Correlation Between the Brachial Blood Pressure Values Obtained Using the Cuff Method and the Central Blood Pressure Values Obtained Invasively

Hiroshi Kobayashi, Mineko Kinou and Kenji Takazawa

Abstract

Objective This study was designed to identify why the central blood pressure (cSBP) values obtained using the catheter method tend to be higher than brachial systolic blood pressure (bSBP) values obtained using the cuff method.

Methods This study enrolled 20 patients who underwent coronary angiography (CAG) (mean age, 68.9 years; 13 men). Using the catheter method, a pressure guide wire was inserted via the radial artery at the time of CAG to measure the cSBP. The guide wire was then removed and the bSBP was obtained using two methods (the pressure guide wire method and the cuff method). The cSBP obtained with the catheter and the bSBP obtained with the cuff were compared, as were the bSBP obtained with the cuff and the bSBP obtained with the catheter.

Results The cSBP obtained with the catheter was 4.6 mmHg higher than the bSBP obtained with the cuff. The bSBP obtained with the cuff was 8.3 mmHg lower than the bSBP obtained with the catheter. The cSBP obtained with the catheter was 1.7 mmHg lower than the bSBP obtained with the catheter.

Conclusion In elderly patients with evident or suspected coronary heart disease, the finding of a higher cSBP measured using the catheter method than the bSBP obtained using the cuff method is attributable to bSBP underestimation (by 8.3 mmHg) using the cuff method compared to the bSBP directly obtained using the catheter method.

Key words: central blood pressure, brachial blood pressure, oscillometric method


Introduction

The term “central blood pressure” usually refers to the systolic blood pressure at the origin of the aorta (central aorta) (1). In recent years, the importance of measuring the central blood pressure has been stressed (2-4). There are two reasons for this view: the central blood pressure reflects the status of the systemic blood vessels (1, 5), and the central blood pressure is the pressure at a point immediately outside the left ventricle and serves as a direct load (after-load) toward the left ventricle (6, 7). In particular, in the ASCOT CAFÉ study (3), which compared vasodilator (amlodipine) treatment with beta-blocker (atenolol) treatment, the central blood pressure was significantly lower following vasodilator treatment, although the decrease in the brachial systolic blood pressure did not differ between the two groups. That study also reported that a reduction in central blood pressure was associated with a decreased incidence of cardiovascular events in the vasodilator treatment group. These findings resulted in close attention being paid to the central blood pressure.

In the past, there was only one method for measuring the central blood pressure, i.e., the invasive direct insertion of a catheter or pressure wire into the origin of the aorta (8). In recent years, however, a noninvasive method used to estimate the central blood pressure based on the radial artery pulse waves has emerged. This method can be divided into
two techniques, one of which uses an HEM-9000AI (Omron Corporation, Kyoto, Japan). In this technique, radial artery pulse waveforms are recorded with a tonometer fitted with an automated sensor, and an automated analysis of the forth derivative is used to estimate the central blood pressure (4).

The other technique employs a SphygmoCor (AtCor Medical, Sydney, Australia) to estimate the central blood pressure. In this technique, radial artery pressure waves are recorded with a tonometer, and the central blood pressure is estimated using the generalized transfer function obtained from the simultaneous recording of radial artery pressure waves and pressure waves at the aortic origin (1, 9).

It is commonly known that systolic blood pressure increases due to pressure wave amplification as the site of measurement becomes more distant from the aortic origin, moving toward the periphery (10). However, the central blood pressure estimated using the catheter method or the non invasive method is higher than the brachial systolic blood pressure obtained using the oscillometric method (the cuff method) (4, 11). In the present study, we compared the central blood pressure obtained using the catheter method, the brachial systolic blood pressure values obtained using the cuff method, and the brachial systolic blood pressure obtained using the catheter method during the first session (catheter cSBP) was 138.1±18.5 mmHg, while the brachial systolic blood pressure obtained using the cuff method (cuff bSBP) was 133.5±18.6 mmHg. Therefore, the mean catheter cSBP was approximately 4.7 mmHg higher than the mean cuff bSBP (Fig. 2). Comparing the cuff bSBP and the brachial systolic blood pressure obtained using the catheter method (catheter bSBP), the cuff bSBP was 133.5±18.6 mmHg and the catheter bSBP was 141.8±19.8 mmHg. Therefore, the mean cuff bSBP was approximately 8.3 mmHg lower than the mean catheter bSBP (Fig. 3).

The catheter cSBP obtained in the second session was 140.1±20.9 mmHg, while the catheter bSBP was 141.8±19.2 mmHg. Therefore, the mean catheter cSBP obtained in the second session was approximately 1.7 mmHg lower than the mean catheter bSBP (Fig. 4). Figure 5 compares the mean systolic blood pressure values among the different measurement sites. Figure 6 provides sample cSBP and bSBP pres-

Materials and Methods

Subjects

This study included 20 patients who underwent cardiac catheterization between April 2007 and December 2008. The patient population comprised 13 men and seven women, with a mean age of 69±8.1 years. The clinical diagnosis was angina pectoris in 12 cases, old myocardial infarction in seven cases, and valvular heart disease in one case. The radial blood pressure on the right side was measured in advance, and patients with a difference of ≥10 mmHg in brachial blood pressure between the right and left sides were excluded from the study. Table summarizes the background variables of the study patients.

This clinical study was conducted after informed consent was obtained from all subjects under approval of the Clinical Study Ethics Committee of Tokyo Medical University Hachioji Medical Center.

Study protocol

Cardiac catheterization was performed using right radial artery puncture. The pressure guide wire (PRESSURE WIRE; RADI Medical System, Gothenburg, Sweden) inserted via the right radial artery was kept at the origin of the aorta to measure the central blood pressure (cSBP) (first session). At the same time, the left brachial blood pressure was obtained using the cuff method (HEM-9000AI, Omron). Before the pressure guide wire was removed, the cSBP was measured again (second session). The pressure guide wire was subsequently pulled to the brachium and the brachial blood pressure was obtained using the catheter method. Figure 1 illustrates the study procedures.

We compared the cSBP obtained using the catheter method (first session) and the brachial systolic blood pressure (bSBP) obtained using the cuff method, the bSBP obtained using the catheter method and the bSBP obtained using the cuff method, and the cSBP obtained using the catheter method (second session) and the bSBP obtained using the catheter method.

Statistical analysis

The mean of each parameter was expressed as the mean ± SD. The correlations among the parameters were analyzed using Pearson’s correlation coefficients.

Results

The central blood pressure obtained using the catheter method during the first session (catheter cSBP) was 138.1±18.5 mmHg, while the brachial systolic blood pressure obtained using the cuff method (cuff bSBP) was 133.5±18.6 mmHg. Therefore, the mean catheter cSBP was approximately 4.7 mmHg higher than the mean cuff bSBP (Fig. 2). Comparing the cuff bSBP and the brachial systolic blood pressure obtained using the catheter method (catheter bSBP), the cuff bSBP was 133.5±18.6 mmHg and the catheter bSBP was 141.8±19.8 mmHg. Therefore, the mean cuff bSBP was approximately 8.3 mmHg lower than the mean catheter bSBP (Fig. 3).

The catheter cSBP obtained in the second session was 140.1±20.9 mmHg, while the catheter bSBP was 141.8±19.2 mmHg. Therefore, the mean catheter cSBP obtained in the second session was approximately 1.7 mmHg lower than the mean catheter bSBP (Fig. 4). Figure 5 compares the mean systolic blood pressure values among the different measurement sites. Figure 6 provides sample cSBP and bSBP pres-

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SBP: systolic blood pressure, DBP: diastolic blood pressure, PP: pulse pressure, radial AI: radial augmentation index, HR: heart rate, BMI: body mass index.
Discussion

Systolic blood pressure generally increases as the measurement site approaches the periphery from the center due to pulse pressure amplification (9). This phenomenon is particularly marked in younger individuals with high degrees of arterial wall extensibility (12). However, as demonstrated in the present study (Fig. 2), the central blood pressure obtained using the catheter method is higher (by 4.7 mmHg) than the brachial blood pressure obtained using the oscillometric method. We explored the cause for this discrepancy in the present study by directly measuring blood pressure waveforms recorded by the pressure guide wire.
The results of the present study demonstrate that the systolic blood pressure measured at the brachium using the cuff method is an average of 8.3 mmHg lower than the systolic blood pressure obtained using the catheter method (Fig. 3). Ochiai et al. also reported that the blood pressure obtained using the cuff method is 12.2 mmHg lower than that obtained using the catheter method (13), a finding that is consistent with the results of the present study. The underestimation of the blood pressure using the cuff method compared to that obtained using the catheter method appears to explain why the central blood pressure obtained using the catheter is higher than the brachial systolic blood pressure obtained using the cuff method.

The difference between the central blood pressure obtained using the catheter method and the brachial blood pressure was small (1.7 mmHg) in the present study (Fig. 4). This small difference is attributable to the high mean age of the subjects evaluated in this study (69±8.1 years). Atherosclerosis tends to advance with age. As such, it seems likely that reduced arterial wall compliance was accompanied by reduced amplification, resulting in a smaller difference between the central blood pressure and the brachial blood pressure. Another factor possibly involved in this small difference is the relatively high percentage of patients with atherosclerotic heart disease (e.g., angina pectoris) among the study subjects. If the inclusion of more subjects in the future leads to an increase in the number of younger patients or those without cardiovascular diseases, the difference between the central blood pressure obtained using the catheter method and the brachial blood pressure may be larger than 1.7 mmHg because the degree of pressure amplification would be greater.

Blood pressure measurement methods can be roughly divided into the direct method (invasive method), which involves the insertion of a catheter into the blood vessels, and...
Figure 6. A central and brachial blood pressure wave form of a representative case. The cSBP obtained using the catheter method was 144.5 mmHg, while the bSBP obtained using the catheter method was 156.0 mmHg. The bSBP obtained using the cuff method was 146 mmHg, which was 10 mmHg lower that the bSBP obtained using the catheter method.

the indirect method, which does not. The direct method we performed in the present study involved direct measurement using a pressure guide wire inserted directly into the blood vessel. In a study conducted by Ding et al., invasive measurement was performed using a 6-Fr diagnostic catheter connected to a fluid-filled manometer system (14). In obtaining measurements with this system, damping of pressure waves due to microbubbles, etc., occasionally becomes a problem. Moreover, the measurements obtained via catheter placement can on occasion be incorrect depending on the size of the catheter and the direction of the catheter tip in relation to the vascular wall. On the other hand, the use of a 0.014-inch pressure guide wire allows for more accurate invasive measurement without unwanted effects, such as damping of pressure waves. The indirect method involves measurement of blood pressure on the basis of the interactions between the external pressure applied to the arterial wall from outside the body and the pressure within the artery. The cuff (oscillometric) method is indirect. If compressed by the cuff, the artery exhibits oscillation synchronized with cardiac beating and its amplitude changes depending on the relative relationship between the blood pressure and the cuff pressure. The oscillometric method calculates blood pressure by analyzing the changes in the oscillation amplitude in accordance with the predetermined relationship between the cuff pressure and the arterial pressure.

For many years, reports have described the discrepancies in blood pressure readings observed between the direct and indirect methods (13-16). The findings of the present study regarding underestimation of blood pressure by the indirect method are consistent with the findings previously reported by Ochiai (13), Nielsen (15) and others. Therefore, existing reports support the findings of the present study. The currently available device (HEM-9000AI, Omron) estimates the central blood pressure using an equation of linear regression between the radial artery late-systolic blood pressure (rSBP2) calibrated according to the indirect method and the central blood pressure obtained via the direct method. Based on a report by Takazawa et al. (4), the rSBP2 is calculated employing the radial artery pulse wave ratio and the brachial blood pressure obtained using the oscillometric method. Many reports have demonstrated that the rSBP2 obtained using this technique is strongly correlated with the central blood pressure (4, 17-19). Moreover, the oscillometric method employing the Omron device is often used in global clinical trials. Notably, the Omron oscillometric device (Omron 705CP) was used to calibrate blood pressure measurements obtained with the SphygmoCor in the ASCOT-CAFÉ study conducted by Williams et al. (3). Under the present circumstances, the oscillometric method employing the Omron device appears to be a valid noninvasive calibration method. However, the HEM-9000AI estimates the central blood pressure using a linear regression equation. When this device is used, underestimation of blood pressure by the cuff method and the absence of effects reducing variation in the estimated error of rSBP2 in addition to other problems must be taken into consideration. As such, when one interprets the estimated central blood pressure recorded using this device, it is necessary to bear in mind the possible differences associated with the direct and indirect calibration methods.

Limitations

This study was conducted in a single center and involved only a small number of subjects. Future studies of this kind should be conducted at multiple centers and include a larger number of subjects. Furthermore, this study most likely involved selection bias because most of the subjects were patients with ischemic heart disease and the mean patient age (68.9 years) was high.

Conclusion

In elderly patients with evident or suspected coronary heart disease, the higher central blood pressure obtained using the catheter method compared to the brachial blood pressure obtained using the cuff method is an outcome of blood pressure amplification due to underestimation of the brachial blood pressure by the cuff method.

The authors state that they have no Conflict of Interest (COI).

References


