Meta-Analysis of Transradial vs Transfemoral Access for Percutaneous Coronary Intervention in Patients With ST Elevation Myocardial Infarction

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Transradial access (TRA) has emerged as an alternative to transfemoral access (TFA) for percutaneous coronary intervention (PCI) in ST elevation myocardial infarction (STEMI) patients. However, the rate of TRA adoption has been much slower in the acute coronary syndrome (ACS) patient population. This meta-analysis was conducted to assess clinical outcomes of TRA compared with TFA in STEMI patients undergoing PCI. A manual search of PubMed, EMBASE, Cochrane library database, Cumulative Index to Nursing and Allied Health Literature (CINAHL), ClinicalTrials.gov, and recent major scientific conference sessions from inception to October 15th, 2019 was performed. Primary outcomes in our analysis were all-cause mortality and trial-defined major bleeding. Secondary outcomes included vascular complications, myocardial infarction, stroke, procedure, and fluoroscopy time. 17 randomized controlled trials (RCTs) (N = 12,018) met inclusion criteria. TRA was associated with lower all-cause mortality (risk ratio [RR]: 0.71, 95% confidence interval [CI]: 0.57 to 0.88), major bleeding (RR: 0.59, 95%CI: 0.45 to 0.77), and vascular complications (RR: 0.42, 95%CI: 0.32 to 0.56) compared with TFA. There was no difference in the incidence of myocardial infarction (MI), stroke, or procedure duration between the 2 groups. The difference in all-cause mortality between TRA and TFA was statistically nonsignificant when major bleeding was held constant. In conclusion, TRA was associated with lower risk of all-cause mortality, major bleeding, and vascular complications compared with TFA in STEMI patients undergoing PCI. **(Am J Cardiol 2021;141:23−30)**

Percutaneous coronary intervention (PCI) remains the standard of care for treatment of ST-elevation myocardial infarction (STEMI).[1] Procedural advances and tailoring of antithrombotic regimens have improved outcomes post PCI in STEMI patients at the expense of increased risk of periprocedural bleeding complications that vary from 0.9% to 9% in STEMI.[2] Efforts to minimize these risks were developed including alternative strategies of arterial access such as the transradial access (TRA). However, the utilization of TRA has been limited by the perception of higher procedural failure and longer procedural duration that can be detrimental, especially in STEMI patients where immediate reperfusion is essential. Earlier randomized controlled trials (RCTs) that compared TRA with transfemoral access (TFA) were inadequately powered to detect meaningful reductions in hard outcomes such as mortality.[3−16] Previously published meta-analysis have shown that TRA reduced the risk of all-cause mortality, major bleeding, and major adverse cardiovascular events (MACE).[17,18] However, results from the recently conducted Safety and Efficacy of Femoral Access versus Radial Access in ST-Elevation Myocardial Infarction (SAFARI-STEMI) trial showed no difference in 30-day all-cause mortality and major bleeding between the two approaches.[19] Given these conflicting findings, we performed an updated meta-analysis of RCTs to compare the efficacy and safety of TRA versus TFA in STEMI patients undergoing PCI.

Methods

The systematic review and meta-analysis was performed according to the PRISMA (**P**referred **R**eporting **I**tems for **S**ystematic **R**eviews and **M**eta-**A**nalysis) guidelines.[20] The initial search strategy was developed by 2 authors (AJ and RD). A systematic search, without language restriction was

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See page 27 for disclosure information.

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0002-9149/
https://doi.org/10.1016/j.amjcard.2020.11.016

performed in PubMed, EMBASE, Cochrane Library database, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and ClinicalTrials.gov from inception to October 15th, 2019 for studies comparing TRA versus TFA in STEMI. Conference proceedings of American College of Cardiology, American Heart Association, European Society of Cardiology, and Transcatheter Cardiovascular Therapeutics from 2016 to October 2019 were also searched. The reference lists of original studies, conference abstracts, and relevant review articles were further reviewed. We used varied combinations of the following keywords in our search strategy: *Radial access, transradial access, femoral access, transfemoral access, ST elevation myocardial infarction, STEMI, acute myocardial infarction, acute coronary syndrome, percutaneous coronary intervention, coronary intervention, randomized controlled trial, randomized trial, and clinical trial*. The search strategy was verified and independently validated by an experienced librarian. Additional details of the search terms and strategy are provided in *Supplementary Table 1*.

We included studies that met the following eligibility criteria: (1) Randomized controlled trials, (2) evaluating the efficacy and safety of TRA versus TFA, (3) PCI (primary or rescue) in STEMI.

Two investigators (AJ and RD) independently performed the literature search, screened studies for eligibility and extracted data using a standardized data collection form. Any differences in the included studies and collected data were resolved through consensus among the authors.

We extracted the following prespecified clinical outcomes from individual trials: (1) All-cause mortality (cardiovascular and noncardiovascular causes), (2) trial-defined major bleeding, (3) vascular complications, (4) myocardial infarction (MI), (5) stroke, 6) procedure duration, and (7) fluoroscopy time. Trial specific definitions were used for major bleeding, *Supplementary Table 2*. The primary study outcomes were all-cause mortality and major bleeding. Secondary outcomes included stroke, MI, vascular complications, procedure, and fluoroscopy time.

The meta-analysis was performed using R version 3.4.0 (The R Project for Statistical Computing, Vienna, Austria) with the metafor package and Review Manager (RevMan), Version 5.3. (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). Due to heterogeneity in the methodologies of the included studies, the risk ratios [RRs] and 95% confidence intervals (CI) were calculated using random effects Mantel-Haenszel method for dichotomous variables. Heterogeneity was assessed using Higgins' and Thompson's I^2 statistic, with I^2 values of <25%, 25% to 75%, and >75% corresponding to low, moderate, and high levels of heterogeneity, respectively. Since the duration of follow-up was variable among the included studies, we performed a subgroup analysis for primary outcomes based on the duration of follow-up (in-hospital vs 30-day or longer). Meta regression using random effects was performed to measure the influence of baseline characteristics on all-cause mortality and major bleeding. Sensitivity analysis was performed using fixed effects model and study exclusion method. Publication bias was visually estimated by constructing funnel plots. A 2-tailed $p < 0.05$ was considered statistically significant for all analyses. The risk of bias among the included RCTs was assessed using Cochrane risk of bias assessment tool, Supplementary Table 3.

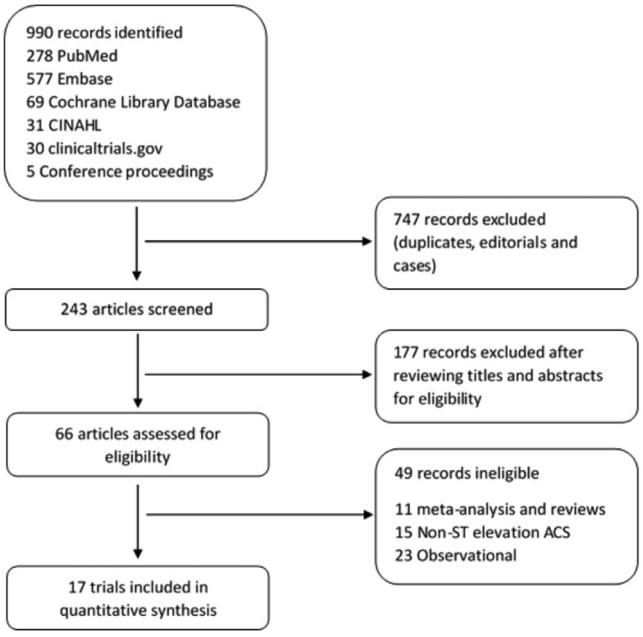

Figure 1. Consort diagram. Flow diagram for the included studies. ACS= acute coronary syndrome; CINAHL= Cumulative Index to Nursing and Allied Health Literature

Results

A total of 990 articles were identified through database search. After excluding duplicates and studies that did not meet inclusion criteria, a total of 17 RCTs comparing TRA and TFA in STEMI-PCI were selected for the quantitative analysis (Figure 1).

This meta-analysis included 17 RCTs with 12,018 patients, of which 5,958 underwent PCI using TRA and 6,060 using TFA in STEMI.[3–16,19,21–23] Mean/median age of study population ranged from 52 to 71.4 years, and 76.6% were males, Table 1. The prevalence of diabetes mellitus (DM) and hypertension were 24.5% and 47.5% respectively with 17.4% patients having a previous history of MI. The proportion of rescue PCI ranged from 0% to 100%, Supplementary Table 4. The use of glycoprotein IIb/IIIa inhibitors was 50.4% in TRA and 50.3% in TFA. Cross over rate in TRA group was 5.7%, and 1.6% in the TFA group. Follow-up duration varied among included trials. Post-hospitalization follow-up was unavailable in 5 trials whereas 8 trials reported outcomes at 30 days.

All-cause mortality was reported in 16 trials. Radial access was associated with lower risk of all-cause mortality compared with femoral access (RR: 0.71, 95%CI: 0.57 to 0.88), Figure 2A. Test of heterogeneity was low ($I^2 = 0\%$). Data on major bleeding were available in 16 trials. Trial-defined major bleeding was significantly lower with TRA compared with TFA (RR: 0.59, 95%CI: 0.45 to 0.77), Figure 2B. Test of heterogeneity was low ($I^2 = 0\%$).

Data on vascular complications were reported in 13 trials. Vascular complications were significantly lower with TRA compared with TFA (RR: 0.42, 95%CI: 0.32 to 0.56),

Table 1
Baseline characteristics of study population in the included RCTs

Study	Study period	Single/ Multicenter	Patient population TRA	TFA	Mean age (years) TRA	TFA	Men	DM	Hypertension	Smoking	Prior MI	Follow up (days)
SAFARI-STEMI, 2019	07/2011- 12/2018	Multi	1136	1156	61.6 ± 12.3	62 ± 12.1	78%	17%	48%	39%	10%	30
MATRIX, 2017	10/2011-07/2014	Multi	2001	2009	63.7 ± 12.1	64 ± 12.1	77%	18%	56%	41%	10%	30
OCEAN RACE, 2014	09/2010-10/2012	Single	52	51	61 (IQR 49.7-72.2)	62.8 (IQR: 50.2-75.4)	NR	23%	69%	66%	8%	TRA-478 days; TFA-891
RIFLE-STEACS, 2012	01/2009-07/2011	Multi	500	501	65 (IQR: 56-75)	65 (IQR: 55-77)	73%	24%	61%	40%	14%	30
RIVAL, 2012	06/2006-11/2010	Multi	955	1003	62 ± 12	62 ± 12	73%	21%	60%	31%	18%	30
STEMI-RADIAL, 2012	10/2009-02/2012	Multi	348	359	62.7 ± 11.7	61.5 ± 11.2	77%	21%	61%	51%	75%	183
Wang, 2012	07/2008-12/2010	Single	60	59	59.8 ± 12.4	60.2 ± 11.4	85%	30%	71%	48%	NR	In-hospital
RADIAMI II, 2011	11/2006-03/2008	Single	49	59	62.1 ± 9.3	57.6 ± 10.3	64%	19%	39%	67%	11%	In-hospital
Hou, 2010	08/2005-11/2008	Single	100	100	64.9 ± 8.4	66.2 ± 7.7	70%	18%	46%	46%	NR	30
Vazquez-Rodriguez, 2009	05/2004-07/2005	Multi	217	222	60 ± 13	62 ± 12	84%	18%	44.6%	60%	NR	30
RADIAMI, 2009	04/2005-06/2006	Single	50	50	59.9 ± 9.4	59.1 ± 9	68%	15%	47%	64%	11%	In-hospital
Gan, 2009	06/2004-07/2017	Multi	90	105	53.6 ± 12.5	52.3 ± 11.9	81%	80%	47%	63%	10%	180
Yan 2008	06/2005-06/2007	Single	57	46	70.3 ± 7.5	71.4 ± 8.4	75%	23%	45%	48%	NR	30
Li 2007	06/2004-06/2006	Single	184	186	56.5 ± 10.9	55.4 ± 12.8	66%	19%	41%	43%	NR	In hospital
FARMI 2007	01/2004-09/2005	Single	57	57	60 ± 12	58 ± 13	84%	18%	41%	76%	NR	In hospital
RADIAL- AMI 2005	NR	Multi	25	25	52 (IQR: 48 – 60)	58 (IQR: 49 – 72)	88%	24%	44%	52%	NR	30
TEMPURA 2003	07/1999- 02/2001	Single	77	72	66 ±12	67 ±10	81%	25%	51%	46%	7%	270

DM = diabetes mellitus; IQR = interquartile range; MI = myocardial infarction; RCT = randomized controlled trial; TFA = transfemoral access; TRA = transradial access.

Figure 3**A**. Test of heterogeneity was low ($I^2 = 14\%$). Data on MI were reported in 14 trials. There was no difference in risk of MI between TRA and TFA (RR: 0.97, 95%CI: 0.75 to 1.25), Figure 3**B**. Test of heterogeneity was low ($I^2 = 0\%$). The data on stroke were reported in 10 trials. There was no difference in risk of stroke between the 2 groups (RR: 1.37, 95%CI: 0.82 to 2.29), Figure 4A. Test of heterogeneity was low ($I^2 = 0\%$).

Procedure duration was reported in 9 trials. There was no difference in procedure duration between the two groups (SMD: 0.12, 95%CI: −0.03 to 0.28), Figure 4B. Test of heterogeneity was moderate ($I^2 = 63\%$). Fluoroscopy time was reported in 10 trials. TFA was associated with shorter fluoroscopy time compared with TRA (SMD: 0.19, 95%CI: 0.00 to 0.39), Figure 4C. Test of heterogeneity was high ($I^2 = 86\%$).

Meta-regression showed, baseline characteristics of female gender, single versus multicenter, glycoprotein IIb/IIIa inhibitor use (%) and primary PCI (%) were not associated with all-cause mortality or major bleeding, *Supplementary Table 5*. The use of vascular closure device in TFA group was not associated with major bleeding ($p = 0.55$). The difference in all-cause mortality between TRA and TFA became statistically nonsignificant when major bleeding was held constant ($p = 0.85$), *Supplementary Figure 1*.

Since the duration of follow-up was variable among the included studies, we performed a subgroup analysis for primary outcomes based on the duration of follow-up (in-hospital vs 30 day or longer). No significant difference was seen in the risk of all-cause mortality and major bleeding between the 2 groups when patients were followed until the end of their hospitalization. Risk of all-cause mortality (RR: 0.70, 95%CI: 0.55 to 0.90) and major bleeding (RR: 0.55, 95%CI: 0.39 to 0.79) were significantly lower in TRA for a follow-up period of 30 days or longer, Figures 2A and B. Additionally, vascular complications were significantly lower in-hospital and 30-days or longer in TRA compared with TFA, Figure 3A. There was no significant difference between the 2 groups in-hospital and at 30-day or longer for MI and stroke, Figures 3B, 4A. Sensitivity analysis using fixed effects model revealed outcomes were same as random effects model, Supplementary Figure 2. Sensitivity analysis by study exclusion method also showed that results were unaffected by exclusion of the largest study (MATRIX trial), Supplementary Figure 3. Funnel plot showed asymmetry on visual inspection, Supplementary Figure 4.

Discussion

In this meta-analysis of 17 RCTs evaluating 12,018 patients randomized to TRA versus TFA for PCI in STEMI, TRA was associated with a 29% lower risk of all-cause mortality, 58% lower risk of vascular complications and 41% lower risk of trial-defined major bleeding. There was no difference in stroke, MI, or procedure duration between the 2 access sites. Meta-regression demonstrated that the difference in all-cause mortality between TRA and TFA became statistically nonsignificant when major bleeding was held constant which is a novel finding not previously reported in previous studies.

Since its first use in 1989, TRA has garnered widespread use in clinical practice due to lower risk of vascular and

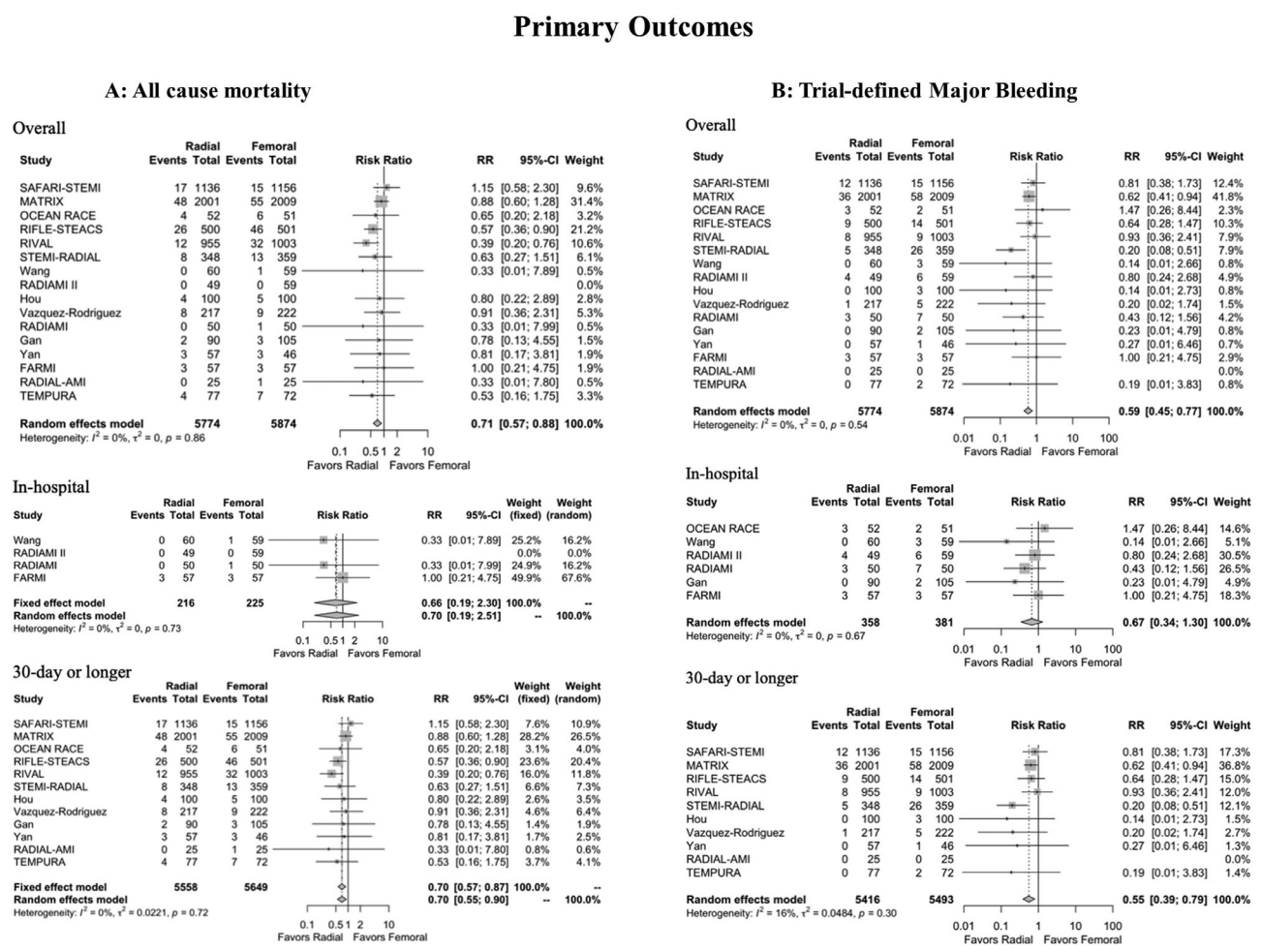

Figure 2. Forest plot showing primary outcomes between TRA and TFA. (A) All-cause mortality, (B) Trial-defined major bleeding. M-H = Mantel-Haenszel.

bleeding complications compared with the traditional TFA to become the most used access site in PCI. However, the rate of TRA adoption has been much slower in the ACS patient population.[23] Some concerns such as procedural failure and longer reperfusion time associated with TRA are based on confounded data from earlier observational studies derived from less experienced operators and have contributed to physician apprehension in selection of this technique. An analysis of the National Cardiovascular Disease Registry (NCDR) demonstrated that TRA was associated with a modest increase in door-to-balloon time compared with TFA, however this was off-set by the lower risk-adjusted mortality rate driven by lower rates of major bleeding with TRA.[24] Another analysis of the NCDR among 692,433 patients undergoing PCI for STEMI found that a greater use of TRA across operators was associated with reduced bleeding and an increasing use of TRA across institutions was associated with a decrease in in-hospital mortality.[25] In our analysis, mortality benefit observed among patients randomized to TRA was mainly driven by lower risk of bleeding and vascular complications. Such benefit has been consistently demonstrated in previous meta-analyses as well. However, when compared with the other previous meta-analyses, we found that the weighted bleeding rate of 2.2% with TRA was lower than 3.8% observed with TFA. For every 1000 patients receiving TRA PCI for STEMI, the bleeding events were fewer by at least 16. Moreover, the difference in all-cause mortality between TRA and TFA was no longer statistically significant when major bleeding was held constant.

STEMI patients represent the highest risk population in the spectrum of ACS that are subjected to aggressive pharmacological treatments with ischemic benefits, albeit with higher vascular and bleeding complications. This also means that they are likely to derive the largest benefit from reduction of such bleeding and vascular complications. As it is well reported, bleeding from both access and nonaccess sites has been directly correlated with short-term and long-term mortality, with nearly 12% of in-hospital deaths reported in NCDR CathPCI registry attributed to periprocedural bleeding complications.[26] As such TRA can effectively minimize access site bleeding complications without any direct effect on nonaccess site bleeding. Even a modest reduction of such bleeding can accommodate additional doses of antithrombotics providing an overall net benefit of ischemic outcomes. It is also worth noting that similar magnitude of benefit in terms of bleeding complications has been observed with TRA even in high risk STEMI population (cardiogenic shock, hemodynamic instability, or failed antithrombotic therapy) enrolled in the RIFLE-STEACS

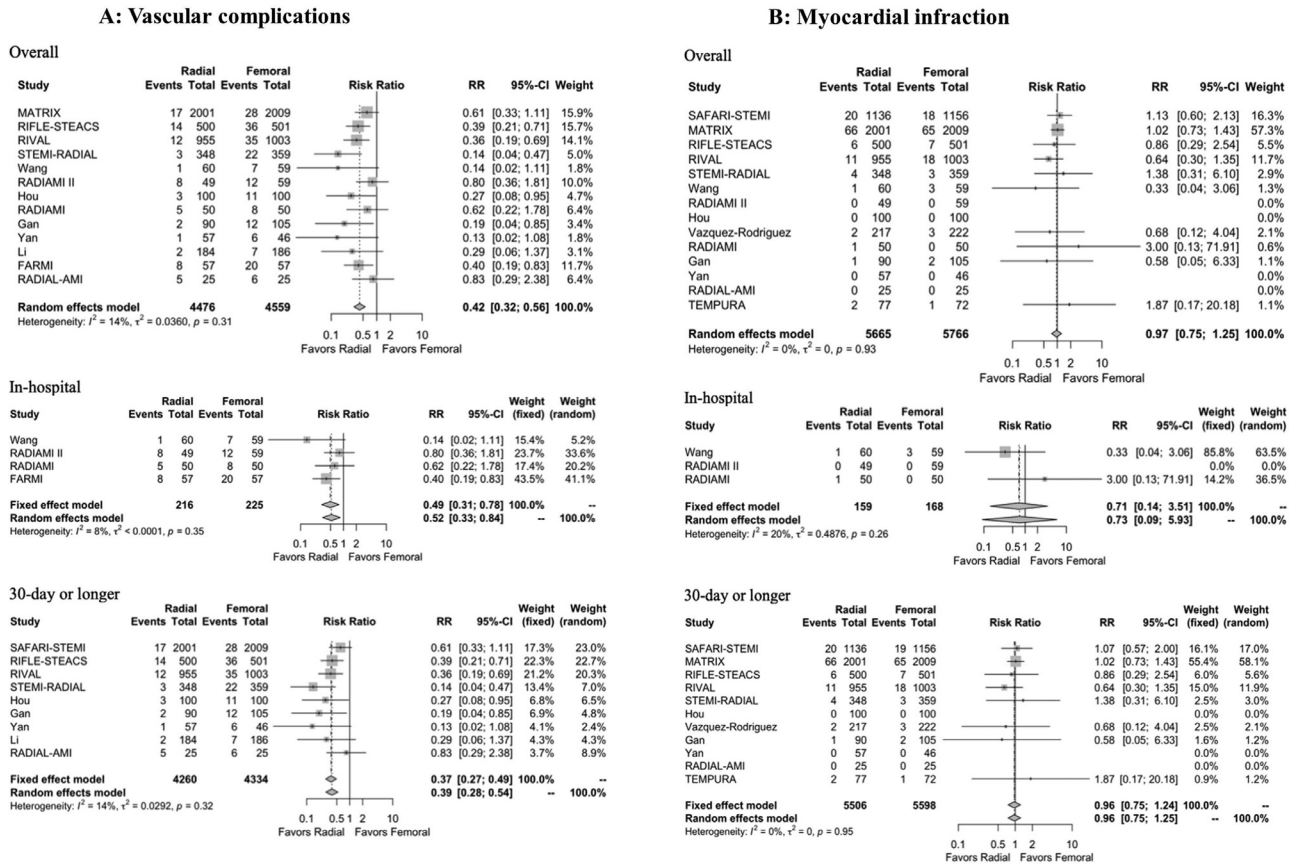

Figure 3. Forest plot showing secondary outcomes between TRA and TFA. (A) Vascular complications, (B) Myocardial infarction. M-H = Mantel-Haenszel.

(Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) trial.[15] Similar results were later reproduced in real world patient registries as well.[27] Paradoxically, TRA is less frequently utilized in such high-risk groups.

One of the many reasons for limited utilization of TRA among the U.S. operators included longer fluoroscopy and procedure times that were attributed to the steep learning curve including challenges in obtaining radial access.[28] Our results demonstrate a modest increase in fluoroscopy time with TFA but no difference in total procedure time. TRA has also been shown to shorten the time to ambulation, improve patient satisfaction, comfort and substantially lower healthcare costs.[29] Nevertheless, TRA is highly operator dependent, with a strong direct correlation between operator volume and procedural outcomes. To minimize the learning curve and enhance performance metrics, certain volume requirements have been previously laid down by SCAI (Society for Cardiovascular Angiography and Interventions) transradial working group.[30] Other measures include gradual operator escalation through complex cases with ultimate plan for use in STEMI setting and increased use of hydrophilic transradial sheaths to help facilitate the rapid dispersion of radial-first strategy. Once TRA technique is mastered, and patients with high-bleeding risk are selected, the benefits will likely be greatest.

Some potential limitations of our meta-analysis are worth mentioning while interpreting the results. First, the use of intention to treat protocol in the included RCTs likely affected the interpretation of bleeding events due to high crossover rates, often favoring TFA. Second, TRA is highly operator dependent; hence results might have been influenced by underlying confounders that cannot be accounted. Third, the proportion of patients undergoing rescue PCI varied widely across the trials and may have potentially confounded the bleeding rates. Fourth, the definition of major bleeding varied widely among the included RCTs. Fifth, only 4 out of the 17 trials provided follow-up data beyond 30 days, thus the findings of our analysis may not be applicable over a longer follow-up period. Sixth, all the included RCTs except, RIFLE-STEACS excluded patients with cardiogenic shock, hence these results cannot be extrapolated to this high-risk population. Seventh major proportion of study population were male and less than 70 years of age. Finally, an inherent limitation of any meta-analysis is publication bias.

In conclusion, in STEMI patients undergoing PCI, TRA was associated with lower risk of all-cause mortality driven by lower bleeding complications compared with TFA. The difference in all-cause mortality between TRA and TFA was no longer statistically significant when major bleeding was held constant.

Disclosures

Aravdeep Jhand: None.
Varunsiri Atti: None.
Rahul Dhawan: None.

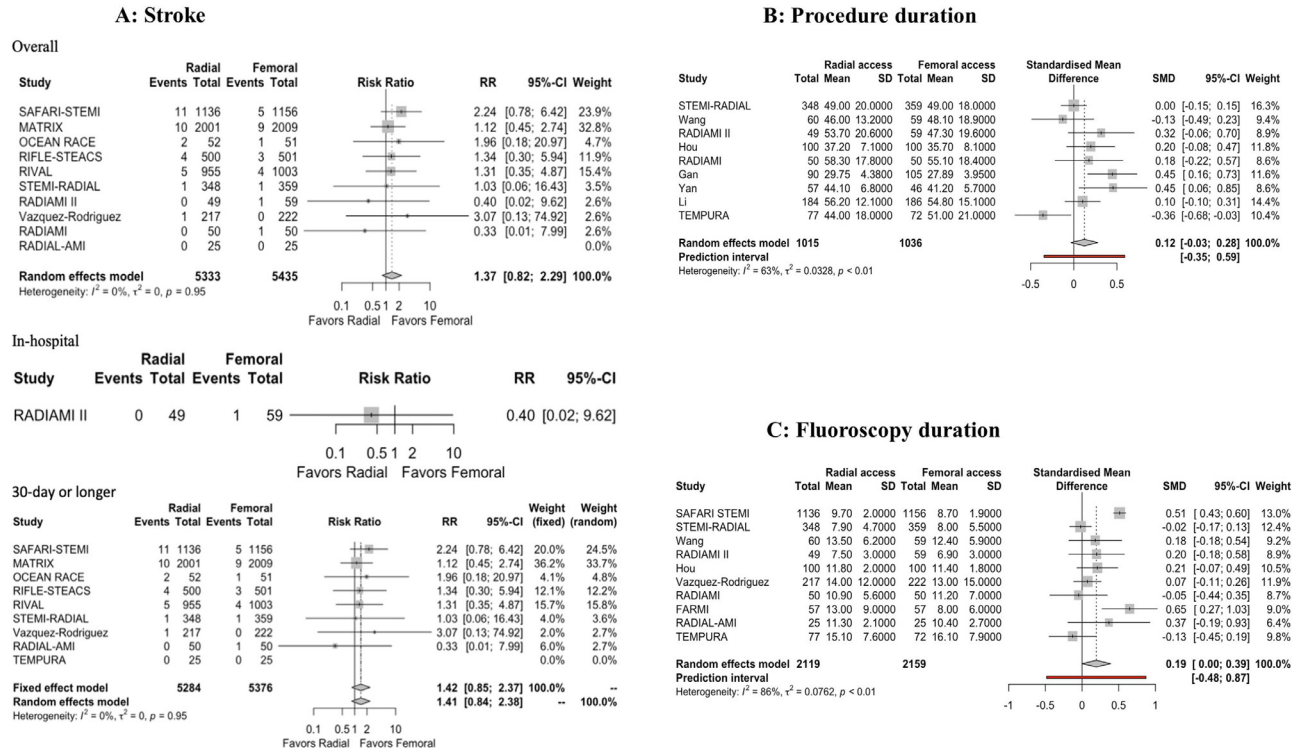

Figure 4. Forest plot showing secondary outcomes between TRA and TFA. (A) Stroke, (B) Procedure duration, (C) Fluoroscopy time. M-H = Mantel-Haensz.

Yeongjin Gwon: None.

Mohit Turagam: None.

Mamas Mamas: None.

Emmanouil Brilakis: Consulting/speaker honoraria from Abbott Vascular, American Heart Association (associate editor Circulation), Biotronik, Boston Scientific, Cardiovascular Innovations Foundation (Board of Directors), CSI, Elsevier, GE Healthcare, InfraRedx, Medtronic, Siemens, and Teleflex; research support from Regeneron and Siemens. Shareholder: MHI Ventures.

Arnav Kumar: None.

Natraj Katta: None.

Yiannis Chatzizisis: Consultation fees, speaker honoraria and research grant by Boston Scientific and Research grant by Medtronic.

Manish Parikh: Advisory board and speaker bureau for Medtronic, Boston Scientific and Abbott Vascular.

J Dawn Abbott: Research grants with no direct compensation from Abbott vascular, Sinomed, Astrazeneca, Bristol myers squibb, Biosensors Research USA Inc.

Ajay Kirtane: Institutional funding to Columbia University and/or Cardiovascular Research Foundation from Medtronic, Boston Scientific, Abbott Vascular, Abiomed, CSI, Philips, ReCor Medical.

Deepak L. Bhatt: Dr. Deepak L. Bhatt discloses the following relationships - Advisory Board: Cardax, Cereno Scientific, Elsevier Practice Update Cardiology, Medscape Cardiology, PhaseBio, PLX Pharma, Regado Biosciences; Board of Directors: Boston VA Research Institute, Society of Cardiovascular Patient Care, TobeSoft; Chair: American Heart Association Quality Oversight Committee; Data Monitoring Committees: Baim Institute for Clinical Research (formerly Harvard Clinical Research Institute, for the PORTICO trial, funded by St. Jude Medical, now Abbott), Cleveland Clinic (including for the ExCEED trial, funded by Edwards), Duke Clinical Research Institute, Mayo Clinic, Mount Sinai School of Medicine (for the ENVISAGE trial, funded by Daiichi Sankyo), Population Health Research Institute; Honoraria: American College of Cardiology (Senior Associate Editor, Clinical Trials and News, ACC.org; Vice-Chair, ACC Accreditation Committee), Baim Institute for Clinical Research (formerly Harvard Clinical Research Institute; RE-DUAL PCI clinical trial steering committee funded by Boehringer Ingelheim; AEGIS-II executive committee funded by CSL Behring), Belvoir Publications (Editor in Chief, Harvard Heart Letter), Duke Clinical Research Institute (clinical trial steering committees, including for the PRONOUNCE trial, funded by Ferring Pharmaceuticals), HMP Global (Editor in Chief, Journal of Invasive Cardiology), Journal of the American College of Cardiology (Guest Editor; Associate Editor), Medtelligence/ReachMD (CME steering committees), Population Health Research Institute (for the COMPASS operations committee, publications committee, steering committee, and USA national coleader, funded by Bayer), Slack Publications (Chief Medical Editor, Cardiology Today's Intervention), Society of Cardiovascular Patient Care (Secretary/Treasurer), WebMD (CME steering committees); Other: Clinical Cardiology (Deputy Editor), NCDR-ACTION Registry Steering Committee (Chair), VA CART Research and Publications Committee (Chair); Research Funding: Abbott, Afimmune, Amarin, Amgen, AstraZeneca, Bayer, Boehringer Ingelheim, Bristol-Myers Squibb, Cardax, Chiesi, CSL Behring, Eisai, Ethicon, Ferring Pharmaceuticals, Forest Laboratories, Fractyl,

Idorsia, Ironwood, Ischemix, Lexicon, Lilly, Medtronic, Pfizer, PhaseBio, PLx Pharma, Regeneron, Roche, Sanofi Aventis, Synaptic, The Medicines Company; Royalties: Elsevier (Editor, Cardiovascular Intervention: A Companion to Braunwald's Heart Disease); Site Co-Investigator: Biotronik, Boston Scientific, CSI, St. Jude Medical (now Abbott), Svelte; Trustee: American College of Cardiology; Unfunded Research: FlowCo, Merck, Novo Nordisk, Takeda.

Poonam Velagapudi: None.

Contributorship Statement

Aravdeep Jhand, Varunsiri Atti and Poonam Velagapudi were involved in planning, conduct, and reporting the described work.

Rest of the authors were involved in reviewing the manuscript and providing critical feedback.

Ethics Committee Approval

The study is exempted from IRB approval as it involves study level data from previous publications.

Reporting Patient and Public Involvement in Research

No patients were involved for this research.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

We thank Kimberly A Harp, MLS; Education and Research Services Librarian, Assistant Professor, McGoogan Library of Medicine, University of Nebraska Medical Center for her assistance with the review of literature search for this meta-analysis.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2020.11.016.

1. Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, Chambers CE, Ellis SG, Guyton RA, Hollenberg SM, Khot UN, Lange RA, Mauri L, Mehran R, Moussa ID, Mukherjee D, Ting HH, O'Gara PT, Kushner FG, Ascheim DD, Brindis RG, Casey DE, Chung MK, JAd Lemos, Diercks DB, Fang JC, Franklin BA, Granger CB, Krumholz HM, Linderbaum JA, Morrow DA, Newby LK, Ornato JP, Ou N, Radford MJ, Tamis-Holland JE, Tommaso CL, Tracy CM, Woo YJ, Zhao DX. 2015 ACC/AHA/SCAI focused update on primary percutaneous coronary intervention for patients with ST-elevation myocardial infarction: an update of the 2011 ACCF/AHA/SCAI Guideline for percutaneous coronary intervention and the 2013 ACCF/AHA Guideline for the management of ST-elevation myocardial infarction. *Circulation* 2016;133:1135–1147.
2. Giustino G, Mehran R, Dangas GD, Kirtane AJ, Redfors B, Généreux P, Brener SJ, Prats J, Pocock SJ, Deliargyris EN, Stone GW. Characterization of the average daily ischemic and bleeding risk after primary PCI for STEMI. *J Am Coll Cardiol* 2017;70:1846–1857.
3. Saito S, Tanaka S, Hiroe Y, Miyashita Y, Takahashi S, Tanaka K, Satake S. Comparative study on transradial approach vs. transfemoral approach in primary stent implantation for patients with acute myocardial infarction: results of the test for myocardial infarction by prospective unicenter randomization for access sites (TEMPURA) trial. *Cath Cardiovasc Interv* 2003;59:26–33.
4. Cantor WJ, Puley G, Natarajan MK, Dzavik V, Madan M, Fry A, Kim HH, Velianou JL, Pirani N, Strauss BH, Chisholm RJ. Radial versus femoral access for emergent percutaneous coronary intervention with adjunct glycoprotein IIb/IIIa inhibition in acute myocardial infarction—the RADIAL-AMI pilot randomized trial. *Am Heart J* 2005;150:543–549.
5. Brasselet C, Tassan S, Nazeyrollas P, Hamon M, Metz D. Randomised comparison of femoral versus radial approach for percutaneous coronary intervention using abciximab in acute myocardial infarction: results of the FARMI Trial. *Heart* 2007;93:1556.
6. Yan ZX, Zhou YJ, Zhao YX, Liu YY, Shi DM, Guo YH, Cheng WJ. Safety and feasibility of transradial approach for primary percutaneous coronary intervention in elderly patients with acute myocardial infarction. *Chinese Med J* 2008;121:782–786.
7. Gan L, Lib Q, Liuc R, Zhaoc Y, Qiuc J, Liao Y. Effectiveness and feasibility of transradial approaches for primary percutaneous coronary intervention in patients with acute myocardial infarction. *J Nanjing Med Univer* 2009;23:270–274.
8. Chodór P, Krupa H, Kurek T, Sokal A, Swierad M, Was T, Streb W, Duszańska A, Swiatkowski A, Honisz G, Kalarus Z. RADIal versus femoral approach for percutaneous coronary interventions in patients with Acute Myocardial Infarction (RADIAMI): a prospective, randomized, single-center clinical trial. *J Cardiol* 2009;16:332–340.
9. Vázquez-Rodríguez JM. Comparación del acceso radial frente al acceso femoral en la revascularización percutánea durante la fase aguda del infarto agudo de miocardio con elevación del segmento ST [Comparison of Radial Access from Femoral Access in Percutaneous Revascularization During the Acute Phase of Acute Myocardial Infarction ST Segment Elevation] [doctorate thesis]. Coruna, Spain: Universidade da Coruna; 2009 [In Spanish].
10. Hou L, Wei YD, Li WM, Xu YW. Comparative study on transradial versus transfemoral approach for primary percutaneous coronary intervention in Chinese patients with acute myocardial infarction. *Saudi Med J* 2010;31:158–162.
11. Chodór P, Kurek T, Kowalczuk A, Świerad M, Wąs T, Honisz G, Świątkowski A, Streb W, Kalarus Z. Radial vs femoral approach with StarClose clip placement for primary percutaneous coronary intervention in patients with ST-elevation myocardial infarction. RADIAMI II: a prospective, randomised, single centre trial. *Kardiologia Polska* 2011;69:763–771.
12. Wang YB, Fu XH, Wang XC, Gu XS, Zhao YJ, Hao GZ, Jiang YF, Li SQ, Wu WL, Fan WZ. Randomized comparison of radial versus femoral approach for patients with STEMI undergoing early PCI following intravenous thrombolysis. *J Invasive Cardiol* 2012;24:412–416.
13. Bernat I, Horak D, Stasek J, Mates M, Pesek J, Ostadal P, Hrabos V, Dusek J, Koza J, Sembera Z, Brtko M, Aschermann O, Smid M, Polansky P, Al Mawiri A, Vojacek J, Bis J, Costerousse O, Bertrand OF, Rokyta R. ST-segment elevation myocardial infarction treated by radial or femoral approach in a multicenter randomized clinical trial: the STEMI-RADIAL Trial. *J Am Coll Cardiol* 2014;63:964–972.
14. Jolly SS, Yusuf S, Cairns J, Niemelä K, Xavier D, Widimsky P, Budaj A, Niemelä M, Valentin V, Lewis BS, Avezum A, Steg PG, Rao SV, Gao P, Afzal R, Joyner CD, Chrolavicius S, Mehta SR. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *The Lancet* 2011;377:1409–1420.
15. Romagnoli E, Biondi-Zoccai G, Sciahbasi A, Politi L, Rigattieri S, Pendenza G, Summaria F, Patrizi R, Borghi A, Di Russo C, Moretti C, Agostoni P, Loschiavo P, Lioy E, Sheiban I, Sangiorgi G. Radial versus femoral randomized investigation in ST-segment elevation acute coronary syndrome: the RIFLE-STEACS (Radial versus femoral randomized investigation in ST-elevation acute coronary syndrome) Study. *J Am Coll Cardiol* 2012;60:2481–2489.
16. Kołtowski L, Filipiak KJ, Kochman J, Pietrasik A, Rdzanek A, Huczek Z, Scibisz A, Mazurek T, Opolski G. Access for percutaneous coronary intervention in ST segment elevation myocardial infarction: radial vs. femoral−a prospective, randomised clinical trial (OCEAN RACE). *Kardiologia polska* 2014;72:604–611.

17. Ferrante G, Rao SV, Jüni P, Da Costa BR, Reimers B, Condorelli G, Anzuini A, Jolly SS, Bertrand OF, Krucoff MW, Windecker S, Valgimigli M. Radial versus femoral access for coronary interventions across the entire spectrum of patients with coronary artery disease: a meta-analysis of randomized trials. *JACC: Cardiovascular Interventions* 2016;9:1419–1434.
18. Singh S, Singh M, Grewal N, Khosla S. Transradial vs transfemoral percutaneous coronary intervention in ST-segment elevation myocardial infarction: a systemic review and meta-analysis. *Can J Cardiol* 2016;32:777–790.
19. Le May M, Wells G, So D, Chong AY, Dick A, Froeschl M, Glover C, Hibbert B, Marquis J-F, Blondeau M, Osborne C, MacDougall A, Kass M, Paddock V, Quraishi A, Labinaz M. Safety and efficacy of femoral access vs radial access in ST-segment elevation myocardial infarction: the SAFARI-STEMI randomized clinical trial. *JAMA Cardiol.* 2020;5:126–134.
20. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009;151:264–269.
21. Vranckx P, Frigoli E, Rothenbühler M, Tomassini F, Garducci S, Andò G, Picchi A, Sganzerla P, Paggi A, Ugo F, Ausiello A, Sardella G, Franco N, Nazzaro M, de Cesare N, Tosi P, Falcone C, Vigna C, Mazzarotto P, Di Lorenzo E, Moretti C, Campo G, Penzo C, Pasquetto G, Heg D, Jüni P, Windecker S, Valgimigli M, Investigators ftM. Radial versus femoral access in patients with acute coronary syndromes with or without ST-segment elevation. *Eur Heart J* 2017;38:1069–1080.
22. Li WM, Li Y, Zhao JY, Duan YN, Sheng L, Yang BF, Wang FL, Gong YT, Yang SS, Zhou LJ, Liu PD, Zhang L, Chu S. Safety and feasibility of emergent percutaneous coronary intervention with the transradial access in patients with acute myocardial infarction. *Chin Med J* 2007;120:598–600.
23. Howe MJ, Seth M, Riba A, Hanzel G, Zainea M, Gurm HS. Underutilization of radial access in patients undergoing percutaneous coronary intervention for ST-segment elevation myocardial infarction. *Circ Cardiovasc Interv* 2015;8:e002036.
24. Baklanov DV, Kaltenbach LA, Marso SP, Subherwal SS, Feldman DN, Garratt KN, Curtis JP, Messenger JC, Rao SV. The prevalence and outcomes of transradial percutaneous coronary intervention for ST-segment elevation myocardial infarction: analysis from the national cardiovascular data registry (2007 to 2011). *J Am Coll Cardiol* 2013;61:420–426.
25. Valle JA, Kaltenbach LA, Bradley SM, Yeh RW, Rao SV, Gurm HS, Armstrong EJ, Messenger JC, Waldo SW. Variation in the adoption of transradial access for ST-segment elevation myocardial infarction: insights from the NCDR CathPCI Registry. *JACC: Cardiovasc Interv* 2017;10:2242–2254.
26. Rao SV, McCoy LA, Spertus JA, Krone RJ, Singh M, Fitzgerald S, Peterson ED. An updated bleeding model to predict the risk of post-procedure bleeding among patients undergoing percutaneous coronary intervention: a report using an expanded bleeding definition from the national cardiovascular data registry CathPCI Registry. *JACC: Cardiovasc Interv* 2013;6:897–904.
27. Feldman DN, Swaminathan RV, Kaltenbach LA, Baklanov DV, Kim LK, Wong SC, Minutello RM, Messenger JC, Moussa I, Garratt KN, Piana RN, Hillegass WB, Cohen MG, Gilchrist IC, Rao SV. Adoption of radial access and comparison of outcomes to femoral access in percutaneous coronary intervention. *Circulation* 2013;127:2295–2306.
28. Sciahbasi A, Romagnoli E, Trani C, Burzotta F, Pendenza G, Tommasino A, Leone AM, Niccoli G, Porto I, Penco M, Lioy E. Evaluation of the ;learning curve; for left and right radial approach during percutaneous coronary procedures. *Am J Cardiol* 2011;108:185–188.
29. Cooper CJ, El-Shiekh RA, Cohen DJ, Blaesing L, Burket MW, Basu A, Moore JA. Effect of transradial access on quality of life and cost of cardiac catheterization: a randomized comparison. *Am Heart J* 1999;138:430–436.
30. Rao SV, Tremmel JA, Gilchrist IC, Shah PB, Gulati R, Shroff AR, Crisco V, Woody W, Zoghbi G, Duffy PL, Sanghvi K, Krucoff MW, Pyne CT, Skelding KA, Patel T, Pancholy SB. Best practices for transradial angiography and intervention: a consensus statement from the society for cardiovascular angiography and intervention's transradial working group. *Catheter Cardiovasc Interv* 2014;83:228–236.