Evaluate the Relationship between Coronary Artery Calcification (CAC) and Arterial Compliance

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Abstract

The objective of this article is to evaluate the relationship between coronary artery calcification (CAC) and arterial compliance for patients with different calcification scores.

Sixty one patients under went coronary artery calcification examination were recurred for this study. Patients were divided into three groups: low-score (0~11), mid-score (11~100) and high-score (101~), according to their CAC score. Two measurements of arterial compliance from the continuous blood pressure waveforms were examined, the time constant during diastolic and the ration of area during systolic and diastolic.

The results indicate that when comparing compliances estimated by diastolic time constant according to their CAC scores, there are significant different between low-score and mid-score (p < 0.05) and between low-score and high-score (p < 0.05). On the other hand, no significant different was found between these three groups when comparing compliances estimated by area method.

However, due to the uneven distribution of patients, more patients with high CAC score will be needed to generate more reliable results.

1. Introduction

Coronary artery calcification (CAC) examination using CT scan is a fast and convenient method for CAD screening. However, it is not suitable for long term tracking due to its high cost and radiation. This study hypothesizes that the higher the CAC score, the stiffer the coronary and systemic arteries are. On the other hand, the arterial compliance is a good indicator of arterial stiffness and can be assessed using the diastolic pressure decay time from the blood pressure waveform. This exponential decay curve during diastolic period represents large artery compliance, sometimes referred to as C_1 [1].

In a non-clinical environment, it is not possible to obtain continuous blood pressure invasively. The two commonly used noninvasive blood pressure monitoring method, the oscillometric and the syphygmomanometer methods, can only provide systolic and diastolic pressure readings.

Penaz proposed the unloading plethysomography technique to monitor the blood pressure waveform in the human finger [2]. However, this technique requires applying cuff pressure that is higher than diastolic pressure that makes long-term monitoring uncomfortable.

The author developed a non-invasive blood pressure waveform monitoring technique that uses dynamic feedback to maintain constant low cuff pressure. A two-cuff system using the proposed method is constructed (Figure 1) [3]. The system is capable of observing blood pressure waveform non-invasively for long period of time. In turn, the exponential decay time during diastolic period can be obtained from these non-invasive blood pressure waveforms.

Figure 1. The continuous blood pressure measurement system.

2. Methods

Sixty patients under went coronary artery calcification examination, using 64 slices CT scan in the Cheng-Hsin Rehabilitation and Medical Center, were recurred for this study. Patients were divided into three groups: low-score (0~11), mid-score (11~100) and high-score (101~), according to their CAC score. After a short orientation, and informed consent, continuous blood pressure measurement was conducted for five minutes (Figure2) using the above mentioned device from Chung-Yuan Christian University. The blood pressure waveforms were digitized with 1000Hz sampling rate and stored in a personal computer.

This study developed a Matlab graphical user interface analysis program. During the off-line signal processing phase, first, the program displayed waveforms on the computer screen for visual inspection. The operator selected at least 10 continuous beats of blood pressure waveforms from the five minutes recording (Figure 3). After selection, the program detected the local minima that correspond to the diastolic pressure in each heart beat. A straight line, representing the baseline of pressure waveform, was established using linear interpolation between two adjacent diastolic pressures. The baseline drift was removed from the selected waveform by subtracting the established straight line from the pressure waveform, before the estimation of compliance (Figure 4). The arterial compliance was estimated as the time constant during diastolic for each heart beat (Figure 5). Averaged compliances of each subject were used in the following statistic analysis.

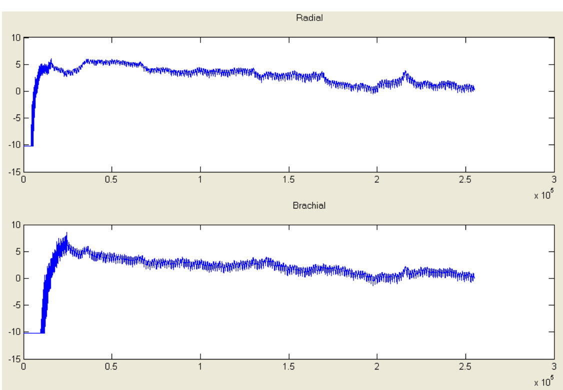

Figure 2. Five minutes recording of continuous blood pressure waveforms measured by the continuous blood pressure measurement system.

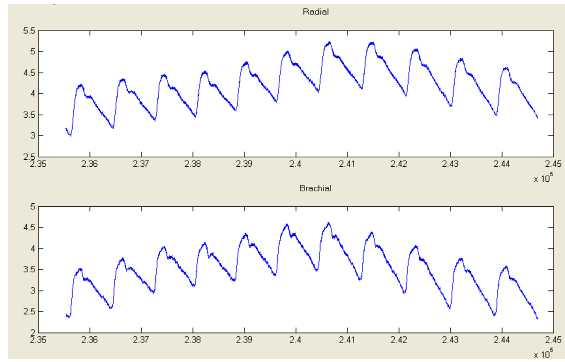

Figure 3. After visual inspection, the operator selects 10 continuous beats of blood pressure waveforms from the five minutes recording.

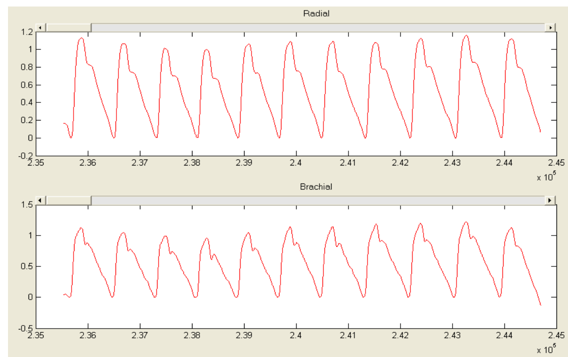

Figure 4. The baseline drift was removed from the selected waveform by subtracting the established straight line from the pressure waveform, before the estimation of compliance.

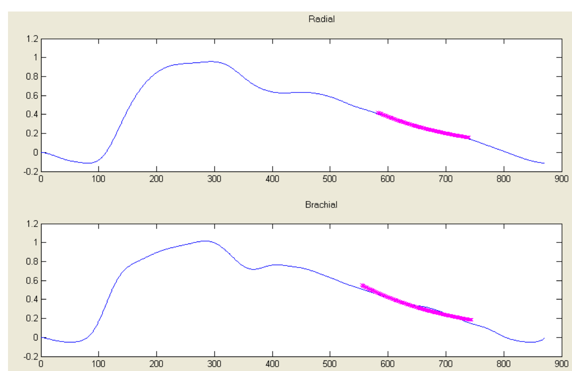

Figure 5. The arterial compliance was estimated as the time constant during diastolic for each heart beat

3. Results

Table one illustrates the baseline characteristics and time constants of the 60 subjects. First of all, the distribution of patient groups is uneven. There are 30 low-score patients and the patient numbers for mid-score and high-score are 17 and 13, respectively. The highest CAC score amount the 60 subjects is 646. For the estimation of compliance, at least 10 continuous blood pressure waveforms were selected from each subject to obtain the compliance parameters.

The results of paired t-test indicate that when comparing compliances estimated by diastolic time constant according to their CAC scores, there are significant different between low-score and mid-score ($p < 0.05$) and between low-score and high-score ($p < 0.05$). On the other hand, no significant different was found between these three groups when comparing compliances estimated by area method.

4. Discussion and conclusions

Arterial compliance parameters obtained from continuous blood pressure waveform were used to correlate the CAC score with the arterial stiffness. Significant different are found between patients with low CAC score and mid CAC score (11~100) and between low CAC score and high CAC score (101~) patients. However, due to the uneven distribution of patients, more patients with high CAC score will be needed to generate more reliable results.

Acknowledgements

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Table 1. The baseline characteristic and time constant of 60 subjects.

	Low group (n = 30)	Mid group (n = 17)	High group (n = 13)
Age(y)	49.6±6.54	55.9±6.33*	56.8±3.42*
M/F	8/22	10/7	9/4
Mean CAC	0.17±0.75	56.6±16.2	361±181.2
Systolic BP(mmHg)	120.9±13.94	128.8±11.27	125.2±13.89
Diastolic BP(mmHg)	83±9.96	86.1±10.2	81.2±9.44
time constant (atu)	-0.00435	-0.00464	-0.0048
	±0.000348	±0.000338*	±0.000689*