



TRANSRADIAL VERSUS TRANSFEMORAL PERCUTANEOUS CORONARY INTERVENTION IN ACUTE CORONARY SYNDROMES: AN OBSERVATIONAL STUDY OF BLEEDING, VASCULAR COMPLICATIONS, CONTRAST USE AND IN-HOSPITAL OUTCOMES

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Abstract

Background: Vascular access is an important determinant of bleeding and procedural complications during percutaneous coronary intervention (PCI), particularly in patients with acute coronary syndromes (ACS) receiving intensive antithrombotic therapy. Transradial access has increasingly become the preferred access strategy in contemporary ACS practice, although transfemoral access remains important in selected patients and in centers with variable radial expertise. Randomized trials and meta-analyses have consistently demonstrated reductions in access-site bleeding and vascular complications with radial access, while differences in ischemic outcomes have varied according to ACS phenotype, operator experience and study population.

Objective: To compare transradial and transfemoral PCI in patients with ACS with respect to contrast volume, bleeding, vascular complications, procedural characteristics and in-hospital clinical outcomes.

Methods: This retrospective observational study included 150 consecutive patients with ACS undergoing PCI. Patients were categorized according to initial arterial access: radial (n=105) or femoral (n=45). Baseline characteristics, procedural variables, contrast volume, bleeding events, access-site complications, acute kidney injury, length of stay and in-hospital major adverse cardiovascular events (MACE) were compared. Bleeding was classified according to clinically relevant categories informed by Bleeding Academic Research Consortium definitions.

Results: Mean contrast volume was lower in the radial group than in the femoral group (153.3±35.1 vs 177.2±45.8 mL; simulated P<0.001). Major bleeding occurred in 2.9% versus 15.6% (P=0.008), hematoma in 11.4% versus 35.6% (P=0.001), vascular complications in 1.9% versus 11.1% (P=0.026), and blood transfusion in 1.9% versus 11.1% (P=0.026), respectively. Contrast-associated acute kidney

Vol. 32 No.11 (2025): JPTCP (2893-2902)

injury occurred in 7.6% versus 11.1% ($P=0.53$). In-hospital MACE occurred in 7.6% of radial-access patients and 17.8% of femoral-access patients ($P=0.084$). Median/mean hospital stay was shorter with radial access (3.8 ± 1.1 vs 4.4 ± 1.4 days; $P=0.01$).

Conclusion: In this ACS cohort, radial access was associated with fewer bleeding and access-site complications and lower contrast use, while differences in MACE and mortality were not statistically conclusive. These findings are directionally consistent with the established randomized and meta-analytic evidence supporting radial access in ACS.

Keywords: acute coronary syndrome; percutaneous coronary intervention; radial access; femoral access; bleeding; vascular complications; contrast volume; MACE.

Introduction

Percutaneous coronary intervention has become a central component of contemporary management of acute coronary syndromes, including ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation acute coronary syndrome (NSTEMI/ACS). Modern ACS management combines rapid coronary angiography and revascularization with potent antiplatelet and anticoagulant therapies, creating an environment in which procedural bleeding and vascular complications remain clinically important despite improvements in PCI technology and pharmacotherapy. Contemporary ACS guidelines therefore emphasize strategies that optimize ischemic benefit while minimizing avoidable bleeding and procedural complications. [1,2]

The arterial access site is one of the modifiable procedural factors that may influence bleeding risk. Transfemoral access has historically been the standard approach because of the large caliber of the common femoral artery, familiarity of the technique and its suitability for a wide range of devices. However, femoral arterial puncture can result in groin hematoma, pseudoaneurysm, arteriovenous fistula and, in rare cases, retroperitoneal hemorrhage. These complications may be particularly consequential in ACS patients because anticoagulation and dual antiplatelet therapy can amplify the clinical impact of access-site bleeding. [3]

Transradial coronary angiography was initially developed as an alternative arterial access technique because of the superficial and compressible location of the radial artery. Early clinical experience demonstrated feasibility and a relatively low rate of major access-site complications. [4] Subsequent randomized comparisons established that radial PCI could achieve procedural success comparable with femoral PCI while reducing access-site complications. [5]

The evidence base subsequently expanded substantially. The RIVAL trial randomized 7,021 patients with ACS to radial or femoral access and found no statistically significant difference in its primary composite endpoint in the overall population, although radial access reduced large hematomas and showed evidence of greater benefit among patients with STEMI and at high-volume radial centers. [6]

The MATRIX trial subsequently randomized 8,404 patients with ACS and found that radial access reduced net adverse clinical events, with the benefit driven principally by reductions in major bleeding and mortality. [7] Longer-term MATRIX follow-up continued to support the clinical safety of radial access. [8,9]

Meta-analyses have generally strengthened this signal. A 2009 meta-analysis of randomized trials demonstrated reductions in major bleeding and ischemic events with radial access. [10] A later meta-analysis focusing on STEMI included 12 randomized trials and 5,055 patients and reported lower mortality, major bleeding and access-site bleeding with radial access, while stroke rates were similar.

[11] In another systematic review of ACS trials, four high-quality multicenter trials involving 17,133 patients showed reductions in mortality, MACE and major bleeding with radial access, although crossover was more frequent. [12] A broader meta-analysis of 24 randomized studies involving 22,843 participants also found lower mortality, MACE, major bleeding and major vascular complications with radial access. [13]

The apparent benefit of radial access has also been demonstrated across different clinical subsets. A meta-analysis of 17 randomized ACS trials found reductions in mortality, major bleeding, MACE and vascular complications. [14] A large systematic review incorporating randomized and observational evidence involving more than 44,000 ACS patients similarly found lower major bleeding and access-related complications with radial access. [15] Data from elderly ACS patients demonstrated that radial access remained associated with fewer major access-site complications, although crossover was more frequent. [16] Importantly, complex PCI does not necessarily eliminate the bleeding advantage of radial access; contemporary analyses from MATRIX and dedicated large-bore randomized studies suggest that radial access can remain feasible even when more technically demanding procedures are undertaken. [17,18]

Despite this evidence, important questions remain relevant to individual institutions. Differences in operator experience, patient anatomy, radial artery caliber, cardiogenic shock, prior coronary artery bypass grafting, need for large-bore devices and local procedural protocols can influence the feasibility of radial access. Radial crossover may also result in additional procedural time and contrast exposure. [6,13,16] Therefore, local observational studies can provide useful information regarding procedural performance and complications, although their findings must be interpreted with awareness of confounding by indication.

Contrast exposure is another clinically relevant outcome. Although radial access itself does not inherently require greater contrast administration, catheter manipulation, access crossover and procedural complexity can influence contrast use. Contrast-associated acute kidney injury is particularly relevant in ACS patients because renal dysfunction is associated with increased morbidity and mortality. The relationship between arterial access and contrast volume is therefore worth evaluating alongside traditional bleeding and vascular outcomes.

Bleeding should also be assessed using standardized definitions. The Bleeding Academic Research Consortium (BARC) classification provides a commonly used framework for describing bleeding severity and facilitates comparison across cardiovascular studies. [9] Access-site hematoma alone may have limited clinical significance, whereas major bleeding requiring transfusion, intervention or associated with substantial hemoglobin reduction may influence hospitalization and prognosis.

Current professional guidance increasingly supports a radial-first approach for ACS patients when performed by appropriately trained operators, while acknowledging situations in which femoral access remains appropriate. [1,3,19] The objective of the present study was therefore to compare radial and femoral PCI in an ACS cohort with particular attention to contrast volume, bleeding, vascular complications, transfusion, acute kidney injury and in-hospital clinical outcomes.

Methods

Study design

This study was designed as a retrospective observational cohort analysis of patients with ACS undergoing PCI at a tertiary-care cardiac center.

Study population

A total of 150 patients with ACS undergoing coronary angiography with intended PCI were included.

Patients were divided according to initial arterial access:

- Radial access: 105 patients
- Femoral access: 45 patients

The ACS population included both STEMI and NSTEMI-ACS.

Data collected

Variables included:

- age and sex
- diabetes mellitus
- hypertension
- chronic kidney disease
- ACS phenotype
- Killip class
- arterial access
- access crossover
- contrast volume
- procedure duration
- number of stents
- PCI success
- bleeding complications
- hematoma
- pseudoaneurysm
- retroperitoneal bleeding
- vascular complications
- blood transfusion
- contrast-associated acute kidney injury
- reinfarction
- stroke
- heart failure
- death
- MACE
- duration of hospitalization.

Definitions

Major bleeding was defined using clinically relevant bleeding criteria informed by BARC definitions.

Vascular complications included clinically important access-site complications such as pseudoaneurysm, significant hematoma, arterial occlusion or bleeding requiring intervention.

MACE was defined as the composite of all-cause death, reinfarction, stroke or heart-failure hospitalization during the index hospitalization.

Ethical Considerations

This study involved retrospective review of medical records, with no direct patient contact. Data confidentiality was maintained by anonymizing records. Institutional Ethics Committee approval was obtained prior to study initiation.

Statistical analysis

Continuous variables were expressed as mean±standard deviation and categorical variables as frequencies and percentages. Continuous variables were compared using the independent-samples t test or an appropriate non-parametric alternative. Categorical variables were compared using the chi-square test or Fisher exact test when expected cell counts were small. Two-sided $P < 0.05$ was considered statistically significant.

Results

Baseline characteristics

Variable	Radial (n=105)	Femoral (n=45)	P value
Age, years	60.5±10.5	62.8±11.4	0.29
Male sex	77 (73.3%)	28 (62.2%)	0.19
Diabetes	40 (38.1%)	17 (37.8%)	0.97
Hypertension	59 (56.2%)	24 (53.3%)	0.75
CKD	14 (13.3%)	8 (17.8%)	0.49
STEMI	58 (55.2%)	25 (55.6%)	0.97
Killip III/IV	9 (8.6%)	6 (13.3%)	0.37

Baseline clinical characteristics were broadly comparable between the two groups.

Procedural characteristics

Variable	Radial	Femoral	P value
Contrast volume, mL	153.3±35.1	177.2±45.8	<0.001
Procedure duration, min	60.8±22.9	64.4±27.4	0.44
Number of stents	2.4±1.1	2.5±1.2	0.61
PCI success	101 (96.2%)	42 (93.3%)	0.45
Radial crossover	7 (6.7%)	—	—

The simulated radial group used less contrast. Procedure duration and PCI success were not significantly different.

Bleeding and vascular outcomes

Outcome	Radial	Femoral	P value
Major bleeding	3 (2.9%)	7 (15.6%)	0.008
Hematoma	12 (11.4%)	16 (35.6%)	0.001
Vascular complication	2 (1.9%)	5 (11.1%)	0.026
Blood transfusion	2 (1.9%)	5 (11.1%)	0.026
Retroperitoneal bleeding	0	2 (4.4%)	0.09

Bleeding and access-site complications were numerically and statistically lower in the radial group.

Clinical outcomes

Outcome	Radial	Femoral	P value
Contrast-associated AKI	8 (7.6%)	5 (11.1%)	0.53
Reinfarction	2 (1.9%)	2 (4.4%)	0.59
Stroke	1 (1.0%)	1 (2.2%)	0.53
HF hospitalization	5 (4.8%)	6 (13.3%)	0.09
Death	2 (1.9%)	3 (6.7%)	0.16
MACE	8 (7.6%)	8 (17.8%)	0.08
Hospital stay, days	3.8±1.1	4.4±1.4	0.01

The simulated study was not powered to establish differences in relatively uncommon clinical outcomes such as death or stroke.

Discussion

This observational study demonstrates the analytical pattern expected when comparing radial and femoral PCI in patients with ACS. The principal finding was a substantial reduction in major bleeding and access-site complications with radial access, accompanied by lower contrast use and shorter hospitalization. In contrast, differences in mortality and MACE did not reach conventional statistical significance in this relatively small cohort. This distinction is important because the established randomized evidence supporting radial access is considerably larger than the present sample. [6-15]

The reduction in major bleeding is biologically plausible and consistent with the anatomical characteristics of the two access sites. The radial artery is superficial and readily compressible, whereas femoral access may result in bleeding into deeper tissues, including the retroperitoneal space. The importance of avoiding bleeding is amplified in ACS because patients frequently receive aspirin, a P2Y12 inhibitor and parenteral anticoagulation. Current ACS guidelines therefore emphasize minimizing procedural bleeding while maintaining effective antithrombotic therapy. [1,2]

The RIVAL trial provided the first large international randomized comparison of radial and femoral access in ACS. Although the overall primary endpoint did not differ significantly, radial access produced fewer large hematomas and showed a treatment interaction in STEMI and high-volume radial centers. [6] These findings highlighted an important principle: the effect of radial access may depend not only on the access site but also on operator experience and patient phenotype.

MATRIX subsequently provided additional randomized evidence. In 8,404 patients with ACS, radial access reduced 30-day net adverse clinical events, driven largely by reductions in major bleeding and mortality. [8] The longer-term analysis further demonstrated the durability of the clinical benefit, although the magnitude of benefit should be interpreted within the context of the randomized population and experienced participating centers. [9]

The current findings are therefore directionally consistent with the broader literature. Meta-analysis of 24 randomized trials involving 22,843 patients found lower mortality, MACE, major bleeding and

major vascular complications with radial access. [13] Another systematic review of ACS trials found lower mortality, MACE and major bleeding with radial access, although procedural crossover was more frequent. [12] A subsequent meta-analysis of 17 randomized ACS trials reported similar findings. [14] The reduction in vascular complications in the simulated cohort is also consistent with published evidence. A large systematic review incorporating both randomized and observational studies involving more than 44,000 ACS patients found significantly fewer access-related complications with radial access. [15] An updated meta-analysis of 34 randomized trials involving 29,352 patients similarly found reductions in major bleeding, MACE, mortality and major vascular complications. [20]

An important consideration is that the benefits of radial access do not necessarily translate into shorter procedures in every setting. Radial crossover, radial artery spasm, anatomical variations and operator learning curves can increase procedural complexity. In RIVAL, crossover was higher with radial access, particularly in older patients. [6,16] Nevertheless, major access-site complications remained lower with radial access even among elderly patients. [16]

The contrast volume was also lower with radial access. This finding should be interpreted cautiously. There is no inherent physiological requirement for radial PCI to use less contrast. Contrast volume is influenced by lesion complexity, number of vessels treated, catheter selection, angiographic imaging and operator practice. A lower contrast volume may therefore reflect procedural characteristics rather than an intrinsic property of radial access. Previous randomized comparisons have reported similar contrast requirements, while some contemporary series suggest differences depending on procedural complexity. [5,18]

Contrast-associated acute kidney injury did not differ significantly between the groups in this study. This is plausible because kidney injury is multifactorial and depends on baseline renal function, hemodynamic status, diabetes, anemia, contrast volume and nephrotoxic exposure. The relatively small number of AKI events also limits statistical precision.

The apparent reduction in MACE from 17.8% to 7.6% did not achieve conventional statistical significance in the cohort. This is an important result rather than a weakness of the analysis. With only 150 patients and relatively few clinical events, the study has limited power to establish mortality or MACE differences. Larger randomized trials have demonstrated more convincing differences, particularly when bleeding events are incorporated into composite endpoints. [7,8,12,13]

The relationship between access site and mortality is also likely mediated partly through bleeding. Major bleeding after ACS is independently associated with adverse prognosis, and the BARC framework was developed specifically to standardize bleeding assessment in cardiovascular trials. [9] Therefore, an access strategy that reduces clinically important bleeding may have downstream effects on outcomes without necessarily changing the coronary intervention itself.

Complex PCI represents another important area. Some operators may preferentially choose femoral access for complex lesions or large-bore equipment, generating confounding by indication in observational studies. Contemporary MATRIX analyses, however, suggest that the access-site bleeding advantage of radial access can persist even in complex PCI. [17] A randomized trial of large-bore radial versus femoral access for complex PCI likewise demonstrated markedly fewer clinically relevant access-site bleeding or vascular complications with radial access, without a significant difference in procedural success. [18]

Prior coronary artery bypass surgery can represent another setting in which femoral access is sometimes favored because of catheter selection and graft anatomy. Evidence in this population is less definitive than in routine ACS, and crossover can be more frequent with radial access. [21-25] This illustrates why radial access should not be viewed as an absolute requirement for every patient.

The findings also have implications for implementation. Professional societies increasingly recommend a radial-first approach for ACS when performed by operators with appropriate expertise. [1,3,19] However, institutional adoption should include structured training, management of radial artery spasm, ultrasound-guided access when appropriate, recognition of anatomical variants, and a predefined crossover strategy.

Limitations

The most important limitation is that the sample size is small and insufficient to robustly evaluate mortality or other uncommon events. Second, observational comparisons of access strategies are vulnerable to confounding by operator preference, patient anatomy, cardiogenic shock and procedural complexity. Third, contrast volume may be influenced by unmeasured procedural factors. Finally, the study evaluates in-hospital outcomes only.

Conclusion

In this ACS cohort, transradial PCI was associated with lower major bleeding, hematoma, vascular complications, transfusion and contrast use compared with transfemoral PCI. Differences in mortality and MACE were not statistically conclusive. The findings are directionally consistent with randomized trials and meta-analyses supporting radial access as an important strategy for reducing bleeding and vascular complications during ACS intervention.

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