Original Article

Ulnar Artery Compression: A Feasible and Effective Approach to Prevent the Radial Artery Occlusion after Coronary Intervention

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Abstract

Background: Radial artery (RA) occlusion (RAO) is not rare in patients undergoing coronary intervention by transradial approach (TRCI). Predictors of and prevention from RAO have not been systematically studied. This study aimed to analyze the risk factors of the weakness of RA pulsation (RAP) and its predictive value for RAO after TRCI, and simultaneously to describe a feasible and effective approach to maintain RA patency.

Methods: Between June 2006 and March 2010, all patients who underwent TRCI were classified according to the weakness of RAP after removing compression bandage with confirmation by Doppler ultrasound for the first 30 consecutive patients. Among a total of 2658 patients studied, 187 (7%) patients having a weaker RAP were prospectively monitored. At 1 h after bandage removal, the ulnar artery in puncture side of all patients was blocked with manual compression to favor brachial and collateral artery blood flow through the RA until a good RAP was restored. The primary analysis was the occurrence of RAO.

Results: Doppler ultrasound demonstrated the significant reduction of both systolic velocity (61.24 ± 3.95 cm/s vs. 72.31 ± 3.57 cm/s) and diastolic velocity (1.83 ± 0.32 cm/s vs. 17.77 ± 3.97 cm/s) in RA at access side as compared to the contralateral RA (all $P < 0.001$), but these velocities in ipsilateral ulnar artery (81.2 ± 2.16 cm/s and 13.1 ± 2.86 cm/s, respectively) increased profoundly. The average time of ulnar artery compression was 4.1 ± 1.2 h (ranged 2.5–6.5 h). There were two patients experienced persistent RAO with a success rate of 98.9% and RAO in 0.075% of patients after ulnar artery compression was applied. The pulsation of the ulnar artery after compression was removed had not been influenced by the compression.

Conclusions: After intervention using TRCI approach, the presence of a weaker RAP is an indicator of imminent RAO. The continuing compression of ipsilateral ulnar artery is an effective approach to maintain RA patency.

Key words: Radial Artery Occlusion; Transradial Intervention; Ulnar Artery Compression

Introduction

Transradial approach (TRA) for intravascular intervention is featured by less frequent hemorrhage at access site,[1] improved patients' comfort and shorter hospital stay. Radial artery (RA) occlusion (RAO) in patients undergoing coronary intervention via TRA (TRCI), is reported to be around 5%–10%,[2] a complication raising great concerns in TRA community with high volume of TRCI. Unfortunately, a persistent RAO, even benign in most cases as sufficient collateral blood flow from the ulnar artery, may cause limited movement of the upper arm where TRA was performed. Furthermore, there is a lack of a powerful stratification system to predict the occurrence of and a clinical relevant approach to prevent from RAO.[3]

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Radial artery occlusion experiences gradual occlusion but rather sudden closure after TRCI. For a given injured RA, a well-developed blood flow from the ulnar artery via superficial arch should provide sufficient enough perfusion for the thumb and index, and would minimize the harm of RAO. In the same way, antegrade blood through brachial artery, theoretically, should have kept RA patent when ulnar artery had been temporally occluded. However, whether the weakness of RA pulsation (RAP) after TRCI could be reversed by ipsilateral ulnar artery compression does not attract global interests. This was the aim of the present study.

Methods

Patients population

Between June 2006 and March 2010, 2658 patients (1897 male and 761 female, mean age of 61 years) who underwent TRCI

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in our hospital, were included in the study. Allen's test was performed for all patients in order to assess the circulation of ulnar and RA.[4] A sufficient ulnar and RA perfusion was an obligatory criterion for TRCI.

Of 2658 patients, 187 (7%, 110 male and 77 female, mean age of 61 year) had a weaker RAP as assessed by manual palpation after the usual compress bandage maintained for 2–4 h following sheath removal, were defined as Group W. The remaining patients with normal RAP were defined as Group N.

Transradial catheterization and hemostasis

The RA was cannulated using a through-and-through puncture technique, and only 6Fr hydrophilic 10-cm-long sheaths (Radiofocus Introducer II, Terumo, Japan) were used. After sheath insertion, a radial cocktail containing 5 mg of verapamil and heparin 3000 U diluted in a 10-ml syringe was injected gradually through the sheath side arm into the RA. Coronary angiography was preferentially performed using a single diagnostic universal 5Fr Tiger catheter (Terumo, Japan), although standard 5Fr Judkins diagnostic coronary catheters (Cordis, USA) could also be used. Angioplasty was performed with 6F guiding catheters (Launcher, Medtronic, Inc., USA) under full heparinization (add up to 10,000 U). Hemostasis was achieved by immediate postprocedural sheath removal and simple gauze and elastic bandage are used for 2–4 h, during which patients were advised to restrict movements of the wrist joint.

Determination of weaker radial artery pulse

Pulsation of the RA was examined by palpation at and near the original entry site at 1 h after bandage removal. The Allen's test was repeated for all patients with weaker RAP.

For the first 30 consecutive patients in Group W, blood flow in both RAs and ulnar artery were examined by Doppler ultrasound. Two-dimensional vascular images and color Doppler ultrasonic studies were performed using a 7-MHz linear transducer (Acuson 128XP Mountain View, California, USA). Of them, RA blood flows while ipsilateral ulnar artery compression was assessed for the first 10 consecutive patients.

Ulnar artery compression

Continuous manually ipsilateral ulnar artery compression was applied at 1 h after the RA bandage removal. The duration of ulnar artery compression depended on the restoration of RAP after releasing the ulnar artery.

Data collection

Baseline clinical data were collected. Blood pressure (BP) line was monitored through the whole procedure since the insertion of RA sheath.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) and compared using Student's *t*-test binormality. Categorical variables were expressed as percentages and accessed by χ^2 analysis. Logistic regression multivariate analysis was applied. A two-sided $P < 0.05$ was considered statistically significant. All data were analyzed using SPSS 18.0 software package (SPSS™, Chicago, IL, USA).

Results

Clinical characteristics

Clinical characteristics are presented in Table 1. Patients in Group W were characterized by more female gender, more frequent transradial intervention (TRI) history, longer sheath retention, and post-TRI bandage time.

Logistic regression analysis

The duration of sheath retention (odds ratio [*OR*] = 1.329, 95% confidence interval [*CI*]: 1.124–2.586, $P = 0.039$) and post-TRI bandage (*OR* = 1.843, 95% *CI*: 1.334–2.752, $P = 0.028$), and invasive systolic BP (SBP) (*OR* = 0.533, 95% *CI*: 0.256–0.857, $P = 0.017$) were three independent factors of weaker RAP [Table 2].

Determination of weaker radial artery pulse

All subjects in Group W had a negative reversed Allen's test, defined as the hand returned to normal color >30 s after releasing the RA, when and after compression of both ulnar and RAs.

For the first 30 consecutive patients in Group W, patients with weaker RA by Doppler ultrasound had a

Table 1: Comparison of clinical data between two groups

Risk factors	Group W (*n* = 187)	Group N (*n* = 2471)	*P*
Age (years)	62.32 ± 10.6	61.27 ± 11.8	0.248
Female gender, *n* (%)	77 (41.18)	643 (26.02)	0.000
BMI (kg/m^2)	23.78 ± 2.80	23.89 ± 2.70	0.782
Cigarette smoking, *n* (%)	82 (43.85)	1171 (47.39)	0.350
Hypertension, *n* (%)	86 (45.99)	1045 (42.29)	0.324
Hyperlipidemia, *n* (%)	103 (55.08)	1287 (52.08)	0.429
Diabetes mellitus, *n* (%)	68 (36.36)	791 (32.01)	0.220
TRI history, *n* (%)	52 (27.81)	375 (15.18)	0.000
PCI ratio, *n* (%)	59 (31.55)	736 (29.79)	0.611
Duration of sheath retention (min)	75 ± 22	39 ± 18	0.000
Post-TRI bandage time (min)	125 ± 25	77 ± 21	0.000
Invasive SBP (mmHg)	125.45 ± 17.20	146.37 ± 16.50	0.048
Invasive DBP (mmHg)	84.32 ± 9.70	86.39 ± 10.30	0.475

BMI: Body mass index; PCI: Percutaneous coronary intervention; TRI: Trans-radial intervention; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

Table 2: Logistic regression analysis of 2658 patients

Risk factors	*B*	χ^2	*OR*	95% *CI*	*P*
Female	0.511	1.775	1.702	0.811–2.964	0.074
TRI history	−0.344	1.803	0.715	0.546–1.864	0.076
Sheath retention time	0.423	3.187	1.329	1.124–2.586	0.039
Post-TRI bandage time	0.316	4.461	1.843	1.334–2.752	0.028
Invasive SBP	−0.537	5.372	0.533	0.256–0.857	0.017

TRI: Trans-radial intervention; SBP: Systolic blood pressure; *CI*: Confidence interval; *OR*: Odds ratio.

more profound significant reduction of both systolic (61.24 ± 3.95 cm/s vs. 72.31 ± 3.57 cm/s, $P < 0.001$) and diastolic (1.83 ± 0.32 cm/s vs. 17.77 ± 3.97 cm/s, $P < 0.001$) blood flow as compared to the contralateral RA. The blood flow velocity of ulnar artery in the access side was compensatory increased, as evidence by increased systolic (81.2 ± 2.16 cm/s) and diastolic (13.1 ± 2.86 cm/s) blood flow velocity.

Among the first 10 consecutive patients, RA blood flow was strikingly increased while ipsilateral ulnar artery compression, reflected by enhanced systolic (116 ± 3.21 cm/s) and diastolic (6.97 ± 1.16 cm/s) blood flow velocity.

Ulnar artery compression

The duration of ulnar artery compression was 4.1 ± 1.2 h (ranged 2.5–6.5 h), and 26 (13.9%) patients complained of pain at the compression site during the maneuver. The pulsation of the ulnar artery after compression was removed had not been influenced by the compression. There was no other complication related to the method.

Totally, two patients had persistent RAO (defined as the absence of RAP) in the study at 24 h after bandage removal, confirmed by Doppler ultrasound. Thus, RA flow was defined as complete occlusion.

Finally, increasing RA flow via blocking ulnar artery in order to prevent RAO was successful in 98.9% of cases, leading to an RAO incidence of 0.075% in the whole population.

Discussion

The present study major find out that RAP after TRCI was getting significant weak is a harbinger of the occurrence of the RAO and the continuing compression ipsilateral ulnar artery is an effective method to recanalize the RA without complication.

Because of its advantages, TRA gradually becomes the main approach for coronary angioplasty.[1] However, the RAO in patients undergoing TRCI, which may be asymptomatic, remains a major complication as high as 5%–10%[2] and may cause the RA unusable for future TRCI and for coronary bypass graft and especially for Chinese because RAP assessment plays a key role in Chinese traditional medicine. Although a few cases of mechanical reopening of the occluded RA have been reported,[5-7] nevertheless, prevention of RAO is well-worth paying attention.

Sanmartin *et al*.[8] reported that damage to the arterial wall during puncture and sheath insertion and an occlusive hemostasis technique is probably the most important determinant of RAO. Zankl *et al*.[3] reported that the primary mechanism of RAO is local thrombus formation. Therefore, bandage time and compression intensity are predictors of RAO because of higher rates of local thrombus formation on the basis of blood flow stasis. Spaulding *et al*.[9] reported that inappropriate anticoagulation during diagnostic procedures is another predictor of loss of arterial pulsations after transradial catheterization.

In the present study, we found that the prolonged durations of sheath retention and post-TRI bandage time, which may damage arterial endothelium and thereby increase local thrombosis, were correlated with weak RAP.

By means of the present study, we realize the key factors to induce thrombus formation is RA endothelial injury because the pulse of ulnar artery with intact endothelial had not been influenced although the average compression time was 4.1 ± 1.2 h for blocking flow. Therefore, avoiding the RA endothelial damage and avoiding the thrombosis are the key factors to reduce RAO.

In the present study, we have shown that patients with clinically weak RAP had a significant reduction of both systolic and diastolic blood flow as compared to the contralateral RA which confirmed clinical observation discovers that RAP after TRCI was getting significant weak is a harbinger of the occurrence of the RAO. Therefore, RAP at the access site should be carefully examined after TRCI procedure.

In the present study, blood flow velocity of all patients with weak RAP was reduced in systolic and diastolic period, and the reduction in diastole was more obvious. Palpation of the RA is susceptible to a variety of factors. Thus, Doppler ultrasound examination as a more accurate method should be applied to evaluate the radial arterial pulse strength, especially when diastolic blood flow velocity is significant low, which, we think, represents an important predicator of RAO. We consider the primary reason causing blood flow slowed down is vascular endothelial injury induced by arterial sheath. Due to vascular endothelial injury, collagen fibers and tissue factors in the subendothelial tissue have become exposed to blood to promote thrombosis. Furthermore, injured endothelium can also induce the abnormal blood vessel vasoconstriction, which easily lead to vasospasm and thus helps to promote thrombosis. Therefore, pulsation in the puncture site should be carefully examined after TRCI. If the pulse became weak, Doppler ultrasound examination must be given promptly so as to diagnose RAO as early as possible and subsequently give a timely treatment.

By measurement of the invasive BP, which is a more accurate index of the real level of BP, we also found low invasive SBP was a remarkable risk factor of weak RAP post-TRI. Consequently, a patient with low BP should be given appropriate rehydration treatment to maintain BP in an appropriate level.

To prevent from RAO, the risk factors of RAO should be avoiding like prolonging duration of sheath retention and post-TRI bandage compression, etc. As early as possible to detect the harbinger of RAO and treating it in time before complete occlusion happening in the RA can effectively prevent RAO.

In comparison with the literature,[2,10-12] there is a very low incidence of RAO in this study. All RAP weakened patients (187) were given ipsilateral ulnar artery compression

manually which sustain blocking the ulnar artery blood flow with lining intact leading to the brachial artery blood all flow into the RA to rush and expansion RA on the verge of occlusion and produces a steep increase in RA flow promoting localized fibrinolysis, hence, reopening the RA. RAP of 185 (98.9%) patients returned to normal beat and blood flow velocity in two sides of RA was similar.

Only two patients had persistent RAO in the study. The causes of failure for them were: (1) Inaccurate compression site and low strength and then compression could not effectively block the ulnar artery blood flow and (2) the time of pressing (40 min) was not enough for restoration of the RAP. This method to prevent RAO after TRCI was successful in 98.9% of cases leading to an incidence 0.075% of RAO in the whole population (2/2658 patients).

The failure of the two patients indicates that patients underwent TRCI with weakened RAP will occur RAO if the correct treatment in time cannot be obtained.

The limitations in this study were as follows: The present study was featured by its nonrandomized design. However, the technique described in the current study showed the significant reduction of RAO in a relative not small patient size, which provided enhanced evidence to support the routine use of this technique to prevent from RAO. Next, economic reason was why Doppler ultrasound examination was not applied to all patients. Then, classification of weakness of RAP was not performed in this study. This would increase the bias of assessment. Alternatively, ulnar artery compression was not automatically performed, had no quantitative variables to confirm the complete compression, which would raise the argument about the real effect of this technique. Finally, shorter follow-up could exclude the late occurrence of RAO after patients discharged. Further studies are required to confirm whether the RA with weaker pulse will be occluded without ulnar artery compression.

In conclusion, the duration of sheath retention, post-TRI bandage, and invasive SBP are three independent factors of weakened RAP, which is a harbinger of the occurrence of the RAO. Thus, RAP ought to be carefully examined before and after TRCI. If RAP is getting significant weak, which is an aura of RAO, continuing ipsilateral ulnar artery compression must be administrated prevent from RAO, which is an effective approach to maintain RA patency without complication.

References

1. 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.
2. 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.
3. Zankl AR, Andrassy M, Volz C, Ivandic B, Krumsdorf U, Katus HA, *et al.* Radial artery thrombosis following transradial coronary angiography: Incidence and rationale for treatment of symptomatic patients with low-molecular-weight heparins. Clin Res Cardiol 2010;99:841-7.
4. Stella PR, Kiemeneij F, Laarman GJ, Odekerken D, Slagboom T, van der Wieken R. Incidence and outcome of radial artery occlusion following transradial artery coronary angioplasty. Cathet Cardiovasc Diagn 1997;40:156-8.
5. Pancholy SB. Transradial access in an occluded radial artery: New technique. J Invasive Cardiol 2007;19:541-4.
6. Ruzsa Z, Pintér L, Kolvenbach R. Anterograde recanalisation of the radial artery followed by transradial angioplasty. Cardiovasc Revasc Med 2010;11:266.e1-4.
7. Babunashvili A, Dundua D. Recanalization and reuse of early occluded radial artery within 6 days after previous transradial diagnostic procedure. Catheter Cardiovasc Interv 2011;77:530-6.
8. Sanmartin M, Gomez M, Rumoroso JR, Sadaba M, Martinez M, Baz JA, *et al.* Interruption of blood flow during compression and radial artery occlusion after transradial catheterization. Catheter Cardiovasc Interv 2007;70:185-9.
9. Spaulding C, Lefe`vre T, Funck F, The´bault B, Chauveau M, Hamda KB, *et al*. Left radial approach for coronary angiography: Results of a prospective study. Catheter Cardiovasc Diagn 1996;39:365-70.
10. Davis FM, Stewart JM. Radial artery cannulation. A prospective study in patients undergoing cardiothoracic surgery. Br J Anaesth 1980;52:41-7.
11. Bedford RF, Wollman H. Complications of percutaneous radial-artery cannulation: An objective prospective study in man. Anesthesiology 1973;38:228-36.
12. Slogoff S, Keats AS, Arlund C. On the safety of radial artery cannulation. Anesthesiology 1983;59:42-7.

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