Starting A Radial Artery Program

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Director Cardiovascular Research
Director Women’s Heart and Vascular Health Program
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Few Do It – Many Want To

- Need trained physicians to train the next generation
- No formal guidance for fellow’s education
- Early failures sour interventionalists on the technology

Roa JACC Interv. 2008; 379-86

NCDR data on 593,094 PCIs at 637 US sites from 2004-2007

~ 1.3% of all PCIs in the US are performed transradial artery, most centers perform <10% of PCIs transradially
Unadjusted Rates of Bleeding and Vascular Complications of r-PCI and f-PCI in Key Subgroups

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Influence of Single TR Operator

Cohen, M. G., Alfonso, C. J Invasive Cardiol 2007;21:11A-17A
Trend in the Use of r-PCI Over Time in Key Subgroups

### 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>

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Cohen and Alfonso, *Starting a Transradial Vascular Access Program in the Cardiac Catheterization Laboratory* J INVASIVE CARDIO 2009;21(Suppl A):11A–17A

(Adapted from: Cooper CJ. A Physician’s Guide: Radial Approach)
Is there a real learning curve?

Careful planning, patient selection and training of entire team will shorten this

Where to Start?

- Young patients
- Obese patients
- Tall $\geq 5'\ 9''$
- Diagnostic only
- No grafts
- Not on chronic pain meds
- Low anxiety patients
- No coumadin
- No severe PVD
Using TRI for all cases

• Start easy, become non-selective
• Selective Operators
  – Slower to achieve technical excellence
  – Never fully realize transradial potential
  – Never get to the groups with the most to gain
    • Higher risk STEMI/NSTEMI
    • Elderly
    • Women
“After compressing both radial an ulnar arteries, the patient clenches the fist and relaxes the hand. The ulnar artery is then released and the return of normal skin color is observed. The skin color should normalize in eight seconds or less.”
Barbeau’s Test


HEAL. TEACH. DISCOVER. SERVE.
A short puncture needle is used to access the radial artery.

Local anesthetic is administered.

30-45°
Arterial Sheath

Terumo access kit
Anatomical Challenges: Radial Loop

- Using a hydrophilic wire will allow the wire to follow the looped anatomy
- Careful insertion of the catheter, will allow the loop to straighten

“Caution should be used when delivering guidewire(s) or catheter(s). If resistance is encountered, interventionalist should stop advancing & perform an angiogram.”
Radial Loop

Pyne, C., Mann, T. Cardiac Interventions Today Mar/Apr, 2010; 38-40
Radial Loop

Pyne, C., Mann, T. Cardiac Interventions Today Mar/Apr, 2010; 38-40
Anatomical Challenges: Tortuous Subclavian

- Generally more common in older pts
- Often more pronounced on the right side
- Soft tipped wires will generally traverse
- Deep breath often allow entrance into the ascending aorta

Subclavian and brachiocephalic tortuosity

“Caution should be used when delivering guidewire(s) or catheter(s). If resistance is encountered, interventionalist should stop advancing & perform an angiogram.”
Right Subclavian Artery


HEAL. TEACH. DISCOVER. SERVE.
Counter Tension on Wire to Straighten Loop

Advance & Move On

Equipment Choices

- For the most part, the same products used for femoral approach are used for radial approach

- There are some product choices operators may make specifically for radial approach.
  - Short puncture needle
  - Hydrophilic sheath
  - Short vs. long sheath
  - Specific guide catheter curves and sizes
Transradial Curves for Left Coronary – EBU

Workhorse curve for left coronary artery

Sizing suggestions:
- JL35 = EBU35
- JL40 = EBU35
- JL40 = EBU40

Comparable to:
- Cordis: XB, XBLAD
- BSC: Muta Left, Radial Curve, Brachial Curve

Apply torque to point the tip to the left coronary cusp and turn catheter. Pull wire back and the catheter will engage the left coronary artery. Backup support from the sinus of valsalva.

“Guide catheter recommendations on this slide are not intended to replace patient specific clinical judgment”
Transradial Curves for Left Coronary – Judkins Left

Standard curve for the left coronary artery (may be particularly useful for short left coronary arteries)

Sizing suggestions:
Downsize the curve by 0.5 from what is used for a femoral approach

Comparable to:
Cordis: Judkins Left
BSC: Judkins Left

Judkins engagement technique, similar to femoral approach. Very fine torquing movements may be required to direct the catheter toward the left coronary artery.

“Guide catheter recommendations on this slide are not intended to replace patient specific clinical judgment.”
Guide Selection: Femoral vs Radial

- Guide Catheter Manipulation Technique
  - Catheters placed via radial approach have better torque transmission compared to transfemorally placed catheters, and hence guide manipulation from the radial artery requires small (finger based) clockwise and counterclockwise torquing movements.

JL 3.5 Radial
Different curve mechanics, sizing and backup support

JL 4.0 Femoral

“Guide catheter recommendations on this slide are not intended to replace patient specific clinical judgment.”
Wires

- Careful advancement of wires
  - If any resistance is encountered, the interventionalist should stop advancing and do an angiogram

- If the standard J-angiographic wire is unable to pass, switching for a hydrophilic coated straight tip or angle tipped 0.032/0.035” wire is an option (Terumo™)
  - This wire should be advanced with care and visualized under fluoroscopy
Considerations for Using 5F Guide Catheters

- Miniaturization of products allow 5F use
- Small radial arteries may not be suited for 6F guides
- Less Spasm, less patient discomfort
- Lower incidence of radial vessel occlusion
- Less contrast/ injection = less nephrotoxicity
<table>
<thead>
<tr>
<th>Catheter Size</th>
<th>Devices</th>
<th>Techniques</th>
<th>Radial Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>5f</td>
<td>Balloons ≤ 5 mm</td>
<td>No Kissing Balloon</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Stents ≤ 4.5 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ivus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rota 1.25 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6f</td>
<td>All Coronary balloons</td>
<td>Kissing Balloon</td>
<td>86.9%</td>
</tr>
<tr>
<td></td>
<td>All Coronary stents</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cutting Balloon</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rota ≤ 1.75 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protection device (EPI...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7f</td>
<td>Angioguard</td>
<td>Kissing Stent</td>
<td>76.9%</td>
</tr>
<tr>
<td></td>
<td>Rota 2 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8f</td>
<td>Percusurge</td>
<td></td>
<td>64.7%</td>
</tr>
<tr>
<td></td>
<td>Simpson</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rota &gt; 2 mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ideal Hemostasis
(Patency With Hemostasis)
Positioning the morbidly obese patient
Complications

- Spasm
- Hematomas
- Asymptomatic radial artery occlusion
- Forearm discomfort
- Radial artery perforation
- Compartment syndrome
- Neuralgias, AV fistula, radial artery eversion, brachial arterial thrombosis
Patient Satisfaction

• Among the patients who had both methods, the transradial method was strongly preferred in 80% and moderately preferred in 7%, with only 2% preferring transfemoral catheterization.

Cooper et al. Am Heart J 1999;138:430-436
QOL 1 day post-cath
Generic measures (SF-36)

- At 1 day post-cath, body pain, social function, mental health, overall discomfort, back pain, ability to use bathroom, and walking ability were all significantly better in the transradial group (p<0.01)

Cooper et al. Am Heart J 1999;138:430-436
QOL 1 week post-cath
Procedure specific measures

- Patients reported significantly less overall discomfort, back pain, and difficulty walking with the transradial approach

Cooper et al. Am Heart J 1999;138:430-436
Nurse Workload

- Workload is reduced by 50% in the cath lab and 46% in the ward/CCU
  - Less sheath removal
  - Fewer vascular complications
  - Shorter hospital stay
  - Small changes in nurse staffing (1-2%) result in large shifts in annual expenditure ($140K-$220K)*

*Steinbrook et al. NEJM 2002;346:1757-1766


Nurse workload after invasive procedures according to the arterial access used: radial (yellow boxes) or femoral (blue boxes). The median values (5–95 percentiles) are reported. Both in the cath lab and in the coronary care unit (CCU)/ward, the transradial approach results in a significant reduction ($P < 0.01$) in nurse workload.
Tips on Starting a Radial Program

• Imperative to train cath lab staff from the outset, their “buy-in” is essential

• Learning curve ~100 cases, need to have a learning partner (i.e. colleague)

• Expect an increase in procedure time initially and allocate time
Women, the Elderly, and Acute Coronary Syndrome:
Tough patients, but lots to gain from this approach and it’s always interesting!
Radial vs. Femoral

- “Where else in medicine do we have two equally efficacious therapies, yet we routinely use the one that poses more risk and discomfort to our patients?” - Jennifer Tremmel MD, Transradial Debate 2009
## TRA- Meta-analysis

### Procedural failure

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Radial nN</th>
<th>Femoral nN</th>
<th>OR (random) 95% CI</th>
<th>OR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann 1986</td>
<td>7/76</td>
<td>3/76</td>
<td>2.47 [0.61, 9.39]</td>
<td>1996</td>
</tr>
<tr>
<td>ACCESS</td>
<td>21/300</td>
<td>1/300</td>
<td>22.51 [3.01, 168.42]</td>
<td>1997</td>
</tr>
<tr>
<td>BRAFE Stent</td>
<td>6/56</td>
<td>1/56</td>
<td>6.60 [0.77, 56.74]</td>
<td>1998</td>
</tr>
<tr>
<td>Cooper</td>
<td>2/101</td>
<td>1/99</td>
<td>1.98 [0.18, 22.19]</td>
<td>2001</td>
</tr>
<tr>
<td>GARAFE</td>
<td>1/140</td>
<td>0/70</td>
<td>1.52 [0.06, 79.70]</td>
<td>2001</td>
</tr>
<tr>
<td>Gorge</td>
<td>1/214</td>
<td>0/216</td>
<td>3.60 [0.74, 17.40]</td>
<td>2002</td>
</tr>
<tr>
<td>Mortysma</td>
<td>6/106</td>
<td>2/92</td>
<td>9.04 [0.12, 75.09]</td>
<td>2002</td>
</tr>
<tr>
<td>OCTOPLUS</td>
<td>20/180</td>
<td>17/183</td>
<td>1.16 [0.59, 2.30]</td>
<td>2003</td>
</tr>
<tr>
<td>TEMPURA</td>
<td>6/77</td>
<td>0/77</td>
<td>0.31 [0.01, 7.67]</td>
<td>2003</td>
</tr>
</tbody>
</table>

Total (95% CI): 1472
Total events: 107 (Radial), 33 (Femoral)
Test for heterogeneity: $\chi^2 = 16.71$, df = 10 ($P = 0.04$)
Test for overall effect: $Z = 3.31$ ($P = 0.0009$)

Figure 3. Overall risk of procedural failure. CI = confidence interval; OR = odds ratio; year = year of publication.

OR 3.3; $p<0.001$; 7.2% vs 2.4%

Favours radial
Favours femoral

TCT 2004 Kiemeneij

P. Agostoni et al- JACC 2004;44:349-56
**TR-A- Meta-analysis**

**Access complications**

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Radial n/N</th>
<th>Femoral n/N</th>
<th>OR (random) 95% CI</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gristfield</td>
<td>0/128</td>
<td>2/141</td>
<td>0.14 [0.01, 2.79]</td>
<td>1996</td>
</tr>
<tr>
<td>Mann 1996</td>
<td>0/76</td>
<td>4/76</td>
<td>0.11 [0.01, 1.99]</td>
<td>1996</td>
</tr>
<tr>
<td>ACCESS</td>
<td>0/300</td>
<td>6/300</td>
<td>0.08 [0.00, 1.34]</td>
<td>1997</td>
</tr>
<tr>
<td>BRAFE Stent</td>
<td>1/56</td>
<td>3/56</td>
<td>0.32 [0.02, 3.13]</td>
<td>1997</td>
</tr>
<tr>
<td>Mann 1998</td>
<td>0/74</td>
<td>6/38</td>
<td>0.12 [0.02, 0.48]</td>
<td>1998</td>
</tr>
<tr>
<td>Cooper</td>
<td>0/101</td>
<td>0/99</td>
<td>Not estimable</td>
<td>1999</td>
</tr>
<tr>
<td>CARAFE</td>
<td>1/56</td>
<td>2/70</td>
<td>0.10 [0.00, 0.20]</td>
<td>2001</td>
</tr>
<tr>
<td>Gorge</td>
<td>0/101</td>
<td>7/136</td>
<td>0.01 [0.00, 0.24]</td>
<td>2002</td>
</tr>
<tr>
<td>Moriyama</td>
<td>0/108</td>
<td>0/92</td>
<td>0.12 [0.00, 2.31]</td>
<td>2003</td>
</tr>
<tr>
<td>OCTOPULS</td>
<td>0/100</td>
<td>12/100</td>
<td>0.23 [0.00, 0.69]</td>
<td>2003</td>
</tr>
<tr>
<td>TEMPURA</td>
<td>0/77</td>
<td>0/77</td>
<td>0.18 [0.00, 0.85]</td>
<td>2003</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>1472</td>
<td>1373</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.** Overall risk of entry site complications. CI = confidence interval; OR = odds ratio; year = year of publication.

Predictors: Females, small vessel size

TCT 2004

P. Agostoni et al- JACC 2004;44:349-56
Advantages of Radial PCI

- Radial approach preferred by majority of patients
- Significant Improvement in Patients’ Physical Function, Bodily Pain, Social Function, and Mental Function With TR PCI
- Decreased major access complications
  - Decreased access-related bleeding
  - Immediate sheath removal
- Superficial, easy hemostasis
  - Improved patient mobility
  - Immediate sheath removal
  - Decreased time to ambulation
- Decreased post-procedural cost
  - Early discharge
  - Decreased nursing care
- Overcome difficulties in vascular access for specific populations (i.e., morbidly obese, peripheral vascular disease, anticoagulation)

Cohen and Alfonso, *Starting a Transradial Vascular Access Program in the Cardiac Catheterization Laboratory* J INVASIVE CARDIOLOGY 2009;21(Suppl A):11A–17A
Disadvantages of Radial PCI

- Longer learning curve than TF PCI
- Vascular anomalies (ie, radial loops, high radial take-off in the BA)
- Limited compatibility with larger devices (ie, >2 mm Rotablator® burrs)
- RAS
- Increased fluoroscopy time, radiation exposure?
- Failure to reach ascending aorta
- Catheter manipulation for coronary cannulation
- Navigation of arm vasculature

Is it safe and can it be done?

Exclusion Rates

MD preference & Need for RHC

Success

Vascular Complications

All >80 y.o.

<70 y.o. >70 y.o.

Should it be done?

- No difference in major entry site complications in those <75 and ≥75 years old with same day discharge.
- 5-9% crossover rate reported, slightly longer procedure time overall
- No increased fluoroscopy time, number of catheters used, or contrast amount.
  - 3.2% major complication rate transfemoral, 0% transradial
  - 5.8% minor complication rate transfemoral, 1.3% transradial

Safe & Feasible Primary PCI

• Lower vascular access complications, shorter length of stay.
• Lower bleeding both minor and major regardless of antithrombotic or antiplatelet agents.
• Lower one year death/MI
• Meta-analysis finds lower stroke rate

Why we fail?

Access
- Inadequate arterial puncture
- Failure of arterial access

Getting there
- Radial artery spasm
- Radial artery dissection
- Radial artery loop/tortuosity
- Radial artery stenosis
- Failure to advance catheter to ascending aorta

PCI failure
- Subclavian tortuosity
- Inadequate guide backup support
- Failure to complete PCI due to lack of guide support

Dehghani JACC Interv 2009;2:1057-64
Sex Differences in Procedural Failure

- Women are more likely than men to require a second access site (14% vs. 1.7%, p=0.0001)
- Although with operators who do primarily radials, these numbers are lower (9.6% vs. 2.6%, p=0.0002)

Pristipino et al. Am J Cardiol 2007;99:1216-1221
Challenging Cases

- Overall failure rate of 4.7%
- Choose patients you are likely to be successful early on

```
<table>
<thead>
<tr>
<th></th>
<th>TR-All (n = 2,100)</th>
<th>TR-Success (n = 2,002)</th>
<th>TR-Failure (n = 98)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>64 ± 12</td>
<td>62 ± 11</td>
<td>67 ± 13</td>
<td>&lt;0.001</td>
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<tr>
<td>Female sex</td>
<td>357 (17)</td>
<td>329 (16)</td>
<td>26 (26)</td>
<td>0.009</td>
</tr>
<tr>
<td>BMI</td>
<td>28 ± 5</td>
<td>29 ± 5</td>
<td>29 ± 5</td>
<td>NS</td>
</tr>
<tr>
<td>Height, cm</td>
<td>170 ± 9</td>
<td>170 ± 9</td>
<td>166 ± 10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>405 (19)</td>
<td>381 (19)</td>
<td>24 (24)</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1165 (55)</td>
<td>1101 (55)</td>
<td>64 (64)</td>
<td>NS</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>1092 (52)</td>
<td>1030 (52)</td>
<td>61 (62)</td>
<td>NS</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>153 (7)</td>
<td>140 (7)</td>
<td>13 (13)</td>
<td>NS</td>
</tr>
<tr>
<td>Prior PCI</td>
<td>180 (8.6)</td>
<td>168 (8)</td>
<td>12 (12)</td>
<td>NS</td>
</tr>
<tr>
<td>Prior CABG</td>
<td>64 (3.0)</td>
<td>52 (2.6)</td>
<td>11 (11)</td>
<td>&lt;0.001</td>
</tr>
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<td>Indication for PCI</td>
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<tr>
<td>Stable angina</td>
<td>1,295 (62)</td>
<td>1,234 (62)</td>
<td>61 (61)</td>
<td>NS</td>
</tr>
<tr>
<td>UA/NSTEMI</td>
<td>683 (32)</td>
<td>576 (29)</td>
<td>33 (34)</td>
<td>NS</td>
</tr>
<tr>
<td>STEMI</td>
<td>122 (6)</td>
<td>118 (6)</td>
<td>4 (4)</td>
<td>NS</td>
</tr>
</tbody>
</table>
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Dehghani JACC Interv 2009;2:1057-64
Arch Distortion

1. Normal anatomy
2. Z Loop
3. Roller-Coaster Loop
4. Cobra Loop
Is there more Fluoro? Contrast? Time?

• No randomized trials have shown they are different
• This rationale continues to be circulated and continues to lower transradial adoption rates
• The door to balloon times do not suffer, bleeding always found to be less and all studies find a trend or real improvement in long term outcomes.

Metanalysis

- 11 trials reported procedural time
  - 3,082 patients
  - Definitions varied from arterial time to time in room
  - 35 minutes transradial vs. 33.8 minutes transfemoral, p=NS

- 10 trials reported fluoroscopy time
  - 2,970 patients
  - 8.9 minutes transradial vs. 7.8 minutes transfemoral, p<0.001

30 cm extension tube
Data Collected for 3 years identifying very high levels

Training program included:
  • radiation protection course
  • new x-ray equipment
  • formalized program to lower dose to patients & staff

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample</th>
<th>Range</th>
<th>Mean ± SD</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>8</td>
<td>1.9-26.5</td>
<td>9.0 ± 9.3</td>
<td>5.1</td>
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<tr>
<td>1992</td>
<td>11</td>
<td>0.9-24.2</td>
<td>7.4 ± 8.5</td>
<td>3.7</td>
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<tr>
<td>1993 (training)</td>
<td>7</td>
<td>1.0-4.4</td>
<td>1.9 ± 1.0</td>
<td>1.6</td>
</tr>
<tr>
<td>1994 (training)</td>
<td>12</td>
<td>0.6-13.0</td>
<td>3.0 ± 3.3</td>
<td>1.6</td>
</tr>
<tr>
<td>1995</td>
<td>10</td>
<td>0.7-4.1</td>
<td>1.8 ± 1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>1996</td>
<td>13</td>
<td>0.4-5.8</td>
<td>1.5 ± 1.6</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Difficult to ignore the effect of starting a formalized program and individualized radiation protection training.
0.5 mm lead equivalent

Non-obtrusive

<table>
<thead>
<tr>
<th></th>
<th>Standard protection alone n = 50</th>
<th>Standard protection +TRPB n = 56</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median operator exposure (( \mu )SV) (25(^{th}) and 75(^{th}) per)</td>
<td>28.0 (18, 65)</td>
<td>19.5 (10.5, 35)</td>
<td>0.003</td>
</tr>
<tr>
<td>Median total fluoroscopy dose (cGycm) (25(^{th}) and 75(^{th}) per)</td>
<td>1,928 (1,085; 4,946)</td>
<td>2,914 (1,794; 5,948)</td>
<td>0.17</td>
</tr>
<tr>
<td>Median total screening time (min) (25(^{th}) and 75(^{th}) per)</td>
<td>5.5 (4.2, 15.1)</td>
<td>10.9 (5.1, 19.6)</td>
<td>0.12</td>
</tr>
<tr>
<td>Median total procedure duration (min) (25(^{th}) and 75(^{th}) per)</td>
<td>45 (35, 60)</td>
<td>60 (40, 85)</td>
<td>0.08</td>
</tr>
<tr>
<td>Median total contrast load (ml) (25(^{th}) and 75(^{th}) per)</td>
<td>122.5 (100, 172.5)</td>
<td>150 (110, 210)</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Operator Radiation Exposure, Total Fluoroscopy Dose, Total Screening Time, Procedure Duration, and Contrast Dose for Coronary Angiograms

<table>
<thead>
<tr>
<th></th>
<th>Standard protection alone (n = 28)</th>
<th>Standard protection + TRPB (n = 19)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median operator exposure (µSv) (25th and 75th per)</td>
<td>19.0 (12.0, 37.0)</td>
<td>12.0 (5.0, 22.0)</td>
<td>0.02</td>
</tr>
<tr>
<td>Median total fluoroscopy dose (cGy/cm) (25th and 75th per)</td>
<td>1,347 (975, 1,722)</td>
<td>2,237 (751, 2,977)</td>
<td>0.25</td>
</tr>
<tr>
<td>Median total screening time (min) (25th and 75th per)</td>
<td>4.4 (3.5, 53)</td>
<td>3.9 (3.0, 7.5)</td>
<td>0.16</td>
</tr>
<tr>
<td>Median total procedure duration (min) (25th and 75th per)</td>
<td>35 (30-40)</td>
<td>35 (30-37.5)</td>
<td>0.14</td>
</tr>
<tr>
<td>Median total contrast load (ml) (25th and 75th per)</td>
<td>100 (90, 120)</td>
<td>100 (90, 120)</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Operator Radiation Exposure, Total Fluoroscopy Dose, Total Screening Time, Procedure Duration, and Contrast Dose for Coronary Angiograms with Ad Hoc PCI

<table>
<thead>
<tr>
<th></th>
<th>Standard protection alone (n = 7)</th>
<th>Standard protection + TRPB (n = 14)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median operator exposure (µSv) (25th and 75th per)</td>
<td>63.0 (58.0, 147.0)</td>
<td>31.5 (14.0, 38.0)</td>
<td>0.002</td>
</tr>
<tr>
<td>Median total fluoroscopy dose (cGy/cm) (25th and 75th per)</td>
<td>5.001 (3.695, 7.716)</td>
<td>5.583 (2.345, 6.865)</td>
<td>0.08</td>
</tr>
<tr>
<td>Median total screening time (min) (25th and 75th per)</td>
<td>14.3 (12.4-34.6)</td>
<td>14.3 (10.2-30.0)</td>
<td>0.45</td>
</tr>
<tr>
<td>Median total procedure duration (min) (25th and 75th per)</td>
<td>85 (60, 95)</td>
<td>80 (65, 90)</td>
<td>0.23</td>
</tr>
<tr>
<td>Median total contrast load (ml) (25th and 75th per)</td>
<td>220 (160, 250)</td>
<td>200 (170, 240)</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Operator Radiation Exposure, Total Fluoroscopy Dose, Total Screening Time, Procedure Duration, and Contrast Dose for Elective PCI

<table>
<thead>
<tr>
<th></th>
<th>Standard protection alone (n = 15)</th>
<th>Standard protection + TRPB (n = 23)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median operator exposure (µSv) (25th and 75th per)</td>
<td>61.0 (28.0, 116.0)</td>
<td>23.0 (11.0, 38.0)</td>
<td>0.002</td>
</tr>
<tr>
<td>Median total fluoroscopy dose (cGy/cm) (25th and 75th per)</td>
<td>5.215 (3.458, 6.608)</td>
<td>3.347 (2.032, 6.293)</td>
<td>0.25</td>
</tr>
<tr>
<td>Median total screening time (min) (25th and 75th per)</td>
<td>15.7 (13.3, 20.6)</td>
<td>15.3 (10.4, 22.0)</td>
<td>0.03</td>
</tr>
<tr>
<td>Median total procedure duration (min) (25th and 75th per)</td>
<td>60 (48, 90)</td>
<td>70 (55, 95)</td>
<td>0.15</td>
</tr>
<tr>
<td>Median total contrast load (ml) (25th and 75th per)</td>
<td>165 (150, 250)</td>
<td>200 (150, 245)</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Angulations Makes a Difference to the Patient

50% Reduction of Patient Dose by Changing Left Coronary Angles

Angulations Make a Difference to the Operator Exposure

LAO & left lateral views the worst for radiation exposure especially with angulations