Transradial approach in diagnostic and therapeutic interventional coronary artery procedures

Tanısal ve tedavi edici girişimsel koroner arter işlemlerinde radiyal arter kullanımının yeri

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Transradial access was first used in 1989 for diagnostic coronary angiography. With further improvements in the technique, it has gained wide popularity in percutaneous transluminal coronary angioplasty and percutaneous coronary interventions including stenting. When performed with appropriate indications, the transradial approach is a preferable technique for coronary interventions due to lower rate of bleeding complications, increased patient comfort, shorter hospital stay and follow-up period, and decreased workload.

Key words: Angioplasty, transluminal, percutaneous coronary/methods; coronary angiography; femoral artery; heart catheterization; radial artery.

Transradiyal yaklaşım ilk kez 1989 yılında tanısal koroner anjiyografi için uygulanmıştır. Ardından geliştirilerek perkütan translüminal koroner anjiyoplasti ve stentleme gibi perkütan koroner girişim işlemlerinde kullanılmaya başlanmıştır. Girişimsel koroner arter işlemlerinde radiyal arter kullanımı, kanama komplikasyonlarının az görülmesi, hasta konforu, hastanede yatış ve takip süresinin kısa olması ve sağlık personelinin iş yükünde azalma sağlaması nedeniyle tercih edilir hale gelmiştir.

Anahtar sözcükler: Anjiyoplasti, translüminal, perkütan koroner/yöntem; koroner anjiyografi; femoral arter; kalp kateterizasyonu;radial arter.

The radial artery was first used in 1989 for invasive coronary interventions and is currently a more preferred approach due to its several advantages.[1-4]

Historical development of the radial artery

Use of the radial artery has been on the increase for approximately 20 years now. Patients with acute myocardial infarction were especially avoided as much as possible during the early days of transradial intervention use. However, recent studies have demonstrated that primary percutaneous coronary intervention (PCI) via the radial route is safe and has produced successful results.[5-9] Studies performed in patients who underwent anticoagulation therapy have also demonstrated that the radial approach is safe.[10,11] On the other hand, a variety of aggressive anticoagulation treatment are being used in accordance with current guidelines in the patients who present with acute coronary syndrome treatment; however, an increased rate of bleeding complications (7% risk of bleeding with the used of the femoral route and glycoprotein IIb/IIIa inhibitor) has been reported when invasive procedures were administered using the femoral route during the early stage. Use of the radial route in this group of patients may eliminate conditions which delay discharge from the hospital after treatment by decreasing the risk of bleeding complication.[10,12,13]

Many studies have shown that the transradial approach can be used safely and successfully in the management of unprotected left main coronary artery lesions, chronic complete obstruction of the coronary artery, invasive interventions for renal, cerebral artery and saphenous bypass grafts.[14-17]

With advances in technology, low profile balloons and stents have been developed facilliating interventions. When necessary, radial artery intervention may be performed in selected cases, particularly on male patients using the 6F or 7F catheter.[18,19]

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The radial artery and usage properties

The most important advantages of radial artery use are its superficial nature, the absence of structures such as nerves and veins in the vicinity, making it possible for the development of fewer site complications.[20] It is also important to evaluate the structure of the palmar vessels before using the radial artery. The Allen test is mostly used. The ischemic Allen test is the condition where there is absence of blood flow to the hand and provision made from the ulnar artery alone after elimination of pressure exerted on the radial and ulnar arteries. The radial artery is said to be safe for use even under this condition.[18] Normally, a few minutes after the ischemic Allen test, there is frequently a reversion to normal condition associated with delay in the collateral flow. Despite abnormal results were obtained from 14% of patients who underwent the Allen test alone, placement of the pulse oximeter probe when applying pressure on the radial and ulnar arteries would provide additional information on capillary refilling and reactive hyperemia.[21]

Radial intervention training requires a lengthily period.[22] In a study conducted in Turkey Yigit et al.[23] compared use of the femoral and radial arteries in 180 patients who underwent diagnostic coronary angiography. Duration of the procedure and the related radiation and quantity of contrast substance used was found to be more, and the success rate was low in the patients group with radial artery use. The different results obtained in this first randomized trial in Turkey as opposed to results from Western countries may have been due to the traditional use of the femoral route for invasive interventions. The radial route is not used for the placement of a temporary pacemaker or an intraaortic balloon pump or for procedures requiring an 8F catheter. The other disadvantages include interventions on vessels with small diameter, high incidence of arterial anomalies, predisposition for spasm and problems with coronary cannulation.[24,25] Yoo et al.[26] investigated 1191 transradial coronary invasive intervention performed on 275 patients with normal Allen test, and demonstrated that preprocedural determination of radial artery diameter is important for the use of an appropriate sheath and catheter; and the use of a large diameter sheath would increase the risk of obstruction. This risk is independent of age and is mostly observed in patients with PCI. They also demonstrated that abnormalities in arterial branching did not lead to a significant prolongation in the duration of the procedure. A cocktail of agents should be administered in order to prevent vasospasm following puncture of the radial artery. Failure at the point of entry depends mostly of the experience of the operator undertaking the procedure. Louvard et al.[27] reported a failure rate 10% for the first 100 patients, 3-4% in 500 patients and <1% for up to 1000 patients. Conditions where the radial route should not be used include presence of an arteriovenous fistula for hemodialysis, presence of a weak radial pulse in female patients, known pathology of proximal vessels, and the need for a catheter with large lumen.

The technique of radial artery catheterization

The use of the 6F catheter during invasive treatment interventions administered with the radial route has been shown to produce similar success rate to those of 5F catheter,[28] and the choice of catheters with small diameter is thought to reduce the rate of post-procedural pulse loss. However, the most important limitation with the 5F catheter is the inadequate back-up provision. In the *in vitro* artery model formed by Ikari et al.[29] the supportive power of the guiding catheters was evaluated and it was demonstrated that catheters with a large diameter had the greatest power, and the Judkins guiding catheter had a 60% power with the femoral route compared to the radial route, whereas the EBU and XB guiding catheters had an 8% greater power with the femoral route. On the other hand, the Ikari guiding catheter was reported to have the same effect on both intervention routes. The catheter diameter, aortic angle and area of attachment are known to be important indicators for supportive power.[29] However, appropriate cannulation would provide safe and successful results with PCI via the radial route. Cannulation can be facilitated by the operator by asking patients to hold their breath during the procedure especially since respiratory movements may reflect on the right coronary. Curves particularly of the innominate subclavian artery may pose a problem for correct placement of the guiding catheter. Under certain conditions the radial route has advantages over the femoral route as in the case with saphenous graft lesions on the mammarian artery as well as in the presence of coronary anomaly when the right coronary artery exits from the left. Additional support is required when using the right radial artery approach, especially during interventions with lesions of the left anterior descending artery and the circumflex artery. The left Amplatz 2 guiding catheter is especially very supportive for the circumflex artery. On the other hand, the standard Judkins catheters are less supportive, but produce good results with deep cannulation. The Judkins catheters normally produce adequate results during right coronary interventions; however, multipurpose catheters should be used for inferior placements especially with a large aorta, whereas the AL should be preferred for superior exit.[30] Judkins, multipurpose or the Amplatzer catheters may be used for bypass grafting, or special catheters may also be used for radial interventions. Aortocoronary grafts may easily be found by the Amplatzer catheters during left radial artery intervention.[31] When choosing the appropriate catheter and curve the operator must remember that left radial intervention is very similar to femoral. On the other hand, the catheter curve should be changed in relation to the length of aorta during right radial interventions especially in hypertensive and elderly patients.[30]

Advantages and disadvantages of using the radial artery

In the comparison of clinical and operational endpoint meta-analysis, Agostoni et al.[3] evaluated 22 studies and demonstrated that transradial intervention was a safe alternative to transfemoral intervention during coronary invasive procedures. The analysis included a very heterogeneous group with a mean procedural duration of 35 min in transradial group and 33.8 min in the transfemoral group. The duration of fluoroscopy was found to be 7.8 min in the femoral group and 8.9 min in the radial group. Evaluation of patients in terms of failure rate demonstrated that failure occurred especially in those of the OCTO-PLUS study due to age above 80 years, with a failure rate of 9.3% in the femoral group and 10.6% in the radial group; however, exclusion of the OCTO-PLUS study show a 1.9% radial failure rate and a 0.7% femoral failure rate. Complications at site were observed only in three patients, with a femoral complication rate of 2.8%.[3] The transulnar approach can be used when there is failure to reach the radial artery. Lanspa et al.[32] successfully performed cardiac catheterization with the ipsilateral ulnar artery in 12 patients in whom access could not be made by the radial route, using the standard transradial approach after the hand angiography. They observed that temporary vasoconstriction could not permit cannulation despite an open radial artery in 7 patients.[32] In the PCVI-CUBA study by Aptecar et al.[33] the ulnar artery was found to be as successful as the radial artery, not different in terms of complications; they suggested that the radial artery should be preserved for surgery especially as the ulnar artery is currently more preferred as a bypass graft and that the use of the ulnar artery would produce the anticipated benefits. Use of the ulnar artery following unsuccessful interventions with the radial artery is suggested to prevent time lost in cleaning the surgical area and the use of more materials. Moreover, the ulnar approach is similar to the radial approach. However, a shift to the femoral approach would necessitate the need for a different catheter and sheath. The transulnar approach is not currently a routine recommendation due to limited data on different anatomic variations and approaches.

Mann et al.[34] compared the transradial route with the transfemoral route where the closure devices were used at the intervention area, in 218 patients and demonstrated that the cost of the procedure, the complication rate and the duration of stay in the hospital was higher with the transfemoral approach. The femoral route did not show any advantages over the radial route where there are fewer site complications even when closure devices were used for the femoral approach, and as expected the cost was very high.

In general, diagnostic coronary procedures are performed in outpatient setting. However, one night monitoring for PCI is required. This is due to the 2-25% subacute occlusion rate observed in the target vessel, especially 4-6 hours after the procedure.[35-38] In the OUTCLASS study, patients who underwent PCI by the transradial or transfemoral approach were discharged on the same day.[39] Major cardiac event was observed in only one patient (0.3%) and the radial route was found to be more beneficial in terms of bleeding.

Radiation

Exposure to radiation is another matter of concern addressed by interventional cardiologist regarding use of the radial artery for intervention procedure. Brasselet et al.[40] evaluated the exposure to radiation though the use of dosimeters by physicians following 420 diagnostic (coronary angiography) and therapeutic PCI procedures performed by four cardiologists. A significant radiation effect was observed from the use of the radial artery, when compared to the femoral artery. Fallout radiation during coronary angiography for the radial and femoral artery use was found to be 29 µSv (range 1-195) and 13 µSv (range 1-164) ($p<0.0001$), respectively; whereas for the PCI procedure it was measured as 69.5 µSv (range 4-531) and 41 µSv (2-360) respectively ($p=0.018$). On the other hand, fluoroscopy and duration of the procedure was found to be significantly associated with the radial route.[40] As a result, limitation to increases in dosage seems to be the most important factor despite specific preventive measures.

Post-procedural changes with the radial artery

Anatomical and physiological changes in the arterial structure are observed after transradial catheterization. As a result, there are reservations concerning use of the radial artery for multiple interventions as a graft during bypass surgical operation. Madssen et al.[41] analyzed the radial artery of 30 patients who underwent coronary angiography by the right radial route, 10-14 hours after the procedure and observed a significant shortening of the right radial artery diameter compared to the left. However, they demonstrated that the result did not change with vascular dilatation. Due to structural changes in the form of intimal hyperplasia and segmental damage, it is recommended to perform ultrasonographic evaluation of the structural and vascular dilatation characteristics of the radial artery, as a determinant for postoperative bypass graft opening.[41] Dogan et al.[42] evaluated the structure of the radial artery of 16 patients using computed tomography angiography, and emphasized the importance of radial approach especially before coronary artery bypass surgical operation due to the anatomic features of the radial artery and the detailed circulatory information of the hand obtained from this artery.

Complications involved with use of the radial artery

Vasoconstriction is the most commonly encountered complication of the intervention point, with an incidence rate of 10-25%.[43,44] Increased risk is generally found to be indirectly correlated with vascular diameter and directly correlated with duration of the procedure. This problem can be resolved through the use of hydrophilic sheaths and anti-vasoconstriction agents, and also by careful direction of the catheter and guiding wire during the procedure.[18] The radial artery is a muscular artery which is very rich in particularly alpha-1 adrenoceptors. Vascular shorten mostly occurs during placement of the sheath or catheter. Verapamil and nitroglycerin are effective agents.[45] Chen et al.[46] evaluated the effect of administering heparin, heparin-nitroglycerin and heparin-nitroglycerin-verapamil combinations drugs in 133 patients who underwent radial intervention, and reported that intraarterial administration of 100 µSv of nitroglycerin and 3000U of heparin was the most effective route. This condition may be damaging especially with verapamil use and is of clinical importance especially in patients with left ventricular dysfunction and in bradycardic patients.[46] Byrne et al.[47] compared the effect of magnesium and verapamil on 86 patients who underwent radial intervention, and reported that 150 mg of magnesium was more effective than 1 mg of verapamil. Moreover, the adverse hemodynamic effects observed with verapamil were not reported with magnesium. Coppola et al.[48] in their study observed vascular shortening in 44 of the 379 patients who underwent coronary intervention by the radial approach. This condition was found to be independent of gender, presence of diabetes mellitus, body surface area, and cigarette smoking, with the most important factors being the radial artery diameter/expansion index and the sheath diameter/radial artery diameter index. Since circulatory levels of catecholamine plays an important role in the development of contraction, preventive measures such as administration of local anesthesia and adequate sedation for anxiety control should be considered. The use of hydrophilic-coated sheaths for the prevention of vascular shortening has been reported to be associated with a 1-6% development of sterile inflammation.[49,50]

Completed occlusion in patients who develop inadequate contralateral palmar flow after the procedure is regarded as a complication which should prevent the standard use of the radial route. It is very rarely observed (<1%) particularly when catheters with a small diameter are used, during administration of intraarterial heparin, immediate retrieval of the sheath after the procedure, and during avoidance of band application which may cause occlusion. Moreover, the development of ischemia is normally prevented with collateral development even in the event of an occlusion.[18,51] Intimal hyperplasia may develop after the procedure; however, this condition is mild and damage does not occur in response to vascular dilatation. Edmundson and Mann[52] evaluated post-procedural damage in 30 patients who underwent radial intervention and reported a segmental damage associated with the placement area of the sheath.

Lund et al.[53] demonstrated by magnetic resonance imaging that the development of subclinical cerebral microembolism associated with radial artery use was 15% more common than with femoral intervention. Hematoma of the intervention area is observed at the rate of 1%, and most frequently develops due to puncture of the small side branch.[54] Early diagnosis of the condition is important due to the risk of development of compartment syndrome a from continuous bleeding.

Acute coronary syndrome and use the radial artery

Currently, use of the radial artery in diagnostic and therapeutic coronary artery interventions is increasingly becoming more common. Successful results have also been reported in patients with acute coronary syndrome where the transradial approach is relatively less used. In the AGGRASTENT study, no major cardiac and cerebral event was reported, and the one-year event-free survival rate was found to be 91% in patients who presented with ST-elevation myocardial infarction, and underwent primary PCI by the transradial route under glycoprotein IIb/IIIa inhibitor (tirofiban), and who were discharged at an early period (within the first four days).[55] In the PRESTO-ACS vascular subgroup study where the invasive and conservative approaches were evaluated patients who presented with non-ST elevation myocardial infarction, comparison with the femoral approach demonstrated that intensive anti-platelet therapy was administered more in patients who underwent PCI by the radial artery route, and observed that the long term prognosis in these patients was better than with the femoral route.[56] This study was the first to demonstrate the effect of the route used on the prognosis; reduction of the bleeding complication observed in patients with acute coronary syndrome is suggested to be due to transradial route use.[56] On the other hand, increased use of glycoprotein IIb/IIIa inhibitor in this group of patients was attributed to the reduced risk of bleeding.[56]

Conclusion

Many studies have demonstrated that diagnostic and therapeutic interventional procedures by the transradial route are safe and successful in the management of unprotected left main coronary artery lesions, chronic complete obstruction of the coronary artery, and for renal, cerebral artery and saphenous bypass grafts.[14-17] Use of the radial artery for invasive interventions is advantageous in patients with acute coronary syndrome due to the lower rate of invasive area and bleeding complications, increased patient comfort, shorter hospital stay and follow-up period. Success rate increases when the number of patients increases and thereby complication rate decreases. As a result, the transradial route should be used as a routine interventional approach.

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