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Usefulness of rescue ultrasound guidance for transradial cardiac catheterization

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ABSTRACT

Introduction and objectives: Transradial cardiac catheterization reduces access site complications and is more comfortable for patients than the transfemoral approach. However, failure of the transradial approach is more common than the transfemoral approach. This study aimed to investigate whether ultrasound-guided rescue could facilitate transradial cardiac catheterization.

Methods: We retrospectively analyzed 592 consecutive patients who underwent coronary angiography and/or percutaneous coronary intervention. Patients were divided into 2 groups: the palpation technique (PT) ($n = 280$) and the ultrasound guidance (UG) available group ($n = 312$). The application and the timing of introduction of ultrasound guidance in the UG group were at the discretion of the individual operators.

Results: Real-time ultrasound guidance was used in 98 patients (31.4%) in the UG group. No statistically significant intergroup differences were observed in the incidence of hematoma (6.8% vs. 5.8%, $p = 0.62$). Although the procedural time in the UG group was longer than that in the PT group (303 s vs. 357 s, $p < 0.01$), the success rate of sheath insertion was significantly higher in the UG group (97% vs. 92%, $p < 0.01$). Multivariate analysis revealed that the availability of UG was the only independent predictor of success of sheath insertion (odds ratio 2.79, 95% confidence interval 1.24–6.31, $p = 0.01$).

Conclusions: Although UG maneuvers require additional procedural time for setting up systems, UG rescue was effective for successful transradial cardiac catheterization.

1. Introduction

Transradial cardiac catheterization reduces access site complications and is more comfortable for patients than the transfemoral approach [1]. Despite its efficacy, the transfemoral approach shows a higher rate of vascular bleeding, pseudoaneurysms, and arteriovenous fistula formation than that observed with the transradial approach [1, 2]. Moreover, mortality and major adverse cardiovascular event rates are also higher secondary to access site complications [3]. Therefore, awareness regarding the potential benefits and technique of transradial catheterization is increasing.

Initial practice and a learning curve are essential for the transradial approach because the radial artery is small and measures 2.5–3.0 mm in diameter. Previous reports have observed that the failure rate of the transradial approach (approximately 6–7%) was higher than that associated with the transfemoral approach (2%) [4]. Even in high-volume centers, the failure rate approaches 4–6% [5]. >50% of failed attempts were secondary to inappropriately performed punctures; thus, improving the puncture technique could effectively reduce failure rates associated with the transradial approach [6].

Ultrasound guidance (UG) has been established as a safe and effective method for vascular access in central veins [7]. Several studies have demonstrated the possibility of better outcomes using UG for the radial artery approach [8, 9]. This study aimed to investigate whether rescue application of UG (not routine use) improved the success rate of transradial cardiac catheterization.

2. Materials and methods

2.1. Study design

We retrospectively included all consecutive patients who were scheduled to undergo coronary angiography (CAG) and/or percutaneous coronary intervention (PCI) via the radial artery at Shingu Municipal Medical Center between April 2015 and March 2017. Because the real-time UG approach was introduced at our hospital in April 2016, patients

Abbreviations: CAG, coronary angiography; PCI, percutaneous coronary intervention; PT, palpation technique; UG, ultrasound guidance.

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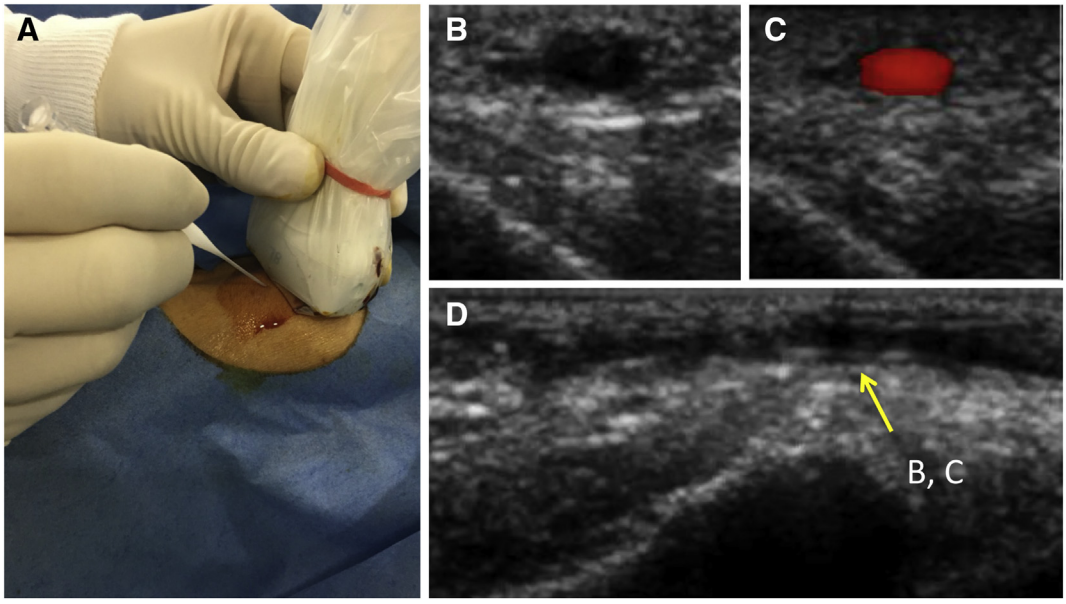

Fig. 1. Real-time ultrasound-guided transradial catheterization technique. A. Image shows an ultrasound probe positioned over the radial artery with the needle inserted and advanced toward the radial artery under real-time ultrasound guidance. B. Image shows the radial artery in a short axis view. C. A color Doppler image can be observed. D. Image shows a longitudinal view of the radial artery.

treated during the first 1 year (April 2015–March 2016) were assigned to the palpation technique (PT) group and the remaining patients (April 2016–March 2017) were assigned to the ultrasound guidance (UG) available group. Demographic and clinical data were obtained retrospectively. The study was approved by the Institutional Review Board of Shingu Municipal Medical Center and was performed according to the Declaration of Helsinki. All patients provided written informed consent before undergoing cardiac catheterization.

2.2. Clinical parameters

Clinical parameters assessed were age, sex, renal function, and coronary risk factors including hypertension, diabetes mellitus, hyperlipidemia, smoking status, and family history. An active smoker was defined as a patient who was a current smoker or one who had stopped smoking <1 month before catheterization.

2.3. Radial artery catheterization technique

All procedures were performed by operators with an experience of performing at least 100 previous transradial cardiac catheterizations. Four attending physicians and 4 fellows from the Advanced Interventional Cardiology Fellowship program participated in the operations. The approach site was determined by the operator.

After the administration of a local anesthetic, the radial artery was punctured using a 22-gauge needle with a hydrophilic sheath. The hydrophilic sheath was pulled back until arterial blood was obtained. A guidewire was inserted via the hydrophilic sheath and advanced toward the central artery under radiographic guidance. Subsequently, a 4, 5 or 6-F sheath was inserted over the guidewire. All patients received unfractionated heparin (2000 U) before undergoing CAG, and additional heparin was administered if the procedure lasted >90 min or PCI was planned. Procedural time was defined as the time from the administration of local anesthesia to the completion of sheath insertion. Therefore, this time included the time required to set up the ultrasonography machine for real-time ultrasonographic monitoring required in the study. We defined failure of the transradial approach as an inability to insert the sheath into the radial artery using the original technique necessitating a crossover to another site.

After the completion of the procedure, hemostasis was achieved using the TR Band (Terumo Medical, Tokyo, Japan), which was removed after 8 h in keeping with the standard practice. A hematoma was defined as a localized blood-filled swelling around the puncture site, and its occurrence was determined by individual operators.

Table 1
Patients' characteristics.

	PT group	UG group	*p* value
Patient, n	280	312	
Age (years)	72 ± 11	73 ± 10	0.25
Men	202 (72)	231 (74)	0.64
Hypertension	220 (79)	255 (82)	0.35
Diabetes mellitus	107 (38)	110 (35)	0.49
Dyslipidemia	181 (65)	185 (59)	0.20
Family history	53 (19)	51 (16)	0.45
Smoking	36 (13)	42 (13)	0.90
Chronic kidney disease	54 (19)	73 (23)	0.23
Diagnosis			
Acute Coronary Syndrome	61 (22)	88 (28)	0.09
Stable angina pectoris	172 (61)	167 (54)	0.06

Data presented are mean ± SD or No.(%).
PT: palpation technique, UG: ultrasound guidance.

Table 2
Procedural characteristics.

	PT group (n = 280)	UG group (n = 312)	p value
Emergency	60 (21)	88 (28)	0.06
Intervention	110 (39)	133 (43)	0.45
6-F sheath	178 (64)	197 (63)	0.93
Left radial access	207 (74)	275 (88)	< 0.01
Rescue ultrasound guide	0 (0)	98 (31)	< 0.01

Data presented are No.(%).
PT; palpation technique, UG; ultrasound guidance.

Table 3
Multivariate analysis for success of transradial approach.

	OR (95% CI)	*p* value
Age ≥ 75	1.04 (0.47–2.34)	0.91
Men	0.74 (0.29–1.90)	0.54
Hypertension	1.98 (0.85–4.61)	0.11
Diabetes mellitus	0.95 (0.44–2.04)	0.89
Dyslipidemia	1.65 (0.75–3.60)	0.21
Family history	0.76 (0.31–1.91)	0.76
Smoking	1.40 (0.39–5.05)	0.61
Acute coronary syndrome	0.59 (0.12–2.92)	0.52
Stable angina pectoris	0.76 (0.24–2.40)	0.64
Emergency	1.46 (0.38–5.67)	0.59
Intervention	1.44 (0.55–3.74)	0.45
6-F sheath	0.87 (0.33–2.28)	0.78
Left radial access	1.75 (0.76–4.03)	0.19
UG available	2.79 (1.24–6.31)	0.01

OR: odds ratio.
CI: confidence interval.
UG: ultrasound guidance.

2.4. Real-time ultrasound-guided transradial catheterization technique

Individual operators decided the necessity and timing of introduction of the real-time UG rescue in the UG group. A portable ultrasound device (Vivid i, General Electric, Horten City, Norway) covered by a sterile sheath was used. The radial artery was imaged in the axial plane and positioned at the center of the ultrasound probe, and a needle was inserted toward the radial artery under real-time UG (Fig. 1).

2.5. Statistical analysis

All statistical analysis was performed using the JMP Pro software version 13 for Macintosh (SAS Institute, Cary, NC, USA). Results are expressed as means ± standard deviation for normally distributed variables. Qualitative data are presented as numbers (%). Intergroup differences were tested using the Student's *t*-test for approximately normally distributed variables, the Mann-Whitney test for variables showing a skewed distribution, and the Fisher exact test for categorical variables. Multiple logistic regression analysis was performed to determine independent predictors of successful transradial catheterization. A p value <0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics

We analyzed 592 patients between April 1, 2015 and March 31, 2017. Patients were divided into 2 groups: the PT ($n = 280$) and the UG ($n = 312$) groups. No significant intergroup differences were observed regarding baseline patient characteristics as shown in Table 1.

3.2. Procedural and outcome data

Procedural characteristics are summarized in Table 2. Approximately 40% of the procedures performed were interventions. The TR band was used for hemostasis in all patients, and no serious access site complications were observed. Left radial artery access was more common in the UG than in the PT group (88% vs. 74%, $p < 0.01$) (Table 3). In the UG group, 98 patients eventually underwent a real-time UG procedure (Fig. 2). As shown in Fig. 3-A, the success rate in the UG group was significantly higher than that in the PT group regardless of partial application of UG (97% vs. 92%, $p < 0.01$). No statistically significant intergroup difference was observed in the incidence of hematoma (6.8% vs. 5.8%, $p = 0.62$) (Fig. 3-B). The procedural time in the UG was longer than that in the PT group (303 s vs. 357 s, $p < 0.01$) (Fig. 3-C). No patient developed a severe hematoma requiring transfusion and/or nerve injury. Multivariate analysis revealed that the availability of UG was the only independent predictor of success with the transradial approach (odds ratio 2.79, 95% confidence interval 1.24–6.31, $p = 0.01$). No statistically significant intergroup differences were observed in the UG group regarding patient and procedural characteristics between those with and without UG rescue (Table 4).

4. Discussion

We demonstrated that the application of real-time UG rescue was effective for transradial cardiac catheterization. Although the procedural time was longer in the UG than in the PT group, the success rate of the transradial approach was significantly higher in the UG group.

Numerous randomized trials have revealed that transradial cardiac catheterization could reduce complications and provide greater patient comfort than that observed with the transfemoral approach, with consequent reduction in hospital administrative issues and costs [10].

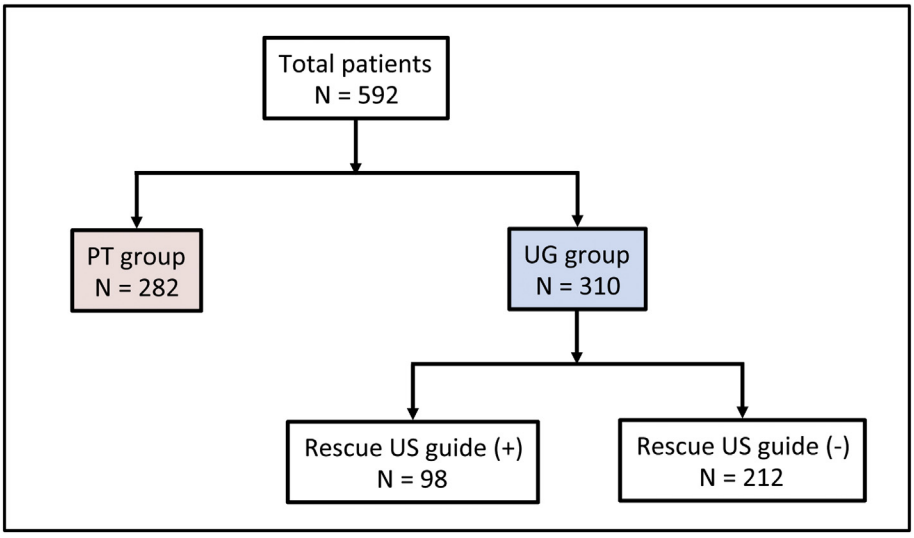

Fig. 2. Study population included in this study. PT: palpation technique, UG: ultrasound guidance, US: ultrasound.

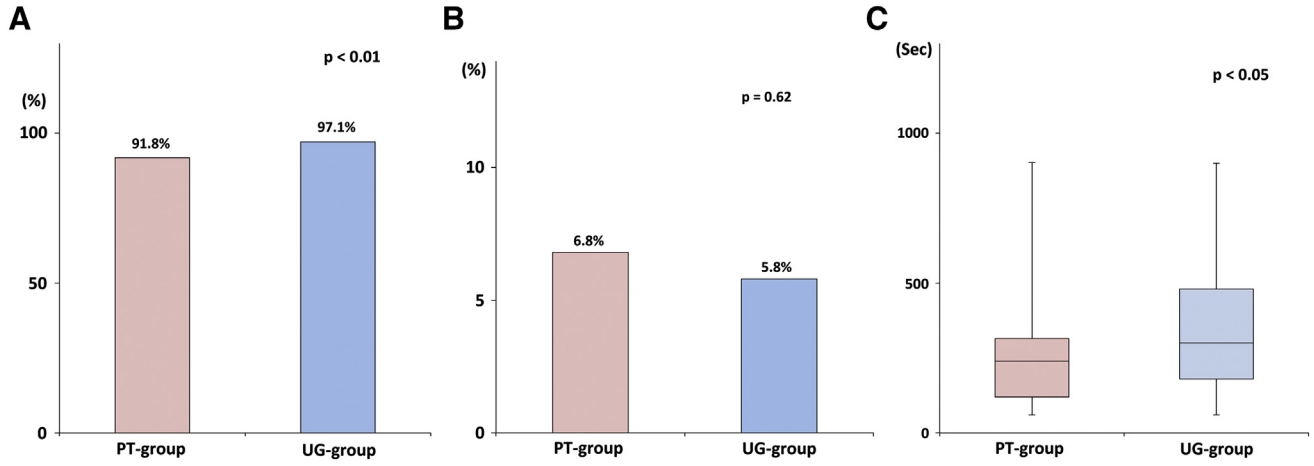

Fig. 3. A. Success rate of the transradial approach. B. Incidence rate of approach site hematoma. C. Procedural time. PT: palpation technique, UG: ultrasound guidance. Data are presented as box plots with median and 25th and 75th percentiles (box) and 10th to 90th percentiles (whiskers).

Severe access site bleeding, particularly retroperitoneally could be fatal and might necessitate transfusion [11, 12]. Reportedly, marked hemorrhage is associated with poor prognosis observed during both, short and long-term follow-up [13]. Therefore, transradial catheterization is encouraged globally in the current era [14, 15].

The transradial approach requires a learning curve because the radial artery is of a relatively small diameter with a technically difficult approach. Reportedly, the failure rate of the transradial approach is approximately 4–7%. Even in high-volume centers, the failure rate of approximately 4% remains higher than that of the transfemoral approach. Several methods have been developed to overcome these difficulties, and the contralateral approach is one such technique whereby operators attempt to catheterize the contralateral radial artery [6].

Another useful solution is the application of real-time UG, which has been established as a safe and effective method for vascular access in central veins. Although a previous trial denies the utility of real-time UG for the radial artery [16, 17], a multicenter randomized controlled trial (RAUST trial) has demonstrated that UG improved the success rate and efficacy of the transradial approach [8]. Success rates of the transradial approach observed in the previous 2 reports (that denied any benefit of UG) were relatively lower (80–90%) than those observed in our series (97%), which concurs with the RAUST trial. Similar to the RAUST trial, all procedures in our study were performed by operators who had been trained in UG techniques with an experience of performing at least 100 previous transradial cardiac catheterizations. These factors might have contributed to a higher success rate.

In the RAUST trial, UG was used from the onset of the procedure. We applied UG based on the operator's decision; thus, approximately one-third of patients underwent a UG rescue procedure. Although the procedural time is significantly longer, UG could provide higher success rates. The use of UG rescue saves the application of a sterile sheath with consequent reduction in medical costs.

However, in some cases, the transradial approach is difficult. In the present study, transradial catheterization using UG failed in 9 patients secondary to radial artery spasm ($n = 5$), occlusion ($n = 2$), tortuosity ($n = 1$), and crossover to another site because of an emergency($n = 1$). Pre-procedural ultrasonographic examination was not performed to evaluate the size of the radial artery and anatomical variations. In patients with arterial spasm, occlusion, and tortuosity, pre-procedural ultrasonographic examination could reduce failure rates. Thus, pre-procedural ultrasonographic examination should be encouraged prior to the use of a transradial approach.

Table 4
Patients' and procedural characteristics between with and without rescue ultrasound guidance.

	Rescue ultrasound guide (−)	Rescue ultrasound guide (+)	*p* value
Patient, n	214	98	
Age (years)	73 ± 9	72 ± 11	0.28
Men	163 (76)	68 (69)	0.21
Hypertension	178 (83)	77 (79)	0.35
Diabetes mellitus	78 (36)	32 (33)	0.53
Dyslipidemia	124 (58)	61 (62)	0.54
Family history	35 (16)	16 (16)	1.00
Smoking	31 (14)	11 (11)	0.48
Chronic kidney disease	46 (22)	27 (28)	0.25
Diagnosis			
Acute coronary syndrome	63 (29)	25 (26)	0.50
Stable angina pectoris	111 (52)	56 (57)	0.40
Emergency	64 (30)	24 (24)	0.35
Intervention	88 (41)	45 (46)	0.46
6-F sheath	134 (62)	63 (64)	0.80
Left radial access	192 (90)	83 (85)	0.26

Data presented are mean ± SD or No.(%).

5. Limitations

The limitations of our study are: 1) The operators between the groups were different. In April 2015, 2 operators left and 2 new operators joined the study. Therefore, a left-sided approach was more commonly used in the UG group. 2) Patients from 2 different time periods were included in the study. Therefore, operators' skill of radial artery puncture might have been improved without UG. 3) The retrospective study design may have introduced a selection bias. 4) The pre-access size of the radial artery was unknown, which might influence the success rate. 5) The procedure time was not formalized. 6) Data were not obtained regarding the number of radial artery puncture attempts.

6. Conclusions

Although UG needs additional procedural time for setting up the systems, UG rescue is effective for successful transradial cardiac catheterization.

References

[1] Jolly SS, Yusuf S, Cairns J, Niemelä K, Xavier D, Widimsky P, et al. RIVAL trial group. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. Lancet 2011;377:1409–20.
[2] de Kinnaird TD, Stabile E, Mintz GS, Lee CW, Canos DA, Gevorkian N, et al. Incidence, predictors, and prognostic implications of bleeding and blood transfusion following percutaneous coronary interventions. Am J Cardiol 2003;92:930–5.

[3] Ferrante G, Rao SV, Jüni P, Da Costa BR, Reimers B, Condorelli G, et al. Radial versus femoral access for coronary interventions across the entire Spectrum of patients with coronary artery disease: a meta-analysis of randomized trials. JACC Cardiovasc Interv 2016;9:1419–34.
[4] Agostoni P, Biondi-Zoccai GG, de Benedictis ML, Rigattieri S, Turri M, Anselmi M, et al. Radial versus femoral approach for percutaneous coronary diagnostic and interventional procedures; systematic overview and meta-analysis of randomized trials. J Am Coll Cardiol 2004;44:349–56.
[5] Jolly SS, Amlani S, Hamon M, Yusuf S, Mehta SR. 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 2009;157:132–40.
[6] Guédès A, Dangoisse V, Gabriel L, Jamart J, Chenu P, Marchandise B, et al. Low rate of conversion to transfemoral approach when attempting both radial arteries for coronary angiography and percutaneous coronary intervention: a study of 1,826 consecutive procedures. J Invasive Cardiol 2010;22:391–7.
[7] McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med 2003;348:1123–33.
[8] Seto AH, Roberts JS, Abu-Fadel MS, Czak SJ, Latif F, Jain SP, et al. Real-time ultrasound guidance facilitates transradial access: RAUST (radial artery access with ultrasound trial). JACC Cardiovasc Interv 2015;8:283–91.
[9] Roberts J, Manur R. Ultrasound-guided radial artery access by a non-ultrasound trained interventional cardiologist improved first-attempt success rates and shortened time for successful radial artery cannulation. J Invasive Cardiol 2013;25:676–9.
[10] Cooper CJ, El-Shiekh RA, Cohen DJ, Blaesing L, Burket MW, Basu A, et al. Effect of transradial access on quality of life and cost of cardiac catheterization: a randomized comparison. Am Heart J 1999;138:430–6.
[11] Chase AJ, Fretz EB, Warburton WP, Klineke WP, Carere RG, Pi D, et al. Association of the arterial access site at angioplasty with transfusion and mortality: the M.O.R.T.A.L study (mortality benefit of reduced transfusion after percutaneous coronary intervention via the arm or leg). Heart 2008;94:1019–25.
[12] Vora AN, Stanislawski M, Grunwald GK, Plomondon ME, Rumsfeld JS, Maddox TM, et al. Association between chronic kidney disease and rates of transfusion and progression to end-stage renal disease in patients undergoing transradial versus transfemoral cardiac catheterization-an analysis from the veterans affairs clinical assessment reporting and tracking (CART) program. J Am Heart Assoc 2017;6(4). pii: e004819.
[13] Eikelboom JW, Mehta SR, Anand SS, Xie C, Fox KA, Yusuf S. Adverse impact of bleeding on prognosis in patients with acute coronary syndromes. Circulation 2006;114:774–82.
[14] Tanaka Y, Moriyama N, Ochiai T, Takada T, Tobita K, Shishido K, et al. Transradial coronary interventions for complex chronic total occlusions. JACC Cardiovasc Interv 2017;10:235–43.
[15] Bertrand OF, Rao SV, Pancholy S, Jolly SS, Rodés-Cabau J, Larose E, et al. Transradial approach for coronary angiography and interventions: results of the first international transradial practice survey. JACC Cardiovasc Interv 2010; 3:1022–31.
[16] Tangwiwat S, Pankla W, Rushatamukayanunt P, Waitayawinyu P, Soontrakom T, Jirakulsawat A. Comparing the success rate of radial artery cannulation under ultrasound guidance and palpation technique in adults. J Med Assoc Thail 2016; 99:505–10.
[17] Zaremski L, Quesada R, Kovacs M, Schernthaner M, Uthoff H. Prospective comparison of palpation versus ultrasound-guided radial access for cardiac catheterization. J Invasive Cardiol 2013;25:538–42.