

Large-Bore Access Closure: The Current Landscape

An assessment of vascular closure techniques, including surgical closure, suture-based devices, and dedicated large-bore devices.

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Vascular access site complications from percutaneous cardiac interventions—including percutaneous coronary intervention (PCI), structural heart procedures, and electrophysiology—remain a significant cause of morbidity and mortality.¹⁻³ The transition from femoral to radial artery access has reduced the frequency of vascular complications in the field of PCI; however, the emergence of percutaneous structural heart and aortic interventions that often necessitate large-bore vascular access (> 12 F) has been associated with a renewed focus on avoiding and managing access site complications. In particular, the development of transcatheter aortic valve implantation (TAVI), percutaneous mechanical circulatory support, endovascular aortic repair, and thoracic endovascular aortic repair have heralded a new era in which preprocedural multislice CT assessment of access site dimensions and calcification, ultrasound-guided puncture, and large-bore vascular closure are commonplace. In this article, we provide an overview of the current landscape of devices and techniques used for vascular closure in the setting of structural heart procedures.

THE IMPACT OF VASCULAR COMPLICATIONS AND BLEEDING

Transfemoral vascular access is the default strategy for TAVI, and it is currently expanding toward more challenging patient anatomies due to the development of lower-profile devices, expandable sheaths, and other innovative techniques such as intravascular lithotripsy.⁴ Compared with more invasive alternative access strategies, such as transapical or transaortic access, transfemoral procedures are associated with lower early and late mortality, lower bleeding rates, shorter hospital stays, and reduced resource

utilization.³ Despite these advantages, vascular complications still occur and are associated with increased rates of acute kidney injury, blood transfusion, and 30-day and 1-year mortality in patients who undergo TAVI. In the PARTNER I trial, a fourfold increase in 30-day mortality was observed among patients with major vascular complications.² Moreover, a retrospective analysis of 17,672 patients undergoing large-bore arterial access between 2012 and 2013 reported a nearly threefold higher risk of mortality (adjusted odds ratio, 2.7; 95% confidence interval, 2.27–3.22; $P < .001$), a longer hospital stay (7 vs 2 days), and a 60% increase in hospital costs in patients with vascular or bleeding events compared with those without.¹ Taken together, these data clearly demonstrate the impact of bleeding and vascular complications and the importance of avoidance strategies to reduce the frequency of these events.

Gratifyingly, the rates of vascular complications and bleeding associated with TAVI have improved with greater operator experience, widespread adoption of multislice CT preassessment, and smaller-profile delivery systems (Figure 1).⁵⁻¹⁵ In 2012, the PRAGMATIC initiative reported major vascular complications and major bleeding in 14.2% and 17.8% of cases, respectively.⁷ More recent data, however, show major vascular complications rates of 6% to 8%.^{6,16} Risk factors for vascular complications include female sex, anticoagulation, presence of moderate or severe artery calcification, and peripheral vascular disease.^{17,18} Importantly, most vascular complications derive from failure of the vascular closure device (VCD).⁷

VASCULAR CLOSURE DEVICES

VCDs were first developed in the 1990s in response to high rates of complications and bleeding from femoral

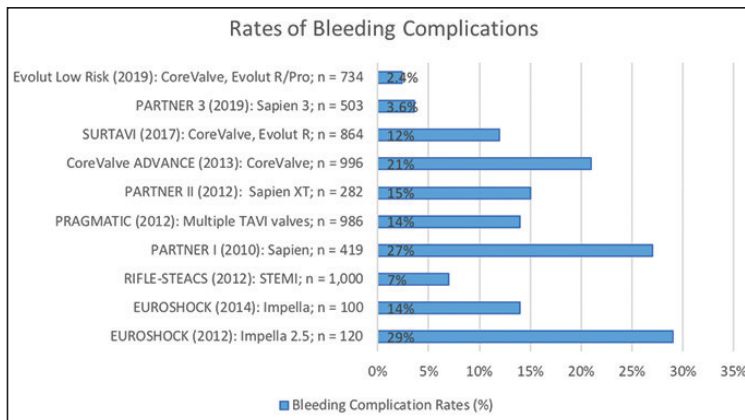


Figure 1. Rates of major and life-threatening intraprocedural and immediate postprocedural bleeding per Valve Academic Research Consortium criteria for various procedures requiring large-bore access.⁶⁻¹⁵

access in patients undergoing PCI. In the early 1990s, $\leq 6\%$ of patients undergoing PCI had major vascular complications, of whom 21% to 38% required vascular surgical repair and 22% to 25% required a blood transfusion.^{19,20} Closure devices used in this space are composed of a variety of methods and materials to close the 5- to 8-F arteriotomy, including suture alone, extravascular collagen plug, or combinations of these techniques. The requirement for VCDs capable of closing arteriotomies created by 12- to 24-F sheaths has seen the successful adaptation of suture-mediated devices and, more recently, the emergence of novel large-bore plug- and patch-based closure systems.

Surgical Closure

A surgical “cutdown” to the common femoral artery affords accurate puncture of the anterior wall of the common femoral artery, proximal and distal control of the arteriotomy site, and suture-mediated closure under direct visualization. This technique has, however, been associated with longer procedural time, wound infections, and longer hospital stay compared with percutaneous approaches.²¹ Hence, surgical techniques are generally reserved for patients with challenging features for percutaneous closure, including obesity with deep femoral vessels (> 5 cm), localized calcification of the common femoral artery, and previous surgical bypass graft.

Suture-Based Closure Devices

Suture-based techniques are the most frequently used method for percutaneously closing large-bore arteriotomies. Two devices are currently in use globally: Prostar XL (Abbott) and Perclose ProGlide (Abbott) (Figure 2).

The Prostar XL percutaneous vascular closure system is a 10-F suture-based device that is licensed to close arteriotomy sites between 8.5 and 10 F but is used off-label for arteriotomies between 10 and 24 F. Deployed prior to insertion of a large sheath (preclosure technique), the Prostar device deploys two pairs of suture needles around the arteriotomy. It leaves two polyester sutures that are manually tied and, upon removal of the sheath, advanced to the adventitia of the vessel wall.

The Prostar XL is more cumbersome and has become less frequently used in recent years because there is a relatively long learning curve and recent data suggest an increased risk of complications.²² In 2015, Barbash et al performed a multicenter retrospective study comparing outcomes with Prostar XL and

Perclose ProGlide in propensity score–matched patients undergoing transfemoral TAVI. When compared with Perclose ProGlide, the Prostar XL was associated with higher rates of major vascular complications (7.4% vs 1.9%; $P < .001$), acute kidney injury (17.6% vs 4.4%; $P < .001$), and longer hospital stay (median, 6 vs 5 days; $P = .007$).²²

The Perclose ProGlide is the most frequently used method for large-bore vessel closure (≤ 26 -F arteriotomy). Initially designed for single-device deployment in

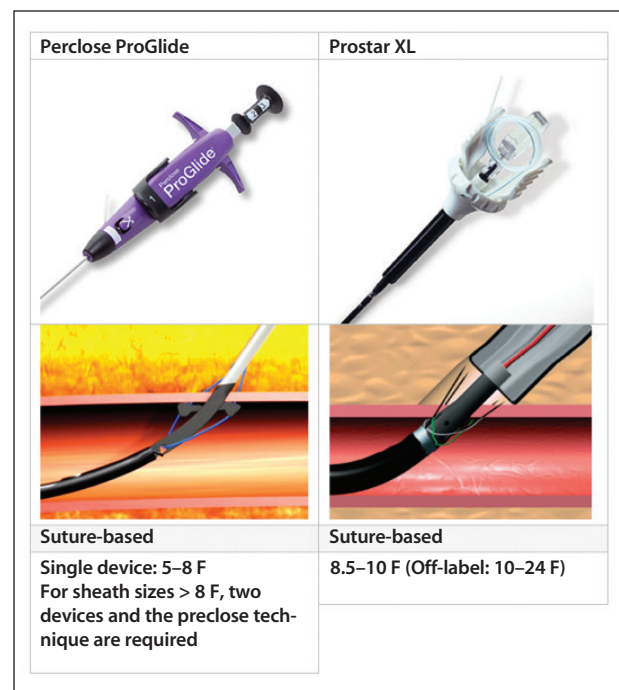


Figure 2. Suture-based closure devices: Perclose ProGlide and Prostar XL.

smaller-bore arteriotomies (≤ 8 F), two consecutive Perclose ProGlide devices are now frequently deployed, either in a parallel or angulated configuration, before inserting the large sheath. This simple device has preformed suture knots that are advanced to the vessel wall for final vascular closure. Recent trends include using a single Perclose ProGlide for 14-F arteriotomies or using a hybrid closure technique, which combines Perclose ProGlide and Angio-Seal (Terumo Interventional Systems), a plug-based closure device, for 14- to 24-F arteriotomies.²³

Although these fully percutaneous suture-based techniques are the current standard of care, they remain technically demanding for inexperienced operators and are time consuming. Additionally, failure of vascular closure with this technique is not infrequent (1%–8%).^{22,24,25}

Dedicated Large-Bore Closure Devices

Dedicated large-bore closure devices offer potential solutions to the limitations of surgical- or suture-based closure. Three dedicated systems (patch-, plug-, and membrane-based) have received CE Mark approval, allowing routine clinical use in Europe.

Manta. Available in 14- and 18-F sizes, a single Manta VCD (Teleflex) effectively closes femoral arterial access sites after the use of sheaths ranging from 12- to 25-F outer diameters (Figure 3). The system is composed of an 8-F depth locator that denotes the depth of the artery prior to large sheath insertion, the dedicated Manta sheath, and a delivery unit, which consists of an intra-arterial bioresorbable polymer (polylactic-co-glycolic acid) anchor, an extravascular hemostatic bovine collagen pad, a connecting nonresorbable polyester suture, and a stainless steel radiopaque lock. The same guidewire is used to first advance the 8-F depth locator and then the large-bore delivery sheath, avoiding multiple wire passages, which can be an advantage in tortuous vascular anatomy or in the setting of upstream arterial dissection. Hemostasis is achieved by the mechanical sandwiching of the arteriotomy between the anchor and the procoagulant collagen pad. The system is resorbable within 6 months, with the exception of the radiopaque lock and connecting suture. Closure is performed with an activated clotting time of < 250 seconds and systolic blood pressure < 180 mm Hg. The 18-F Manta device is

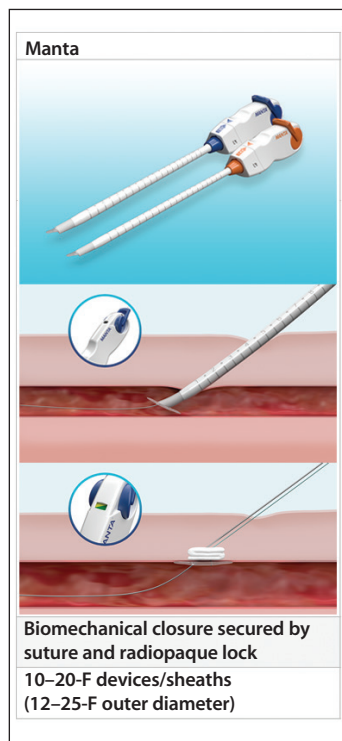


Figure 3. The Manta VCD.

compatible for use in vessels ≥ 6 mm, and the 14-F Manta device is compatible for use in vessels ≥ 5 mm.

The Manta device received premarket approval from the FDA in February 2019 after publication of the SAFE MANTA investigational device exemption clinical trial, a prospective, multicenter, single-arm trial of purpose-designed large-bore femoral access site closure. In this 263-patient open-label study, major vascular complications occurred in 5.3% of patients, with a high rate of technical success (97.7%). The median time from deployment to hemostasis was 24 seconds.²⁶ To date, there are no randomized studies comparing Manta with a suture-mediated closure device, yet small single-center studies, including one propensity score-matched analysis, have suggested fewer vascular complications with the Manta system.^{25,27} However, one case report of embolization of a Manta device has been reported.²⁸

PerQseal. PerQseal (Vivasure Medical Limited) is a percutaneous fully bioabsorbable synthetic VCD that is available in two sizes (small and large) and approved in Europe for closure of arteriotomies from 14- to 24-F (Figure 4). PerQseal does not yet have FDA approval. The system is composed of an introducer sheath that is inserted at the end of the case, a delivery device, and a low-profile synthetic patch with a textured abluminal surface that seals the vessel, internally promoting vessel healing, and is fully reabsorbed within 180 days. The safety and efficacy of the PerQseal device has been evaluated in the FRONTIER clinical program, which recently culminated in the presentation of the FRONTIER IV results. This open-label study of 76 patients undergoing TAVI or endovascular aortic repair reported technical success in 96% of patients, an 8% rate of minor device-related complications, and no major vascular complications.²⁹

InSeal. The InSeal VCD (InSeal Medical Ltd.) is CE Mark approved for the closure of arteriotomies created by 14- to 25-F sheaths (Figure 5). InSeal does not yet have FDA approval. The device is deployed through the large-bore sheath used during the procedure. The device seals the artery internally with a biodegradable membrane kept in contact with the vessel wall by a self-expanding nitinol frame. The closure element is composed of a self-expanding nitinol frame (length, 22 mm; width, 100 μ m), an internal L-lactide/caprolactone biodegradable membrane supported by the nitinol frame, and a bioresorbable

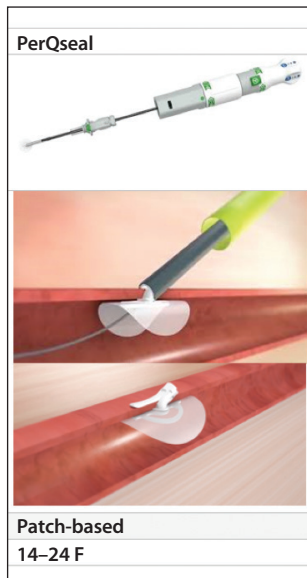


Figure 4. The PerQseal VCD.

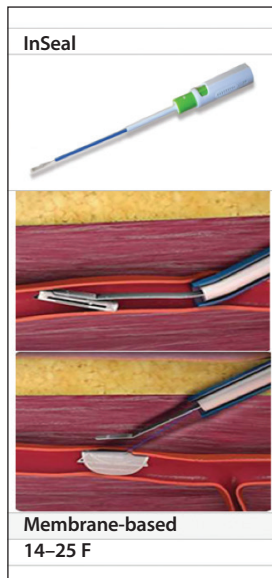


Figure 5. The InSeal VCD.

polyglycolic acid tether. The biodegradable membrane is fully reabsorbed within 6 months. Although early feasibility data were encouraging,³⁰ further safety and efficacy data have not been published to date.

CURRENT STATUS

Suture-based closure with the Perclose ProGlide system remains the standard of care in 2019. However, the dedicated closure devices, Manta and PerQseal in particular, are gaining popularity. Widespread adoption of these devices is limited by several factors, including the availability of the device in specific geographies, the elevated cost compared with Perclose ProGlide, and the absence of comparative efficacy studies demonstrating clinical benefit compared with foundation devices.

CONCLUSION

Vascular and bleeding complications continue to pose challenges for clinicians who are involved in a variety of structural heart and aortic repair procedures. Novel VCDs have the potential to reduce these complications, facilitate expedited patient mobilization, and reduce procedure time. Comparative safety and efficacy studies are required to demonstrate superiority compared with suture-based closure. ■

1. Redfors B, Watson BM, McAndrew T, et al. Mortality, length of stay, and cost implications of procedural bleeding after percutaneous interventions using large-bore catheters. *JAMA Cardiol.* 2017;2:798–802.
2. G  n  reux P, Webb JG, Svensson LG, et al. Vascular complications after transcatheter aortic valve replacement: insights from the PARTNER (placement of aortic transcatheter valve) trial. *J Am Coll Cardiol.* 2012;60:1043–1052.
3. Blackman DJ, Baxter PD, Gale CP, et al. Do outcomes from transcatheter aortic valve implantation vary according to access route and valve type? The UK TAVI registry. *J Interv Cardiol.* 2014;27:86–95.
4. Di Mario C, Goodwin M, Ristalli F, et al. A prospective registry of intravascular lithotripsy-enabled vascular access for transfemoral transcatheter aortic valve replacement. *JACC Cardiovasc Interv.* 2019;12:502–504.
5. Barbanti M, Binder RK, Freeman M, et al. Impact of low-profile sheaths on vascular complications during transfemoral transcatheter aortic valve replacement. *EuroIntervention.* 2013;9:929–935.

6. Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med.* 2016;374:1609–1620.
7. Van Mieghem NM, Tchetche D, Chieffo A, et al. Incidence, predictors, and implications of access site complications with transfemoral transcatheter aortic valve implantation. *Am J Cardiol.* 2012;110:1361–1367.
8. Romagnoli E, Biondi-Zoccai G, Sciahbasi A, et al. 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.
9. Toggweiler S, Humphries KH, Lee M, et al. 5-year outcome after transcatheter aortic valve implantation. *J Am Coll Cardiol.* 2013;61:413–419.
10. Barbanti M, Schiltgen M, Verdoliva S, et al. Three-year outcomes of transcatheter aortic valve implantation in patients with varying levels of surgical risk (from the CoreValve ADVANCE study). *Am J Cardiol.* 2016;117:820–827.
11. O'Neill WW, Schreiber T, Wolsky DH, et al. The current use of Impella 2.5 in acute myocardial infarction complicated by cardiogenic shock: results from the USPELLA registry. *J Interv Cardiol.* 2014;27:1–11.
12. Lauten A, Engstr  m AE, Jung C, et al. Percutaneous left-ventricular support with the Impella-2.5—Assist device in acute cardiogenic shock: results of the Impella-EUROSHOCK-registry. *Circ Heart Fail.* 2013;6:23–30.
13. Popma JJ, Deeb GM, Yakubov SJ, et al. Transcatheter aortic-valve replacement with a self-expanding valve in low-risk patients. *N Engl J Med.* 2019;380:1706–1715.
14. Reardon MJ, Van Mieghem NM, Popma JJ, et al. Surgical or transcatheter aortic-valve replacement in intermediate-risk patients. *N Engl J Med.* 2017;376:1321–1331.
15. Mack MJ, Leon MB, Thourani VH, et al. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. *N Engl J Med.* 2019;380:1695–1705.
16. Thourani VH, Kodali S, Makkar RR, et al. Transcatheter aortic valve replacement versus surgical valve replacement in intermediate-risk patients: a propensity score analysis. *Lancet.* 2016;387:2218–2225.
17. Toggweiler S, Gurvitch R, Leipsic J, et al. Percutaneous aortic valve replacement: vascular outcomes with a fully percutaneous procedure. *J Am Coll Cardiol.* 2012;59:113–118.
18. Doyle BJ, Ting HH, Bell MR, et al. Major femoral bleeding complications after percutaneous coronary intervention: incidence, predictors, and impact on long-term survival among 17,901 patients treated at the Mayo Clinic from 1994 to 2005. *JACC Cardiovasc Interv.* 2008;1:202–209.
19. Waksman R, King SB III, Douglas JS, et al. Predictors of groin complications after balloon and new-device coronary intervention. *Am J Cardiol.* 1995;75:886–889.
20. Omoigui NA, Cluff RM, Pieper K, et al. Peripheral vascular complications in the coronary angioplasty versus excisional atherectomy trial (CAVEAT-I). *J Am Coll Cardiol.* 1995;26:922–930.
21. Kadakia MB, Hermann HC, Desai ND, et al. Factors associated with vascular complications in patients undergoing balloon-expandable transfemoral transcatheter aortic valve replacement via open versus percutaneous approaches. *Circ Cardiovasc Interv.* 2014;7:570–576.
22. Barbash IM, Barbanti M, Webb J, et al. Comparison of vascular closure devices for access site closure after transfemoral aortic valve implantation. *Eur Heart J.* 2015;36:3370–3379.
23. Amponsah MK, Tayal R, Khakwani Z, et al. Safety and efficacy of a novel “hybrid closure” technique in large-bore arteriotomies. *Int J Angiol.* 2017;26:116–120.
24. Kodama A, Yamamoto M, Shimura T, et al. Comparative data of single versus double proglide vascular preclosure technique after percutaneous transfemoral transcatheter aortic valve implantation from the optimized catheter valvular intervention (OCEAN-TAVI) Japanese multicenter registry. *Catheter Cardiovasc Interv.* 2017;90:E55–E62.
25. Biancari F, Romppanen H, Savontaus M, et al. MANTA versus ProGlide vascular closure devices in transfemoral transcatheter aortic valve implantation. *Int J Cardiol.* 2018;263:29–31.
26. Wood D. Pivotal clinical study to evaluate the safety and effectiveness of the Manta percutaneous vascular closure device: the SAFE Manta study. Presented at: Structural Heart Disease Summit 2018; June 22, 2018; Chicago, Illinois.
27. Moriyma N, Lindstr  m L, Laine M. Propensity-matched comparison of vascular closure devices after transcatheter aortic valve replacement using MANTA versus ProGlide. *EuroIntervention.* 2019;14:e1558–e1565.
28. Wong YH, De Backer O, S  ndergaard L, Bieliauskas G. Percutaneous management of embolized MANTA large bore arteriotomy closure device. *EuroIntervention.* 2019;15:74–75.
29. Sievert H. FRONTIER IV: results from a fully absorbable large hole vascular closure device in percutaneous closure of large bore femoral punctures. Presented at: EuroPCR 2019; May 21–24, 2019; Paris, France.
30. Kambara AM, Bastos Metzger P, Ribamar Costa J Jr, et al. First-in-man assessment of the InSeal VCD, a novel closure device for large puncture accesses. *EuroIntervention.* 2015;10:1391–1395.

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