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Transradial approach in the diagnosis and treatment of coronary artery disease: a 2-center experience

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Background/aim: To document the safety, success, and complications of transradial coronary procedures.

Materials and methods: This retrospective study consisted of 427 patients who had undergone transradial coronary angiography and/or angioplasty between June 2010 and May 2012. The main outcome measures were the procedural safety, success rate, and complications associated with transradial interventions.

Results: Procedural success rate was 93.2% (398/427), with cannulation time of 2.1 ± 1.4 min, diagnostic time of 5.6 ± 2.1 min, fluoroscopy time of 9.5 ± 6.6 min, and total procedure time of 47.1 ± 20.2 min. The main causes for unsuccessful procedures were failed radial puncture (11 patients), serious radial artery spasm (12 patients), and distinct tortuosity (5 patients) and severe proximal stenosis (1 patient) of the right subclavian artery. Of 398 patients, 345 (86.7%) underwent both coronary angiography and angioplasty, while the remaining 53 (13.3%) had coronary angiography only. Major complication was recorded in only 1 patient (transient ischemic attack), whereas minor complications were observed in 76 patients (17 with symptomatic sinus bradycardia, 12 with venous thrombosis, 22 with hematoma, and 25 with radial artery occlusion).

Conclusion: Our experience revealed that the transradial approach is a safe and feasible method for coronary procedures in patients with various manifestations of coronary disease.

Key words: Radial artery, coronary disease, angiography, angioplasty

1. Introduction

Coronary angiography (CAG) and percutaneous coronary intervention (PCI) have been conventionally performed via the transfemoral approach (TFA). The size of the femoral artery has been regarded as the most crucial factor in preferring this localization for access, and in particular for the use of large diameter diagnostic and guiding catheters and balloons. Other advantages of the TFA are that it allows optimal catheter manipulation, the use of other devices such as an intraaortic balloon pump (IABP), and coronary or aortic valve interventions requiring greater than 7 F catheters. However, there are some complications that limit the use of femoral access points, such as hematoma, serious blood loss, pseudoaneurysm, and arteriovenous fistula. These complications may be especially more serious owing to the use of antiaggregants and anticoagulants, such as acetylsalicylic acid (ASA), heparin, and glycoprotein (Gp) IIb/IIIa inhibitors in the setting of acute coronary syndrome (ACS) (1–3). Compared with the TFA, the transradial approach (TRA) is associated with fewer access point complications, shorter hospital stay, and better quality of care after the procedure. The safety and feasibility of this procedure have been reported in great numbers of clinical studies (4–7). However, little is known about angiographies and/or angioplasties performed through the TRA in Turkey. In the present trial, we aimed to report the procedural safety, success, and complications related to the transradial CAG and PCI applied in 2 different cardiology clinics.

2. Materials and methods

2.1. Patient population

Among 2164 consecutive patients who had undergone CAG and/or PCI via both the femoral and radial approaches between June 2010 and May 2012 in 2 cardiology clinics, 427 had coronary procedures that had been performed using the only TRA. Indications for CAG and/or PCI were significant symptomatic angina,

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abnormal stress test or myocardial perfusion scan, and ACS, including acute myocardial infarction (AMI). All ACS patients had received 300 mg of ASA and 600 mg of clopidogrel in the emergency department, as well as an intravenous (iv) bolus of unfractionated heparin (UFH) (5000 IU). In the catheterization room, an additional iv bolus of 5000 IU of UFH was delivered into the sheath immediately after arterial cannulation. Some patients with excessive thrombotic burden were administered an intracoronary bolus of Gp IIb/IIIa platelet inhibitor (tirofiban) followed by an iv infusion for at least 12 h after PCI. Some of the patients with AMI had a history of prehospital administration of fibrinolytic therapy. The study protocol was carried out according to the principles of the Declaration of Helsinki and was approved by the Investigational Review Board of the Kafkas University School of Medicine.

2.2. Clinical assessment

The clinical and angiographic data of 427 patients were reviewed retrospectively. All patients underwent routine history and clinical examination. Clinical and oxymetric Allen tests were carried out for the assessment of dual arterial supply to both hands. Exclusion criteria for the transradial approach were an abnormal Allen test, chronic kidney disease (creatinine of ≥2.0 mg/dL) requiring dialysis (to avoid any injury to the forearm circulation), absence of the radial pulse, and previous brachial cut-down. Radial artery access was the default approach in unselected patients undergoing coronary procedures. Left rad al access was the default approach in patients with previous coronary artery bypass grafting using a left internal mammary artery.

2.3. Sheath placement and hemostasis

After local anesthesia with 1 mL of 2% lidocaine and 1 mL of nitroglycerine, the radial artery was punctured with a metal needle of 20G×1½″, and a straight guidewire of 0.025″ was inserted through the needle. Upon removal of the needle, a 16-cm 6 F sheath (Radifocus Introducer II, Terumo Europe, Belgium) was placed over the guidewire. To reduce spasm and to prevent thrombosis, intraarterial drugs such as nitroglycerine (200 to 400 µg), verapamil or diltiazem (1 to 2.5 mg), and UFH (5000 IU) were routinely given through the sheath. CAG and PCI were performed using 6 F diagnostic (Cordis Corporation) and 6 F guiding catheters manufactured by either Boston Scientific/Scimed (Maple Grove, MN, USA) or Medtronic (Maple Grove, MN, USA), respectively. After completion of the procedure, the radial sheath was immediately removed, and hemostasis was achieved by local compression for an average of 10 min, followed by an adhesive pressure bandage for an average of 3 h. All patients were encouraged to attempt early ambulation. All procedures were performed by 2 interventional cardiologists with significant experience (annual transradial coronary procedures [angiography and angioplasty] volume ranged from 15% to 45% of total annual coronary procedures volume for 2 operators).

2.4. Operational definitions

Radial artery cannulation time was described as the time from infiltration of lidocaine to radial sheath placement. The diagnostic time was described as the time from radial sheath placement to termination of bilateral CAG. Fluoroscopy time was defined as the total time of fluoroscopy use during the CAG and/or PCI. Total procedure time was defined as the time from infiltration of local anesthesia to finalizing of bilateral CAG and/or PCI. Procedural success was described as the completion of a transradial coronary procedure (angiography and/or angioplasty). The duration of cannulation was defined as the time from radial sheath placement to the decannulation of the radial sheath. Vascular spasm was described as the resistance between the radial artery and the equipment used (8). Access site bleeding was described according to Thrombolysis in Myocardial Infarction criteria (9). Radial artery occlusion (RAO) was defined as the absence of palpable radial pulsation verified by a negative Allen test, and/or visible obstruction on 2-dimensional ultrasound, and/or the absence of a Doppler flow signal at or distal to the original access site (10).

Complications were described as minor (spasm, hematoma of >5 cm, symptomatic sinus bradycardia and/or atrioventricular block, RAO, venous thrombosis, aneurysm, and arteriovenous fistulae) and major (death caused by vascular injury, transient ischemic attack (TIA), stroke, need for blood transfusion or a decrease in hemoglobin of >3 g/dL due to vascular bleeding, and major vascular occlusion, such as of the brachial artery).

2.5. Statistical analysis

The data obtained were analyzed by the SPSS 20 (IBM). Continuous variables were presented as mean value ± standard deviation (SD), and categorical variables were shown as percentages.

3. Results

Clinical and demographic features of all patients are detailed in Table 1. The trial population comprised 146 females (34.2%) and 281 males (65.8%) with a mean age of 52.8 ± 9.4 years. Out of 427 patients, 263 (61.6%) had stable angina pectoris (SAP), 83 (19.4%) had unstable angina pectoris (USAP), 19 (4.5%) had non-Q MI, and 57 (13.3%) had acute ST elevation MI (STEMI); (confirmed by marked symptoms, laboratory and electrocardiographic findings, and exercise test and/or myocardial perfusion scan results). The remaining 5 patients (1.17%) had evaluation of coronary anatomy before mitral and/or aortic valve surgery. The success rate of the TRA was 93.2% (398/427). The access sites and procedure failures

Table 1. Clinical and demographic features of the overall study population.

Number of patients, n	427
Age, mean years ± SD	52.8 ± 9.4
Sex (female), n (%)	146 (34.2)
BMI (kg/m^2)	29 ± 5
Risk factors, n (%)	
▪ Smoking	105 (24.6)
▪ Hypertension	150 (35.1)
▪ Hyperlipidemia	176 (41.2)
▪ Diabetes mellitus	58 (13.6)
▪ Family history	60 (14.1)
Clinical presentation, n (%)	
▪ SAP and/or inducible ischemia	263 (61.6)
▪ Unstable angina	83 (19.4)
▪ Non-Q MI	19 (4.5)
▪ STEMI	57 (13.3)
▪ Valvulopathy (mitral and/or aortic valve disease)	5 (1.17)
Previous percutaneous coronary intervention	62 (14.5)
Previous coronary artery surgery	13 (3.0)
Previous prosthetic heart valve operation	
▪ Mitral position	6 (1.41)
▪ Aortic position	4 (0.94)
▪ Both positions	2 (0.47)

BMI, body mass index; SAP, stable angina pectoris; Non-Q MI, non-Q wave myocardial infarction; STEMI, ST elevation myocardial infarction.

in the total study population are shown in Table 2. The main reasons for procedural failure involved failed radial puncture in 11 patients (7 SAP, 3 USAP, 1 STEMI), severe radial artery spasm in 12 patients (9 SAP, 1 USAP, 1 non-Q MI, 1 STEMI), and marked tortuosity (5 patients) and tight proximal stenosis (1 patient) of the right subclavian artery in 6 patients with SAP, hindering the reaching of the guidewire and/or catheter into the ascending aorta (Figures 1A and 1B). Among the 29 patients who experienced first access failure, the second approach was a femoral artery in 18 (4.2%) cases (16 SAP, 2 USAP) and an ipsilateral ulnar artery in the other 11 (2.6%) cases (6 SAP, 2 USAP, 1 non-Q MI, and 2 STEMI). All attempts for the ulnar and femoral arteries were successful. Thus, of these 398 patients with successful transradial procedure, 345 (86.7%) had received both CAG and PCI, while the remaining 53 (13.3%) had received CAG only, based on whether coronary artery stenosis was significant or not. Gp IIb/IIIa inhibitors were administered to 34 USAP, 8 non-Q MI, and 42 AMI patients during the interventional procedures according to the operator's decision. Left radial artery cannulation was applied successfully in all of the 13 patients who had coronary artery bypass surgery with left internal mammary artery graft. In the total study population, the radial artery cannulation time was 2.1 ± 1.4 min, the diagnostic time 5.6 ± 2.1 min, the fluoroscopy time 9.5 ± 6.6 min, total procedure time 47.1 ± 20.2 min, the mean duration of cannulation 22 ± 5.6 min, and the mean length of stay in hospital 11.6 ± 8.5 h (Table 3). Vascular complications are depicted in Table 4. There were no major complications

Table 2. Vascular accesses and procedures failures in the total study population.

Primary arterial vascular access, n (%)	
▪ Right radial artery	408 (95.5)
▪ Left radial artery	19 (4.5)
Failure of primary vascular access, n (%)	29 (6.8)
▪ With crossover to ipsilateral ulnar artery	11 (2.6)
▪ With crossover to femoral artery	18 (4.2)
Reasons for procedural failure, n (%)	
▪ Failed radial puncture	11 (2.6)
▪ Radial artery spasm	12 (2.8)
▪ Subclavian artery tortuosity	5 (1.2)
▪ Subclavian artery stenosis	1 (0.23)

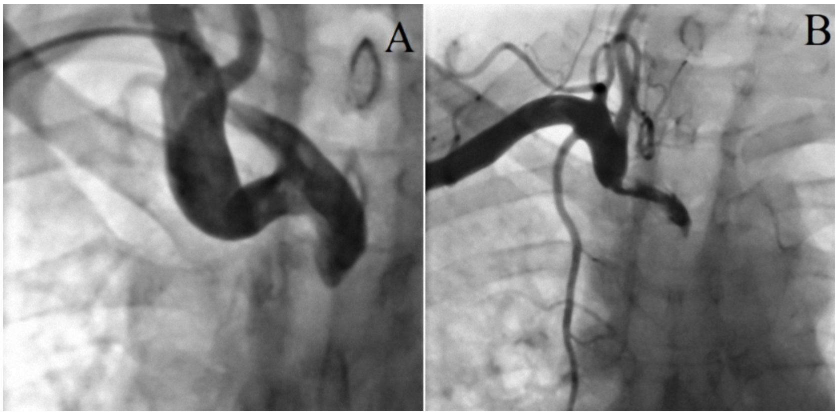

Figure 1. Extreme tortuosity (A) and severe proximal stenosis (B) of the right subclavian artery interrupting the reach of the catheter into the ascending aorta.

throughout the whole study, except for 1 patient (47 years old) with minimal coronary artery disease (CAD), in whom TIA developed soon after the right TRA and spontaneously ceased within seconds. Computed tomography (CT) and diffusion magnetic resonance imaging (MRI) of the brain showed no pathology for this patient. In addition, while no atrioventricular block was observed, sinus bradycardia developed in 17 (4.3%) patients (for this condition, appropriate doses of atropine were administered intravenously) during and/or a very short time after the radial artery cannulation. Within 1 and 30 days after the transradial cardiac procedure, a 2-dimensional and Doppler ultrasonography assessment of 59 (14.8%) patients who presented with pain, edema, and rigidness in the right forearm was applied, showing minor hematoma in 22 (5.5%) patients, venous thrombosis of the right upper extremity in 12 (3.0%) patients, and RAO in 25 (6.3%) patients. All these minor complications were treated conservatively. Neither an aneurysm nor a fistula was detected. After a follow-up period of 3–6 months, 11 patients with successful transradial PCI were admitted to our clinic again due to some symptoms such as chest pain and dyspnea. We successfully performed repetitive transradial coronary procedures in 7 patients who had positive exercise test and/or myocardial scintigraphy results (CAG only in 3 patients, both CAG and PCI in 4 patients [new single LAD lesion in 3 patients, restenotic single Cx lesion in 1 patient; radial cannulation time 2.3 ± 1.6 min, diagnostic time 4.8 ± 1.8 min, fluoroscopy time 5.7 ± 2.6 min, total procedure time 18.1 ± 12.7 min). Complications were not observed in any of these patients.

Table 3. Data regarding transradial angiography and angioplasty.

Number of patients with successful transradial procedures, n	398
Diagnostic coronary angiography only, n (%)	53 (13.3)
Both coronary angiography and angioplasty, n (%)	345 (86.7)
Single-vessel PCI, n (%)	303 (76.1)
Two-vessel PCI, n (%)	28 (7)
Three-vessel PCI, n (%)	12 (3)
Use of Gp IIb/IIIa inhibitors, n (%)	84 (21.1)
Cannulation time (min)	2.1 ± 1.4
Diagnostic time (min)	5.6 ± 2.1
Total procedure time (min)	47.1 ± 20.2
Fluoroscopy time (min)	9.5 ± 6.6
The duration of cannulation (min)	22 ± 5.6
The length of hospital stay (h)	11.6 ± 8.5

PCI, percutaneous coronary intervention; Gp, glycoprotein.

Table 4. Complications in patients with coronary procedures successfully performed via transradial approach.

Minor complications, n (%)	
▪ Venous thrombosis	12 (3.0)
▪ Hematoma	22 (5.5)
▪ Radial artery occlusion	25 (6.3)
▪ Symptomatic sinus bradycardia	17 (4.3)
▪ Atrioventricular block	-
▪ Aneurysm	-
▪ Arteriovenous fistulae	-
Major complications, n (%)	
▪ Death	-
▪ Blood transfusions	-
▪ Major vascular occlusion	-
▪ Transient ischemic attack	1 (0.25)
▪ Stroke	-

4. Discussion

Our results showed that the TRA for CAG and/or PCI is a safe method with high success rates, as well as low vascular and access site complications. As far as we know, this is the first study to demonstrate the feasibility and clinical applicability of the TRA in patients with a wide range of CAD, including AMI, in Turkey.

The TRA for the diagnosis and treatment of CAD has been successfully used in many cardiology clinics over the past 20 years, since its introduction by Campeau, who was the first to perform diagnostic catheterization in 1989 (11), and later by Kiemeneij and Laarman, who were the first to report successful coronary stent implantation in 1993 through the TRA (12). The first data regarding this issue in Turkey come from a case published in 1996, in which Yalçınkaya et al. reported successful implantation of a coronary stent to the left anterior descending artery via the TRA in a 65-year-old male patient (13). Yiğit et al. then presented the first randomized trial comparing transradial and transfemoral diagnostic CAG in Turkey, and they concluded that the radial approach is as safe as the femoral approach, with a procedural success rate of 85.2% in the TRA group (4). The data available show that the success rate for transradial coronary interventions has increased in parallel with experience, in which the failure rate could be diminished from 10% to 1% after 1000 cases (7,14,15). Our procedural success rate was 93.2%, and this rate is consistent with the success rates of 94%–98% reached in some centers (5,7). In addition, the TRA was found to be associated with a low crossover or failure rate in our study. It was necessary to switch to either a femoral artery or an ipsilateral ulnar artery in only 29 patients (6.8%) by virtue of serious radial spasm, subclavian tortuosity, and failed radial puncture. The failure or crossover rate was expressed as 14.8% in a study conducted in a Turkish population (4), while this rate was 5.9% in the TRA group in a metaanalysis (5), strongly supporting the findings obtained from this study.

Coronary interventions performed through the TFA carry a risk of entry point complications ranging between 1.4% and 23% (1–3). This situation may become particularly more important in those patients with concomitant use of thrombolytic therapy, Gp IIb/IIIa inhibitors, and other antiaggregants or anticoagulants. Some recent studies and a metaanalysis of 23 randomized controlled studies have clearly shown the superiority of the TRA to brachial and femoral approaches in terms of major access site, major bleeding, and vascular complications (5,7,16). Similarly, long-term warfarin therapy is presumed to increase the bleeding and access point complications after coronary procedures, and thus it is often recommended to postpone invasive procedures to reach international normalized ratio (INR) levels of <1.8. Ziakas et al. prospectively studied the efficacy and procedural safety of the radial versus femoral approach for cardiac procedures during uninterrupted warfarin therapy, and they concluded that the TRA is as efficacious and safe as the TFA for diagnostic CAG in fully anticoagulated patients, but is related with fewer access-site complications in patients who also undergo PCI (17). In the present study, 37.9% of all patients had the clinical picture of ACS, and the vast majority of them received multiple antiplatelets and anticoagulants, such as ASA, clopidogrel, and Gp IIb/IIIa inhibitors, while a small portion of patients with AMI received also thrombolytic therapy during their transfers to our hospitals. As a side note, only 5 patients with mechanical heart valve(s) had long-term warfarin management with INR levels between 2 and 3.5. Whereas none of these patients developed major bleeding complications, some patients experienced some access site and vascular complications, such as minor hematoma and venous thrombosis of an upper extremity. On the other hand, RAO has been reported to be an important complication of transradial coronary procedures, with an incidence of 2%–30% (10,16,18–20). In our study, RAO was observed to be low, with an incidence of 6.3%. Routine administration of heparin (5000 IU) immediately after the transradial puncture and additional doses of heparin (5000 IU) during the transradial PCI and, if necessary, intracoronary use of tirofiban may have diminished the RAO rate. In the early days of transradial procedures, Spaulding et al. found a RAO rate of 71% without heparin, 24.4% with 2000 to 3000 IU of heparin, and 4.3% with 5000 IU of heparin (21). In addition, the short duration of cannulation (mean: 22 min) may have contributed to the low incidence of RAO. Stella et al. investigated the incidence of RAO in patients who underwent transradial coronary interventions using 6 F introducer sheaths and 6 F guiding catheters with a short duration of cannulation (mean: 40 min), and they reported a very low incidence of RAO at both discharge (5.3%) and 1 month of follow-up (2.8%) (10), strongly supporting the findings of the current study.

Neurologic complications have been reported as a rare but potentially catastrophic complication following coronary procedures via the TFA (22). The transradial approach's value in achieving fewer neurologic complications after diagnostic coronary angiography and/or angioplasty has not been elucidated yet. Burzotta et al., in their study of >10,000 patients undergoing coronary diagnostic or interventions procedures with the TRA, noted that 0.06% had cerebrovascular accidents (0.03% TIA, 0.03% stroke) (7). A retrospective analysis, in which a total of 306,716 procedures had been performed either by TRA or TFA, demonstrated that neurologic complications occurred in 148 (0.118%) of 125,725 procedures with TRA and in 180 (0.099%) of 180,991 procedures with TFA (23). This study concluded that the vascular access site did not appear to be a predictor of neurologic complications following coronary intervention. Similar to those results, we found that 1 (0.25%) patient in our study had a TIA, with no evidence of hemorrhage or infarction on cerebral CT and MRI. TIA observed in this patient was ascribed to a possible microembolic event. All cardiac catheterization procedures may give rise to microemboli, consisting of benign microbubbles and atheromatous materials from the aortic wall. In addition, it is important to note that the posterior circulation nourishing the functionally crucial territory of the brain might be more compromised by the TRA as the vertebral artery originates from the subclavian artery (24).

The TRA to PCI tends to be technically extremely challenging and time-consuming, especially during the initial learning curve period. This may result in more prolongation of the door-to-balloon time in patients with AMI, which is closely associated with mortality rate (25). The door-to-balloon time was reported as 81 ± 38 min in a study by Jen et al. (26) and as 76.9 ± 25.9 min in the RADIAMI study (27). In our study, the mean procedure time and mean fluoroscopy time for only diagnostic CAG in the whole study population were 5.6 ± 2.1 min and 2.3 ± 1.4 min, respectively, whereas in patients with AMI, mean total procedure time was 70 ± 23 min, mean fluoroscopy time was 15.0 ± 6.1 min, and door-to-balloon time was 62 ± 22 min. All procedures times obtained in our study were shorter than those of the studies described above. Several factors may have contributed to the emergence of this result. First, all procedures were implemented by interventional cardiologists with at least 5 years of experience in radial interventions. Second, our hospitals and health personnel are capable of primary PCI within 30–60 min in patients with AMI. Third, our study did not enroll patients with cardiogenic shock or hemodynamic instability requiring a transvenous pacemaker and/or IABP.

The TRA allows early mobilization of patients, which is especially important to reduce hospital charges and to improve patient's comfort. Escarcega et al. showed that the TRA in coronary procedures is clearly more cost-effective than the TFA, as a consequence of lower requirements for medical and nursing staff in patient management, as well as more rapid return to productivity for working patients with same-day PCI in the TRA group (28). Moreover, some recent studies have demonstrated that coronary interventions with the TRA were associated with shorter hospital stay when compared to the TFA in a wider population of patients (29,30). In the current study, we detected that the length of hospital stay after procedures was 11.6 ± 8.5 h in the total study population, 4.9 ± 0.6 h in those with CAG only, and 28.2 ± 12.8 h in those with AMI.

Another important point is whether repetitive transradial coronary procedures might be performed using the same route. Many studies related to this topic have recently shown that repeated transradial coronary procedures from the same route could be safely and effectively carried out (31,32). In line with these studies, we also observed that repetitive transradial CAG and PCI could be easily and safely applied through the same artery, with a high procedural success, comparable procedural times, and no complications.

The most important limitations of the present study were that it was retrospective and nonrandomized. Another limitation was the absence of systematic Doppler findings for determination of asymptomatic radial artery occlusion and/or any other vascular complications. Consequently, the rates of vascular complications, such as RAO and venous thrombosis, may have been underestimated. The amounts of contrast agent used, and operator radiation exposure, which may vary according to operator location and X-ray source, were not estimated.

In conclusion, transradial CAG and/or PCI can be safely and effectively performed with high success and low complication rates, provided that it is employed by skilled operators, in patients with a wide range of CAD, including AMI, and in particular in hemodynamically stable patients who do not require IABP or temporary pacemakers. We also concluded that the TRA may also be alternative to the TFA for patients who have conditions requiring chronic warfarin treatment with INR levels of >1.8, such as prosthetic heart valves.

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