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Distal radial artery access in the anatomical snuffbox for coronary angiography and percutaneous coronary intervention

Koroner anjiyografi ve perkütan koroner girişimlerde, anatomik enfiye çukurundan distal radyal arter girişimi

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Abstract

Purpose: Compared with transfemoral access, transradial access (TRA) has been shown to reduce major adverse cardiac events, major bleeding, and access site-related vascular complications. This study aimed to investigate the safety and feasibility of the novel distal TRA in the anatomical snuffbox (AS) for coronary angiography and percutaneous coronary intervention (PCI).

Materials and methods: This cross-sectional study included a total of 102 consecutive patients (67 male; mean age: 56.1±13.2 years) who underwent coronary angiography and/or PCI via distal TRA in the AS.

Results: Distal TRA was successfully performed in 98% of the patients. The crossover rate was very low (2%). The right distal TRA was the preferred approach and was used in 90.2% of the patients. Mean artery puncture time was 3.9±1.6 min. Mean compression time to achieve hemostasis at puncture site was 17.0±6.9 min. The post-procedural hematoma rate was very low (1%). One-month follow-up Doppler ultrasound showed zero cases of arteriovenous fistula and pseudo-aneurysm. However, proximal radial artery occlusion was observed in 1 patient (1%) and it was asymptomatic. Artery puncture time, unfractionated heparin dose, time to sheath removal, procedural numerical rating scale (NRS) score and post-procedural NRS score at 6 h were significantly different between diagnostic catheterization and PCI procedures (p<0.001).

Conclusion: The distal TRA in the AS is safe and feasible for coronary angiography and PCI. However, further studies are warranted.

Key words: Anatomical snuffbox, coronary angiography, distal transradial access, percutaneous coronary intervention.

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Öz

Amaç: Transfemoral erişim ile karşılaştırıldığında, transradyal erişimin majör advers kardiyak olayları, majör kanamayı ve girişim bölgesine bağlı vasküler komplikasyonları azalttığı gösterilmiştir. Bu çalışmada koroner anjiyografi ve perkütan koroner girişim için anatomik enfiye çukurundaki distal transradyal erişimin güvenilirliği ve fizibilitesi araştırıldı.

Gereç ve yöntem: Bu kesitsel çalışmaya anatomik enfiye çukurundaki distal transradyal erişim yoluyla yapılan koroner anjiyografi ve/veya perkütan koroner girişim uygulanan toplam 102 ardışık hasta (67 erkek, ortalama yaş: 56,1±13,2 yıl) dahil edildi.

Bulgular: Hastaların %98'inde distal transradyal erişim başarıyla gerçekleştirildi. Başarısızlık oranı çok düşüktü (%2). Sağ distal transradyal erişim tercih edilen yaklaşımdı ve hastaların %90,2'sinde kullanıldı. Ortalama arter ponksiyon süresi 3,9±1,6 dakika idi. Ponksiyon bölgesinde hemostaz elde etmek için ortalama kompresyon süresi 17,0±6,9 dakika idi. İşlem sonrası hematom oranı çok düşüktü (%1). Bir aylık takipte Doppler ultrasonografide arteriyovenöz fistül ve/veya psödo-anevrizma saptanmadı. Ancak 1 hastada (%1) proksimal radyal arter oklüzyonu izlendi ve asemptomatik seyretti. Arter ponksiyon süresi, fraksiyone olmayan heparin dozu, kılıf çıkarılma süresi, işlem sırasındaki NRS skoru ve işlemden 6 saat sonraki NRS skoru tanısal kateterizasyon ve perkütan koroner girişim prosedürleri arasında anlamlı olarak farklıydı (p<0,001).

Sonuç: Anatomik enfiye çukurundaki distal transradyal erişim koroner anjiyografi ve perkütan koroner girişim için güvenli ve uygulanabilirdir. Bununla birlikte, bu teknik için daha fazla araştırma gerekmektedir.

Anahtar kelimeler: Anatomik enfiye çukuru, koroner anjiyografi, distal transradyal erişim, perkütan koroner girişim.

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Introduction

Coronary artery disease (CAD) is still the main cause of death worldwide. Coronary angiography and percutaneous coronary intervention (PCI) are important tools for the diagnosis and treatment of CAD [1]. Cardiac interventions are performed using several access routes, including femoral, brachial, radial, and ulnar arteries. Compared with transfemoral access, transradial access (TRA) has been shown to reduce major adverse cardiac events [2], major bleeding, access site-related vascular complications [3], patient discomfort, and allow early mobilization. However, TRA is not without challenges and complications. Transradial access is technically more difficult and is associated with radial artery spasm and radial artery occlusion (RAO) particularly in females and elderly patients [4, 5]. Transradial access has grown to become the default access site in Europe, Asia, and is rapidly growing in the United States [2, 6-8]. Also, the European Society of Cardiology guidelines gave class I recommendation to use TRA as the preferred method of access [9].

A novel, safe, and feasible technique of accessing the distal TRA in the anatomical snuffbox (AS) was first described by Kiemeneij [10]. Compared with conventional TRA, distal TRA may yield some advantages, including preserving antegrade blood flow in the hand and thus minimizing hand ischemia risk, as well as obtaining faster hemostasis due to smaller vessel size beyond the bifurcation. However, there is a lack of data examining the routine use of distal TRA.

The AS is a surface anatomy feature described as a triangular depression on the dorsum of the hand at the base of the thumb. The AS is visible with ulnar deviation of the wrist and extension and abduction of the thumb. Anatomically, the AS is bordered medially by the tendon of the extensor pollicis longus muscle, and laterally by the tendons of the extensor pollicis brevis and the abductor pollicis longus muscles. The floor of the AS is formed by the scaphoid bone and trapezium bone of the wrist, as well as the tendons of the extensor carpi radialis longus and the extensor carpi radialis brevis muscles. The base of the first metacarpal bone can be palpated distally, and the styloid process of the radius can be palpated proximally. The distal part of the radial artery, the superficial branches of the radial nerve, and the cephalic vein pass within the AS [11]. In this study, we aimed to investigate the safety and feasibility of the novel distal TRA in the AS for coronary angiography and PCI.

Materials and methods

Study population and design

This cross-sectional study included a total of 102 consecutive patients who underwent coronary angiography and/or PCI via distal TRA in the AS. Patients with an absent arterial pulse in the AS, history of previous coronary artery bypass grafting and concomitant radial artery use, history of forearm arterial malformation, severe chronic kidney disease, chronic liver disease, and abnormal coagulation function, previous ipsilateral radial access were excluded. The study was conducted following the Declaration of Helsinki. Prof.Dr. Cemil Taşçıoğlu City Hospital Clinical Research Ethics Committee approved the study protocol (No: 121, 05.05.2020). Each participant provided written informed consent.

Procedure

The patient was positioned supine on the angiography table. For both left and right distal TRA, the patient's upper arm was positioned comfortably next to on a side-board. The patient was asked to grasp his thumb under the other four fingers to bring the distal radial artery on the surface of the radial fossa. After subcutaneous injection of 1 ml lidocaine, Seldinger's technique puncture was performed in the AS using a 21-gauge open needle and a 0.025" wire. We do not recommend a through-and-through puncture to avoid the pain caused by the needle tip touching the periosteum of the scaphoid or trapezium bones. A 6-French sheath was used in all diagnostic catheterization and PCI procedures (Figure 1). A spasmolytic cocktail consisting of 200 mcg of nitroglycerine and weight-based unfractionated heparin (50 IU/kg) was given intraarterially after the successful insertion of the sheath. If PCI was performed, an additional dose of unfractionated heparin was administered. Angiogram with distal TRA was performed by two different experienced operators.

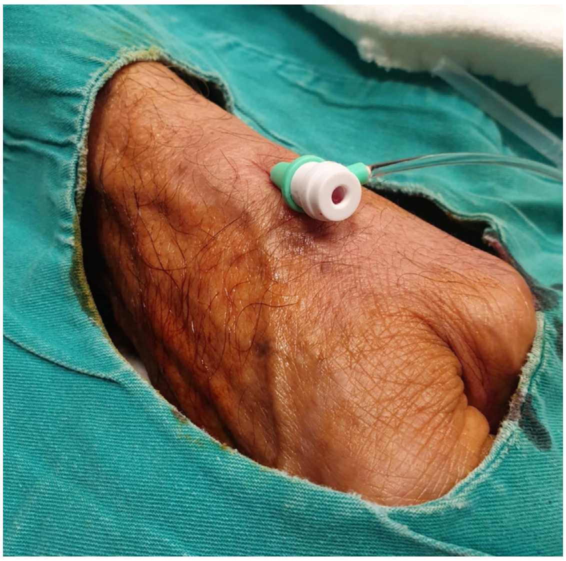

Figure 1. The introduction of a 6-French hydrophilic radial sheath into the right distal radial artery in the anatomical snuffbox

The success rate was defined as successful cannulation of the sheath and completion of the angiogram and/or PCI via distal TRA. Access time was defined as the time between the subcutaneous local anesthetic to the administration of a spasmolytic cocktail. The numerical rating scale (NRS) score was used to describe pain intensity during and 6 h after the procedure. Since it was before discharge, we evaluated the pain score at the 6th hour.(0–10 numeric rating scales; higher scores = greater pain; 0: painless; 1–3: mild pain; 4–6: moderate pain; 7–10 severe pain).

After the completion of the procedure, the radial sheath was pulled out and early hemostasis was obtained by manual compression on the puncture site. Manual compression was applied as we did not have a vascular closure device.

Until hemostasis was achieved then a slightly compressive bandage with gauze was applied over the access site. The puncture site was checked for the presence of radial pulse and absence of hematoma or bleeding before discharge. All patients underwent follow-up Doppler ultrasound one month following the procedure.

Statistical analysis

Data analyses were performed using SPSS version 22.0 statistical software package (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean±standard deviation or median (minimum-maximum). Categorical variables were expressed as number (percentage). The normal distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. The independent samples t-test was used to compare continuous variables and the Chi-square test was used to compare categorical variables. A two-tailed *p*-value of less than 0.05 was considered significant.

Results

A total of 102 consecutive patients (67 male and 35 females; mean age: 56.1±13.2 years) who underwent coronary angiography and/or PCI via distal TRA in the AS were included in this study. The demographic characteristics of the study population are shown in Table 1. Diabetes mellitus, hypertension, hyperlipidemia,

Table 1. Demographic characteristics of the study population

Demographic feature	Mean ± SD, Median (Min-Max), N (%)
Age (year)	56.1±13.2
Gender, (male)	67 (65.7)
Body mass index (kg/m^2)	25.5 (22.8-31.6)
Diabetes mellitus	33 (32.4)
Hypertension	20 (19.6)
Hyperlipidemia	6 (5.9)
Family history of CAD	38 (37.3)
Smoking status	59 (57.8)
Acute coronary syndrome	22 (21.6)
Left ventricular ejection fraction (%)	60 (35-65)

CAD: Coronary artery disease, SD: Standard deviation family history of CAD and smoking were present in 32.4%, 19.6%, 5.9%, 37.3% and 57.8% of the patients respectively. Almost one-fifth (21.6%) of the patients underwent coronary angiography and/or PCI due to acute coronary syndrome.

The procedural and post-procedural characteristics of the study population are shown in Table 2. Distal TRA was successfully performed in 98% of the patients. The crossover rate was very low (2%). Two patients sustained radial artery spasm and the procedure was completed via the contralateral conventional TRA in these patients. The right distal TRA was the preferred approach and it was used in 90.2% of the patients. Mean artery puncture time was 3.9±1.6 min. The median number of puncture

Table 2. Procedural and post-procedural characteristics of the study population

Variable	Mean ± SD, Median (Min-Max), N (%)
Success rate	100 (98.0)
Crossover rate	2 (2.0)
Radial artery spasm	2 (2.0)
Crossover access site	
Contralateral proximal radial artery	2 (2.0)
Right distal TRA	92 (90.2)
Artery puncture time (min)	3.9±1.6
Number of puncture attempts	1 (1-3)
Compression time (min)	17.0±6.9
Procedural NRS score	
0: Painless	0 (0.0)
1-3: Mild pain	64 (62.8)
4-6: Moderate pain	35 (34.3)
7-10: Severe pain	3 (2.9)
Post-procedural NRS score at 6 h	
0: Painless	21 (20.6)
1-3: Mild pain	81 (79.4)
4-6: Moderate pain	0 (0.0)
7-10: Severe pain	0 (0.0)
Diagnostic catheterization	50 (49)
Percutaneous coronary intervention	52 (51)
Coronary artery treated	
Left anterior descending artery	21 (40.4)
Left circumflex artery	20 (38.5)
Right coronary artery	11 (21.1)
Unfractionated heparin (unit)	8137.3±2298.5
Early postoperative complication	
Hematoma	1 (1.0)
Arm movement disability	0 (0.0)
One-month follow-up Doppler ultrasound	
Radial artery occlusion	1 (1.0)
Arteriovenous fistula	0 (0.0)
Pseudo-aneurysm	0 (0.0)
Radial sheath (6-French)	102 (100.0)
Time to sheath removal (min)	18.3±7.7
Contrast volume (ml)	104.2±32.8

NRS: Numeric rating scale (Scoring system used to assess pain intensity), SD: Standard deviation, TRA: Transradial access attempts for distal TRA was 1 (1-3) attempt. Mean compression time to achieve hemostasis at the puncture site was 17.0±6.9 min. Most patients had mild pain during the procedure. However, most of them were painless 6 h after the procedure. Almost half of the patients (51%) underwent PCI. The mean heparin dose was 8137.3±2298.5 units. Post-procedural hematoma rare was very low (1%), and arm movement disability was not seen in any patient. One-month follow-up Doppler ultrasound showed zero cases of arteriovenous fistula and pseudo-aneurysm. However, proximal RAO was observed in 1 patient (1%), who was managed conservatively with anticoagulation.

A comparison of some characteristics between diagnostic catheterization and PCI procedures is shown in Table 3. Artery puncture time, unfractionated heparin dose, time to sheath removal, procedural NRS score and post-procedural NRS score at 6 h were significantly different between diagnostic catheterization and PCI procedures (*p*<0.001).

Table 3. Comparison of some characteristics between diagnostic catheterization and percutaneous coronary intervention procedures

Variable	Diagnostic catheterization (n=50)	Percutaneous coronary intervention (n=52)	*p*-value
Artery puncture time (min)	3.1±1.1	4.6±1.6	**<0.001**
Unfractionated heparin (unit)	6450±2148	9759±744	**<0.001**
Time to sheath removal (min)	14.8±5.0	21.7±8.3	**<0.001**
Compression time (min)	15.8±8.6	18.3±4.1	0.076
Procedural NRS score			
0: Painless	0 (0.0)	0 (0.0)	**<0.001**
1-3: Mild pain	38 (76.0)	26 (50.0)	
4-6: Moderate pain	10 (20.0)	25 (48.0)	
7-10: Severe pain	2 (4.0)	1 (2.0)	
Post-procedural NRS score at 6 h			
0: Painless	16 (32.0)	5 (9.6)	**<0.001**
1-3: Mild pain	34 (68.0)	47 (90.4)	
4-6: Moderate pain	0 (0.0)	0 (0.0)	
7-10: Severe pain	0 (0.0)	0 (0.0)	

Data are presented as mean ± standard deviation or number (%).
NRS: Numeric rating scale (Scoring system used to assess pain intensity).
p-value was calculated using the Independent-Samples T test for continuous variables and the Chi-Square test for categorical variables as appropriate.
p-value <0.05 was considered significant.

Discussion

The main finding of our study is that distal TRA in the AS is feasible and safe, and can be used to perform coronary angiography and PCI with a very high success rate (98%), and very low access site-related vascular complications. It is noteworthy that our study was not limited to left distal TRA, which offers several advantages including a more natural route of the aortic arch to engage the coronary arteries.

There are substantial advantages of distal TRA over conventional TRA, which may contribute to decreasing the risk of RAO and subsequently potential hand ischemia [12]. Distal TRA preserves superficial palmar archflow because the puncture site is beyond the bifurcation into the deep palmar arch. Also, distal TRA achieves early hemostasis due to smaller vessel size [12], and anatomical position over a bony basement. In male patients, the diameters of the conventional radial artery and distal radial artery are 2.62±0.60 mm and 2.04±0.43 mm, respectively. However, in females, these diameters are 2.44±0.51 mm and 1.96±0.44 mm, respectively [13].

Distal TRA in the AS is more challenging compared to conventional TRA and there is a learning curve to overcome. A recent study investigated the learning curve for distal TRA and artery puncture time demonstrated stabilization after approximately 150 cases [14]. A recent study by Aoi et al. [12], reported that the mean puncture time of distal TRA was 7.3±5.7 min. Al Azizi et al. [15], reported that mean lidocaine injection-to-sheath time was 4.32 min. In our study, the mean puncture time of distal TRA was 3.9±1.6 min. In our study, puncture attempts made for distal TRA were reported in all patients. Distal TRA was successfully performed at the first attempt in most patients. However, some cases required more than one to three attempts. Lee et al. [14] suggested keeping the puncture angle to be less than 30°to maximize the chance of successful puncture. As the distal radial artery is smaller and pulsation is less apparent compared to the conventional radial artery, in some patients. The ultrasound-guided technique may increase the success rate and minimize the risk of puncture-mediated vasospasm in Patients whose distal radial artery is too weak to attempt a puncture. However, this can lead to longer artery puncture time which maybe not favorable in time-sensitive situations such as primary PCI. In our study, ultrasound guidance was not required in any patient. There is strong evidence for improved outcomes with TRA over transfemoral access in ACS. However, distal TRA may not be the best choice for access compared to conventional TRA in this setting, especially for non-experienced operators. In our study, 21.6% of the patients underwent coronary angiography due to acute coronary syndrome.

Once the radial artery was successfully cannulated, the rate of the crossover rate was very low. Prior meta-analysis comparing right and left radial approaches showed no significant differences in total procedure time and crossover rate with a small benefit in the left radial approach in terms of fluoroscopy time and contrast use [16]. These aspects may be related to anatomical variations.

Aoi et al. [12] reported that artery compression device removal time was 104.6±40.6 min in Patients undergone distal TRA. Although we did not use an artery compression device, the mean compression time to achieve hemostasis at the puncture site was 17.0±6.9 min. Also, our study interestingly showed that there was no significant difference between diagnostic catheterization and PCI procedures regarding hemostasis time. However, PCI cases had a higher dose of heparin. We think that smaller distal artery size in the AS and anatomical position over a bony basement had contributed to early hemostasis.

Radial artery occlusion is a quiescent complication of TRA that rarely leads to critical hand ischemia requiring intervention because of the dual vascular supply of the hand from the palmar arch. Once the radial artery is occluded, its future use as an access site for coronary angiography, as a conduit for coronary bypass grafting, or fistula formation in hemodialysis patients is precluded. The reported incidence of RAO varies widely, from 0.8% to as high as 38% [17-21]. Some baseline patient-related characteristics such as body mass index and diabetes have been reported to influence RAO [22]. Also, several procedural variables such as sheath size [23], use of anticoagulants [19-24], and patent hemostasis [19], have also been shown to reduce the incidence of RAO. In our study, one-month follow-up Doppler ultrasound revealed a very low incidence of access site-related vascular complications. The RAO rate was very low (1%). Proper techniques such as puncture in the AS, radial cocktail, a relatively high dose of heparin and short duration of manual compression were important factors in our study that may explain the low incidence of RAO.

The distal radial artery should be punctured in the AS and not further distal to the tendon of extensor pollicis longus muscles due to less bony structure underneath the more distal part of the artery outside of the AS. This hint should be taken into consideration to minimize potential post-procedural complications.

Limitations of the study

Our study has several limitations. First, it should be noted that our results are based on a study including a relatively small number of patients. A multi-center study involving more patients could have more significant results and data. Second, all the procedures were performed by a highly experienced operator in radial access. Third, due to the non-randomized nature of the study and the lack of a control group, conclusions should be made with caution. Fourth, the artery compression device was not used to achieve hemostasis at the puncture site.

In conclusion, the distal TRA in the AS is safe and feasible for coronary angiography and PCI. Despite the difficulty in cannulation, this technique yields less arterial occlusion and earlier hemostasis. However, more studies, especially randomized studies and meta-analyses, are needed to be a guideline in the future.

Conflict of interest: No conflict of interest was declared by the authors.

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Ethics committee approval: The study was conducted following the Declaration of Helsinki. Prof.Dr. Cemil Taşçıoğlu City Hospital Clinical Research Ethics Committee approved the study protocol (No: 121, 05.05.2020). Each participant provided written informed consent.

Contributions of the authors to the article

G.A. and A.Q. constructed the main idea and hypothesis of the study. G.A. and A.Q. they developed the theory and organized the material method section. G.A. and A.Q. made the evaluation of the data in the results section. Discussion section of the article written by G.A. has reviewed and made the necessary corrections and approved. In addition, all authors discussed the entire study and confirmed its final version.