Journal of Cardiovascular Diseases & Diagnosis
ISSN: 2329-9517

Mansour et al., J Cardiovasc Dis Diagn 2019, 7:2

Research Article Open Access

Challenge to Reduce Crossover from Radial to Femoral Access for Coronary Procedures: "RURU" Approach- A Single Center, Single Operator Experience in 1000 Procedures

Mansour S[1], Mohamad A[2], Ibrahim Y[2], Ahmad F[2], Mostafa E[2], Nasser A[3], Osama T[3], Suhaib A[4], Syed R[5], and Taher S[6]*

[1]*Cardiology Unit, Sultan Qaboos University Hospital, Muscat, Oman*
[2]*Cardiology Unit, Al-Azhar University, Cairo, Egypt*
3Department of Medicine, Sultan Qaboos University Hospital, Muscat, Oman
[4]*Catheterization Laboratory, Sultan Qaboos University Hospital, Muscat, Oman*
[5]*Department of Bio-statistics, College of Medicine and Health Sciences, Sultan Qaboos University Hospital, Muscat, Oman*
[6]*Faculty of Medicine, Islamic Center of Cardiology, Al-Azhar University, Cairo, Egypt*

Abstract

Aim: Our study aimed highlighting experience in reducing crossover rate from radial to femoral access to maintain coronary procedure safety and patients' satisfaction.

Methods and results: A prospective, single center, single operator observational study included all comers for coronary procedures. The default access for coronary procedures was the right Radial artery, whenever failed, right Ulnar artery utilized then left Radial then left Ulnar "RURU". We studied 1000 procedures "964 patients" whom the default access was the radial artery. Radial access succeeded in 908 "90.8%" procedures and failed in 92 "9.2%" procedures necessitating crossover to other access site. One of the right ulnar, left radial or left ulnar succeeded in 51 out of 92 patients reducing the total crossover to femoral access to 4.1%. The remaining 41 procedures were obliged to crossover to femoral access. Radial artery spasm and vessel tortuosity were the commonest causes of crossover from radial to RURU/femoral artery "p=0.012 and 0.0017 respectively". Minor hematomas were the commonest immediate complication "p<0.022" with non significant prolongation of procedural time and radiation exposure.

Conclusion: RURU approach has resulted in significant crossover rate reduction from radial to femoral access maintaining procedural safety and patient's satisfaction on expense of increased minor hematomas and non-significant increase of procedural time and radiation exposure.

Keywords: Radial Ulnar Radial Ulnar (RURU); Radial; Femoral; Ulnar; Coronary procedure; Crossover; Safety; Patient satisfaction; Procedural time; Radiation exposure

Introduction

During coronary interventions, procedure safety and patients' satisfaction are of paramount importance. The radial access has gained superiority as opposed to femoral access mainly because of less local vascular complications and early patient ambulation. Our study highlights experience in achieving both via crossover to ipsilateral ulnar or left radial/ulnar once the right radial fails. We enrolled 1000 procedure. Primary failure to complete the procedure from right radial was 9.2, after applying our new tactic, the final crossover to femoral access was 4.1%. We concluded this new tactic was successful on expense of increased minor hematomas and non-significant increase of procedural time and radiation exposure.

Over the past few decades, radial artery access for coronary procedures has gained sound recognition as compared to femoral access mainly due to superior safety ،principally fewer local vascular complications coupled with amplified patient satisfaction because of early post procedure ambulation and hospital discharge [1-7]. The worth of radial access over femoral is more pronounced in certain settings like acute ST segment elevation myocardial infarction (STEMI) [8-11]. Due to various pitfalls, utilization of radial access is associated with higher crossover rate to femoral route [12-14]. Recent report confirmed clinical utility of ulnar approach as an alternative to radial access whenever radial access fails [15] and many publications described safety and feasibility of transulnar approach for diagnostic and therapeutic coronary intervention especially when performed by operators who are skilled in the radial technique [16-23]. Despite feasible, transulnar approach found to be inferior to transradial approach when head to head comparison was carried out 24. Nevertheless, there is no study compared safety and feasibility of ulnar versus femoral access during coronary procedures.

What is known?

Both radial and femoral artery access during coronary procedures have their pros and cons, in general:

1. Radial access is safer as compared to femoral for coronary procedures especially in the settings of ST segment elevation myocardial infarction [8-11].
2. Crossover rate is higher from radial access to femoral access than from femoral to radial [12-14].
3. Ulnar artery access is a feasible alternative to radial artery access with similar safety compared to radial access [15-23].

***Corresponding author:** Taher S, Faculty of Medicine, Islamic Center of Cardiology, Al-Azhar University, 32511, Cairo, Egypt, Tel: 01120313136; E-mail: Tahersalman2013@yahoo.com

Received January 16, 2019; **Accepted** March 25, 2019; **Published** April 01, 2019

Citation: Mansour S, Mohamad A, Ibrahim Y, Ahmad F, Mostafa E, et al. (2019) Challenge to Reduce Crossover from Radial to Femoral Access for Coronary Procedures: "RURU" Approach: A Single Center, Single Operator Experience in 1000 Procedures. J Cardiovasc Dis Diagn 7: 362.

What the study adds

An attempt to reduce crossover rate from radial to femoral to maintain procedure

safety and patients' satisfaction, this was the chief aim of the current study. Up to the best of my knowledge, this is the first manuscript addresses this tactic.

Research Methodology

The present study was a single centre, single operator; prospective observational study conducted between January 2010 and May 2015 and enrolled all eligible patients undergoing coronary procedures at a tertiary care institute. All patients were suitable candidates for radial, femoral and ulnar vascular access sites; patients were approached to participate in the study that was approved by our local research ethics committee. During the study period 1186 coronary procedures "1145 patients" have been performed, out of them 186 procedures "181 patients" have been excluded as the primary access site was the femoral approach. The remaining 1000 procedures "964 patients" constituted our study population.

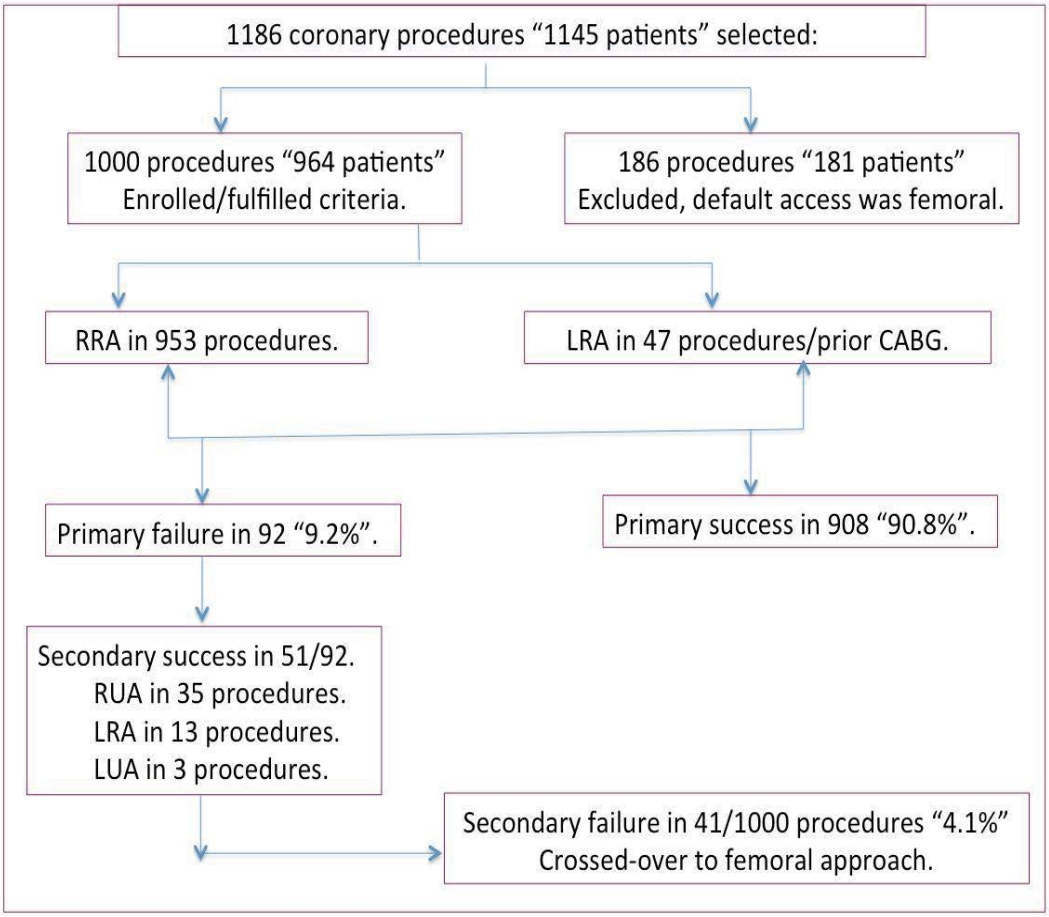
Patient population

Inclusion criteria: All patients admitted with no contraindication for coronary angiography and or intervention via radial or femoral access was enrolled in this observational study. Age equal to or older than 18 years. First time or prior angiography via either radial or femoral access. All patients with chronic stable angina, acute coronary syndrome unstable angina/non-STEMI" or acute STEMI with or without cardiogenic shock. Patients with prior coronary artery bypass graft "CABG" surgery whenever left internal mammary artery was utilized with intact left radial artery.

Exclusion criteria: Patients were excluded if the primary access site was the femoral approach due to any reason. All patients with prior CABG surgery whenever left radial artery utilized as a conduit. All patients having or planning to have arterio venous fistula. All patients who refused to participate in the study.

Strategic plan

Figure 1 is a self-explanatory flow chart of the study profile. The default access site was the right radial artery "RRA" except for the patients with prior bypass surgery, the default access was left radial access "LRA" unless LRA has been harvested or all grafts were venous. In general, whenever RRA failed, the second choice was the right ulnar artery "RUA" if failed the third choice was LRA, if failed the fourth choice was the left ulnar access "LUA" respectively. However, if the cause of radial access failure was above the level of radial origin, I shifted directly to the LRA in case of RRA failure or to right femoral access "RFA" in case of LRA [24].



Note: A self-explanatory study flow chart. (RRA: Right Radial Access. LRA: Left Radial Access. RUA: Right Ulnar Access. LUA: Left Ulnar Access).

Figure 1: Study flow chart.

Parameters	Group I (n=908)	Group II (n=51)	Group III (n=41)	p-value
	Radial	RURU	Femoral	
Age	58.3 ± 11.6	58.4 ± 11.7	57.6 ± 13.8	0.924
Gender (Males)	635 (69.9%)	34 (66.7%)	30 (73.2%)	0.794
Body mass index	28.8 ± 6.1	30.7 ± 5.7	31.4 ± 7.8	0.013
Hypertension	581 (64%)	33 (64.7%)	29 (70.7%)	0.677
Diabetes mellitus	499 (55%)	20 (39.2%)	23 (56.1)	0.087
Dyslipidemia	349 (38.4%)	18 (35.3%)	16 (39%)	0.9
Smoking	178 (19.6%)	13 (25.5%)	11 (26.8%)	0.332
Prior MI	404 (44.5%)	26 (51%)	15 (36.6%)	0.385
Prior PCI	220 (24.2%)	11 (21.6%)	10 (24.4%)	0.91
Prior CABG	59 (6.5%)	5 (9.8%)	2 (4.9%)	0.588
CKD	95 (10.5%)	9 (17.6%)	7 (17.1%)	0.131
Ejection fraction	0.868 ± 3.929	0.499 ± 0.164	0.525 ± 0.151	0.83
Chronic stable angina	710 (78.2%)	39 (76.5%)	29 (70.7%)	0.517
ACS/NSTEMI	127 (14%)	9 (17.6%)	4 (9.8%)	0.555
STEMI	69 (7.6%)	4 (7.8)	7 (17.1%)	0.091
Cardiogenic Shock	11 (1.2%)	1 (2%)	3 (7.3%)	0.064
BMI: Body Mass Index, HF: Heart Failure, CKD: Chronic Kidney Disease, Mi: Myocardial Infarction.				

Table 1: Baseline demographic characteristics.

Parameters	Group I (n=908)	Group II (n=51)	Group III (n=41)	p-value
	Radial	RURU	Femoral	
eGFR	77.4 ± 18.2	75.9 ± 20.3	77.0 ± 18.5	0.878
Hemoglobin	12.85 ± 2.01	12.71 ± 1.96	12.89 ± 1.84	0.893
Platelets	257.0 ± 87.8	265.4 ± 110.8	277.4 ± 78.5	0.33
INR	1.08 ± 0.464	1.02 ± 0.183	1.03 ± 0.175	0.532
Note: eGFR: Estimated Glomerular Filtration Rate, INR: International Randomized Ratio.				

Table 2: Baseline laboratory investigations.

Parameters	Group I (n=908)	Group II (n=51)	Group III (n=41)	p-value
	Radial	RURU	Femoral	
Diagnostic only	534 (58.8%)	30 (58.8%)	22 (53.7%)	0.806
PCI	363 (40%)	21 (41.2%)	19 (46.3%)	0.713
Contrast amount	136.5 ± 80.6	148.6 ± 88.8	176.3 ± 134.1	0.066
Procedure time	41.73 ± 30.9	43.8 ± 30.5	46.5 ± 34.5	0.67
Fluoro time	12.41 ± 11.65	13.30 ± 11.99	13.40 ± 10.71	0.85
Dose area product	142931.9 ± 105422.3	161544.0 ± 114397.2	172826.2 ± 120166.5	0.235
Spasm	59 (6.5%)	17 (33.3%)	22 (53.6%)	0.0121
Vessel tortuosity	57 (6.3%)	6 (11.8%)	21 (51.2%)	0.0017
No support	14 (1.5%)	0 (0%)	1 (2.4%)	0.597
Radial/ulnar loop	3 (0.3%)	0 (0%)	1 (2.4%)	0.101
Feeble pulse	17 (1.9%)	1 (2%)	0 (0%)	0.675
PCI: Percutaneous Coronary Intervention.				

Table 3: Baseline procedural characteristics.

Parameters	Group I (n=908)	Group II (n=51)	Group III (n=41)	p-value
	Radial	RURU	Femoral	
Minor hematoma	65 (7.1%)	3 (5.9%)	5 (12.2%)	0.022
Grade I	56 (6.2%)	1 (2.0%)	3 (7.3%)	0.011
Grade II	10 (1.1%)	2 (3.9%)	2 (4.9%)	0.046
Major Hematoma	11 (1.2%)	0 (0.0%)	0 (0.0%)	0.15
Grade III	10 (1.1%)	0 (0.0%)	0 (0.0%)	0.12
Grade IV	5 (0.6%)	0 (0.0%)	1 (2.4%)	0.59
Grade V	0 (0.0%)	0 (0.0%)	0 (0.0%)	1
R/U perforation	5 (0.6%)	0 (0.0%)	1 (2.4%)	0.59
Vasovagal attack	19 (0.02%)	2 (3.9%)	0 (0.0%)	0.42
CVA	1 (0.1%)	0 (0.0%)	0 (0.0%)	0.95
Death	6 (0.7%)	0 (0.0%)	0 (0.0%)	1
CVA: Cerebrovascular Stroke, NB: Minor hematoma includes grade I and II, major hematoma includes grade III, IV and V. All deaths presented with cardiogenic shock complicating STEMI (5 cases) and NSTEMI (one case).				

Table 4: Baseline procedural complications.

Procedure

All procedures performed by a single operator who is proficient in radial, ulnar and femoral access. The patients were assigned for diagnostic coronary angiography and ad hoc percutaneous coronary intervention "PCI" if clinically indicated. All patients were prepared according to the American College of Cardiology/American Heart Association (AHA/ACC) task force on Cardiac Catheterization Laboratory Standards [25]. In the vast majority of patients, diagnostic angiography was performed with a dedicated 6 French radial sheath (Micro puncture radial artery access, William Cook Europe, Bjaeverskov, Denmark) and 5 French diagnostic TIG catheter (Terumo corporation, Tokyo, Japan) for both left and right coronaries and 5 French pigtail catheter if left ventriculuography, aortography and/or non-selective renal angiography were required. Different 6 French guiding catheters as Extra Backup, Judkin's or Amplatz were used in case of intervention. A cocktail of 100 microgram glyceryltrinitrate and verapamil 2.5 milligram was injected after sheath insertion followed by 5000 international units of unfractionated heparin through the side port of the sheath. Occasionally, one-milligram midazolam plus or minus 25 micrograms of fentanyl were given intravenously depending on patient's clinical situation. The sheath was immediately removed at the completion of the diagnostic and or interventional procedure. Hemostasis was obtained by local compression using tight pressure bandage for 4 hours in the first half of the study that replaced by trans-

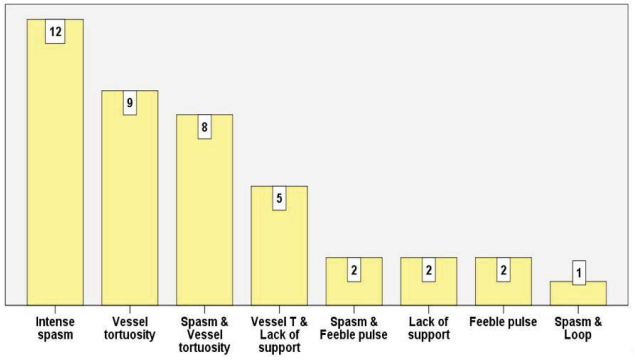


Figure 2: Intense spasm and vessel tortuosity represented the commonest causes. Other less common causes were lack of catheter support, feeble pulse and radial/ulnar loop.

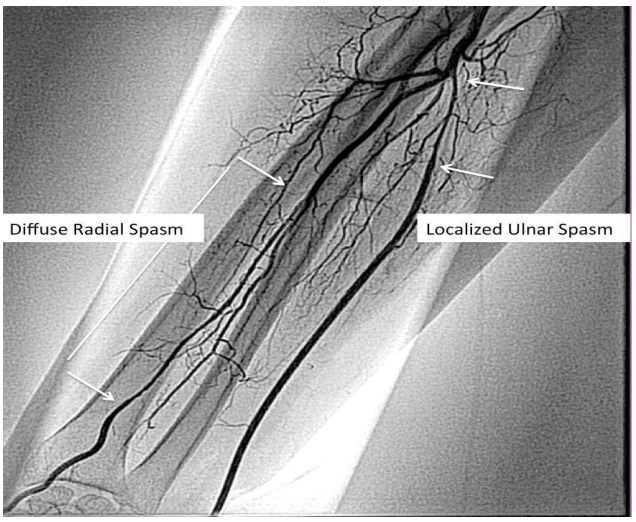


Figure 3: Intense and prolonged diffuse right radial artery spasm despite sedation before the procedure preventing sheath insertion necessitating crossover to ipsilateral ulnar artery. Also, ulnar displayed short segment spasm 15 mm from its origin.

Figure 4: A 360 degrees right radial artery loop, successfully straightened by 0.035-inch guidewire. The diagnostic angiography accomplished via the radial route, nevertheless, the patient had severe pain and radial spasm.

Note: A 60-year old lady admitted with high-risk Non-ST segment Elevation Myocardial Infarction, she did prefer to die rather to get the catheterization via femoral approach. There was a 360 degrees loop in the right radial artery that could not be straightened, right ulnar approach was not feasible because of significant right subclavian artery tortuosity, and the left radial approach was also not suitable owing to another 360 degrees loop. Finally, the coronary procedure accomplished from the left ulnar artery.

Figure 5: Simultaneous left radial and ulnar artery cannulation.

radial band in the second half (Terumo corporation, Tokyo, Japan). Patients were allowed to ambulate immediately unless their clinical status compelled otherwise. The patient's demographic, clinical and procedure criteria as well as complications have been recorded.

End points

The primary efficacy outcome was the final crossover from both upper arm vessels to femoral access. We defined the final crossover rate "procedural failure" from arm blood vessels to femoral approach as inability to perform and complete the coronary procedure from the arm blood vessels owing to any etiology. All causes of procedure failure have been recorded.

Note: Massive hematoma complicating radial artery perforation "A" grade IV Bertrand's hematoma proximal and distal to the right elbow complicating radial artery perforation resulted in massive superficial and deep hematoma, skin burning and peeling with no clinical or ultrasound evidence of compartment syndrome.

Figure 6A: Massive hematoma complicating radial artery perforation.

Figure 6B: Four weeks later, the hematoma has completely disappeared and skin healed with intact radial pulses.

Key secondary outcomes were the percentage of immediate local vascular complications, cerebrovascular stroke, vasovagal attack, local nerve injury and death. Local vascular complications included hematoma and perforation. Hematoma defined as a localized collection of extravasated blood and graded as per Bertrand's and colleagues dedicated transradial classification system 26. This scale includes a hematoma < 5 cm (Grade I), < 10 cm (Grade II), distal to the elbow (Grade III > 10 cm), proximal to elbow (Grade IV) and compartment syndrome (Grade V). Hematomas Grade I and II are confined to the access site while Grade III and IV are not directly related to the puncture site, but resulted from wire damage to vessels and small perforations. Compartment syndrome represents acute threatening limb ischemia. All patients who experienced major local vascular complications were subjected to Doppler vascular forearm ultrasound evaluation for any extravasation or deep hematoma.

Statistical analysis

Statistical analysis was carried out using the IBM SPSS version 23 statistical package for Windows. For description purpose; the continuous variables were shown as mean±SD and the categorized variables were displayed as percentages. Chi-square test was used to find the association between the categorized variables and the three groups under study. Continuous variables were tested for normality using the Kolmogorov-Smirnov test and if the variables were found to be following normal pattern then analysis of variance technique (ANOVA) was used to find the significance of difference in the averages of the three groups under study. In case of non-normal pattern of the variable, the non-parametric, Kruskal-Wallis test was used to test the significance of the difference between the three groups and for pairwise comparison; Mann-Whitney U test was applied. For all the statistical analysis, the level of $P \leq 0.05$ was considered cut-off value of statistical significance.

Results

In the current study we succeeded to complete the procedures from the primary default access site (RRA) in 908 procedures "90.8%" and ranked them as Group 1 Radial. The remaining 92 procedures "9.2%" instead to crossover directly to RFA, I attempted to engage other forearm access and attained in 51 procedures and ranked them as group II. The remaining 41 procedures "4.1%" crossed to RFA and labeled them as group III, the latest group represents the true procedure failure.

Baseline demographic and laboratory characteristics illustrated in Tables 1 and 2 respectively. Mean age was approximately 58 years, more than two thirds of our patients were men and hypertensive. We did not notice any statistical difference among groups except in body mass index (BMI) that was higher in group III (p= 0.013).

The procedure characteristics are depicted in Table 3. There was statistically significant increase in spasm and vessel tortuosity in group II and III (0.012 and 0.001 respectively) with a trend to highr contrast amount consumption in group III.

Procedural complications are shown in Table 4. Minor hematomas have been reported more in group III (p=0.02). Six patientsexpereinced

radial/ulnar artery perforation (5 in group I and 1 in group III) that were successfully managed as per our stepwise approach protocol [26,27]. No compartment syndrome was noted in any of the patients. One patient experienced post procedural minor stroke that fully resolved 3 days later after immediate local thrombolytic therapy.

Figure 2 portrays and self explains the reasons for failure to crossover from arm to femoral approach. Intense spasm and vessel tortuosity represent the commonest causes. Other less common causes were feeble pulse, lack of catheter support and radial/ulnar loop were reported.

Discussion

It is a routine practice to crossover to femoral access whenever radial approach fails to accomplish coronary procedure. Aiming at sustaining the better safety profile gained from the radial access as opposed to groin as well as patients' satisfaction, the current editorial addressed extraordinary perspective to reduce crossover rate to femoral access whenever radial route fails by adopting what has been proposed "RURU" approach "Radial Ulnar Radial Ulnar" by which once the right radial access failed if the reason was not above the radial artery origin as significant subclavian artery tortuosity, the second access site was the right ulnar artery, if failed the subsequent choice was the left radial artery then left ulnar artery.

Safety profile of radial approach

Many literature has documented better safety profile of radial as compared to femoral access for coronary procedures mainly due to less local vascular complications as well as patients' satisfaction and improved quality of life, this conclusion was genuine in the most clinical settings as elective coronary procedures "1,3,4", uninterrupted anticoagulation "6", women [7] and STEMI patients "8-11". Another edge of the safety is almost appropriate control of complications. One of the most distressing complication is the radial perforation (Figure 1) that can be treated simply by placing the diagnostic or guide catheter across the perforated segment, if not sealed, the stepwise approach that we proposed can be applied "27".

Crossover rate from radial to femoral before and after RURU

Despite many rewards of the radial access as opposed to femoral one, radial approach requires a steep learning curve and associated with higher crossover rate to femoral approach owing to many physio-anatomic disparities as but not limited to intense spasm, tortuous configuration, hypoplasia, loop, and lusoriasubclavian artery [28-32]. There is marked disparity in literature observing the percentage of crossover rate from radial to femoral access with a reported very low incidence at 1.2% to very high 18% [33-35], however, the average rate ranges between 4%-9%. In the current study I failed to get access to radial artery in 92 out of 1000 procedures "9.2%" that is high acceptable level as per international standard. Aiming at reducing crossover to femoral access it was my routine practice to crossover to the ipsilateral ulnar artery if the cause of the radial access failure was not above the radial origin, the ipsilateral right ulnar access was succeeded in 35 out of 92 procedures, reducing the crossover rate to 5.7%. Out of the 57 failed procedures, the left radial approach succeeded in extra 13, reducing the crossover to 4.4%, and the left ulnar approach succeeded in extra 3 procedures, reducing the total crossover rate to 4.1%. The remaining 41 procedures (4.1%) crossed over to the femoral approach. The initial encountered crossover rate was 9.2% that challenged by the RURU approach to 4.1% with p=0.0001. To the best of my knowledge, there are no prior studies similar to the current one to compare with.

Causes of radial artery access failure

In the current study, the most frequent two underlying etiologies of radial access failure were intense spasm (Figure 2) and extensive vascular tortuosity (43.5% and 20.5% respectively) and combined spasm and tortuosity in 7.7%. Other causes included small, feeble radial artery pulse in 5.1%. Full 360 degrees radial loop (Figure 3) encountered in 4 patients, two out of them could manage and failed in other two (2.5%) due to intense forearm pain and crossed over to other site. The crossover rate as well as causes of failure is in agreement with other studies [12-14].

Accessibility and applicability of ulnar access whenever radial fails

Ulnar access for coronary procedures is a feasible alternative whenever radial route fails, it gives an opportunity of avoiding crossover to the femoral approach with a satisfactory success rate (15) with negligible prolongation of procedure time as the ipsilateral ulnar is already sterilized. Despite the encouraging results, there are many difficulties preventing generalization of ulnar approach, as the ulnar artery is located deep inside the muscle as well as it runs closely to the ulnar nerve, cannulation requires operators who master the radial approach and having considerable knowledge in the forearm anatomy, such limitations mandated interventional cardiologists to preclude transulnar as a first-line strategy due to higher crossover rates and concluded at present, the transulnar route should not be regarded as an acceptable alternative to the transradial access site [20].

Safety of simultaneous ipsilateral ulnar access and hazards of hand ischemia

Many studies have proven safety of immediate ipsilateral ulnar access after failure to get the radial artery [14,21], even-more, additional studies have proved safety of ulnar access in patients with documented ipsilateral radial artery unavailability or occlusion [36-38].

Arterial supply of the hand explains low incidence of ischemia

The current manuscript as well as other studies documented broad safety profile of utilizing ulnar approach either after failure to get the radial access or as a default access [19], such safety profile can be attributed to complex and rich vascular network formed by anastomosis of radial and ulnar arteries in the hand to form two arches, the superficial and deep palmar arches coupled with a supplementary arterial supply derived from the common interosseous and occasionally the median artery, all of which are branches of the ulnar artery [39,40]. Such huge network of collaterals circulation explains very low incidence of hand ischemia even with concomitant cannulation of both radial and ulnar arteries as demonstrated in one of our patients who presented with high risk ACS/NSTEMI requiring emergent transfer to catheterization laboratory. The patient absolutely refused procedure from the groin. The Right radial approach failed owing to a 360 degrees loop that could not be aligned, an attempt to straighten was associated with severe forearm pain, right ulnar approach was not feasible because of significant right subclavian artery tortuosity, and the left radial approach was also not suitable because of another 360 degrees loop. I discussed with the patient and her relatives to crossover to groin but again refused and given a verbal consent to utilize the left ulnar artery. While the left radial sheath was in place, the ulnar artery accessed (Figure 4) and the tight proximal LAD stented successfully. Immediately after PCI both sheathes removed and the patient discharged next day with good pulse and no evidence of hand

ischemia.

Secondary endpoints

Majority of these complications were due to hematomas and vast majority were superficial mild Grade I hematomas. As graded per Bertrand classification, Grade I minor hematomas encountered in 7.3%, 5.9% and 12.2% in group I, II and III respectively (p=0.02). Such mild grade bruises were due to leakage at the access site during sheath removal that noticed mainly in patients necessitating excessive anticoagulation therapy, most of these cases were self-limited and did not require further intervention. Grade III and IV hematomas were met in 16 patients out of 1000 procedures (1.6%), most of these hematomas were related to perforation of either radial (Figure 5) or ulnar arteries. Compartment syndrome did not complicate any of our patients, which is compatible with the reported very low incidence in one literature (0.004%).

Perforation of the radial artery can occur during sheath or catheter insertion and is related to large sheath/artery size ratios (>1) or any other impedance to sheath/wire/catheter advancement, which are aggravated by spasm, excessive tortuosity, and aggressive antithrombotic therapy and congenital anatomic variations. In the current study perforation was complicated radial/ulnar cannulation in seven patients, all have been managed as we proposed. Most of patients suffered from perforation developed Grade III or IV hematomas, fortunately, no one experienced compartment syndrome and most of these hematomas disappeared within few weeks with no peculiar actions. Radial/ulnar perforation considered being the most devastating complication at the vascular access site; however, its management is much simpler and less dreadful as compared to femoral access site justifying our resistance to crossover directly to femoral access (Figures 6A and 6B).

Out of 964 patients enrolled in the current study 7 died, all of these patients admitted with cardiogenic shock complicating STEMI "6 patients" and NSTEMI "one patient", 5 out of these patients presented with cardiac arrest before shifting to the catheterization laboratory. Cerebrovascular stroke complicated one procedure in a patient who was on fondaparinux, the patient treated promptly with local thrombolytic therapy and totally recovered.

Conclusion

Adopting right Radial-right Ulnar-left Radial- left Ulnar artery "RURU" approach consecutively after failure of right radial access has markedly reduced crossover to femoral approach for coronary procedures. Resulting in maintaining the proposed procedure safety and patient satisfaction as compared to immediate crossover once the right radial and or left radial access fails. The proposed RURU approach success was on expense of significant increase of minor hematomas and non-significant prolongation of procedure time and increase of contrast media as well as radiation exposure.

Study Limitations

Although this manuscript presents a single center and single operator experience, however, the same limitation point is a clinically useful as it can be adopted by any experienced operator in radial approach with a considerable knowledge in the hand anatomy. Another important limitation was the long duration of the study. During study period many interventions have been developed to improve the technique. One of the most important of them is local subcutaneous infiltration of 100-microgram nitrate and routine premedication with anxiolytic therapy to reduce and overcome spasm. Another important development was balloon tracking technique to overcome subclavian and aortic arch tortuosity. Such interventions definitely reduced the failure to approach the radial access and crossing over from one site to another. However, the salient effect of long study duration was the follow up of most of these patients that documented safety of the technique as well as long-term patients' satisfaction, as the info regarding long-term outcome is not feasible to all patients I did not display. Lastly, being an educational institute, many trainees had chance to access the radial artery, this approach had definitely spoiled success rate, increased unnecessarily the procedure and radiation times.

Acknowledgment

I would like to highly acknowledge and appreciate Mr. Rathinasekar, Mrs. Nabila AL-Wadhahi and Mr. Mohammad Al-Hinai, Senior Technologists at our catheterization laboratory for their kind and sincere help in collecting patients' data.

References

1. Dangoisse V, Guédès A, Gabriel L, Jamart J, Chenu P, et al. (2013) Full conversion from transfemoral to transradial approach for percutaneous coronary interventions results in a similar success rate and a rapid reduction of in-hospital cardiac and vascular major events. Euro Intervention 9: 345-352.
2. Numasawa Y, Kohsaka S, Miyata H, Kawamura A, Noma S, et al. (2013) Safety of transradial approach for percutaneous coronary intervention in relation to body mass index: A report from a Japanese multicenter registry. Cardiovasc Interv Ther 28: 148-156.
3. Sallam M, Al-Hadi H, Rathinasekar S, Chandy S (2009) Comparative study of the radial and femoral artery approaches for diagnostic coronary angiography. Sultan Qaboos Univ Med J 9: 272-278.
4. Jolly SS, Amlani S, Hamon M, Yusuf S, Mehta SR (2009) Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: A systematic review and meta-analysis of randomized trials. Am Heart J 157: 132-140.
5. Koltowski L, Koltowska M, Filipiak KJ, Kochman J, Golicki D, et al. (2014) Quality of life in patients with ST-segment elevation myocardial infarction undergoing percutaneous coronary intervention--radial versus femoral access (from the OCEAN RACE Trial). Am J Cardiol 114: 516-521.
6. Baker NC, O'Connell EW, Htun WW, Sun H, Green SM, et al. (2014) Safety of coronary angiography and percutaneous coronary intervention via the radial versus femoral route in patients on uninterrupted oral anticoagulation with warfarin. Am Heart J 168: 537-544.
7. Sunil VR, Connie NH, Britt B, Laura HA, Kevin JA, et al. (2014) A registry-based randomized trial comparing radial and femoral approaches in women undergoing percutaneous coronary intervention: the SAFE-PCI for Women (Study of Access Site for Enhancement of PCI for Women) trial. JACC Cardiovasc Interv 7: 857-867.
8. Ivo B, David H, Josef S, Martin M, Jan P, et al. (2014) ST-Segment Elevation Myocardial Infarction Treated by Radial or Femoral Approach in a Multicenter Randomized Clinical TrialThe STEMI-RADIAL Trial. J Am Coll Cardiol 63: 964-972.
9. Piccolo R, Galasso G, Capuano E, De Luca S, Esposito G, et al. (2014) Transradial versus transfemoral approach in patients undergoing percutaneous coronary intervention for acute coronary syndrome. A meta-analysis and trial sequential analysis of randomized controlled trials. PLoS One 9: e96127.
10. De Luca G, Schaffer A, Wirianta J, Suryapranata H (2013) Comprehensive meta-analysis of radial vs. femoral approach in primary angioplasty for STEMI. Int J Cardiol 168: 2070-2081.
11. Jolly SS, Yusuf S, Cairns J, Niemela K, Xavier D, et al. (2011) Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): A randomized, parallel group, multicenter trial. Lancet 377: 1409-1420.
12. Deftereos S, Giannopoulos G, Raisakis K, Hahalis G, Kaoukis A, et al. (2013) Moderate procedural sedation and opioid analgesia during transradial coronary interventions to prevent spasm: A prospective randomized study. JACC Cardiovasc Interv 6: 267-273.
13. Murphy JC, Kozor R, Figtree GA, Ward MR, Bhindi R (2012) Percutaneous coronary intervention via the radial artery: comparison of procedural success in emergency versus non-emergency cases. Cardiovasc Revasc Med 13: 277-280.

14. Carrillo X, Mauri J, Fernandez-Nofrerias E, Rodriguez-Leor O, Bayes-Genis A (2012) Safety and efficacy of transradial access in coronary angiography: 8-year experience. J Invasive Cardiol 24: 346-351.

15. Sallam M, Al-Riyami A, Misbah M, Al-Sukaiti R, Al-Alawi A, et al. (2014) Procedural and clinical utility of transulnar approach for coronary procedures following failure of radial route: Single centre experience. J Saudi Heart Assoc 26: 138-144.

16. Gokhroo R, Bisht D, Padmanabhan D, Gupta S, Kishor K, et al. (2015) Feasibility of ulnar artery for cardiac catheterization: AJmerULnarARtery (AJULAR) catheterization study. Catheter Cardiovasc Interv 86: 42-48.

17. Liu J, Fu XH, Xue L, Wu WL, Gu XS, et al. (2014) A comparative study of transulnar and transradial artery access for percutaneous coronary intervention in patients with acute coronary syndrome. J Interv Cardiol 27: 525-530.

18. Geng W, Fu X, Gu X, Jiang Y, Fan W, et al. (2014) Safety and feasibility of transulnar versus transradial artery approach for coronary catheterization in non-selective patients. Chin Med J 127: 1222-1228.

19. Agostoni P, Zuffi A, Faurie B, Tosi P, Samim M, et al. (2013) Same wrist intervention via the cubital (ulnar) artery in case of radial puncture failure for percutaneous cardiac catheterization or intervention: the multicenter SWITCH registry. J Cardiol 169: 52-56.

20. George H, Grigorios T, Ioanna X, Spyridon D, Antonios Z, et al. (2013) Transulnar compared with transradial artery approach as a default strategy for coronary procedures: A randomized trial. The Transulnar or Transradial Instead of Coronary Transfemoral Angiographies Study (the AURA of ARTEMIS Study). Circ Cardiovasc Interv 6: 252-261.

21. De Andrade PB, Tebet MA, Nogueira EF, Esteves VC, De Andrade MV, et al. (2012) Transulnar approach as an alternative access site for coronary invasive procedures after transradial approach failure. Am Heart J 164: 462-467.

22. Yun-Zhi L, Yu-Jie Z, Ying-Xin Z, Yong-He G, Yu-Yang L, et al. (2010) Safety and efficacy of transulnar approach for coronary angiography and intervention. Chin Med J 123: 1774-1779.

23. Aptecar E, Pernes JM, Chabane-Chaouch M, Bussy N, Catarino G, et al. (2006) Transulnar versus transradial artery approach for coronary angioplasty: The PCVI-CUBA study. Catheter Cardiovasc Interv 67: 711-720.

24. Dahal K, Rijal J, Lee J, Korr KS, Azrin M (2015) Transulnar versus transradial access for coronary angiography or percutaneous coronary intervention: A meta-analysis of randomized controlled trials. Catheter Cardiovasc Interv 87: 857-865.

25. Bashore TM, Bates ER, Berger PB, Clark DA, Cusma JT, et al. (2001) American college of cardiology/society for cardiac angiography and interventions clinical expert consensus document on cardiac catheterization laboratory standards. A report of the American college of cardiology task force on clinical expert consensus documents. J Am Coll Cardiol 37: 2170-2214.

26. Bertrand OF, Larose E, Rodes-Cabau J, Gleeton O, Taillon I, et al. (2009) Incidence, predictors, and clinical impact of bleeding after transradial coronary stenting and maximal antiplatelet therapy. Am Heart J 157: 164-169.

27. Sallam MM, Ali M, Al-Sekaiti R (2011) Management of radial artery perforation complicating coronary intervention: a stepwise approach. J Interv Cardiol 24: 401-406.

28. Goldsmit A, Kiemeneij F, Gilchrist IC, Kantor P, Kedev S, et al. (2014) Radial artery spasm associated with transradial cardiovascular procedures: Results from the RAS registry. Catheter Cardiovasc Interv 83: E32-E36.

29. Rosencher J, Chaïb A, Barbou F, Arnould MA, Huber A, et al. (2014) How to limit radial artery spasm during percutaneous coronary interventions: The spasmolytic agents to avoid spasm during transradial percutaneous coronary interventions (SPASM3) study. Catheter Cardiovasc Interv 84: 766-771.

30. Abdelaal E, Brousseau-Provencher C, Montminy S, Plourde G, MacHaalany J, et al. (2013) Risk score, causes, and clinical impact of failure of transradial approach for percutaneous coronary interventions. JACC Cardiovasc Interv 6: 1129-1137.

31. Patel T, Shah S, Pancholy S, Deora S, Prajapati K, et al. (2014) Working through challenges of subclavian, innominate, and aortic arch regions during transradial approach. Catheter Cardiovasc Interv 84: 224-235.

32. Gunasekaran S, Kallarakkal JT, Thanikachalam S (2006) Percutaneous transluminal coronary angioplasty by right transradial approach in a patient with arterialusoria. Indian Heart J 58: 365-367.

33. Burzotta F, Trani C, Mazzari MA, Tommasino A, Niccoli G, et al. (2012) Vascular complications and access crossover in 10,676 transradial percutaneous coronary procedures. Am Heart J 163: 230-238.

34. Rubartelli P, Crimi G, Bartolini D, Bellotti S, Iannone A, et al. (2014) Switching from femoral to routine radial access site for ST-elevation myocardial infarction: a single center experience. J IntervCardiol 27: 591-599.

35. Koutouzis M, Matejka G, Olivecrona G, Grip L, Albertsson P (2010) Radial vs. femoral approach for primary percutaneous coronary intervention in octogenarians. Cardiovasc Revasc Med 11: 79-83.

36. Kedev S, Zafirovska B, Dharma S, Petkoska D (2014) Safety and feasibility of transulnar catheterization when ipsilateral radial access is not available. Catheter Cardiovasc Interv 83: E51-60.

37. Kwan TW, Ratcliffe JA, Chaudhry M, Huang Y, Wong S, et al. (2013) Transulnar catheterization in patients with ipsilateral radial artery occlusion. Catheter Cardiovasc Interv 82: E849-55.

38. Gellman H, Botte MJ, Shankwiler J, Gelberman RH (2001) Arterial patterns of the deep and superficial palmar arches. Clin Orthop Relat Res 383: 41-46.

39. Sahin B, Seelig LL (2000) Arterial, neural and muscular variations in the upper limbs of a single cadaver. Surg Radiol Anat 22: 305-308.

40. Tizon-Marcos H, Barbeau GR (2008) Incidence of compartment syndrome of the arm in a large series of transradial approach for coronary procedures. J Interv Cardiol 21: 380-384.