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Transradial Artery Access in Percutaneous Coronary Intervention for ST-Segment Elevation Myocardial Infarction and Cardiogenic Shock

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Abstract

Early revascularization is the gold standard for management of patients with ST-elevation myocardial infarction (STEMI) and cardiogenic shock (CS). The use of transradial artery access (TRA) in percutaneous coronary intervention (PCI) has increased in recent years and has emerged as a safe and effective approach to PCI in high-risk patients, with advantages in reduced major bleeding events, other peri-procedural complications, and all-cause mortality when compared with transfemoral artery access (TFA). Multiple randomized clinical trials have demonstrated these advantages of TRA vs. TFA PCI in STEMI patients. Although there remains a lack of dedicated randomized trials in CS, observational data suggest benefits on the same endpoints as in STEMI with TRA vs. TFA PCI in CS. This review summarizes the existing literature on the use of TRA compared to TFA for STEMI and CS patients; the reduction of major bleeding events, other peri-procedural complications, and mortality associated with TRA in STEMI and CS; and technical considerations and challenges in the care of these high-risk patient populations.

Keywords

Transradial artery; Transfemoral artery; Percutaneous coronary intervention; ST-segment myocardial infarction

Introduction

Coronary revascularization is the gold standard for management of patients with ST-elevation myocardial infarction (STEMI) with or without cardiogenic shock (CS) [1]. The adjunctive antithrombotic and high potency antiplatelet regimens used during the acute

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Conflict of Interest

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Human and Animal Rights and Informed Consent

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management of STEMI and percutaneous coronary intervention (PCI) places these patients at high risk for bleeding and access site vascular complications [2]. Patients with STEMI and CS are also at high risk for adverse renal complications [3]. Both bleeding and renal complications, in turn, are associated with a higher mortality [3, 4].

While the femoral artery has historically been the access site of choice, the radial artery is a more superficial vessel that is easily compressible and, on approach to the coronary arteries, bypasses the renal arteries—ideal characteristics to reduce access site-related bleeding and vascular complications, as well as procedural-related atheroemboli to the renal arteries. There is growing data that demonstrates lower bleeding, vascular, and renal complications post-PCI with transradial (TRA) vs. transfemoral (TFA) artery access in the STEMI and CS settings. Furthermore, TRA is preferred by patients undergoing PCI for acute coronary syndrome and may be associated with lower cost [5•, 6]. In the USA, as of 2012, the use of TRA has increased to 1 in 6 of all PCIs performed [7]. An analysis from the National Cardiovascular Data Registry (NCDR) demonstrated an increase in the proportion of PCIs performed for STEMI via TRA from 0.9% in 2007 to 6.4% in 2011; however, this rate of use in the USA remains much lower than that observed in Europe [8, 9]. While the American College of Cardiology/American Heart Association/Society for Cardiovascular Angiography and Intervention guidelines place TRA for PCI as a Class IIa indication (Level of Evidence A), the European Society of Cardiology guidelines now place TRA for PCI in acute coronary syndrome as a Class I indication (Level of Evidence A) [1, 10].

TRA and outcomes in STEMI

Bleeding events

Bleeding events after PCI are associated with increased risk of recurrent ischemic events and remains a significant contributor to morbidity and mortality in patients with acute coronary syndrome [11, 12]. This may be related to the detrimental effects of the bleed itself, associated blood transfusions, comorbidities of patients at risk for bleeding, or alterations in antiplatelet regimens after a bleeding event [13–15]. The reported rate of bleeding events after TFA PCI for STEMI in the contemporary era varies from 0.9 to 12% in large part due to the heterogeneous definitions of bleeding used in the trials [12, 16•]. When standardized by the Thrombolysis in Myocardial Infarction (TIMI) criteria, the rate of non-CABG-related major bleeding events after TFA PCI for STEMI varies from 0.6 to 2.8%.

TRA and bleeding events in STEMI subgroups—TRA has been associated with a significantly lower rate of access site-related bleeding events when compared to TFA in patients undergoing PCI for STEMI (Table 1). In the STEMI subgroup of the Radial vs. femoral access for coronary intervention (RIVAL) trial, the protocol-defined rates of non-CABG-related major bleeding events were not significantly different between groups [12]. However, when redefined by the Acute Catheterization and Urgent Intervention Triage strategY (ACUITY) criteria, there was a significantly lower rate of major bleeding events with TRA compared with TFA (1.99 vs. 4.10%, $p = 0.009$) that was driven by a lower rate of access site-related bleeding events (1.26 vs. 3.39%, $p = 0.003$). There were no differences in non-access site bleeding events (0.74 vs. 0.71% $p = 0.95$). In the STEMI subgroup of

the Minimizing Adverse Haemorrhagic Events by TRansradial Access Site and Systemic Implementation of AngioX (MATRIX Access) trial, there was no difference in TIMI non-CABG-related major bleeding events (1.0 vs. 1.2%, $p = 0.44$), but there was a significant 37% relative reduction in Bleeding Academic Research Consortium (BARC)-defined major bleeding events that was also driven by a lower rate of access site-related bleeding events (1.9 vs. 3.0%, $p = 0.022$) [17•].

TRA and bleeding events in dedicated STEMI trials—The lower bleeding event rates with TRA were also observed in dedicated STEMI trials (Table 1). In the Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome (RIFLE-STEACS) trial, there was a significantly lower rate of protocol-defined non-CABG-related bleeding events with TRA than that with TFA (7.8 vs. 12.2%, $p = 0.026$) with a 60% relative reduction in the rate of non-CABG-related access site bleeding events (2.6 vs 6.8%, $p = 0.002$) [16••]. There were also significant reductions in TIMI minor bleeding (4.0 vs. 7.2%, $p = 0.038$), bleeding events requiring transfusion (1.0 vs. 3.2%, $p = 0.025$), and a decrease in hemoglobin level by ≥ 3 g/dL (6.0 vs. 9.8%, $p = 0.036$) with TRA when compared with TFA. There was no significant difference, however, in events when defined by the TIMI major bleeding criteria or in non-access site-related bleeding. Similarly, in the ST Elevation Myocardial Infarction treated by RADIAL or femoral approach (STEMI-RADIAL) trial, TRA also significantly reduced the rate of protocol-defined major bleeding events when compared with TFA (1.4 vs. 7.2%, $p = 0.0001$), which was driven by lower rates of hematoma > 15 cm and hemoglobin drop ≥ 3 g/dL (relation to access site was not specified) [18•]. A subsequent trial sequential analysis of randomized trials confirmed a significant reduction with TRA vs. TFA in protocol-defined major and access site bleeding events (RR of 0.45 [95% CI 0.30–0.60] and RR 0.35 [95% CI 0.25–0.51], respectively) in patients undergoing PCI for STEMI [19].

Potential confounders for bleeding events in TRA vs. TFA STEMI trials—

Overall, the benefit of TRA on bleeding events in STEMI is driven by the reduction in access site-related bleeding events. The highest rates of bleeding events were observed in the RIFLE-STEACS and STEMI-RADIAL trials [16••, 18]. Although the RIFLE-STEACS trial enrolled patients at high risk of bleeding (7.6% failed thrombolysis, 11.3% Killip class III or IV), there was also a high rate of glycoprotein IIb/IIIa (GPIIb/IIIa) inhibitor use (68%) and large bore sheath placement (18.6% of TFA cases utilized ≥ 7 Fr sheaths) [16••]. Further, the protocol mandated GPIIb/IIIa inhibitors to be continued for at least 12 h post-PCI and the average dose of peri-procedural heparin was 71 IU/kg, which is higher than the guideline-recommended dose of 50–70 IU/Kg in the setting of GPIIb/IIIa inhibitor use [1]. The STEMI-RADIAL trial also had a high rate of GPIIb/IIIa inhibitor use (45%) with an average peri-procedural heparin dose of 104 IU/kg [18]. There was a lower rate of GPIIb/IIIa inhibitor use (33%) in the STEMI subgroup of RIVAL, where the major bleeding rate was also observed to be lower [12].

The use of intra-procedural heparin plus GPIIb/IIIa inhibitors compared with bivalirudin alone is known to result in significantly higher rates of major bleeding events [2].

Therefore, the routine use of GPIIb/IIIa is not recommended [1]. The recent VALIDATE-

SWEDHEART study randomized 6006 patients with acute coronary syndrome (50% STEMI; 90.3% TRA) to heparin or bivalirudin monotherapy without the routine use of GPIIb/IIIa inhibitors (2.6% received rescue GPIIb/IIIa inhibitor) during PCI [20]. Despite the use of more potent P2Y₁₂ inhibitors (94.9% ticagrelor), there was a low rate of BARC category 3 or 5 major bleeding events in both arms (1.9%). Whether or not the low bleeding event rate observed in VALIDATE-SWEDHEART was due to the low rate of GPIIb/IIIa inhibitor use or the high rate of TRA remains uncertain; however, the rate of BARC 3 or 5 major bleeding events was identical to that observed in the TRA arm of the STEMI subgroup of the MATRIX trial where a higher rate of GPIIb/IIIa inhibitor was used (21.7%) [17•]. This question may be addressed by the ongoing Safety and Efficacy of Femoral Access Versus Radial for Primary Percutaneous Coronary Intervention in ST-Elevation Myocardial Infarction (SAFARI STEMI) trial ([NCT01398254](#)), which plans to enroll 4884 patients undergoing primary PCI for STEMI to TRA vs. TFA in the setting of bivalirudin without the planned use of GPIIb/IIIa inhibitors.

Furthermore, the use of smaller guide and sheath sizes and vascular closure devices (VCD) may also reduce the risk of access site bleeding events with TFA [21, 22]. In the TFA arm of the RIVAL study, the rate of non-CABG major access site-related bleeding events was 0.7% in those who did compared to 1.0% in those who did not receive a VCD [5]. In the STEMI-RADIAL trial, there was no difference in access site complications in those with or without VCD in the TFA arm [18]. However, only a minority of patients in the TFA arms of these trials underwent hemostasis with a VCD, and therefore, data are limited.

Other adverse peri-procedural events

Vascular access complications—Vascular access complication rates are consistently lower in patients who undergo TRA vs. TFA PCI in patients with STEMI (Table 1).

Adverse renal events—Acute kidney injury (AKI) may occur in up to 27% of patients with acute coronary syndrome undergoing PCI and is another significant predictor of morbidity and mortality in the setting of STEMI [3, 23]. In a retrospective analysis of 48,155 patients with chronic kidney disease undergoing a cardiac catheterization procedure, TRA was associated with a lower risk of progression to dialysis at 1 year (HR 0.83 [95% CI 0.70–0.98]) [24]. A meta-analysis of six retrospective observational studies demonstrated decreased odds of AKI with TRA in patients undergoing PCI, particularly in the STEMI cohort (OR 0.42 [95% CI 0.24–0.72]) [25]. Most recently, the AKI substudy of the MATRIX trial demonstrated a significantly lower rate of AKI with TRA vs. TFA (15.43 vs. 17.36%, $p = 0.018$). Although there was no significant interaction by clinical presentation of non-STEMI vs. STEMI, there was a trend towards benefit in the STEMI subgroup (OR 0.87 [95% CI 0.74–1.02]). Significant benefit with TRA was observed in subgroups with a baseline glomerular filtration rate ≥ 60 ml/min/1.73 m², presence of Killip III or IV, and a Mehran AKI risk prediction score > 10 points [26]. There are no dedicated randomized trials that evaluate the effect of TRA vs. TFA on post-procedural AKI, and the underlying mechanism of benefit remains unclear. Mediation of the association by contrast dose has not been consistent [12, 18, 24, 27]. TRA may be associated with a lower risk of cholesterol atheroembolic events to the renal arteries given the avoidance of catheter manipulation in the

descending aorta. In addition, TRA is associated with increased rate of bleeding events and transfusion of blood products, both of which are factors that may lead to AKI [28].

Mortality

A mortality benefit with TRA in STEMI has been observed in a few studies. While the STEMI subgroup of the RIVAL study observed a large 61% relative reduction in all-cause mortality at 30 days with TRA vs. TFA (1.26 vs. 3.19%, $p = 0.006$), the STEMI subgroup of the MATRIX trial demonstrated numerically fewer deaths but no statistically significant difference between access groups (2.4 vs 2.7% $p = 0.49$) [12, 17•]. In the RIFLE-STEACS trial, the significant reduction in the primary endpoint of net adverse cardiovascular events with TRA was driven by both a 36% relative reduction in non-CABG bleeding events and a 43% relative reduction in cardiac death at 30 days (9.2% vs. 5.2%, $p = 0.020$) [16••]. The STEMI-RADIAL study, on the other hand, demonstrated no significant differences in all-cause mortality at 30 days (2.3 vs. 3.1%, $p = 0.64$) or at 6 months (2.3 vs. 3.6%, $p = 0.31$) between access groups [18]. Importantly, the STEMI-RADIAL trial was the smallest of the trials and not powered to assess for differences in mortality. Two large meta-analyses demonstrated significant reductions in all-cause mortality with TRA compared with TFA in STEMI (OR 0.55 [95% CI 0.40–0.75] and OR 0.66 [95% CI 0.52–0.83]) [29, 30]. Finally, data from the NCDR demonstrated a significant reduction in in-hospital mortality with TRA in STEMI (OR 0.76 [95% CI 0.57–0.99]) [8].

Mechanism of benefit on mortality with TRA in STEMI—The mechanisms of benefit on mortality with TRA vs. TFA in STEMI, however, remains unclear given that the rates of myocardial infarction, stroke, target lesion revascularization, and procedural success do not differ by access groups [12, 16••, 17•, 18]. While access site bleeding is associated with increased mortality and mitigated with TRA, the degree of reduction in mortality observed is greater than would be expected with a reduction in access site-related bleeding events alone. In the STEMI subgroup of RIVAL, only 11% of deaths suffered a major bleeding or access site complication [12]. Similarly, in both the RIFLE-STEACS and STEMI-RADIAL trials, the majority of deaths were related to pump failure in the first 24 to 48 h, and in the STEMI-RADIAL trial, only one patient's death was attributable to a major bleeding event [16••, 18]. The reduction in mortality observed with TRA when compared with TFA PCI in STEMI may be due to a combination of factors including the already described lower rate of bleeding events and AKI, as well as higher bleeding-associated blood transfusions, earlier mobility, and shorter hospital stay.

Transfusion of blood products in STEMI is associated with increased morbidity and mortality possibly independent of bleeding [12, 31, 32]. Decreased deformity and ability of red blood cells to transport nitric oxide seen in stored blood products may lead to endothelial dysfunction and microvascular plugging. This, along with the prothrombotic effects of transfused blood, may account for the increased risk of adverse outcomes observed in patients receiving blood transfusions [13]. While the rate of blood transfusion was only significantly lower with TRA compared with TFA in the RIFLE-STEACS trial (1.0 vs. 3.2%, $p = 0.025$), the rate was numerically lower in the TRA arms of all four randomized trials [12, 16••, 17, 18].

Finally, early mobility and shorter intensive care unit and hospital length of stays may also lead to improved outcomes in patients with STEMI [16, 18]. This may be due to potentially lower risks of deep venous thrombosis, deconditioning, hospital-acquired infections, and iatrogenic complications.

Procedural considerations in STEMI

Procedural success and reperfusion time—The procedural success rates with TRA in STEMI have been consistently high and not significantly different than with TFA [12, 16•, 17•, 18]. The RIFLE-STEACS study demonstrated no significant difference in door-to-device time, and both the STEMI RADIAL trial and the STEMI substudy of RIVAL trial reported no significant difference in procedure duration [12, 16•, 18]. Two large meta-analyses found a statistically significant but clinically negligible 1.5-min increase in procedural time and 0.30-min increase in door-to-device time with TRA vs. TFA in STEMI [27, 30]. In the real world setting, TRA was associated with increases in door-to-balloon time by 3 to 4 min [8, 33]. An analysis of patients from RIFLE-STEACS and the STEMI subgroup of RIVAL showed that the delay in reperfusion with TRA would have to exceed 83 min to null the mortality benefit observed with TRA in clinical trials [34]. Furthermore, if one assumes the mortality benefit is one quarter of that observed in clinical trials, the delay in reperfusion would have to exceed 20.3 min to null the benefit [34].

Radiation exposure

While fluoroscopy time was reported to be higher with TRA compared with TFA in the STEMI subgroup of RIVAL (9.3 vs 8.0 min, $p < 0.0001$), there was no observed significant difference in fluoroscopy time in the STEMI-RADIAL trial [12, 18]. In the MATRIX trial, the fluoroscopy time was also higher with TRA vs. TFA (10 vs 9 min $p < 0.001$); however, data are not reported for the STEMI subgroup alone [35]. Overall, in the setting of STEMI, TRA is associated with a significant increase in fluoroscopy time by 0.14 min in a meta-analysis of the randomized trials and by 2.40 min in an analysis from the NCDR [8, 27].

Access site crossover

Access site crossover occurs more commonly with TRA than TFA [12, 36]. In the STEMI subgroups of RIVAL and MATRIX, crossover rates in the TRA arms were 5.34 and 7.2%, respectively, while the crossover rates in the TFA arms of both trials was 1.6% [12, 17•]. In RIFLE-STEACS, the rate of crossover was 6% in the TRA group vs. 1% in the TFA group [16•]. Although the STEMI RADIAL trial also reported a higher rate of crossover in the TRA vs. TFA groups (3.7 vs. 0.6%, $p = 0.003$), the overall TRA crossover rate was low, possibly due to one center's use of left radial artery access as the default access site [18]. Crossover rates with TRA are lowest in high-volume centers and with experienced operators and can be attenuated over time [5, 37, 38]. Crossover commonly occurs due to peripheral artery disease, significant tortuosity of the upper extremity vessels, or inadequate catheter support and less commonly due to failed puncture or radial artery spasm [18, 37]. Predictors of crossover include CS, female sex, age > 75 years, and previous thrombolysis or CABG [16•, 37, 38].

Technical considerations

Door-to-balloon time of < 90 min decreases the rate of major adverse cardiovascular events in STEMI [39–41]. Although there is limited data on the choice and sequence of catheters used in primary PCI, the following strategies may be considered: (1) use of a coronary-specific diagnostic catheter for the contralateral artery and a coronary-specific guide catheter for angiography and PCI of the culprit artery, (2) use of a universal diagnostic catheter for complete angiography, followed by a coronary specific guide catheter for PCI of the culprit artery, or (3) use of a universal guide catheter strategy for complete angiography and PCI [42]. A small single-center retrospective observational study demonstrated a significantly lower door-to-balloon time with the use of a single universal guide catheter (Ikari Left guide catheter) vs. a conventional dual catheter strategy in TRA PCI for STEMI (55 ± 16 min vs. 63 ± 17 min, respectively; $p = 0.01$) [43]. However, experience and proficiency with universal catheters are needed when considering a universal catheter approach, while a dual catheter approach may be more appropriate for operators early in the TRA learning curve.

A technique that has been shown to increase the rate of procedural success with TRA PCI in STEMI is balloon assisted tracking (BAT), which involves positioning of a semicompliant angioplasty balloon (2.0 mm in diameter) over a 0.014-in.-diameter coronary wire halfway out of the tip of the guide catheter, inflation to minimal pressure (3–6 atm), and then advancement en bloc to the ascending aorta. The protruding balloon maintains the coaxial alignment of the catheter and of the artery, resulting in a smooth and usually painless passage across a spastic or tortuous arterial segment. The use of BAT was evaluated in a single-center prospective observational study of 2223 consecutive patients undergoing primary TRA PCI for STEMI and found to be associated with a lower crossover rate than no BAT use in the prior 12-month run-in period (2.5 vs. 6.1%, $p < 0.01$) with no differences in mean procedural time or mean reperfusion time [44].

TRA and outcomes in CS

Bleeding events and other access site complications

Of the four large randomized comparing TRA vs. TFA PCI in acute coronary syndrome, the MATRIX and RIFLE-STEACS trials included patients with CS. While the rate of CS was very low (0.9%) in the MATRIX study, 6.1% of patients in the RIFLE-STEACS study had Killip class IV heart failure and intra-aortic balloon pump was used in 7.6 and 8.4% of the TRA and TFA groups, respectively ($p = 0.73$) [16•, 45]. CS at STEMI presentation was shown to be a predictor of vascular access crossover (HR 3.43 [95% CI 1.7 to 7.1], $p = 0.01$) [16••].

While the data on access site and bleeding complications are less robust in CS, it is biologically valid to consider that the loss of hemoglobin from the vascular space likely compounds the reduction in oxygen delivery already present due to low stroke volume in CS and may incrementally increase the risk of morbidity and mortality [46]. In a prospective, observational, single-center study of 1400 consecutive emergent PCIs between February 2007 and January 2012, 8.7% ($n = 122$) had CS (TRA $n = 80$ and TFA $n = 42$) [47]. Although the rate of protocol-defined major bleeding events was not different between TRA

vs. TFA (11.2 vs. 14.3%, $p = 0.62$), serious access site complications (2.5 vs 11.9%, $p = 0.03$), and access site complications requiring blood transfusion (0 vs 7.1%, $p = 0.04$) was significantly lower with TRA when compared with TFA. Another prospective, observational, single-center study of 101 consecutive patients who underwent PCI for CS (TRA $n = 74$ and TFA $n = 27$) also demonstrated significantly lower rates of TIMI major bleeding events (adjusted HR 0.34 [95% CI 0.13–0.87]) [48]. A meta-analysis of six studies of acute myocardial infarction-related CS confirmed significantly lower rates of major bleeding events (RR 0.43 [95% CI 0.32–0.59]) and transfusion use (RR 0.49 [95% CI 0.35–0.67]) associated with TRA when compared with TFA [48].

Mortality and major adverse cardiovascular events

Early mechanical revascularization reduces mortality in patients with acute myocardial infarction complicated by CS [49–51]. A significant reduction in mortality following TRA vs. TFA PCI in patients with CS has been consistently observed in observational studies. A meta-analysis of 8 of these observational studies included 8131 patients with CS and demonstrated a significantly reduced risk for all-cause mortality at 30 days (unadjusted RR 0.60 [95% CI 0.52–0.71]; adjusted RR 0.55 [95% CI 0.46–0.65]) [52•]. Furthermore, TRA was also significantly associated with major adverse cardiac and cerebral events, which comprised death, nonfatal myocardial infarction, cerebrovascular event, and target vessel revascularization, at 30 days (unadjusted RR 0.68 [95% CI 0.63–0.73]; adjusted RR 0.63 [95% CI 0.52–0.75]) [52•]. However, whether or not this associated reduction in major adverse cardiac and cerebral events is driven by mortality alone or in combination with other adverse cardiovascular events remains uncertain. Table 2 summarizes these observational studies in CS patients.

Technical considerations

Patients presenting with CS may have associated arterial vasoconstriction either in response to shock or the pharmacotherapy used to treat shock. This, in turn, may challenge procedural success via TRA and possibly lead to a higher rate of access site crossover. However, with TRA experience and emerging techniques, there has been an increase in the use of TRA for CS [53••]. Techniques used to potentially increase procedural success via TRA PCI in CS include the use of ultrasound for arterial access. Although there is no data particular to the CS population, a prospective, multicenter randomized controlled all-comers trial ($n = 698$) evaluated the use of ultrasound guidance facilitated TRA compared with palpation alone and demonstrated a significantly lower number of attempts (2.4 vs. 18.6% for ≥ 5 attempts, $p < 0.001$) and a numerically lower time to access (3.7 vs. 6.8% for ≥ 5 min, $p = 0.07$) in the ultrasound group [54]. Other techniques that may facilitate procedural success in CS include the use of smaller caliber guides, sheathless guides, and/or BAT techniques; however, data with all of these techniques in CS are lacking [44, 55, 56].

Use of TRA vs. TFA for primary PCI in setting of hemodynamic support—CS continues to be associated with a high mortality rate in the contemporary era, and at times, a mechanical hemodynamic support device is needed. Although these support devices will often be placed via TFA, a “radial first” strategy likely still applies in most patients given the magnitude of benefit with TRA vs. TFA for PCI in STEMI. A retrospective multicenter

observational study evaluated 321 consecutive patients who underwent IABP support during PCI for CS and hemodynamic instability and demonstrated a significantly lower rate of post-procedural bleeding events, myocardial infarction, target lesion revascularization, stroke, or cardiac death at 30 days in patients who underwent one radial and one femoral access ($n = 112$) compared with those who underwent bilateral femoral access ($n = 209$) (36.6 vs. 57.4%, $p < 0.01$) [57]. This difference was confirmed after propensity score adjustment (HR 0.57 [95% CI 0.4–0.9]) and largely driven by a lower rate of access site-related bleeding (6 vs. 19%, $p < 0.01$).

Conclusions

Multiple large multicenter randomized controlled trials demonstrate that TRA PCI is feasible and effective and reduces peri-procedural complications and all-cause mortality when compared with TFA PCI in patients with STEMI. Although dedicated randomized trials in CS are lacking, observational data suggest a mortality benefit with TRA vs. TFA PCI in CS. TRA experience and advancement in TRA procedural techniques is needed to change practice to a “radial-first” strategy in these high-risk patient populations.

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Table 1.

Randomized controlled trials of transradial artery access (TRA) vs. transfemoral artery access (TFA) for percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction (STEMI)

Citation	Year	Study design	Patient population			30-day mortality			Protocol-defined bleeding		
			Total	STEMI	Shock	TRA	TFA	p value	TRA	TFA	p value
RIVAL subgroup [12]	2011	RCT	7021	28%	–	1.3%	3.2%	0.006	0.8%		
RIFLE-STEACS [16]	2012	RCT	1001	100%	6.1%	5.2%	9.2%	0.02	7.8%		
STEMI-RADIAL [15]	2014	RCT	707	100%	–	2.3%	3.1%	0.64	1.4%		
MATRIX subgroup [17]	2015	RCT	8404	47.7%	0.9%	2.4%	2.7%	0.49	9.4%		

Citation	Protocol-defined bleeding			Protocol defined access site bleeding			Vascular complications		
	TFA	p value	TRA	TFA	p value	TRA	TFA	p value	TRA
RIVAL subgroup [12]	0.9%	0.87 ^a	0.1%	0.2%	0.604	1.3%	3.5%	0.002	
RIFLE-STEACS [16]	12.2%	0.026 ^b	2.6%	6.8%	0.002	2.6%	6.8%	0.002	
STEMI-RADIAL [15]	7.2%	0.0001 ^c	0.6%	5.3%	0.0002	0.3%	0.8%	0.62	
MATRIX subgroup [17]	16.3%	< 0.001 ^d	1.6%	5.3%	< 0.0001	0.2%	0.6%	0.07 [*]	

^aBleeding that was fatal resulted in transfusion of 2 units of blood; caused substantial hypotension requiring inotropes, needed surgical intervention, caused severely disabling sequelae, intracranial and symptomatic or intraocular, and led to significant visual loss, decrease in hemoglobin of at least 50 g/l.

^bBleeding requiring blood transfusion or surgical repair, cerebral bleeding, intracranial or retroperitoneal bleeding, decrease in hemoglobin level 3 g/dl, intrapericardial with tamponade, fatal bleeding. These must have led to unplanned diagnostic examinations and/or prolonged hospitalization and/or lifesaving drug discontinuation

^cIntracranial or intraocular hemorrhage, bleeding at the access site with a hematoma that was 15 cm or larger in diameter or that required intervention, a decrease in hemoglobin concentration of 40 g/L or more without an overt source of bleeding or 30 g/L or more with an overt source of bleeding, reoperation for bleeding, or blood product transfusion only hematomas > 15 cm included

^dBARC 2, 3, or 5

^{*} Access site complications requiring surgery

Table 2.

Observational studies of transradial artery access (TRA) vs. transfemoral artery access (TFA) for percutaneous coronary intervention in patients with cardiogenic shock (CS)

Citation	Year	Study design	Patient population			30-day mortality		
			Overall	STEMI	Shock	TRA	TFA	P value
Roule [48]	2015	Prospective	101	90%	100%	37.8%	70.4%	0.0037 [*]
Rodriguez [47]	2013	Prospective	122	72.9%	100%	32.5%	64.3%	0.001 [*]
Mamas [53]	2014	Retrospective	7231	68%	100%	24.7%	39.8%	< 0.001
Bernat [58]	2013	Retrospective	197	100%	100%	41%	53%	0.11
Fujii [59]	2014	Retrospective	81	100%	100%	32%	30%	0.7
Iga [60]	2014	Retrospective	85	100%	100%	26.7%	40%	0.30
Kedev [61]	2014	Retrospective	33	100%	100%	6%	7%	–
Radial Pump UP [57]	2013	Retrospective	321	76%	100%	19.6%	34.9%	0.004

Citation	Protocol-defined bleeding			Vascular complications		
	TRA	TFA	P value	TRA	TFA	P value
Roule [48]	1.4%	14.8%	0.006 [*]	0%	14.8%	0.0007 [#]
Rodriguez [47]	11.2%	14.3%	0.62 ^b	2.5%	11.9%	0.03
Mamas [53]	1.5%	3.5%	< 0.001 ^c	0.06%	0.12%	< 0.0001 [^]
Bernat [58]	13%	25%	0.042 ^d	–	–	–
Fujii [59]	0%	2.3%	0.344 ^e	–	–	–
Iga [60]	6.7%	28%	< 0.05 ^f	0%	12%	< 0.05
Kedev [61]	5%	7%	– ^g	–	–	–
Radial Pump UP [57]	16.1%	33.5%	0.001 ^h	6.3%	18.7%	0.002

^aIn-hospital TIMI major and minor bleed

^bIntracranial, respiratory, gastrointestinal, genitourinary, or access site-related bleeding that was life threatening or required blood transfusion

^cGastrointestinal bleed, intracerebral bleed, retroperitoneal hematoma, blood or platelet transfusion, or an arterial access site complication requiring surgery

^dTIMI major bleeding

^e Hematoma/bleeding

^f Non-CABG major bleeding and vascular complications: access site hemorrhage/hematoma requiring transfusion, delaying hospital discharge, or resulting in death; proved false aneurysm formation; intracranial bleeding; intraocular bleeding; retroperitoneal bleeding; or any other bleeding requiring transfusion not related to CABG

^g TIMI major bleeding

^h BARC 2 bleeding

^{*} In-hospital mortality

[#] PCI related

[^] Retroperitoneal bleed