The transradial approach for percutaneous coronary intervention (PCI) was first introduced by Campeau in 1989. However, the use of the radial artery for vascular access in PCI remains rare, with the femoral artery being the most common site of access. Currently, it is estimated that only 1% to 3% of cardiac catheterizations in the United States employ the transradial approach, despite a number of studies demonstrating reductions in vascular complications with its use. The importance of reducing these vascular complications—such as access site hematomas, arterial dissections, retroperitoneal bleeds, and pseudoaneurysms—is increasingly being emphasized because their impact on clinical outcomes is becoming better understood. Furthermore, with significant improvements in the ischemic outcomes from PCI as a result of advancements in anticoagulation and procedural technique, reducing bleeding complications has become a clinical priority. The radial approach for PCI is an important means by which these vascular complications can be reduced.

THE IMPORTANCE OF REDUCING BLEEDING COMPLICATIONS

Bleeding complications that occur in the peri-PCI period, including minor bleeding, are associated with worse clinical outcomes and increased mortality. In the setting of acute coronary syndromes (ACS), an association between the severity of bleeding and worse clinical outcomes was demonstrated by Rao and colleagues, who analyzed 26,452 patients enrolled in four large ACS trials and showed a stepwise relationship between bleeding severity and 30-day and 6-month mortality. Additionally, moderate or severe bleeding that was procedure related was associated with a higher mortality rate than moderate or severe bleeding that was not procedure related. The majority of bleeding events associated with PCI are hematomas at the site of vascular access. Data from the National Heart, Lung, and Blood Institute Dynamic Registry, which included 6,656 patients, demonstrated that 97% of the patients who had hematomas underwent femoral artery access. One feared access site–related complication is retroperitoneal hematoma that can occur with femoral artery access. These events have been shown to be associated with very poor outcomes. Some studies have shown that up to three-fourths of patients with retroperitoneal bleeds require blood transfusions and that the mortality rate of patients with retroperitoneal bleeds exceeds 10%. Therefore, methods to reduce access site bleeding, such as using the radial artery for access, can substantially reduce overall bleeding complications.

REDUCING BLEEDING COMPLICATIONS THROUGH THE TRANSRADIAL APPROACH

Transradial coronary angiography and intervention is associated with a significant decrease in bleeding complications. The radial artery is smaller in size, easily compressible, and distant from other major vascular structures and the retroperitoneal space. The transradial approach has been shown to be a feasible and reliable approach in many clinical settings, including high-risk PCI during acute myocardial infarction.

Randomized Trials Comparing Radial and Femoral Approaches

There have been several randomized trials comparing transradial and transfemoral PCI. Brueck and colleagues...
compared the two approaches in 1,024 patients undergoing coronary catheterization (512 transradial, 512 transfemoral) by four interventional cardiologists at a community hospital. The patients were analyzed for procedure success, procedure time, radiation exposure, and vascular access site complications such as pseudoaneurysm, arteriovenous fistula, retroperitoneal hematoma, limb ischemia, surgical vascular repair, loss of radial artery pulse, and major bleeding that was defined as a decrease of at least 3 g/dL of hemoglobin or administration of blood products.17

In this study, successful catheterization was slightly lower in the transradial group versus the transfemoral group (96.5% vs 99.8%; \(P < .0001\)), with a small increase in both procedure time and radiation exposure in the transradial group. However, the rate of vascular complications was greatly reduced from 3.71% in the transfemoral group to 0.58% in the transradial cohort (\(P = .0008\)). This difference was seen despite the use of vascular closure devices in 93.2% of patients undergoing an intervention in the transfemoral group. In the transfemoral group, there were three pseudoaneurysms, three patients developed a groin hematoma that required a blood transfusion, 11 patients had a decline in hemoglobin of at least 3 g/dL without the need for transfusion, and two patients developed an arteriovenous fistula. In the transradial group, no major vascular or bleeding complications were noted except for three patients who had no beating radial artery pulse at discharge.

These data are consistent with other smaller trials. Agostoni and colleagues published a meta-analysis comparing outcomes with the radial versus femoral approach for PCI.5 Major adverse cardiac events, access site complications (including bleeding), and procedural success were all evaluated. Although major adverse cardiac events did not differ between the two groups, there were significantly fewer access site complications in the transradial group compared to the femoral group (0.3% vs 2.8%; odds ratio [OR], 0.2; 95% confidence interval [CI], 0.09–0.42; \(P < .0001\)). Similarly, an updated meta-analysis by Jolly and colleagues found a significant 73% reduction in major bleeding in the radial access group compared to the femoral access group (0.05% vs 2.3%; OR, 0.27; 95% CI, 0.16–0.45). There was a higher rate of access site crossover in the radial group (ie, crossover to the femoral site due to failed access), and there was no significant difference in mortality (Table 1).18

**OBSERVATIONAL STUDIES**

In addition to randomized trial data, single- and multicenter registries have compared clinical outcomes between radial and femoral approaches to PCI. In the
PREVAIL (Prospective Registry of Vascular Access in Interventions in Lazio Region) study, 1,052 patients undergoing any percutaneous cardiovascular procedure requiring arterial access were analyzed. Among that group, radial access was performed in 509 and femoral access was performed in 543, and 40% of patients in both groups underwent PCI. Radial access was associated with a significant reduction in the primary outcome of in-hospital major and minor bleeding, stroke, or access site vascular complications compared with femoral access (4.2% vs 1.9%; \( P = .03 \)). In addition, the secondary endpoint of in-hospital death or myocardial reinfarction was also lower in the radial access group (3.1% vs 0.6%; \( P = .005 \)).

After multivariable adjustment, the radial approach was independently associated with a reduction in both the primary endpoint (OR, 0.37; 95% CI, 0.16–0.84) and the secondary endpoint (OR, 0.14; 95% CI, 0.03–0.62). The largest observational study included 593,094 patients from the National Cardiovascular Data Registry. In this study, only 0.19% of patients who underwent radial access experienced a vascular complication (defined as access site occlusion, arterial dissection, pseudoaneurysm, peripheral embolization, or arteriovenous fistula formation) compared with femoral access (4.2% vs 1.9%; \( P = .03 \)). In addition, the secondary endpoint of in-hospital death or myocardial reinfarction was also lower in the radial access group (3.1% vs 0.6%; \( P = .005 \)). After multivariable adjustment, the radial approach was independently associated with a reduction in both the primary endpoint (OR, 0.37; 95% CI, 0.16–0.84) and the secondary endpoint (OR, 0.14; 95% CI, 0.03–0.62).

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Given the relationship between bleeding and mortality as previously described, it is reasonable to expect that the bleeding reduction afforded by the radial approach would be associated with improved survival; however, only one observational study has demonstrated this. The MORTAL (Mortality Benefit of Reduced Transfusion After Percutaneous Coronary Interventions Via the Arm or Leg) study evaluated 38,872 PCI procedures in 32,822 patients in British Columbia. In this study, femoral access was used in 79.5% of the procedures, with radial access used in 20.5%. The need for a periprocedural transfusion was cut in half by using the radial approach. In the femoral group, 2.8% of the patients required a periprocedural transfusion, while only 1.4% in the radial group needed a transfusion (adjusted OR, 0.59; 95% CI, 0.48–0.73). This reduction in the need for transfusions translated to a significant mortality benefit at 30 days and 1 year.

Observational data also suggest that patients who are at higher risk for bleeding experience a greater benefit from the radial approach. For example, elderly patients are particularly susceptible to bleeding and vascular complications and represent a growing percentage of patients undergoing coronary angiography and interventions. Two studies have now demonstrated that radial access for PCI is not only feasible in this group but leads to significant reductions in vascular complications. The prospective, multicenter OCTOPLUS study evaluated 377 octogenarians undergoing coronary angiography and PCI via either the femoral or radial approach. In this analysis, the incidence of vascular complications was significantly lower in the radial group (OR, 0.42; 95% CI, 0.31–0.56) without any observed reduction in procedural success (adjusted OR, 1.02; 95% CI, 0.93–1.12) (Figure 1).

### TABLE 1. OUTCOMES OF RADIAL VERSUS FEMORAL ACCESS

<table>
<thead>
<tr>
<th></th>
<th>Radial (n/%)</th>
<th>Femoral (n/%)</th>
<th>Odds Ratio (95% CI)</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major bleeding</td>
<td>13/2,390 (0.05)</td>
<td>48/2,068 (2.3)</td>
<td>0.27 (0.16, 0.45)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Death, MI, or stroke</td>
<td>56/2,209 (2.5)</td>
<td>71/1,874 (3.8)</td>
<td>0.71 (0.49, 1.01)</td>
<td>.058</td>
</tr>
<tr>
<td>Death</td>
<td>22/1,906 (1.2)</td>
<td>28/1,565 (1.8)</td>
<td>0.74 (0.42, 1.3)</td>
<td>.29</td>
</tr>
<tr>
<td>MI</td>
<td>39/1,931 (2)</td>
<td>46/1,595 (2.9)</td>
<td>0.76 (0.49, 1.17)</td>
<td>.21</td>
</tr>
<tr>
<td>Stroke</td>
<td>2/1,428 (0.1)</td>
<td>5/1,107 (0.5)</td>
<td>0.39 (0.09, 1.75)</td>
<td>.22</td>
</tr>
<tr>
<td>Access site crossover</td>
<td>150/2,542 (5.9)</td>
<td>34/2,460 (1.4)</td>
<td>3.82 (2.83, 5.15)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Inability to cross the lesion</td>
<td>60/1,274 (4.7)</td>
<td>40/1,186 (3.4)</td>
<td>1.31 (0.87, 1.96)</td>
<td>.2</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; MI, myocardial infarction. Reprinted from the American Heart Journal, 157/1, Jolly et al, Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials, 132-410, Copyright 2009, with permission from Elsevier.
reduced in the radial group (1.6% vs 6.5%; \( P = .03 \)), with all vascular complications except for one occurring in the transfemoral group.\(^9\) Finally, Jaffe and colleagues studied over 200 octogenarians undergoing PCI via the femoral or radial approach.\(^{20}\) They found that there was an equal rate of procedural success between the two groups, but that radial access led to a marked reduction in vascular access complications and bleeding at the expense of longer fluoroscopy time and higher contrast use. Access site bleeding (4% vs 14%; \( P = .007 \)), hematoma (1% vs 11%; \( P = .001 \)), and vascular complications (5% vs 26%) were all lower with radial access. Multivariate analysis showed that the radial approach was an independent negative predictor of procedural vascular complications (OR, 0.23; CI, 0.08–0.65).

In addition to older patients, women and patients with ACS are also at high risk for bleeding. Although there are no prospective randomized trials comparing access approaches in these populations, there are observational data. Rao and colleagues examined the interaction between sex and access site in the National Cardiovascular Data Registry and found that the radial approach was associated with greater bleeding reduction in women compared with men. The same was true for patients with ACS compared with patients with stable angina.\(^2\)

**CONCLUSION**

Vascular complications from coronary angiography and interventions play an important role in the clinical outcomes of these procedures. It is now recognized that any amount of bleeding that complicates PCI leads to worse clinical outcomes and an increase in mortality. Access site hematomas account for the majority of these complications. Using the radial artery for access, as opposed to the femoral artery, can significantly reduce bleeding and other vascular complications primarily due to its smaller size and easy compressibility. Through reductions in bleeding, the transradial approach may lead to improved long-term clinical outcomes. Although there have been a number of studies that demonstrate the feasibility of this approach, with substantial reductions in vascular complications even in high-risk populations and the elderly, there has been slow adoption of this approach in the United States. Improved awareness of the clinical benefits of the transradial approach should be encouraged.

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