Transient ulnar artery compression facilitates transradial access

Zhi-ming Zhou, MD, PhD, Zhen-xian Yan, MD, PhD, Bin Nie, MD, PhD, Yong-he Guo, MD, Yu-jie Zhou, MD, PhD∗

Abstract
Background: Unsuccessful radial artery puncture is one of the important causes of transradial procedure failure. Ulnar artery compression made the radial artery pulse stronger. Whether it would make transradial access easier, however, is uncertain.

Methods: A prospective randomized controlled trial was conducted among 446 patients who planned for transradial cardiac catheterization. Patients were randomized to receiving either transient ulnar artery compression (UC) or standard treatment (standard) for half an hour prior to needle insertion (217 UC, 229 standard). The diameters of right radial artery and ulnar artery were measured by ultrasound on admission and before artery puncture. Primary endpoints included the number of attempts to access, the rate of first-pass success, and time for a successful access. Secondary endpoints were the number of difficult procedures, and the incidence of puncture failure.

Results: The diameters of radial artery were larger after half an hour’s ulnar artery compression, but there were no obvious changes in that of ulnar artery. As compared with standard group, the number of attempts was significantly decreased (1.42±1.10 vs 2.97±2.38, \(P<0.001\)), and the rate of first-pass success was greatly enhanced (73.27% vs 57.64%, \(P<0.001\)) in UC group. Meanwhile, the time for access was decreased (59±15 seconds vs 71±18 seconds, \(P<0.001\)) with UC. In addition, the proportion of difficult procedures of UC group was less than that of standard group (4.61% vs 10.92%, \(P=0.013\)). No significant differences were found in failure rates of sheath insertion and puncture between the 2 groups.

Conclusion: Transient ulnar artery compression enhances the efficacy and feasibility of radial artery intubation in transradial catheterization.

Abbreviations: CA = coronary angiography, PCI = percutaneous coronary intervention, RRA = right radial artery, RUA = right ulnar artery, UC = ulnar artery compression.

Keywords: coronary heart disease, transradial catheterization, ulnar artery compression

1. Introduction
Transradial approach coronary procedures, including coronary angiography and percutaneous coronary intervention (PCI), are associated with lower rates of bleeding complications compared with femoral approach, have increased around the world as well as in China over the past decade. One of the important reasons of transradial procedure failure is unsuccessful access to the transradial artery. The weak pulse may make radial artery puncture difficult, whether caused by a small artery, a deep artery, or hypotension. Ulnar artery compression (UC) made the radial artery pulse stronger, could it make the access easier? We tried to assess the efficacy and feasibility of transient ulnar artery compression on transradial arterial access.

2. Methods
2.1. Study design
The study was a prospective, randomized controlled trial. Adult patients who were planned for transradial cardiac catheterization were included. The Allen test was performed and presence of dual circulation and patency of palmar arch was confirmed. Patients with emergent procedures, nonpalpable radial pulse, abnormal Allen test, or chronic renal disease on hemodialysis were excluded from the study. Those having radial puncture within a week before the procedure were also excluded. All patients who were included provided written informed consent, and the study was approved by the Beijing Anzhen Hospital Institutional Review Board.

2.2. Operators
In total, 15 operators joined this study. To avoid differences caused by operators, all operators who participated in this study
had performed at least 100 radial artery catheterization per year in the last 5 years.

2.3. Randomization
Patients were randomly allocated on a 1:1 basis to either UC or standard treatment through sealed envelopes. Briefly, random numbers were generated from discrete uniform distribution and the random numbers were then placed in the sealed envelopes. One investigator was responsible for enrolling all patients and allocating them to either treatment according to the serial number of the randomized numbers. The envelope was unsealed when a single operator was assigned to a special patient for the procedure.

2.4. Study procedures
Before the procedure, the hand circulation was assessed using Allen test among all the patients, by placing a hemostatic band over their right ulnar artery pulse with a silica gel (Xemex, Zeon Medical, Tokyo, Japan). Patients in UC group received transient completely ulnar artery compression for half hour before the procedure, verified by pulse oximetry. Those patients in standard treatment group just received the band without compression. The diameters of the right radial artery and ulnar artery were evaluated by ultrasound on admission before the intervention procedure. The diameter of the radial artery was measured at 1 cm proximal to the styloid process of the radius, while that of the ulnar artery was measured at 1 cm proximal to the styloid process of the ulna. After local anesthesia with 1% lidocaine, radial artery puncture was performed with a sheath set, including a 20-gauge 2-piece needle, 0.025-inch straight wire, and a 16 cm long 6Fr sheath (TERUMO, Tokyo, Japan). Double-wall technique was used per operator preference. The guidewire would then be inserted, the skin nicked per operator practice, and the sheath inserted over the guidewire and flushed. Baseline patient demographics and comorbidities were recorded. Procedural details including number of attempts, time to access, and incidence of puncture failure were tracked.

2.5. Endpoints and power
The primary endpoints of the study were the number of attempts, the rate of first-pass success, and the time for a successful access. Attempts were defined as needle punches separated by withdrawals, if only these performed in the skin or tissue above the plane of the artery. The number of attempts to access were first reported by the operator and then confirmed by a technician. The time to access was from the point of the first application of the operator’s fingers to successful sheath placement and flushing. Secondary endpoints included difficult procedures and incidence of puncture failure. Difficult procedures were defined prospectively as either requiring no less than 5 attempts or 5 min for assess. Puncture failure was defined as the guidewire failed to insert.

The estimated sample size was 430 patients. It was capable of showing a difference of 15% in first-pass success with an alpha of 5% and an estimated power of 90%. In addition, it was sufficiently powered to study the other 2 primary endpoints, with >97.5% power to detect a 30-second difference with the standard deviation of 16 seconds in time for access, and >97.5% power to detect a difference of 1 with the standard deviation of 1.5 in the number of attempts.

2.6. Statistical analysis
Baseline demographic and clinical characteristics were compared between the 2 groups. Categorical variables are presented as numbers and percentages, and continuous variables as the mean ±SD. Demographic characteristics were analyzed using the Student t test for independent continuous data and the Fischer exact test or χ² test for categorical data. P values lower than 0.05 were considered statistically significant with 2 tailed tests. Statistical analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC).

3. Results
In total, 446 patients who were planned for transradial cardiac catheterization procedures were consecutively recruited between January 2013 and August 2016 in Beijing Anzhen Hospital. They were randomized to UC (n = 217) or standard (n = 229) treatment. Baseline clinical data and procedural characteristics are presented in Table 1, and there were no significant differences in the baseline characteristics of the patients. There were also no significant differences in clinical characteristics, such as the distribution of gender, BMI, and ages as well as prevalence of diabetes mellitus, hypertension, dyslipidemia, and cigarette smoking.

The diameters were similar between 2 groups patients on admission (Table 2), of both radial artery (2.28±0.44 mm vs 2.29±0.39 mm, P = 0.799) and ulnar artery (2.31±0.41 mm vs 2.30±0.44 mm, P = 0.804). However, the diameters of radial in UC group were larger by half an hour of ulnar artery compression than those in standard group (2.39±0.50 mm vs 2.30±0.45 mm, P = 0.046), whereas there are no obvious differences in that of ulnar artery between the 2 groups (2.30±0.38 vs 2.31±0.42, P = 0.793). In addition, as compared with those on admission, the diameters of radial were significantly increased (2.39±0.50 vs

| Table 1 | Baseline characteristics of participants. |
|---|---|---|
| Characteristics | UC group (n = 217) | Standard group (n = 229) | P value |
| Age, y | 55.34±8.96 | 56.72±9.23 | 0.110 |
| Female, % | 52.53 | 51.96 | 0.828 |
| BMI | 26.34±4.21 | 25.85±4.93 | 0.261 |
| Diabetes, % | 24.88 | 22.27 | 0.516 |
| Hypertension, % | 54.34 | 51.53 | 0.547 |
| Dyslipidemia, % | 55.30 | 50.66 | 0.526 |
| Cigarette smoking, % | 50.69 | 55.02 | 0.360 |

UC = ulnar artery compression.

| Table 2 | Diameters of RA and RU. |
|---|---|---|
| Characteristics | UC group (n = 217) | Standard group (n = 229) | P value |
| RA | Admission, mm | 2.28±0.44 | 2.29±0.39 | 0.799 |
| Prior, mm | 2.39±0.50 | 2.30±0.45 | 0.046 |
| RU | Admission, mm | 2.31±0.41 | 2.30±0.44 | 0.804 |
| Prior, mm | 2.30±0.38 | 2.31±0.42 | 0.793 |

RA = right radial, RU = right ulnar, UC = ulnar artery compression.
*Compared with the diameters of RA on admission, P = 0.042.
†Compared with the diameters of RU on admission, P = 0.838.
artery by the compression of hemostatic band. The blood flow could be completely obstructed on the ulnar artery compression. There was a significant reduction in the number of attempts required for access the radial artery by UC versus standard (1.42 ± 1.10 vs 2.97 ± 2.38, P < 0.001), as shown in Table 3. This was accompanied by increased rate of first-pass success (73.27% vs 57.64%, P < 0.001). The difficult procedures that were defined as any procedures requiring >5 attempts, and/or requiring 5 minutes for access, were reduced by UC from 10.92% to 4.61%, P = 0.013. The vascular access time was shorter in patients with half hour’s ulnar artery compression than patients with standard treatment (59 ± 15 seconds vs 71 ± 18 seconds, P < 0.001). There was few incidences of puncture failure (none in UC and 3 cases in standard, P = 0.249), and failure of sheath insertion was rare (1 in UC and none in standard, P = 0.487), and no statistical difference existed between the 2 groups.

4. Discussion

The radial artery access failure was related to anatomic and technical factors, and the diameter of the target artery is an important factor in vascular puncture, especially to the operators with less experiences. Our previous study showed that in Chinese adult patients the diameter of RRA ranges from 1.3 to 3.6 mm (mean 2.38 ± 0.36 mm), and the diameter of RUA is 1.1 to 3.5 mm (mean 2.36 ± 0.49 mm). These data were confirmed in this study. We try to seek a method to enlarge the diameter of radial artery. The hand receives a dual arterial supply from the radial and ulnar arteries, which come together to form deep and superficial palmar arches. An arterial waveform was recorded by a pulse oximetry placed on the index finger. The waveform maintained when the ulnar artery compressed by a hemostatic band, and disappeared when the radial artery simultaneously oppressed by hand. It verified that the blood flow could be completely obstructed on the ulnar artery by the compression of hemostatic band. The phenomenon that compression on ulnar artery can increase the diameter radio artery, was a great inspiration to us. In this study, the radial artery diameters were enlarged by this kind of simple and feasible method; it could be the reason for significant reduction in the number of attempts and improvement on first-pass success rate. The proportion of difficult access procedures was reduced by UC too, it decreased from 10.92% to 4.61% at meantime. These results suggest that “enlarging” the radial artery by UC may have advantages in artery puncture over standard treatment, due to the small size of artery and discrimination limit of fingertip palpation. UC is particularly useful in those patients with weak pulse caused by a small artery, a deep artery, or hypotension, which make palpation-guided access difficult.

There were a few incidences of puncture failure in both group patients, none in UC, and 3 cases in standard, P = 0.249. The reason may be that the operators are all experienced in our study, if more operators were included, the successful rate of puncture would be different; however, the bigger diameter means the more easier for most operators, whatever the experienced one or the beginner.

As a matter of fact, the vascular access time may be a better issue that can represent the level of difficulty on artery puncture and sheath insertion; the duration may be longer in patients with several attempt puncture than those who were successful in the first time. In this study, the vascular access time was shorter in the patients with half hour’s ulnar artery compression than the others with standard treatment. Failure of sheath insertion was reported rarely in both groups, 1 in UC and none in standard, P = 0.487, due to artery spasm, tortuosity, and needs to be crossover to another site (usually femoral); it could not be altered by the size of artery obviously.

There are concerns about whether a half-an-hour compression would have unfavorable impact on the ulnar artery, especially the possibility of thrombus forming. Fortunately, there were no obvious changes in diameters of ulnar artery (2.30 ± 0.38 mm vs 2.31 ± 0.41 mm, P = 0.838). Meanwhile, the safety of the method was verified, there was no thrombus case detected in this study, and there were no ischemic events on those patients too. It might be the effect of oral antiplatelet perioperative.

The findings of this study indicate that UC facilitated radial artery access as measured by the first-pass success rate, number of attempts, and time to access. UC is an efficacy and feasibility method that can improve the process of transradial catheterization. In addition, the superficial course of the distal ulnar artery provides easy compression, even can be compressed by themselves, and the future is worth looking forward to.

4.1. Study limitations

This study is limited by its single-center study design; therefore, our findings should primarily be viewed as hypothesis generating. Despite the use of an observer and the lab timer, we cannot exclude a bias in the performance, measurement, or recording of the procedure or clinical data. The second, the open-label design may increase the possibility of bias. That is, patients or operators may be influenced by their knowledge of the procedure.

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Table 3: Parameter of clinical procedure data.

| Characteristics                  | UC group (n = 217) | Standard group (n = 229) | P value |
|----------------------------------|-------------------|-------------------------|---------|
| First-pass success rate          | 73.27%            | 57.64%                  | <0.001  |
| Number of attempts               | 1.42±1.10 (n = 217) | 2.97±2.38 (n = 229)     | <0.001  |
| Proportion of difficult access   | 4.61% (n = 217)   | 10.92% (n = 229)        | 0.013   |
| Failure of sheath insertion      | 1                 | 0                       | 0.487   |
| Puncture failure (n)             | 0                 | 3                       | 0.249   |
| Vascular access time, s          | 59±15 (n = 216)   | 71±18 (n = 226)         | <0.001  |

UC = ulnar artery compression.
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