



## Correlation of Invasive and Non-Invasive Central Aortic Pressures in Patients Undergoing Diagnostic Coronary Angiogram

### KEYWORDS

Applanation tonometry, Invasive central aortic pressure, Non-invasive central aortic pressure.

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**ABSTRACT** Central aortic pressure (CAP) is pathophysiologically more relevant than peripheral brachial pressure for predicting cardiovascular risk. Recording of CAP can be acquired invasively and non-invasively. Study aim was to compare SphygmoCor® derived non-invasive CAP with invasive CAP. In 50 eligible patients, non-invasive CAP was recorded using applanation tonometry with SphygmoCor and invasive CAP were recorded using Recor pressure Recording system. Mean systolic CAP by non-invasive and invasive techniques were  $116.1 \pm 15.18$  &  $121.04 \pm 16.6$  mmHg respectively and mean diastolic CAP by non-invasive and invasive techniques were  $76.66 \pm 9.32$  mmHg &  $78.14 \pm 7.58$  mmHg respectively. Non-invasive CAP underestimated catheter-measured central systolic pressure by 4.9 mmHg and diastolic pressure by 1.5 mmHg as analysed by Bland-Altman plot. High correlation was observed between non-invasive and invasive systolic and diastolic blood pressures ( $r = 0.74$ ,  $r = 0.74$  respectively). Non-invasive CAP were found to be in agreement with invasive CAP.

### INTRODUCTION

Growing body of evidence suggests that central aortic pressure is pathophysiologically more relevant than peripheral brachial pressure for predicting the cardiovascular risk<sup>[1]</sup>. The word 'central' is used to emphasize the estimation of aortic root pressures and haemodynamic indices as opposed to 'peripheral', i.e. brachial pressures, which are not always a perfect surrogate for central aortic pressures because of a variable degree of amplification of the pulse pressure wave from the aortic root to the peripheral circulation. Moreover, this amplification process can be profoundly influenced by many factors, including the effects of ageing, disease, heart rate, height, gender, and, importantly, drug therapies<sup>[2]</sup>. Thus, central blood pressure assessment becomes necessary as pressure amplification between two arterial sites (e.g. brachial artery and aorta) is highly variable within and between subjects<sup>[3]</sup>.

Recording of CAP can be acquired invasively as well as non-invasively. Although, invasive estimation of CAP is a gold standard but as it is associated with high costs and technical limitations, non-invasive techniques are becoming widely used<sup>[1]</sup>. These methods allow relatively simple estimation of central pressures with high reproducibility<sup>[1,4,5,6]</sup>. One of the methods used for non-invasive recording of CAP includes, radial tonometry which uses generalized transfer functions based on pressure wave recordings at the radial artery. SphygmoCor® system is the most widely used commercial device which estimates the central pressures by applanation tonometry<sup>[1]</sup>.

However, it remains to be confirmed whether the CAP recorded non-invasively is close to that recorded invasively. Hence, the present study was designed to compare SphygmoCor® derived non-invasive CAP with invasive CAP obtained while performing routine diagnostic left heart catheterization in subjects undergoing diagnostic coronary angiogram.

### MATERIALS AND METHODS

This study was carried out in the Department of Clinical

Pharmacology and Therapeutics and Department of Cardiology, Nizam's Institute of Medical Sciences, Hyderabad, India in accordance with the Declaration of Helsinki following approval of Institutional Ethics Committee. Informed consent was obtained from all patients before cardiac catheterization.

Patients of either gender aged more than 18 yrs, posted for diagnostic left heart catheterization for 'risk stratification' with anginal symptoms for determining the extent of coronary vascular disease were enrolled into the study. Patients with the history of arrhythmias, peripheral vascular disease and heart failure were excluded from the study.

### Methods

#### Applanation tonometry

Applanation tonometry was performed with Sphygmocor® (AtCor Medical device, version no 8). Brachial blood pressure was measured using a validated, automated oscillometric device (Omron). Subjects were asked to lie down in a quiet room for 15 min, after which blood pressure was measured over the brachial artery 3 times at 2 min intervals. The mean of the three readings was recorded as representative of brachial blood pressure. After the last measurement, radial pulse of right arm was detected by a non-invasive sensor using applanation tonometry and pressure waveforms were sampled over 20 sec using pulse wave analysis mode. Three consecutive radial pressure waveforms were recorded with operator index more than 85%, and the mean of resulting central aortic pressure parameters were considered as representative readings.

#### Cardiac catheterization:

Cardiac catheterization was performed in each subject under local anaesthesia with 1% lignocaine, via right femoral artery puncture using a Cordis 6F pigtail catheter in the Department of Cardiology under stable conditions. Invasive opening aortic pressures were recorded over 10 sec using Recor Pressure Recording system.

#### Statistical analysis:

Bland–Altman plots were used to assess the agreement between the invasive and non-invasive measurements of CAP. This analysis plots the difference between the two readings against the average of the two readings, and has now been widely accepted as a good way of comparing two comparative measurements [7,8]. The strength of the association was assessed by Pearson correlation coefficient.

**RESULTS**

In this study, 50 (36 males and 14 females) patients were included in the study and their age was 52.06 ± 7.15 yrs and body mass index 25.04 ± 3.62 Kg/ m<sup>2</sup> (Table 1). Out of the 50 patients recruited, 42 patients were having hypertension and 24 patients were having diabetes mellitus.

The mean central systolic pressure measured by SphygmoCor® and catheter were 116.1± 15.18 and 121.04 ± 16.6 mmHg respectively and the mean central diastolic pressures were 76.66 ± 9.32 & 78.14 ± 7.58 mmHg respectively (Table 2). The mean difference for all patients studied showed that Sphygmocor® under estimated systolic CAP by 4.9 mmHg (S.D 11.4, 95% CI -17.5 /27.4) and central diastolic pressure by 1.5 mmHg (S.D 6.3, 95% CI -10.8 / 13.8 ). The mean difference of central pulse pressure for all patients estimated by SphygmoCor® was 3.46 mmHg less than that measured by catheter. (Table 2).

As shown in Fig 1 & 2, Bland and Altman analysis between the non-invasive CAP and invasive CAP systolic and diastolic measurements showed good agreement between the two methods (Bias: 95% limits of agreement).

In order to assess the correlation between the non-invasive and invasive measurements of systolic, diastolic blood pressures and pulse pressures, Pearson correlation was done and results showed significant correlation between the non-invasive and invasive measurements of systolic and diastolic blood pressures and pulse pressure (r= 0.74, 0.74, and 0.70, p<0.0001) respectively.

**DISCUSSION**

The invasive measurement of CAP is the gold standard method, because of its invasive nature, it is generally reserved for critically ill patients where rapid variations in blood pressure are anticipated [9]. But, as CAP has been shown to be surrogate marker for CAD, and studies have shown that measuring central pressure is important for detecting elevated risk for cardiovascular events such as heart attack and stroke and in assessing the effects of anti-hypertensive therapy. Therefore, non-invasive CAP measurement may play a major role in predicting the risk for CAD.

In this study, there was agreement between the CAP estimated with SphygmoCor® and by cardiac catheter. We observed that non-invasive CAP measured by SphygmoCor® underestimated catheter-measured central systolic pressure by 4.9 mmHg and diastolic pressure by 1.5 mmHg.

In a similar study done by Takazawa et al., non-invasive method for measuring CAP was found to underestimate systolic CAP by 11 mmHg and overestimated diastolic CAP by

8 mmHg [10].

In another study done, SphygmoCor®, underestimated systolic CAP by 13.3 mmHg and overestimated diastolic pressure by 11.5 mmHg measured by catheter [11].

In our study, the pulse pressure estimated by SphygmoCor® was 3.46 mmHg lower than that measured by catheter. Earlier studies had shown greater differences of estimated pulse pressures (24.8 mmHg and 20.0 mmHg) by SphygmoCor® than that were measured by catheter [11,12]

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In the present study, the non- invasive values were recorded prior to catheter measurement of CAP and were compared with the data of catheter measurement. The analysis showed good correlation between the non-invasive and invasive measurements of systolic and diastolic blood pressures and pulse pressure, which were shown to be 0.74, 0.74, and 0.70 (P<0.0001) respectively. In a study by Li Wei – Wei et al, the correlation coefficients for systolic BP, diastolic BP, and pulse pressure between catheter measurements and SphygmoCor® estimations were reported to be 0.84, 0.60, and 0.82 (P<0.001), respectively [12]

**CONCLUSION**

Our study demonstrated the applicability of non-invasive measurements of CAP using SphygmoCor® and showed strong correlation with CAP measured with invasive catheterization method. However, the utility of non-invasive measurement of CAP by SphygmoCor® in clinical settings needs to be verified in studies with large sample size.

**Table legends**

Table I Demographic characteristics of patients

Characteristics	n (%)
Male, Female	36, 14
Age (years)	52.06 ± 7.15
Body mass index (Kg/m <sup>2</sup> )	25.04 ± 3.62

Table II Non-invasive and invasive central aortic pressure

Parameter (mmHg)	SphygmoCor®	Catheter	Difference
Systolic blood pressure	116.1 ± 15.18	121.04 ± 16.6	4.9
Diastolic blood pressure	76.66 ± 9.32	78.14 ± 7.58	1.5
Pulse pressure	39.44 ± 10.29	42.9 ± 14.03	3.46

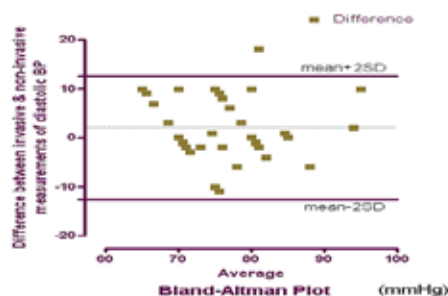
**Figure legends**

Fig 1 Bland-Altman plot showing difference values of invasive catheter versus non-

invasive Sphygmocor measurements of systolic central aortic pressures

Fig 2: Bland-Altman plot showing difference values of Invasive catheter versus non-

invasive Sphygmocor measurements of diastolic central aortic pressures



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