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Review / Derleme

Transradial Approach in Coronary Angiography from Past to Present

Geçmişten Günümüze Koroner Anjiyografide Transradyal Yaklaşım

Serhat Günlü[a*]

[a] Assistant Professor, Mardin Artuklu University, School of Medicine, Department of Cardiology, Mardin, Türkiye.
[*] Corresponding Author, E-mail: serhat8086@hotmail.com

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ABSTRACT

The transradial approach is a novel method for coronary angiography and percutaneous coronary intervention. Its popularity has grown since its initial application and is now a common technique in many facilities. This is because the transradial approach is less invasive than the conventional approach, which requires catheter placement into the coronary arteries. Transradial access is safer than trans-femoral access because it results in fewer complications at the interventional site, requires a shorter hospital stay, enables the patient to be mobilized sooner, provides a higher degree of patient comfort, and carries a lower risk of significant bleeding events. This research examines the advantages of accessing coronary arteries through the radial artery, as well as the suggestions made by the guidelines and the challenges generated by the technique. All these issues were discussed in light of existing studies.

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ÖZET

Transradyal yaklaşım, koroner anjiyografi (CAG) ve perkütan koroner girişim (PCI) için yeni bir yöntemdir. İlk uygulamasından bu yana popülaritesi arttı ve şimdi birçok tesiste yaygın kullanılmaktadır. Bunun nedeni, transradyal yaklaşımın, koroner arterlere kateter yerleştirilmesini gerektiren geleneksel yaklaşımdan daha az invaziv olmasıdır. Transradial erişim, girişim bölgesinde daha az komplikasyona neden olması, daha kısa hastanede kalış süresi gerektirmesi, hastanın daha erken mobilize olmasını sağlaması, daha yüksek derecede hasta konforu sağlaması ve daha düşük risk taşıması nedeniyle trans-femoral erişimden daha güvenlidir. Bu makale, koroner arterlere radyal arter yoluyla erişmenin faydalarını, kılavuzların önerilerini ve tekniğin gündeme getirdiği sorunları incelemektedir. Tüm bu konular araştırmalar ışığında tartışılmaktadır.

1. Introduction

Coronary Angiography (CAG) and Percutaneous Coronary Intervention (PCI) can be performed via femoral, brachial, and radial arteries. The preferred access route was the femoral artery. Studies have shown that it is associated with a high vascular and bleeding intervention complication rate (1,2). Including shorter hospital stay duration, patient comfort, and major bleeding events, the transradial intervention has shown fewer complications than the trans-femoral intervention (3,4). The radial artery has a superficial course, so hemostasis can be easily achieved after the procedure. When an occlusion occurs in the radial artery due to the procedure, the ulnar artery supplies the bloodstream of the hand. Thus, hand ischemia can be avoided (5,6). Although the radial artery remains patent in most cases after transradial CAG, physical damage to the arterial endothelium may impair vascular vasodilator function and cause intimal thickening and diffuse stenosis (7). The deterioration of the remodelling and vasodilation response in the artery after transradial CAG affects the quality of the radial artery, making it difficult to use the radial artery as a bypass graft or dialysis shunt in the future (8).

2. History of Transradial Intervention

The transradial approach to diagnostic angiography was first reported by Campeau et al. in 1989 (9). In 1992, Kiemeneij performed stent implantation using a transradial approach (10). The feasibility and reliability of PCI were later proven in several studies (11). In emergency cases, when access to the radial artery became difficult, intervention from the ulnar artery was used (12). Although there is a non-inferior alternative option for forearm access, it has

not gained popularity among experienced interventional cardiologists. Instead of ulnar artery access, interventional cardiologists tried the distal radial artery, which is less than the diameter of the ulnar artery (13). First, Kiemeneij et al. used a distal transradial approach (snuffbox) instead of traditional radial access (14). Indications have not yet been determined. It is preferred in elderly patients with a high probability of bleeding. Although it is still not included in the guideline recommendations, it has fewer complications and a high success rate than traditional radial access. Hemostasis was seen faster than traditional access in studies. Since the CAG procedure applied through the radial artery was defined, it has been increasingly accepted worldwide, has become a standard approach in many centers, and has started to be included in the guidelines in recent years. The recommendations of the European Society of Cardiology (ESC) guidelines regarding radial interventions are summarized in Table 1 (15).

Table 1. ESC guideline recommendations

Guidelines	Recommendations	Class	Evidence level
2017 STEMI guideline	Radial access should be preferred to femoral intervention when performed by a qualified radial operatör	I	A
2017 Guidelines for dual antiplatelet therapy in acute coronary syndrome	It is recommended that radial access is preferred to femoral intervention for coronary angiography and PCI when performed by a specialist radial operator.	I	A
2017 Peripheral arterial diseases guideline	Radial as first-line coronary angiography in patients with lower extremity arterial disease intervention is recommended.	I	C
2018 Myocardial revascularization guideline	Radial intervention is recommended as the standard approach unless there is a contrary situation regarding the procedure.	I	A
2019 Guidelines for diagnosis and treatment of chronic coronary syndromes	Radial intervention is recommended in elderly patients to reduce puncture site bleeding complications.	I	B
2020 NSTEMI guideline	Radial intervention is recommended as the standard approach unless there is a contrary situation regarding the procedure.	I	A

ESC: European Society of Cardiology, STEMI: ST-elevated Myocardial Infarction, NSTMI: Non-ST elevated Infarction, PCI: Percutan Coronary Intervention.

3. Advantages and Disadvantages

There are no major nerves or vessels near the radial artery, minimizing the risk of nerve and vascular injuries during the transradial intervention (16). The advantages of transradial intervention include a lower risk of bleeding, lower morbidity, lower total hospital costs, early discharge, higher patient comfort, and lower risk of ischemia in the hand due to double blood supply (17). Transradial intervention allows the treatment of patients and lesions of the same type as a trans-femoral intervention but allows it to be performed successfully in complex PCI (e.g., left main coronary lesions, chronic total occlusions, and bifurcation lesion interventions). Transradial CAG is technically a trans-femoral CAG due to difficulties in cannulating the radial artery during the procedure, anatomical variations, the possibility of spasms, and more complex difficulties in manipulating the catheter process (18,19). All these difficulties cause the need. Operator experience is important in transradial coronary angiography (20). In a study evaluating 532 transradial CAG procedures, 260 right radial and 272 left radial intervention methods; it was revealed that the radial cannulation time of the operators during the radial intervention training time phases decreased gradually over time for both radial approaches (at the initial stage of training, the procedures were followed by the left radial approach <40% requires ≤3 min. for radial cannulation, while radial cannulation time in the final stage was ≤3 min. in >60% of procedures ($p<0.001$) (21). In another study of operator experience in transradial intervention, it was found that operators without experience of radial intervention at the baseline of analysis had longer fluoroscopy and procedure times than those with experience (8 vs 4.4 minutes, $p=0.02$ and 32 vs. 22 minutes, $p<0.01$), but no difference was detected between the groups in the last 3 months of the analysis (5.2 vs. 4.5 and 26 vs. 19 min, p=non-significant, respectively) (22). Crossing the radial artery and aortic arch with guide wires and catheters is more difficult and requires more technique than the femoral approach. Therefore, the training process of the radial intervention is more difficult than the femoral intervention (T1, T2). Catheter orientation and insertion maneuvers into the femoral coronary openings vary according to the intervention. Therefore, the experience of the process operator plays a very important role in its success.

3.1. Advantages

- The risk of developing ischemia in hand is low due to a double blood supply.
- It is advantageous for patients with the severe obstructive aortoiliac disease.
- The vein can be compressed easily.
- It is advantageous in patients with obesity and back pain.
- It is a low-risk area in terms of local nerve injury.
- The risk of vascular complications is low.

- Provides early discharge opportunity.

3.2. Disadvantages

- Since it has small dimensions (approximately 2-3 mm in diameter), it may be difficult to poke.
- Small sheath sizes are required.
- Vascular spasms may be observed more frequently compared with other intervention methods.
- Catheter manipulation is difficult and requires a different learning technique.
- Many of these disadvantages can be mitigated with improved equipment and increased operator experience.

4. Transradial Intervention in ST-Elevation Myocardial Infarction

In the management of ST-Elevation Myocardial Infarction (STEMI) rapid reperfusion is the most important focus. However, bleeding complications should not be disregarded. It has been shown to reduce intervention site complications in patients with transradial intervention with STEMI undergoing primary PCI (23). The multicenter, randomized study of MATRIX showed that STEMI patients using the radial access route had a lower incidence of bleeding complications but similar overall major cardiovascular events compared to the femoral access route (24). Because STEMI treatment requires high levels of systemic anticoagulation and antiplatelet therapy, the lower incidence of site bleeding complications with the radial intervention compared to the femoral intervention seems to be one of the benefits of transradial intervention in this patient population (25). However, observational data from studies performed despite increased gate-balloon times in transradial CAG showed that intervention site complications and mortality were reduced (26). According to the results of a meta-analysis of 14 randomized studies including 3758 patients evaluating vascular intervention failure rates, fluoroscopy time, gate balloon time, and contrast volume of the transradial and trans-femoral approaches, the intervention site failure rate was significantly higher in transradial CAG than in trans-femoral CAG (RR: 3.30; CI: 2.16-5.03; 1% vs. 4%, p<0.001). In a recent meta-analysis of 11,992 patients and 17 studies that performed a sequential analysis of randomized controlled trials comparing transradial versus trans-femoral intervention in patients with STEMI, a lower 30-day mortality rate was found in the transradial CAG group. [OR (95% CI), 0.72 (0.58-0.90), p=0.003], major bleeding [OR (95% CI), 0.62 (0.49-0.79), p=0.001], major adverse cardiovascular event ratio [OR (95% CI), 0.74 (0.58-0.93), p=0.001] and fewer site complications [OR (95% CI), 0.37 (0.28-0.48), p<0.001] were observed (27).

4.1. Allen test

Before the transradial CAG procedure, the Allen Test (AT) can be used to evaluate whether hand circulation is adequately provided by the ulnar artery. However, whether this test can predict ischemia in hand, and in many centers, the Allen test is not routinely performed before transradial CAG. In a study evaluating the safety and feasibility of Allen's test in transradial coronary catheterization, 203 patients (three groups with normal Allen test (n=83), moderate (n=60), and abnormal (n=60)) were used for thumb capillary lactate level, plethysmography, and ulnar frame measurements. Post-procedure lactate levels (1.85±0.93 mmol/l in the normal AT group, 1.85±0.66 mmol/l in the moderate AT group, and 1.97±0.71 mmol/l in the abnormal AT group; p= 0.59) or at other time points during the study did not differ between the 3 study groups. In the groups whose Allen test was not normal, ulnar circulation evaluated by plethysmography after transradial CAG improved compared to baseline, and ulnar artery flow improved. These findings show that ulnar flow improves after radial approach in patients with abnormal Allen tests. No complications of hand ischemia were observed in the study. This study shows that there is an increase in ulnar artery blood flow after transradial CAG in patients with defective Allen tests and supports not deciding on the transradial CAG procedure based on the Allen test results (28).

4.2. Radial artery ultrasonography

The radial artery is superficial, usually easily palpable, and relatively small (2-3 mm in diameter). However, the radial arteries may be calcified or have anatomical variants that complicate vascular access. Problems in radial artery cannulation are the leading (57%) cause of failure in transradial procedures (29). Although radial artery intervention is usually performed by manual palpation, studies have suggested ultrasonography (USG) guided intervention to increase cannulation success rates and reduce port-site complications. Two-dimensional (2D) radial artery USG may be useful for evaluating the radial artery size and anomalies before the procedure and guiding the intervention during the procedure. USG is useful in determining arterial puncture and intraluminal wire position before sheath insertion by visualizing the location of the radial artery, needle tip, and wire. A multicenter randomized study involving 69 patients showed that USG-guided puncture reduced the number of attempts compared to palpation (mean 1.65±1.2 vs. 3.05±3.4, p<0.001), first pass success rate improved (64.8% vs. 43.9%; p<0.001) and decreased intervention time (88±78 s vs 108±112 s; p=0.006) (30).

4.3. Complications of transradial interventions

Although the transradial approach is safer than trans-femoral, some complications could be seen for PCI and CAG. Radial artery sheaths

usually have a hydrophilic coating to minimize vasospasms. However, agents such as verapamil, diltiazem, nitroglycerin, papaverine, or adenosine can also be used to prevent spasms that may occur in the radial artery (31). Heparin is routinely administered to prevent thrombosis at the sheath insertion site during the transradial intervention procedure. Symptomatic radial artery occlusion (RAO), non-occlusive radial artery injury, and radial artery spasm are common transradial complications. Pseudoaneurysm and radial artery perforation have been reported as rare complications. Among the risk factors; penetrating injury to the arterial wall during cannulation, multiple punctures to the artery, catheter infection, aggressive anticoagulant therapy, and large sheath sizes used during the procedure can be considered (32). The intervention site complications that may develop after transradial CAG are summarized in Table 2.

Table 2. Intervention site complications after transradial CAG

Non-occlusive radial artery injury	Spasm
Radial artery occlusion	Pseudoaneurysm
Perforation	Bleeding/hematoma
Wound infection	Nerve damage/regional pain syndrome
Compartment syndrome	Arteriovenous fistula

In the multicenter MATRIX study of 8,404 patients with acute coronary syndrome, the radial intervention was found to be associated with reduced all-cause mortality, surgical site repair, and blood transfusion need. There was no significant difference in the incidence of RAO within one year between the groups after transradial CAG (8.57% vs 12.84%; p=0.313) (33). In addition, no significant difference was observed in the incidence of local vascular complications during hospitalization. Based on the results of this study, the 7-Fr sheath did not increase the incidence of RAO in the short or long term after transradial CAG compared with the 6-Fr sheath (34).

4.4. Radial artery function after intervention

The long-term patency of the bypass graft depends on normal endothelial function. Post-radial CAG or PCI, normalization of flow-mediated vasodilation, and normal endothelial function are important (35). In a study involving 200 patients evaluating the efficacy and safety of the distal radial and conventional radial approaches during coronary angiography, it was found that the arterial cannulation time was longer in the distal group than in the conventional group (269±251 s vs 140±161 s; p<0.001) (36). However, hemostasis time was shorter in patients who underwent distal radial intervention than in patients who underwent conventional radial intervention (568±462 s vs 841±574 s; p=0.002). According to the results of the study, the distal radial approach had lower successful cannulation rates and a shorter time than the conventional radial approach. In the radial artery patency study, which included 510 patients with three-vessel disease, the radial graft was compared with the saphenous graft. Functional graft occlusion was lower in the radial artery graft than in the saphenous graft (12% vs. 19.7%; p=0.003) (37). Similarly, complete graft occlusion was observed less frequently in the radial artery group (8.9% vs. 18.6%; p=0.002). The study results showed that radial artery grafts are superior to saphenous grafts in long-term follow-up.

5. Conclusion

The use of the transradial intervention method in CAG and PCI has become increasingly widespread worldwide and has become the standard approach in many centers. Fewer complications and less bleeding especially in the elderly population, have directed experienced invasive cardiologists to transradial intervention.

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