

Radial Approach for Left Main and Bifurcation Stenting

Supporting data and technical aspects of an attractive route for complex coronary interventions.

BY DAVIDE CAPODANNO, MD, PhD

Transradial coronary intervention (TRI) was introduced in 1992 by Kiemeneij et al¹ after revisiting the pioneering experiences from Radner² (the first to describe transradial catheterization using radial artery cutdown in 1948) and Campeau³ (the first to report on percutaneous entry into the distal radial artery for selective coronary angiography in 1989). Approximately 25 years after the seminal works from Kiemeneij et al, and with a slow uptake over the course of years, TRI is now an established, standardized procedure in contemporary interventional cardiology, with well-defined advantages and disadvantages (Figure 1).⁴

Percutaneous coronary intervention (PCI) in coronary bifurcation lesions is relatively common in everyday practice and accounts for approximately 15% to 20% of PCI procedures.⁵ The distal left main is regarded as a particular form of bifurcation that poses specific challenges relevant to anatomy, plaque layout and composition, and the patient's clinical status.^{6,7} Transradial PCI of left main or non-left main bifurcation lesions can be successfully accomplished in most cases, but this practice is still restricted in many centers worldwide due to the perceived technical challenges of guiding catheter support, limitations of catheter sizes, need for the simultaneous use of stents and balloons, and consequences of procedural failure.

TRI FOR BIFURCATIONS AND LEFT MAIN DISEASE: A LITERATURE UPDATE

PCI for Non-Left Main Bifurcation Lesions

The impact of TRI on bifurcation PCI has been explored in a subanalysis of the COBIS (Coronary Bifurcation Stenting) registry, a large multicenter series of bifurcation procedures collected from 16 major centers in Korea.⁸ The study included coronary bifurcation lesions treated with at least one drug-eluting stent

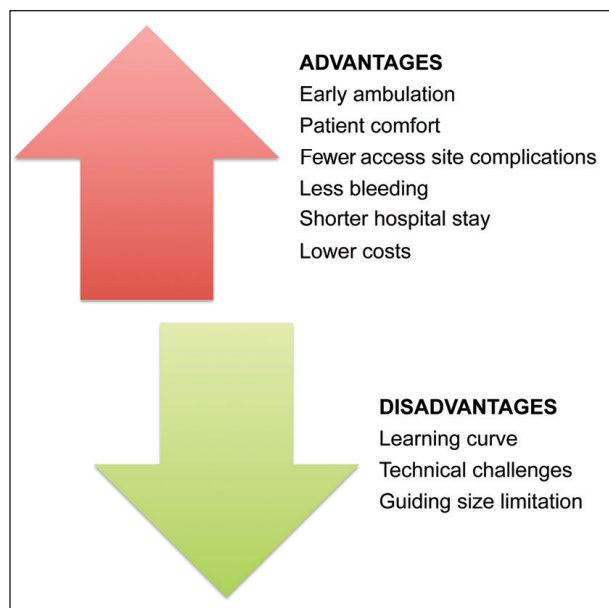


Figure 1. Pros and cons of the radial approach for PCI.

(DES) and excluded patients with cardiogenic shock, recent ST-segment elevation myocardial infarction, and left main bifurcations. Of 1,668 patients included in the registry, 30% underwent transradial PCI. Patients in the transradial group were less likely to have peripheral artery occlusive disease and chronic renal failure and to present with acute coronary syndromes. The prevalence of true bifurcations and glycoprotein IIb/IIIa inhibitor administration tended to be nonsignificantly higher in the TRI group, whereas the rates of intravascular ultrasound (IVUS) guidance and the use of two-stent techniques were significantly higher in patients treated with a transfemoral approach. For two-stent TRI procedures (10.9%, 55 patients), bifurcation strategies included T-stenting

(85.5%), crush (7.2%), culotte (1.8%), and V-stenting (5.5%). Corresponding data for patients undergoing two-stent transfemoral procedures (20.3%, 236 patients) were 29.8%, 40.3%, 3%, and 16.9%, respectively. There were no significant differences between the two groups for procedural success in both the main vessel and side branches. Over a mean follow-up of 22 months, cardiac death or myocardial infarction, target lesion revascularization, and major adverse cardiac events (MACE) did not significantly differ between the two groups, with consistent results after a propensity score–matched analysis of 424 pairs. Unfortunately, data describing procedure time, contrast amount, radiation times, length of hospital stay, or the numbers or ratio of access crossover due to technical reasons were not available in this registry, and bleeding data were available only in a minority of patients.

Another study compared the procedural and long-term outcomes of PCI in 805 consecutive patients with true bifurcation lesions requiring two-stent implantation via either a transradial (63%) or transfemoral approach.⁹ The demographic, angiographic, and procedural characteristics were similar between the two access site groups, with the exception of less left main bifurcation or multivessel disease in patients who were treated transradially. Angiographic success and fluoroscopy times were similar, the duration of hospitalization and rate of in-hospital bleeding were significantly lower in the transradial group, and the long-term clinical safety and efficacy rates were comparable. In aggregate, these registries suggest that the transradial approach is feasible and safe in patients with bifurcation lesions selected according to the operator's experience and clinical judgment.

Left Main PCI

Many studies have systematically compared the feasibility of left main PCI based on vascular access, with consistent results. In an early single-center experience of 80 patients, TRI was performed in 34%.¹⁰ There were apparently no differences between the two groups in terms of indication for PCI and lesion location (with the distal segment being involved in approximately 70% of cases), but patients in the TRI group had significantly higher left ventricular ejection fractions. Larger sheath sizes (7 or 8 F) were more likely to be used in transfemoral patients, who also more frequently were assisted by an intra-aortic balloon pump during PCI (possibly a reflection of more patients presenting with cardiogenic shock, wherein the radial artery is more difficult to palpate and cannulate). The mean fluoroscopy time, procedural time, amount of contrast used, procedural success, and in-hospital and 6-month MACE rates were similar in the two groups, but only patients in the transfemoral group experienced

vascular complications (5.7%), a finding that may be confounded by the higher use of heparin.

In another small (N = 131) series from China, 89% of patients underwent TRI of the left main, with no notable differences in baseline clinical and angiographic characteristics between the groups.¹¹ In most cases in the TRI group, 6-F catheters were used, but 7-F sheaths were also used in 14% of patients. Overall, patients in the transfemoral group required more debulking procedures with large guiding catheters and had larger minimal luminal diameters after PCI. There were similar high rates of angiographic and procedural success between the radial and femoral groups, but patients in the TRI group had fewer in-hospital MACE driven by a markedly lower incidence of vascular complications (1.7% vs 26.6%; $P < .001$), a benefit that was sustained at 6 months.

Presently, Yang et al have reported the largest comparison of transradial versus transfemoral PCI for left main disease (N = 821).¹² Clinical and angiographic characteristics were similar between groups, but patients in the TRI group were less likely to receive two stents for distal bifurcation PCI. Once again, there were no differences in procedural success or total procedural time between the procedures, but the duration of hospital stay and bleeding complications were significantly lower in the TRI group. The authors used propensity score modeling and yielded 254 matched pairs, showing no differences in ischemic events nor repeat revascularizations over time. Interestingly, this study was performed in a setting of skilled operators using the transradial approach in more than 80% of all PCI cases, whereas radial PCI of the left main was accomplished in just 43% of the procedures, which underscores the persistence of some degree of resistance in adopting the radial approach in this setting due to real or perceived technical challenges.

The study from Yang et al did not directly correlate prolonged hospitalization in the transfemoral group with bleeding events or vascular access complications, although the parallel remains suggestive. In aggregate, despite the previously mentioned studies being limited by their small sample size^{10,11} and nonrandomized nature,¹⁰⁻¹² they extend the understanding of the advantage of radial PCI in reducing vascular complications to selected patients at high angiographic risk, with no notable differences in procedure success and long-term outcomes. Also, these studies show that in such patients, TRI is feasible without notable delays in interventional maneuvers that can prolong ischemia.

Left Main Bifurcation PCI

Two multicenter registries specifically compared the transradial and transfemoral approaches for left main

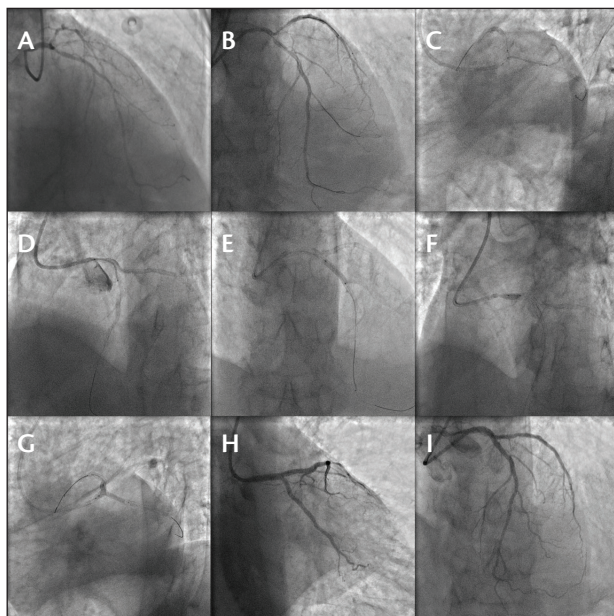


Figure 2. Case example of multistep transradial PCI in a patient with left main and three-vessel disease. Transradial coronary angiography (A) of a 62-year-old man with stable angina symptoms and a stress test positive for anterior and inferior posterior-lateral ischemia, showing severe narrowing of the ostial left main and the distal left main bifurcation involving the ostial-proximal segments of the left anterior descending (LAD) and left circumflex (LCX) arteries. There was also downstream disease of the proximal and mid-portion of the LAD and of a long segment from the proximal LCX to the proximal part of an obtuse marginal branch. The right coronary artery (not shown) was also severely diseased in the mid-proximal portion, with an additional severe stenosis of the posterior descending artery. After a discussion with the heart team, the patient was scheduled for PCI due to his multiple comorbidities and high surgical risk. The right coronary artery was first treated (not shown). In a staged procedure with IVUS guidance after transradial cannulation of the left main with a 6-F, extra-backup, 3.5 side hole guiding catheter and using standard techniques, a 2.75- X 30-mm DES was implanted in the LCX-obtuse marginal segment (not shown), followed by provisional T-stenting at the mid-LAD–diagonal bifurcation with a 2.75- X 34-mm DES (B). The left main bifurcation was treated with a two-stent T-stenting technique, using a 3- X 22-mm DES in the ostial LCX (C) and a 3.5- X 28-mm DES from the ostial left main to the proximal LAD (D). A further 3- X 18-mm DES was implanted in the LAD, in partial overlap with the proximal and distal DES that were previously placed (E). After proximal optimization of the left main (F), final kissing-balloon inflation was performed with low-profile noncompliant balloons (G), with a good final angiographic result (H, I).

bifurcation stenting. In the LABOR (Left Main Bifurcation Oxford-Rome) study, a collaborative series of 467 patients from two tertiary, large-volume PCI centers, 53% were treated via a transradial approach.¹³ The authors noted that the rate of transradial left main bifurcation PCI dramatically increased over a 9-year period (from 9% in 2005 to 91% in 2013), which demonstrates the increase in operators' experience and confidence. Reassuringly, despite the growing proportion of complex procedures that were performed transradially, the procedural success remained stable. Patients in the transfemoral group more likely presented with true bifurcation lesions (60% vs 40%; $P < .001$), were more frequently treated via large guiding catheters, and were exposed to less radiation. Although the difference in sheath size in the transfemoral group is justified by the more complex procedures performed (ie, double-stenting techniques were more commonly adopted), the authors advocate that the higher radiation exposure in the TRI group was the reflection of more multivessel PCIs performed in that group. Notably, the two groups did not differ in terms of the use of IVUS guidance and rotational atherectomy; however, preventive left ventricle support was used more frequently in the transfemoral group.

In a multivariable analysis that was restricted to more recent procedures performed after 2010, the only predictors of "residual" transfemoral access preference were the year of the procedure, the presence of a true bifurcation lesion, and cardiogenic shock. Procedural success was similar in the transradial and transfemoral groups, with the latter experiencing more access-site complications (mostly minor). No difference in ischemic outcomes was noted up to 1 year, which was confirmed by a propensity-matched analysis of 107 pairs.

Another substudy from a large registry (COBIS II) included 853 nonshock patients with left main bifurcation lesions at 18 centers in Korea.¹⁴ Left main TRI was performed in 25%, and these patients were less likely to have chronic renal failure and to present with acute coronary syndromes. From an angiographic standpoint, they were less likely to have true bifurcation lesions, and the rates of IVUS guidance, use of a double-stent technique, and final kissing-balloon inflation were significantly higher in patients treated via a transfemoral approach. There were no significant differences between the two access sites in terms of procedural success in the main vessel and side branches, and bleeding occurred less frequently in the transradial group. Over a median follow-up of 35 months, the MACE rate did not significantly differ between the two groups, a finding that remained consistent after a propensity-score matched analysis of 161 pairs.

Overall, these studies confirm that PCI of the left main bifurcation is feasible in selected cases, with long-term clinical results that are similar to those achievable by the transfemoral approach. The LABOR study highlighted a positive trend in the use of TRI for left main bifurcation disease, but this approach remains limited by clinical presentation and plaque distribution, suggesting that patients with hemodynamic instability or with a foreseeably challenging left main anatomy are still preferentially treated transfemorally, even in dedicated high-volume radial centers. This finding is consistent with COBIS II, in which only one out of four patients with left main bifurcation disease was treated transradially.

STANDARDS OF BIFURCATION AND LEFT MAIN PCI: IS THE RADIAL APPROACH A LIMITATION?

Standards of left main and non-left main bifurcation PCI, which are generally compatible with the transradial approach, are annually reviewed and updated by the European Bifurcation Club.¹⁵ Main vessel stenting with provisional side branch treatment can address most angiographic presentations. Most bifurcation techniques (excluding simultaneous implantation of two stents) can be performed using 6-F sheaths (Figure 2),^{15,16} in some cases with modifications.¹⁷ However, if necessary, placement of 7-F and even 8-F sheaths is achievable in some patients.¹⁸ Sheathless 6.5-, 7.5-, and 8.5-F guiding catheters have been introduced on the market, which allow for a larger internal lumen without increasing the outer diameter size, but at the price of lower backup. The 7.5-F sheathless catheters have a smaller outer diameter (2.49 mm) than a 6-F sheath introducer (2.62 mm), whereas the outer diameter of an 8.5-F sheathless catheter is 2.8 mm. Slender sheaths are also available with a thin-wall structure where the outside diameter is reduced by one French size while the inner-diameter equivalent is maintained. As such, the need for a large guiding catheter to deliver bulky devices or to use stents and balloons simultaneously should not represent a limitation per se when selecting the transradial approach for PCI of a bifurcation lesion or the left main. Of course, TRI should not be offered to patients with a predictable mismatch between the radial artery and sheath/catheters required for treatment.⁴

Although there are case reports in the literature that suggest that TRI is feasible in even the most extreme clinical and angiographic settings, the totality of the evidence from the published series demonstrate that TRI intervention for bifurcation and left main lesions is still less likely to be performed in patients with cardiogenic shock, acute coronary syndromes, true bifurcation

lesions, or trifurcations, as well as those requiring the use of rotational atherectomy with large burrs.

CONCLUSION

Radial access use has been steadily growing over the last 25 years, but owing to practical, patient, and technical problems, the implementation of TRI has remained limited in some complex coronary lesion subsets, such as coronary bifurcation and left main lesions. The simplification, standardization, and adaptation of most bifurcation techniques, in parallel with adjunct equipment improvements (ie, the decreased profile of balloons and stents used for PCI or the availability of sheathless guiding catheters) has made transradial access an attractive and feasible route for PCI of bifurcation and left main lesions. Still, the proportion of such patients who are treated transradially worldwide greatly varies among operators and centers depending on their comfort level and expertise. ■

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- Kiemeneij F, Laarmann GJ. Percutaneous transradial artery approach for coronary stent implantation. *Cathet Cardiovasc Diagn*. 1993;30:173-178.
- Radner S. Thoracic aortography by catheterization from the radial artery; preliminary report of a new technique. *Acta Radiol*. 1948;29:178-180.
- Campeau L. Percutaneous radial artery approach for coronary angiography. *Cathet Cardiovasc Diagn*. 1989;16:3-7.
- Hamon M, Pristipino C, Di Mario C, et al. Consensus document on the radial approach in percutaneous cardiovascular interventions: position paper by the European Association of Percutaneous Cardiovascular Interventions and Working Groups on Acute Cardiac Care and Thrombosis of the European Society of Cardiology. *EuroIntervention*. 2013;8:1242-1251.
- Stankovic G, Lassen JF, Hildick-Smith D, et al. The EuroIntervention coronary bifurcation treatment supplement. *EuroIntervention*. 2015;11(suppl V):V9-11.
- Capodanno D, Gargiulo G, Longo G, Tamburino C. Three-dimensional angle assessment and plaque distribution classification in left main disease: impact of geometry on outcome. *Rev Cardiovasc Med*. 2015;16:131-139.
- Lefevre T, Girasis C, Lassen JF. Differences between the left main and other bifurcations. *EuroIntervention*. 2015;11(suppl V):V106-110.
- Chung S, Her SH, Song PS et al. Trans-radial versus trans-femoral intervention for the treatment of coronary bifurcations: results from Coronary Bifurcation Stenting Registry. *J Korean Med Sci*. 2013;28:388-395.
- Gao Z, Xu B, Yang Y, et al. Transradial versus transfemoral method of two-stent implantation for true bifurcation lesions: comparison of immediate and long-term outcomes. *J Interv Cardiol*. 2014;27:99-107.
- Ziakas A, Klinke P, Mildnerberger R, et al. Comparison of the radial and femoral approaches in left main PCI: a retrospective study. *J Invasive Cardiol*. 2004;16:129-132.
- Hsueh SK, Hsieh YK, Wu CJ, et al. Immediate results of percutaneous coronary intervention for unprotected left main coronary artery stenoses: transradial versus transfemoral approach. *Chang Gung Med J*. 2008;31:190-200.
- Yang YJ, Kandzari DE, Gao Z, et al. Transradial versus transfemoral method of percutaneous coronary revascularization for unprotected left main coronary artery disease: comparison of procedural and late-term outcomes. *JACC Cardiovasc Interv*. 2010;3:1035-1042.
- De Maria GL, Burzotta F, Trani C, et al. Trends and outcomes of radial approach in left-main bifurcation percutaneous coronary intervention in the drug-eluting stent era: a two-center registry. *J Invasive Cardiol*. 2015;27:E125-136.
- Chung S, Yang JH, Choi SH, et al. Transradial versus transfemoral intervention for the treatment of left main coronary bifurcations: results from the COBIS (Coronary Bifurcation Stenting) II registry. *J Invasive Cardiol*. 2015;27:35-40.
- Lassen JF, Holm NR, Stankovic G, et al. Percutaneous coronary intervention for coronary bifurcation disease: consensus from the first 10 years of the European Bifurcation Club meetings. *EuroIntervention*. 2014;10:545-560.
- Zhou BQ, Fu GS, Sun Y. Treatment of coronary bifurcation lesions with 6F-guiding catheter by transradial approach [in Chinese]. *Zhejiang Da Xue Xue Bao Yi Xue Ban*. 2009;38:204-207.
- Lim PO, Dzavik V. Balloon crush: treatment of bifurcation lesions using the crush stenting technique as adapted for transradial approach of percutaneous coronary intervention. *Catheter Cardiovasc Interv*. 2004;63:412-416.
- Williams PD, Eichhofer J, Mamas MA, et al. Transradial intervention via large-bore guide catheters: a study of coronary bifurcation disease treatment using the crush technique. *J Invasive Cardiol*. 2013;25:455-459.