Radial Versus Femoral Access for Primary Percutaneous Interventions in ST-Segment Elevation Myocardial Infarction Patients

A Meta-Analysis of Randomized Controlled Trials

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Objectives  This study sought to determine the safety and efficacy of radial access compared with femoral access for primary percutaneous coronary intervention (PCI) in patients with ST-segment elevation myocardial infarction (STEMI).

Background  Numerous randomized controlled trials, including several new studies, have compared outcomes of these approaches in the context of primary PCI for STEMI patients with inconclusive results.

Methods  We performed a meta-analysis of randomized controlled trials to compare outcomes in STEMI patients undergoing radial versus femoral access for primary PCI. Primary outcomes were death and major bleeding evaluated at the longest available follow-up. Secondary outcomes included access site bleeding, stroke, and procedure time. Twelve studies (N = 5,055) were included. All trials were conducted in centers experienced with both approaches.

Results  Compared with femoral approach, radial approach was associated with decreased risk of mortality (2.7% vs. 4.7%; odds ratio [OR]: 0.55, 95% confidence interval [CI]: 0.40 to 0.76; p < 0.001) and decreased risk of major bleeding (1.4% vs. 2.9%; OR: 0.51, 95% CI: 0.31 to 0.85; p = 0.01). Radial access was also associated with reduction in relative risk of access site bleeding (2.1% vs. 5.6%; OR: 0.35, 95% CI: 0.25 to 0.50; p < 0.001). Stroke risk was similar between both approaches (0.5% vs. 0.5%; OR: 1.07, 95% CI: 0.45 to 2.54; p = 0.87). The procedure time was slightly longer in the radial group than in the femoral group (mean difference: 1.52 min; 95% CI: 0.33 to 2.70, p = 0.01).

Conclusions  In STEMI patients undergoing primary PCI, the radial approach is associated with favorable outcomes and should be the preferred approach for experienced radial operators.

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Bleeding is among the most common in-hospital complications of percutaneous coronary intervention (PCI) and is independently and strongly associated with long-term adverse outcomes, including myocardial infarction (MI), stroke, and death (1–5). Patients with ST-segment elevation myocardial infarction (STEMI) require an urgent revascularization strategy as well as aggressive antiplatelet and antithrombotic pharmacotherapy and thus are particularly susceptible to bleeding complications. Trials of antithrombotic regimens designed to decrease bleeding complications during STEMI treatment have been shown to decrease mortality (6,7).

Given that a frequent source of bleeding is the arterial access site, a radial approach rather than the traditional femoral approach for primary PCI is an attractive strategy to further improve outcomes due to the well-documented reduced risk of bleeding complications (8,9). However, lower bleeding risk with radial access may be counterbalanced by higher rates of procedural failure and longer procedural times, which may be detrimental in STEMI patients where timely reperfusion is critical.

The current American College of Cardiology Foundation/American Heart Association STEMI guidelines do not mention the preferred approach for access site in STEMI patients (10). A number of nonrandomized studies have compared radial access with femoral access in patients undergoing primary PCI for STEMI. However, most of these studies were observational in nature and thus limited because of the potential for confounding and selection bias. On the other hand, firm conclusions from the randomized controlled trials available are limited due to a lack of power for the main outcomes of mortality, bleeding, and stroke. We have performed an updated meta-analysis of randomized clinical trials comparing the efficacy and safety of radial versus femoral approaches for primary PCI in STEMI patients incorporating data from 3 recently published randomized controlled trials (11–13).

Methods

This meta-analysis was performed in accordance with the PRISMA (Preferred Reporting Items for Systemic Reviews and Meta-Analyses) checklist (14). We conducted a systematic review of the literature for studies published from 1960 to December 2012 in PubMed, Scopus, Clinicaltrials.gov, Web of Science, and Cochrane Central databases. The following search terms were used: “ST-elevation myocardial infarction,” “STEMI,” “Radial,” and “Radial vs. Femoral.” Our search was limited to articles in English. A manual search was also performed using the “related results” section of PubMed and references from selected papers. We also performed a hand search of abstracts presented at conferences (through Web of Science, as well as Transcatheter Cardiovascular Therapeutics, American College of Cardiology, and American Heart Association online presentations).

Trial selection. To be selected for inclusion in the meta-analysis, studies were required to meet the following inclusion criteria: 1) be randomized; 2) have a comparison between radial and femoral access; 3) have a patient population comprising patients undergoing primary PCI for STEMI; and 4) have measured at least 1 of the following outcomes as their endpoint: death; major bleeding; major cardiovascular adverse events (MACE); access site complications/bleeding; stroke; MI; target lesion revascularization (TLR)/target vessel revascularization (TVR); and procedure time. Studies that did not fit these criteria were excluded from the analysis (Fig. 1).

Outcomes. The outcomes of interest were evaluated at the longest available follow-up. We used death and major bleeding as our coprimary outcomes of interest. For major bleeding, Thrombolysis In Myocardial Infarction (TIMI) major bleeding rates were used where available; in the studies where this was not possible, the study definition of major bleeding was used (Table 1). Secondary outcomes analyzed were MACE, access site bleeding, stroke, MI, TLR/TVR, and procedure time. For MACE, individual components were noted and included in the table for study characteristics, but the outcome values were taken as presented from the studies despite variations in definitions.

Data extraction and quality assessment. Two authors evaluated each study for inclusion and extracted data in duplicate using a standardized protocol and reporting form. Differences were resolved by consensus. The risk assessment tool recommended by the Cochrane Collaboration was used to evaluate the risk of bias in the included studies.

Data synthesis and analysis. Data were extracted on an intent-to-treat basis. The odds ratio (OR) was used as the measure of effect in the overall comparison test, and the Mantel-Haenszel method was used to combine study data. The heterogeneity of the studies was analyzed using a chi-square test for which a p value <0.2 was considered potentially heterogeneous. An I² test of heterogeneity, which describes the percentage of total variation across studies that is due to heterogeneity rather than due to chance, was also performed for each of the comparisons. Heterogeneity is
described as low, moderate, and high, based on $I^2$ values of 25%, 50%, and 75%, respectively. A 2-sided $p$ value < 0.05 was considered to be statistically significant. We used a random effects model for all our analyses. Results for individual trials and summary results are expressed as an OR with 95% confidence intervals (CI). We also created funnel plots to visually assess publication bias. All statistical calculations were performed using Review Manager (RevMan version 5.1, The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark).

Results

Of the 678 studies that returned on our literature search, 12 studies met the inclusion criteria (Fig. 1, Table 1) (11–13, 15–23). One study has been presented only as an abstract, but was included in the analysis (13). The included studies contained a combined total of 5,055 patients, with 2,492 patients being in the radial arm and 2,563 in the femoral arm. The mean age was 61 years (range 53 to 71 years) and men accounted for the majority of subjects (average: 75%, range 64% to 88%) (Table 1). In the majority of the studies, the arterial access was obtained with a 6-F sheath, however, usage of 7-F sheath was relatively more common in the femoral access in 3 studies (11,12,16) (Table 1). Use of glycoprotein IIb/IIIa receptor inhibitors was common and did not differ between the study arms in most of the included studies. Crossover to the other arm was more frequent in the radial group (4.6%) than in the femoral group (1.1%). Follow-up was limited to in-hospital only in 4 studies (17,18,20,23), whereas it ranged from 1 month to 9 months for the remainder.

On evaluating heterogeneity, we found the studies to be homogeneous for all outcomes ($I^2$ ranging from 0% to 17%, $p > 0.2$) except for procedure time, where a potential for heterogeneity was noted ($I^2 = 30\%, p = 0.18$). Funnel plots for the primary outcomes did not show obvious evidence for publication bias (Online Figs. 1 to 3). The risk of bias assessment tool found most of the studies to be low risk with regard to attrition and reporting bias, but the risk was unclear regarding selection, performance, and detection bias in the majority of the studies, mostly due to inadequate reporting in the manuscripts (Online Figs. 4 and 5).

Primary and secondary outcomes. All studies except Li et al. (18) reported data on death and major bleeding. There were 62 of 2,308 (2.7%) deaths in the radial group compared with 112 of 2,377 (4.7%) deaths in the femoral group. This analysis showed a significant reduction in mortality with radial access, with the odds of death being almost one-half that for femoral arm (OR: 0.55, 95% CI: 0.40 to 0.76; $p < 0.001$) (Fig. 2). A similar reduction was seen in the rate of major bleeding: 32 of 2,308 (1.4%) versus 70 of 2,377 (2.9%) (OR: 0.51, 95% CI: 0.31 to 0.85; $p < 0.05$) (Fig. 3). A separate meta-analysis was done for our primary outcomes stratified based on the single-center versus multicenter trials (Online Figs. 6 and 7). Neither death nor major bleeding was significantly different in the study arms in the single-center trials analysis, likely because of the low number of patients included. For the analysis of the data derived from multicenter trials, there was a significantly decreased rate of death with the radial approach and no significant difference in major bleeding.

Nine studies had extractable data for composite MACE. Rates of MACE were lower in the radial group: 102
### Table 1. Individual Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study/First Author (Ref. #)</th>
<th>TEMPURA (15)</th>
<th>RADIAL-AMI (16)</th>
<th>FARMII (17)</th>
<th>Li et al. (18)</th>
<th>Yan et al. (19)</th>
<th>RADIAMI (20)</th>
<th>Gan et al. (21)</th>
<th>Hou et al. (22)</th>
<th>RADIAMI II (23)</th>
<th>RIFLE-STEACS (11)</th>
<th>RIVAL (12)</th>
<th>STEMI-RADIAL (13)</th>
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<tr>
<td>Mean age, yrs</td>
<td>67</td>
<td>55</td>
<td>59</td>
<td>56</td>
<td>70.8</td>
<td>59.5</td>
<td>52.95</td>
<td>29.5</td>
<td>36</td>
<td>26.7</td>
<td>20.9</td>
<td>33</td>
</tr>
<tr>
<td>Female, %</td>
<td>17.9</td>
<td>12</td>
<td>15.8</td>
<td>25.2</td>
<td>32</td>
<td>19.5</td>
<td>29.5</td>
<td>36</td>
<td>36</td>
<td>26.7</td>
<td>20.9</td>
<td>33</td>
</tr>
<tr>
<td>No. of centers</td>
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<td>Multiple*</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Patients, N</td>
<td>149</td>
<td>50</td>
<td>114</td>
<td>370</td>
<td>103</td>
<td>100</td>
<td>195</td>
<td>200</td>
<td>108</td>
<td>1,001</td>
<td>1,958</td>
<td>707</td>
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<td>Primary PCI, %, TRA/TFA</td>
<td>All</td>
<td>36/32</td>
<td>11112114</td>
<td>14</td>
<td>10</td>
<td>14</td>
<td>1</td>
<td>58</td>
<td>4</td>
<td>158</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Gp IIb/IIIa Inhibitors, %, TRA/TFA</td>
<td>None</td>
<td>95/92</td>
<td>NR</td>
<td>NR</td>
<td>All</td>
<td>44/42</td>
<td>31.1/34.3</td>
<td>All</td>
<td>51/54</td>
<td>67.4/69.9</td>
<td>34.5/31.1</td>
<td>45/45</td>
</tr>
<tr>
<td>MACE definition</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
<td>Death</td>
</tr>
<tr>
<td>Sheath size, ≤5-F ≥7-F</td>
<td>NR</td>
<td>TRA: 100%/0%</td>
<td>TFA: 88%/12%</td>
<td>100%/0%</td>
<td>100%/0%</td>
<td>100%/0%</td>
<td>100%/0%</td>
<td>TRA: 81.4%/18.6%</td>
<td>TFA: 90.8%/9.2%</td>
<td>TRA: 98.6%/1.4%</td>
<td>TFA: 95.5%/4.5%</td>
<td>TRA: 100%/0%</td>
</tr>
<tr>
<td>Crossover, %TRA to TFA, %NTA to TRA</td>
<td>0%</td>
<td>4%</td>
<td>1.4%</td>
<td>12.3%</td>
<td>1.6%</td>
<td>1.8%</td>
<td>8%</td>
<td>1.1%</td>
<td>4%</td>
<td>1.7%</td>
<td>2.8%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Bleeding definition used</td>
<td>Study page 27</td>
<td>Study page 544</td>
<td>TIMI</td>
<td>None</td>
<td>TIMI</td>
<td>Study page 334</td>
<td>None</td>
<td>Study page 159</td>
<td>Study page 765</td>
<td>TIMI</td>
<td>TIMI</td>
<td>HORIZONS-AMI</td>
</tr>
<tr>
<td>Follow-up duration</td>
<td>Hospital/9 months</td>
<td>Hospital/30 days</td>
<td>Hospital</td>
<td>Hospital</td>
<td>Hospital</td>
<td>Hospital/6 months</td>
<td>30 days</td>
<td>Hospital</td>
<td>30 days</td>
<td>Hospital</td>
<td>30 days</td>
<td>30 days</td>
</tr>
</tbody>
</table>

*Exact number not reported in manuscript. (Nonprimary PCI were: rescue PCI (RADIAL-AMI, RIFLE-STEACS), rescue PCI + facilitated PCI (FARMII), and Secondary PCI (i.e., facilitated, rescue, or routine adjunctive) (RIVAL). TIMI major vascular bleeding. 5-F or 6-F sheaths.

FARMI = Five French Arterial Access With Reopen in Myocardial Infarction; Gp = glycoprotein; HORIZONS-AMI = Harmonizing Outcomes With Revascularization and Stents in Acute Myocardial Infarction; MACE = major adverse cardiac events; MI = myocardial infarction; NA = not applicable; No. = Numbers; NR = not reported; PCI = percutaneous coronary intervention; RADIAMI = Radial versus femoral access for emergent percutaneous coronary intervention with adjunct glycoprotein IIb/IIIa inhibition in acute myocardial infarction; RADIAMI II = Radial Versus Femoral Approach for Percutaneous Coronary Interventions in Patients With Acute Myocardial Infarction; RADIAMI III = Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome; RIVAL = Radial Versus Femoral Access for coronary intervention trial; STEMI-RADIAL = A Prospective Randomized Trial of Radial vs. Femoral Access in Patients With ST-Segment Elevation Myocardial Infarction; TEMPURA = Test for Myocardial Infarction by Prospective Uncenter Randomization for Access Sites; TFA = transfemoral approach; TIMI = Thrombolysis In Myocardial Infarction; TLR = target lesion revascularization; TRA = transradial approach; TVR = target vessel revascularization.
of 2,226 (4.6%) versus 155 of 2,295 (6.8%) (OR: 0.64, 95% CI: 0.49 to 0.83; p < 0.001) (Fig. 4). There was a markedly lower risk of access site bleeding with radial access, with the odds of such bleeding for the radial group being one-third of that for the femoral group: 49 of 2,390 (2.1%) versus 139 of 2,466 (5.6%) (OR: 0.35, 95% CI: 0.25 to 0.50) (Fig. 5). Six studies were included in the analyses for stroke, and no difference between the 2 groups was found: 10 of 1,927 (0.5%) versus 10 of 1,997 (0.5%) (OR: 1.04, 95% CI: 0.45 to 2.41) (Fig. 6). Similarly, no difference was found between radial and femoral access on comparing rates of MI (25 of 2,251 [1.1%] vs. 31 of 2,320 [1.3%]; OR: 0.83, 95% CI: 0.49 to 1.41) (Fig. 7) or TLR/TVR (23 of 948 [2.4%] vs. 28 of 958 [2.9%]; OR: 0.79, 95% CI: 0.44 to 1.41) (Fig. 8). Finally, whereas the procedure time was found to be longer in the radial access group than in the femoral access group,
this difference was small, with the radial access group taking only 1.5 min longer on average (mean difference: 1.52 min, 95% CI: 0.33 to 2.70; p = 0.01) (Fig. 9).

Discussion

In the present meta-analysis, we found that, compared with femoral access, radial access was associated with nearly a 2-fold reduction in the odds of death and a 1.5-fold reduction in the odds of MACE in STEMI patients undergoing primary PCI. Whereas the risk of stroke, MI, and TLR/TVR were similar between the approaches, major bleeding and access site bleeding were significantly lower with the radial approach than with the femoral approach. Importantly, these benefits were observed despite a slight increase in procedure time with the radial approach.

This meta-analysis is the most comprehensive in evaluating safety and efficacy endpoints and the first to include data from the RIFLE-STEACS (Radial Versus Femoral Randomized Investigation in ST-Segment Elevation Acute
Coronary Syndrome) (11) and STEMI-RADIAL (A Prospective Randomized Trial of Radial vs. Femoral Access in Patients With ST-Segment Elevation Myocardial Infarction) studies (13). The RIVAL (Radial Vs. Femoral Access for Coronary Intervention) and RIFLE-STEACS studies contributed most of the data analyzed. However, major bleeding was not significantly different between the study arms in either of these trials, which is likely due to having insufficient power to demonstrate a difference. On the contrary, by combining all the randomized evidence, we were able to demonstrate a significant decrease in major bleeding using the radial approach. Overall, our results are robust, given the lack of heterogeneity within studies for all of our included endpoints. Two previous meta-analyses have been conducted to study the best access approach in acute MI patients. The first included both randomized and observational studies (84% of the studied population) and thus was likely affected by confounding and selection bias (24). A recently published meta-analysis limited only to randomized controlled trials, but did not include data from RIFLE-STEACS or STEMI-RADIAL, demonstrated a decrease in mortality with a nonsignificant trend of decrease in major bleeding (25). This again is likely secondary to insufficient number of populations studied.

### Figure 6. Stroke

Meta-analysis of pooled data from randomized studies showing the effect of radial versus femoral access approach on risk of stroke in STEMI patients treated with primary PCI. Abbreviations as in Table 1 and Figure 2.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Radial Events</th>
<th>Radial Total</th>
<th>Femoral Events</th>
<th>Femoral Total</th>
<th>Weight</th>
<th>Odds Ratio M–H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADIAL–AMI 2005</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>25</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>RADIAMI 2009</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>7.2%</td>
<td>0.33 [0.01, 8.21]</td>
</tr>
<tr>
<td>RADIAMI II 2011</td>
<td>0</td>
<td>49</td>
<td>0</td>
<td>59</td>
<td>7.2%</td>
<td>0.39 [0.02, 9.89]</td>
</tr>
<tr>
<td>RIFLE–STEACS 2012</td>
<td>4</td>
<td>500</td>
<td>3</td>
<td>501</td>
<td>33.0%</td>
<td>1.34 [0.30, 6.01]</td>
</tr>
<tr>
<td>RIVAL 2012</td>
<td>5</td>
<td>955</td>
<td>4</td>
<td>1003</td>
<td>42.9%</td>
<td>1.31 [0.35, 4.91]</td>
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<tr>
<td>STEMI–Radial 2012</td>
<td>1</td>
<td>348</td>
<td>1</td>
<td>359</td>
<td>9.7%</td>
<td>1.03 [0.06, 16.56]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td></td>
<td>1927</td>
<td>1997</td>
<td>100.0%</td>
<td></td>
<td>1.07 [0.45, 2.54]</td>
</tr>
</tbody>
</table>

Total events: 10
Heterogeneity: Tau^2 = 0.00; Chi^2 = 1.07, df = 4 (P = 0.90); I^2 = 0%
Test for overall effect: Z = 0.16 (P = 0.87)

### Figure 7. Recurrent MI

Meta-analysis of pooled data from randomized studies showing the effect of radial versus femoral access approach on risk of recurrent myocardial infarction in STEMI patients treated with primary PCI. MI = myocardial infarction; other abbreviations as in Table 1 and Figure 2.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Radial Events</th>
<th>Radial Total</th>
<th>Femoral Events</th>
<th>Femoral Total</th>
<th>Weight</th>
<th>Odds Ratio M–H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gan 2009</td>
<td>1</td>
<td>90</td>
<td>2</td>
<td>105</td>
<td>4.9%</td>
<td>0.58 [0.05, 6.49]</td>
</tr>
<tr>
<td>Hou 2010</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td></td>
<td>Not estimable</td>
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<tr>
<td>RADIAL–AMI 2005</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>25</td>
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<td>Not estimable</td>
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<tr>
<td>RADIAMI 2009</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>2.8%</td>
<td>3.06 [0.12, 76.95]</td>
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<td>RADIAMI II 2011</td>
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<td>49</td>
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<td>59</td>
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<td>RIFLE–STEACS 2012</td>
<td>6</td>
<td>500</td>
<td>7</td>
<td>501</td>
<td>24.0%</td>
<td>0.86 [0.29, 2.57]</td>
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<td>RIVAL 2012</td>
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<td>955</td>
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<td>1003</td>
<td>50.6%</td>
<td>0.64 [0.30, 1.36]</td>
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<td>STEMI–Radial 2012</td>
<td>4</td>
<td>348</td>
<td>3</td>
<td>359</td>
<td>12.8%</td>
<td>1.38 [0.31, 6.21]</td>
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<tr>
<td>TEMPURA 2003</td>
<td>2</td>
<td>77</td>
<td>1</td>
<td>72</td>
<td>4.9%</td>
<td>1.89 [0.17, 21.34]</td>
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<td>Yan 2008</td>
<td>0</td>
<td>57</td>
<td>0</td>
<td>46</td>
<td></td>
<td>Not estimable</td>
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<tr>
<td>Total (95% CI)</td>
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<td>2251</td>
<td>2320</td>
<td>100.0%</td>
<td></td>
<td>0.83 [0.48, 1.42]</td>
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</table>

Total events: 25
Heterogeneity: Tau^2 = 0.00; Chi^2 = 2.07, df = 5 (P = 0.84); I^2 = 0%
Test for overall effect: Z = 0.69 (P = 0.49)
Since its introduction in 1989, the radial route has gained increased popularity especially with the evolving technology and increasing experience of interventional cardiologists (26). The radial artery’s superficial course permits early recognition of bleeding at access sites and allows easy compressibility. Thus, hemostasis can be achieved safely and rapidly. In addition, there are no adjacent structures susceptible to be damaged during percutaneous procedures and thus access site complications are expected to decrease with the radial approach in comparison with the femoral approach. The limitation of the smaller caliber of the radial artery is overcome with the evolving technology and even the advanced equipment that are potentially useful in current PCI practice (such as distal embolic protection devices, aspiration catheters, bifurcation balloons and stents, and intravascular imaging probes) are compatible with 6-F access sheaths.

The improved survival associated with the radial approach observed in our analysis is consistent with recent data demonstrating that implementing peri-PCI bleeding avoidance strategies leads to reduction in mortality (6). Both access- and non-access-site bleeding have been independently associated with increased short-term and long-term mortality (9). STEMI patients treated with primary PCI are particularly likely to benefit from the bleed reduction of the radial approach as these patients have a greater risk of access site bleeding and other access-related complications given the emergent nature of the procedure and the need for aggressive antiplatelet and antithrombotic therapies (12). Another potential benefit of the radial approach is that it may allow higher doses of anticoagulants to be used for further ischemic reduction while minimizing the penalty of increased bleeding (8).
The overwhelming results favoring the radial approach notwithstanding, its acceptance as a preferred route of access in primary PCI might be met by several challenges. The greater anatomic variability of the course and distribution of the radial artery in the arm as well as challenges in cannulating the coronary arteries via radial access may increase procedural time and account for a higher rate of crossover to the femoral route. This may be detrimental in STEMI patients, where timely reperfusion is critical. We found that procedure time with the radial approach was longer by only 1.5 min, suggesting that procedural delay may not be a significant concern when performed by experienced operators. Conversely, the femoral approach allows for the convenient acquisition of central venous access and insertion of hemodynamic assist devices in unstable patients. Patients with cardiogenic shock were excluded from most of the trials except RIPLE-STEACS, where an intra-aortic balloon pump was used 8.4% and 7.6% in the femoral and the radial approaches, respectively (p = 0.73) (11). However, it remains unknown whether the radial approach would remain efficacious in unstable patients and patients with cardiogenic shock. Finally, in a recent study of 51 patients randomized to the radial approach versus the femoral approach during diagnostic coronary angiography, the radial approach generated significantly more particulate cerebral microemboli (27). In the current study, we found no difference in clinically evident strokes between the 2 approaches.

Study limitations. The low rate of crossover and difference in procedure time in the included studies reflects the adequate experience of operators with both techniques and raises a concern of generalizability of our findings. Most of the included studies are either single-center or include only a few centers with high concentrations of experienced radial operators. Degree of operator experience is important, especially given that a learning curve for radial artery intervention has been clearly demonstrated (28). Another limitation of our study is the substantial heterogeneity among the bleeding definitions used in the included studies. The newly proposed consensus classification for bleeding may help overcome such a limitation in the future (29). Finally, 4 studies (11,12,16,17) included in our analysis were not strictly limited to primary PCI and included patients with rescue PCI. However, these patients were equally distributed in the both treatment arms and were unlikely to affect the major findings of the current study (Table 1).

Conclusions

Our findings support the use of the radial artery over the femoral artery in primary PCI to optimize outcomes in STEMI patients. Radial access for STEMI by experienced operators is associated with decreased bleeding and improved survival.

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APPENDIX

For supplemental figures, please see the online version of this paper.