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COMPARATIVE STUDY BETWEEN RADIAL AND ULNAR ARTERY ACCESS FOR CORONARY ANGIOGRAPHY AND FOR PERCUTANEOUS CORONARY INTERVENTION

By

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ABSTRACT

Background: Transulnar approach had been suggested for elective procedures in patients not suitable for transradial approach. It is as safe and effective as the transradial approach for coronary angiography and intervention.

Objective: To evaluate the safety and feasibility of percutaneous transulnar approach for coronary angiography and intervention.

Patient and Methods: This study is a prospective study which was done in Cardiology department of Alazhar University Hospitals and National Heart Institute from the period of July 2019 to July 2020.

One hundred patients requiring coronary angiography plus or minus intervention were enrolled and randomly assigned for 2 equal groups: Group I with radial access and Group II with ulnar access. Demographic and comparative analyses of both access sites were obtained.

Results: Group II was notably older than Group I (60.9 ± 7.9 versus 57.7 ± 6.7, p= 0.029). There was no difference between the two groups concerning puncture time, number of attempts to fix the artery, procedure and fluoroscopy times. Procedural success rate in both groups was (96% versus 90% in group I and II respectively, p= 0.240) with similar frequency of acute complications as spasm, hematoma or hand ischemia. Vascular anomalies as high takeoff and tortuosities encountered more common in the radial as compared to ulnar group, however, did not reach statistical significance.

Conclusion: Transulnar approach was as safe and feasible as transradial access for coronary procedures with similar technical tactic, success and complication rates. However, because of radial artery was more superficial, transulnar access was a realistic alternative to radial route whenever not attainable.

Key words: Transradial access, Transulnar access, coronary procedures, percutaneous coronary intervention.

INTRODUCTION

Interventional cardiovascular medicine continues to quickly evolve in both diagnostic and therapeutic arenas because of tremendous refinement and advances in intravascular and intracardiac imaging, hemodynamic support and drug-eluting stents *(Mukherjee et al., 2010)*. Transfemoral approach (TFA) had been the preferred vascular access for coronary angiography and percutaneous coronary intervention (PCI) for many decades.

However, over the past three decades, transradial access (TRA) for coronary angiography and interventions has gained sound approval as an alternative approach to TFA because of better safety profile and similar efficacy and moreover better patient satisfaction *(Gatzopoulos et al., 2018)*. Whenever TRA is not feasible, transulnar approach (TUA) had been proposed to be alternative to TRA for coronary procedures. Because of frequent variant anatomy of the radial artery and noteworthy prevalence of spasm, TRA is not always reachable; TUA denotes a good alternative to avoid crossing over to TFA maintaining safety, efficacy and patients' satisfaction *(Li et al., 2010)*.

We aimed to evaluate the safety and feasibility of percutaneous transulnar approach for coronary angiography and intervention as compared to transradial access.

PATIENTS AND METHODS

This was a prospective comparative study included total of 100 patients admitted at our institutes. Patients were enrolled in the study after obtaining their written informed consent and approval of the local ethics committee of the hospital.

Patients included in the study were referred for coronary angiography (CAG) plus or minus percutaneous coronary intervention (PCI) and divided according to vascular access into two groups; Group I subjected to trans radial access (TRA) (n = 50 patients) and Group II trans ulnar access (TUA) (n = 50 patients).

Exclusion Criteria:

Patients with history of prior angiography via radial access, cardiogenic shock, history of CABG using radial grafts, chronic renal failure, patients with arteriovenous fistula or any bone deformity in the arm/forearm.

All patients were subjected to detailed history taking, including CAD risk factors and medical history, physical examination, pre and post procedure electrocardiography (ECG) and echocardiography, procedural success to assess incidence of crossover, procedural time, fluoroscopy time and access site complications were recorded.

TRA technique: An essential component of patient positioning was an arm board extending usually from the side of the catheterization table, and preferably hinged to allow lateral motion toward and away from the table. The patients were placed on the catheterization table in the usual fashion with the right arm extended on the arm board, palm upward; the wrist was extended by placing a roll of gauze underneath it *(Aptecar et al., 2006)*.

- Anterior puncture technique: The radial artery was punctured with a 21-gauge open needle to obtain a pulsatile blood flow 2–3 cm, above the styloid process, where the artery was best palpable. The subsequent punctures in a patient who had a prior unsuccessful access attempt was at 1 cm proximal to the initial site. Longer needles prevented the operator to see the "flash" of blood return, so shorter needles seemed to be more desirable. The wires that were supplied are usually 30-50 cm and often have floppy tip and a more rigid shaft *(Bazamore et al., 2005)*.
- Counter-puncture technique: This technique was done by arterial puncture with Teflon sheathed needle,

after advent of blood in the needle hub, indicating anterior wall puncture, the needle was advanced through the lumen and the posterior wall was punctured then the inner stylet was removed after stabilization of the needle. The needle was then gently withdrawn in to the arterial lumen and the guide wire was advanced once continuous or pulsatile flow is seen *(Pacholy et al., 2012)*.

TUA technique: Ulnar artery access technique was similar to the radial approach. After infiltration of local anesthetic and nitroglycerin (100µg) arterial puncture was achieved either by palpation of the site of maximal pulse prominence (hyperextension of the wrist accentuated the ulnar arterial pulsation). The ulnar nerve lied just medial to the ulnar artery, so arterial puncture should start on the lateral side of the ulnar artery to reduce pain and spasm *(Shafik et al., 2020)*. The ideal ulnar artery puncture site was approximately 5 to 30 millimeters proximal to the flexor crease skinfold along the axis with the most powerful pulsation of the artery. The needle was inserted at a 45° to 60° angle along the vessel axis and from lateral to medial, avoiding the ulnar nerve. Seldinger technique was applied by passing a 0.021 inch hydrophilic guide wire through the needle and after removing the needle, passing a 6 French hydrophilic sheath over the guide wire, vasodilators (nitroglycerin and verapamil) and heparin (50–70 IU/kg, up to 5,000 units) were administered intra arterially, after which cardiac catheterization ready to be commenced. Following completion of the cardiac catheterization, the sheath was removed with patent hemostasis achieved using trans-radial ban (TRB) *(Kedev et al., 2014)*.

In cases when ulnar artery pulsations were weak but palpable at the distal wrist, it was safe to puncture the ulnar artery more distally, at the level of skin folds (over the carpal bones). The risk of post procedural hematoma was lower when puncturing the ulnar artery near the wrist skinfolds. Although the ideal site for puncture was 5 to 30 millimeters proximal to the pisiform bone, the ulnar artery was punctured up to the mid-forearm as long as the pulsation was felt. This approach was useful for an experienced operator performing coronary or endovascular interventions requiring larger-bore devices *(Geng et al., 2014)*.

The primary outcome of this study was a combined endpoint of bleeding access site or non-access site, arterial spasm, acute arterial occlusion.

The secondary outcome was major adverse cardio-cerebrovascular event (MACCE) including acute non-fatal myocardial infarction, stroke, acute heart failure and death.

Statistical analysis: Statistical analysis was performed using Statistical Package for The Social Sciences Version 25 (IBM Corp., Armonk, NY, USA). Description of quantitative variables was in the form of mean and standard deviation (SD). Description of qualitative variables was in the form of numbers and percentage. Comparison between both groups regarding categorical data was done using the Chi square test. Comparison between both groups regarding scale data was done using the independent t- test. P-Value $\leq$ 0.05 was considered to indicate significance.

RESULTS

The mean age of the two groups was 57.68 ± 6.74 and 60.94±7.92 years respectively with statistically significant difference (p value 0.029), whereas there was a non-significant difference `among the studied groups regarding gender and risk factors of CAD **(Table 1)**.

Table (1): Demographic data and risk factors among the studied groups

Parameters	Radial N=50	Ulnar N=50	P-value
Age	57.6 ± 6.7	60.9 ±7.9	0.029
Male N (%)	31(62%)	27(54%)	0.418
Female N (%)	19(38%)	23(46%)	
Smoking N(%)	19(38.00%)	23(46.00%)	0.418
HTN N(%)	30(60.00%)	34(68.00%)	0.405
Dyslipidemia N(%)	27(54.00%)	30(60.00%)	0.545
DM N(%)	28(56.00%)	34(68.00%)	0.216
Prior MI N(%)	18(36.00%)	10(20.00%)	0.075
Prior CABG N(%)	1(2%)	2(4%)	0.749
Prior CVA N(%)	0(0.00%)	0(0.00%)	1

N= number. Categorical data was presented as number and percentage-

Only CAG was performed in 64% and 74% in Group 1 and 2 respectively, while, PCI with stent deployment in 36 % and 26% of both groups with no remarkable statistical significance. Owing to deeper position, puncture time was a bit longer in ulnar than in radial group with average time was 1.6 ± 0.3 versus 1.7 ±0.3 minutes respectively, however it did not reach statistical significance (p= 0.09).

One of the striking findings in our study that there was no significant differences in both groups regarding number of attempts to get the vascular access, procedure or radiation time and amount of contrast used alongside the most important parameter which is the procedure success. The mean fluoroscopy time in our study was (5.8 ± 1.7) minutes in CAG and (11.1 ±3.5) minutes in PCI in ulnar group, while in radial group it was (6.1 ±1.6) minutes in CAG and (10.2 ± 1.6) minutes in PCI.

The crossover rate between the two groups: Radial punctures were successful in the radial group except in two patients (success rate 96%), crossed over to ipsilateral ulnar artery because of persistent intense spasm. In the ulnar group, failed to get in access in 5 patients (success rate 90%), crossed over to ipsilateral radial in four patients and one to the right groin with significant statistical difference (P-value 0.04). The cause of failure in ulnar group was owing to feeble pulse and inability to get the ulnar artery and in one patient due to catheter knot. There was no significant statistical difference in success in both groups (96% vs 90%, P=0.240) **Table (2)**.

Table (2): Catheterization data among the studied groups

Parameters \ Access		Radial	Ulnar	P-value
Procedure	**PCI N(%)**	18(36.00%)	13(26.00%)	0.280
	CA N(%)	32(64.00%)	37(74.00%)	
No of trials	**One N(%)**	23(46.00%)	13(26.00%)	0.061
	>One N(%)	27(54.00%)	37(74.00%)	
Puncture time (min)		1.658±0.306	1.763±0.319	0.097
Fluoroscopy time (min)				
Total Median (Interquartile Range)		7 (6-9.25)	7 (5-8.25)	0.233
PCI Median (Interquartile Range)		11 (9-11.25)	11 (9.5-13.5)	0.296
CA Median (Interquartile Range)		6 (5-7)	6 (4.5-7)	0.501
Radiation dose gray (cm^2)				
Total Median (Interquartile Range)		49.5 (28.5-71.25)	38.5 (24-65.25)	0.198
PCI Median (Interquartile Range)		79 (62-95.25)	88 (68.5-112)	0.357
CA Median (Interquartile Range)		34.5 (25-48.75)	32 (22.5-44)	0.413
Contrast (ml)				
Total Median (Interquartile Range)		62 (37-184.25)	61 (38.75-159.25)	0.962
PCI Median (Interquartile Range)		191.5 (173-206.25)	195 (181-215)	0.482
CA Median (Interquartile Range)		49 (28-59.5)	53 (35-66.5)	0.226
Procedure time (min)				
Total Median (Interquartile Range)		23.5 (20-33)	23 (22-34.25)	0.511
PCI Median (Interquartile Range)		35 (32.5-38)	37 (35-41)	0.147
CA Median (Interquartile Range)		21 (18.25-23.75)	22 (21-23)	0.038*
Crossover N(%)		2(4.00%)	5(10.00%)	0.240
2ry Access	**Radial N(%)**	0(0.00%)	4(8.00%)	0.04*
	Ulnar N(%)	2(4.00%)	0(0.00%)	
	Femoral N(%)	0(0.00%)	1(2.00%)	
Cause	**Weak pulse N(%)**	0(0.00%)	4(8.00%)	0.04*
	Spasm N(%)	2(4.00%)	0(0.00%)	
	CK N(%)	0(0.00%)	1(2.00%)	
Procedural success N(%)		48(96.00%)	45(90.00%)	0.240

N= number. CA=coronary angiography, PCI=Percutaneous Coronary Intervention Categorical data was presented as number and percentage.

There were low incidences of major and minor complications reported in both groups as death, stroke, hematoma or hand ischemia with no significant difference between both groups. Regarding arterial spasm: Our study showed that four cases in each group (8%) developed intense spasm which was persistent in two cases in the radial group with no statistical difference (P-value=1.00), Minor hematoma occurred in two cases (4%) in the radial group and four case in the ulnar group (8%) (P-value=0.400) while minor bleeding occurred in two cases in the radial group (4%) and one case in the ulnar group (2%) (P=0.558). There were no documented cases of major hematoma, hand ischemia or compartmental syndrome except for 1 case of major hematoma in the radial group with non-significant P-value between both group. Our results showed that radial approach showed one incident of non-access site complications (death during hospitalization), and each group showed one case of stroke **(Table 3)**.

Table (3): Incidence of complications among the studied groups

Complications \ Access		Radial	Ulnar	P-value
Non-Access	No N(%)	48(96.00%)	49(98.00%)	0.603
	Death N(%)	1(2.00%)	0(0.00%)	
	Stroke N(%)	1(2.00%)	1(2.00%)	
	Pulmonary edema	0(0.00%)	0(0.00%)	
Access	Spasm N(%)	4(8.00%)	4(8.00%)	1.000
	Minor bleeding N(%)	2(4.00%)	1(2.00%)	0.558
	Hand ischemia N(%)	0(0.00%)	0(0.00%)	-
	Major hematoma N(%)	1(2.00%)	0(0.00%)	0.603
	Minor hematoma N(%)	2(4.00%)	4(8.00%)	0.400
	Compartment syndrome N(%)	0(0.00%)	0(0.00%)	-

N= number. Categorical data was presented as number and percentage

Radial group had 3 patients with radial tortuosity, and 2 patients with high take off, while ulnar group had only 1 patient with high take off ulnar artery originating from axillary artery with absent brachial artery **(Table 4)**.

Table (4): Vascular anomalies among the studied groups

VascularAccess \ Anomalies	Radial	Ulnar	P-value
High takeoff N(%)	2(4.00%)	1(2.00%)	0.558
Tortuosity N(%)	3(6.00%)	0(0.00%)	0.079
Loop N(%)	0(0.00%)	0(0.00%)	-
Hypoplasia N(%)	0(0.00%)	0(0.00%)	-

N= number. Categorical data was presented as number and percentage.

Documented cases of vascular anomalies and local complication: The ulnar artery originates from the axillary artery and the brachial artery was completely absent **(Figure 1)**.

Figure (1): High take off ulnar artery

A hematoma extended above the elbow **(grade IV-Figure 2)**.

Figure (2): Major hematoma in the radial group cases

Diffuse and persistent intense radial artery spasm despite extra doses of vasodilatory cocktail necessitating crossover to ipsilateral ulnar access. Note, there is associated intense spasm of the ulnar artery in the proximal segment **(Figure 3)**.

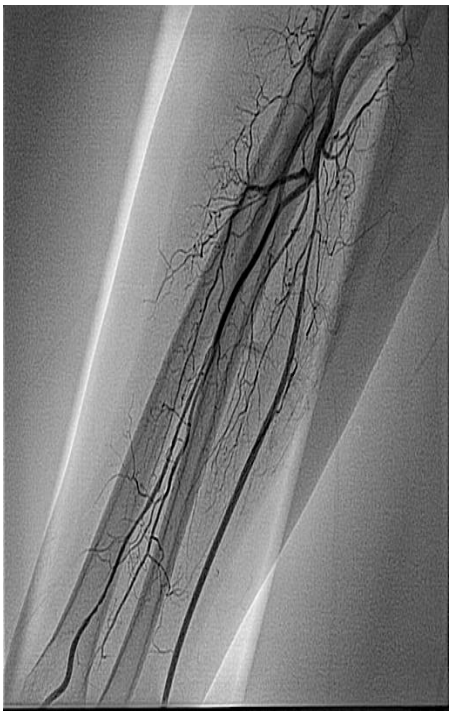

Figure (3): Radial artery spasm

DISCUSSION

The procedural success in our study in both radial and ulnar groups was high (96% versus 90%). In the radial group, there were two cases of crossover to ipsilateral ulnar access. In the ulnar group, there were four cases of crossover to ipsilateral radial access and one case of crossover to femoral access without statistically significant differences, this achievement was in agreement with other studies and mismatch others too. *Geng et al. (2014)* stated that successful puncture was obtained in 91.5% of the patients in the transulnar approach group, and 95.1% of the patients in the transradial approach group. *Shafiq et al. (2020)* found that transulnar success rate was 82.5% versus 93.7%. The above sequence matches the RURU approach, in which the default access for coronary procedures was the right radial artery, whenever failed, right ulnar artery utilized then left radial then left ulnar "RURU" *(Mansour et al., 2019)*.

The etiology of crossing over in radial group was attributed to persistent radial artery spasm in spite of repeating the vasodilatory cocktail *(Fernandez et al., 2018)*.

Regarding the ulnar group, the reason for crossover to ipsilateral radial access was inability to puncture the ulnar artery in four cases. While in one case, we have to crossover to femoral access due to catheter knot, with total crossover rate (10%). Weak ulnar pulse constituted the most common cause of puncture failure as the artery is deeply seated underneath the muscles. However, in few patients who presented with weak ulnar pulse, we succeeded in puncturing the artery and successfully performing the coronary procedure. On the other hand, despite finding a good palpable ulnar pulse in two patients, we could not access the artery. The current finding went in agreement with *Sallam et al. (2014)* who documented the main reason for ulnar access failure was inability to puncture and get blood flow in 17.7% of their patient population.

Our study disagreed with *De Andrade et al. (2012)* study where trans ulnar procedure success was high (98.5%), with a crossover rate of 1.5%.

Regarding ulnar group, [26%] of cases had single puncture attempt, and [74%] had two trials or more. Number of trials decreased along the study, ulnar artery was located deeper that made a successful puncture much more difficult which is matched with *Hahalis et al. (2013)* study which showed that the average number of attempts until successful arterial access in trans ulnar group was 3 trials compared with transradial group that was 1 trial, these results also matched with *Fernandez et al. (2018)*.

No major cardiovascular events had occurred in our study except one case in radial group during hospitalization. This patient underwent an elective PCI for LAD long lesion which was successful but during hospital stay patient suffered a massive anterior STEMI and was diagnosed to have acute in stent thrombosis. He had ventricular tachycardia that ended into cardiac arrest and was not responsive to CPR. The safety profile of radial and ulnar approaches in our study was in agreement with *Roghani-Dehkordi et al. (2015)* and *Roghani-Dehkordi et al. (2018)*.

Minor hematoma occurred in ulnar group, and in radial group which was

healed by local compression, bandage. This matched with *Roghani-Dehkordi et al. (2018)* who reported higher incidence of minor hematoma 10.4% in transulnar group and 9.9% in transradial group, but mismatched with *De Andrade et al. (2012)* who found minor hematoma occurred in 3.2% of cases underwent CA or PCI via ulnar artery approach, and also with *Roghani-Dehkordi et al. (2015)* where 5.1% of cases experienced grade 1 hematoma. This could be due to the difference in sample sizes.

The most frequent procedural event was the radial artery spasm. Hence, the vasodilatory cocktail was mandatory unless contraindicated. Spasm ensued equally in both groups (8%). *Dahal et al. (2016)* showed that spasm in transulanr group was matched with transradial group 9.4 vs. 8.9% in CA or PCI. However, *Roghani-Dehkordi et al. (2015)* reported very low incidence of spasm in the transulnar group 1.9%, while in the same study radial artery spasm occurred in 12.6% of cases underwent trans radially.

Regarding fluoroscopy time, the mean fluoroscopy time in our study was 5.8 ± 1.7 minutes in CA, and 11.1 ±3.5 minutes in PCI in ulnar group, while in radial group it was 6.1 ±1.6 minutes in CA, and 10.2 ± 1.6 minutes in PCI. Our results agreed with *Mujtaba et al. (2019)* who found that the mean fluoroscopy time in the patients subjected to PCI was 9.61±6.07 minutes while in cases subjected to CA was 4.17 ± 4.13 minutes using transradial access. *Sallam et al. (2014)* found that the fluoroscope time during CA and PCI were 6.5± 4.2 minutes and 14.2± 10.7 minutes respectively using ulnar approach.

Regarding procedural time, the mean procedure time in our study was 22.4 ± 2.5 min in CA and 37.8 ± 3.6 min in PCI in ulnar group. While in radial group it was 20.7 ± 2.7 in CA and 35.2 ± 4.9 in PCI. The procedure time of CA in the ulnar group was significantly longer than that of the radial group while the procedural time for PCI showed no statistically significant difference in both groups. The mean procedure time in our study was 26.4 ± 7.4 min in ulnar group, while in radial group it was 25.9 ± 7.7min. The mean procedure time showed no statistically significant difference between both groups. Our results agreed with *Roghani-Dehkordi et al. (2018)* who found that the mean procedure time of transulnar approaches was 21 ± 11 minutes slightly longer than transradial approaches 20 ± 8 minutes. *Hahalis et al. (2013)* stated that the total procedure time was 19 min 11-30 in radial group, and was 24 min 15-40 in ulnar group. While *Sallam et al. (2014)* reported that the procedure times for diagnostic and interventional procedures using ulnar approach were 26.4 ± 18.04 and 44.6 ± 25.2 min, respectively. Our study disagreed with the last two studies.

Study Limitations:

The study lacked a large validation population. Further prospective studies are thus needed to confirm our results. Also, the study included patients mostly younger than 60 years with only observation follow up. Therefore, additional studies are required including older patients and pre and post-operative duplex follow up.

CONCLUSION

Transradial access for coronary procedures becomes the standard access for coronary procedures because of its higher safety profile and similar efficacy. Transulnar approach is as safe and practical as transradial one without any major complications and it can be used when radial artery is not amenable. The most frequent cause of transulnar access failure was weak ulnar pulse after multiple trials.

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مقارنة بين عمل القسطرة التشخيصية والتداخلية عن طريق الشريان الكعبري و عمل القسطرة التشخيصية والتداخلية عن طريق الشريان الزندي

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خلفية البحث: إجراء القسطرة عن طريق الشريان الزندي هي بديل مقترح للمرضي الغير ملائمين لإجراء القسطرة عن طريق الشريان الكعبري واجراء القسطرة التشخيصية والتداخلية عن طريق الشريان الزندي لها نفس درجة أمان وفاعليه إجرائها عن طريق الشريان الكعبري.

الهدف من البحث: تقييم درجه أمان وفاعلية القسطرة القلبية التداخلية عن طريق الشريان الزندي مقارنة بالشريان الكعبري.

المرضي وطرق البحث: أجريت هذه الدراسة علي ١٠٠ مريض ممن خضعوا لإجراء القسطرة التشخيصية أو العلاجية بهدف تقييم جدوى وسلامة قسطرة الشرايين التاجية التشخيصية والعلاجية عن طريق الشريان الزندي في مستشفى جامعة الأزهر ومعهد القلب القومي وقد تم تقسيم المرضي بصورة عشوائية الي مجموعتين متساويتين: المجموعة الأولي أجريت لهم القسطرة التشخيصية أو العلاجية عن طريق الشريان الكعبري, أما المجموعة الثانية فكانت عن طريق الشريان الزندي وذلك بعد تدوين التاريخ المرضي وإجراء التقييم السريري لجميع المرضي.

نتائج البحث: أظهرت النتائج أن (٦٢٪) من الحالات التي خضعت لهذه الدراسة كانوا من الذكور ومتوسط العمر كان ٥٧ سنه تقريبا، وكان ارتفاع ضغط الدم هو عامل الخطر السائد يليه مرض السكرى، ثم ارتفاع الكوليسترول في الدم، وأخيراً التدخين في كلا المجموعتين.

كانت نسبة نجاح إجراء قسطرة الشرايين التشخيصية والعلاجية عن طريق الشريان الزندي حوالي(٩٠٪)، بينما وصلت نسبة النجاح إلي (٩٦٪) من المرضي الذين خضعوا لمثل هذا الاجراء عن طريق الشريان الكعبرى، وكان السبب الأغلب لعدم نجاح إجراء القسطرة عن طريق الشريان الزندي هو عدم القدرة علي ثقب الشريان، بينما كان السبب لعدم نجاح إجراء القسطرة عن طريق الشريان الكعبري هو تشنج الشريان الغير مستجيب للأدوية الباسطة للشرايين.

وقد أظهرت دراستنا عدم حدوث مضاعفات كبري في الحالات التي خضعت لإجراء التدخل عن طريق الشريان الزندي، بينما حدثت حالة وفاة واحدة في الحالات التي خضعت للإجراء عن طريق الشريان الكعبري، كما حدث تشنج في الشريان الكعبري وفى الشريان الزندي في أربعة حالات لكل منهما. وقد أعاق استكمال القسطرة عن طريق الشريان الكعبري في حالتين مما استدعي إجراء القسطرة عن طريق الشريان الزندي في نفس الذراع.

وفيما يتعلق بزمن التصوير الفلوروسكوبي فلم تكن هناك اختلافات كبيرة بين إجراء القسطرة التشخيصية أو العلاجية عن طريق الشريان الزندي أو الكعبري. أما المدة الكلية للقسطرة التشخيصية او العلاجية فقد كانت أطول في الشريان الزندي عنها في الشريان الكعبري بصورة لا تمثل قيمة إحصائية.

الاستنتاج: إجراء القسطرة عن طريق الشريان الزندي لها نفس درجة أمان وفاعلية إجرائها عن طريق الشريان الكعبري، وكذلك لها نفس معدلات النجاح والمضاعفات والتكتيكات التقنية. ونظرًا لأن الشريان الكعبري اكثر سطحية من الشريان الزندي فإن استخدام الشريان الزندي لعمل القسطرة يكون أكثر واقعية في حالة عدم إمكانية إجرائها عن طريق الشريان الكعبري.

الكلمات الدالة: التدخل عن طريق الشريان الكعبري، التدخل عن طريق الشريان الزندي، إجراءات الشريان التاجي، التدخل بالشريان التاجي باستخدام القسطرة عن طريق الجلد.