Safety and feasibility of simultaneous left and right heart catheterization via single-arm arterial and venous access

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Editorial by
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DOI: 10.33963/KP.a2022.0080

Received:
March 22, 2022

Accepted:
March 23, 2022

Early publication date:
March 24, 2022

ABSTRACT

Background: Catheterization *via* the radial artery has become the method of choice for evaluation of the coronary arteries; however in patients requiring simultaneous coronary and right heart catheterization upper extremity access is not commonly used.

Aims: In the present study we aimed to assess whether simultaneous left and right heart catheterization *via* the radial artery and antecubital vein might increase the vascular access site complications.

Methods: In this prospective cohort study, 49 patients with congenital and valvular heart disease requiring both left and right heart catheterization were enrolled, and rates of vascular access complications, including radial artery obstruction (RAO), were compared to 49 subjects in the control group who underwent catheterization only *via* radial artery access.

Results: No major vascular complications occurred in the study population. Post-procedural radial artery obstruction was detected in 14 patients (28.5%) in the venous-radial artery group and 7 (14.2%) in the control group ($P = 0.09$). Age, sex, body mass index, wrist circumference, hemoglobin concentrations, and history of smoking, diabetes mellitus, hypertension, and anticoagulant use did not affect the rate of radial pulse perseverance. However, shorter times of radial compression device removal were significantly related to lower rates of radial artery obstruction in both groups.

Conclusion: Right and left heart catheterization *via* an upper-extremity route in patients with congenital and valvular heart disease is safe and practical with greater patient comfort and no serious vascular complications. A longer duration of radial compression is an important predictor of RAO, regardless of using additional upper-extremity venous access.

Key words: catheterization, radial artery, brachial vein, congenital heart disease, valvular heart disease

INTRODUCTION

Transradial artery coronary catheterization has become the preferred route over transfemoral access, as there is a lower incidence of serious vascular complications and enhanced patient comfort [1]. However minor and occasionally major complications could occur with radial access including radial artery spasm, perforation, dissection during the procedure and radial artery occlusion (RAO), pseudoaneurysm, or arteriovenous fistula formation, and access site hematoma following the procedure. Predisposing factors include radial artery anomalies (e.g. high take-off or tortuous radial artery), small radial artery diameter, female sex, increased number of puncture attempts, pain during radial artery cannulation, and using multiple catheters [2, 3]. In adult patients with congenital and structural heart disease, both left and right heart catheterization are required on many occasions. Frequently there is a tendency to use

WHAT'S NEW

Catheterization *via* radial artery has become a widely preferred route for evaluation of the coronary arteries; however, in patients requiring concomitant right heart catheterization, radial access is used much less frequently despite its advantages. In the current study, we showed that right and left heart catheterization via the upper-extremity route in patients with congenital and valvular heart disease is safe and practical with greater patient comfort and no serious vascular complications.

femoral access in this population, and patients are deprived of the advantages of upper-extremity access. With simultaneous utilization of upper extremity arterial and venous access, there is a need for additional compression on the forearm vessels to achieve hemostasis of the venous route prior to the radial artery. In the present study, we aimed to evaluate the safety and efficacy of the concomitant radial artery-antecubital vein catheterization and additional complications that might be associated with this method.

METHODS

In this prospective study, we included 49 consecutive adults with the diagnosis of congenital or valvular heart disease, who underwent upper extremity vein-radial artery cardiac catheterization, and 49 controls, who underwent catheterization only *via* radial artery between 2018 and 2020 at our referral heart center. Data regarding age, sex, body mass index (BMI), hemoglobin concentrations, history of cigarette smoking, diabetes mellitus, hypertension, anticoagulant and antiplatelet use, wrist circumference, quality of radial pulse, and time to removal of radial compression devices (TR band®) were collected. BMI was defined as the body mass divided by the square of the body height expressed in units of kg/m^2. The presence of diabetes mellitus was defined based on the American College of Endocrinology guidelines. Hypertension was defined if the patient had a history of constant blood pressures above 139/89 mm Hg and was on antihypertensive medications [4, 5]. Thirteen (26.5%) patients in the radial-brachial group and three (6.1%) in the radial group had a history of atrial fibrillation and were using anticoagulants. In the radial-venous group, 20 (40.8%) patients were using aspirin. Twenty-seven (55%) patients in the radial group were using both aspirin and clopidogrel, and five (10%) were using aspirin alone.

Exclusion criteria included inadequate radial artery circulation and an abnormal test for dual circulation of the hand, scar or infection over the access insertion site, history of end-stage renal disease and presence of a dialysis graft in the arm, history of thromboangiitis obliterans, Raynaud syndrome, and superior vena cava or upper extremity venous obstruction. To obtain venous access, a tourniquet was applied a few centimeters above the elbow to facilitate the identification of a suitable vein. An Angiocath™ IV catheter was then inserted into the most medially identified vein and sealed with a valve cap. The arm was prepped from fingers to above the elbow. Antecubital veins may be easier to use, but more distal veins can also be used. Ultrasound imaging could also be utilized at the operator's discretion to find and puncture the appropriate vein when the upper extremity veins are not clearly visible. Local anesthesia was injected adjacent to the Angiocath™ IV catheter, then the cap was removed, and a 0.018" guidewire was introduced. After the guidewire was well into the vein, the Angiocath™ IV catheter was removed, the vascular sheath was inserted, and the wire and dilator were removed.

Complications of the catheterization site, including radial pulse quality 24 hours after the procedure, were examined and recorded. In the case of reduced radial pulse intensity, a Doppler ultrasound was performed for further assessment.

Statistical analysis

The study sample size was determined based on the findings of previous similar studies. In the previous studies, the rate of complication in radial artery catheterization was 30%, and in the brachial vein, catheterization it was about 6%. Therefore, the difference in rates was about 24%. The level of significance was 0.05, and the power was 80% [6–9] Categorical variables were displayed as numbers (percentages) and compared between groups by the χ^2 test and Fisher's exact test. Numerical variables were described by mean with standard deviation (SD) or median with interquartile range (IQR) and compared between groups using a t-test or the Wilcoxon test as appropriate. *P*-values <0.05 were considered statistically significant. Analysis was performed using SPSS Statistics for Windows, version 18. 0 (SPSS Inc., Chicago, IL, US).

RESULTS

Of the 49 venous-radial access subjects, 33 (67.3%) and 16 (32.7%) had a history of congenital and valvular heart disease, respectively. All the patients in the control group were catheterized for evaluation of coronary artery disease. Patients in the venous-radial group were relatively younger and had a smaller wrist circumference and a lower BMI (Table 1). Six French sheaths were used in all patients. Among 98 subjects, RAO occurred in 23 (23.5%) of cases. No other complications occurred in our study population. Among those with RAO, 15 (14.2%) were in the venous-radial and 8 (7.1%) were in the radial-only group, this difference was not statistically significant although it was higher in the venous-radial group. Mean (SD) wrist circumference was 17.6 (9) cm in the venous-radial group and 18.3 (1) cm in the radial ($P = 0.004$). Mean (SD) time to

Table 1. Baseline characteristics of the study population

	Radial-brachial group	Radial group	*P*-value
Age, years, mean (SD)	46.2 (15)	58 (10)	0.001
Male gender, n (%)	29 (59)	26 (53)	0.5
BMI, kg/m^2, mean (SD)	26 (6)	28 (6)	0.007
Smoking, n (%)	2 (4.1)	9 (18.2)	0.025
DM, n (%)	2 (4.1)	9 (18.2)	0.025
HTN, n (%)	6 (12.2)	24 (49)	0.001
Anticoagulant use, n (%)	13 (26.5)	3 (6.1)	0.006
Antiplatelet use, n (%)	20 (40.8)	32 (65.3)	0.015
Wrist circumference, cm, mean (SD)	17.65 (0.9)	18.25 (1)	0.004

Abbreviations: BMI, body mass index; DM, diabetes mellitus; HTN, hypertensive heart disease, SD, standard deviation

Table 2. Baseline characteristics and their relationship with radial pulse preservation in the radial group

	Optimal pulse (42)	Radial artery thrombosis (7)	*P*-value
Age, years, mean (SD)	58.4 (9.7)	55.4 (10.3)	0.49
Male gender, n (%)	20 (40.8)	9 (18.4)	0.93
BMI, kg/m^2, mean (SD)	28.6 (4.6)	28.8 (6.6)	0.91
Smoking, n (%)	1 (2)	1 (2)	0.54
DM, n (%)	2 (4)	0	0.33
HTN, n (%)	4 (8.1)	2 (4)	0.87
Wrist circumference, cm, mean (SD)	18.1 (1)	18.4 (1.8)	0.43
Anticoagulant use, n (%)	10 (20.4)	3 (6.1)	0.49
Antiplatelet use, n (%)	17 (34.6)	3 (6.1)	0.5
Duration to TR band removal, hours, mean (SD)	4.1 (0.8)	7.1 (2.2)	<0.001
Hemoglobin concentration, mg/dl, mean (SD)	13.3 (1.4)	13.7 (1.4)	0.31

Abbreviations: see Table 1

Table 3. Baseline characteristics and their relationship with radial pulse preservation in the venous-radial group

	Optimal pulse (35)	Non-optimal pulse (14)	*P*-value
Age, years, mean (SD)	48.6 (16.8)	40.1 (11.8)	0.09
Male gender, n (%)	21 (42.8)	5 (10.2)	0.55
BMI, kg/m^2, mean (SD)	26.4 (6.4)	26.1 (4.5)	0.88
Smoking, n (%)	7 (14.3)	2 (4)	0.59
DM, n (%)	8 (16.3)	1 (2)	0.63
HTN, n (%)	22 (44.8)	2 (4)	0.13
Wrist circumference, cm, mean (SD)	17.8 (0.9)	17.5 (0.8)	0.23
Anticoagulant use, n (%)	3 (6.1)	0 (0)	0.43
Antiplatelet use, n (%)	27 (55.1)	5 (10.2)	0.85
Duration to TR band removal, hours, mean (SD)	4.1 (0.8)	5.7 (0.8)	<0.001
Hemoglobin concentration, mg/dl, mean (SD)	13.5 (1.6)	14.4 (1.6)	0.07

Abbreviations: see Table 1

Table 4. Characteristics of patients with radial artery obstruction in the radial only and radial-venous groups

	Radial artery (total RAO:7)	Radial-Venous (total RAO:14)	*P*-value
Age, years, mean (SD)	55.4 (10.3)	40.1 (11.8)	0.52
Male gender, n (%)	9 (71)	5 (64)	0.42
BMI, kg/m^2, mean (SD)	28.8 (6.6)	26.1 (4.5)	0.18
Smoking, n (%)	1 (14)	2 (14)	0.4
DM, n (%)	0 (0)	1 (7)	0.47
HTN, n (%)	2 (28)	2 (14)	0.13
Wrist circumference, cm, mean (SD)	18.4 (1.8)	17.5 (0.8)	0.05
Anticoagulant use, n (%)	3 (42)	0 (0)	0.37
Antiplatelet use, n (%)	3 (42)	5 (35)	0.047
Duration to TR band removal >6 hours,	100	72	<0.001
Hemoglobin concentration, mg/dl, mean (SD)	13.7 (1.4)	14.4 (1.6)	0.39

Abbreviations: see Table 1

TR band removal was 4.51 (0.3) hours in the venous-radial and 4.55 (0.4) in the radial group ($P = 0.79$).

The baseline characteristics of the two groups are summarized in Table 1. Tables 2–4 summarize the comparison of characteristics of patients with RAO in each and between two groups. The use of antiplatelet agents was significantly more frequent in the venous-radial group with RAO, and a smaller wrist circumference showed a difference of borderline significance. In each group, however, those requiring radial compression of more than four hours had a significantly higher rate of RAO.

DISCUSSION

Transradial catheterization has become the method of choice for left heart catheterization as major vascular complications are considerably fewer than for the trans-femoral route. With transradial access, major bleedings occur in slightly over one percent of patients. There is a much lower risk of fatal bleeding, in addition to greater patient comfort and shorter length of hospital stay. RAO, which is the most frequent complication, is clinically asymptomatic in most cases and might resolve during follow-up. The reported rates of RAO are very variable. Limiting the number of puncture attempts and peri-procedural spasms, the use of intra-procedural anticoagulation, and the smallest French sheath is believed to reduce the rates of RAO [1, 6–9].

Right heart catheterization *via* upper-extremity veins has been reported to be safe and feasible in most patients. Right antecubital veins are preferred due to technical and anatomical considerations, including operator comfort and a less complex course towards the superior vena cava. The largest vein that is preferably equal to or larger than 6mm should be punctured. Reported complications are limited to local bleeding and hematomas. There is no need for prior interruption of anticoagulation, and right catheterization *via* antecubital veins is reported to be safe in anti-coagulated patients. Limitations include superior vena cava obstruction and no readily accessible forearm vein. Considering patient comfort and low complication rates, right heart catheterization *via* upper-extremity veins is a preferred approach whenever possible [10].

Over the past years and with the advances in surgical and interventional techniques, the number of adults with congenital heart disease has increased remarkably. Many of these subjects continue to have residual lesions and may require right and left heart catheterization in their clinical course to assess hemodynamics, intracardiac pressures, response to drug therapy, and evaluation of the coronary arteries [6].

Many congenital heart disease patients have variable degrees of coagulopathy with both bleeding and prothrombotic tendencies. Achieving complete hemostasis is faster and more reliable with upper extremity accesses. Reduced time to patient ambulation lowers the probability of deep vein thrombosis. Upper extremity access also decreases the need for intra-procedural sedation, which could be an issue in patients with pulmonary hypertension or heart failure who are also prone to vasovagal reactions [11, 12]. There are no reported increases in fluoroscopy or procedural time [13–15].

There are not many studies on the safety of a single arm catheterization in patients requiring invasive evaluation of both right and left heart chambers. Our study demonstrated that patients undergoing right and left heart catheterization could benefit from the advantages of upper extremity access. No serious access-related complications were observed with the addition of upper extremity venous access. The increased rate of RAO seemed to be mostly related to the longer time to achieve radial hemostasis, which might be associated with baseline patient characteristics. Those with a longer interval to removing radial compression devices had significantly higher rates of RAO regardless of venous access. We believe this could be addressed by using the smallest possible sheath size and reducing the peri-procedural radial artery spasm.

CONCLUSION

The simultaneous use of the radial artery and upper extremity vein for catheterization does not increase vascular access complications and is a feasible and safe method. Use of the smallest possible sheath and minimizing the time for radial compression after catheterization could lower the rates of subsequent radial artery occlusion.

Article information

Conflict of interest: None declared.

Funding: None.

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