

# Transradial versus Transfemoral Artery Access in Cardiac Catheterizations: An Overview

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## Abstract

Cardiac catheterization procedures, such as coronary angiography (CA) and percutaneous coronary intervention (PCI), are crucial for diagnosing and managing cardiovascular diseases. These procedures are currently performed using both radial and femoral arteries as vascular access sites. However, the transradial approach has gained popularity because of its association with reduced bleeding and mortality. Although recent evidence supports the use of the transradial approach as the default method for CA and PCI, femoral access remains preferable in specific cases. Because nurses are responsible for providing care to patients undergoing both CA and PCI procedures using either approach,

knowledge of the differences in risks, complications, and nursing considerations of these procedures is important for the provision of quality nursing care. This overview highlights the key differences between transradial and transfemoral approaches, focusing on specific risks and complications and the nursing implications for these approaches to cardiac catheterization procedures.

**Keywords:** cardiac catheterization, coronary angiography, percutaneous coronary intervention, complications, transradial access, transfemoral access, nursing management

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## Key Highlights

- As CVD remains the leading cause of death globally, high volumes of cardiac catheterization procedures are performed in both the United States and Canada.
- The transradial approach for cardiac catheterization has shown significant benefits and less complications compared with the transfemoral approach.
- Transfemoral access is still preferable and appropriate for some specific cardiac catheterization procedures, including those in which radial access is not possible and those that require large bore access.
- Awareness of the specific nursing considerations for the transfemoral and transradial approaches will enable cardiovascular nurses to provide optimal, individualized care to this patient population.

## Introduction

Cardiac catheterization procedures, including coronary angiography (CA) and percutaneous coronary intervention (PCI), are fundamental for the diagnosis and treatment of a broad range of structural and functional cardiovascular diseases, including coronary artery disease (CAD), cardiac arrhythmias, valvular heart disease, congenital heart disease, and heart failure (Khin, 2020; Manda & Baradhi, 2023). Cardiovascular disease remains the leading cause of death globally (World Health Organization [WHO], 2021). Accordingly, cardiac catheterization procedures are commonly performed in both the United States and Canada

with annual volumes of more than 1,000,000 (Virani et al., 2020), and 47,000 (Canadian Institute for Health Information, 2017) respectively.

The cardiac catheterization procedure involves the insertion and advancement of a radiopaque catheter through a vein or artery to either the left or the right side of the heart (Khin, 2020). Both CAs and PCIs require arterial access, which is usually achieved through either the radial or femoral artery (Shroff & Pinto, 2019). Over the past two decades, a growing body of evidence has supported the use of the transradial approach for CA and PCI because of the reduced risk of bleeding complications and mortality (Bajraktari et al., 2021; Batra et al., 2020; Bhat et al., 2017; Chiarito et al., 2020; Ferrante et al., 2016; Gargiulo et al., 2022; Jolly et al., 2011; Ng et al., 2021). Thus, the use of radial access for CA and PCI has become increasingly common, and many catheterization laboratories have adopted this approach as their default access method (Bangalore et al., 2021; Feldman et al., 2013; Naidu et al., 2021; Reifart et al., 2022; Shamkhani et al., 2023; Wong et al., 2019). However, femoral access is still required for specific patients and procedures; for example, where radial access is not possible, and cardiac catheterization procedures that require large-bore access (Shroff & Pinto, 2019).

Cardiovascular nurses are often the key members of the healthcare team responsible for caring for patients undergoing cardiac catheterizations. With the high volumes of PCIs being performed in the United States and Canada,

these nurses are likely to continue to encounter numerous patients undergoing these procedures using both the transfemoral and transradial approaches. Therefore, the aim of this overview is to inform cardiovascular nurses about the advantages and disadvantages of transradial and transfemoral approaches for CA and PCI, with a focus on identifying the unique risks and nursing management for patients undergoing these procedures.

## Femoral Versus Radial Artery Access Approaches

The femoral and radial arteries are the two most common and preferred sites for CA and PCI, respectively (Shroff & Pinto, 2019), with advantages and disadvantages to both approaches. Although several complications are common to both, certain complications are specific to the access approach. Therefore, it is vital for nurses to be aware of the advantages and disadvantages of both access site approaches. The following section discusses these advantages and disadvantages, including the risks of specific complications, of the femoral and radial access approaches.

### Femoral Artery Access Approach

The percutaneous transfemoral access approach was introduced by Judkins in 1967 (Judkins, 1967). Since then, the femoral artery has been routinely used for CA and PCI procedures and remains the preferred access site in emergent cases, patients with ST elevated myocardial infarction (STEMI), elderly patients (Yee et al., 2017), and in patients with absent or difficult-to-palpate radial and brachial pulses (Anjum et al., 2017). The size and location of the femoral artery are the two primary advantages of the transfemoral approach (Shroff & Pinto, 2019). Due to its large size, the femoral artery can be easily palpated and allows for the use of large sheaths and catheters, which remain necessary in some cardiac catheterization procedures (Anjum et al., 2017; Shroff & Pinto, 2019). The location of the femoral artery also allows it to be easily compressed against the femoral head for post-procedural hemostasis (Shroff & Pinto, 2019).

The main disadvantage of the transfemoral versus transradial approach is its association with an increased incidence of several complications. The risk of bleeding and large hematoma formation (Bajraktari et al., 2021; Bhat et al., 2017; Brener et al., 2017; Chiarito et al., 2020; Jolly et al., 2011). As well, the incidence of pseudoaneurysm and arteriovenous fistula formation is reported to be higher with the transfemoral approach than with the transradial approach (Brueck et al., 2009; Jolly et al., 2011). In addition, the risk of all-cause mortality increases with the transfemoral approach versus the transradial approach in patients with acute coronary syndrome and STEMI (Bernat et al., 2014; Jolly et al., 2011; Romagnoli et al., 2012; Valgimigli et al., 2015). Although rare (0.06%), retroperitoneal

hemorrhage is a life-threatening bleeding complication that can occur as a consequence of the transfemoral approach (Kwok et al., 2018).

### Radial Artery Access Approach

The transradial approach to CA was first reported by Campeau in 1989 (Campeau, 1989) and has since demonstrated several advantages over the transfemoral approach, including a significantly reduced risk of vascular complications, major bleeding, all-cause mortality, and major adverse cardiovascular events (Batra et al., 2020; Bhat et al., 2017; Brener et al., 2017; Ferrante et al., 2016; Gargiulo et al., 2022; Jolly et al., 2011; Ng et al., 2021; Reifart et al., 2022). Additionally, the radial artery can be easily palpated, punctured, and compressed to control bleeding (Anjum et al., 2017). The absence of major nerves and veins near the radial artery also makes it a favourable access site, as it minimizes the risk of nerve and vascular injuries (Anjum et al., 2017). For these reasons, transradial access is preferred in diagnostic catheterization (Gladden et al., 2022; Yee et al., 2017), in morbidly obese patients (BMI  $\geq$  35), and in patients less than 70 years of age (Yee et al., 2017).

Despite its advantages over the transfemoral approach, the transradial access has several disadvantages. Vascular access may be complicated by the small diameter of the radial artery and the potential for anatomical variation (Shroff et al. 2019). The radial artery can also become occluded because of endothelial damage from sheath insertion and thrombus formation (Alkagiet et al., 2021; Avdikos et al., 2017; Kotowycz & Džavík, 2012; Roy et al., 2022). This complication is often asymptomatic due to the hand's dual vascular supply and, consequently, it is commonly underdiagnosed (Alkagiet et al., 2021; Avdikos et al., 2017; Roy et al., 2022). Finally, radial artery perforation is rare and most common in elderly women who typically have narrow and tortuous arteries (Alkagiet et al., 2021). If not managed properly, this complication can lead to significant bleeding, hematoma, and compartment syndrome (Alkagiet et al. 2021; Roy et al. 2022; Sandoval et al. 2019).

## Nursing Considerations

Nurses practising in various clinical areas play a central role in providing care to patients undergoing cardiac catheterization. Several key nursing considerations vary based on whether the patient has undergone cardiac catheterization with the transfemoral or the transradial approach. Therefore, nurses caring for these patients must be knowledgeable about these specific differences, so they can provide appropriate care for each unique patient. Table 1 summarizes the differences in nursing considerations based on access approach.

Regardless of the access approach, pre-procedural nursing care generally includes completing a nursing assessment, reviewing allergies, confirming fasting time, administering medications, and obtaining necessary preprocedural

**Table 1**

*Summary of Specific Evidence-Based Best Practice Guidelines and Nursing Considerations for Transfemoral vs Transradial Cardiac Catheterization Patients*

	<b>Transfemoral Approach</b>	<b>Transradial Approach</b>
Pre-procedural Nursing Considerations	<p>Mark the best sites for palpation of the dorsalis pedis, and posterior tibial pulses.<sup>2</sup></p> <p>Inform the patient of the expected length of bedrest after the catheterization: 4–6 hrs.<sup>2</sup></p>	<p>Inform the patient that they can ambulate once recovered from sedation.<sup>2</sup></p>
Post-procedural Nursing Considerations	<p>Bedrest for 4–6 hours.<sup>2</sup></p> <p>Head of bed may be elevated to max of 30°.<sup>2</sup></p> <p>Instruct patient not to flex or hyperextend the hip joint of the affected leg for 4–6 hrs.<sup>2</sup></p> <p>If compression device applied, monitor peripheral pulses as per protocol.<sup>2</sup></p> <p>Monitor for signs of retroperitoneal hemorrhage: back, flank, or abdominal pain, hypotension, tachycardia, restlessness, agitation.<sup>3</sup></p> <p>Bleeding can be managed with application of pressure for 15–20 minutes either manually or with a compression device.<sup>2</sup></p>	<p>Patient can ambulate after recovered from sedation.<sup>2</sup></p> <p>Instruct patient to avoid flexing, hyper flexing, or lying on the affected arm for 24 hrs.<sup>2</sup></p> <p>Monitor for signs of arterial occlusion: blanching, cramping, coolness, pain, numbness, tingling, or absent/diminished pulse.<sup>2</sup></p> <p>If signs of arterial occlusion occur, first check the compression device (if used) and release pressure. If symptoms do not resolve, notify the provider immediately.<sup>2</sup></p> <p>Monitor for signs of radial artery perforation and notify provider immediately if they occur: lost/weakened pulse distal to sheath insertion site, cool, cyanotic, and painful extremity.<sup>3</sup></p> <p>Bleeding can be managed with application of pressure for 15–20 minutes either manually or with inflation of a transradial band.<sup>2</sup></p>
Discharge Teaching	<p>Avoid straining during bowel movements for the first 3–4 days post-procedure.<sup>1</sup></p> <p>Avoid strenuous activities (most sports, jogging, golfing, etc.) for 5 days post-procedure.<sup>1</sup></p> <p>Avoid heavy lifting (&gt;10 lbs) for the first 5–7 days post-procedure.<sup>1</sup></p> <p>Limit excessive stair climbing;<sup>2</sup> if necessary, do stairs slower than usual.<sup>1</sup></p>	<p>Avoid flexing, hyper flexing, or lying on the affected arm for 24 hrs and do not lift anything heavier than 5lb for the next 48 hrs.<sup>2</sup></p> <p>Avoid strenuous activities (most sports, jogging, golfing, etc.) for 2 days post-procedure.<sup>1</sup></p>

Note: <sup>1</sup>Cleveland Clinic (n.d.); <sup>2</sup>Julien, 2021; <sup>3</sup>Then & Rankin, 2020.

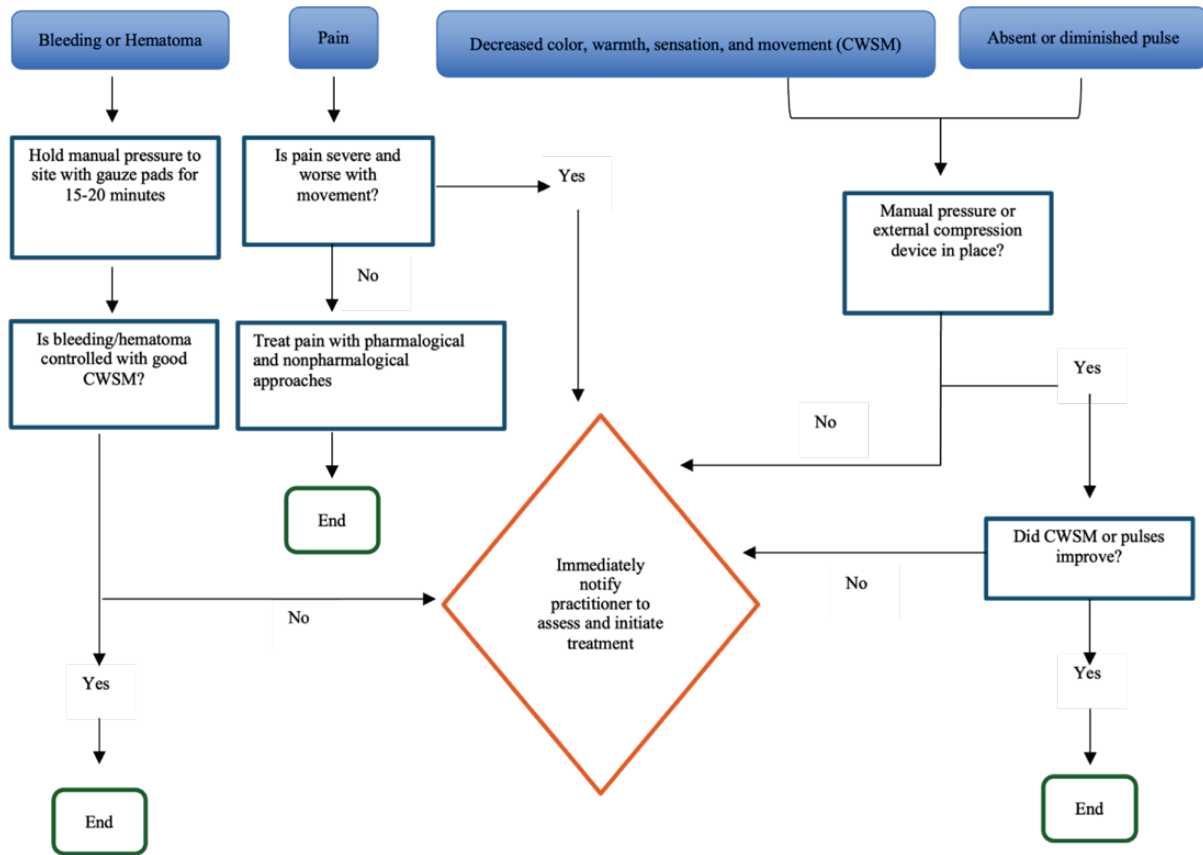
laboratory studies as ordered by the interventionalist, (Julien, 2021; Naidu et al., 2021). If the transfemoral approach is being used, the sites for best palpation of the dorsalis pedis and posterior tibialis pulses are marked on the patient’s skin for comparison to evaluate peripheral pulses after the procedure (Julien, 2021). In addition to general patient teaching aimed at preparing patients for catheterization experiences and alleviating anxiety, specific explanations for patients scheduled for a transfemoral procedure should include the expected duration of post-procedure bedrest; between 4–6 hours (Julien, 2021).

Postprocedural nursing care for all cardiac catheterization patients focuses on monitoring the patient, preventing and identifying potential complications (see Figure 1), and providing discharge teaching (Julien, 2021). Although

unit protocols dictate specific time intervals, frequent monitoring of patients’ vital signs and assessment of the access site and corresponding limb are central to post-procedural nursing care for all patients (Julien, 2021; Lippincott Procedures, 2023a; Lippincott Procedures, 2023b). However, activity restrictions depend on the access approach. Patients who have undergone catheterization with the transfemoral approach should maintain bedrest, with the head of the bed elevated no more than 30 degrees and avoid flexion and hyperflexion of the hip joint of the affected leg for 4 to 6 hours post-procedure (Julien, 2021). Patients who have undergone catheterization with the transradial approach can ambulate once recovered from sedation and should be instructed to avoid flexing, hyper flexing, or lying on the affected arm for 24 hours (Julien, 2021).

Figure 1

## Nursing Pathway for Managing Potential Post-Procedural Complications



Adapted from: Lippincott Procedures. (2023a) Left heart catheterization postprocedure care. Retrieved December 27, 2023 from <https://procedures-lww-com.ahs.idm.oclc.org/lnp/view.do?pId=6695604&hits=catheterization,cardiac&a=true&ad=false&q=cardiac%20catheterization>, Lippincott Procedures. (2023b) Neurovascular assessment. Retrieved from <https://procedures-lww-com.ahs.idm.oclc.org/lnp/view.do?pId=4181558>

An important role of nurses in post-procedural care is to monitor for access-specific complications. Because retroperitoneal hemorrhage is a potential life-threatening complication that can occur with the transfemoral approach (Kwok et al., 2018), nurses must be particularly diligent in assessing for the signs and symptoms of this complication, including back, flank, or abdominal pain, hypotension, tachycardia, restlessness, and agitation (Then & Rankin, 2020). Nurses must also be aware of the urgency in managing this complication, which includes notifying the provider and anticipating administering IV fluids, stopping anticoagulant therapy, and preparing the patient for diagnostic testing and/or further intervention (Then & Rankin, 2020).

Likewise, nurses must be diligent in monitoring for complications of the transradial approach, including signs of

radial artery occlusion (i.e., blanching, cramping, coolness, pain, numbness, tingling, or an absent/diminished pulse in the affected extremity; Julien, 2021), especially because initially it is often asymptomatic (Alkagiet et al., 2021; Avdikos et al., 2017; Roy et al., 2022). Assessing for potential signs of radial artery perforation including, coolness, cyanosis, pain, and lost/weakened pulse distal to the insertion site in the affected extremity (Julien, 2021) is also critically important in patients who have undergone catheterization using the transradial approach because it can lead to significant bleeding, hematoma, and compartment syndrome (Alkagiet et al., 2021; Roy et al., 2022; Sandoval et al., 2019).

Finally, standard discharge teaching for all cardiac catheterization patients includes informing their physician if they experience fever, new bleeding, swelling, increased

tenderness, redness, or discharge at the catheterization site, instructing them to manage bleeding by pressing their hand firmly over the site and calling 911, and instructing them to continue taking prescribed medications unless otherwise indicated by their provider (Julien, 2021). However, unique discharge instructions are also required for patients who have undergone the procedure using the transfemoral approach versus the transradial approach (Julien, 2021). Patients who have undergone catheterization with the transfemoral approach should be instructed to avoid straining during bowel movements for the first three to four days, avoid strenuous activity (e.g., most sports, jogging, golfing, etc.) for five days, and avoid heavy lifting (>10 lbs) for the first five to seven days after the procedure (Cleveland Clinic, n.d.). Patients should also be instructed to avoid excessive stair climbing (Julien, 2021); if necessary, patients can climb stairs, but they should be instructed to do so slower than usual (Cleveland Clinic, n.d.). Unique discharge instructions for transradial approach patients include instructing the

patient to avoid flexing, hyperflexing, or lying on the affected arm for 24 hours, and not lifting anything heavier than 5 lbs for 48 hours post-catheterization (Julien, 2021). Additionally, patients should avoid strenuous activity for two days after the procedure (Cleveland Clinic, n.d.).

## Conclusion

The development of the transradial approach to CA and PCI has significantly improved patient outcomes by reducing the risk of vascular complications, major bleeding, and mortality compared to the transfemoral approach. Although these factors have contributed to a growing preference for the default use of the transradial approach, the transfemoral approach is still necessary in some cardiac catheterization procedures. As both access sites are used for cardiac catheterization, awareness of the advantages, disadvantages, complications, and differences in nursing considerations of each approach will enable nurses to provide optimal care to patients undergoing cardiac catheterization procedures.

## REFERENCES

- Alkagiet, S., Petroglou, D., Nikas, D. N., & Kolettis, T. M. (2021). Access-site complications of the transradial approach: Rare but still there. *Current Cardiology Reviews*, 17(3), 279–293. <https://doi.org/10.2174/1573403x16999200819101923>
- Anjum, I., Khan, M. A., Aadil, M., Faraz, A., Farooqui, M., & Hashmi, A. (2017). Transradial vs. transfemoral approach in cardiac catheterization: A literature review. *Cureus*, 9(6), e1309. <https://doi.org/10.7759/cureus.1309>
- Avdikos, G., Karatasakis, A., Tsoumeleas, A., Lazaris, E., Ziakas, A., & Koutouzis, M. (2017). Radial artery occlusion after transradial coronary catheterization. *Cardiovascular Diagnosis and Therapy*, 7(3), 305–316. <https://doi.org/10.21037/cdt.2017.03.14>
- Bajraktari, G., Rexhaj, Z., Elezi, S., Zhubi-Bakija, F., Bajraktari, A., Bytyci, I., Batalli, A., & Henein, M. Y. (2021). Radial access for coronary angiography carries fewer complications compared with femoral access: A meta-analysis of randomized controlled trials. *Journal of Clinical Medicine*, 10(10), 2163. <https://doi.org/10.3390/jcm10102163>
- Bangalore, S., Barsness, G. W., Dangas, G. D., Kern, M. J., Rao, S. V., Shore-Lesserson, L., & Tamis-Holland, J. E. (2021). Evidence-based practices in the cardiac catheterization laboratory: A scientific statement from the American Heart Association. *Circulation*, 144(5). <https://doi.org/10.1161/cir.0000000000000996>
- Batra, M. K., Rai, L., Khan, N. U., Mengal, M. N., Khowaja, S., Hassan Rizvi, S. N., Saghir, T., Qamar, N., Sial, J. A., & Karim, M. (2020). Radial or femoral access in primary percutaneous coronary intervention (PCI): Does the choice matters? *Indian Heart Journal*, 72(3), 166–171. <https://doi.org/10.1016/j.ihj.2020.05.004>
- Bernat, I., Horak, D., Stasek, J., Mates, M., Pesek, J., Ostadal, P., Hrabos, V., Dusek, J., Koza, J., Sembera, Z., Brtko, M., Aschermann, O., Smid, M., Polansky, P., Al Mawiri, A., Vojacek, J., Bis, J., Costerousse, O., Bertrand, O. F., & Rokyta, R. (2014). ST-segment elevation myocardial infarction treated by radial or femoral approach in a multicenter randomized clinical trial. *Journal of the American College of Cardiology*, 63(10), 964–972. <https://doi.org/10.1016/j.jacc.2013.08.1651>
- Bhat, F. A., Chandal, K. H., Raina, H., Trambo, N. A., & Rather, H. A. (2017). Transradial versus transfemoral approach for coronary angiography and angioplasty – A prospective, randomized comparison. *BioMed Central Cardiovascular Disorders*, 17(1). <https://doi.org/10.1186/s12872-016-0457-2>
- Brener, M. I., Bush, A., Miller, J. M., & Hasan, R. K. (2017). Influence of radial versus femoral access site on coronary angiography and intervention outcomes: A systematic review and meta-analysis. *Catheterization and Cardiovascular Interventions*, 90(7), 1093–1104. <https://doi.org/10.1002/ccd.27043>
- Brueck, M., Bandorski, D., Kramer, W., Wiecezorek, M., Höltgen, R., & Tillmanns, H. (2009). A randomized comparison of transradial versus transfemoral approach for coronary angiography and angioplasty. *Journal of the American College of Cardiology: Cardiovascular Interventions*, 2(11), 1047–1054. <https://doi.org/10.1016/j.jcin.2009.07.016>
- Campeau, L. (1989). Percutaneous radial artery approach for coronary angiography. *Catheterization and Cardiovascular Diagnosis*, 16(1), 3–7. <https://doi.org/10.1002/ccd.1810160103>
- Canadian Institute for Health Information (2017). *Cardiac Care Quality Indicators Report*. [https://secure.cihi.ca/free\\_products/cardiac-care-quality-indicators-report-en-web.pdf](https://secure.cihi.ca/free_products/cardiac-care-quality-indicators-report-en-web.pdf)
- Chiarito, M., Cao, D., Nicolas, J., Roumeliotis, A., Power, D., Chandiramani, R., Goel, R., Claessen, B. E., Ferrante, G., Stefanini, G. G., Mehran, R., & Dangas, G. (2020). Radial versus femoral access for coronary angiography and interventions: A systematic review and meta-analysis of randomized trials. *European Heart Journal*, 41(Supplement\_2). <https://doi.org/10.1093/ehjci/ehaa946.2454>
- Cleveland Clinic. (n.d.) *After Your Cardiac Catheterization*. <https://my.clevelandclinic.org/departments/heart/patient-education/recovery-care/interventional-procedures/after-your-cardiac-catheterization>
- Ferrante, G., Rao, S. V., Jüni, P., Da Costa, B. R., Reimers, B., Condorelli, G., Anzuini, A., Jolly, S. S., Bertrand, O. F., Krucoff, M. W., Windecker, S., & Valgimigli, M. (2016). Radial versus femoral access for coronary interventions across the entire spectrum of patients with coronary artery disease. *Journal of the American College of Cardiology: Cardiovascular Interventions*, 9(14), 1419–1434. <https://doi.org/10.1016/j.jcin.2016.04.014>
- Feldman, D. N., Swaminathan, R. V., Kaltenbach, L. A., Baklanov, D. V., Kim, L. K., Wong, S. C., Minutello, R. M., Messenger, J. C., Moussa, I., Garratt, K. N., Piana, R. N., Hilleagass, W. B., Cohen, M. G., Gilchrist, I. C., & Rao, S. V. (2013). Adoption of radial access and comparison of outcomes to femoral access in percutaneous

- coronary intervention. *Circulation*, 127(23), 2295–2306. <https://doi.org/10.1161/circulationaha.112.000536>
- Gargiulo, G., Giacoppo, D., Jolly, S. S., Cairns, J., Le May, M., Bernat, I., Romagnoli, E., Rao, S. V., van Leeuwen, M. A. H., Mehta, S. R., Bertrand, O. F., Wells, G. A., Meijers, T. A., Siontis, G. C. M., Esposito, G., Windecker, S., Jüni, P., & Valgimigli, M. (2022). Effects on mortality and major bleeding of radial versus femoral artery access for coronary angiography or percutaneous coronary intervention: Meta-analysis of individual patient data from seven multicenter randomized clinical trials. *Circulation*, 146(18), 1329–1343. <https://doi.org/10.1161/circulationaha.122.061527>
- Gladden, J. D., Gulati, R., & Sandoval, Y. (2022). Contemporary techniques for femoral and radial arterial access in the cardiac catheterization laboratory. *Reviews in Cardiovascular Medicine*, 23(9), 316. <https://doi.org/10.31083/j.rcm2309316>
- Jolly, S. S., Yusuf, S., Cairns, J., Niemelä, K., Xavier, D., Widimsky, P., Budaj, A., Niemelä, M., Valentin, V., Lewis, B. S., Avezum, A., Steg, P. G., Rao, S. V., Gao, P., Afzal, R., Joyner, C. D., Chrolavicius, S., & Mehta, S. R. (2011). Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (rival): A randomised, parallel group, multicentre trial. *The Lancet*, 377(9775), 1409–1420. [https://doi.org/10.1016/s0140-6736\(11\)60404-2](https://doi.org/10.1016/s0140-6736(11)60404-2)
- Judkins, M. P. (1967). Selective coronary arteriography. *Radiology*, 89(5), 815–824. <https://doi.org/10.1148/89.5.815>
- Julien, M. B. (2021). Cardiac catheterization. In Perpetua, E. M., & Keegan, P. A. (Eds.), *Cardiac nursing: The red reference book for cardiac nurses* (7th ed., pp. 428–460). Lippincott Williams & Wilkins.
- Kotowycz, M. A., & Džavík, V. (2012). Radial artery patency after transradial catheterization. *Circulation: Cardiovascular Interventions*, 5(1), 127–133. <https://doi.org/10.1161/circinterventions.111.965871>
- Khin, A. S. W. (2020). Assessment of cardiovascular function. In M. T. El-Hussein & J. Osuji (Eds.), *Brunner & Suddarth's Canadian Textbook of Medical-Surgical Nursing* (4th ed., pp. 652–690). Wolter Kluwer.
- Kwok, C. S., Kontopantelis, E., Kinnaird, T., Potts, J., Rashid, M., Shoaib, A., Nolan, J., Bagur, R., de Belder, M. A., Ludman, P., & Mamas, M. A. (2018). Retroperitoneal hemorrhage after percutaneous coronary intervention. *Circulation: Cardiovascular Interventions*, 11(2). <https://doi.org/10.1161/circinterventions.117.005866>
- Lippincott Procedures. (2023a). Left heart catheterization postprocedure care. <https://procedures-lww-com.ahs.idm.oclc.org/lnp/view.do?pId=6695604&hits=catheterization,cardiac&a=true&ad=false&q=cardiac%20catheterization>
- Lippincott Procedures. (2023b). Neurovascular assessment. <https://procedures-lww-com.ahs.idm.oclc.org/lnp/view.do?pId=4181558>
- Manda, Y. R., & Baradhi, K. M. (2023). *Cardiac catheterization risks and complications*. StatPearls [Internet]. <https://www.ncbi.nlm.nih.gov/books/NBK531461/>
- Naidu, S. S., Abbott, J. D., Bagai, J., Blankenship, J., Garcia, S., Iqbal, S. N., Kaul, P., Khuddus, M. A., Kirkwood, L., Manoukian, S. V., Patel, M. R., Skelding, K., Slotwiner, D., Swaminathan, R. V., Welt, F. G., & Kolansky, D. M. (2021). SCAI expert consensus update on best practices in the cardiac catheterization laboratory. *Catheterization and Cardiovascular Interventions*, 98(2), 255–276. <https://doi.org/10.1002/ccd.29744>
- Ng, A. K., Ng, P. Y., Ip, A., Jim, M., & Siu, C. (2021). Association between radial versus femoral access for percutaneous coronary intervention and long-term mortality. *Journal of the American Heart Association*, 10(15). <https://doi.org/10.1161/jaha.121.021256>
- Reifart, J., Göhring, S., Albrecht, A., Haerer, W., Levenson, B., Ringwald, G., Gärtner, P., & Reifart, N. (2022). Acceptance and safety of femoral versus radial access for percutaneous coronary intervention (PCI): Results from a large monitor-controlled German Registry (QuIK). *BioMed Central Cardiovascular Disorders*, 22(1). <https://doi.org/10.1186/s12872-021-02283-0>
- Romagnoli, E., Biondi-Zoccai, G., Sciahbasi, A., Politi, L., Rigattieri, S., Pendenza, G., Summaria, F., Patrizi, R., Borghi, A., Di Russo, C., Moretti, C., Agostoni, P., Loschiavo, P., Liroy, E., Sheiban, I., & Sangiorgi, G. (2012). Radial versus femoral randomized investigation in ST-segment elevation acute coronary syndrome. *Journal of the American College of Cardiology*, 60(24), 2481–2489. <https://doi.org/10.1016/j.jacc.2012.06.017>
- Roy, S., Kabach, M., Patel, D. B., Guzman, L. A., & Jovin, I. S. (2022). Radial artery access complications: Prevention, diagnosis and management. *Cardiovascular Revascularization Medicine*, 40, 163–171. <https://doi.org/10.1016/j.carrev.2021.12.007>
- Sandoval, Y., Bell, M. R., & Gulati, R. (2019). Transradial artery access complications. *Circulation: Cardiovascular Interventions*, 12(11), 1–14. <https://doi.org/10.1161/circinterventions.119.007386>
- Shamkhani, W., Moledina, S., Rashid, M., & Mamas, M. A. (2023). Complex high-risk percutaneous coronary intervention types, trends, and outcomes according to vascular access site. *Catheterization and Cardiovascular Interventions*, 102(5), 803–813. <https://doi.org/10.1002/ccd.30846>
- Shroff, A., & Pinto, D. (Eds.). (2019). *Vascular access, management, and closure best practices*. Society for Cardiovascular Angiography & Interventions. <https://dkxi8lp3rdmhs.cloudfront.net/SCAI/pdf/0698fc96-81b9-4511-bdf4-95a826e5cab5.pdf>
- Shroff, A. R., Gulati, R., Drachman, D. E., Feldman, D. N., Gilchrist, I. C., Kaul, P., Lata, K., Pancholy, S. B., Panetta, C. J., Seto, A. H., Speiser, B., Steinberg, D. H., Vidovich, M. I., Woody, W. W., & Rao, S. V. (2019). SCAI expert consensus statement update on best practices for transradial angiography and Intervention. *Catheterization and Cardiovascular Interventions*, 95(2), 245–252. <https://doi.org/10.1002/ccd.28672>
- Then, K. L., & Rankin, J. A. (2020). Management of patients with coronary vascular disorders. In M. T. El-Hussein & J. Osuji (Eds.), *Brunner & Suddarth's Canadian Textbook of Medical-Surgical Nursing* (4th ed., pp. 729–776). Wolter Kluwer.
- Valgimigli, M., Gagnor, A., Calabrò, P., Frigoli, E., Leonardi, S., Zaro, T., Rubartelli, P., Briguori, C., Andò, G., Repetto, A., Limbruno, U., Cortese, B., Sganzerla, P., Lupi, A., Galli, M., Colangelo, S., Ierna, S., Ausiello, A., Presbitero, P., ... Jüni, P. (2015). Radial versus femoral access in patients with acute coronary syndromes undergoing invasive management: A randomised multicentre trial. *The Lancet*, 385(9986), 2465–2476. [https://doi.org/10.1016/s0140-6736\(15\)60292-6](https://doi.org/10.1016/s0140-6736(15)60292-6)
- Virani, S. S., Alonzo, A., Benjamin, E. J., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Delling, F. N., Djousse, L., Elkind, M. S. V., Ferguson, J. F., Fornage, M., Khan, S. S., Kissela, B. M., Knutson, K. L., Kwan, T. W., Lackland, D. T., ... Tsao, C. W. (2020). Heart disease and stroke statistics—2020 update: A report from the American Heart Association. *Circulation*, 141(9). <https://doi.org/10.1161/cir.0000000000000757>
- Wong, G. C., Welsford, M., Ainsworth, C., Abuzeid, W., Fordyce, C. B., Greene, J., Huynh, T., Lambert, L., Le May, M., Lutchmedial, S., Mehta, S. R., Natarajan, M., Norris, C. M., Overgaard, C. B., Perry Arnesen, M., Quraishi, A., Tanguay, J. F., Traboulsi, M., van Diepen, S., ... So, D. (2019). 2019 Canadian Cardiovascular Society/Canadian Association of Interventional Cardiology Guidelines on the acute management of ST-elevation myocardial infarction: Focused update on regionalization and reperfusion. *Canadian Journal of Cardiology*, 35(2), 107–132. <https://doi.org/10.1016/j.cjca.2018.11.031>
- World Health Organization. (2021, June 11). *Cardiovascular diseases (CVDs)*. [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds))
- Yee, J., Kumar, V., Li, S., Petraskova, T., Pham, A., Stys, J., Thompson, Paul, A., Petrasko, M., Stys, A., & Stys, T. (2017). Clinical factors associated with physician choice of femoral versus radial access: A real-world experience from a single academic center. *Journal of Interventional Cardiology*, 31(2), 236–243. <https://doi.org/10.1111/joic.12479>