Complications of Transradial Catheterization:
What to Look For and How to Avoid Them

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Conflicts of interest

None to declare
Radial Artery Catheterization: The way to go
MORTON KERN, 2009

“The complications from radial artery access are trivial compared to femoral, with <4% loss of radial artery pulse as the worst of it”

“Why do I persist with femoral artery access when complications from radial access are so much lower?”

“I left Quebec with the enthusiasm of a converted sinner, returning to UCI to begin our radial program ….”

http://www.cathlabdigest.com/articles/Radial-Artery-Catheterization-The-way-go
Transradial Catheterization Complications:

*What to Look for and How to Avoid Them*

- Why Use Radial Access?
- Anatomical Considerations
- Complications: Classification and Incidence
- Complications: Prevention and Management
Transradial Catheterization Complications:

**Why Use Radial Access?**

- Patient comfort, early ambulation/discharge
- Safety (...?)
Transradial Catheterization Complications

Radial vs. Femoral Access: Safety

RIVAL CURRENT sub-study

n=7,021

femoral: 3,514
radial: 3,507

1. death/MI/CVA/non CABG bleed

p=NS

4.0%
3.7%

2. non CABG bleed

p=NS

0.5%
0.3%

RIVAL. LANCET 2011
## Transradial Catheterization Complications

### Radial vs. Femoral Access

**RIVAL. LANCET 2011**

<table>
<thead>
<tr>
<th>Other secondary outcomes</th>
<th>Radial</th>
<th>Femoral</th>
<th>Ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI success*</td>
<td>2204 (95.4%)</td>
<td>2235 (95.2%)</td>
<td>1.01 (0.95–1.07)</td>
<td>0.83</td>
</tr>
<tr>
<td>Access site crossover</td>
<td>265 (7.6%)</td>
<td>70 (2.0%)</td>
<td>3.82 (2.93–4.97)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Major vascular complications</td>
<td>49 (1.4%)</td>
<td>131 (3.7%)</td>
<td>0.37 (0.27–0.52)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Minor bleeding</td>
<td>100 (2.9%)</td>
<td>118 (3.4%)</td>
<td>0.84 (0.65–1.10)</td>
<td>0.21</td>
</tr>
</tbody>
</table>

**Post-hoc exploratory outcomes**

| ACUITY major bleeding†                | 66 (1.9%)    | 157 (4.5%)   | 0.43 (0.32–0.57) | <0.0001 |
| Death, MI, or stroke, or ACUITY major bleed† | 167 (4.8%)   | 256 (7.3%)   | 0.65 (0.53–0.78) | <0.0001 |
| Non-CABG major bleeding and major vascular complications | 67 (1.9%) | 157 (4.5%) | 0.43 (0.32–0.57) | <0.0001 |
| Death, MI, stroke, non-CABG major bleeding, or major vascular complications | 167 (4.8%) | 260 (7.4%) | 0.63 (0.52–0.77) | <0.0001 |
Vascular Complications Associated With Arteriotomy Closure Devices in Patients Undergoing Percutaneous Coronary Procedures: A Meta-Analysis

n=37,066

Nikolsky. JACC 2004
Transradial Catheterization Complications:

**What to Look for and How to Avoid Them**

- Why Use Access?
- Anatomical Considerations
- Classification and Incidence
- Prevention and Management
Transradial Catheterization Complications:

Anatomical Considerations

Congenital variants

Arterial tortuosity

Lo et al. Heart 2009
### Congenital anatomical variants

<table>
<thead>
<tr>
<th>Location</th>
<th>Variant</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm</td>
<td>Superficial brachial</td>
<td>≦2-3:1,000</td>
</tr>
<tr>
<td></td>
<td>Accessory brachial</td>
<td>≦2-3:1,000</td>
</tr>
<tr>
<td>Arm and Forearm</td>
<td>Brachio-radial</td>
<td>≦15:100</td>
</tr>
<tr>
<td></td>
<td>Brachio-ulnar</td>
<td>≦15:100</td>
</tr>
<tr>
<td></td>
<td>Brachio-interosseous</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brachio-median</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Superficial brachio-radial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Superficial brachio-ulnar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Superficial brachio-ulnoradial</td>
<td></td>
</tr>
<tr>
<td>Forearm</td>
<td>Superficial radial</td>
<td>≦3:10,000</td>
</tr>
<tr>
<td></td>
<td>Absent radial</td>
<td>≦3:10,000</td>
</tr>
<tr>
<td></td>
<td>Absent ulnar</td>
<td>≦1-2:10,000</td>
</tr>
</tbody>
</table>

### Arterial tortuosity

<table>
<thead>
<tr>
<th>Location</th>
<th>Variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial</td>
<td>Loops 2.5:100</td>
</tr>
<tr>
<td></td>
<td>Tortuosity 2:100</td>
</tr>
</tbody>
</table>

Transradial Catheterization Complications: Anatomical Considerations

- **n=1,560**
- **4.6%**
- **37%**
- **23%**
- **13%**

Lo et al. Heart 2009
Transradial Catheterization Complications:

Anatomical Considerations

Radial Anomaly vs. No Radial anomaly

- Mean age: $p < 0.001$
- Women (%): $p = 0.02$
- Mean procedure time (min): $p = NS$
- Procedural failure (%): $p < 0.001$

Lo et al. Heart 2009
Transradial Catheterization Complications:

What to Look for and How to Avoid Them

- Why Use Access?
- Anatomical Considerations
- Classification and Incidence
- Prevention and Management
Transradial Catheterization Complications: Classification and Incidence

<table>
<thead>
<tr>
<th>Event</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic radial artery occlusion</td>
<td>2-18%</td>
</tr>
<tr>
<td>Nonocclusive radial artery injury</td>
<td>common</td>
</tr>
<tr>
<td>Radial artery spasm</td>
<td>5-10%</td>
</tr>
<tr>
<td>Sterile granuloma</td>
<td>2.8%</td>
</tr>
<tr>
<td>Hand ischemia</td>
<td>rare</td>
</tr>
<tr>
<td>Perforation</td>
<td>rare</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>rare</td>
</tr>
<tr>
<td>AV fistula</td>
<td>rare</td>
</tr>
<tr>
<td>Nerve damage</td>
<td>rare</td>
</tr>
<tr>
<td>Hemorrhage/transfusion</td>
<td>rare</td>
</tr>
</tbody>
</table>

Kanei al. CCI 2011
## Transradial Catheterization Complications:

### Risk Factors

<table>
<thead>
<tr>
<th>Event</th>
<th>Risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic radial artery occlusion</td>
<td>- Prolonged high pressure compression</td>
</tr>
<tr>
<td></td>
<td>- Sheath/Artery diameter</td>
</tr>
<tr>
<td></td>
<td>- Multiple puncture attempts</td>
</tr>
<tr>
<td>Nonocclusive radial artery injury</td>
<td>- Inadequate “spasmolysis”/anticoagulation</td>
</tr>
<tr>
<td></td>
<td>- Large caliber catheters</td>
</tr>
<tr>
<td></td>
<td>- Multiple catheter exchanges</td>
</tr>
<tr>
<td></td>
<td>- Aggressive wiring</td>
</tr>
<tr>
<td></td>
<td>- Occlusive hemostasis</td>
</tr>
<tr>
<td>Hand ischemia</td>
<td>- Inadequate anticoagulation</td>
</tr>
<tr>
<td></td>
<td>- Large sheaths</td>
</tr>
<tr>
<td></td>
<td>- Multiple punctures</td>
</tr>
<tr>
<td>Radial artery spasm</td>
<td>- Inadequate “spasmolysis”/anticoagulation</td>
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<tr>
<td>Perforation</td>
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<tr>
<td>Pseudoaneurysm</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>AV fistula</td>
<td>- Multiple punctures</td>
</tr>
<tr>
<td>Sterile granuloma</td>
<td>- Cook sheaths</td>
</tr>
<tr>
<td>Nerve damage</td>
<td>- Multiple punctures</td>
</tr>
</tbody>
</table>

**Operator-related factors:**
- multiple punctures
- inadequate “spasmolysis”/anticoagulation
- large caliber catheters
- multiple catheter exchanges
- aggressive wiring
- occlusive hemostasis
Transradial Catheterization Complications:

Radial Occlusion and Critical Hand Ischemia

Case Report (I)

Kanei et al. CCI 2011
Critical Hand Ischemia

“Hand ischemia with necrosis has never been reported during TRC with thorough pre-examination of intact collateral circulation...”
56 y.o. ♀
Suspected troponin positive ACS
Urgent TRC cath (negative Allen test) ⇒ NCA

Severe “hand pain”
Physical exam reportedly normal, palpable radial pulse
⇒ required opiates
Doppler study
⇒ radial artery occlusion
Transradial Catheterization Complications:

**Case Report (II)**

Vascular surgery consult: heparin, analgesia
RAO can result in critical hand ischemia (i.e., tissue loss) despite dual palmar arch supply !!!
Transradial Catheterization Complications: *What to Look for and How to Avoid Them*

- Why Use Access?
- Anatomical Considerations
- Classification and Incidence
- Prevention and Management
Transradial Catheterization Complications:

**Prevention**

- **Case selection**
  - Age, gender
  - Co-operative patient
  - Palmar arch circulation

- **Access**
  - Liberal anesthesia, analgesia & sedation
  - Small caliber catheters
  - Spasmolytic cocktail
  - Hydrophilic sheaths
  - Anticoagulation (i.v.=i.a., weight adjusted dose)

- **Negotiation of upper extremity vasculature**
  - Avoid non-J-tipped 0.035” wires >> 0.014”
  - Liberal fluoroscopic guidance
  - Anticipate spasm and adverse anatomic features

- **Hemostasis**
  - “Patent hemostasis”
Transradial Catheterization Complications:
Prevention - Case selection

Evaluation of palmar arch circulation
Transradial Catheterization Complications:

**Prevention: Palmar arch circulation**

The use of the Allen’s test is controversial in the transradial catheterization community. It is a standard practice in our institution to perform the Allen’s test as a part of a thorough examination for intact collateral circulation, however many high-volume transradial operators have stopped using the Allen’s test due to a perception that there is no evidence supporting its use in preventing vascular complications.

Would you access the ulnar artery following ipsilateral radial artery harvesting for CABG?

Just Test It!!!
Transradial Catheterization Complications:

**Prevention: Palmar arch circulation**

**Barbeau Test**

Barbeau et al. AHJ 2004

2 separate series:
n=1, 010
n=7, 049

*No* cases of acute hand ischemia
Access site management
Transradial Catheterization Complications:

**Prevention: Access**

- Local anesthesia, liberal analgesia & sedation
- Small caliber catheters
- Spasmolytic cocktail
- Hydrophilic sheaths
- Anticoagulation

*Hydrophilic sheath use reduces radial spasm*

Rathore et al. JACC Cardiovasc Interv 2010

*Route of heparin administration has no impact on radial occlusion rates (i.v.=i.a.)*

Pancholy SB et al. AJC 2009
### Transradial Catheterization Complications:

**Prevention: Access**

*Hydrophilic sheath use reduces radial spasm*

Rathore et al. JACC Cardiovasc Interv 2010

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coated (n = 397)</th>
<th>Uncoated (n = 393)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator RAS</td>
<td>75 (19.0)</td>
<td>155 (39.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patient discomfort</td>
<td>60 (15.1)</td>
<td>112 (28.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Local complication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large hematoma</td>
<td>3 (0.8)</td>
<td>14 (3.7)</td>
<td>0.006</td>
</tr>
<tr>
<td>Noncoronary dissection</td>
<td>1 (0.3)</td>
<td>2 (0.5)</td>
<td>1.00</td>
</tr>
<tr>
<td>RAO at discharge</td>
<td>35 (8.9)</td>
<td>28 (10.0)</td>
<td>0.624</td>
</tr>
<tr>
<td>Late complication (n = 625)</td>
<td>315</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td>9 (2.8)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>11 (3.5)</td>
<td>1 (0.3)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>1 (0.3)</td>
<td>0 (0)</td>
<td>0.570</td>
</tr>
<tr>
<td>RAO at follow-up (n = 625)</td>
<td>24 (7.6)</td>
<td>19 (6.1)</td>
<td>0.436</td>
</tr>
</tbody>
</table>
Transradial Catheterization Complications:

Prevention: Access

Route of heparin administration has no impact on radial occlusion rates

Pancholy SB et al. AJC 2009

n=500

Early and Chronic RAO

Activated Clotting Time

Mean and Standard Deviation

* P > 0.8
** P > 0.6

Early RAO (24h)  Chronic RAO (30d)
Transradial Catheterization Complications:
Prevention –
Negotiation of upper extremity vasculature

“Easy does it”
Transradial Catheterization Complications:

Prevention: **Upper Extremity Vessel Negotiation**

- Minimize use of non-"J-tipped" 0.035" wires
- Fluoroscopic guidance/road mapping
- Anticipate spasm/adverse anatomy
Transradial Catheterization Complications:

**Prevention: Upper Extremity Vessel Negotiation**

- Minimize use of non-”J-tipped” 0.035” wires
- Fluoroscopic guidance/road mapping
- Anticipate spasm/adverse anatomy
Transradial Catheterization Complications: Prevention – Radial artery occlusion

Patent Hemostasis
Transradial Catheterization Complications:

**Prevention: Patent hemostasis**

Pancholy et al. PROPHET. CCI 2008

“Patent hemostasis” reduces risk of radial occlusion

- n=436
- Conventional
- Patent hemostasis “Barbeau test”
- Radial artery patency @ 24-hr, 30-d

Early occlusion (24h) Persistent Occlusion (30d)

- Early occlusion (24h): n=27
  - Conventional: 12%
  - Patent hemostasis: 5%
- Persistent occlusion (30d):
  - Conventional: 7%
  - Patent hemostasis: 1.8%
# Transradial Catheterization Complications: Prevention and Management

<table>
<thead>
<tr>
<th>Event</th>
<th>Prevention/Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial artery occlusion</td>
<td>• Anticoagulation&lt;br&gt;• Patent hemostasis</td>
</tr>
<tr>
<td>Nonocclusive radial artery injury</td>
<td>• Careful evaluation prior to harvesting for CABG</td>
</tr>
<tr>
<td>Hand ischemia</td>
<td></td>
</tr>
<tr>
<td>Radial artery spasm</td>
<td></td>
</tr>
<tr>
<td>Perforation</td>
<td>• Early detection</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>• Compression&lt;br&gt;• Thrombin injection</td>
</tr>
<tr>
<td>AV fistula</td>
<td>• Surgery</td>
</tr>
<tr>
<td>Sterile granuloma</td>
<td>• Removal of hydrophillic coating</td>
</tr>
<tr>
<td>Nerve damage</td>
<td>• Supportive care</td>
</tr>
</tbody>
</table>

**Prevention:**
- Verify functionality of dual palmar arch supply (*Allen, Barbeau tests*)
- Technique and dedicated devices
- Patent hemostasis
Transradial Catheterization Complications:
Prevention and Management of Critical Hand Ischemia

What should be done when radial occlusion is detected?

- Recognize the potential consequences
- Avoid nihilism

- Ulnar artery compression for radial artery occlusions

- Early angiography and intervention for CHI
Transradial Catheterization Complications:

Prevention of Hand ischemia

Ulnar compression can resolve early radial occlusion

Berant et al. AJC 2011

n=465

i.v. heparin 2000u

i.v. heparin 5000u

TR hemostatic band
3-4 hour duplex

RAO

1-hr ulnar occlusion
Transradial Catheterization Complications:

**Prevention of Hand ischemia**

*Ulnar compression can resolve early radial occlusion*

Berant et al. AJC 2011

- n=465
- i.v. heparin 2000u
- i.v. heparin 5000u
- TR hemostatic band
- 3-4 hour duplex

**RAO**

- 1-hr ulnar occlusion

![Graph showing comparison between initial RAO and RAO after UA compression.](chart.png)

- P = 0.17
- P = 0.03
Transradial Catheterization Complications:

Management of Hand ischemia

Early angiography and intervention for critical hand ischemia

Kawarada et al. CCI 2010
Transradial Catheterization Complications:

**Summary**

TRC enhances patient comfort and is likely to reduce the rates of minor vascular complications (vs. TFC).

Though generally very safe, serious potential complications of TRC should be recognized.

Most complications are easily avoided by simple **preventive measures** (*case selection, technique and dedicated devices, patent hemostasis*).

Early detection and intervention should may prevent permanent radial occlusion and critical hand ischemia.