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The Predictors of Post-Procedural Arm Pain after Transradial Approach in 1706 Patients Underwent Transradial Catheterization☆,☆☆

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ABSTRACT

Background: Although patients prefer radial over femoral approach, some develop post-procedural arm pain after transradial procedures. This complication has been poorly defined in prior studies. We evaluated the extent of non-ischemic arm pain after transradial arterial access and identify variables that may be associated with this complication.
Methods: We performed a retrospective analysis of a 1706 patient database on patients who underwent transradial catheterization at three experienced radial centers. Arm pain was assessed by adult visual analogue scale (score > 4) defined as moderate to severe pain at the accessed forearm not related to hand ischemia and was evaluated at one day after the procedure. Logistic regression was used to identify the predictors of post-procedural arm pain.
Results: The overall incidence of post-procedural arm pain one day after a transradial procedure was 4.5%. Covariate associated with post-procedural arm pain were hemostasis compression >4 h (odds ratio (OR) = 29.47, $p < 0.001$), radial artery occlusion by Doppler evaluation (OR = 3.35, $p < 0.001$), radial artery diameter < 2.8 mm (OR = 2.66, $p = 0.01$), and multiple puncture attempts (OR = 2.31, $p = 0.03$).
Conclusion: Approximately 1 in 20 patients undergoing transradial procedure have post-procedural arm pain one day after the procedure. Predictors of this complication relate to radial hemostasis, radial artery occlusion, radial artery diameter, and number of access attempts.

1. Introduction

Studies have shown that patients undergoing catheterization prefer radial over femoral approach [1–3]. This may be related to early mobilization after the procedure [3,4] lower procedural and total hospital cost [4–6], shorter hospital length of stay [7], and less major bleeding and access site-related vascular complications [8]. Despite these advantages, some patients may experience post-procedural arm pain of the accessed arm, which may limit the satisfaction of the patients who had transradial catheterization. We assessed the incidence and predictors of post-procedural arm pain in patients who underwent transradial catheterization at three experienced radial centers.

2. Patients and methods

The database of 1706 patients who underwent transradial catheterization during three months at three experienced radial centers in Indonesia, India and Macedonia were retrospectively analyzed. This data had been prospectively collected in a randomized trial of post-procedure nitroglycerin to reduce radial artery occlusion and has been previously reported [9]. Demographic characteristic, procedural data and the incidence of post-procedural arm pain were collected from the database. Radial artery was the default access (>80%) for coronary procedures in the three centers and all operators involved in the study were very experienced radial operators (>300 radial procedures per year).

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3. Radial artery cannulation

After a successful puncture of the radial artery, a 0.025-in guidewire was inserted, followed by insertion of a hydrophilic radial sheath. Spasmolytic regimens were then administered through the radial sheath. All patients received 50–100 IU/kg of unfractionated heparin that was administered intravenously or intra-arterially. The diagnostic or interventional procedures were then completed.

4. Radial sheath type

Hydrophilic-coated sheath were used in all patients. Most of the patients ($n = 1207$) received 6F radial sheath (RADIFOCUS Introducer II, Terumo, Europe N.V., Leuven, Belgium) and has outer diameter of 2.10 mm, 7 and 10 cm length. Five-French sheaths (RADIFOCUS Introducer II, Terumo, Europe, N.V., Leuven, Belgium) were used in 496 patients and has outer diameter of 1.78 mm and 7 cm. Two patients received 7F sheath (RADIFOCUS Introducer II, Terumo, Europe N.V., Leuven, Belgium) with outer diameter of 2.41 mm and 10 cm length. One patient received 8F sheath (RADIFOCUS Introducer II, Terumo, Europe N.V., Leuven, Belgium) with outer diameter of 2.77 mm and 10 cm length.

5. Hemostasis protocol

The complete description of the hemostasis protocol of the studied population has been described previously [9]. In brief, TR-Band (Terumo Corporation, Japan) was used as hemostasis device in 1309 patients. The TR-Band was applied by inflating 13–15 cc of air at the puncture site. After each hour, TR-Band was gradually deflated until totally removed. Other hemostasis devices used in the study were Finale (Merit Medical EMEA, Maastricht, the Netherlands) and Stepty$_{TM}$P (Nichiban Company, Japan). During hemostasis, a patent hemostasis protocol was applied for each patient soon after deployment of the hemostasis device.

6. Doppler ultrasound of the radial artery

Doppler ultrasound of the accessed artery was performed at one day after the radial procedure in all patients. The presence of radial artery occlusion (RAO) and diameter of the radial artery were recorded.

7. Study outcome

The primary outcome of the present study was the incidence of post-procedural arm pain at discharged, evaluated the day after the transradial procedure.

8. Definition

Post-procedural arm pain was assessed by an adult Visual Analogue Scale (VAS) [10]. The VAS is a measure of pain intensity on a continuous scale anchored by pain descriptor ranging from “no pain (0 score)” to worst pain (score 10). We included patients with score > 4 to define the moderate to severe arm pain of the accessed forearm.

Radial artery occlusion was defined as absence of antegrade flow of the accessed radial artery evaluated by Doppler ultrasound on the day after the transradial procedure. Multiple puncture attempts were defined as more than one skin puncture attempt with positive blood return before a successful puncture of the radial artery [9]. Severe radial artery spasm (RAS) was defined as severe local pain and discomfort during catheter movement compelling the operator to stop the procedure and cross over to the other route [11]. Hematoma size was assessed as defined by the EASY bleeding scale [12].

9. Statistical analysis

Continuous data are presented as mean ± standard deviation or median (interquartile range) and compared by *t*-test or Mann-Whitney *U* test as appropriate. Categorical data are presented as percentages and differences were compared by Chi-square test or Fischer exact test as appropriate. Logistic regression analyses were performed to identify the predictors of post-procedural arm pain. Covariates included in the multivariate model were age, female, body mass index, diabetes mellitus, repeated procedure, multiple puncture attempts, sheath size, severe RAS, procedural time, post-procedural nitroglycerin, duration of hemostasis, radial artery diameter and RAO.

A *p*-value of <0.05 was considered statistically significant. Statistical analyses were performed using SPSS 17.0.

10. Results

10.1. Clinical and procedural characteristics

Women accounted for 31% of the population. Most of the transradial procedures were coronary angiograms (60%) followed by percutaneous coronary intervention (39%). None of the patients had signs or symptom of hand ischemia after their procedure. The right radial artery was the predominant access site (98%) and 6F radial sheathes were used in the majority of cases (71%). Hemostasis was obtained predominantly by using a TR-Band (Terumo Corporation, Japan) (77%). Clinical and procedural characteristics are displayed in Table 1.

10.2. Study outcomes

Post-procedural arm pain was found in 76 patients (4.5%) (Table 1). After multivariable analyses, a hemostatic compression time of >4 h (odds ratio (OR) = 29.47, $p < 0.001$), RAO (OR = 3.35, $p < 0.001$), radial artery diameter < 2.8 mm (OR = 2.66, $p = 0.01$), and multiple puncture attempts (OR = 2.31, $p = 0.03$) were each associated with post-procedural arm pain at discharge (Table 2).

11. Discussion

This study shows that approximately 1 in 20 patients have post-procedural arm pain after a transradial procedure. From multivariate analysis, several variables were associated with post-procedural arm pain and deserve further discussion (Table 2).

First, hemostasis duration was the strongest predictor of the primary outcome (OR = 29.47, $p < 0.001$). This finding emphasizes the importance of early hemostasis after a transradial catheterization and, therefore, a longer duration of hemostasis (>4 h) should be avoided if possible. The prolonged hemostasis duration found in some of the studied population may be associated with the difference of hemostasis protocol and devices used at the three hospitals.

Prolonged compression at the radial artery puncture site may result in damage to the radial sensory nerve, resulting pain, weakness and dysfunction [13]. In addition, radial compression may result in blood flow reduction into the surrounding muscle. A previous study showed how lactate released from ischemic muscle may contribute to ischemic pain by acting on sensory neurons innervating muscles [14].

Second, RAO was found to be associated with the incidence of post-procedural arm pain (OR = 3.35, $p < 0.001$). We observed that none of the studied patients had signs or symptom of hand ischemia (e.g. weakness, pallor) suggesting that the mechanism by which RAO causes arm pain is not related to hand ischemia but may be an inflammatory arteritis from thrombus irritating the arterial wall. Acute thrombosis of the radial artery following an acute arterial injury associated with the transradial access is a putative mechanism for RAO [15]. Furthermore, our previous study showed that duration of hemostasis was associated with the incidence of RAO (OR = 3.11 $p < 0.001$) [9]. In the

Table 1
Clinical and procedural characteristics.

Variables	All patients ($N = 1706$)	Patients with post-procedural arm pain ($N = 76$)	No post-procedural arm pain ($N = 1630$)	p-Value
Clinical characteristics				
Female	539 (31)	22 (28)	517 (31)	0.61
Age, years	59 ± 10.37	57.22 ± 11.02	59.36 ± 10.34	0.07
Age > 75 years	127 (7)	7 (9.2)	120 (7.3)	0.54
Body mass index, kg/m^2	25 (23–28)	26 (23–29)	25.7 (23.8–28.3)	0.41
Diabetes mellitus	413 (24)	24 (31)	389 (23)	0.12
Procedure				
Coronary angiography	1025 (60)	51 (67)	974 (59)	0.2
Percutaneous coronary intervention	677 (39)	25 (32)	652 (40)	0.21
Others	4 (0.2)	0	4 (0.2)	1.0
Severe radial artery spasm	13 (0.8)	3 (3.9)	10 (0.6)	0.01
Hematoma EASY score > 3	0	0	0	NA
Sign and symptom of hand ischemia	0	0	0	NA
Incidence of radial artery occlusion	170 (9.9)	31 (40)	139 (8.5)	<0.001
Procedural characteristics				
Right radial access	1684 (98)	75 (98)	1609 (98)	1.0
Multiple puncture attempts	207 (29)	11 (14)	196 (12)	0.52
Sheath size				
5F	496 (29)	47 (62)	449 (27)	<0.001
6F	1207 (71)	29 (38)	1178 (72)	<0.001
7F	2 (0.1)	0	2 (0.1)	1.0
8F	1 (0.1)	0	1 (0.06)	1.0
Procedural time, minute	20 (10−30)	6.5 (3–11.7)	20 (10–30)	<0.001
Hemostasis compression >4 h	553 (32)	71 (93)	482 (29)	<0.001
Use of TR-Band	1309 (77)	67 (88)	1242 (76)	0.01
Radial artery diameter, mm	2.8 (2.4–3.1)	2.4 (2.2–2.5)	2.8 (2.4–3.1)	<0.001

Continuous data are presented as mean ± standard deviation or median (interquartile range) and categorical data are presented as number (percentage). NA = not analyzed.

present analysis, the arm pain related with RAO was thought to be associated with hemostasis duration.

Third, smaller diameter of the radial artery (<2.8 mm) was also associated with post-procedural arm pain. Most of the patients in this study (71%) received 6F radial sheaths (outer diameter of 2.1 mm) and the median radial artery diameter of the studied population was 2.8 mm. The sheath to radial artery ratio (0.75) is a potential factor to precipitate endothelial injury and ischemia when the sheath is still inside the radial artery. The release of lactate induced by the ischemic state [14] may explain the occurrence of significant arm pain after the radial procedure. This finding suggests that the sheath to radial artery ratio may play a role in the occurrence of post-procedural arm pain perhaps due to mechanical injury of contact with the artery. It is also important to note that mechanical injury of the radial artery can lead to RAO; thus the two covariates of RAO and smaller radial artery diameter underscore the importance of preventing radial artery injury to prevent post-procedure arm pain.

Fourth, multiple puncture attempt was associated with post-procedural arm pain (OR = 2.31, $p = 0.03$). Just like a large sheath to artery ratio, multiple arterial attempts traumatize the artery and may contribute to the initiation of arteritis. In addition, the flexor carpi radialis, median nerve and flexor pollicis longus are all located next to the radial artery [16], and multiple puncture attempts could damage these structures and causing a sensory deficit reflected as arm pain.

Moreover, multiple puncture attempts may be required in patients with small radial arteries, and these arteries are more prone to RAO. All of these factors suggest that better “slender” solutions are needed to facilitate radial procedures in patients with small radial arteries and avoid RAO and post-procedure arm pain.

Endothelial dysfunction [17], intimal tears and medial dissections [18] and intimal hyperplasia of the radial artery [19] have been observed following transradial catheterization and are also potential targets for future trials to minimize procedural morbidity. The pathological mechanisms-related to the puncture and cannulation of the radial artery, as well as post-procedural care may either result in pain from arterial damage itself or collateral damage to surrounding musculoskeletal components. Despite this complication of arm pain, the overall risk-benefit ratio of preferential radial access over femoral access remains intact given the well-documented reduction in the risk of bleeding, vascular complications and reduced risk of death.

Table 2
Multivariate predictors of post-procedural arm pain.

	Odds ratio	95% confidence interval	p-Value
Age ≥ 75 years	1.59	0.63–3.97	0.31
Female	1.26	0.72–2.21	0.41
Body mass index <25 kg/m^2	0.74	0.44–1.24	0.25
Diabetes mellitus	1.01	0.58–1.73	0.96
Repeated procedure	1.13	0.60–2.12	0.69
Multiple puncture attempts	2.31	1.04–5.09	0.03
Use of >6F sheath	1.46	0.79–2.68	0.22
Severe radial artery spasm	1.76	0.38–8.20	0.46
Procedural time >60 min	1.59	0.33–7.71	0.55
Post-procedural nitroglycerin	1.33	0.80–2.21	0.27
Hemostasis compression >4 h	29.47	10.87–79.86	<0.001
Radial artery diameter <2.8 mm	2.66	1.24–5.71	0.01
Radial artery occlusion	3.35	1.94–5.78	<0.001

12. Study limitation

The study is an ad hoc analysis and initial data collection was not set to collect all data that might interact with forearm pain. Pain evaluation occurred only on the day after catheterization and data on serial evaluation were not available. The VAS score used to assess the arm pain is subjective and other aspects of arm function and strength were not examined. We did not analyze the causative mechanism for each of the predictors of arm pain. The discussion speculates on several potential pathological mechanisms related to transradial catheterization and, therefore, should only be considered as hypothesis generating for future studies rather than a direct statement of direct causality.

13. Conclusion

Transradial catheterization is associated with low rates of post-procedural arm pain of the accessed arm evaluated at one day after the procedure. Given the high odds of hemostasis duration in determining post-procedural arm pain, the post-procedural care is a potential target for care

improvement, and together with improvement on the radial artery puncture technique and special threat for patient with small radial artery may further increase patient satisfaction with transradial catheterization.

Conflict of interest

Nothing to declare.

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