Radial Access Best Practices in 2019

An update on procedural considerations for transradial artery access based on the most recent data.

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Since the advent of transradial access (TRA) in the cardiac catheterization laboratory more than 3 decades ago, substantial evidence has emerged to demonstrate the benefit of TRA over transfemoral access (TFA) in patients undergoing coronary angiography and percutaneous coronary intervention (PCI). TRA is associated with lower rates of bleeding and vascular and renal complications after PCI, and it has also been shown to have a mortality benefit in the acute coronary syndrome (ACS) population.[1-7] Despite these data, the uptake of TRA has varied globally, with operators in Europe and Asia performing a higher percentage of TRA PCI versus TFA PCI compared with operators in the United States.[8] However, recently, the proportion of TRA PCI in the ACS population has risen in the United States. According to data from the National Cardiovascular Data Registry (NCDR), the proportion of patients undergoing PCI for ST-segment elevation myocardial infarction (STEMI) via TRA has increased from 2% in 2009 to more than 23% in 2015.[9] Given the uptrend of TRA in the United States, this article provides an overview of the previously controversial patient subgroups that should undergo a "radial-first" approach in 2019 and the most recent data in relation to procedural considerations for TRA.

PATIENT SELECTION

The advantages of TRA over TFA are especially pronounced in high-risk patient subgroups, such as those with ACS, cardiogenic shock, or baseline renal disease. In addition, patients undergoing TRA PCI are more likely to ambulate earlier and undergo same-day discharge compared with those undergoing TFA PCI, and these results, in turn, are associated with fewer complications and greater cost savings.[10] Although the benefit in bleeding and vascular complications with TRA versus TFA relates directly to the access site, the mechanisms of mortality and renal benefit in high-risk subgroups are not fully understood.[11] However, these benefits have been observed across multiple studies, and consequently, these high-risk subgroups of patients should be prioritized for TRA on initial presentation to the cardiac catheterization laboratory.[3,4,6,12-14]

Acute Coronary Syndrome

Several trials have demonstrated decreased bleeding and vascular complications, as well as lower rates of mortality, with TRA compared with TFA in patients with ACS (Table 1).[1-4,13] The MATRIX trial demonstrated a significantly lower rate of the coprimary endpoint of net adverse cardiovascular events (composite of all-cause mortality, myocardial infarction [MI], stroke, and major bleeding not related to coronary artery bypass graft [CABG] surgery) at 30 days with TRA compared with TFA (rate ratio, 0.83; 95% confidence interval [CI], 0.73–0.96).[4] Rates of major (1.6% vs 2.3%; $P = .013$) and minor (4% vs 7.4%; $P < .0001$) bleeding, surgical access site repair (0.1% vs 0.4%; $P = .0115$), and all-cause mortality (1.6% vs 2.2%; $P = .045$) at 30 days were also significantly reduced in the TRA group compared with the TFA group.[4] Similarly, the RIFLE-STEACS trial demonstrated a significantly lower rate of the primary endpoint of net adverse cardiovascular events (composite of cardiac death, recurrent MI, stroke, target lesion revascularization, or non-CABG bleeding) at 30 days with TRA versus TFA (13.6% vs 21.0%; $P = .003$). Rates of protocol-defined major bleeding (7.8% vs 12.2%; $P = .026$) and cardiac mortality (5.2% vs 9.2%; $P = .02$) were also lower with TRA than with TFA.[3]

Although it was the first of the large multicenter randomized TRA versus TFA trials, RIVAL did not demonstrate a significant difference in the primary endpoint of net adverse cardiovascular events, major bleeding, or all-cause mortality at 30 days; the rate of vascular complications was significantly lower with TRA versus TFA (1.4% vs 3.7%; $P < .0001$).[2] The RIVAL trial was an all-comers ACS trial with an overall very low major bleeding rate, and per-protocol analysis demonstrated that major bleeds were lower with TRA versus TFA (hazard ratio, 0.53; 95% CI, 0.30–0.92). Furthermore, prespecified subanalyses demonstrated a significant interaction by TRA PCI volume and ACS presentation such that the highest-volume centers and STEMI presentation

TABLE 1. RANDOMIZED TRIALS OF TRA VERSUS TFA ACCESS IN PATIENTS WITH ACS

Trial (Year)	Design	Population	Primary Endpoint: Rate (TRA vs TFA)	All-Cause Mortality at 30 Days (TRA vs TFA)
RIVAL[2] (2011)	Multicenter, 32 countries, 1:1 randomization, open label	7,021 with ACS	Composite of death, MI, stroke, or non-CABG bleeding (30 days): 3.7% vs 4% (*P* = .50)	1.3% vs 1.5% (*P* = .47)
RIVAL: STEMI subgroup analysis[13] (2012)	Multicenter, 32 countries, 1:1 randomization, open label	1,958 with STEMI	Composite of death, MI, stroke, or non-CABG bleeding (30 days): 3.1% vs 5.2% (*P* = .026)	1.26% vs 3.19% (*P* = .006)
RIFLE-STEACS[3] (2012)	Multicenter, European centers, 1:1 randomization, open label	1,001 with STEMI	Composite of cardiac death, recurrent MI, stroke, TLR, or non-CABG bleeding (30 days): 13.6% vs 21% (*P* = .003)	5.2% vs 9.2% (*P* = .02)*
STEMI-RADIAL[1] (2014)	Multicenter, national (Canada), randomized	707 with STEMI	Composite of major bleeding and vascular complications: 1.4% vs 7.2% (*P* = .0001)	2.3% vs 3.1% (*P* = .64)
MATRIX[4] (2015)	Multicenter, European centers, 1:1 randomization, open label	8,404 with ACS	Coprimary composite endpoints of: ▪ Death, MI, or stroke: 8.8% vs 10.3% (*P* = .0307) ▪ Death, MI, stroke, or BARC non-CABG major bleed (30 days): 9.8% vs 11.7% (*P* = .0092)	1.6% vs 2.2% (*P* = .045)

Abbreviations: ACS, acute coronary syndrome; BARC, Bleeding Academic Research Consortium; CABG, coronary artery bypass grafting; MI, myocardial infarction; STEMI, ST-segment elevation myocardial infarction; TFA, transfemoral access; TLR, target lesion revascularization; TRA, transradial access.
*Cardiac mortality (not all-cause mortality).

favored TRA over TFA for the primary endpoint. In the RIVAL subgroup of STEMI patients, the primary endpoint of net adverse cardiovascular events (composite of death, MI, stroke, or non–CABG-related major bleeding) at 30 days (3.1% vs 5.2%; *P* = .026) and all-cause mortality at 30 days (1.26% vs 3.19%; *P* = .006) was significantly lower in the TRA versus TFA groups.[13]

The STEMI-RADIAL study, on the other hand, demonstrated numerically fewer deaths in the TRA group compared with the TFA group, but this was not statistically different (2.3% vs 3.1%; *P* = .64).[1] Notably, unlike the MATRIX, RIFLE-STEACS, or RIVAL trials, which included a heterogeneous group of STEMI patients, including those who underwent rescue PCI or received fibrinolytic therapy, the STEMI-RADIAL trial only enrolled patients undergoing primary PCI and enrolled at least 30% fewer patients than the other STEMI trials.

Given the overall robust data supporting TRA over TFA in patients with ACS, the 2015 European Society of Cardiology guidelines for the management of ACS recommend TRA as the preferred method of access (class I indication, level of evidence A).[15] Although the 2011 American College of Cardiology/American Heart Association/Society for Cardiovascular Angiography and Intervention guidelines recommend TRA for PCI as a class IIa indication (level of evidence A), a 2018 scientific statement from the American Heart Association recommends a default strategy of TRA in the invasive management of patients with ACS.[14,16]

Cardiogenic Shock

The current limited nonrandomized data available on the use of TRA in cardiogenic shock demonstrates improved morbidity and mortality when compared to TFA at experienced centers. In addition, TRA PCI maintains TFA access availability in case mechanical support is needed. The largest retrospective analysis of PCI in cardiogenic shock was from the United Kingdom, which demonstrated increased utilization of TRA in cardiogenic shock, from 9.5% in 2006 to 34.2% in 2012 (*P* for trend < .0001).[17] Furthermore, TRA was associated with lower rates of 30-day mortality, in-hospital major adverse cardiac and cerebrovascular events, and major bleeding complications when compared with TFA. This benefit was largely observed at centers with a higher proportion of TRA PCI (> 25% of cases). Two prospective observational studies demonstrated significant reductions in 30-day mortality with TRA versus TFA in cardiogenic shock.[18,19] A subsequent meta-analysis evaluating access site and mortality in cardiogenic shock demonstrated a significantly reduced risk of death at 30 days with TRA when compared with TFA (risk ratio, 0.60; 95% CI, 0.52–0.71; *P* < .001).[20]

Chronic Kidney Disease

It is well known that acute kidney injury (AKI) after PCI is associated with increased morbidity and mortality.[21,22] In a substudy of the HORIZONS-AMI trial, patients who developed contrast-induced AKI had higher rates of bleed-

ing and major adverse cardiac events out to 3 years after PCI.[23] Patients with chronic kidney disease (CKD) are even more susceptible. In an analysis of NCDR data, nearly 30% of patients undergoing PCI had CKD at baseline, and worsening severity of baseline CKD was associated with increasing incidence of AKI. AKI, in turn, was associated with increased odds of bleeding, MI, and death.[24]

In addition to hydration therapy, TRA may be beneficial to patients with kidney disease when compared with TFA. The AKI substudy of the MATRIX trial demonstrated a significantly lower rate of AKI with TRA versus TFA (15.43% vs 17.36%; $P = .018$).[12] This benefit was particularly evident in those with baseline kidney disease. In a large retrospective analysis of 48,155 veterans with CKD undergoing cardiac catheterization, TRA was associated with a lower risk of progression to end-stage renal disease within 1 year postprocedure.[6] The mechanism of benefit for AKI remains unclear. The volume of contrast use in the AKI substudy of the MATRIX trial was not different between the two access site groups, whereas in the Veterans Affairs database, contrast use was significantly lower in the TRA cohort compared with the TFA cohort. Additional potential mechanisms include lower risk of atheroemboli to the kidneys with TRA due to a bypass of the renal arteries and increased oral hydration after the procedure due to earlier upright position and ambulation.

Although the benefit of TRA seems evident in this population at high risk of bleeding complications and AKI, the impact of TRA on subsequent arteriovenous fistula creation or as a bypass conduit remains an area of uncertainty. The incidence of radial artery occlusion (RAO) is minimized by contemporary practices of a smaller sheath-to-radial artery diameter ratio, adequate anticoagulation, and patent hemostasis.[25-27] Furthermore, a study of radial arteries harvested at the time of CABG demonstrated significant pathologic differences between patients who had undergone previous TRA versus those who had not undergone previous TRA procedures within 5 mm from the puncture site and not at the proximal end, where most fistulas are placed.[28]

CONTEMPORARY PROCEDURAL CONSIDERATIONS

Preprocedural Stage

To optimize the previously detailed benefits of TRA, the catheterization laboratory and staff should be equipped to safely, efficiently, and effectively facilitate TRA angiography and interventions. During the preprocedural planning stage, routine use of the Allen or Barbeau test is not recommended because an abnormal result is not associated with adverse outcomes.[14,29,30] Although the reverse Allen or Barbeau test may aid in the identification of an occluded radial artery, ultrasound provides direct visualization of both the radial and ulnar arteries in their entirety and may better aid in access site triage, particularly to identify severe radial artery loops prior to access. The use of radial arm boards that include a provision for ergonomically effective left TRA allows for dedicated workspace to improve the ease of the procedure (Figure 1).

Access and Navigation of Peripheral Anatomy

Ultrasound guidance has been shown to be beneficial in achieving radial access. The RAUST trial randomized 698 patients undergoing transradial catheterization to palpation or real-time ultrasound-guided radial access and demonstrated a significant reduction in the number of attempts required to obtain TRA (1.65 vs 3.05; $P < .0001$), improved first-pass success rate (64.8% vs 43.9%; $P < .0001$), and shorter time to access (88 ± 78 seconds vs 108 ± 112 seconds; $P = .006$) with ultrasound-guided access.[31] Ultrasound guidance may provide added benefit in patients with hypotension, weak pulse, or ulnar access. Radial artery spasm may be minimized with the use of adequate periprocedural sedation, vasodilators, hydrophilic sheaths, and lower-profile sheaths and catheters.[32] The use of a 0.035-inch-diameter hydrophilic wire with a 1.5-mm-radius J-tip is effective in the navigation of anomalous or tortuous peripheral or subclavian arteries. In addition, the use of 4-F diagnostic catheters and 5-F guiding catheters, balloon-assisted tracking, and the "mother-child" technique (eg, a 4-F, 110-cm multipurpose catheter in a 6-F guiding catheter) may be considered in cases with significant peripheral or subclavian artery calcification or tortuosity.[33-35]

Radiation Exposure

TRA is associated with increased radiation exposure to both the patient and operator compared with TFA.[36,37] Although this association may be attenuated at high-volume radial centers,[38] additional measures should be undertaken to minimize radiation exposure. The use of low-dose fluoroscopy (7.5 frames per second) or, in patients without a large abdominal circumference, recording of all images using fluoroscopy (15 frames per second) and reservation of cineangiography for inadequate image quality reduce radiation exposure to both the patient and operator.[39,40] The recent RAD-MATRIX study demonstrated that positioning the arm so that it is adducted close to the leg and use of a larger upper lead shield were associated with lower radiation exposure.[41] Finally, keeping the image detector close to the patient and utilizing collimation[42] with the routine use of radiation protection drapes[43] can further reduce operator radiation exposure.

Left-sided TRA has also been associated with lower radiation to both the patient and operator[44,45] and may be the preferred access site in patients with previous left internal mammary artery grafting or those at increased risk of right TRA approach failure (ie, patients who are < 64 inches in height or > 75 years).[44,46] However, left TRA is associated with greater operator discomfort compared with right TRA

Figure 1. Example of a dedicated left TRA setup that allows for dedicated workspace to improve the ease of the procedure. During access, an arm board is positioned outward (A). After access is achieved, the arm board is removed, the arm is crossed over the patient's body, and a block is placed to keep the arm propped up (B).

and is therefore not commonly used as the default access site.[45] Left arm support systems allow the operator to stand to the right of the patient, and the use of sheath extenders or distal radial ("anatomical snuffbox") access may allow for further optimization of access site ergodynamics.[47,48] However, in tall patients or those with peripheral tortuosity, sheath extenders may lead to an inability to cannulate the coronary arteries limited by standard catheter length. Furthermore, the long-term effects of distal radial access are not known.

Radial Artery Occlusion

Although RAO is usually asymptomatic, it may prohibit use of the radial artery as an access site for future procedures. The risk of RAO can be substantially diminished by minimizing the sheath-to-artery ratio[25] with the use of smaller French systems, thin-walled sheaths, or sheathless systems, as well as optimizing patent hemostasis[27,49] with dedicated radial artery closure devices and minimizing hemostasis times.[50] More recently, patients randomized to receive unfractionated heparin at a dose of 100 U/kg had a 65% reduction in RAO when compared to those randomized to 50 U/kg without an apparent increase in the risk of bleeding.[26] Intravenous and intra-arterial administration of unfractionated heparin have been shown to have similar efficacy.[51] Bivalirudin utilization for TRA PCI in the absence of heparin therapy may be sufficient to prevent RAO[52]; however, further data are needed. Other novel techniques to reduce the risk of RAO include an "exit cocktail" of 500 µg of nitroglycerin given immediately prior to sheath removal and hemostasis,[53] as well as ipsilateral ulnar artery compression.[54]

THE FUTURE OF TRA

The advantages of TRA now extend beyond the procedure itself; high-volume "radial-first" centers focus on the recovery experience of patients undergoing cardiac catheterization via TRA with the development of radial lounges. A radial lounge is an area near the cardiac catheterization laboratory where patients are brought to recover after an uncomplicated procedure. The novelty of such a lounge is that they are intentionally designed as a sitting room with lounge chairs, facilitating early ambulation and same-day discharge. There are no beeping cardiac monitors, and emergency medical equipment is kept partitioned off, away from patient's view. Beyond provision of a comforting environment for patients to recover after the procedure, the combination of TRA and same-day discharge results in significant cost savings. In a linked analysis of Medicare beneficiaries in the NCDR CathPCI Registry, TRA PCI with same-day discharge was found to cost nearly $3,700 less than TFA PCI without same-day discharge.[10] A single-center study compared overall rates of same-day discharge after elective PCI in the year before and after the opening of a dedicated radial lounge, and the overall rate of same-day discharge increased from 2.3% to 51.2%.[55] Candidates for monitoring in radial lounges are generally lower-risk patients, such as those who undergo elective uncomplicated coronary angiography and PCI. Further studies on patient selection for both radial lounges and same-day discharge are warranted. However, a recent expert consensus document update from the Society for Cardiovascular Angiography and Interventions provides guidance on patient selection for same-day discharge based on patient, procedural, and programmatic characteristics, as well as example protocols and discharge checklists to implement a successful same-day discharge program.[56]

SUMMARY

TRA should be the preferred method of access for patients undergoing coronary angiography and PCI in settings of high risk for bleeding and/or vascular complications such as ACS, cardiogenic shock, and renal disease. In the ACS population, there are substantial data demonstrating decreased bleeding and vascular complications, as well as lower mortality rates with TRA compared with TFA. Although limited, current nonrandomized data on cardiogenic shock patients show improved morbidity and mortality with TRA. In addition, there is a lower rate of AKI and lower risk of progression to end-stage renal disease in patients with baseline renal disease who undergo TRA versus TFA. Aside from the improvements in morbidity and mortality rates, TRA has shown benefit from a systems level by reducing health care costs, particularly in the same-

day discharge setting. These benefits have led to a growing number of cases in the United States being performed with a "radial-first" approach. ■

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Disclosures: Consultant to Terumo Interventional Systems (minor); on an advisory board for Philips Volcano (major); receives grant funding from the VA Office of Research and Development.