

Radial vs Femoral Approach in Complicated Percutaneous Transluminal Coronary Angioplasty: A Systematic Review

Article History:

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Abstract:

Coronary disease treatment has evolved over the past several decades; however, the use of percutaneous transluminal coronary angioplasty (PTCA) has become a mainstay of care within this population. One of the most important factors related to successful completion of PTCA procedures, as well as risk of complications and overall outcome, is the selection of the access site for percutaneous coronary intervention (PCI). For many years, the femoral artery access route has been the standard for all PCIs, primarily due to the larger diameter of the femoral artery, which allows the use of larger guide catheters and interventional devices. Increasingly, over the past 20 years, the use of the radial artery as the access route for PCI has gained popularity; numerous studies have shown the safety and effectiveness of radial access compared to femoral access. Studies comparing femoral and radial access routes have shown a decrease in bleeding complications, improved patient satisfaction, and earlier ambulation following PCI procedures with radial access. As PCIs become more technically advanced with longer procedure times, more catheters and devices employed, and larger bore sheaths used, the choice of access route becomes even more critical, specifically in complex PTCA cases, including chronic total occlusions (CTOs), bifurcation lesions, calcified coronary arteries, left main disease and/or hemodynamically unstable patients. Historically, the various characteristics of complex PTCA procedures have supported the use of the femoral access route. However, due to improved catheter technology, operator experience and miniaturization of interventional devices, radial access has been increasingly used for complex PCI procedures. There have been several clinical trials and observational studies evaluating the femoral and radial access routes with respect to procedural success, vascular complications, bleeding complications, mortality and length of stay in the hospital. Results of the clinical trials demonstrate that patients who undergo a radial access procedure have, on average, significantly lower rates of access site-related bleeding and/or major vascular complications than those who undergo a femoral access procedure. Therefore, patients who undergo a radial access procedure demonstrate an earlier ambulation, shorter length of stay and greater procedural comfort than those who undergo femoral access methods. Despite these advantages, there are still limitations to the radial access route due to the smaller diameter of the radial artery and risk of vascular spasm, as well as a longer learning curve for operators than with the femoral access route. Another advantage associated with the femoral access route compared to the radial access route would be the greater support of guide catheters for certain complex cases. With increasing evidence and expanding use of radial access throughout the realm of interventional cardiology, careful appraisal of the respective advantages and disadvantages of the access routes for complex PTCA procedures is warranted.

The purpose of this systematic review is to aggregate the existing literature regarding the use of radial and femoral access methods during complex coronary interventions regarding procedural

success, bleeding complications, major vascular complications, mortality and health outcomes.

Keywords:

Percutaneous transluminal coronary angioplasty, Radial approach, Femoral approach, Complex coronary intervention, Vascular complications, Interventional cardiology

INTRODUCTION

Coronary artery disease continues to be one of the leading global causes of morbidity and mortality. As a result, the use of percutaneous transluminal coronary angioplasty (PTCA) has emerged as a standard treatment for patients with both stable coronary artery disease and acute coronary syndromes. Along with advancements in interventional cardiology techniques, imaging technology, and device innovations over the last few decades, coronary interventions are much safer and more effective than they were even a few years ago [1]. However, the choice of vascular access site continues to be an important factor that influences the success of the procedure, the complication rate, and the outcomes for patients. Historically, the femoral artery has been the most frequently utilized access route for both coronary angiography and PTCA. Among the many technical benefits of using a femoral approach, the most significant is that it provides a sufficiently large arterial diameter that permits the use of larger sheaths and guiding catheters for multiple interventional devices [2]. This enhanced access allows for improved catheter support during complex coronary interventions. These advantages made the femoral approach the method of choice for challenging PTCA cases, such as chronic total occlusions, bifurcation lesions, heavily calcified vessels, and left main coronary artery disease. Unfortunately, access through this route is associated with an increased risk of access-site complications, including bleeding, hematomas, pseudoaneurysms, and retroperitoneal hemorrhage. Such complications can result in increased patient morbidity and longer hospital stays and may lead to higher patient mortality rates [3]. This risk is exacerbated in those patients who are receiving aggressive antithrombotic and/or antiplatelet therapy during complicated coronary interventions. Because of these limitations, the radial artery will continue to serve as an alternate route of vascular access for coronary interventions. The initial goal of utilizing a radial approach was to minimize bleeding complications [4]. Following

its introduction, the radial approach has gained much popularity due to its excellent safety profile, created by the ability to easily compress the radial artery following removal of the catheter, thereby decreasing the risk of major vascular complications. Additionally, patients who undergo radial access procedures experience significantly more comfort, earlier ambulation, and shorter hospitalizations. Both operator experience and advances in catheters have led to greater usage of radial access in complicated PTCA procedures [5]. Data show that the radial approach achieves comparable procedural success to the femoral route, but has lower incidences of bleeding complications. Still, there exist some limitations associated with the radial route, including a smaller vessel diameter, potential for radial artery spasms, and decreased support from catheters in extremely complex procedures [6].

Thus, the expanding role of radial access in interventional cardiology and the continued use of femoral access for complex procedures warrant a critical review of the comparing (and contrasting) effectiveness and safety of both access points. An understanding of the advantages and disadvantages of each type of access point will allow for optimizing the procedural approach for improved patient outcomes in complicated PTCA procedures. As such, the aim of this systematic review is to critically review and synthesize the current literature comparing the radial and femoral approach for complicated PTCA procedures, with a focus on procedural success and bleeding complications, vascular events, mortality, and clinical outcomes.

Materials and Methods

Study Design

This article describes a systematic literature review that aims to evaluate and compare the clinical outcomes related to the use of radial and femoral approaches to vascular access during complicated percutaneous transluminal coronary angioplasty (PTCA). The review seeks

to provide an overview of the scientific literature and what information there is regarding: 1) procedural success rates; 2) bleeding-related complication rates; 3) vascular complication rates; 4) mortality rates; and 5) additional pertinent clinical outcomes for patients who have undergone complicated coronary procedures.

Search Strategy

In order to find all of the literature on the subject, a full literature search was conducted using the major electronic databases (i.e. PubMed, Scopus, Web of Science, and Google Scholar) in accordance with an established search strategy. This strategy was created specifically to identify articles that compared radial and femoral access during complex PTCA. Articles that met the search criteria were retrieved by using keywords and combinations of medical subject headings. The key terms used the most were radial approach, femoral approach, percutaneous transluminal coronary angioplasty, complex coronary intervention, transradial intervention, transfemoral intervention, vascular complications, and bleeding outcomes. A combination of Boolean operators (AND OR) helped to narrow the focus of the overall search and allowed for the selection of articles that pertained to the study's objectives. In addition to limiting the search to English language publications, the reference lists of all articles that were found relevant to the search were reviewed to identify any additional articles not found through the database searches.

Eligibility Criteria

A review of the literature will be performed using a systematic review method to identify and evaluate studies that meet specific methodological criteria, in order to determine the most clinically relevant evidence available in the literature related to patients with complicated PTCA procedures. The specific inclusion criteria for this review are: studies comparing radial versus femoral access for PTCA procedures among patients who had complicated PTCA procedures (i.e., include any number of the following elements in this definition); randomised controlled trials; prospective cohort studies; retrospective cohort studies; observational studies that report clinical outcomes related to vascular access; and studies reporting clinical outcomes related to vascular access, i.e., successful procedure completion, bleeding complications, vascular complications, mortality and length of hospital stay.

The exclusion criteria are: any study being conducted that did not contain intervention

data; any study that did not provide a direct comparison between radial and femoral access; any review articles that did not contain original data; any editorials; any conference abstracts without complete data; and any studies that did not provide adequate methodologic information.

Study Selection

The first stage of the screening process involved screening each article by title/abstract for matching relevance to the scope of this Project. Articles that passed the title/abstract evaluation and seemed to meet the eligibility requirements were read in their entirety (full-text review). Studies fulfilling the inclusion requirements at the completion of the full-text review were included as an end result. All duplicate records across the various databases were deleted before the actual screening process began.

Data Extraction

Systematic extraction of the relevant information in each of the studies selected for the preparation of this review involved identifying the variables related to the findings of the study, including the type of data/analysis presented in the published literature. In addition to these variables, the date of publication, study design, number of patients included in the respective studies, characteristics of the patients studied, coronary lesion sub-type treated during each procedure, technical details of each procedure, and clinical outcomes reported for each procedure were also systematically extracted. Additionally, clinical outcomes with the greatest clinical significance were specifically evaluated, including procedural success, access site bleeding, complications related to an access site vascular injury, overall mortality, and length of hospitalisation after the procedure.

Outcome Measures

In this systematic review, the main outcomes were procedural success rates and the incidence of large blood loss (i.e., major bleeding episodes) from either radial (i.e., arm) or femoral (i.e., groin) access routes for catheterization (e.g., balloon angioplasty and stenting). The secondary outcomes examined were other complications related to the vascular access points used during these procedures, including: hematoma formation at the access site(s), development of pseudo-aneurysms due to puncture of the artery (which subsequently formed either a large or small collection of blood), complications due to occlusion of the artery (i.e., complete blockage of blood flow through the artery), amount of time in the hospital following the procedure(s), and overall

rate of successful recovery from the procedure(s).

Data Synthesis

In a qualitative manner, we summarized the results from our included studies by comparing them to each other, considering their outcome measures, and assessing how they compared between radial and femoral access for complex PTCA procedures. We aimed to find overarching themes among the studies with regard to safety, feasibility of the procedures, and the results that patients experienced. In addition, we also took into account the differences in how each study was designed, what types of patients were included, as well as how difficult each procedure was, when we analyzed the findings. By taking a structured approach to evaluating all of the literature related to this issue, we were able to gain an extensive understanding of the pros and cons associated with using both radial and femoral accesses for complicated coronary interventions.

Results

A systematic literature search has led to the discovery of many studies assessing and comparing the efficacy and safety of radial and femoral vascular access during difficult cases of percutaneous transluminal coronary angioplasty (PTCA). A series of these articles were then evaluated based on the possibility that they would meet the case definition as stated in this eligibility criteria, before ultimately being selected for inclusion in this qualitative synthesis of the literature on this subject. These articles included randomized clinical trials, cohort studies, and observational studies regarding patients undergoing complex coronary procedures, and they have reported outcomes such as success rates of procedures, bleeding complications, vascular complications, mortality rates, and lengths of stay in the hospital for these patients. The studies reviewed showed that the radial access method is associated with significantly fewer access-site bleeding complications than the femoral access method. Access-site bleeding is one of the most prevalent complications of coronary interventions, especially in patients taking dual antiplatelet therapy and anticoagulation during challenging procedures. Due to the superficial nature of the radial artery and the ease of compression and control of bleeding following catheter passage, radial access has a much lower risk for access-site bleeding than does femoral access; many studies consistently showed fewer major bleeding events, and fewer cases of hematoma formation associated with radial access compared to femoral access. Most

studies demonstrated that procedural success rates were the same for radial and femoral access methods. With improved experience of operators and advances in catheter technology, radial access has been successfully employed in the treatment of a variety of difficult coronary interventions, including bifurcation lesions, multivessel coronary disease, and heavily calcified coronary artery deposits. In addition to the above-mentioned advantages of the radial approach compared to the femoral approach for PTCA, some studies have found that the femoral approach offers greater catheter support for complex cases such as chronic total occlusions (CTOs) and left main coronary artery interventions that involve the use of larger guiding catheters and/or specialized devices. There were also fewer vascular complications associated with the radial approach than with the femoral approach. Vascular complications associated with femoral access include complications such as pseudoaneurysms, arteriovenous fistulas, retroperitoneal hemorrhages, and hematomas needing intervention. In contrast, complications arising from radial access tend to be less severe and easier to manage. One example is Radial Artery Occlusion, which may occur in a small percentage of patients, but most of these patients remain asymptomatic because of the dual arterial blood supply to the hand. Several studies reported a shorter length of stay (LOS) in the hospital following radial access procedures than following femoral access procedures. Patients with radial PTCA were able to ambulate earlier and have less requirement for post-procedure monitoring compared with patients having femoral access. Ambulating early can improve patient comfort and convenience, while also improving hospital staff efficiency and reducing overall healthcare costs. The mortality rates of patients with acute coronary syndrome studied in randomized controlled trials and observational studies show a greater trend towards mortality reduction or improvement with radial access surgery. It is believed that there is a strong correlation between lower rates of bleeding complications leading to improved survival outcomes in these patients. However, the difference in mortality rates between femoral access and radial access may also depend on other patient characteristics such as age, comorbidity, or risk factors, as well as procedural difficulty and provider experience in performing the procedure.

Overall, the data reviewed indicates that there are significant safety advantages of using the radial approach versus the femoral approach, especially with respect to bleeding complications and Vascular Complication rates,

and that the two approaches have nearly identical procedural success rates. However, the femoral approach will remain viable for selected cases where the complex nature of a procedure or requirement for larger catheters or devices, restrict the use of the radial approach. Consequently, the choice of the access route should be based on the specific patient's needs and characteristics, lesion complexity, and operator's experience.

Discussion

This systematic review of the literature compared the safety and effectiveness of radial versus femoral vascular access for patients undergoing complicated percutaneous coronary interventions (PCI). The majority of studies reviewed demonstrated that using a radial access site for PCI provides several safety advantages when compared to using a femoral access site [7]. Radiologists found that although both methods have similar procedural success rates, patients who were treated using radial access had fewer incidents of bleeding and adverse events related to vascular access [8]. In many centers, this information supports an increased acceptance by practicing interventional cardiologists of the radial access site as a preferred method for PCI. Among the most significant findings from this review was the large decrease in access-site bleeding complications when using a radial access site. Bleeding after coronary intervention has been associated with poor clinical outcomes, including an increase in morbidity, hospitalization length, and mortality. Patients experiencing complicated PCI usually require aggressive antithrombotic and antiplatelet therapy, which adds to their risk of developing a bleeding complication [9]. Due to the anatomy of the radial artery (e.g., the shallow depth of the artery and its proximity to the skin surface), compression of the artery is much easier to achieve and maintain after removing the catheter than when using a femoral access site, thereby decreasing the likelihood of developing bleeding. In addition to the substantially decreased number of access site bleeding complications, using a radial access site can also significantly decrease the incidence of vascular complications [10]. In patients treated through the femoral artery, complications such as hematoma formation, pseudoaneurysms, arteriovenous fistulas, and retroperitoneal hemorrhages may be more common and require further intervention (i.e., surgical repair or vascular closure). In general, the most common complications of using the radial artery as an access site for cardiovascular procedures are less severe than those seen with the femoral approach. In fact, most individuals

who suffer from radial artery occlusion post-procedure are asymptomatic due to the presence of collateral blood supply from the ulnar artery [11]. Most studies reviewed indicate comparable procedural success rates between the radial and femoral arteries for complicated percutaneous transluminal coronary angioplasty (PTCA) cases. The development of new interventional devices, the introduction of lower-profile catheters, and improved operator experience have increased the feasibility of using the radial artery for complicated coronary interventions. The radial approach has been successfully utilized for cases of multivessel disease, bifurcation lesions, and calcific coronary arteries [12]. However, when utilizing the radial artery for highly complex procedures requiring significant guide catheter support and/or large-bore devices, some challenges still exist. In selected complicated interventions, the femoral artery provides certain technical advantages. Procedures such as chronic total occlusion revascularization, complex left main intervention, and those requiring mechanical circulatory support devices generally require either larger guiding catheters or multiple access points [13]. In such cases, the increased diameter of the femoral artery allows for greater catheter stability and compatibility with devices. Although radial access has gained popularity, femoral access is still an important option in specific procedural scenarios. Another benefit associated with radial access procedures is that patients tend to have shorter hospital stays compared to those who undergo femoral access procedures. Following the use of the radial approach, patients tend to be able to mobilize sooner due to the lack of a requirement for prolonged bed rest for hemostasis [14]. This leads to improved patient comfort and satisfaction as well as more efficient use of hospital resources. Shorter hospital stays translate into reduced overall treatment costs for healthcare systems and improved patient throughput. Some studies conducted on larger samples indicate that patients treated using the radial approach have improved survival rates compared to those treated using the femoral approach, particularly among patients presenting with acute coronary syndromes. This has been attributed primarily to the decreased incidence of bleeding complications among patients treated via the radial approach. However, the degree of mortality reduction varies considerably across studies and is likely influenced by patient factors, procedural complexity, and institutional experience with radial techniques [15].

This systematic review highlights the increasing importance of using the radial artery for complicated PTCA cases. While using the radial

approach has distinct safety and comfort advantages, using the femoral approach remains an important option for particular high-complexity procedures. By judiciously selecting the appropriate vascular access site based on the patient, lesion complexity, and operator skill, optimal clinical outcomes may be achieved.

Limitations

There are a number of constraints associated with interpreting the results of this systematic review. The studies included in this review varied greatly with respect to study design, sample size, and patient populations. The evidence included in this systematic review came from both randomised trials but also from observational and cohort studies and may lead to heterogeneity in methodology and outcome reporting. Areas of difference in study design can have an impact on the strength of evidence provided, as such, we may limit our ability to make direct comparisons of study findings. The second limitation is related to the definition of complicated percutaneous transluminal coronary angioplasty (PTCA) throughout the different studies included in this review. In some studies complicated PTCA was defined based on specific lesion characteristics, for example chronic total occlusions, bifurcation lesions, calcified vessels or left main disease; in contrast, some studies defined complicated PTCA by including patients who presented with multivessel disease or haemodynamically unstable presentations. The inconsistency with which procedural complexity has been defined by the different studies could influence how we can interpret the rates of success and the rates of complications associated with complicated PTCA. The third limitation concerns the experience of the operator with the radial approach. Operator experience is an important variable in determining the overall outcome of the procedure. Most of the studies included in this review were performed in high-volume centres where the operators had significant amounts of expertise with transradial interventions. Therefore, the improved outcomes reported for the radial approach in these studies may not be as directly generalisable to centres with little experience with the radial approach. Another limitation relates to the fact that technology has changed over the course of time. Catheter design, sheath technology, and interventional devices have evolved and improved the feasibility of using the radial approach for complex coronary interventions. Studies using older technology would likely not be comparable to newer technology in comparing the radial and femoral approach. The possibility that publication bias

exists because studies showing favourable results using the radial approach are more likely to be published than a study that demonstrated neutral or unfavourable findings. Additionally, by limiting this review to studies written in English we may not have included a number of studies that may provide useful additions to our body of knowledge if they were published in other languages.

Finally, this review performed a qualitative synthesis of currently available research rather than including a quantitative meta-analysis; although this approach to synthesis allows for more thorough discussion of clinical findings, it does not provide a pooled statistical estimate of the effect of treatment. Despite these limitations, this review provides a thorough summarisation of the evidence comparing the radial and femoral approaches for complicated PTCA and provides clinical reasoning for selecting the most appropriate vascular access technique.

Conclusion

This systematic review's findings suggest that the radial route has significant safety benefits, including fewer access site related bleeding and vascular complications. Additionally, patients obtaining their access via radial access are able to begin moving sooner after the procedure than those with a femoral route and have shorter hospital stays, as well as greater comfort than those with a femoral route. These advantages are helping to increase the adoption of the radial route technique among interventional cardiologists treating patients today. Procedural success rates with the radial versus femoral routes will be comparable for many complex coronary interventions when performed by experienced operators. Newer catheter technology and advances in interventional devices will continue to increase the use of radial access for many challenging PTCA procedures. However, the femoral route still plays an important role in the care of specific highly complex interventions that require increased catheter guidance and/or larger devices to perform. Many times, the femoral route may provide a more suitable access route for chronic total occlusions, complex left main disease, and/or the use of mechanical circulatory support systems due to a larger vessel size, which will allow for better device compatibility with other devices. Because of the considerable differences in vessel size and procedure complexity when looking for a vascular access route, it is critical to choose the appropriate route for each specific case, taking into account the complexity of the intervention, the patient's particular characteristics, and the experience of the

operator performing the procedure. The use of a tailored approach to the selection of vascular access will help to maximize the chances of a successful procedure and minimize the chances of complications. This will ultimately result in improved outcomes for patients with the use of complicated PTCA interventions.

References

1. De Luca G, Schaffer A, Wirianta J, Suryapranata H. Comprehensive meta-analysis of radial vs femoral approach in primary angioplasty for STEMI. *Int J Cardiol.* 2013 Oct 3;168(3):2070-81. doi: 10.1016/j.ijcard.2013.01.161. Epub 2013 Mar 13. PMID: 23490083.
2. Koutouzis M, Matejka G, Olivecrona G, Grip L, Albertsson P. Radial vs. femoral approach for primary percutaneous coronary intervention in octogenarians. *Cardiovasc Revasc Med.* 2010 Apr-Jun;11(2):79-83. doi: 10.1016/j.carrev.2009.04.107. PMID: 20347796.
3. Chodór P, Kurek T, Kowalczyk A, Świerad M, Wąs T, Honisz G, Świątkowski A, Streb W, Kalarus Z. Radial vs femoral approach with StarClose clip placement for primary percutaneous coronary intervention in patients with ST-elevation myocardial infarction. RADIAMI II: a prospective, randomised, single centre trial. *Kardiol Pol.* 2011;69(8):763-71. PMID: 21850615.
4. Hu F, Yang Y, Qiao S, Xu B, Liu H, Wu Y, Chen J, You S, Chen J, Gao R. Comparison between radial and femoral approach for percutaneous coronary intervention in patients aged 80 years or older. *J Interv Cardiol.* 2012 Oct;25(5):513-7. doi: 10.1111/j.1540-8183.2012.00732.x. Epub 2012 May 11. PMID: 22575015.
5. Dziki B, Miechowicz I, Iwachów P, Kuzemczak M, Kałmucki P, Szyszka A, Baszko A, Siminiak T. Cath lab costs in patients undergoing percutaneous coronary angioplasty - detailed analysis of consecutive procedures. *Kardiol Pol.* 2017;75(9):914-921. doi: 10.5603/KP.a2017.0098. Epub 2017 May 25. PMID: 28541592.
6. Jolly SS, Yusuf S, Cairns J, Niemelä K, Xavier D, Widimsky P, Budaj A, Niemelä M, Valentin V, Lewis BS, Avezum A, Steg PG, Rao SV, Gao P, Afzal R, Joyner CD, Chrolavicius S, Mehta SR; RIVAL trial group. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *Lancet.* 2011 Apr 23;377(9775):1409-20. doi: 10.1016/S0140-6736(11)60404-2. Epub 2011 Apr 4. Erratum in: *Lancet.* 2011 Apr 23;377(9775):1408. Erratum in: *Lancet.* 2011 Jul 2;378(9785):30. PMID: 21470671.
7. Arzamendi D, Ly HQ, Tanguay JF, Chan MY, Chevallereau P, Gallo R, Ibrahim R, L'Allier P, Levesque S, Gosselin G, Deguise P, Joyal M, Gregoire J, Bonan R, Crepeau J, Doucet S. Effect on bleeding, time to revascularization, and one-year clinical outcomes of the radial approach during primary percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction. *Am J Cardiol.* 2010 Jul 15;106(2):148-54. doi: 10.1016/j.amjcard.2010.02.028. PMID: 20598995.
8. Barthélémy O, Silvain J, Brieger D, Mercadier A, Lancar R, Bellemain-Appaix A, Beygui F, Collet JP, Costagliola D, Montalescot G. Bleeding complications in primary percutaneous coronary intervention of ST-elevation myocardial infarction in a radial center. *Catheter Cardiovasc Interv.* 2012 Jan 1;79(1):104-12. doi: 10.1002/ccd.23164. Epub 2011 Dec 8. PMID: 22162411.
9. 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, Lioy E, Sheiban I, Sangiorgi G. 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 Dec 18;60(24):2481-9. doi: 10.1016/j.jacc.2012.06.017. Epub 2012 Aug 1. PMID: 22858390.
10. Chung S, Her SH, Song PS, Song YB, Hahn JY, Choi JH, Lee SH, Jang Y, Yoon JH, Tahk SJ, Park SJ, Choi SH, Seung KB, Gwon HC. Trans-radial versus trans-femoral intervention for the treatment of coronary bifurcations: results from Coronary Bifurcation Stenting Registry. *J Korean Med Sci.* 2013 Mar;28(3):388-95. doi: 10.3346/jkms.2013.28.3.388. Epub 2013 Mar 4. PMID: 23486858; PMCID: PMC3594602.
11. Alonzo A, Rigattieri S, Giovannelli F, Di Russo C, Sciahbasi A, Berni A, Volpe M. Transfemoral approach with systematic use of FemoSeal™ closure device compared to transradial approach in primary angioplasty. *Catheter Cardiovasc Interv.* 2016 Apr;87(5):849-54. doi: 10.1002/ccd.26076. Epub 2015 Jun 23. PMID: 26104978.

12. Sansanayudh N, Champasri K, Piamsomboon C, Sanguanwong S, Narksawasdee C, Tengtrakulcharoen P, Laotavorn P. The efficacy and safety of transradial approach in comparison with transfemoral approach for coronary angiography and ad hoc coronary angioplasty in Thailand. *J Med Assoc Thai*. 2010 Nov;93 Suppl 6:S145-51. PMID: 21280527.
13. Xia K, Ding RJ, Hu DY, Yang XC, Wang LF. [The efficacy and safety of transradial versus transfemoral approach for percutaneous coronary intervention in acute myocardial infarction]. *Zhonghua Nei Ke Za Zhi*. 2011 Jun;50(6):478-81. Chinese. doi: 10.3760/cma.j.issn.0578-1426.2011.06.008. PMID: 21781530.
14. Nadarasa K, Robertson MC, Wong CK, Green BK, Chen VH, Wilkins GT, Williams MJ. Rapid cycle change to predominantly radial access coronary angiography and percutaneous coronary intervention: effect on vascular access site complications. *Catheter Cardiovasc Interv*. 2012 Mar 1;79(4):589-94. doi: 10.1002/ccd.23120. Epub 2011 Jun 6. PMID: 21523899.
15. Subherwal S, Peterson ED, Dai D, Thomas L, Messenger JC, Xian Y, Brindis RG, Feldman DN, Senter S, Klein LW, Marso SP, Roe MT, Rao SV. Temporal trends in and factors associated with bleeding complications among patients undergoing percutaneous coronary intervention: a report from the National Cardiovascular Data CathPCI Registry. *J Am Coll Cardiol*. 2012 May 22;59(21):1861-9. doi: 10.1016/j.jacc.2011.12.045. PMID: 22595404; PMCID: PMC3908898.