen-Hines Syndrome
• In 1942, Chief Medical Consultant for the Seventh Service Command in the United States Army Medical Corps
• In 1946, wrote “Peripheral Vascular Disease”, which was considered the “… Bible in his specialty for some time.”

Modified Allen’s Test  Oxymetry + Plethysmography
The clamp sensor is applied to the thumb

- **Type A**: No damping of pulse tracing immediately after radial artery compression (15%)
- **Type B**: Damping of pulse tracing (75%)
- **Type C**: Loss of pulse tracing followed by recovery of pulse tracing within 2 minutes (5%)
- **Type D**: Loss of pulse tracing without recovery within 2 minutes (5%)

n=1,010 patients

Arm is very well collateralized

- No correlation to hand ischemia & arterial lines¹
- Extensive radial CABG experience without ischemia
- Radial harvest with abnormal Allen’s Test is possible²
- Hand ischemia from transradial procedures has not been a problem despite a >15 year experience

Theoretical fears from an abnormal Allen’s Test is a poor excuse for a real risk of groin complications

1. J Trauma 2006;206:468-70
Superficial palmar arch (primarily ulnar) Deep palmar arch (primarily radial)
RADAR Study $N=203$ patients

Valgimigli M, et. al. JACC 2014
RADAR Study $N=203$ patients

Valgimigli M, et. al. JACC 2014
From this carefully performed mechanistic study, one can conclude that the AT and oximetry-plethysmography are not reliable tests to predict distal ischemia, loss of strength, or discomfort after transradial catheterization.

On the basis of the results of RADAR, we believe that the denial of radial access for diagnostic angiography or interventions solely on the basis of an abnormal AT or oximetry-plethysmography curve is not warranted, because these tests are not scientifically predictive of pathologic rises in lactate levels, weakness in the hand, or persistent discomfort during or after transradial catheterization.

The time has come to remove the AT from pre-procedural triage for transradial catheterization. We need to refocus our attention on the use of oximetry-plethysmography and other techniques to guide “patent hemostasis” once the transradial procedure is completed to minimize RAO.
Patient Positioning

- Use of an oversized board
- Hyperextension of the wrist
- Use a “brachial/radial drape”
- Setup to facilitate comfortable work
Safe and effective methods for patient assessment and procedural setup from the right or left radial artery approach

<table>
<thead>
<tr>
<th>TABLE 1. COMPARISON BETWEEN RIGHT AND LEFT RADIAL ACCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right Radial Access</strong></td>
</tr>
<tr>
<td>Acceptability</td>
</tr>
<tr>
<td>Preparation and setup</td>
</tr>
<tr>
<td>Comfort for the operator</td>
</tr>
<tr>
<td>Learning curve</td>
</tr>
<tr>
<td>Catheter manipulation</td>
</tr>
<tr>
<td>Radiation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Efficacy and safety</td>
</tr>
</tbody>
</table>
Left Radial Access

• Prop up arm to be above left groin
• Access artery from left side, then have patient pronate arm and place it over the left leg
• Case is performed from the right side as usual
• Catheters
  – JR4, JL3.5, MPA2
  – TIG 4.0
  – May need IMA for LIMA, AL1.0 for SVGs
In this left radial access setup, the wrist is positioned across the midline on top of the right groin. The operator performs the catheterization on the right side of the patient, as in right femoral access.
TALENT TRIAL: Right vs. Left Radial

Cross-over to Femoral: Incidence and Classification


Overall 14 puncture and radial failure vs 1 epi-aortic failure, p = 0.0008
TALENT TRIAL: Right vs. Left Radial  Operator’s experience matters

The pulse oxymeter is placed on the thumb and the wrist is hyper extended using a towel.
Access Techniques

• Access the radial artery ≥ 2 cm proximal to the radial styloid process
• Avoid access over the flexor retinaculum
• Back-wall puncture technique
  – Seldinger method
  – Micropuncture IV catheter (fine metal needle and a 22G Teflon catheter) → “Angiocath”
• Single wall technique
  – Short 2.5 cm stainless steel 21G needle
• Both allow the passage of a 0.018”-0.021” guidewire
Smooth venous access
Better comfort for the patient
Pts Undergoing Cath or PCI via the Radial Artery

2x2 Factorial Randomization

<table>
<thead>
<tr>
<th></th>
<th>Long (23 cm) n=396</th>
<th>Short (13 cm) n=394</th>
<th>Coated n=397</th>
<th>Uncoated n=393</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operator RAS</strong></td>
<td>110 (27.9%)</td>
<td>120 (30.8%)*</td>
<td>75 (19.0%)</td>
<td>155 (39.9%)^</td>
</tr>
<tr>
<td><strong>Patient discomfort</strong></td>
<td>85 (21.5%)</td>
<td>87 (22.2%)*</td>
<td>60 (15.1%)</td>
<td>112 (28.5%)^</td>
</tr>
</tbody>
</table>

*p=NS  ^p<0.001

Young age, female sex, diabetes, and low BMI to be independent predictors of RAS
Tapered transition between sheath and wire makes skin nick unnecessary.
Radial Artery Access Technique Evaluation Trial

Pancholy, Sanghvi et al. CCI 2012

Radial Catheterization

- Back wall technique (n=210)
- Single wall technique (n=202)

Procedural Characteristics
Complications

<table>
<thead>
<tr>
<th>Two operators</th>
<th>Anticoagulation: 50 U/Kg UFH</th>
</tr>
</thead>
<tbody>
<tr>
<td>5F hydrophylic-coated sheaths</td>
<td>Hemostasis: TR Band applied for 2 hs</td>
</tr>
<tr>
<td>Vasodilators: Diltiazem 5 mg + NTG 200 mcg</td>
<td></td>
</tr>
</tbody>
</table>
Results: Complications

- Hematoma:
  - Back wall (n=210): 0.5%
  - Single wall (n=202): 1.5%

- Early RAO:
  - Back wall (n=210): 8%
  - Single wall (n=202): 7.9%

- Chronic RAO:
  - Back wall (n=210): 4.3%
  - Single wall (n=202): 3.9%
## Results: Procedure Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Back wall Technique (n=210)</th>
<th>Single Wall Technique (n=202)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Time (sec)</td>
<td>78.3 ± 37.7</td>
<td>134.2 ± 87.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>17.1 ± 6.4</td>
<td>19.3 ± 7.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number of attempts</td>
<td>1.7 ± 0.8</td>
<td>2.2 ± 0.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>First Attempt Access</td>
<td>53%</td>
<td>16%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Crossover</td>
<td>0</td>
<td>10.8%</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
What if We Lose the Radial Pulse?

- Can occur in up to 5% of cases after repeated attempts to puncture the radial artery

Watch and wait for the return of radial pulse

Sublingual NTG

Subcutaneous NTG 200 mcg

Pancholy et al. CCI 2012
Time to Return of Radial Pulse

![Bar chart showing time to return of radial pulse for different therapies.]

- **No Therapy**: 18 minutes
- **SL NTG**: 8 minutes
- **SQ NTG**: 3 minutes

* * p< 0.001

Pancholy et al. CCI 2006
US Tips:
• Keep probe near/over needle
• Mark the center of the probe and line up artery with centerline marker of image
• Short jabs on the skin or tissue to identify needle tip
• Compress the skin to close the veins
• Note compression of artery
1. Image

2. Compress

3. Puncture

4. Confirm

Courtesy A. Seto, MD
Design

DESIGN: Prospective, multicenter randomized study

OBJECTIVE: To evaluate the accuracy of ultrasound vs. palpation guidance for radial access.

SITE LEAD INVESTIGATORS: Arnold Seto, Jonathan Roberts, Mazen Abu-Fadel, Zoran Lasic

SITES:
Jamaica / Lenox Hill Hospital (357)
Long Beach VA / UC-Irvine (193)
Miami Baptist (98)
Oklahoma VA (50)

* First 225 patients from Jamaica Hospital censored due to first-pass success (96.5% P and 97.3% US) incorrectly counted by # separate punctures rather than # of attempts. Data included for other outcomes esp. time to access.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Palpation N=351</th>
<th>Ultrasound N=347</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>62.3</td>
<td>61.5</td>
<td>0.80</td>
</tr>
<tr>
<td>Male</td>
<td>262 (75%)</td>
<td>254 (73%)</td>
<td>0.66</td>
</tr>
<tr>
<td>Outpatient</td>
<td>141 (40%)</td>
<td>139 (40%)</td>
<td>0.98</td>
</tr>
<tr>
<td>Body mass index (BMI)</td>
<td>30.2</td>
<td>30.4</td>
<td>0.64</td>
</tr>
<tr>
<td>Obesity (BMI &gt;30)</td>
<td>153 (44%)</td>
<td>149 (43%)</td>
<td>0.86</td>
</tr>
<tr>
<td>Hypertension</td>
<td>305 (87%)</td>
<td>292 (84%)</td>
<td>0.30</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>265 (75%)</td>
<td>254 (73%)</td>
<td>0.49</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>151 (43%)</td>
<td>149 (43%)</td>
<td>0.98</td>
</tr>
<tr>
<td>Tobacco</td>
<td>107 (30%)</td>
<td>128 (37%)</td>
<td>0.07</td>
</tr>
<tr>
<td>PVD</td>
<td>16 (5%)</td>
<td>14 (4%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Barbeau’s Class B or C</td>
<td>54 / 149 (36%)</td>
<td>56 / 149 (38%)</td>
<td>0.81</td>
</tr>
</tbody>
</table>
# Procedural Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Palpation N=351</th>
<th>Ultrasound N=347</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>63 (18%)</td>
<td>73 (21%)</td>
<td>0.30</td>
</tr>
<tr>
<td>SF Sheath</td>
<td>193 (55%)</td>
<td>185 (53%)</td>
<td>0.66</td>
</tr>
<tr>
<td>Single wall technique</td>
<td>306 (87%)</td>
<td>295 (85%)</td>
<td>0.41</td>
</tr>
<tr>
<td>Right radial access</td>
<td>323 (92%)</td>
<td>328 (95%)</td>
<td>0.19</td>
</tr>
<tr>
<td>Verapamil (≥2.5mg)</td>
<td>340 (97%)</td>
<td>342 (99%)</td>
<td>0.20</td>
</tr>
<tr>
<td>Nitroglycerin (≥100mcg)</td>
<td>271 (77%)</td>
<td>278 (80%)</td>
<td>0.35</td>
</tr>
<tr>
<td>Lidocaine IA (5mg)</td>
<td>167 (48%)</td>
<td>170 (49%)</td>
<td>0.71</td>
</tr>
<tr>
<td>TR band Closure</td>
<td>225 (64%)</td>
<td>229 (66%)</td>
<td>0.60</td>
</tr>
<tr>
<td>D-stat band</td>
<td>114 (33%)</td>
<td>111 (32%)</td>
<td>0.89</td>
</tr>
<tr>
<td>Heparin</td>
<td>322 (92%)</td>
<td>321 (92%)</td>
<td>0.71</td>
</tr>
<tr>
<td>Heparin dose</td>
<td>3487 U</td>
<td>3700 U</td>
<td>0.16</td>
</tr>
<tr>
<td>GPIIb/IIIa</td>
<td>13 (4%)</td>
<td>14 (4%)</td>
<td>0.82</td>
</tr>
<tr>
<td>Bivalirudin</td>
<td>51 (15%)</td>
<td>50 (14%)</td>
<td>0.96</td>
</tr>
<tr>
<td>P2Y12 Inhibitor</td>
<td>193 (55%)</td>
<td>200 (58%)</td>
<td>0.48</td>
</tr>
</tbody>
</table>
Number of Attempts

- **Palpation**: 3.05 attempts (N = 237)
- **Ultrasound**: 1.65 attempts (N = 236)

Significance:

\[ p < 0.0001 \]
First Pass Success Rate

- **Ultrasound**: 64.8%
- **Palpation**: 43.9%

**N = 237** (Palpation) vs **N = 236** (Ultrasound)

Statistical significance: *p* < 0.0001

Courtesy A. Seto, MD
Time to access

Palpation: 108 seconds (N = 351)
Ultrasound: 88 seconds (N = 347)

P = 0.006
Difficult Access

≥ 5 attempts
P<0.001

≥ 5 minutes
P=0.07

Percent

2.4%
3.7%

237
236

237
236

6.8%
18.6%

351
347

Palpation
Ultrasound
Palpation
Ultrasound

Courtesy A. Seto, MD
## Clinical Outcomes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Palpation (N=351)</th>
<th>Ultrasound (N=347)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spasm</td>
<td>12 (3%)</td>
<td>15 (4.3%)</td>
<td>0.56</td>
</tr>
<tr>
<td>Pain score (0-10)</td>
<td>0.71</td>
<td>0.69</td>
<td>0.85</td>
</tr>
<tr>
<td>Bleeding</td>
<td>4 (1.1%)</td>
<td>5 (1.4%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Crossover to ultrasound rescue attempts after &gt;5 minutes</td>
<td>10 (8 successful)</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Crossover to other site after successful sheath insertion</td>
<td>5</td>
<td>2</td>
<td>0.45</td>
</tr>
<tr>
<td>Crossover to other site before sheath insertion / failed access</td>
<td>7</td>
<td>3</td>
<td>0.34</td>
</tr>
</tbody>
</table>
• No pretreatment is associated with symptomatic spasm in up to 30% of cases
• No definite consensus in terms of spasmolytic agent
  – Verapamil
  – Nicardipine
  – Nitroglycerin

Caputo R et al. SCAI TR Committee. CCI 2011
Radial Spasm Best Management Strategy ➔ Prevention

• Multiple local agents used according to operator’s preference
  – Calcium Channel Blockers: Verapamil or Nicadipine
    • Patient will complain of burning in the hand
  – Consider Nitroglycerin
    • NTG SQ 400 mcg – Pancholy et al. CCI 2006;68:389-91
• Sedation
  – Anxious patients have increased adrenergic tone that can contribute to spasm
• Use a hydrophilic-coated sheath
• Switch to a smaller size catheter
• Look for anatomic variation (high radial origin from the brachial artery)
Anticoagulation and Radial Artery Patency

*Assessed by Doppler examination

Figure 1: General Guideline to Determine Vascular Access, Using a “Radial First” Strategy

1. Determine Guide Catheter Size
   - ≤6 Fr
   - 7 or 8 Fr
   - >8 Fr

2. Radial Artery Ultrasound or Angiogram
   - Radial Artery Accommodates Guide or Sheath
   - Radial Artery Does Not Accommodates Guide or Sheath

3. Access with Real-Time Ultrasound Guidance
   - Yes
   - No

4. Able to Obtain TR access
   - Yes
   - No

5. Extreme Brachial or Subclavian Tortuosity
   - Yes
   - No

6. Presence of Radioulnar Loop
   - Yes
   - No

7. Inability to Engage the Coronaries
   - Yes
   - No

8. No Need for Switch

* Caution is needed when considering ipsilateral ulnar switch after placing a sheath in the radial artery. A limited forearm angiogram is recommended to confirm the presence of a well-developed interosseous branch, a source of collateral circulation to the hand.
Figure 2: Switch to Ipsilateral Ulnar Access in the Presence of a Radioulnar Loop
Conclusions

• Comfortable environment and position
• Precise puncture – never push (finesse over muscle)
• Back wall puncture technique is quicker and easier to teach → Preferred
• Prophylactic antispasm medication is needed
  – Verapamil 3 mg / NTG
• Sequence: RRA → LRA → RFA