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

Methods

Patients population
Between June 2006 and March 2010, 2658 patients (1897 male and 761 female, mean age of 61 years) who underwent TRCI
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. A sufficient ulnar and RA perfusion was an obligatory criterion for TRC.

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 RA.

**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 $\chi^2$ 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

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**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/m²)                | 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      | $\chi^2$ | 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
pulsion 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
gaining 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. However, the RAO in
patients undergoing TRCI, which may be asymptomatic,
remains a major complication as high as 5%–10% 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,[15-7] 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.[9] 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.[10] 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 predictor
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,
pulsion 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
Radial artery thrombosis following transradial coronary intervention (TRCI) is a common complication. Interruption of blood flow during compression and the time of clamping (40 min) was not enough for restoration of the radial artery (RA) blood flow. The failure of two patients indicates that patients underwent TRCI with weakened radial artery pulse (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, RAP 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-TRCI 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.

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