Journal of Cardiovascular Emergencies 2025;11(4):164-171
DOI: 10.2478/jce-2025-0018

ORIGINAL RESEARCH

Peripheral Vascular Access Complications After Percutaneous Procedures: A Single-Center Experience

Marius Mihai Harpa[1,2], Ștefania Cătălina Anghel[3,*], Alexandru Stan[4,5], Ayman Elkahlout[5], David-Emanuel Anitei[4], Mircea Catalin Cosarca[6], Cosmin Marian Banceu[1,2], Horatiu Suciu[1,2], Hussam Al-Hussein[1,2]

[1] Department of Surgery IV, George Emil Palade University of Medicine, Pharmacy, Science and Technology, Târgu Mureș, Romania
[2] Department of Cardiovascular Surgery, Emergency Institute for Cardiovascular Diseases and Transplantation, Târgu Mureș, Romania
[3] Medical Student, George Emil Palade University of Medicine, Pharmacy, Science and Technology, Târgu Mureș, Romania
[4] Doctoral School, George Emil Palade University of Medicine, Pharmacy, Science and Technology, Târgu Mureș, Romania
[5] Department of Interventional Cardiology, Emergency Institute for Cardiovascular Diseases and Transplantation, Târgu Mureș, Romania
[6] Department of Anatomy, George Emil Palade University of Medicine, Pharmacy, Science and Technology, Târgu Mureș, Romania

ABSTRACT

Background: The Seldinger technique is a fundamental method for percutaneous vascular access in cardiovascular interventions, including extracorporeal membrane oxygenation, transcatheter aortic valve implantation, percutaneous coronary intervention, and coronary angiography. Despite its critical role in hemodynamic monitoring, drug delivery, and device placement, peripheral vascular access is associated with complications such as pseudoaneurysm, hematoma, arteriovenous fistula, thrombosis, and bleeding, which may adversely impact clinical outcomes. **Aim of the Study:** This study aimed to evaluate the incidence, risk factors, and management strategies of severe vascular complications requiring surgical intervention following peripheral vascular access in cardiovascular procedures. **Materials and Methods:** A retrospective analysis was conducted on 81 patients treated at the Emergency Institute for Cardiovascular Diseases and Transplantation Târgu Mureș between 2017 and 2024 for vascular complications after percutaneous interventions. From a total of 23,370 procedures, including 592 cases of transcatheter aortic valve implantation, 73 patients with femoral artery complications were analyzed. Demographic data, comorbidities, procedural history, complication type, and surgical management were recorded. **Results:** The cohort had a mean age of 65.7 ± 13.3 years; 60.2% were male, and 87.6% were over 50 years of age. Frequent comorbidities included cardiopathies (97.5%), anemia (67.1%), peripheral arterial disease (32.8%), and coagulopathies (28.7%). Previous vascular interventions were significantly associated with increased complication risk ($p < 0.001$). Pseudoaneurysm was the most prevalent complication (43.8%), followed by hematoma and arteriovenous fistula. Arterial suturing constituted the primary surgical management (67.1%). **Conclusions:** Femoral artery access in cardiovascular interventions carries a measurable risk of severe complications, particularly in older patients with comorbidities and prior vascular procedures. Pseudoaneurysm represents the most frequent adverse event. Optimal outcomes require meticulous patient selection, procedural planning, and early recognition of complications, supported by advanced imaging, closure devices, and prompt surgical intervention when necessary.

Keywords: Seldinger, vascular complications, percutaneous technique, pseudoaneurysm, hematoma

ARTICLE HISTORY

Received: October 7, 2025
Accepted: November 9, 2025

CORRESPONDENCE

Ștefania Cătălina Anghel
Email: catalinaanghel29@yahoo.com

INTRODUCTION

The Seldinger technique is a widely used percutaneous method for vascular and hollow organ access in numerous medical specialties, including interventional radiology, cardiology, cardiovascular surgery and vascular surgery.

Peripheral vascular access is fundamental in cardiovascular surgery, enabling hemodynamic monitoring, drug administration, mechanical circulatory support, and device-based interventions. Despite its necessity, vascular access is frequently associated with complications that may adversely affect outcomes. Complications can occur with both peripheral and central venous cannulation, including arterial puncture, hematoma, infection, and thrombosis, underscoring the need for careful technique selection and management strategies.[1] Central venous catheter insertion, for instance, has evolved with approaches such as posterior access to the internal jugular vein to reduce adverse events, though procedural risks remain.[2]

In the context of percutaneous coronary interventions, vascular access site complications can significantly influence procedural success and patient prognosis. Advances in percutaneous techniques have improved safety; however, bleeding, vascular injury, and access-site failure are still reported, especially in complex cases.[3] Similarly, extracorporeal membrane oxygenation (ECMO) requires large-bore vascular cannulation, which carries risks of ischemia, bleeding, and vessel injury. These complications are associated with increased morbidity and mortality, and require vigilant monitoring and timely management.[4]

Transcatheter aortic valve implantation (TAVI) is another cardiovascular intervention during which vascular complications are common and clinically relevant. Studies have shown that vascular injury during transfemoral TAVI not only complicates the procedure but is also associated with higher mortality.[5,6] Broader reviews of vascular access complications emphasize the importance of early diagnosis and structured management approaches to mitigate these risks.[7] Similarly, complications after other valvular interventions demand multidisciplinary strategies for optimal outcomes.[8]

The challenge is further compounded by the growing use of temporary percutaneous mechanical circulatory support devices, which also introduce unique vascular risks, particularly in patients with cardiogenic shock.[9] Moreover, delayed vascular complications, such as those seen after ECMO, highlight the importance of long-term surveillance and tailored management strategies.[10] Even routine diagnostic procedures such as coronary angiography can carry vascular risks, including dissection, perforation, and access-related bleeding, necessitating preventative measures and contingency planning.[11]

Recent case reports and series have added nuance to our understanding of access-related and adjunct complications. For example, a case of unilateral pulmonary edema occurring after minimally invasive mitral valve surgery required peripheral venoarterial ECMO and independent lung ventilation for its resolution, illustrating how access-site or access-adjacent complications may escalate into life-threatening situations if not managed promptly.[12] Another report described endoscopic mitral surgery in a patient with Noonan syndrome, underscoring how anatomical or genetic factors may complicate otherwise routine vascular access or surgical exposures.[13]

Given the increasing reliance on peripheral vascular access across a wide range of cardiovascular interventions, understanding the spectrum of complications and developing evidence-based management strategies are critical. This paper aims to review the management of complications associated with peripheral vascular access in cardiovascular surgery, integrating insights from contemporary literature across diverse procedural contexts.

MATERIAL AND METHOD

In this in-hospital study, carried out at the Emergency Institute for Cardiovascular Diseases and Transplantation in Târgu Mureș, Romania, we examined a cohort of 81 patients admitted between 2017 and 2024, who had severe vascular complications that required surgical interventions for vascular axis reconstruction after cardiovascular procedures using the Seldinger vascular technique, including peripheral cannulations, ECMO, TAVI, coronary angiography, and angioplasty.

In our center, approximately 3,000 percutaneous interventions are performed annually, amounting to a cumulative total of 23,370 procedures in the studied period, including 592 TAVI procedures. Among these, only 81 patients (0.35%) experienced vascular complications related to peripheral vascular access that required surgical intervention as definitive therapy. Of this cohort, 73 patients (90.1%) presented with complications involving the femoral artery, whereas 8 patients (9.9%) developed complications at the radial artery. Given the predominance of femoral access-related complications, the present analysis focuses on this subgroup.

Statistical analysis was performed using Microsoft Excel and IBM SPSS 25. Descriptive analysis was conducted, and group comparisons were made using the chi-squared test. The level of statistical significance was set at $p < 0.05$.

TABLE 1. Characteristics of the patients enrolled in the study

Variable	Patients (n = 73)
Demographic data	
Age (years), mean ± s.d.	65.7 ± 13.3
Male, n (%)	44 (60.2%)
Female, n (%)	29 (39.8%)
BMI <24.99	14 (19.18%)
BMI 25–29.99	31 (42.47%)
BMI 30–34.99	22 (30.14%)
BMI 35–39.99	5 (6.85%)
BMI >40	1 (1.37%)
Comorbidities and risk factors	
Hypertension	46 (63.01%)
Diabetes mellitus	27 (36.99%)
Cardiopathies	73 (100%)
Peripheral arterial disease	14 (19.18%)
Chronic kidney disease	19 (26.03%)
Liver disease	6 (8.22%)
Active smoking	25 (36.99%)
Obesity	32 (43.84%)
Dyslipidemia	26 (35.62%)

TABLE 2. Overview of procedures, complications, and anesthetic approaches

Variable	Patients (n = 73)
Hemostatic type, n (%)	
Angio-Seal/Proglide	23 (31.51%)
Manual	50 (68.49%)
Intervention type, n (%)	
Coronarography	34 (46.58%)
Angioplasty	25 (34.25%)
TAVI	17 (23.29%)
ECMO	3 (4.11%)
Cannulation	5 (6.85%)
Endoprosthesis	2 (2.74%)
Complication type, n (%)	
Pseudoaneurysm	46 (63.01%)
Hematoma	27 (36.99%)
Others	73 (100%)
Anesthesia type, n (%)	
Local	46 (63.01%)
Analgo-sedation	5 (6.85%)
General anesthesia	22 (30.14%)

RESULTS

The study included 73 patients with a mean age of 65.7 ± 13.3 years, comprising 87.6% who were over 50 years old, the majority being men (60.2%). The major modifiable cardiovascular risk factors identified were hypertension (42.4%), diabetes mellitus (36.9%), dyslipidemia (35.6%), and smoking (34.2%). Among the associated diseases, the following stand out: cardiopathies (97.5%), anemia (67.1%), peripheral arterial disease (32.8%), coagulopathies (28.7%), chronic kidney disease (26.0%), and liver diseases (9.5%). Patients with previous vascular interventions experienced a higher incidence of vascular complications (45.2%) compared to those without such a history (42.9%). The chi-squared test confirmed a statistically significant association between previous procedures and the risk of complications in future interventions ($p < 0.001$). Analysis of post-puncture vascular complications indicated that the most frequent were pseudoaneurysm (43.8%), followed by hematoma and fistula. When comparing distribution by sex, pseudoaneurysm was present in 40.91% of men and 48.28% of women ($p = 0.7042$). The most frequently used surgical intervention was arterial suturing (67.1%). When comparing distribution by sex, suturing was performed in 61.36% of men and 75.86% of women ($p = 0.3003$).

The demographic and clinical features of the study population, including age, sex distribution, BMI categories, and prevalence of comorbidities, are presented in Table 1. Procedural details, complications, and anesthetic approaches are presented in Table 2.

DISCUSSION

Peripheral vascular access in cardiovascular interventions carries substantial risks, and complications remain a significant contributor to morbidity and mortality. . The incidence of severe access-site complications requiring surgical intervention was low in our center, with only 81 cases among 23,370 percutaneous procedures (0.35%), of which 73 involved femoral artery access. Considering the high volume of coronary interventions and the substantial number of large-bore procedures such as TAVI and ECMO, this rate is comparable to contemporary reports from high-volume cardiovascular institutions.[3,9] Femoral artery pseudoaneurysms are among the most frequent complications following catheterization, with risks heightened by anticoagulation, large sheath sizes, and repeated punctures. In our study, pseudoaneurysm was the most frequent severe complication requiring surgery (43.8%), which is consistent with published data. Management has evolved from surgical repair toward less invasive strategies such as ultrasound-guided compression and thrombin injection, which have become standard due to their safety and efficacy. However, surgical interven-

tion remains necessary in cases of rupture, infection, or failed percutaneous management.[14] The clinical profile of the cohort, however, reflects a population at inherently high risk for vascular injury. The prevalence of anemia (67.1%), peripheral arterial disease (32.8%), chronic kidney disease (26.0%), coagulopathies (28.7%), and obesity (38.36%) underscores the fragility of these patients. Each of these comorbidities is independently associated with impaired vessel wall integrity, delayed hemostasis, and increased susceptibility to bleeding complications. When analyzing complications by sex, pseudoaneurysm was identified in 40.91% of men and 48.28% of women ($p = 0.7042$). Hematomas and pseudoaneurysms were likewise more frequently observed in female patients, although without statistical significance. Simple arterial suturing represented the most common surgical approach (67.1%), performed in 61.36% of men and 75.86% of women ($p = 0.3003$). Although women exhibited a slightly higher proportion of access-site complications, this difference did not substantially alter the overall distribution of surgical management strategies. The predominance of cases managed by primary arterial suturing suggests that most defects were limited in extent and did not involve major arterial ruptures. This observation further supports the assumption that many of these lesions might have been amenable to treatment with vascular closure devices (VCDs). Consequently, the failure of VCDs in this cohort may be attributed to several factors, including operator experience, device malfunction, unfavourable femoral arterial anatomy, or suboptimal puncture site selection, preventing proper deployment of the closure system. In contrast, the cases requiring patch angioplasty or bypass grafting were associated with extensive arterial ruptures, situations in which currently available VCDs are inherently ineffective and cannot provide adequate hemostasis.

In transcatheter aortic valve implantation, access-site complications such as bleeding, arterial rupture, and dissection are strongly associated with adverse outcomes, necessitating meticulous pre-procedural risk assessment, advanced imaging, and appropriate device selection to minimize procedural risk.[15] These considerations are particularly relevant given that TAVI is predominantly recommended for elderly patients, typically those older than 70 years, and individuals with significant comorbidities who are at increased surgical risk. Our results align with this clinical profile, as 87.6% of the patients in our cohort were older than 50 years, and comorbidities were highly prevalent, further supporting the vulnerability of this population to access-site complications. Prevention of vascular complications in TAVR is critical, with strategies including sheath-to-artery ratio optimization, meticulous puncture technique, and prompt recognition of bleeding or vessel injury. Recent studies have highlighted that procedural techniques can further influence outcomes. Predilatation does not significantly affect long-term survival, whereas postdilatation may be associated with a trend toward increased mortality, independent of transprosthetic gradient. Furthermore, CT-derived anatomical assessment did not predict acute complications after TAVI, emphasizing the importance of careful procedural planning and operator experience in achieving safe outcomes.[16,17]

Iatrogenic complications may also arise from technical errors, such as guidewire retention, which, although rare, highlight the risks of procedural oversight and the importance of strict adherence to protocols to mitigate preventable harm.[18] More broadly, cardiac catheterization itself is associated with vascular trauma, bleeding, embolism, and arrhythmic events, reinforcing the need for meticulous patient selection, procedural planning, and complication preparedness.[19] Complication risks are amplified in complex cases of percutaneous coronary intervention (PCI). Consensus-derived management algorithms now provide structured responses to vascular perforation, dissection, and access-site bleeding, ensuring rapid and systematic intervention.[20] Previous vascular interventions were strongly associated with the occurrence of complications ($p < 0.001$), reinforcing the concept of cumulative arterial injury. Repeated femoral punctures, progressive atherosclerosis, and previous endovascular or surgical manipulations contribute to structural weakening of the arterial wall. Patients with repeated access should thus be systematically considered high-risk, warranting ultrasound-guided puncture, meticulous access planning, and careful selection of closure devices.

Although transradial access reduces bleeding compared with femoral approaches, it is not without risk. Complications such as radial artery occlusion, spasm, and perforation remain clinically relevant, requiring careful sheath selection, adequate anticoagulation, and post-procedural surveillance.[21] This is supported by our finding that only eight radial complications over 8 years required surgery, highlighting the rarity of severe radial injuries. For femoral access, vascular injuries, including pseudoaneurysm, arteriovenous fistula, and retroperitoneal hemorrhage, are increasingly treated with endovascular approaches such as covered stents and coil embolization, which offer effective minimally invasive management.[22] Long-term multicenter experience supports the safety and durability of percutaneous techniques for vascular access complica-

tions when appropriately applied.[23] Nevertheless, surgical repair continues to play a role in cases where endovascular treatment is not feasible, such as in extensive vessel rupture, infection, or hemodynamically unstable patients.

Vascular closure devices (VCDs) represent an essential component in minimizing femoral access-related complications. In our cohort of 73 patients requiring surgical revision for hemostatic failure, VCDs (AngioSeal VIP, ProGlide) had been used in 23 cases (31.51%), whereas 50 patients (68.49%) initially underwent manual compression. In all cases included in the study, these hemostatic techniques, whether device-assisted or manual, ultimately failed, leading to the development of clinically significant femoral artery complications. Despite this, the overall complication rates associated with femoral access remain low, with failure rates consistently reported to be higher following manual compression compared with VCD-assisted hemostasis.

Manual hemostasis in the femoral region is technically challenging, particularly in obese patients, where increased adipose tissue and deeper vessel location diminish the effectiveness of external compression. In such patients, first-intention hemostasis using VCDs is generally recommended due to superior efficacy and reduced failure rates. Conversely, in normal-weight individuals, manual compression or external compression systems may be acceptable alternatives, particularly in settings where closure devices are unavailable.

In our cohort, obesity classification further highlighted this discrepancy. Among patients with BMI 30–34.9 kg/m^2 (n = 22), VCDs were used in 8 cases (38.09%), whereas 13 patients (61.90%) underwent manual compression. In patients with BMI 35–39.9 kg/m^2 (n = 5), manual compression was used exclusively (100%), and the same was observed in the single patient with BMI ≥ 40 kg/m^2. These findings indicate that, despite evidence favoring device-assisted hemostasis in obese individuals, the majority of overweight and obese patients in our study initially received manual compression. This observation underscores the need to prioritize VCD use as the first-line hemostatic strategy in obese patients, in whom manual compression is inherently less reliable and more frequently associated with hemostatic failure. Studies confirm their role in lowering bleeding and vascular injury rates during PCI, although improper use can itself cause arterial stenosis, infection, or device failure.[24,25] Contemporary reviews emphasize that risk reduction depends on both device type and operator expertise, highlighting the necessity of tailored strategies based on patient and anatomical factors.[26] In TAVR, prevention of vascular complications is equally critical, with strategies including sheath-to-artery ratio optimization, meticulous puncture technique, and prompt recognition of bleeding or vessel rupture.[27]

High-risk scenarios such as percutaneous mechanical circulatory support (pMCS) further amplify vascular access risks due to the use of large-bore sheaths. Here, sheath management protocols and closure systems play a vital role in reducing bleeding and vessel trauma, with growing emphasis on pre-closure techniques.[28] Recent comparative analyses of plug-based versus suture-based closure systems suggest both approaches can mitigate complications, though device choice should be individualized based on operator familiarity and patient anatomy.[29] Updated reviews reinforce the importance of proper deployment technique to minimize risk of stenosis, infection, and late bleeding.[30,31] In our surgically treated cohort, arterial suturing represented the primary therapeutic approach (67.1%), followed by patch angioplasty (31.5%) and bypass grafting in a minority of cases (1.4%). The distribution of complications included pseudoaneurysm in 43.80% of patients, hematoma in 36.99%, and arteriovenous fistula in 20.5%. Pseudoaneurysms and hematomas may occasionally be treated conservatively, particularly when they are small, stable, and responsive to targeted compression, yet in most cases that progress to surgical referral, the arterial wall defect is sufficiently large or unstable to require open repair. Arteriovenous fistulas, on the other hand, exhibit a distinct clinical course: small femoral AV fistulas may close spontaneously, especially when the communication is narrow and flow is low. However, larger fistulas rarely undergo spontaneous closure and typically necessitate surgical intervention, as was the case in our series.

Emerging evidence supports new-generation closure technologies designed to improve hemostasis and enable early ambulation without increasing complication risk.[32] Bioabsorbable systems have demonstrated favorable real-world outcomes, although vigilance is required for rare but serious device-related complications.[33] Notably, Angio-Seal, one of the most widely used VCDs, carries risks of arterial occlusion, infection, and embolization if misapplied, underscoring the need for careful monitoring and readiness to intervene surgically or endovascularly in the event of device failure.[34]

Large-bore sheath management represents another critical frontier in complication prevention. Risk factors such as improper puncture site, sheath size mismatch, and suboptimal anticoagulation are directly linked to vascular injury and bleeding. Standardized protocols emphasizing ultrasound-guided puncture, careful anticoagulation

TABLE 3. Comparison between literature review and study results

Category	Literature review	Study results	Notes/Comparison
Age	Older age increases complication risk[1,3,5]	Mean age 65.7 ± 13.3 years; 87.6% >50 years	Confirms older patients as high-risk
Sex	Women may have a higher bleeding risk; radial vs. femoral differences noted[3,21]	60.2% men; pseudoaneurysm 48.3% in women vs. 40.9% in men; hematoma 34.5% vs. 20.5%	Trends align; differences not significant
Major cardiovascular risk factors	Hypertension, diabetes, dyslipidemia, smoking[1,3,7]	Hypertension 42.4%, diabetes 36.9%, dyslipidemia 35.6%, smoking 34.2%	Quantitative confirmation of literature
Comorbidities	PAD, renal disease, coagulopathies, anemia[4,6,10]	Cardiopathy 97.5%, anemia 67.1%, PAD 32.8%, CKD 26%, coagulopathies 28.7%	Supports comorbidity-related risk
Procedural risk factors	Large-bore sheaths, repeated interventions, complex PCI/ TAVR[3,9,15,27]	Previous interventions increase risk ($p < 0.001$); femoral access predominates	Confirms literature
Common complications	Pseudoaneurysm, hematoma, fistula, retroperitoneal hemorrhage[1,3,5,14]	Pseudoaneurysm 43.8%, hematoma 26%, fistula 20.5%, others 9.6%	Matches literature; pseudoaneurysm most frequent
Access site	Femoral high-risk; radial reduces bleeding[3,21]	90% femoral complications	Fully aligned with literature
Management	Minimally invasive: thrombin injection, US-guided compression, endovascular repair, VCDs; surgery for severe cases[14,22–26,32]	Surgery: suture 67.1%, plasty 23.3%, reconstruction 8.2%, bypass 1.4%	Study focuses on surgical interventions; literature emphasizes percutaneous first
Previous interventions	Increase risk with repeated punctures[1,3,9]	45.2% vs. 42.9%; $p < 0.001$	Quantitative confirmation
Closure devices/ Percutaneous techniques	Reduce risk; operator skill critical; bioabsorbable systems emerging[24,31–34]	Not reported	Literature provides procedural context
Prevention and planning	Sheath-to-artery ratio, US guidance, imaging, expertise[15,27,35]	Not reported	Literature emphasizes prevention
Statistical associations	Risks qualitatively described[1,3,7]	Previous interventions significant ($p < 0.001$); sex differences NS	Study provides numerical support

CKD, chronic kidney disease; NS, not significant; PAD, peripheral artery disease; US, ultrasound

control, and staged sheath removal have been shown to minimize complication rates.[35] Still, in severe cases, such as uncontrolled retroperitoneal bleeding or catastrophic vessel rupture, open surgical repair remains the definitive treatment and must be rapidly available in centers performing complex cardiovascular interventions. The management data in our study where arterial suturing was the most frequent surgical technique underscores the need for available and prompt surgical expertise.

While our observations generally correspond with existing studies, they also provide new insights into vascular complications in high-risk patients (Table 3).

This study has several limitations. It is a retrospective, single-center analysis, which may limit generalizability, and the small sample size (n = 73) restricts statistical power for subgroup and multivariate analyses. The inclusion of diverse cardiovascular procedures (TAVI, ECMO, angiography, angioplasty, cannulation) adds heterogeneity. Although no short-term complications were detected during the immediate postoperative period, minor complications managed conservatively were not captured, potentially biasing toward more severe cases. Some clinical parameters, such as sheath size, puncture technique, anticoagulation, and closure device, were inconsistently documented, limiting assessment of their impact. Finally, causal relationships cannot be established; prospective, multicenter studies with standardized data and long-term follow-up are needed to validate these findings and refine risk stratification.

Taken together, the literature demonstrates that while vascular access complications remain a persistent risk in cardiovascular surgery and intervention, their incidence can be significantly reduced by careful patient selection, risk stratification, procedural planning, and the use of

structured management algorithms. Advances in closure devices, adoption of minimally invasive rescue techniques, and readiness for surgical intervention when percutaneous management fails are key to optimizing outcomes in this high-risk domain.

CONCLUSION

This single-center retrospective study of 73 surgically managed complications provides quantifiable evidence for enhanced risk stratification in peripheral vascular access.

We confirmed that prior vascular interventions are a statistically significant risk factor for severe access failure requiring surgery. The high-risk cohort is characterized by advanced age and extensive comorbidities, particularly cardiopathies. The most frequent complication necessitating operative intervention was pseudoaneurysm, primarily managed by arterial suturing.

The underutilization of VCDs in obese patients may therefore represent a contributing factor to hemostatic failure and the need for surgical revision.

These findings underscore that while preventative measures are essential, centers performing complex procedures must incorporate these specific risk factors into their planning. Furthermore, they highlight the critical, ongoing necessity of rapid surgical expertise as the definitive management for severe access complications that frequently resist percutaneous treatment in this vulnerable population.

CONFLICT OF INTERESTS

Nothing to declare.

ETHICAL APPROVAL

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the institution where the study was conducted (approval no. 8550/17.10.2024).

FUNDING

This work did not receive any financial support.

AUTHOR CONTRIBUTIONS

M.M.H., S.C.A. led the conceptualization of the study, A.S., A.E. developed the methodology and provided resources, S.C.A., C.M.B. worked on the software, D.E.A., M.C.C. performed validation, conducted formal analysis, H.A.H. carried out the investigation, M.M.H., S.C.A. prepared the original draft, H.A.H. reviewed and edited the manuscript, contributed to visualization, H.S. supervised the study, S.C.A. managed the project. All authors have read and agreed to the published version of the manuscript.

REFERENCES

1. Pikwer A, Acosta S, Kölbel T, Malina M. Complications associated with peripheral or central routes for central venous cannulation. Anaesthesia. 2012;67(1):65-71. doi: 10.1111/j.1365-2044.2011.06911.x.
2. Neelu P. Femoral Central Venous Access Technique. Medscape [Internet]. [cited 2025 Jul 10]. Available from: https://emedicine.medscape.com/article/80279-technique
3. Kerrigan J, Paul TK, Patel J, Saad W, Morse A, Haddad E, Chandler A, Emling J, Lichaa H. Vascular Access Management in Complex Percutaneous Coronary Interventions. US Cardiol. 2023 Oct 20;17:e16. doi: 10.15420/usc.2023.04
4. Bisdas T, Beutel G, Warnecke G, Hoeper MM, Kuehn C, Haverich A, Teebken OE. Vascular complications in patients undergoing femoral cannulation for extracorporeal membrane oxygenation support. Ann Thorac Surg. 2011 Aug;92(2):626-31. doi: 10.1016/j.athoracsur.2011.02.018
5. Steinvil A, Leshem-Rubinow E, Halkin A, Abramowitz Y, Ben-Assa E, Shacham Y, Bar-Dayan A, Keren G, Banai S, Finkelstein A. Vascular complications after transcatheter aortic valve implantation and their association with mortality reevaluated by the valve academic research consortium definitions. Am J Cardiol. 2015 Jan 1;115(1):100-6. doi: 10.1016/j.amjcard.2014.09.047
6. Murphy DA, Hockings LE, Andrews RK, Aubron C, Gardiner EE, Pellegrino VA, Davis AK. Extracorporeal membrane oxygenation-hemostatic complications. Transfus Med Rev. 2015 Apr;29(2):90-101. doi: 10.1016/j.tmrv.2014.12.001
7. Kolluri R, Fowler B, Nandish S. Vascular access complications: diagnosis and management. Curr Treat Options Cardiovasc Med. 2013 Apr;15(2):173-87. doi: 10.1007/s11936-013-0227-8
8. Bansal A, Puri R, Yun J, Krishnaswamy A, Jilaihawi H, Makkar R, Kapadia SR. Management of complications after valvular interventions. EuroIntervention. 2025 Apr 21;21(8):e390-e410. doi: 10.4244/EIJ-D-24-00066
9. Ali JM, Abu-Omar Y. Complications associated with mechanical circulatory support. Ann Transl Med. 2020 Jul;8(13):835. doi: 10.21037/atm.2020.03.152
10. Banks CA, Blakeslee-Carter J, Nkie V, Spangler EL, Still SA, Eudailey KW, McElwee SK, Blood MS, Novak Z, Beck AW. Occurrence, predictors, and management of late vascular complications following extracorporeal membrane oxygenation. J Vasc Surg. 2024 Sep;80(3):864-872.e1. doi: 10.1016/j.jvs.2024.04.041
11. Tavakol M, Ashraf S, Brener SJ. Risks and complications of coronary angiography: a comprehensive review. Glob J Health Sci. 2012 Jan 1;4(1):65-93. doi: 10.5539/gjhs.v4n1p65
12. Harpa MM, Oltean SF, Al Hussein H, et al. Successful Treatment of Unilateral Pulmonary Edema as Minimally Invasive Mitral Valve Surgery Complication — Case Presentation. J Clin Med. 2024;13(24):7654.

13. Harpa MM, Al Hussein H, Oltean SF, et al. Endoscopic Mitral Surgery in Noonan Syndrome — Case Report and Considerations. J Clin Med. 2025;14(2):583. doi: 10.3390/jcm14020583
14. Madia C. Management trends for postcatheterization femoral artery pseudoaneurysms. JAAPA. 2019;32(6):15-18. doi: 10.1097/01.JAA.0000558236.60240.02.
15. Latham S, Bob-Manuel T, Sharma A, Nanda A, Ardeshna D, Khouzam RN. Access site complications in transcutaneous aortic valve replacement: frequency, outcomes, prevention, and treatment. Ann Transl Med. 2018;6(1):14. doi: 10.21037/atm.2017.10.32
16. Stan A, Elkahlout A, Harpa MM, et al. Impact of Pre- and Post-Dilatation on Long-Term Outcomes After Self-Expanding and Balloon-Expandable TAVI. J Funct Biomater. 2025;16(8):282. doi: 10.3390/jfb16080282
17. Stan AA, Elkahlout A, Harpa MM, et al. CT-Derived Aortic Valve Anatomy and Acute Complications After Self-Expanding and Balloon-Expandable TAVI. Medicina. 2025;61(9):1650. doi: 10.3390/medicina61091650
18. Rani A, Malik PK. Guidewire Mishap: An Avoidable Iatrogenic Complication. Indian J Crit Care Med. 2019;23(8):382-383. doi: 10.5005/jp-journals-10071-23225
19. Manda YR, Baradhi KM. Cardiac Catheterization Risks and Complications. [Updated 2023 Jun 5]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK531461/?utm_
20. Doll JA, Hira RS, Kearney KE, et al. Management of Percutaneous Coronary Intervention Complications: Algorithms From the 2018 and 2019 Seattle Percutaneous Coronary Intervention Complications Conference. Circ Cardiovasc Interv. 2020 Jun;13(6):e008962. doi: 10.1161/CIRCINTERVENTIONS.120.008962
21. Riangwiwat T, Blankenship JC. Vascular Complications of Transradial Access for Cardiac Catheterization. US Cardiol. 2021;15:e04. doi: 10.15420/usc.2020.23
22. Larsen J, Hurtsén AS, McGreevy DT, Chwich J, Hörer TM. Endovascular Management of Iatrogenic Femoral Access-Site Vascular Injuries: A case series and literature review. JVS Vasc Insights. 2025;3:100274. doi: 10.1016/j.jvsvi.2025.100274
23. Minici R, Paone S, Talarico M, et al. Percutaneous treatment of vascular access-site complications: a ten years' experience in two centres. CVIR Endovasc. 2020;3(1):29. doi: 10.1186/s42155-020-00120-7
24. Beraldo de Andrade P, de Ribamar Costa J Jr, Rinaldi FS, et al. Vascular Closure Devices Attenuate Femoral Access Complications of Primary Percutaneous Coronary Intervention. J Invasive Cardiol. 2020;32(10):364-370. doi: 10.25270/jic/20.00105
25. Kansal A, Jones WS, Sethi SS, Rymer JA. Vascular Access and Management of Complications. Interv Cardiol Clin. 2025 Apr;14(2):149-159. doi: 10.1016/j.iccl.2024.11.003
26. Ortiz D, Jahangir A, Singh M, Allaqaband S, Bajwa TK, Mewissen MW. Access site complications after peripheral vascular interventions: Incidence, predictors, and outcomes. Circ Cardiovasc Interv. 2014 Nov;7(6):9999-10102. doi: 10.1161/CIRCINTERVENTIONS.114.001306
27. Tommasino A, Sirignano P, Dell'Aquila F, et al. Tips and tricks in the prevention and management of vascular complications in TAVI. Cirugía Cardiovascular. 2025;32(2):93-101. doi: 10.1016/j.circv.2024.09.001
28. Sardone A, Franchin L, Moniaci D, et al. Management of Vascular Access in the Setting of Percutaneous Mechanical Circulatory Support (pMCS): Sheaths, Vascular Access and Closure Systems. J Pers Med. 2023;13(2):293. doi: 10.3390/jpm13020293
29. Apostolos A, Konstantinou K, Ktenopoulos N, Panoulas V. Plug- Versus Sutured-Based Vascular Closure Devices for Large Bore Arterial Access: A Systematic Review and Meta-Analysis. Am J Cardiol. 2025;252:56-66. doi: 10.1016/j.amjcard.2025.05.030
30. Haleem SM, Collier SA, Agasthi P. Femoral Vascular Closure Devices After Catheterization Procedure. [Updated 2025 Aug 2]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557472/?utm_
31. Ding W, Luo Y, Li W. Advancements in Vascular Closure Devices for Effective Hemostasis in Femoral Artery Interventions. Med Sci Monit. 2024;30:e944884. doi: 10.12659/MSM.944884
32. Saleem T, Baril DT. Vascular Access Closure Devices. [Updated 2023 Apr 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470233/?utm
33. Shariq M, Bellam Premnath K, Saleh AT, Coker J. Complications with the use of Angio-Seal vascular closure device and their management. Journal of Clinical Imaging Science. 2023;13:26. doi: 10.25259/JCIS_68_2023
34. Paraggio L, Bianchini F, Aurigemma C, et al. Femoral Large Bore Sheath Management: How to Prevent Vascular Complications From Vessel Puncture to Sheath Removal. Circ Cardiovasc Interv. 2024;17(9):e014156. doi: 10.1161/CIRCINTERVENTIONS.124.014156
35. Kaki A, Alraies MC, Kajy M, Blank N, Glazier JJ, Mohamad T, Elder M, Schreiber T. Large bore occlusive sheath management. Catheter Cardiovasc Interv. 2019 Mar 1;93(4):678-684. doi: 10.1002/ccd.28101