HHS Public Access

Author manuscript

*J Invasive Cardiol*. Author manuscript; available in PMC 2022 March 14.

Published in final edited form as:

*J Invasive Cardiol*. 2022 January ; 34(1): E43–E48.

# Practice Patterns in the Interventional Treatment of Coronary Bifurcation Lesions: A Global Survey

**Ilias Nikolakopoulos, MD**[1], **Evangelia Vemmou, MD**[1], **Judit Karacsonyi, MD, PhD**[1], **Lorenzo Azzalini, MD, PhD, MSc**[2], **Brian A. Bergmark, MD**[3], **Yiannis S. Chatzizisis, MD, PhD**[4], **Allison B. Hall, MD**[5], **Jason Wollmuth, MD**[6], **Kevin Croce, MD, PhD**[7], **Hani Jneid, MD**[8], **Bavana V. Rangan, BDS, MPH**[1], **M. Nicholas Burke, MD**[1], **Emmanouil S. Brilakis, MD, PhD**[1]

[1]Minneapolis Heart Institute and Minneapolis Heart Institute Foundation, Abbott Northwestern Hospital, Minneapolis, Minnesota

[2]Division of Cardiology, VCU Health Pauley Heart Center, Virginia Commonwealth University, Richmond, Virginia

[3]TIMI Study Group, Cardiovascular Division, Brigham and Women's Hospital, Boston, Massachusetts

[4]Cardiovascular Biology and Biomechanics Laboratory, Cardiovascular Division, University of Nebraska Medical Center, Omaha, Nebraska

[5]Eastern Health/Memorial University of Newfoundland, St. John's, NL, Canada

[6]Providence Heart and Vascular Institute, Portland, Oregon

[7]Cardiovascular Division, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts

[8]Division of Cardiology, Baylor College of Medicine, Houston, Texas

## Abstract

**Objectives.—**The study aim was to assess current procedural strategies and perceptions for percutaneous coronary intervention (PCI) involving bifurcations.

**Methods.—**We distributed an online survey via email (8050 invitations) and social media.

**Results.—**Among 440 responders, median annual PCI volumes were 15 cases (interquartile range [IQR], 10–29 cases) for left main (LM) and 50 cases (IQR, 27–73 cases) for non-LM (nLM) bifurcation lesions. Radial access use was reported in 51% of LM and 82% of nLM cases. An upfront 2-stent strategy, most commonly double-kissing (DK) crush, was reported in 49% of LM and 29% of nLM lesions. Bailout stenting during provisional stenting was reported in 26% of LM-PCIs, usually using the T and protrusion technique. In provisional stenting cases, most operators (<35%) did not report predilating the side branch, but routinely postdilated after successful provisional stenting (>85%), most often using both kissing-balloon inflation and the

Address for correspondence: Emmanouil S. Brilakis, MD, PhD, Minneapolis Heart Institute, 920 East 28th Street #300, Minneapolis, MN 55407. esbrilakis@gmail.com.

proximal optimization technique. Intravascular imaging was used in 80% of LM and 46% of nLM cases.

**Conclusions.—**Among the survey responders, the DK crush technique was the most frequently used 2-stent strategy for bifurcation PCIs. For LM lesions, bailout stenting was performed after provisional strategy in approximately 25% of cases. For nLM lesions, use of intravascular imaging and coronary physiology was lower than for LM lesions.

### Keywords

percutaneous coronary intervention; radial access; two-stent strategy

The optimal percutaneous coronary intervention (PCI) strategy for bifurcation lesions continues to be debated.[1–6] There is variability in how both provisional and 2-stent strategies are being performed, given the inconclusive data[7–12] on various steps of each strategy and long-term clinical outcomes.

We created an online survey to assess real-world contemporary clinical practice patterns in approaching various aspects of bifurcation PCI.

## Methods

The survey questions were generated through an iterative process involving feedback from practicing interventional cardiologists (JK, LA, BAB, YSC, ABH, JW, MNB, ESB). From May 8, 2020 to July 8, 2020, a 42-question online anonymous survey was distributed via a SurveyMonkey collector (SurveyMonkey, Inc) to 8050 email recipients from the Minneapolis Heart Institute Center for Coronary Artery Disease, with 2 reminders; the survey was also shared on Twitter.

### Statistical analysis.

Categorical variables are presented as percentages and were compared with the Chi-squared statistic. Continuous variables are summarized with mean ± standard deviation or median (interquartile range [IQR]) and compared with t-test or Wilcoxon rank sum test. Between-region 2-stent strategy use was evaluated with estimation statistics,[13] using median difference as effect size and bias-corrected and accelerated bootstrap resampling (5000 resamples) for the calculation of 95% confidence intervals. Results were analyzed with JMP (SAS Institute, Inc).

## Results

### Responder characteristics.

Among 8050 email recipients, a total of 421 responses were collected (5.2% response rate). The Twitter web-link yielded an additional 19 responses. The majority of responders (67%) were based in the Americas, with 63.9% based in the United States (US). European operators represented 16% of the survey responders, while 13% of responders were from the Asia-Pacific region and 4% were from Africa. Annual PCI volumes were 15 cases (IQR, 10–

29 cases) for LM bifurcation lesions, 5 cases (IQR, 2–7 cases) for LM trifurcation lesions, and 50 cases (IQR, 27–73 cases) for nLM bifurcation lesions.

## Left Main PCI

### Stenting strategy.

Operators reported following an upfront 2-stent strategy in 50% of cases, with American operators having the highest reported median rate of upfront 2-stent utilization (Figure 1A). The primary stenting strategy was selected more frequently based on sidebranch diameter stenosis (73%), Medina classification (60%), and sidebranch angle (55%) (Figure 2). Bailout stenting after provisional stenting was reported in 26% of cases, most commonly using T and protrusion (TAP) (37%), culotte (25%), or T-stenting (25%). When an upfront 2-stent strategy was used, the most frequently reported technique was double-kissing (DK) crush (56%) in all geographic regions. Use of the culotte technique was higher in Europe as compared with other regions, and TAP was most commonly used in Africa (Figure 3A).

### Access site.

For LM bifurcation PCI, femoral access was the most common access site, used by 49% of operators, followed by proximal radial (42%) and distal radial (8%). The most commonly used access site differed significantly between regions ($P<.01$); femoral access was the most used access site in America (54%) and Asia/Pacific (51%), while radial access was the most common access site in Europe (67%) and Africa (73%).

Hemodynamic support was used in 30% of LM cases. The single-access for hi-risk PCI (SHiP) technique for Impella (Abiomed) was performed by 41% of operators, in a question that was mainly answered by US operators (88% of responders).

### Technical aspects.

For LM lesions, 25% of operators reported routine predilation of the sidebranch and 86% reported routine jailing of the sidebranch wire during provisional approach. Provisional LM-PCI is finalized with kissing-balloon inflation (KBI), proximal optimization technique (POT), or both by 93% of operators (Figure 4). When good results were achieved with a provisional approach in LM-PCI, 38% of operators stated they systematically opened the stent struts toward the sidebranch.

The new DEFINITION (Definitions and impact of complEx biFurcation lesIons on clinical outcomes after percutaNeous coronary IntervenTIOn using drug-eluting steNts) classification has been adopted for strategy selection in 12% of Asia/Pacific operators, 7% of operators in Europe, 6% of operators in Africa, and 5% of operators in America ($P=.30$).

The Tryton Sidebranch stent (Tryton Medical) was used in 1.7% of LM lesions and the Axxess stent (Biosensors Interventional Technologies) was used in 1.2% of LM lesions (only among non-US operators).

### Imaging and physiology use.

For LM lesions, the use of physiological characteristics to determine sidebranch stenting was reported in 27% of provisional cases. When physiology was used, the pressure wire was jailed by 30% of operators. Median reported physiology use was higher in America (24%), followed by Asia/Pacific (18%), Africa (ll%), and Europe (10%).

Intravascular ultrasound (IVUS) was reportedly used in 76% of PCIs and optical coherence tomography (OCT) was used in 11% of cases. Median reported imaging use was higher in America (100%), followed by Asia/Pacific (80%), Africa (67%), and Europe (55%) ($P$<.001).

### Dual-antiplatelet therapy (DAPT).

After LM bifurcation PCI, 89% of operators recommended ≥12 months of DAPT.

## Non-Left Main PCI

### Stenting strategy.

Respondents reported following an upfront 2-stent strategy in 29% of cases (Figure 1B), most commonly on the basis of sidebranch diameter stenosis (80%), Medina classification (63%), and sidebranch angle (60%) (Figure 2). The most commonly reported 2-stent strategy was DK crush (42%), but regional variation was seen in our results (Figure 3B).

### Access site.

For nLM bifurcation PCI, proximal radial access was the most commonly used access site (67% of operators), followed by femoral (17%) and distal radial (15%).

### Technical aspects.

For nLM lesions, 36% of operators reported routine predilation of the sidebranch and 83% reported routine jailing of the sidebranch wire during provisional approach. Eighty-six percent of operators reported finalizing provisional nLM-PCI with KBI, POT, or both (Figure 4). After a good result with provisional nLM-PCI, 22% of operators reported systematically opening the stent struts toward the sidebranch.

The Tryton Sidebranch stent was used in 2.8% of nLM lesions. The Axxess stent was used in 1.2% of nLM lesions (only among non-US operators).

### Imaging and physiology use.

For LM lesions, physiology use was reported in 24% of provisional cases to determine the need for sidebranch stenting. When physiology was used, jailing of the pressure wire was reported by 25% of operators. Median reported physiology use was higher in America (25%), followed by Africa (10%), Europe (10%), and Asia/Pacific (10%) ($P$<.001).

IVUS was utilized in 44% and OCT was used in 14% of cases. Median reported imaging use was higher in America (50%), followed by Asia/Pacific (20%), Europe (15%), and Africa (10%) ($P$<.001).

### Dual-antiplatelet therapy.

After nLM bifurcation PCI, 69% of operators recommended ≥12 months of DAPT.

## Discussion

Our survey offers a sampling of contemporary practice patterns in bifurcation PCI. Among our survey respondents: (1) provisional stenting was the most commonly reported bifurcation stenting technique; (2) DK crush was the most commonly reported 2-stent strategy for bifurcation PCI; (3) for LM lesions, bailout stenting after an initial provisional strategy was reported in about 25% of cases; and (4) for nLM lesions, intravascular imaging and physiology utilization remained low as compared with LM bifurcations.

### Stenting strategy.

Provisional stenting was the most commonly reported bifurcation PCI strategy, especially in nLM bifurcations. Provisional stenting is currently recommended for most bifurcation PCIs by the European Bifurcation Club (EBC).[14] According to the DEFINITION study, a primary 2-stent approach may reduce the rate of target-lesion failure in complex bifurcation lesions.[15]

Of all the upfront 2-stent strategies, DK crush has the most favorable results, with most of them coming from a specific group of operators.[1,2,4,16] Despite concerns about the associated technical difficulty,[17,18] DK crush was the most frequently used upfront 2-stent technique. Although not currently recommended by the EBC,[14] T-stenting was still used as an upfront 2-stent strategy (in <10%). The simultaneous kissing stent technique (which is also not recommended by the EBC) was almost never reported by the survey respondents.

Regional differences were noted; operators in America reported the highest rates of an upfront 2-stent strategy in LM cases and also the highest utilization rates of crush 2-stent techniques. European operators noted the use of culotte more often as the initial strategy. African operators reported the use of TAP more often as an upfront 2-stent strategy. Although not statistically significant, operators in Asia/Pacific had the highest adoption rate of the DEFINITION classification.

### Access.

Radial access was the most commonly reported access site worldwide, except in America. The SHiP technique[19] has been adopted, although adoption rates may be high only in the US, since few non-US operators responded to that question. To our knowledge, this is the first study to quantify the use of the SHiP technique.

### Technical aspects.

The optimal pre- and postdilation strategies are still a matter of rigorous research.[3,4,20–27] In our group of respondents, most used KBI in tandem with POT to finalize bifurcation PCI. KBI alone was used in 10% of LM and 17% of nLM Global lesions. A POT-side-POT technique without any KBI[28] was used by 13% of operators. Most operators did not routinely predilate the sidebranch. The ongoing FLOW ISR (Effect of Local Biomechanical

Factors on Bifurcation Stent Restenosis and Thrombosis) study assesses the role of computational simulations based on imaging and procedural data toward an individualized management of bifurcation lesions.

### Imaging use.

Despite its association with improved outcomes in bifurcations (especially in 2-stent techniques) and other complex lesions,[29–33] the use of intracoronary imaging was low (<50%) in nLM-PCIs, but higher than in non-bifurcation PCIs.[34] Possible reasons include lack of reimbursement and lack of randomized data.[31] Also, using IVUS in complex PCI increases procedure duration,[35] although this may not be true in bifurcations.[32] OCT has higher spatial resolution and offers 3-dimensional visualization, and trials evaluating its usefulness are ongoing.[36] The higher reported rate of IVUS utilization in America as compared with the Asia/Pacific region might be explained by the inclusion of countries in the Asia/Pacifi cregion (wit hhigh cos tan dno reimbursement for IVUS)[31] along with countries where IVUS is reimbursed, such as Japan.[37] Alternatively, this finding could be due to bias, considering the low overall response rate.

### Dual-antiplatelet therapy.

Long-term (≥12 months) DAPT has been associated with decreased long-term thrombotic complications, but can increase the risk of bleeding.[38,39] In our survey, recommendation for ≥12 month DAPT duration was reported in 9 out of 10 patients after LM and 7 out of 10 patients after nLM bifurcation PCI.

In the Korean Coronary Bifurcation Stenting (COBIS) II registry, ≥12 months DAPT was associated with lower rates of stent thrombosis, myocardial infarction, and cardiac death, suggesting that prolonged DAPT may minimize complications due to stent thrombosis after bifurcation PCI.[38] However, all patients received first-generation drug-eluting stents, which are more thrombogenic than second-generation drug-eluting stent devices.[38] Also, bleeding events were not captured and can have significant clinical consequences.[38] A short-term DAPT strategy may not be beneficial for all comers,[40] but in patients at high risk who receive DAPT with aspirin and ticagrelor, a 3-month DAPT followed by ticagrelor monotherapy can result in fewer bleeding events even in complex lesions, including bifurcation lesions.[41] Following an individualized risk stratification strategy using the PRECISE-DAPT [PREdicting bleeding Complications in patients undergoing stent Implantation and SubsequEnt Dual AntiPlatelet Therapy] score can lead to identification of patients at high bleeding risk who are likely to benefit from shorter DAPT duration after complex PCI. Individuals with high ischemic risk, as quantified by the PARIS (Antiplatelet Regimens In Stented patients) score benefit from ≥12 months of DAPT.[42]

### Study limitations.

The low response rate and unequal regional distribution of responders can lead to bias and limit the generalizability of our findings. Also, survey responses based on responder recall may not accurately reflect actual documented procedural numbers and techniques.

## Conclusion

Provisional stenting was the most common bifurcation stenting technique and DK crush was the most commonly reported 2-stent strategy. Intravascular imaging and physiology utilization remained lower in nLM lesions. Radial access was used in the majority of bifurcation PCIs.

## Acknowledgments

Disclosure: The authors have completed and returned the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Azzalini reports honoraria from Abbott Vascular, Guerbet, Terumo, and Sahajanand Medical Technologies; research support from ACIST Medical Systems, Guerbet, and Terumo. Dr Bergmark reports grant support from Pfizer, AstraZeneca, Abbott Vascular; consulting fee from Philips, Abbott Vascular, Servier, Daiichi-Sankyo, Janssen, and Quark Pharmaceuticals. Dr Bergmark is a member of the TIMI Study Group, which has received institutional grant support through the Brigham and Women's Hospital from Abbott, Amgen, Aralez, AstraZeneca, Bayer HealthCare Pharmaceuticals, Daiichi-Sankyo, Eisai, GlaxoSmithKline, Intarcia, Janssen, MedImmune, Merck, Novartis, Pfizer, Poxel, Quark Pharmaceuticals, Roche, Takeda, The Medicines Company, and Zora Biosciences. Dr Chatzizisis reports consulting/speaker honoraria from Boston Scientific; research support from Boston Scientific and Medtronic; European Bifurcation Club(Board of Directors). Dr Wollmuth reports serving as proctor/speaker/medical advisory board for Abbott Vascular, Boston Scientific and Abiomed, proctor for Asahi Intecc, and medical advisory board with Philips. Dr Croce reports serving on the Speakers' Bureau of St. Jude Medical. Dr Burke reports being a shareholder in Egg Medical and MHI Ventures. Dr Brilakis reports consulting/speaker honoraria from Abbott Vascular, American Heart Association (associate editor, *Circulation*), Amgen, Biotronik, Boston Scientific, Cardiovascular Innovations Foundation (Board of Directors), ControlRad, CSI, Ebix, Elsevier, GE Healthcare, InfraRedx, Medtronic, Siemens, and Teleflex; research support from Regeneron and Siemens; owner, Hippocrates LLC; shareholder, MHI Ventures. The remaining authors report no conflicts of interest regarding the content herein.

## References

1. Crimi G, Mandurino-Mirizzi A, Gritti V,et al. . Percutaneous coronary intervention techniques for bifurcation disease: network meta-analysis reveals superiority of double-kissing crush. Can J Cardiol. 2020;36:906–914. [PubMed: 31924454]
2. Di Gioia G, Sonck J, Ferenc M, et al. Clinical outcomes following coronary bifurcation PCI techniques: a systematic review and network meta-analysis comprising 5,711 patients. JACC Cardiovasc Interv. 2020;13:1432–1444. [PubMed: 32553331]
3. Burzott a F,Lasse n JF, Louvard Y,et al. . European Bifurcation Club white paper on stenting techniques for patients with bifurcated coronary artery lesions. Catheter Cardiovasc Interv. 2020;96:1067–1079. [PubMed: 32579300]
4. Chen HY, Chatzizisis YS, Louvard Y, Kassab GS. Computational simulations of provisional stenting of a diseased coronary artery bifurcation model. Sci Rep. 2020;10:9667. [PubMed: 32541660]
5. Katritsis DG, Th!eodorakakos A, Pantos I, Gavaises M, Karcanias N, Efstathopoulos EP. Flow patterns at stented coronary bifurcations. Circ Cardiovasc Interv. 2012;5:530–539. [PubMed: 22763345]
6. Choi KH, Song YB, Lee JM, et al. Prognostic effects of treatment strategies for left main versus non-left main bifurcation percutaneous coronary intervention with current-generation drug-eluting stent. Circ Cardiovasc Interv. 2020;13:e008543. [PubMed: 32069106]
7. Andreasen LN, Holm NR, Webber B, Ormiston JA. Critical aspects of balloon position during final proximal optimization technique (POT) in coronary bifurcation stenting. Catheter Cardiovasc Interv. 2020;96:31–39. [PubMed: 32087046]
8. Cornelissen A, Guo L, Sakamoto A, et al. Histopathologic and physiologic effect of bifurcation stenting: current status and future prospects. Expert Rev Med Devices. 2020;17:189–200. [PubMed: 32101062]
9. Yoshinobu M, Gérard F, Nicolas F. Final kissing balloon inflation: the whole story. Eurointervention. 2015;11:V81–V85. [PubMed: 25983179]

10. Foin N, Secco GG, Ghilencea L, Krams R, Di Mario C. Final proximal post-dilatation is necessary after kissing balloon in bifurcation stenting. Eurointervention. 2011;7:597–604. [PubMed: 21930464]
11. Stankovic G, Milasinovic D, Mehmedbegovic Z. Left main PCI: are we giving the kiss the attention it deserves? Eurointervention. 2020;16:192–194. [PubMed: 32597763]
12. Annapoorna SK, George DD, Usman B, et al. Influence of final kissing balloon inflation on long-term outcomes after PCI of distal left main bifurcation lesions in the EXCEL trial. Eurointervention. 2020;16:218–224. [PubMed: 31763982]
13. Ho J, Tumkaya T, Aryal S, Choi H, Claridge-Chang A. Moving beyond P values: data analysis with estimation graphics. Nature Methods. 2019;16:565–566. [PubMed: 31217592]
14. Banning AP, Lassen JF, Burzotta F, et al. Percutaneous coronary intervention for obstructive bifurcation lesions: the 14th consensus document from the European Bifurcation Club. Eurointervention. 2019;15:90–98. [PubMed: 31105066]
15. Zhang J-J, Ye F, Xu K, et al. Multicentre, randomized comparison of two-stent and provisional stenting techniques in patients with complex coronary bifurcation lesions: the DEFINITION II trial. Eur Heart J. 2020;41:2523–2536. [PubMed: 32588060]
16. Chiabrando JG, Lombardi M, Vescovo GM, et al. Stenting techniques for coronary bifurcation lesions: evidence from a network meta-analysis of randomized clinical trials. Catheter Cardiovasc Interv. 2021;97:E306–E318. [PubMed: 32662603]
17. Pan M, Ojeda S. Complex better than simple for distal left main bifurcation lesions. Lots of data but few crushing operators. JACC Cardiovasc Interv. 2020;13:1445–1447. [PubMed: 32553332]
18. Hall AB, Chavez I, Garcia S, et al. Double-kiss-crush bifurcation stenting: step-by-step troubleshooting. Eurointervention. 2021;17:e317–e325. [PubMed: 32310131]
19. Wollmuth J, Korngold E, Croce K, Pinto DS. The single-access for hi-risk PCI (SHiP) technique. Catheter Cardiovasc Interv. 2020;96:114–116. [PubMed: 31654483]
20. Sgueglia GA, Chevalier B. Kissing balloon inflation in percutaneous coronary interventions. JACC Cardiovasc Interv. 2012;5:803–811. [PubMed: 22917451]
21. Murasato Y, Kinoshita Y, Yamawaki M, et al. Efficacy of kissing balloon inflation after provisional stenting in bifurcation lesions guided by intravascular ultrasound: short and midterm results of the J-REVERSE registry. Eurointervention. 2016;ll:el237–el248.
22. Zhong M, Tang B, Zhao Q, Cheng J, Jin Q, Fu S. Should kissing balloon inflation after main vessel stenting be routine in the one-stent approach? A systematic review and meta-analysis of randomized trials. PLoS One. 2018;13:e0197580. [PubMed: 29949587]
23. Gaido L, D'Ascenzo F, Imori Y, et al. Impact of kissing balloon in patients treated with ultrathin stents for left main lesions and bifurcations. Circ Cardiovasc Interv. 2020;13:e008325. [PubMed: 32102566]
24. Foin N, Torii R, Mortier P, et al. Kissing balloon or sequential dilation of the side branch and main vessel for provisional stenting of bifurcations: lessons from micro-computed tomography and computational simulations. JACC Cardiovasc Interv. 2012;5:47–56. [PubMed: 22230150]
25. Pan M, Gwon HC. The story of side branch predilatation before provisional stenting. Eurointervention. 2015;11:V78–V80. [PubMed: 25983178]
26. Mirzaee S, Isa M, Thakur U, Cameron JD, Nicholls SJ, Dundon BK. Impact of sidebranch predilation on angiographic outcomes in non-left main coronary bifurcation lesions. J Invasive Cardiol. 2020;32:42–48. [PubMed: 31958071]
27. Jurado-Román A, Rubio-Alonso B, García-Tejada J, et al. Systematic isolated post-dilatation of the side branch as part of the provisional stent technique in the percutaneous treatment of coronary bifurcations. CR12 registry. Cardiovasc Revasc Med. 2018;19:493–497. [PubMed: 29169982]
28. Finet G, Derimay F, Motreff P, et al. Comparative analysis of sequential proximal optimizing technique versus kissing balloon inflation technique in provisional bifurcation stenting: fractal coronary bifurcation bench test.JACC Cardiovasc Interv. 2015;8:1308–1317. [PubMed: 26315733]
29. Park H, Ahn J-M, Kang D-Y, et al. Optimal stenting technique for complex coronary lesions: intracoronary imaging-guided pre-dilation, stent sizing, and post-dilation. JACC Cardiovasc Interv. 2020;13:1403–1413. [PubMed: 32473888]

30. Onuma Y, Katagiri Y, Burzotta F, et al. Joint consensus on the use of OCT in coronary bifurcation lesions by the European and Japanese bifurcation clubs. Eurointervention. 2019;14:el568–el577.
31. Poay Huan L, Jens Flensted L, Nigel J, et al. Asia Pacific consensus document on coronary bifurcation interventions. Eurointervention. 2020;16:e706–e714. [PubMed: 32250248]
32. Chen SL, Ye F, Zhang JJ, et al. Intravascular ultrasound-guided systematic two-stent techniques for coronary bifurcation lesions and reduced late stent thrombosis. Catheter Cardiovasc Interv. 2013;81:456–463. [PubMed: 22899562]
33. Brilakis ES, Mashayekhi K, Tsuchikane E, et al. Guiding principles for chronic total occlusion percutaneous coronary intervention. Circulation. 2019;140:420–433. [PubMed: 31356129]
34. Mentias A, Sarrazin MV, Saad M, et al. Long-term outcomes of coronary stenting with and without use of intravascular ultrasound. JACC Cardiovasc Interv. 2020;13:1880–1890. [PubMed: 32819477]
35. Vemmou E, Khatri J, Doing AH, et al. . Impact of intravascular ultrasound utilization for stent optimization on 1-year outcomes after chronic total occlusion percutaneous coronary intervention. J Invasive Cardiol. 2020;32:392–399. [PubMed: 32694224]
36. Holm N R, Andreasen LN, Walsh S, et al. Rational and design of the European randomized optical coherence tomography optimized bifurcation event reduction trial (OCTOBER). Am Heart J. 2018;205:97–109. [PubMed: 30205242]
37. Maresca D, Adams S, Maresca B, van der Steen AFW. Mapping intravascular ultrasound controversies in interventional cardiology practice. PLoS One. 2014;9:e97215–e97215. [PubMed: 24816741]
38. Jang WJ, Ahn SG, Son g YB, et al. . Benefit of prolonged dual antiplatelet therapy after implantation of drug-eluting stent for coronary bifurcation lesions: results from the coronary bifurcation stenting registry II. Circ Cardiovasc Interv. 201811l:e005849. [PubMed: 30006330]
39. Horowitz JD, Sage PR. Can we improve long-term outcomes postbifurcation stenting by prolonged dual antiplatelet therapy? Circ Cardiovasc Interv. 201811l:e006922. [PubMed: 30006334]
40. Kogame N, Chichareon P, De Wilder K, et al. Clinical relevance of ticagrelor monotherapy following 1-month dual antiplatelet therapy a#er bifurcation percutaneous coronary intervention: insight from GLOBAL LEADERS trial. Catheter Cardiovasc Interv. 2020;96:100–111. [PubMed: 31410968]
41. Mehran R, Baber U, Sharma SK, et al. Ticagrelor with or without aspirin in high-risk patients after PCI. N Engl J Med. 2019;381:2032–2042. [PubMed: 31556978]
42. Gallone G, D'Ascenzo F, Conrotto F, et al. Accuracy of the PARIS score and PCI complexity to predict ischemic events in patients treated with very thin stents in unprotected left main or coronary bifurcations. Catheter Cardiovasc Interv. 2021;97:E227–E236. [PubMed: 32438488]

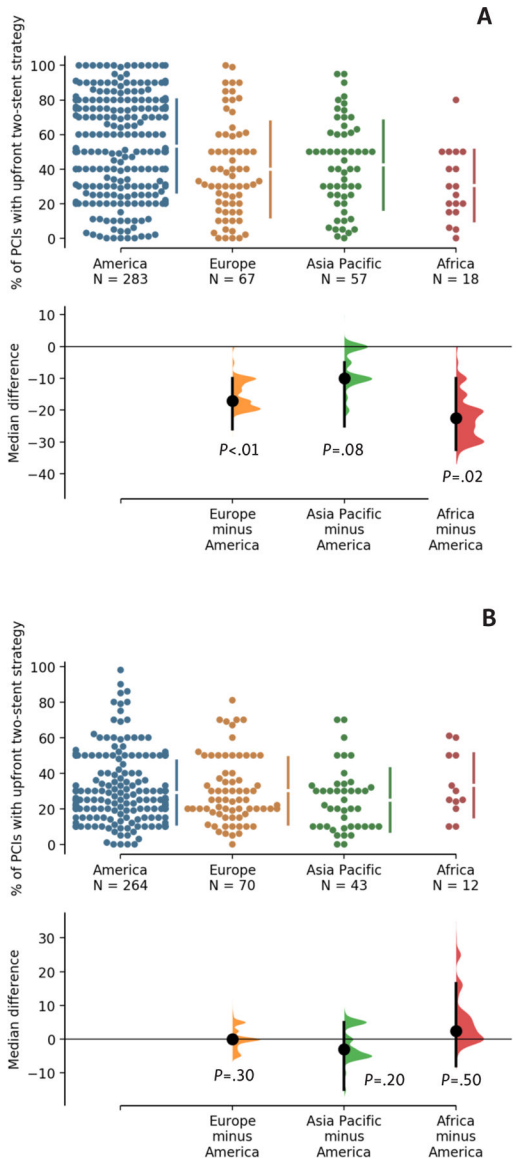


**FIGURE 1.**

Regional utilization rates of an upfront 2-stent strategy in (A) left main (LM) and (B) non-left main (nLM) bifurcation percutaneous coronary intervention (PCI). The median difference for the 3 comparisons is shown in the Cumming estimation plot at the bottom of each figure. The raw data are plotted on the upper axes. On the lower axes, mean differences are plotted as bootstrap sampling distributions. Each mean difference is depicted as a dot. Each 95% confidence interval is indicated by the ends of the vertical error bars.

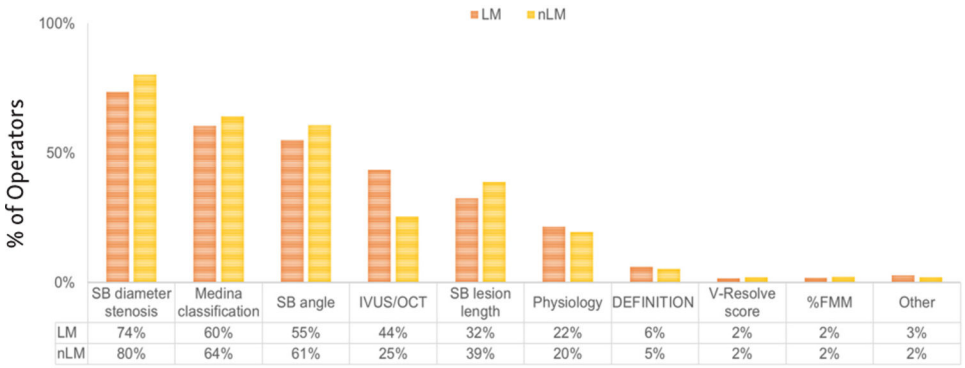


**FIGURE 2.**

Utilization rates of tools for selecting between provisional and upfront 2-stent strategy in left main (LM) and non-left main (nLM) bifurcation percutaneous coronary intervention (PCI). %FMM = % fractional myocardial mass in coronary computed tomography angiography; SB = sidebranch; DEFINITION = Definitions and impact of complEx biFurcation lesIons on clinical outcomes after percutaNeous coronary IntervenTIOn using drug-eluting steNts; IVUS = intravascular ultrasound; OCT = optical coherence tomography.

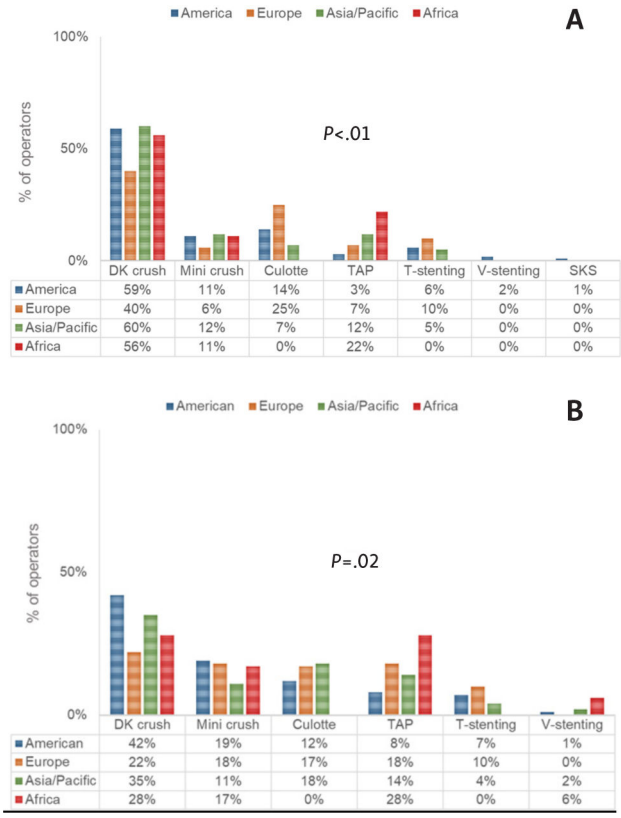


**FIGURE 3.**

Regional utilization rates of upfront two-stent techniques for (A) left main (LM) and (B) non-left main (nLM) bifurcation percutaneous coronary intervention (PCI). DK crush = double-kissing crush; TAP = T and protrusion; SKS = simultaneous kissing stents.

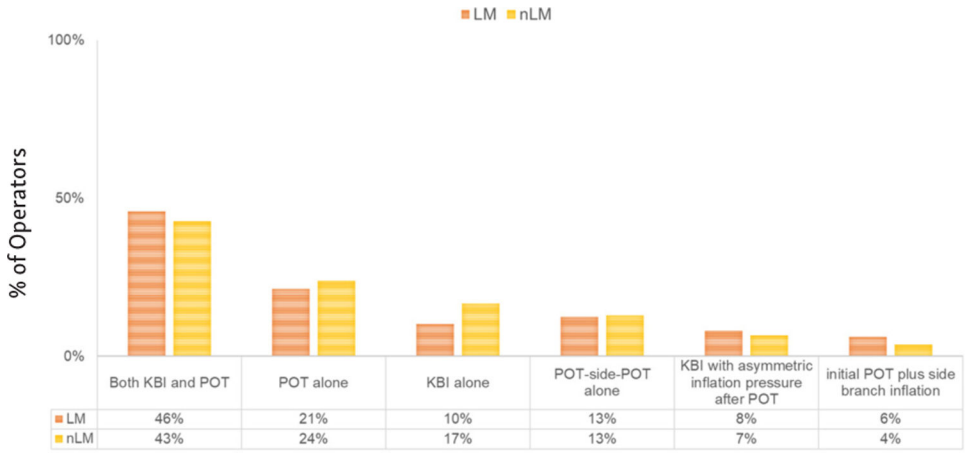


**FIGURE 4.**

Utilization rates of techniques for finalizing left main (LM) and non-left main (nLM) bifurcation percutaneous coronary intervention (PCI). KBI = kissing-balloon inflation; POT = proximal optimization technique.