Why Transradial Now?
The Science and Economics Behind the US Radial Revolution

Mauricio G. Cohen, MD, FACC, FSCAI
Director, Cardiac Catheterization Lab
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.

From the Department of Medicine, Western Reserve University, and the Medical Clinic, Cleveland City Hospital, Cleveland, Ohio.

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
Original Studies

Percutaneous Radial Artery Approach for Coronary Angiography

Lucien Campeau, MD

Percutaneous entry into the distal radial artery and selective coronaryography using a French 5 sheath and preshaded catheters were attempted in 100 patients with a normal Allen test. Cannulation of the radial artery was not possible in ten patients, and selective catheterization of the coronary arteries was unsuccessful in two. Manipulation of catheters presented no problem, and arterial spasm was rarely observed, only before the use of a 23-cm-long sheath. Only two complications without symptoms were observed: arterial dissection of the brachial artery in one patient and occlusion of the radial artery in another. With experience, this approach may become as effective and possibly safer than the transbrachial entry.

Key words: percutaneous radial catheterization, brachial artery catheterization, “Inverae” Allen test, complications of arterial catheterization, coronaryography
Percutaneous Transradial Artery Approach for Coronary Stent Implantation

Ferdinand Kiemeneij, MD, and Gert Jan Laarman, MD, PhD

A new approach for implantation of Palmaz Schatz coronary stents is reported. We describe the technique and rationale for coronary stenting with miniaturized angioplasty equipment in the radial artery.

This technique is illustrated in three patients. One patient underwent Palmaz Schatz stent implantation for a saphenous vein coronary bypass graft stenosis, the second patient for restenosis in the anterior descending coronary artery after aortotomy, and the third patient for a second restenosis after balloon angioplasty in the circumflex coronary artery.

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Key words: Percutaneous transluminal coronary angioplasty coronary stent

Medical Treatment

Patients are treated with Dextran 40, the first 500 ml at a rate of 100 ml/hr, the second 500 ml at a rate of 50 ml/hr. The infusion is started 2 hr before elective stent implantation or from the moment the decision is made to implant a stent in acute situations.

At the day of stent implantation, dipirydamole 225 mg/day and acetylsalicylic acid 300 mg/d are started. After sheath insertion, 10,000 IU heparin is administered intra-arterially, followed by 5,000 IU for each hr the procedure lasts. Three hr after hemostasis is achieved, 3,000 IU heparin is administered intravenously. Heparin is titrated to Activated Partial Thromboplastin Times (APTTs) of 80–100 secs until stable adjustment on oral anticoagulant drug therapy (3 consecutive therapeutic Thrombotests). Coumadin is given for 3 mo and acetylsalicylic acid and dipirydamole are given for 6 mos.

In order to prevent radial and coronary artery spasm, 10 mg nifedipine are administered sublingually.
Transradial Access at the University of Miami

*Cath Lab Digest* talks with Mauricio G. Cohen, MD, FACC, Director of the Cardiac Catheterization Laboratory, Joey Collazo, RCIS, Chief Technologist, Cardiac Cath Lab, and Kymberlee Manni, RCIS, PhD, Associate Vice President Cardiovascular Service Line Administrator, University of Miami Hospital, the flagship facility of UHealth—University of Miami Health System, Miami, Florida.

Dr. Mauricio Cohen has been performing transradial access procedures for approximately 5 years. After joining the University of Miami Hospital cath lab in January of 2009 as director, he instituted a transradial program.

What’s your sense of how transradial access is utilized in Argentina?

I believe it is used slightly more than in the U.S., but not quite as much as in high-use countries like France, Canada, Spain or Sweden.

How often do you use transradial access?

It is worth noting that transradial access has never been used for patients with an AV fistula in the forearm and an abnormal Allen’s test. If we are unsuccessful, we will use a femoral approach.

How often do you find that you are converting to femoral access after beginning with a radial approach?
Except for few indications, PCI does not improve mortality compared with medical therapy, but does improve symptoms and quality of life.

In this context, every effort should be made to make PCI safer and more comfortable for patients.
Procedure-Specific Measures of Quality of Life

Measured on 0-10 visual analog scales at 1 week after catheterization
Economics of Radial Access

- **Vascular complication**
  - Prolonged hospital stay (~3 days)
  - Incremental cost: $6,400
- **Bleeding complication (Incremental cost)**
  - GUSTO IIb
    - Mild/severe bleed $3,770
    - Transfusion $2,080
  - REPLACE-2
    - Major bleed $6,300
- **Diagnostic Cath**
  - Saves $290 per case
    - Driven by lower nursing utilization and pharmacy costs
- **Nursing Workload**
  - Femoral: 174 [134–218] min
  - Radial: 86 [58–126] min, (p <0.001)

Kugelmass AD et al. Am J Cardiol 2006;97:322-7
Cooper CJ et al. Am Heart J 1999;138:430-6
Chhatriwalla AK et al. JAMA 2013;309:1022-29
Worldwide Uptake Radial Access: 2010

Courtesy Dr. Doug Fraser
CATH-PCI Registry (2004-2007): Low Utilization and Paradox in Care

What is the main reason not to use the radial approach?

- Lack of knowledge/training: 32.58%
- Complex PCI: 31.46%
- I feel more comfortable with femoral access: 35.96%

How frequently should radial access for PCI be used?

- >50%: 34.07%
- 20% - 50%: 19.26%
- <20%: 46.67%

Is there any advantage to the radial approach over the femoral approach for PCI access?

- Yes: 32.95%
- No: 22.73%
- Only in a select group of patients: 44.32%
Why has Radial Uptake been so slow in the US?

• Lack of training
  – Few fellowship training programs offer TRA training
• Practicing cardiologists too busy to learn new techniques
• Misalignment between compensation and practice – Lack of financial incentive
• Lack of commercial support and marketing
  – VCDs are heavily marketed in the US
  – Physicians get trained very easily by reps
  – Bivalirudin perceived as a safety reassurance
• Lack of conclusive definitive data and guideline recommendation (least likely reason)
Physician Interest, Experience, Interpretation of Data, Convenience....

Physician Interest and Outcome

Courtesy Dr. David Kandzari
Comparison of transradial and femoral approaches for percutaneous coronary interventions: A systematic review and hierarchical Bayesian meta-analysis

Olivier F. Bertrand, MD, PhD, a,b Patrick Bélisle, MSc, b Dominique Joyal, MD, b Olivier Costerousse, PhD, a
Sunil V. Rao, MD, c Sanjit S. Jolly, MD, MSc, d David Meckin, MBBS, e and Lawrence Joseph, PhD b Quebec, Ontario, Canada; Durham, NC; and Jerusalem, Israel

Randomized trials and observational studies (1993-2011) comparing TRA with TFA for PCI with reports of ischemic and bleeding outcomes (76 studies -15 randomized, 61 observational-involving a total of 761,919 patients)

TRA Practice in the Future?

Bertrand OF. JACC Intervent 2010;3:1022–31
The use of radial artery access can be useful to decrease access site complications.
Contemporary Comparative Trials Evaluating Radial/Femoral Coronary Angiography and PCI

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Patients/Subgroups</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feldman et al. ACC NCDR 2013</td>
<td></td>
<td>2,820,874 PCI (6% radial) between 2007 and 2012</td>
<td>Significantly lower overall bleeding, access site complications across all treatment groups</td>
</tr>
<tr>
<td>Romagnoli et al. RIFLE STEACS JACC 2012</td>
<td></td>
<td>1001 patients with STEMI</td>
<td>Significantly lower overall bleeding, access site bleeding and cardiac mortality</td>
</tr>
<tr>
<td>Olivecrona et al. SCAAR EuroPCR 2011</td>
<td></td>
<td>21 339 patients with STEMI</td>
<td>Significant decrease (22%) in adjusted mortality, maintained across female, elderly subgroups</td>
</tr>
<tr>
<td>Chase et al. Heart 2008</td>
<td></td>
<td>38 872 procedures in 32 822 patients in British Columbia (1999 to 2005)</td>
<td>Tr-PCI associated with halving of transfusion rate; significant reductions in 30-day and 1-year mortality</td>
</tr>
<tr>
<td>Rao et al. JACC Interv 2008</td>
<td></td>
<td></td>
<td>No differences in procedural success between tr-PCI and f-PCI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Significantly decreased bleeding in high-risk subgroups</td>
</tr>
<tr>
<td>Brueck et al. JACC Interv 2009</td>
<td></td>
<td></td>
<td>Significantly lower access complications with tr-PCI</td>
</tr>
</tbody>
</table>
Interventional Cardiology

Adoption of Radial Access and Comparison of Outcomes to Femoral Access in Percutaneous Coronary Intervention
An Updated Report from the National Cardiovascular Data Registry (2007–2012)

Dmitriy N. Feldman, MD; Rajesh V. Swaminathan, MD; Lisa A. Kaltenbach, MS; Dmitri V. Baklanov, MD; Luke K. Kim, MD; S. Chiu Wong, MD; Robert M. Minutello, MD; John C. Messenger, MD; Issam Moussa, MD; Kirk N. Garratt, MD; Robert N. Piana, MD; William B. Hillegass, MD; Mauricio G. Cohen, MD; Ian C. Gilchrist, MD; Sunil V. Rao, MD
3,319,499 Patient records from 1,410 hospitals retrieved from the CathPCI database

498,625 Patient records excluded
- 17,492 PCI involving an access site other than the femoral or radial artery
- 480,747 Procedures performed in patients without angina or ischemic symptoms
- 386 Procedures from hospitals performing <30 PCI

2,820,874 Patients included in final study population

r-PCI procedures n= 178,643
f-PCI procedures n= 2,642,231

Feldman D et al.  
*Circulation* 
2013;127:2295-2306
Suddenly, everyone’s discovered the wrist, we’ve known for a long time it’s prime real estate. We’re prepared.

Kazuo Kashio, CEO, Casio, Inc, July 2013
Quality of Life and Patient Preference

NY Times
July 27, 2009
Quality of Life and Patient Preference

“OMG, RR (radial rocks)!"

Courtesy
Dr. Kandzari
Quality of Life and Patient Preference

Prefer Radial

p<0.000

1

Preference for assigned access site for next procedure

Cooper et al. Am Heart J 138:430, 1999

Jolly et al. Lancet 2011
Radial Lounge Amsterdam OLVG
St Joseph’s Hospital
(Atlanta, GA)
Incentives may be Changing For Physicians and Health System

**Hospitals' PCI readmissions rates go public**

Rates based on national registry data

**All-Cause Readmission and Repeat Revascularization After Percutaneous Coronary Intervention in a Cohort of Medicare Patients**

Jeptha P. Curtis, MD,*§ Geoffrey Schreiner, BS,§ Yongfei Wang, MS,*§ Jersey Chen, MD, MPH,*§ John A. Spertus, MD, MPH,∥ John S. Rumsfeld, MD, PtdD,¶ Ralph G. Brindis, MD, MPH,# Harlan M. Krumholz, MD, SM*‡§

New Haven, Connecticut; Kansas City, Missouri; Denver, Colorado; and Oakland, California
Transitioning to TRA: Wake Forest Experience

n = 4,204

Turner S et al. CCI 2011;80:247-57
Transitioning to TRA: Wake Forest Experience (PCI)

- Major Vasc Comp: 1% Femoral, 0.8% Transition
- Transfusion: 2.4% Femoral, 1.5% Transition
- Death: 1.8% Femoral, 0.4% Transition

n = 4,204
Is There a Cost to Learning Transradial Catheterization?

28 Operators, 1,672 TR PCIs

- Odds of procedural failure decreased 32% for every 50 cases
- Contrast volume, fluoroscopy time highest among low volume operators
- Minimum 50 cases required to achieve outcomes similar to high volume operators\(^1\)

- Cost Savings with TR PCI\(^2\)
  - Year 1: $851
  - Year 2: $1,357

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\(^1\)Ball et al. Circulation Cardiovasc Intervent 2011
\(^2\)Amin et al. ACC 2012
Consecutive procedures during transition from femoral (N=372) to radial (N=374) from 1/2009 to 11/2010

$234

$152

$15

$401

In-Lab Resources

In-Lab Meds

Tx of Vascular Complications

Total

P<0.05 for all comparisons vs femoral

Schafer et al. ACC 2012
Tertiles of Radial PCI Centre Volume/yr

**Primary Outcome**
- High
- Medium
- Low

**Death, MI or stroke**
- High
- Medium
- Low

**Non CABG Major Bleed**
- High
- Medium
- Low

**Major Vascular Complications**
- High
- Medium
- Low

**Access site Cross-over**
- High
- Medium
- Low

No significant interaction by Femoral PCI center volume

**Hazard Ratio (95% CI)**

- Radial better: 0.538
- Femoral better: 0.021

**Interaction p-value**
- 0.021
- 0.013
- 0.538
- 0.019
- 0.003

*High (>146 radial PCI/year/ median operator at centre), Medium (61-146), Low (≤60)
Effect of Radial Vs. Femoral Access on Radiation Dose and the Importance of Procedural Volume

A Substudy of the Multicenter Randomized RIVAL Trial

Air Kerma (mGy) by Radial Center Volume

Air Kerma (mGy) by Radial Operator Volume

Jolly SS et al. J Am Coll Cardiol Intv 2013;6:258–66
Difference in Post Procedural LOS for Femoral and Radial Procedures

- **All Cases**
  - N=609
  - Femoral better
  - Radial better

- **Low Risk**
  - N=101
  - Femoral better
  - Radial better

- **Moderate Risk**
  - N=355
  - Femoral better
  - Radial better

- **High Risk**
  - N=153
  - Femoral better
  - Radial better

609 TRI cases matched with 60,900 TF cases

Safley, et al. AHJ 2013
**Total Costs**

- All Cases: -1,454 to 1,060
- Low Risk: -424 to 553
- Moderate Risk: -49 to 585
- High Risk: -150 to 1,046

**Costs: PCI Day**

- Femoral better vs Radial better:
  - Femoral: -1,454 to -424
  - Radial: 1,060 to 1,046

**Total Costs**

- Δ $553; $11,736 vs $12,288, *P=0.03*
- Δ $585
- Δ $1,046
## Same Day Discharge vs. Overnight Stay
(30-day Complication Rates)

### Randomized Trials

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Same-Day Discharge</th>
<th>Overnight Stay</th>
<th>Odds Ratio M⁻¹, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knopf et al 1999</td>
<td>0</td>
<td>43</td>
<td>0.36 [0.01, 8.98]</td>
</tr>
<tr>
<td>Carere et al 2000</td>
<td>2</td>
<td>50</td>
<td>5.21 [0.24, 111.24]</td>
</tr>
<tr>
<td>Bertrand et al 2006</td>
<td>56</td>
<td>504</td>
<td>1.18 [0.79, 1.77]</td>
</tr>
<tr>
<td>Heyde et al 2007</td>
<td>6</td>
<td>403</td>
<td>1.48 [0.42, 5.30]</td>
</tr>
<tr>
<td>Falcone et al 2011</td>
<td>3</td>
<td>23</td>
<td>0.90 [0.16, 5.04]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>1023</td>
<td>1016</td>
<td>1.20 [0.82, 1.74]</td>
</tr>
</tbody>
</table>

Total events: 67
Heterogeneity: Tau² = 0.00; Chi² = 1.65, df = 4 (P = 0.80); I² = 0%
Test for overall effect: Z = 0.94 (P = 0.35)

### Observational Studies

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Same-Day Discharge</th>
<th>Overnight Stay</th>
<th>Odds Ratio M⁻¹, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koch et al 2000</td>
<td>0</td>
<td>922</td>
<td>0.01 [0.00, 0.26]</td>
</tr>
<tr>
<td>Slagboom et al 2001</td>
<td>0</td>
<td>106</td>
<td>Not estimable</td>
</tr>
<tr>
<td>Dalby et al 2003</td>
<td>3</td>
<td>51</td>
<td>2.81 [0.14, 57.07]</td>
</tr>
<tr>
<td>Yee et al 2004</td>
<td>0</td>
<td>25</td>
<td>Not estimable</td>
</tr>
<tr>
<td>Slagboom et al 2005</td>
<td>4</td>
<td>375</td>
<td>0.40 [0.12, 1.39]</td>
</tr>
<tr>
<td>Khater et al 2007</td>
<td>0</td>
<td>124</td>
<td>0.07 [0.00, 1.72]</td>
</tr>
<tr>
<td>Chung et al 2010</td>
<td>12</td>
<td>214</td>
<td>2.15 [0.95, 4.87]</td>
</tr>
<tr>
<td>Rao et al 2011</td>
<td>129</td>
<td>1339</td>
<td>0.99 [0.83, 1.19]</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>3156</td>
<td>10249</td>
<td>0.67 [0.27, 1.66]</td>
</tr>
</tbody>
</table>

Total events: 148
Heterogeneity: Tau² = 0.65; Chi² = 16.73, df = 5 (P = 0.005); I² = 70%
Test for overall effect: Z = 0.87 (P = 0.38)

### Total (95% CI)

| Total Events | 4179 | 107645 | 100.0% | 1.00 [0.66, 1.54] |

Total events: 215
Heterogeneity: Tau² = 0.15; Chi² = 19.16, df = 10 (P = 0.04); I² = 48%
Test for overall effect: Z = 0.02 (P = 0.99)
Test for subgroup differences: Chi² = 1.34, df = 1 (P = 0.25), I² = 25.6%

Economic dimensions of same-day discharge

Analysis of the EASY Trial

Rinfret S, et. al. JACC Intv 2010
TRI Learning Curve – Fluoro time
N=45,124 TRIs, 819 operators, 631 sites

UnAdjusted

Adjusted

Hess CN, et. al.
Circulation 2014
Elements of a successful transradial program

Adapting the three domains of Quality + 1

• **Structure** – Arms board, access kits, exchange length guidewires, catheters and guides, hemostasis devices

• **Process** – Training of physicians and nursing staff, order sets (pre-procedure, procedural, post-procedure), patient education

• **Outcomes** – Procedure times, Radiation exposure, Contrast load, Bleeding complications, Patient satisfaction, Radial artery occlusion

• “**Other**” – A commitment to transradial by all stakeholders – don’t get frustrated!
Why Radial Now? At The Tipping Point

• Radial is part of the natural evolution of PCI
  o Endeavor to make procedure safer, greater patient satisfaction
• In an era of cost containment, radial makes sense
  o Lower procedural and post-PCI costs
  o Ideally suited for same day discharge
• Benefit of radial most evident in those for whom it is least used
• Learning curve for radial has never been more abbreviated
• Increased training opportunities
  o Newly trained fellows
  o Professional societies efforts
First they ignore you, then they laugh at you, then they get angry and then you win.

– Mahatma Gandhi