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Safety and Feasibility of Retrograde Recanalization of Radial Artery Occlusion in Patients with Need for Repeated Wrist Procedures

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Keywords: Transradial access, Radial artery occlusion, Chronic total occlusion, Recanalization

Abstract

AIM: The purpose of the study was to present a new technique of retrograde recanalization of radial artery (RA) occlusion (RAO) in patients with need for repeated wrist access percutaneous angiographic procedures.

MATERIALS AND METHODS: During a 10-year period from March 2011–May 2021, 53 000 patients were referred for percutaneous coronary intervention (PCI) in a high-volume transradial center. RAO on angiography was documented in 1165 patients. Retrograde recanalization of RAO was attempted in 70 patients. The selected patients were with multiple previous bilateral wrist interventions (n = 3–9). Ipsilateral ulnar artery was usually rudimented or occluded and contralateral wrist approach could not be used. We examined clinical and procedure characteristics, access site bleeding and ischemic complications and procedural success of retrograde recanalization of RAO. Visual analog scale (VAS) score forearm pain assessment was performed after procedure. Technique: All patients had palpable pulse distal of previous puncture site due to collaterals from ipsilateral ulnar and interosseous artery. The RA was punctured with an inner metallic needle with a plastic cannula. Using retrograde radial angiography performed by injecting contrast through the plastic cannula, the occluded segment was visualized and crossed with different types of hydrophilic chronic total occlusion guide wires. After sheath insertion, balloon dilatation of the occluded RA segment, successful catheterization, and/or percutaneous coronary intervention was performed. Final RA angiography was performed on all patients.

RESULTS: Successful retrograde opening of RAO was achieved in 65 out of 70 patients (92%). PCI was performed in 56% of patients through the opened RAO and 5 patients underwent CAS. Procedural success through opened RA was achieved in all 65 patients. Forearm pain during procedure was present in all cases (VAS score 3 ± 2.1). Access site bleeding EASY score 3 and 4 occurred in 6 patients (8.5%). One patient had discharge of embolic material up the arm without clinical consequences. In one patient, we observed dissection of the interosseous artery. Clinical and duplex long-term follow-up with a median of 4.1 years showed patent RA in only 20 patients. There were no registered cases of hand ischemia. About 61% of patients underwent subsequent PCIs, through other alternative access sites.

CONCLUSION: Retrograde recanalization of RAO is successful and safe in patients with need of repeated coronary angiography procedures and inability to use other wrist access sites. Puncturing the collateral and performing retrograde radial angiography through the cannula is a key factor in successful opening of the RAO.

Introduction

Transradial arterial access (TRA) is the default access site for percutaneous cardiovascular interventions [1], [2], [3], [4]. Many published studies over the past 10 years proved decreased access site bleeding and vascular complications, reduced post-procedural costs and facilitation of same day discharge in using radial over femoral approach [5], [6], [7], [8], [9].

TRA is of particular benefit especially in STEMI and acute coronary syndrome patients, where it has proven to be superior to transfemoral arterial access (TFA) in decreasing rates of access site bleeding, mortality, and other major cardiovascular events [7], [8], [9], [10].

TRA is a technically more complex procedure than TFA with an associated learning curve [5], [6]. Radial approach can be challenging in cases with radial artery (RA) anomalies and/or high degree of spasm, not uncommon in the elderly and female patients [11], [12], [13]. Different strategies were implemented over the years by dedicated interventionalists to overcome these issues [14], [15], [16]. Still the greatest challenge in the field of radial access presents patients with multiple previous TRA, where RA occlusion (RAO) or sub-occlusion is present. Gaining a successful wrist access site in these patients can present a real issue for radial interventionalists. This problem is especially present in high-volume experienced transradial centers where most of the angiography procedures are performed using TRA access.

In this study, we aimed to examine the success and potential benefit of opening chronic RA occlusions for the purpose of re-using the RA for percutaneous procedures and providing a safe RA approach. This procedure is of great value especially in patients with

multiple repeated percutaneous coronary interventions (PCIs) through the RA, where preserving radial access and not crossing over to femoral is highly recommended with a great benefit to the patient [5], [6], [7], [8], [9].

Materials and Methods

Patient population

During a 10-year period from March 2011–May 2021, 53 000 patients were referred for PCI in a high-volume transradial center. RAO on angiography was documented in 1165 patients. Retrograde recanalization of RAO was attempted in 70 patients. All procedures were performed by experienced transradial operators (>300 diagnostic TRA procedures and >200 PCI procedures per year).

The selected patients had multiple previous bilateral wrist interventions (n = 2–9) and ipsilateral ulnar artery was usually rudimented or occluded and contralateral wrist approach could not be used. We examined clinical and procedure characteristics, access site bleeding and ischemic complications. Procedural success of retrograde recanalization of RAO and finishing the procedure through the opened RA was also documented. Patients were followed up clinically and with duplex ultrasound with a median of 49.8 ± 21 months. Forearm pain assessment was performed after the procedure. Patients with documented anatomic variations of RA from the previous transradial procedure, such as tortuosity of the vessel and high take off, were excluded from the study.

Technique

All patients had palpable pulse distal of previous puncture site due to collaterals from ipsilateral ulnar and interosseous artery. RA was punctured with an inner metallic needle and a plastic cannula (cannula-over-needle, from Radifocus™ Introducer II, Transradial Kit, Terumo, Japan). Using retrograde radial angiography performed by injecting contrast through the plastic cannula, the occluded segment of the RA was visualized and accessed. According to the type of occlusion/sub-occlusion, different techniques were used to open the vessel (Figures 1, 2 and 3).

Type 1 technique in retrograde recanalization of RAO

This was the most commonly technique used in 88% of patients, where the occluded segment was in place of the previous conventional RA puncture. RA is punctured distally from previous puncture, but still in the conventional RA puncture site. First the operator used the reverse tip of the lead spring mini guidewire (from Radifocus™ Introducer II, Transradial Kit, Terumo, Japan) going through the needle cannula to open the retrograde cap of the chronic total occlusion. Then the occluded segment was crossed with different types of hydrophilic chronic total occlusion (CTO) guide wires, with Pilot 200 guide wire (hi-torque pilot 200 guide wire: 0.014” × 190 cm, Abbott, Chicago, Illinois, United States) being

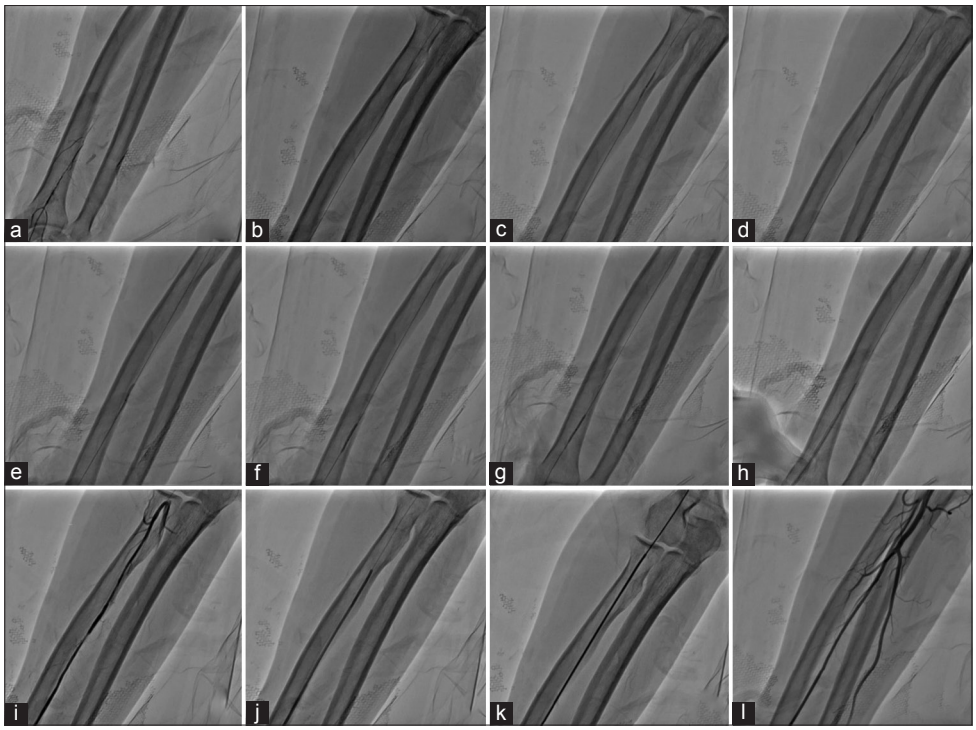


Figure 1: Type 1 technique in retrograde recanalization of radial artery occlusion (RAO). (a) Retrograde RA angiography thorough cannula. (b) Chronic total occlusion guide wire crossing of RAO. (c-g) Consequent balloon dilatations of the occluded vessel. (h-i) Introducer insertion and new RA angiography. (j-k) Catheter advancement. (l) Final angiography post percutaneous coronary intervention

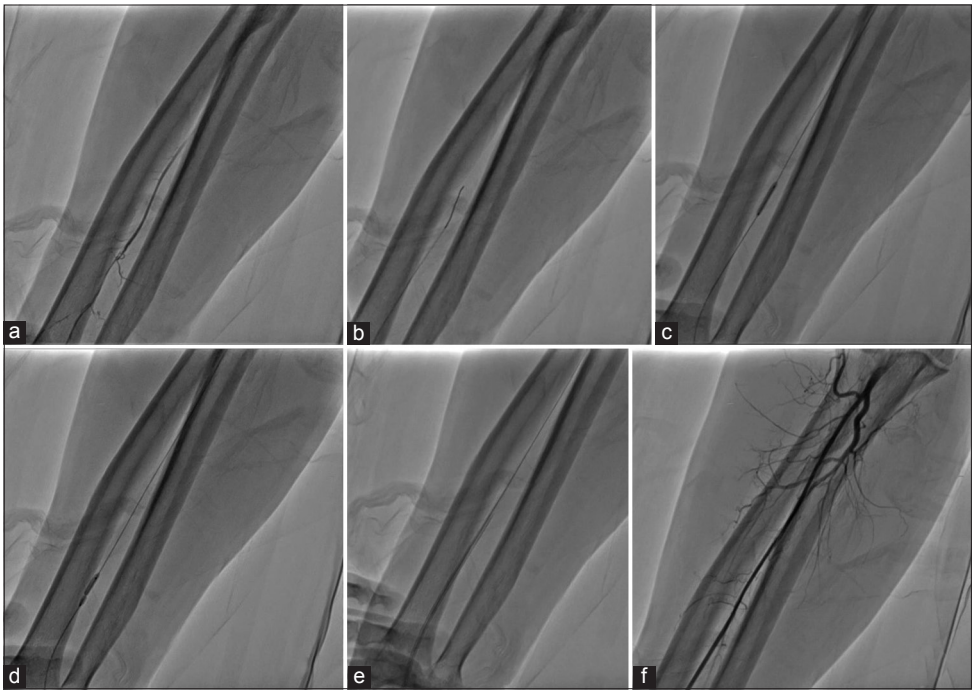


Figure 2: Type 2 technique in retrograde recanalization of sub-occluded radial artery (RA). (a) Retrograde RA angiography thorough canula. (b) Chronic total occlusion guide wire crossing of sub-occluded segment. (c-d) Consequent balloon dilatations of the occluded vessel. (e) Introducer insertion and new RA angiography. (f) Final angiography post percutaneous coronary intervention

most commonly used. This technique is used due to the short segment available for manipulation and the need for extra pushability. After successful wire crossing into the brachial artery, a short 5 or 6F sheath was partially advanced into the RA. Consequent balloon dilatations followed, with a full sheath insertion, after which a successful catheterization and/or PCI was performed.

Type 2 technique in retrograde recanalization of sub-occluded RA

When sub-occlusion was present, the same procedure is followed as in Type 1. Only hydrophilic CTO guidewires were used for lesion crossing and subsequent balloon dilatations with long coronary balloons on low atmospheres over 40 s dilatations.

Type 3 technique in retrograde recanalization of RAO through distal RA access puncture

In this technique, distal RA puncture was performed in the anatomical snuffbox. When distal TRA was achieved, sufficient space for introducing hydrophilic guide wires was available to open the occluded RA segment. The rest of the procedure after puncture is the same as Type 1.

RA puncture procedure

RA puncture and cannulation were performed using a counter-puncture technique with a 20 G plastic intravenous cannula and 0.025-inch mini guidewire of 45 cm followed by placement of a 5 French or 6 French hydrophilic introducer sheath (Terumo, Japan).

Spasmolytic cocktail (verapamil 5 mg) was given intra-arterially through the radial sheath which was applied only once during primary TRA.

After re-opening of the occluded RA, retrograde wrist arteriography [17] was performed again in all patients. A solution of 3 mL of contrast diluted with 7 mL of blood was injected through the side arm of the sheath under fluoroscopy in the posterior-anterior projection.

Before primary sheath insertion, an initial bolus of 5000 IU of unfractionated heparin was administered intravenously.

Post procedure management

The sheath in the RA was removed immediately after the procedure regardless of the level of anticoagulation, and a compressive dressing or a TR band was applied to the wrist to seal the new puncture site. Compression was applied for an approximately 3-h period with gradual deflation of the TR band after the 1st h. In distal TRA puncture, shorter hemostasis protocol was used up to 1 h with compressive dressing positioned at the anatomical snuffbox. Patent hemostasis was applied to all patients [18].

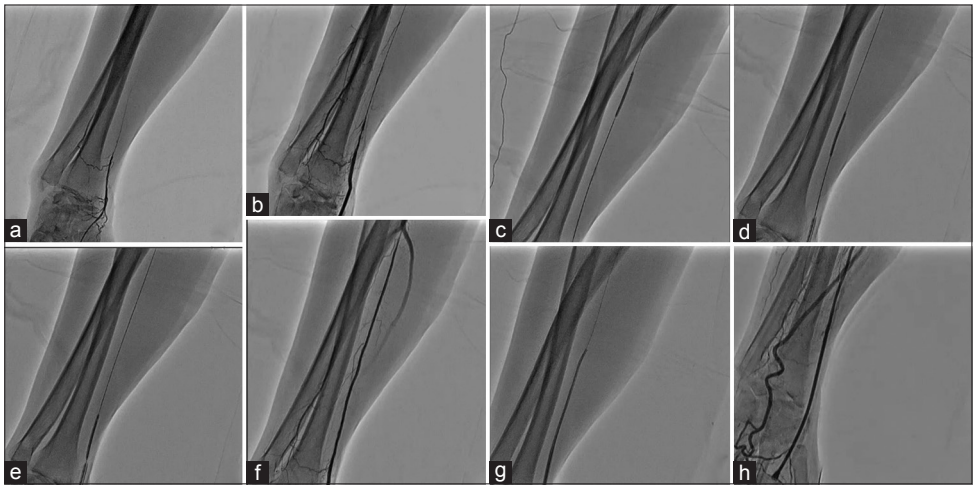


Figure 3: Type 3 technique with distal radial artery (RA) puncture in retrograde recanalization of RA occlusion (RAO). (a) Retrograde RA angiography thorough canula for chronic total occlusion (CTO) visualization. (b) CTO guide wire crossing of RAO. (c-e) Consequent balloon dilatations of the occluded vessel. (f) Result after balloon dilatation and sheath advancement on new RA angiography. (g) Catheter advancement. (h) Final angiography through distal transradial approach post percutaneous coronary intervention

Definitions

Access success was defined as opening of the occluded RA and gaining a successful TRA through the previously occluded RA.

Procedural success was defined as completion of the procedure through the opened RA access site without transfer to another arterial access site.

Procedure time was defined as time from the first puncture of RA until completion of the procedure.

Vascular access site complications were defined as the occurrence of a pseudoaneurysm, fistula, hematoma (EASY score 2–5), loss of radial or ulnar pulse or radial/ulnar nerve injury after procedure and during follow-up.

Hematoma was classified into five grades according to EASY score (Grade I: Local hematoma, superficial <5 cm; Grade II: Hematoma with moderate muscular infiltration; Grade III: Forearm hematoma and muscular infiltration, below the elbow; Grade IV: hematoma and muscular infiltration extending above the elbow; and Grade V: Ischemic threat - compartment syndrome) [19].

Hand ischemia was defined as an inadequate blood supply to the hand resulting in pain, discoloration, frank ulcerations, tissue necrosis, and/or gangrene of fingers, generally starting at the tips.

Major vascular complications were defined as hemoglobin drop >3 g/dL and requiring intervention or surgery and/or blood transfusion for bleeding attributable to a vascular access site.

Pain in the arm at follow-up was accessed with the visual analog scale (VAS) scoring system [20].

Statistical analysis

Categorical variables are expressed as numbers and percentages and continuous variables as the mean ± SD, or median (interquartile range). Statistical analysis was performed with JMP 23 for Windows (SAS Inc.).

Results

During a 10-year period from March 2011–May 2021, 53 000 patients were referred for PCI in a high-volume transradial center. RAO on angiography was documented in 1165 patients. Retrograde recanalization of RAO was attempted in 70 patients. Mean age of patients was 61.3 ± 11 years with 32% females. Among atherosclerosis risk factors, hypertension, diabetes, and smoking were most common in 51 (73%), 30 (42%), and 46 (65%) patients, respectively. This was a high-risk group of patients with prior MI in 70%. Multivessel disease was present in 34 patients (48%) with the previous CABG in 7% of patients. All patients had prior TRA access with the previous RA procedures ranging from 2 to 9 (Table 1).

Table 1: Baseline characteristics

Clinical variables	RAO patients (N = 70)
Age (years)	61.3 ± 11
Female	25 (35%)
BMI (kg/m^2)	26.7 (19-33)
CAD risk factor	
Hypertension	51 (72.8%)
Diabetes mellitus	30 (42%)
Dyslipidemia	25 (35%)
Smoking	46 (65%)
Prior TRA	70 (100%)
Prior MI	49 (70%)
Prior CABG	5 (7.1%)

RAO: Radial artery occlusion, BMI: Body mass index, TRA: Transradial approach.

Successful retrograde opening of RAO was achieved in 65 out of 70 patients (92%). PCI was performed in 56% of patients through the opened RAO and 5 patients underwent CAS. Procedural success through opened RA was achieved in all 65 patients.

Forearm pain during procedure was present in all cases assessed as 3 ± 1.1 on the VAS scale. There was inability to cross the occluded segment with wire in 5 patients (8%).

Procedure duration was 39.7 ± 18 min, contrast volume 140 ± 32 mL, and fluoroscopy time was 10.1 ± 12 min. 5 French sheath was used in 17% of patients and 6 French sheath (Terumo) in 83% of patients (Table 2).

Table 2: Procedural characteristics

Clinical variables	RAO patients (N = 70)
Technique 1	62 (88%)
Technique 2	5 (7.1%)
Technique 3	3 (4.2%)
Procedure success	65 (92%)
PCI	37/65 (56%)
CAS	5/65 (7.6%)
Fluoroscopy time min	10.1 ± 12
Contrast volume	140 ± 32 mL
Procedure time min	39.7 ± 18
Sheath size	
5F	12 (17%)
6F	58 (83%)

RAO: Radial artery occlusion, PCI: Percutaneous coronary intervention.

Access site bleeding easy score 3 and 4 occurred in 6 patients (8%). One patient had discharge of embolic material up the arm without clinical consequences. In 1 patient, we observed dissection of the interosseal artery. Clinical and duplex long-term follow-up at median of 49.8 ± 21 months showed patent RA in only 20 patients (30%). There were no registered cases of hand ischemia at follow-up. About 61% of patients underwent subsequent PCIs, through other access sites (Table 3).

Table 3: Access site complications

Clinical variables	RAO patients (N = 70)
Access site bleeding complications	
Hemathoma Grade 1	16 (22%)
Hemathoma Grade 2	15 (21.4%)
Hemathoma Grade 3	4 (5.7%)
Hemathoma Grade 4	2 (2.8%)
Hemathoma Grade 5	0 (0%)
Dissection of RA	2 (2.8%)
Major access site vascular complication	0 (0%)
Sign of hand ischemia	0 (0%)

RAO: Radial artery occlusion, RA: Radial artery.

Discussion

In this study, we found that retrograde opening of chronic RAO is safe and successful in patients with no other options for wrist access site percutaneous interventions.

At the present time, most of the world's interventionalists have already adopted the TRA as a default approach. According to the latest ESC and SCAI recommendations [1], [2], [3], [4], transradial approach should be the default approach for PCI in experienced transradial centers and therefore more attention should be paid to strategies for achieving successful transradial access [14], [15], [16], [18], [21]. Even the new ACC guidelines from 2021 propose the use of radial approach as a default approach, with numbers of TRA interventions increasing rapidly in the United States over the last decade [2]. Despite its proven advantages, certain characteristics of radial approach as the common occurrence of RAO, particularly when reusing this access site, are worth additional research for alternatives, intervention or even better, decreasing the number of this not so rare complication of TRA. Published studies about crossing over to other wrist access sites as the iplsilateral ulnar have proven to be safe and successful in preserving the benefits of radial access [22], [23]. Still, radial operators must try to conserve the patency of the RA and implement all available data on this topic to protect the RA from occlusion as an integral part of their practice.

Different risk factors for RAO have been reported in published data, including prolonged high-pressure compression especially in the early years of radial access, repeated puncture of the radial access site, and the presence of a small caliber RA. Also, many other factors may have an impact on the patency of the punctured RA, such as pre-procedural pharmacotherapy, use of spasmolytic cocktail (verapamil and intra-arterial nitroglycerin) and administration of i.v. UF Heparin before procedure. The post-procedural care has showed to be of the greatest significance in preserving a patent RA, as the patent hemostasis technique and the ulnar compression technique [18].

The implementation of patent hemostasis to decrease the rate of RAO using pulse oximetry by confirming hemoglobin oxygen saturation on the punctured RA (>90%) after hemostasis, was one of the crucial techniques in the field published by Pancholy *et al.* that changed the narrative of RAO [18]. This was the pivotal technique that saved countless radial arteries and allowed a safe re-use of not only the radial, but also ulnar arteries during wrist percutaneous interventions.

Still high-volume radial centers sometimes have a significant problem in achieving successful radial access in the high-risk group of patients with multiple wrist procedures which sometimes have more than ten PCI interventions performed through the RA. In most of these cases RAO is inevitable even when using patent hemostasis.

Several techniques have been published in the past dealing with the opening of a chronic total occlusion of the RA and re-using it for the following intervention [24], [25], [26], [27].

Mcquillan *et al.* [24] successfully adopted a retrograde coronary CTO strategy (a wire-based reentry into the upstream true lumen) to recanalize the RA. Mori and colleagues [25], in a case series of 22 patients, reported the feasibility and safety of a novel technique: transoccluded radial access via ultrasound guidance, for diagnostic catheterization or PCI. The success rate was 91% with 2 failed cases. Another interesting approach to the recanalization of RAO for

repeat arterial access was introduced by Valsecchi *et al.* [26]. They have successfully used an ipsilateral ulnar approach to recanalize RAO. Although these approaches are technically feasible, the durability of RAO recanalization and patency of the ulnar artery should be proven in large case series and at longer follow-up before any recommendations for wider clinical use can be made.

A new study published recently explored retrograde recanalization of RAO through distal TRA, which proved to be feasible with a 90% patency rate at 1 month follow-up [27]. In our study, we had a smaller rate of patency at long term follow up to 10 years, which shows that patency rate decreases over time.

Furthermore, it is important to note that transulnar access, like radial access, has the same benefits as a wrist puncture site. It reduces procedural time in primary PCI, saves the contralateral RA for future possible coronary artery bypass grafting and avoids the use of femoral access in all patients scheduled for PCI [22], [23]. We consider this access as the best alternative for right radial access even in the presence of RAO, with long-time experience of over 12 years in our center.

We believe that this technique of retrograde recanalization, although not intended for long-term recanalization and patency of the RA, appears safe and feasible for gaining radial access in patients with preexisting RAO, undergoing percutaneous angiographic procedures, when alternative vascular access is limited.

Conclusion

Retrograde recanalization of RAO is successful and safe in patients with need of repeated coronary angiography procedures and inability to use other wrist access sites. We can use this technique when other access options are limited. Puncturing the collateral and performing retrograde radial angiography through the cannula is a key factor in successful opening of the RAO.

References

1. Shroff AR, Gulati R, Drachman DE, Feldman DN, Gilchrist IC, Kaul P, *et al*. SCAI expert consensus statement update on best practices for transradial angiography and intervention. Catheter Cardiovasc Interv. 2020;95(2):245-52. https://doi.org/10.1002/ccd.28672
   PMid:31880380
2. Writing Committee Members, Lawton JS, Tamis-Holland JE, Bangalore S, Bates ER, Beckie TM, *et al*. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: A report of the American college of cardiology/American heart association joint committee on clinical practice guidelines. J Am Coll Cardiol. 2022;79(2):e21-129. https://doi.org/10.1016/j.jacc.2021.09.006
   PMid:34895950
3. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, *et al*. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2018;39(2):119-77. https://doi.org/10.1093/eurheartj/ehx393
   PMid:28886621
4. Hamon M, Pristipino C, Di Mario C, Nolan J, Ludwig J, Tubaro M, *et al*. Consensus document on the radial approach in percutaneous cardiovascular interventions: Position paper by the European Association of Percutaneous Cardiovascular Interventions and Working Groups on Acute Cardiac Care** and Thrombosis of the European Society of Cardiology. EuroIntervention. 2013;8(11):1242-51. https://doi.org/10.4244/eijv8i11a192
   PMid:23354100
5. Rao SV, Cohen MG, Kandzari DE, Bertrand OF, Gilchrist IC. The transradial approach to percutaneous coronary intervention: Historical perspective, current concepts, and future directions. J Am Coll Cardiol. 2010;55(20):2187-95. https://doi.org/10.1016/j.jacc.2010.01.039
   PMid:20466199
6. Jolly SS, Yusuf S, Cairns J, Niemelä K, Xavier D, Widimsky P, *et al*. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): A randomised, parallel group, multicentre trial. Lancet. 2011;377(9775):1409-20. https://doi.org/10.1016/S0140-6736(11)60404-2
   PMid:21470671
7. Romagnoli E, Biondi-Zoccai G, Sciahbasi A, Politi L, Rigattieri S, Pendenza G, *et al*. Radial versus femoral randomized investigation in ST-segment elevation acute coronary syndrome: The RIFLE-STEACS (Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) study. J Am Coll Cardiol. 2012;60(24):2481-9. https://doi.org/10.1016/j.jacc.2012.06.017
   PMid:22858390
8. Valgimigli M, MATRIX investigators. Design and rationale for the Minimizing Adverse haemorrhagic events by TRansradial access site and systemic Implementation of angioX program. Am Heart J. 2014;168(6):838-45.e6. https://doi.org/10.1016/j.ahj.2014.08.013
   PMid:25458646
9. Kedev S, Zafirovska B, Kalpak O, Antov S, Kostov J, Spiroski I, *et al*. Macedonia: Coronary and structural heart interventions from 2010 to 2015. EuroIntervention. 2017;13(Z):Z47-50. https://doi.org/10.4244/EIJ-D-16-00827
   PMid:28504230
10. Kedev S, Zafirovska B, Antov S, Kostov J, Spiroski I, Boshev M, *et al*. Total wrist access for angiography and interventions: Procedural success and access site crossover in a high volume transradial center. Cardiovasc Revasc Med. 2017;19(5 Pt B):570-4. https://doi.org/10.1016/j.carrev.2017.12.009
    PMid:29452842
11. Biljana Z, Danica P, Slobodan A, Ivan V, Aleksandar J, Oliver K, *et al*. Radial artery anomalies in the Macedonian population during transradial angiography procedures. Sanamed Med J.

2016;11(2):87-92. https://doi.org/10.5937/sanamed1602087Z

12. Burzotta F, Brancati MF, Trani C, Tommasino A, Porto I, Niccoli G, *et al*. Impact of radial-to-aorta vascular anatomical variants on risk of failure in trans-radial coronary procedures. Catheter Cardiovasc Interv. 2012;80(2):298-303. https://doi.org/10.1002/ccd.24360
PMid:22431342
13. Lo TS, Nolan J, Fountzopoulos E, Behan M, Butler R, Hetherington SL, *et al*. Radial artery anomaly and its influence on transradial coronary procedural outcome. Heart. 2009;95(5):410-5. https://doi.org/10.1136/hrt.2008.150474
PMid:18977799
14. Patel T, Shah S, Pancholy S, Rao S, Bertrand OF, Kwan T. Balloon-assisted tracking: A must-know technique to overcome difficult anatomy during transradial approach. Catheter Cardiovasc Interv. 2014;83(2):211-20. https://doi.org/10.1002/ccd.24959
PMid:23592578
15. Mamas MA, George S, Ratib K, Kwok CS, Elkhazin A, Sandhu K, *et al*. 5-Fr sheathless transradial cardiac catheterization using conventional catheters and balloon assisted tracking; a new approach to downsizing. Cardiovasc Revasc Med. 2017;18(1):28-32. https://doi.org/10.1016/j.carrev.2016.09.003
PMid:27707595
16. Vasilev I, Spiroski IM, Kostov J, Zafirovska B, Jovkovski A, Taravari H, *et al*. Microcatheter crossing of radial artery loops and tortuosities: New ideas in reducing trans radial approach crossover. South East Eur J Cardiol. 2021;2(1):7-11. https://doi.org/10.3889/seejca.2021.6026
17. Zafirovska B, Antov S, Kostov J, Spiroski I, Vasilev I, Jovkovski A, *et al*. Benefit of routine preprocedural radial artery angiography in STEMI patients. Catheter Cardiovasc Interv. 2018;93(1):25-31. https://doi.org/10.1002/ccd.27711
PMid:30079496
18. Pancholy SB, Bernat I, Bertrand OF, Patel TM. Prevention of radial artery occlusion after transradial catheterization: The PROPHET-II randomized trial. JACC Cardiovasc Interv. 2016;9(19):1992-9. https://doi.org/10.1016/j.jcin.2016.07.020
PMid:27712733
19. Bertrand OF, De Larochelliere R, Rodes-Cabau J, Proulx G, Gleeton O, Nguyen CM, *et al*. A randomized study comparing same-day home discharge and abciximab bolus only to overnight hospitalization and abciximab bolus and infusion after transradial coronary stent implantation. Circulation. 2006;114(24):2636-43.
https://doi.org/10.1161/circulationaha.106.638627
PMid:17145988
20. Delgado DA, Lambert BS, Boutris N, McCulloch PC, Robbins AB, Moreno MR, *et al*. Validation of digital visual analog scale pain scoring with a traditional paper-based visual analog scale in adults. J Am Acad Orthop Surg Glob Res Rev. 2018;2(3):e088. https://doi.org/10.5435/jaaosglobal-d-17-00088
PMid:30211382
21. Seto AH, Roberts JS, Abu-Fadel MS, Czak SJ, Latif F, Jain SP, *et al*. Real-time ultrasound guidance facilitates transradial access: RAUST (Radial Artery access with Ultrasound Trial). JACC Cardiovasc Interv. 2015;8(2):283-91. https://doi.org/10.1016/j.jcin.2014.05.036
PMid:25596790
22. Kedev S, Zafirovska B, Dharma S, Petkoska D. Safety and feasibility of transulnar catheterization when ipsilateral radial access is not available. Catheter Cardiovasc Interv. 2014;83(1):E51-60. https://doi.org/10.1002/ccd.25123
PMid:23832623
23. Zafirovska B, Jovkovski A, Vasilev I, Taravari H, Kitanoski D, Petkoska D, *et al*. Ipsilateral transulnar artery approach catheterizations after failure of the radial approach-Are two sheaths in the same arm safe? Catheter Cardiovasc Interv. 2021;99(2):411-7. https://doi.org/10.1002/ccd.29778
PMid:34047429
24. Mcquillan C, Egred M. Drive-by radial artery re-entry: Extending chronic total occlusion techniques to the peripheral arteries. JACC Case Rep. 2020;2(15):2404-7. https://doi.org/10.1016/j.jaccas.2020.09.013
PMid:34317181
25. Mori S, Hirano K, Makino K, Honda Y, Tsutsumi M, Sakamoto Y, *et al*. Feasibility of ultrasound-guided transoccluded radial access for coronary angiography or percutaneous coronary intervention. JACC Cardiovasc Interv. 2020;13(17):2088-90. https://doi.org/10.1016/j.jcin.2020.06.035
PMid:32912468
26. Valsecchi O, Nardin M, Vassileva A, Bernelli C. Transulnar recanalization of a chronic radial artery occlusion. Cardiovasc Revasc Med. 2017;18(7):504-6. https://doi.org/10.1016/j.carrev.2017.04.011
PMid:28600020
27. Achim A, Kákonyi K, Jambrik Z, Olajos D, Nemes A, Bertrand OF, *et al*. Distal radial artery access for recanalization of radial artery occlusion and repeat intervention: A single center experience. J Clin Med. 2022;11(23):6916. https://doi.org/10.3390/jcm11236916
PMid:36498491