Neurologic complications after transradial or transfemoral approach for diagnostic and interventional cardiac catheterization

Dr Paolo Buja
Trend

Patients undergoing PCI in UK

FEMORAL

RADIAL

Ratib JACC CV Int 2015
Technical issues

- Catheters designed for TFA: curve, mechanic, size and backup
- Catheter manipulation: finger- vs wrist-based, clock- vs counterclockwise
- Friction and resistance points
Rationale

Radial $\uparrow$ embolization risk compared to femoral?
Subclinical events

Cerebral embolism during left catheterization

TC doppler study

100% of patients

GAS 92.1%
Proportional to contrast volume
Especially during catheter flush
Radial = femoral
Not new cerebral lesions

SOLID 7.9%
Radial > femoral
Median 56 vs 36 p 0.012
New cerebral lesions

RCT

Jurga Stroke 2011

Lund Eur Heart J 2005
Risk of brain injury during diagnostic coronary angiography: Comparison between right and left radial approach

Subclinical events

RADIAL

TC doppler study

100% of patients

P 0.035

RIGHT (n 20)  LEFT (n 20)
Neurocognitive impairment

% DW-MRI cerebral infarct

Subclinical events

Lund Eur Heart J 2005

Hamon Am Heart J 2012
Characterization of CVA

Ischemic transient 21.8%

Ischemic permanent 68.2%

Hemorragic 10%

ISCHEMIC 90%
PERMANENT >2/3

Didier Am Heart J 2016, Hoffmann JACC Int 2011
25,626 Pts undergoing PCI from 2002 to 2014

Neurological events 110 = 0.43%
Radial vs Femoral - Registry

348,092 Pts undergoing PCI 2006-2010

Events 386 (0.11%)

439,947 Pts undergoing PCI 2007-2012

<table>
<thead>
<tr>
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<th>TRA (n = 210,260)</th>
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<td>Neurological complication</td>
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<td>0.92 (0.77-1.08)</td>
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Ratib JACC CV Int 2015 and Am Heart J 2013
Radial vs Femoral - RCT

MATRIX – 8000 ACS undergoing PCI: randomized multicentre trial

Stroke incidence and risk

![Graph showing stroke incidence and risk for radial vs femoral access.](image)

- **Pre-RIVAL trials**: 1/341 vs 7/356, OR = 0.26 (0.06-1.23)
- **RIVAL**: 20/3507 vs 14/3514, OR = 1.43 (0.72-2.83)
- **Post-RIVAL trials**: 7/900 vs 5/911, OR = 1.40 (0.45-4.40)
- **MATRIX**: 16/4197 vs 16/4207, OR = 1.00 (0.50-2.00)
- **COMBINED**: 44/8945 vs 42/8988, OR = 1.05 (0.69-1.60)
Right versus left radial artery access for coronary procedures: An international collaborative systematic review and meta-analysis including 5 randomized trials and 3210 patients.

Conclusions: Right and left radial accesses appear largely similar in their overall procedural and clinical performance during transradial diagnostic or interventional procedures. Nonetheless, left radial access can be recommended especially during the learning curve phase to reduce femoral cross-overs.
Independent predictors of neurological complications

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial Access</td>
<td>0.99 (0.79-1.23)</td>
<td>.91</td>
</tr>
<tr>
<td>Age (per 10 years)</td>
<td>1.04 (1.02-1.05)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>GPI use</td>
<td>1.54 (1.23-1.94)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>1.54 (1.05-2.28)</td>
<td>.03</td>
</tr>
<tr>
<td>Female Sex</td>
<td>1.55 (1.24-1.93)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PCI for ACS</td>
<td>2.20 (1.66-2.91)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pre-PCI shock</td>
<td>2.31 (1.43-3.72)</td>
<td>.001</td>
</tr>
<tr>
<td>Previous stroke/TIA</td>
<td>2.80 (2.00-3.95)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>3.02 (1.89-4.82)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Learning curve

Time to PCI end (min)

PCI/y
LOW ≤ 60
MID 61-146
HIGH > 146

Stroke rate (%)

P < 0.001
P 0.001
P 0.78

Jolly JACC 2014
No stroke with 5 Fr

Guiding catheter caliber

No. of catheters

Independent predictors of high incidence of microemboli.

<table>
<thead>
<tr>
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<th>Odds ratio</th>
<th>95% confidence interval</th>
<th>p value</th>
</tr>
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<tbody>
<tr>
<td>Number of catheter</td>
<td>16.47</td>
<td>1.23–219.9</td>
<td>0.034</td>
</tr>
</tbody>
</table>
Transradial Cardiac Catheterization: A Review of Access Site Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Prevalence</th>
<th>Risk factors</th>
<th>Prevention &amp; Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial artery occlusion</td>
<td>2–18%</td>
<td>• Prolonged high-pressure compression&lt;br&gt;• Repeat entry&lt;br&gt;• Low radial artery to sheath ratio</td>
<td>• Anticoagulation&lt;br&gt;• Patent hemostasis</td>
</tr>
<tr>
<td>Nonocclusive radial artery injury</td>
<td>Common</td>
<td></td>
<td>• Careful evaluation before harvesting as a graft</td>
</tr>
<tr>
<td>Hand ischemia</td>
<td>Extremely rare</td>
<td>• Prolonged cannulation</td>
<td>• Careful examination of circulation</td>
</tr>
<tr>
<td>Radial artery spasm</td>
<td>5–10%</td>
<td>• Small radial arteries&lt;br&gt;• Female&lt;br&gt;• Multiple catheter exchanges&lt;br&gt;• Larger sheath size&lt;br&gt;• Inexperience</td>
<td>• Antispasmyotic cocktail&lt;br&gt;• Gentle manipulation</td>
</tr>
<tr>
<td>Perforation</td>
<td>0.1%–1%</td>
<td>• Aggressive wire manipulation&lt;br&gt;• Excessive anticoagulation</td>
<td>• Early detection and pressure bandage for hematoma</td>
</tr>
<tr>
<td>Pseudoaneurysm</td>
<td>Rare (&lt;0.1%)</td>
<td>• Multiple puncture&lt;br&gt;• Catheter infection&lt;br&gt;• Excessive anticoagulation&lt;br&gt;• Larger sheath sizes</td>
<td>• Compression&lt;br&gt;• Thrombin injection&lt;br&gt;• TR band</td>
</tr>
<tr>
<td>Granatoma</td>
<td>2.6%</td>
<td>• Cook sheath</td>
<td>• Supportive care</td>
</tr>
<tr>
<td>AV fistula</td>
<td>Extremely rare</td>
<td>• Multiple puncture</td>
<td>• Removal of the coating&lt;br&gt;• Surgical repair if necessary</td>
</tr>
<tr>
<td>Bleeding/Transfusion</td>
<td>0.15%</td>
<td>•</td>
<td></td>
</tr>
</tbody>
</table>

NERVE DAMAGE: Extremely rare

Our preference or patient preference/need?
And our risk?

Brain malignancy in 35 interventionalist

- Half glioblastoma, **86% left temporal**
- Practice: mean 23 years
- Small studies suggest **OR 6 for brain tumors** among radiologist

RADIATION
Class I carcinogen
Known causal agent

Radial vs femoral - Registry
And our risk?

![Graph showing radiation doses](chart)

- Dose globale al corpo intero: 231 µSv
- Dose agli arti: 6906 µSv
- Dose al cristallino: 1350 µSv
And our risk?

Randomized single center study (n 297)

Radiation exposure

- Femoral
- Radial

Radial vs femoral- Registry

Diagnostic PCI

Lange Cath Card Int 2006
And our risk?

Radial volume and air kerma (mGy)

Radial vs femoral - Registry

PCI/y

LOW ≤70
MID 71-142
HIGH >142

Radial
Femoral

Interaction P 0.021

Radial volume and air kerma (mGy)

Femoral

Radial

Radial volume and air kerma (mGy)

P 0.002
P 0.597
P 0.403

Jolly JACC Int 2013
Conclusion

- **Overall risk very very low for clinical events:**
  - harmful, impressive, permanent, outcome
  - solid embolism (plaque, thrombus)
  - radial= femoral (expert operators)

- **Almost all patients subclinical events:**
  - DTC: air embolism during flush or high volume injection
  - MRI: silent ischemia → neurocognitive impairment
  - radial > femoral

- Association to **catheter** size and number

- **Learning curve**

- Local complications

- Riks is present also for operators
How can we prevent it?

- **Heparinization**
- **Catheters:**
  - aspirate and flush religiously
  - reduce size
  - minimize manipulation and exchanges
- **Continuous training**
- Choice right vs left radial access on patient’s preference
- Protect yourself
Thank you

Paolo Buja

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Rationale

Catheter shape and manipulation

- Catheters are designed for TFA: curve, mechanic, size and backup
- Catheter movements and holding: - finger- vs wrist-based
  - clock- vs counterclock-wise
Rationale

RADIAL worse than FEMORAL?

- Plaque embolization
- Air embolism
- Thrombus formation → ISCHEMIC

TRA = TFA

- Pharmacological treatment
- Predisposing anatomy → HEMORRAGIC
- Trauma
24,126 Pts undergoing PCI

NON TRANISENT 78%
CVA incidence 0.37% (n 89)
Mortality

>10,000 Pts – 1/3 Pts die after PCI related stroke

Jolly Eur Heart J 2015

HR 10.17
(95% CI, 6.7-15.5)
P<0.0001
Radial vs femoral - Registry

16,710 Pts undergoing PCI from 2006 to 2012

Neurological events 0.16%
### Radial vs femoral - Registry

439,947 Pts undergoing PCI 2007-2012

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<td>MACE</td>
<td>3,087 (1.5)</td>
<td>6,079 (2.6)</td>
<td>0.55 (0.53-0.57)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>In-hospital death</td>
<td>1,744 (0.8)</td>
<td>4,275 (1.9)</td>
<td>0.44 (0.42-0.47)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Reinfarction</td>
<td>870 (0.4)</td>
<td>1,150 (0.5)</td>
<td>0.83 (0.76-0.90)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Reintervention</td>
<td>656 (0.3)</td>
<td>932 (0.4)</td>
<td>0.77 (0.70-0.85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bleed</td>
<td>360 (0.2)</td>
<td>1,113 (0.5)</td>
<td>0.35 (0.31-0.40)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Access site complication</td>
<td>209 (0.1)</td>
<td>1,159 (0.6)</td>
<td>0.19 (0.17-0.22)</td>
<td>&lt;0.001</td>
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**TRA = TRF**

Ratib JACC CV Int 2015
Independent predictors of high incidence of microemboli.

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<td>16.47</td>
<td>1.23–219.9</td>
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Cerebral Microembolism During Coronary Angiography
A Randomized Comparison Between Femoral and Radial Arterial Access

TC doppler study

100% of patients

Subclinical events

<table>
<thead>
<tr>
<th>Age</th>
<th>Right Femoral Artery (n=23)</th>
<th>Right Radial Artery (n=20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>4 (17)</td>
<td>2 (10)</td>
<td>0.67</td>
</tr>
<tr>
<td>Hypertension</td>
<td>16 (70)</td>
<td>12 (60)</td>
<td>0.51</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>12 (52)</td>
<td>2 (10)</td>
<td>0.004</td>
</tr>
<tr>
<td>Previous stroke/TIA</td>
<td>4 (17)</td>
<td>2 (10)</td>
<td>0.68</td>
</tr>
<tr>
<td>Previous acute myocardial infarction</td>
<td>3 (13)</td>
<td>4 (20)</td>
<td>0.68</td>
</tr>
<tr>
<td>Previous percutaneous coronary intervention</td>
<td>3 (13)</td>
<td>4 (20)</td>
<td>0.69</td>
</tr>
<tr>
<td>No. of coronary stenoses</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No stenosis</td>
<td>5 (22)</td>
<td>12 (60)</td>
<td></td>
</tr>
<tr>
<td>1–VD</td>
<td>12 (52)</td>
<td>3 (15)</td>
<td></td>
</tr>
<tr>
<td>2–VD</td>
<td>4 (17)</td>
<td>2 (10)</td>
<td></td>
</tr>
<tr>
<td>3–VD</td>
<td>2 (9)</td>
<td>3 (15)</td>
<td></td>
</tr>
<tr>
<td>Contrast volume (mL)</td>
<td>75 (60–100)</td>
<td>82.5 (50–160)</td>
<td>0.31</td>
</tr>
<tr>
<td>Fluoroscopy time (min)</td>
<td>2.5 (1–5)</td>
<td>6 (2–12)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No. of gaseous microemboli</td>
<td>44 (7–131)</td>
<td>58 (19–469)</td>
<td>0.08</td>
</tr>
<tr>
<td>No. of particulate microemboli</td>
<td>6 (1–19)</td>
<td>10 (1–120)</td>
<td>0.02</td>
</tr>
<tr>
<td>Right MCA</td>
<td>2 (0–9)</td>
<td>7 (1–65)</td>
<td>0.004</td>
</tr>
<tr>
<td>Left MCA</td>
<td>3 (0–15)</td>
<td>3 (0–55)</td>
<td>0.57</td>
</tr>
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Jurga Stroke 2011
Cerebral emboli during left heart catheterization may cause acute brain injury

100% of patients (n 47)

GAS 92.1%
Proportional to contrast volume
Especially during catheter flush
Radial = femoral
SOLID 7.9%
Radial > femoral
median 56 vs 36 p 0.012

NEUROCOGNITIVE IMPAIRMENT

MRI
Subclinical events
Silent cerebral infarcts after cardiac catheterization for aortic stenosis: randomized comparison of radial (n 83) vs femoral (n 77)
And our risk?

Paolo Buja - December 2015

Dose globale al corpo intero: 231 μSv
Dose agli arti: 6906 μSv
Dose al cristallino: 1350 μSv
Dose efficace totale: 300 μSv
And our risk?

More patients, more experience

<table>
<thead>
<tr>
<th></th>
<th>Radial</th>
<th>Female</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
</tr>
<tr>
<td>PCI&lt;br&gt;Lange et al (2006) PCI</td>
<td>46.3</td>
<td>28.7</td>
<td>54</td>
</tr>
<tr>
<td>Achenbach et al (2008)</td>
<td>3.74</td>
<td>2.367</td>
<td>152</td>
</tr>
<tr>
<td>Brueck et al (2009)</td>
<td>37.89</td>
<td>20.84</td>
<td>512</td>
</tr>
<tr>
<td>Jolly et al (2013) PCI</td>
<td>90</td>
<td>80</td>
<td>694</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td></td>
<td></td>
<td>1412</td>
</tr>
</tbody>
</table>

Heterogeneity: $\chi^2=1.24$ (p=0.74); $I^2=0%$
Test for overall effect: $Z=2.30$ (p=0.02)

Plourde JACC 2015
And our risk?

BRAIN study

Radiation exposure outside and inside the cap

Reeves JACC Int 2015