Economic Benefits of the Transradial Approach

How cost savings associated with the transradial approach might affect your percutaneous coronary interventions.

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The femoral artery continues to be the dominant access site for diagnostic and interventional cardiac catheterization in the United States. This site remains popular despite increased rates of vascular access site complications, including arteriovenous fistula, pseudoaneurysm, hematoma formation, and retroperitoneal bleeding. In addition to the increased morbidity and mortality, vascular access complications (VACs) remain a significant contributor to hospital costs, with an incidence of 3% to 28%. VACs contribute to both direct and indirect procedural costs resulting from prolonged hospitalization, blood transfusions, increased nursing workload, noninvasive imaging, and surgical repair. More recently, the most common of these complications, major bleeding, has gained much attention given the association of major bleeding with prolonged hospitalization and worse clinical outcomes, including recurrent ischemia and death. Treatment strategies that minimize VACs may decrease costs and, more importantly, have the potential to improve patient outcomes.

In addition to the use of newer antithrombotics with improved safety profiles, another treatment strategy that has shown a significant reduction in procedure-related bleeding and other VACs is the use of the transradial approach (TRA) for diagnostic cardiac catheterization and percutaneous coronary intervention (PCI). The use of TRA for diagnostic catheterization was first introduced by Campeau in 1989, and Kiemeneij and Laarman subsequently described PCI using radial artery access in 1993. Although its adoption has increased in Europe and Asia, where TRA accounts for up to 30% of total procedures, adoption in the United States has been slow. Of the more than 593,094 procedures performed in the United States captured by the National Cardiovascular Data Registry database, only 1.3% (7,804) were performed using a TRA.

Although used infrequently in the United States, there are abundant data demonstrating several advantages of the TRA over the transfemoral approach (TFA), including reduced major bleeding and access site complications, increased patient comfort and quality of life, and reduction in hospital costs. However, it should be noted that the published literature comparing the radial with the femoral approach has some limitations. The published randomized trials have been small and were conducted in centers that have considerable expertise in performing transradial PCI. The observational data are limited by selection bias; older patients, patients with prior coronary artery bypass grafting, and patients undergoing primary PCI for acute ST-segment elevation myocardial infarction are often excluded. In addition, the rate of radial artery occlusion 30 days after the transradial approach is 3% to 5%, with almost all cases being asymptomatic. The rate of occlusion can potentially be minimized by using systemic anticoagulation during diagnostic catheterization and by minimizing the pressure applied for arterial compression and the duration of the compression post-procedure. Finally, the radial artery is often unable to accommodate guide catheter sizes > 7 F, which may be necessary for simultaneous two-stent techniques to treat
bifurcation disease. With the upcoming availability of 6.5-F and 7.5-F sheathless guiding catheters, this limitation may be addressed in the near future.\textsuperscript{25}

In the current health care climate with reductions in hospital reimbursements and rising demands on limited hospital resources, use of the TRA for cardiac catheterization and PCI may become an integral part of cost-containment strategies by improving the safety profile of the procedure while maintaining quality and procedural success. The goal of this article is to review the economic advantages of using the TRA in cardiac catheterization.

ASSOCIATION BETWEEN TRA AND REDUCED BLEEDING

With more than 1 million PCI procedures performed annually in the United States at a mean cost of $9,000, billions of dollars are spent in the care of patients undergoing catheterization.\textsuperscript{26} The most common adverse complications are no longer ischemic but bleeding events, which have the potential to increase hospital costs in excess of $6,000, adding an average of $342 to the cost of each interventional procedure.\textsuperscript{5} Although use of fluoroscopic guidance for bony landmarks and femoral artery palpation help in successful percutaneous access, femoral arterial access remains largely a blind procedure, and various factors, including variations in anatomical positioning, body habitus, use of multiple anticoagulants, and incorrect needle positioning can lead to bleeding and other vascular complications, patient discomfort, prolonged hospitalization, and increased costs. However, the TRA helps minimize risk because the radial artery is not surrounded by other neurovascular structures and is relatively superficial. As such, manual compression of the radial artery is easily performed, thereby preventing major VACs and their associated increased hospital costs.

Although the TRA has the potential for system-wide cost savings, it is important to maintain focus on the improved safety profile of the procedure with minimization of VACs. In appropriate patients (those with collateral flow determined by means of the Allen test), use of the TRA results in procedural success are equal to that of the TFA.\textsuperscript{27-29} Furthermore, recent data show some evidence that the minimization of VACs associated with the use of the TRA, primarily bleeding, may be associated with improved outcomes. A meta-analysis of 23 randomized trials (N = 7,020) by Jolly et al demonstrates a trend for reduction in the composite endpoint of death, myocardial infarction (MI), or stroke with the TRA versus the TFA (2.5% vs 3.8%; odds ratio, 0.71; 95% confidence interval [CI], 0.49–1.01; \(P = .058\)).\textsuperscript{30} A retrospective analysis of the PRESTO-ACS trial, which investigated early invasive and conservative treatment in non-ST segment elevation acute coronary syndrome (ACS), showed that at 1-year follow-up, patients in the TRA group (n = 307) had a statistically significant decrease in death or reinfarction (4.9% vs 8.3%; \(P = .05\)), bleeding (0.7% vs 2.7%; \(P = .03\)), and net clinical outcome (5.5% vs 9.9%; \(P = .03\)) compared with those in the TFA group (n = 863).\textsuperscript{31} Similarly, a registry analysis found that after adjusting for all variables, the TRA was associated with a significant reduction in 30-day and 1-year mortality (odds ratio, 0.71 [95% CI, 0.61–0.82] and 0.83 [95% CI, 0.71–0.98], respectively; all \(P < .001\)).\textsuperscript{32}

INCIDENCE AND ECONOMIC BURDEN OF VASCULAR COMPLICATIONS

Despite advances in technology of smaller catheters, sheaths, and delivery systems, VACs are not uncommon, with a rate of 3% to 28% depending on the definition.\textsuperscript{2-5} In a study of more than 335,477 Medicare beneficiaries who underwent PCI in 2002, nearly 5.5% developed a VAC.\textsuperscript{33} The average incremental cost associated with any vascular complication was estimated to be $4,278, along with an incremental increase in hospital length of stay of 1.8 days.\textsuperscript{33} In an analysis of 5,892 PCI patients who had manual compression of their femoral artery after the procedure: 5.1% developed a hematoma; 2.5% developed a hematocrit decrease > 15%; 0.9% developed an arteriovenous fistula; 1% developed a pseudoaneurysm; and 1.3% required surgical repair of the access site.\textsuperscript{2} Similarly, in another report by Resnic et al, patients with manual compression after catheterization had an overall complication rate of 11%, with incidences of hematoma (5.7%), groin bleeding (3%), pseudoaneurysm (1.7%), arteriovenous fistula (0.83%), retroperitoneal hemorrhage (0.14%), limb ischemia (0.1%), and infection (0.05%).\textsuperscript{34} They also demonstrated attributable costs for an episode of hematoma ($1,399), groin bleeding ($5,440), pseudoaneurysm ($6,357), arteriovenous fistula ($1,415), retroperitoneal hemorrhage ($6,698), limb ischemia ($5,534), and infection ($2,400). Consequently, use of the TRA, which minimizes the rates of these complications compared to the TFA, has the potential of not only decreasing morbidity and mortality, but also decreasing costs associated with management of VACs.

ASSOCIATION BETWEEN MAJOR BLEEDING AND COSTS

Although all VAC complications increase morbidity and have the potential to prolong recovery, major bleeding, the most common complication, has recently gained much attention because of the association between major bleeding and adverse clinical events.\textsuperscript{6-12} Studies investigating the use of the radial artery for catheterization in
appropriate candidates have shown that there is significantly less major bleeding using the TRA compared with the TFA.\textsuperscript{17,18,21,22} This reduction in major bleeding potentially has a significant economic impact because major bleeding is associated with additional hospital expenses. Analysis from the REPLACE-2 trial demonstrated that the independent predictors of hospital costs included both major and minor bleeding, which increased costs by $6,300 and $400, respectively.\textsuperscript{5} Indeed, hospital costs parallel the severity of major bleeding. Using the economic substudy of the GUSTO IIb trial (\(n = 1,235\)), Rao et al demonstrated a stepwise increase in hospital costs associated with bleeding (\$14,282 for no bleeding, \$21,674 for mild bleeding, \$45,798 for moderate bleeding, and \$66,564 for severe bleeding; \(P < .01\)).\textsuperscript{35} Interestingly, bleeding events contributed more to hospital costs than recurrent MI; the total hospital costs associated with recurrent MI with no bleed (\$14,442) was less than with the costs associated with a bleeding event and no MI (\$30,122). After adjusting for baseline factors, each moderate or severe bleeding event was associated with a $3,770 increase in hospital costs. Furthermore, each blood transfusion event was associated with a $2,080 increase in hospital costs after adjustment. Similarly, Lauer et al reported that a single unit of blood transfusion was associated with an $8,000 increase in the overall cost of the hospitalization.\textsuperscript{36} Minimization of bleeding events through treatment strategies such as the TRA may help contain costs through minimization of bleeding events and transfusion requirements.

**LENGTH OF STAY**

Prolonged length of stay has been demonstrated to be a driving force for the increased costs associated with vascular access major bleeding.\textsuperscript{35} Prolonged hospitalization may be required due to necessity for surgical intervention, monitoring of hematocrit, monitoring hematoma size, and/or reinitiation of antithrombotic agents. Rao et al demonstrated that as bleeding severity increased, there was a stepwise increase in length of stay (no bleeding = 5.4 days, mild bleeding = 6.9 days, moderate bleeding = 15 days, severe bleeding = 16.4 days; \(P < .01\)).\textsuperscript{35} Economic analysis of the CURE trial demonstrated that each major bleeding event increased hospital length of stay by 5.94 days, and each life-threatening bleeding event added 4.57 days; the occurrence of both added 9.91 days.\textsuperscript{37}

Although earlier studies of patients with stable or unstable angina demonstrated that the TRA produces similar lengths of stay compared with the TFA, more recent evidence in the era of coronary stenting demonstrates shorter lengths of stay using the TRA in this patient population (Table 1). In the ACCESS study of 900 patients with stable and unstable angina randomized to undergo percutaneous transluminal coronary angioplasty in the mid-1990s, Kiemeneij et al found no statistical difference in the mean length of stay for percutaneous transluminal coronary angioplasty via radial (1.5 ± 2.5 days), brachial (1.8 ± 3.8 days), and femoral (1.8 ± 4.2 days).\textsuperscript{13} However, the CARAFE study of 210 patients with unstable or stable angina randomized to the TRA or TFA demonstrated shorter postprocedure hospital duration with the TRA (1.31 ± 0.94 days) than with the TFA (1.75 ± 1.87 days; \(P < .05\)) and resulted in decreased overall costs (\$4,508 ± 991 vs \$5,213 ± 2,672; \(P < .05\)).\textsuperscript{38}

Studies in the ACS population have demonstrated a significant reduction in hospital length of stay using the TRA compared with the TFA (Table 1). In an analysis of 119 consecutive ACS patients undergoing primary angioplasty (\(n = 64\) in the TRA and \(n = 55\) in the TFA), total hospital length of stay was significantly higher in the TFA group (5.9 ± 2.1 vs 4.5 ± 1.2 days; \(P = .05\)).\textsuperscript{39} In a study of patients with ACS, Mann et al demonstrated that postprocedure length of stay was 1.4 ± 0.2 days in six patients who underwent intervention using the TRA (\(n = 65\)) versus 2.3 ± 0.4 days in those who had their catheterization using the TFA (\(n = 77\)) (\(P < .01\)). In this study, the total hospital length of stay was 3 ± 0.3 days in the TRA group as compared to 4.5 ± 0.5 days in the TFA group (\(P < .01\)), which resulted in total hospital charges of \$20,476 ± 811 for those who underwent TRA versus \$23,289 ± 1,180 in the TFA patients (\(P < .01\)).\textsuperscript{22} The TRA was also shown to decrease the hospital length of stay among elderly (age > 65 years) patients with ACS who were randomized to catheterization from the TRA versus the TFA.

Total hospital stay in the TFA patients (10.1 ± 4 days) was longer than in the TRA group (7.2 ± 2.6 days; \(P < .01\)), and there was a significant difference in VACs between the two groups (1.8% in the TRA group vs 13.1% in the TFA group; \(P < .05\)).\textsuperscript{29} Reduction in bed and pharmacy costs may explain some cost savings resulting from reduced length of stay. In their analysis of stable patients undergoing diagnostic catheterization, Cooper et al demonstrated that the TRA resulted in significant reductions in bed, pharmacy, and total hospital costs by 14% per patient (\$2,010 vs \$2,299; \(P < .0001\)).\textsuperscript{23}

**NURSING WORKLOAD**

A reduction in nursing workload may also help explain some of the cost savings seen using the TRA. Amoroso et al described that the median catheterization lab nurse workload was 174 (134–218) minutes during and after a transfemoral catheterization of 52 patients versus a median of 86 (58–126) minutes after transradial
catheterization in 208 patients ($P < .001$). Regression analysis in this study demonstrated that the independent predictors of increased catheterization lab nurse workload were femoral access, failed radial access and crossover interventional procedures, procedural time, and urgent procedures. The increased nurse workload associated with the TFA also carried over to the wards (ie, patient-care areas outside of the catheterization lab) in patients admitted to the hospital. Ward nurse workload was a median of 386 (226–652) minutes for patients in the TRA group and 720 (314–1375) minutes for patients in the TFA group ($P < .001$). Independent predictors of increased ward nurse workload included access-site complication, length of in-hospital stay, admission to coronary care unit, and interventional procedures. The decreased workload may partly result from saving time pulling sheaths, monitoring large hematomas, and ensuring appropriate bedrest and mobilization. It is noteworthy that the TRA was the only predictor of reduced generic workload in this study. Consequently, the TRA has the potential to help hospital management ease the burden on registered nurses by minimizing time-consuming tasks and increasing productivity at no expense to quality of care.

**INCREASED PATIENT SATISFACTION**

In addition to the increased rate of VACs, the TFA also contributes significantly to patient discomfort and decreases quality of life in comparison to the TRA. The TRA allows the patient to immediately sit upright and ambulate in a very short period of time after catheterization. Cooper et al performed a quality-of-life analysis on 99 patients who underwent TFA catheterization versus 101 who underwent TRA. Using the SF-36 questionnaire, they demonstrated that 1 week after catheterization, patients’ physical function, bodily pain, social function, and mental health favored the TRA. This study demonstrated that of the patients who underwent both approaches, 80% strongly preferred the TRA. Consequently, the TRA has the potential to increase productivity of the patient with quicker recovery to personal and working life.

**CONCLUSION**

Data from observational studies and randomized trials demonstrate that TRA is associated with a significant reduction in bleeding compared with the TFA, with no difference in procedure success. The economic implications of these effects include reduced hospital costs driven by

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>LOS Using TRA$^a$</th>
<th>LOS Using TFA$^a$</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiemeneij et al$^{18}$</td>
<td>Stable and unstable angina patients undergoing PTCA$^b$</td>
<td>1.5 ± 2.5 days n = 275</td>
<td>1.8 ± 4.2 days n = 272</td>
<td>$P = NS$</td>
</tr>
<tr>
<td>Louvard et al$^{18}$</td>
<td>Stable and unstable angina patients undergoing stenting$^b$</td>
<td>1.31 ± 0.94 days n = 140</td>
<td>1.75 ± 1.87 days n = 70</td>
<td>$P &lt; .05$</td>
</tr>
<tr>
<td>Mann et al$^{20}$</td>
<td>Unstable angina or recent MI undergoing PTCA$^b$</td>
<td>1.9 ± 0.3 days n = 50</td>
<td>3.4 ± 0.6 days n = 100</td>
<td>$P &lt; .05$</td>
</tr>
<tr>
<td>Phillipe et al$^{39}$</td>
<td>ACS patients undergoing stenting$^c$</td>
<td>4.5 ± 1.2 days n = 64</td>
<td>5.9 ± 2.1 days n = 55</td>
<td>$P = .05$</td>
</tr>
<tr>
<td>Mann et al$^{22}$</td>
<td>ACS patients undergoing stenting$^b$</td>
<td>1.4 ± 0.2 days n = 68</td>
<td>2.3 ± 0.4 days n = 77</td>
<td>$P &lt; .01$</td>
</tr>
<tr>
<td>Yann et al$^{29}$</td>
<td>Elderly ACS patients undergoing stenting$^c$</td>
<td>7.2 ± 2.6 days n = 57</td>
<td>10.1 ± 4.6 days n = 46</td>
<td>$P &lt; .01$</td>
</tr>
</tbody>
</table>

$^a$Mean ± SD.

$^b$Length of stay defined as postprocedure length of stay.

$^c$Length of stay defined as total hospital length of stay.

Abbreviations: ACS, acute coronary syndrome; LOS, length of stay; NS, not significant; PTCA, percutaneous transluminal coronary angioplasty; TFA, transfemoral approach; TRA, transradial approach.
shorter length of stay and greater patient satisfaction. Another important impact is patient satisfaction, which is greater with the TRA than with the TFA. Given the multiple potential advantages of the TRA in reducing bleeding complications and other vascular access site complications, coupled with the current reduction in reimbursement and elective PCI being billed as an outpatient procedure by Centers for Medicare & Medicaid Services, the use of the TRA may help centers align procedural costs with reimbursement by minimizing VACs and decreasing burden on limited hospital resources. Furthermore, the TRA may permit a safe same-day discharge strategy after uncomplicated elective procedures, although the safety of such a strategy needs to be investigated in a prospective, multicenter study.

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