An experience on radial versus femoral approach for diagnostic coronary angiography in Turkey

Türkiye'de radiyal ve femoral yoldan tanısal koroner anjiyografinin karşılaştırması ile ilgili bir deneyim

Fatma Yiğit, Alpay Turan Sezgin, Tansel Erol, Şenol Demircan, Göknur Tekin, Tuna Katırcıbaşı, Abdullah Tekin, Haldun Müderrisoğlu

Department of Cardiology, Başkent University School of Medicine, Ankara, Turkey

ABSTRACT

Objective: The radial approach has been increasingly used as an alternative to femoral access. The purpose of the present study was to assess the feasibility, success, and safety of the transradial approach (TRA) for diagnostic coronary angiography, and to describe the difficulties associated with the technique as compared with transfemoral approach (TRF).

Methods: A series of 180 consecutive patients were divided to TRA or TFA groups by two operators. We compared the groups regarding procedural time, access time, fluoroscopy time, procedural failure, complications, contrast volume, length of hospital stay, and number of used coronary catheters.

Results: The number of used coronary catheters was not different between the two groups ($p = 0.6$). Total hospital length of stay was significantly shorter in the radial group ($p < 0.0001$) than in femoral one. We found differences between the radial and femoral groups in the success rate ($p<0.0001$), contrast volume ($p = 0.012$), procedural time ($p<0.0001$), access time ($p<0.0001$), and fluoroscopy time ($p<0.0001$). We did not find any major complication in the radial group. There was a major bleeding in the femoral group.

Conclusion: The TRA is a safe alternative to femoral catheterization although with lesser procedural success, longer procedural access, and radiation time, and more contrast volume. *(Anadolu Kardiyol Derg 2006; 6: 229-34)*

Key words: Coronary angiography, transradial approach

ÖZET

Amaç: Radiyal yoldan koroner anjiyografi femoral yola bir alternatif olarak tüm dünyada giderek artan sıklıkta kullanılmaktadır. Bu çalışmanın amacı kliniğimizde radiyal ve femoral yoldan yapılan tanısal koroner anjiyografiyi uygulanabilirlik, başarı ve güvenilirlik açısından karşılaştırmaktı.

Yöntemler: Toplam 180 hastaya iki doktor tarafından radiyal veya femoral yoldan koroner anjiyografi yapıldı. Her iki grup işlem süresi, damara giriş süresi, floroskopi süresi, işlem başarısı, kontrast madde miktarı, hastanede kalış süresi ve kullanılan kateter sayısı yönünden karşılaştırıldı.

Bulgular: Kullanılan kateter sayısı açısından gruplar arasında fark yoktu ($p = 0.6$). Hastanede kalış süresi radiyal grupta anlamlı derecede daha kısaydı ($p < 0.0001$). Femoral grupta işlem başarısı daha yüksek iken ($p<0.0001$) işlem süresi ($p<0.0001$), damara giriş süresi ($p<0.0001$) ve floroskopi süresi ($p<0.0001$) daha kısaydı ve kullanılan kontrast madde miktarı ($p=0.012$) daha azdı. Radiyal grupta majör komplikasyon saptanmazken femoral grupta bir hastada majör kanama gelişti.

Sonuç: Radiyal yoldan koroner anjiyografi femoral yol kadar güvenilirdir. Buna rağmen radiyal yolun işlem başarısı daha düşüktür, işlem süresi, damara giriş süresi ve floroskopi süresi daha uzundur ve kullanılan kontrast madde miktarı daha fazladır. *(Anadolu Kardiyol Derg 2006; 6: 229-34)*

Anahtar kelimeler: Koroner anjiyografi, transradiyal yaklaşım

Introduction

Coronary angiography is one of the most commonly performed diagnostic procedures worldwide (1). The transradial approach (TRA) for performing coronary angiography was initially proposed by Campeau in 1989 (2). Several studies have shown that TRA allows treatment of the same type of patients and lesions as the "classic" transfemoral approach (TFA), with some advantages over TFA because it involves a minimal vascular complication rate, eliminates the necessity for prolonged compression, and allows for earlier ambulation for the patient, rendering the radial approach more comfortable for the patient and

Address for Correspondence: Dr. Fatma Yiğit, Başkent Üniversitesi Hastanesi, Adana Araştırma ve Uygulama Hastanesi Kardiyoloji Anabilim Dalı Dadaloğlu Mah. 39/6 01250 Yüreğir, Adana, Turkey Tel: 0 322 327 27 27 Fax: 0 322 322 72 14 E-mail: yigitfatma2000@yahoo.com

one that decreases hospital costs and length of stay (3).

A meta-analysis that collected twelve randomized trials (n = 3224) has been shown that the transradial approach for coronary procedures is a highly safe and effective technique for both transcatheter diagnostic and therapeutic procedures (4). For coronary angiography, however, the rationale for full-scale conversion to the radial approach is weaker, especially as many patients have angiography and angioplasty as separate procedures and success rates fall with repeat catheterizations (5). Subsequently, a widespread diffusion of coronary procedures via the radial artery took place in America (6), Asia (7), and Europe (8).

Nevertheless, the greater technical complexity of the procedure and the associated significant learning curve has resulted in limited use of this procedure in our country.

The purpose of the present study was to assess the feasibility, success, and safety of TRA for coronary angiography, and to describe the difficulties associated with the technique as compared with TFA in our clinic.

Methods

Study Population

This is a one-year period cross sectional study. One hundred and eighty patients (110 male, 70 female) were enrolled a 12-month period between November 2003 and November 2004 with two partially experienced operators in the TRA (9). They performed diagnostic coronary angiography according to their catheterization day in a randomized fashion.

With informed consent, patients were divided TRA or TFA. The TRA was performed for patients with normal blood perfusion according to the Allen test by pulse oximetry device. The patients with negative Allen test or and not eligible for diagnostic coronary angiography via the radial artery were included to transfemoral group. Transradial approach for diagnostic coronary angiography was attempted in 88 patients except 13 patients, in whom procedure could not be performed because of technique-anatomical reasons and these patients were crossed over to the femoral group. Subsequently, study population consisted of 75 patients in the TRA group and 105 patients in the TFA group.

We compared the TRA group and TFA group for diagnostic coronary angiography in terms of procedural outcomes including procedural, access, and radiation time, contrast volume, major and minor complications, and length of hospital stay.

Exclusion criteria were angiographic (previous bypass grafting) or technical (right heart catheterization, simultaneous aortic angiography, and absence of indication for ventricular angiogram).

Artery Cannulation and Hemostasis

In the TRA group with the patient's wrist hyperextended and after local administration of 1% lignocaine , the radial artery was punctured using 18 gauge Argon AMC/4 arterial needle (Argon, Athens, TX). A valved introducing 6 Fr sheath (Cordis, Miami, USA) was advanced over a 0.018´´ straight wire. A 6 Fr sheath (length, 17 cm) was advanced over a guidewire for diagnostic imaging. A 10 ml mixture of saline, 50 mg xylocaine, 5 mg verapamil, and 2,500 units heparin was injected through the introducer side-port to prevent focal arterial spasm and thrombosis.

Coronary catheters were introduced over a 0.035´´ 150 cm Radifocus guidewire (Terumo Corp., Tokyo, Japan). Hydrophilic or exchange-length guidewires were used if necessary. Different coronary catheters were used for left and right coronary cannulations. Angiography was undertaken using predominantly Judkins-shape catheters. A 260 cm long guidewire was used in catheter exchange to facilitate the procedure and minimize catheter manipulation into the aortic arch and ascending aorta. The sheath was removed immediately after the procedure. For hemostasis an elastic band was used. Patients were free to mobilize immediately following the catheterization procedure but were asked to limit the wrist movements. The hand was checked every 30 min for 2 hours prior to discharge. Patients who underwent diagnostic coronary angiography via TRA were discharged on the same day after hemostasis was done.

In the TFA group, catheterization was performed using 7 Fr diagnostic catheters, usually Judkins curves. After the procedure, the 7 Fr sheath (Cordis, Miami, USA) was removed and hemostasis was achieved by the digital pressure for approximately 10 minutes. Patients were asked to lie flat for 2 hours and then sit up at 30° for 4 hours before walking. These patients were discharged the following morning.

Definitions

The following definitions were used in the study.

Access time: interval between local anesthetic injection and sheath introduction into the radial or femoral artery. Procedural time: interval between local anesthetic injection and completion of both coronary angiography and left ventriculography.

Coronary lesions were classified according to the ACC/AHA Task Force on percutaneous transluminal coronary angioplasty (10). Coronary slow flow was defined as slow dye progression in the coronary arteries during selective coronary angiography (11). Coronary artery ectasia was defined by segmental or diffuse dilation of the coronary arteries to more than 1.5 the diameter of the adjacent segments of the same artery or of different arteries (12).

The body mass index was calculated according to kilo/height^2 formula. Patients with body mass index equal or more than 25 was accepted obese.

Statistical Analysis

All analysis was performed with the SPSS 11.0 statistical package for Windows. Results were shown as means ± standard deviation and percentage. Student t-test was used for comparison of mean values and Chi-square test for comparison of percentages. The Mann-Whitney U test was used to compare continuous variables that were not distributed normally. The differences between groups were statistically significant with a p value of < 0.05.

Results

Patient Characteristics

Baseline demographic and clinical characteristics are shown in Table 1. The majority of patients were males. There was no significant difference in the incidence of hypertension, diabetes, hyperlipidemia, family history of premature coronary heart disease, smoking, and body mass index between the two groups.

Table 1. Clinical, angiographic, and procedural characteristics of patients who underwent transradial or transfemoral coronary angiography

	TRA (n=75)	TFA (n=105)	p
Age, years	58 ± 9	59 ± 15	NS
Men, %	60	61.9	NS
Smoking, %	34.7	38.1	NS
Hypertension, %	54.7	55.2	NS
Diabetes, %	25.3	30.5	NS
Family history, %	41.3	31.4	NS
Hypercholesterolemia, %	49.3	46.7	NS
Without significant lesions, %	24	21.9	NS
One-vessel disease, %	16	24.8	NS
Two-vessel disease, %	14.7	16.2	NS
Three-vessel disease, %	41.3	24.8	0.01
Disease of common trunk, %	5.3	5.7	NS
Dilated cardiomyopathy, %	-	1.9	NS
Coronary slow flow, %	-	1	NS
Coronary ectasia, %	-	2.9	NS
Body mass index, kg/m²	28 ± 4	27 ± 4	NS
Obese patients, %	81	79	NS
Contrast volume, mL	132 ± 18	125 ± 18	0.012
Procedural time, minute	16 ± 6	9 ± 3	<0 .0001
Access time, minute	2.5 ± 1.9	1.2 ± 0.5	< 0.0001
Fluoroscopy time, second	234 ± 103	137 ± 59	< 0.0001
Procedure success rate, %	85.2	99.9	< 0.0001
Hospital length of stay, hour	8.6 ± 3.1	28.4 ± 6.6	< 0.0001

Ns- nonsignificant, TFA - transfemoral approach, TRA - transradial approach

Coronary Angiography

Complete angiographic studies were performed by TRA in 85.2%, compared with 99.9% by TFA ($p < 0.0001$). In the TRA group; in 93% of cases, arterial access time was accomplished in less than 5 minutes.

Of procedures attempted in the 88 TRA patients, they could not be performed via the TRA in 13 patients (dropout rate, 14.8 %, 5 male, 8 female). Of the 13 failures, in 7 patients radial artery spasm occurred and in 6 patients the advancement of the guidewire within the aorta was not succeeded due to failure to negotiate brachial tortuosity (n = 3), radial loop (n = 2), and aortic root elongation (n = 1). In the TFA group the only one failure occurred due to inability to negotiate femoral tortuosity (Table 2).

Angiographic data are shown in Table 1. Three vessel diseases were more often in the radial group (p=0.01). The procedural, radiation, and access times were significantly longer in the TRA group (Table I) than in TFA group. Also the contrast volume was greater in the TRA group in the patients were 60 or more years old but not in those less than 60 years old (Table 3).

The procedural, radiation, and access times, procedure success, and contrast volume for each operator were examined. There was no difference in above mentioned variables between operators ($p > 0.05$).

Catheter Use

Catheters used for coronary angiography are listed in Table 4. In TRA group, coronary left and right heart catheterization and ventriculography were successfully done in 63, 69, and 74 patients by using 1 catheter, respectively. In the remaining patients, an additional catheter was required to engage the left coronary artery in 9 (12%), the right coronary artery in 5 (6%), and ventriculography in 1 (2%) patients. In TFA group, coronary left and right heart catheterization and ventriculography were successfully done in 94, 93, and 103 patients by using 1 catheter, respectively. In the remaining patients, an additional catheter was re-

Table 2. The clinical characteristics and reasons of failure of the patients in whom angiography could not be performed via the radial artery

	Sex	Age, years	SM	HT	DM	FH	HL	BMI, kg/m²	Reason
Patient 1	F	60	-	+	+	-	+	29	Brachial tortuosity
Patient 2	F	49	+	-	+	-	+	27	Brachial tortuosity
Patient 3	M	65	+	-	-	-	-	30	Brachial tortuosity
Patient 4	M	53	+	-	-	+	+	28	Radial spasm
Patient 5	M	45	-	-	-	+	-	32	Radial spasm
Patient 6	F	65	-	+	+	-	+	35	Radial spasm
Patient 7	F	54	+	-	+	-	-	26	Radial spasm
Patient 8	M	70	+	-	-	-	-	22	Failed access
Patient 9	M	47	+	+	-	-	-	25	Radial loop
Patient 10	F	51	-	+	-	+	+	25	Radial loop
Patient 11	F	59	-	+	-	-	+	29	Aortic root elongation
Patient 12	F	51	+	+	-	-	-	35	Failed access
Patient 13	F	53	-	+	+	-	+	24	Failed access

BMI- body mass index, DM- diabetes mellitus, F- female, FH- family history for coronary heart disease, HL- hyperlipidemia, HT- hypertension, M- male, NS- nonsignificant;,SM- smoking

quired to engage the left coronary artery in 11 (10%), the right coronary artery in 9 (8%) and ventriculography in 2 (2%) patients. Two additional catheters were required to engage the left coronary artery in 2 and the right coronary artery in 1 patient in the TRA group, however in the TFA group two additional catheters were required to engage the right coronary artery in 3 patients. Only in the TRA group, three additional catheters were required to engage the left coronary artery in 1 patient.

Changes in Dropout Rate

Procedural failures were higher in TRA group than in TFA group ($p < 0.0001$). The dropout rate was higher among obese patients. When the patients were reanalyzed based on the characteristics; the reasons for dropping out of their TRA, with respect to age, smoking, sex, hypertension, diabetes, and hypercholesterolemia, no significant differences were seen.

Procedural Failures and Complications

The most common minor complications seen after the TRA were forearm bruising and ache. There were no major complications in the radial approach group, only one patient had hematoma along the forearm and one patient developed vasovagal syncope. All patients had a palpable radial artery post procedure and no patient had symptoms or physical signs of hand ischemia. In the femoral group, hematoma formation (> 5 cm in diameter) was reported in 17 patients. There was one large hematoma required blood transfusion in the femoral group. In the present study there were no any differences between the two operators in procedural variables. Although they did not complete their learning curves one hundred transradial cardiac catheterizations were done by them before this study (9). Total length of hospital stay was significantly shorter in the radial group (Table 1) as compared with femoral one.

Table 3. Procedural characteristics of patients < 60 years old and ≥ 60 years old in the two groups

Age < 60 years old (n = 107)	TRA (n=44)	TFA (n=63)	p
Number of used catheters	3.3 ± 0.7	3.2 ± 0.5	NS
Contrast volume, mL	130 ± 16	125 ± 17	NS
Procedural time, minute	16.5 ± 5.6	9.3 ± 3.2	<0 .0001
Access time, minute	2.8 ± 2.2	1.3 ± 0.7	< 0.0001
Fluoroscopy time, second	240 ± 103	129 ± 44	<0 .0001
Procedure success rate, %	85	99	< 0.0001
Hospital length of stay, hour	8.6 ± 3.5	29 ± 8	<0 .0001
Age ≥ 60 years old (n = 73)	**TRA (n=42)**	**TFA (n=31)**	**p**
Number of used catheters	3.3 ± 0.7	3.4 ± 0.7	NS
Contrast volume, mL	134 ± 21	124 ± 20	0.049
Procedural time, minute	15.3 ± 5.9	9.2 ± 2.9	<0 .0001
Access time, minute	2.2 ± 1.4	1.0 ± 0.4	< 0.0001
Fluoroscopy time, second	226 ± 103	148 ± 74	< 0.0001
Procedure success rate, %	84.2	99.1	< 0.0001
Hospital length of stay, hour	8.6 ± 2.6	27.5 ± 3.4	< 0.0001

NS- nonsignificant, TFA- transfemoral approach, TRA- transradial approach

Table 4. Number of catheters used in the two groups

	TRA (n=75)	TFA (n=105)	p
Single catheter			NS
Left coronary catheter	63	94	
Right coronary catheter	69	93	
Pigtail catheter	74	103	
Two catheters			NS
Left coronary catheters	9	11	
Right coronary catheters	5	9	
Pigtail catheters	1	2	
Three catheters			NS
Left coronary catheters	2	-	
Right coronary catheters	1	3	
Pigtail catheters	-	-	
Four catheters			NS
Left coronary catheters	1	-	
Right coronary catheters	-	-	
Pigtail catheters	-	-	

NS- nonsignificant, TFA- transfemoral approach, TRA- transradial approach

Discussion

The present study is the first randomized trial comparing transradial with transfemoral diagnostic coronary angiography in Turkey. Transradial coronary angiography and angioplasty have been documented as safe alternatives to femoral approach in Western populations (13-14), Chinese patients (15), and Japanese patients (7). Nevertheless, the greater technical complexity of the procedure and the associated significant learning curve has resulted in limited use of this procedure in our country.

In this randomized, prospective trial, we found that the radial approach was as safe as the femoral approach. However,

access site bleeding complications were significantly less in the radial group. In addition, more rapid ambulation in this group resulted in a shorter hospital length of stay. The operator's experience plays a major role in the success rate and procedure duration (16).

There were no noticeable differences in the clinical characteristics between the radial and femoral group. The angiographic findings, however, showed a higher frequency of three-vessel disease in the radial group. This may be coincidence.

The technical results were as anticipated except procedural success. Procedural success was 85.2 % in the radial group. This is lower than 94-98% success rates achieved in some studies (17-19). Obese patients also have a high incidence of complications at catheterization, and the radial approach has been shown useful in these patients (20). In our study, 14.8 % patients dropped out at the TRA attempt. Eleven of 13 patients not eligible for cardiac catheterization via the radial artery were obese (Table 2). Procedural success was not significantly different in women, despite the known sex difference in radial artery diameter (21-22).

The number of catheters used was similar in the groups (Table 4). Most of catheterizations in both groups were performed with a Judkins left and Judkins right catheters. This was different from the other studies (17, 19). They were performed mostly with an Amplatz left catheter for both coronary arteries in the radial approach.

In terms of procedure duration, the radial approach was significantly more time-consuming than the femoral approach (21). Achieving access to the radial artery is technically more challenging and time-consuming than gaining femoral access, but when the right skills are grasped, the technique is much easier and reliable (17). Peripheral vascular disease is the most common indication for TRA and has been shown to result in significantly fewer vascular complications than femoral catheterization in this group (23). However, long-term complications, including radial artery occlusion and narrowing, are associated with TRA. However, post procedure Doppler examination was not routinely performed and the incidence of asymptomatic radial artery occlusion was thus not determined. These complications are not seen with TFA (17).

The fluoroscopy time, a more reliable marker of procedural complexity (21), was significantly shorter in the femoral approach group as compared with the radial group. Operator radiation exposure, which may vary according to operator position and X-ray source, was not measured (24).

Contrary to the results involving feasibility, procedure duration, access time, contrast volume, and X-ray exposure time, duration of bed confinement and hospitalization in the radial group was shorter than femoral group (17). Same-day discharge was reported in all radial cases and in no cases when femoral angiography was performed.

All transradial angiograms were performed with administration of heparin in order to prevent radial artery occlusion (25). Vascular complications were scarce in the two groups. One case of transfusion was reported in the femoral group and hematoma in brachial artery was reported in the radial group. No systematic Doppler examination was performed; consequently, the percentage of radial occlusions, even when a radial pulse was present, may have been underestimated (26). Given the dual blood supply of the hand, the superficial course of the radial artery and the absence of major neural and vascular structures immediately adjacent to the radial artery, it is not surprising that the incidence of significant vascular complications is low (27).

Patient comfort was better graded with the transradial than with the transfemoral approach (28), which is reflected in patients' preferences observed in routine practice.

We did not determine the cost analysis. But in the previous study the difference in costs was in favor of transradial procedures, although this difference was mitigated because of the higher cost of transradial equipment (17). Same-day discharge is supposed to be one of the advantages of transradial approach, was mainly for administrative reasons (29).

Consistent with previous studies, our study demonstrates that transradial angiography can similarly be performed safely also in Turkey. The development of specific catheterization equipment for transradial angiography and improvement operator's experience could contribute to a further reduction in procedure duration, X-ray exposure time, and contrast volume.

Although the number of patients was limited, based our study data that coronary angiography can be safely performed using 6 Fr catheters from the radial artery in patients with clinical evidence of a satisfactory ulnar arterial supply to the hand.

Conclusion

Transradial approach is a safe alternative to femoral catheterization in Turkey although with lesser procedural success, longer procedural, access, and radiation time and more contrast volume. As for the femoral approach, after adequate training, the TRA for coronary angiography is no longer merely an alternative strategy when the TFA is impossible (30-31) and can potentially result in an increased number of outpatient procedures.

References

1. Deligonul U. Coronary angiography as a prognostic tool. Anadolu Kardiyol Derg 2001; 1: 189-96.
2. Campeau L. Percutaneous radial artery approach for coronary angiography. Cathet Cardiovasc Diagn 1989; 16: 3-7.
3. Lotan C, Hasin Y, Mosseri M, Rozenman Y, Admon D, Nassar H, Gotsman MS. Transradial approach for coronary angiography and angioplasty. Am J Cardiol 1995; 76: 164-7.
4. Agostoni P, Biondi-Zoccai GG, de Benedictis ML, Rigattieri ML, Turri M, Anselmi M, et al. Radial versus femoral approach for percutaneous coronary diagnostic and interventional procedures; Systematic overview and meta-analysis of randomized trials. J Am Coll Cardiol 2004; 44: 349-56.
5. Sakai H, Ikeda S, Harada T, Yonashiro S, Ozumi K, Ohe H, et al. Limitations of successive transradial approach in the same arm: the Japanese experience. Catheter Cardiovasc Interv 2001; 54: 204-8.
6. Barbeau GR, Arsenault F, Dugas L, Simard S, Lariviere MM. Evaluation of the ulnopalmar arterial arches with pulse oximetry and plethysmography: comparison with the Allen's test in 1010 patients. Am Heart J 2004; 147: 489-93.
7. Saito S, Miyake S, Hosokawa G, Tanaka S, Kawamitsu K, Kaneda H, et al. Transradial coronary intervention in Japanese patients. Cathet Cardiovasc Interv 1999; 46: 37-41.
8. Choussat R, Black A, Bossi I, Fajadet J, Marco J. Vascular comp-

lications and clinical outcome after coronary angioplasty with platelet IIb/IIIa receptor blockade. Comparison of transradial vs transfemoral arterial access. Eur Heart J 2000; 21: 662-7.
9. Salgado Fernandez J, Calvino Santos R, Vazquez Rodriguez JM, Vazquez Gonzalez N, Vazquez Rey E, Perez Fernandez R, et al. Transradial approach to coronary angiography and angioplasty: initial experience and learning curve. Rev Esp Cardiol 2003; 56: 152 -9.
10. Ryan TJ, Faxon DP, Gunnar RM, Kennedy JW, King SB 3rd, Loop FD, et al. Guidelines for percutaneous transluminal coronary angioplasty. A report of the American College of Cardiology/American Heart Association Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures (Subcommittee on Percutaneous Transluminal Coronary Angioplasty). Circulation 1988; 78: 486-502.
11. Tambe AA, Demany MA, Zimmerman HA, Mascarenhas E. Angina pectoris and slow flow velocity of dye in coronary arteries-a new angiographic finding. Am Heart J 1972; 84: 66-71.
12. Swaye PS, Fisher LD, Litwin P, Vignola PA, Judkins MP, Kemp HG, et al. Aneurysmal coronary artery disease. Circulation 1983; 67: 134-8.
13. Kiemeneij F, Laarman GJ. Transradial artery Palmaz-Schatz coronary stent implantation: results of a single-center feasibility study. Am Heart J 1995; 130: 14-21.
14. Mann JT 3rd, Arrowood M, Cubeddu G. PTCA using the right radial artery access site. J Invas Cardiol 1995; 7: 142-7.
15. Wu CJ, Lo PH, Chang KC, Fu M, Lau KW, Hung JS. Transradial coronary angiography and angioplasty in Chinese patients. Catheter Cardiovasc Diagn 1997; 40: 159-63.
16. Louvard Y, Lefevre T, Morice MC. Radial approach: what about the learning curve? Catheter Cardiovasc Diagn 1997; 42: 467-8.
17. Louvard Y, Lefevre T, Allain A, Morice M. Coronary angiography through the radial or the femoral approach : The CARAFE study. Catheter Cardiovasc Interv 2001; 52: 181-7.
18. Spaulding C, Lefevre T, Funck F, Thebault B, Chauveau M, Ben Hamda K, et al. Left radial approach for coronary angiography: results of a prospective study. Cathet Cardiovasc Diagn 1996; 39: 365-70.
19. Louvard Y, Krol M, Pezzano M, Sheers L, Piechaud JF, Marien C, et al. Feasibility of routine transradial coronary angiography: a single operator's experience. J Invas Cardiol 1999; 11: 543-8.
20. McNulty PH, Ettinger SM, Field JM, Gilchrist IC, Kozak M, Chambers CE, et al. Cardiac catheterization in morbidly obese patients. Catheter Cardiovasc Interv 2002; 56: 174-7.
21. Hildick-Smith DJ, Walsh JT, Lowe MD, Shapiro LM, Petch MC. Transradial coronary angiography in patients with contraindications to the femoral approach: an analysis of 500 cases. Catheter Cardiovasc Interv 2004; 61: 60-6.
22. Joannides R, Costentin A, Iacob M, Compagnon P, Lahary A, Thuillez C. Influence of vascular dimension on gender difference in flow-dependent dilatation of peripheral conduit arteries. Am J Physiol Heart Circ Physiol 2002; 282: H1262-H1269.
23. Hildick-Smith DJ, Walsh JT, Lowe MD, Stone DL, Schofield PM, Shapiro LM, et al. Coronary angiography in the presence of peripheral vascular diease: femoral or brachial/radial approach? Catheter Cardiovasc Interv 2000; 49: 32-7.
24. Mann JT 3rd, Cubeddu G, Arrowood M. Operator radiation exposure in PTCA: comparison of radial and femoral approaches. J Invas Cardiol 1996; 8 (Suppl D): 22D-25D.
25. Randolph AG, Cook DJ, Gonzales CA, Andrew M. Benefit of heparin in peripheral venous and arterial catheters: systemic review and meta-analysis of randomized controlled trials. BMJ 1998; 316: 969-75.
26. Saito S, Ikei H, Hosokawa G, Tanaka S. Influence of the ratio between radial artery inner diameter and sheath outer diameter on radial artery flow after transradial coronary intervention. Catheter Cardiovasc Interv 1999; 46: 173-8.
27. Kiemeneij F, Laarman GJ, de Melker E. Transradial artery coronary angioplasty. Am Heart J 1995; 129: 1-7.
28. Ludman PF, Stephens NG, Harcombe A, Lowe MD, Shapiro LM, Schofield PM, et al. . Radial versus femoral approach for diagnostic coronary angiography in stable angina pectoris. Am J Cardiol 1997; 7: 1239-41.
29. Kiemeneij F, Laarman GJ, Slagboom T, van der Wieken R. Outpatient coronary stent implantation. J Am Coll Cardiol 1997; 29: 323-37.
30. Hildick-Smith DJ, Walsh JT, Lowe MD, Petch MC. Coronary angiography in the fully anticoagulated patient: the transradial route is successful and safe. Cathet Cardiovasc Interv 2003; 58: 8-10.
31. Clark DA. Coronary angiography by the left radial approach: a limited but useful technique. Cathet Cardiovasc Diagn 1996; 39: 371.