Mean Arterial Pressure Estimation Method Using Morphological Changes in Oscillometric Waveform

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Abstract

Oscillometric method is the method for the blood pressure measurement using mean arterial pressure (MAP). In the conventional method, the cuff pressure at the largest pulse is determined as MAP. However, it is difficult to find the largest oscillometric pulse from patients who have the cardiovascular disease or the elder subjects. Therefore, we studied a new method to determine the MAP by analyzing the changes of the morphology of oscillometric pulse different from above method.

The new method was applied to the cuff pressure recorded by 11 healthy subjects. Two observers trained by BHS program measured the blood pressure using the auscultatory method to determine the reference MAP.

The mean difference and standard deviation of the MAP determined by the algorithm proposed by this study were 1.45mmHg and 3.47mmHg respectively.

1. Introduction

The estimating method of MAP (Mean Arterial Pressure) has used the magnitude of ocillometric pulses in conventional oscillometric method. When the pressure of cuff is decompressed, the magnitude of oscillometric pulse is usually increased gradually and its peak is shown nearby the MAP point. After this point, the magnitude is shown decreased trend. But this trend is not always shown. For example, as shown in figure 1, oscillometric waveform is shown the flat trend like a trapezoid in some subjects' cases that have cardiovascular disease or ages are high. In these cases, the estimation of MAP is difficult because it is hard to find the maximum magnitude oscillometric pulse. To solve this problem, we designed the new method of estimating MAP through the only morphology changing of pulse without information of magnitude.

2. Methods

2.1. Measuring methods

11 healthy males of twenties were participated to obtain the cuff pressure data. Cuff pressure data was recorded by digital recording system of spygmomanometry which developed by Department of Biomedical Engineering in Hanyang University [1]. And two observers who were trained by British hypertension society (BHS) program measured the SBP and the DBP through the auscaltatory method as a reference. After averaged the measured two SBPs and DBPs, the reference MAP were calculated by the equation 1/3 SBP + 2/3 DBP, and compared with the MAP that were acquired by our new method.

2.2. MAP detecting algorithm

When the pressure of brachial cuff is start to decompress, as shown in figure 2, the morphology of primary oscillometric pulse shows the flat slope from peak to end point of each pulse. However, the cuff pressure is lower gradually, the slope is steeper, and eventually the part of flat slope disappeared. For detecting this point, we normalized the amplitudes and

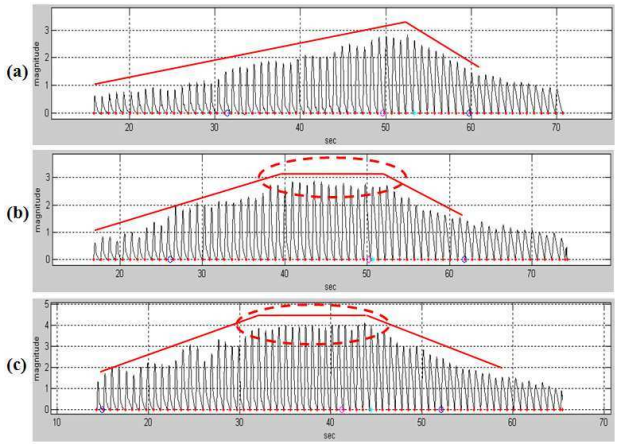

Figure 1. Oscillometric waveforms. Normal subject (a) and hypertension subject (b), and 64 years old subject(c).

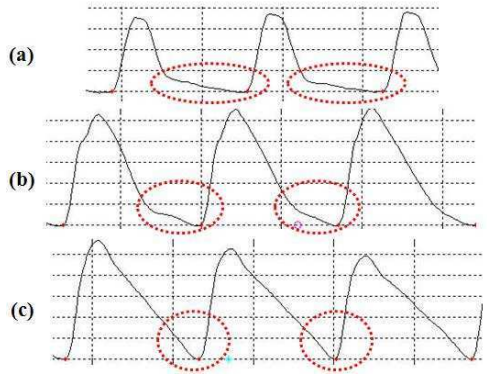

Figure 2. The slope trends from the peak to the end point of each oscillometric pulse.

width of whole pulses, and drew the straight line from peak to end point of each pulse like figure 3. And then we calculated the area between the straight line and the pulse at each pulse. Through this process, we found that the area was rapidly decreased when the part of flat slope was disappeared like figure 4. Finally we were defined this point as a new MAP, then this acquired MAP was compared with the reference MAP for validation.

3. Results

Table 1 shows that the result of comparison between two MAPs, one is the measured MAP by the new algorithm, the other is the calculated MAP by the blood pressure values measured by auscultatory method. The mean difference and standard deviation is 1.45mmHg and 3.47mmHg respectively.

4. Discussion and conclusions

The result that had 1.45mmHg and 3.47mmHg as a mean difference and standard deviation respectively showed high accuracy. This method is less influenced by pulse magnitude's trend than conventional oscillometric method because it considers the only pulse morphology without the amplitude information. Even though we

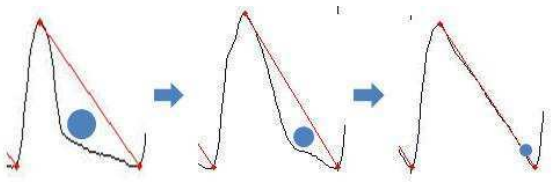

Figure 3. The area between the straight line and the pulse in each pulse is decreasing gradually.

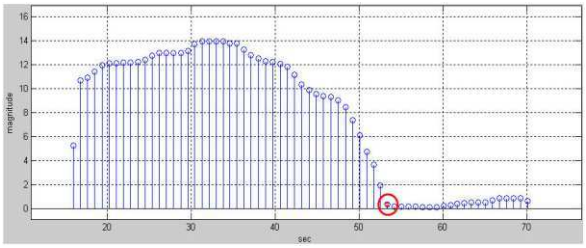

Figure 4. The example of area between the oscillometric waveform and the straight lines. The stem graph is meaning that the area of each pulses.

didn't mention about another result in this study, this method showed the high accuracy better than the result of MAP which was determined by the largest oscillometric pulse using conventional oscillometric method. Recently, there are many researchers who doubts on the accuracy of the result of MAP calculated by one-third equation [2-3]. In fact, the ratio of MAP between SBP and DBP differs individually [4]. Therefore, much reliance about the MAP which calculated by one – third equation is good to avoid. But it is difficult to find the accurate method of estimating the MAP in non-invasive method without invasive method. Therefore, it is the most meaningful

Table 1. The result of comparison between calculated MAP and measured MAP. Calculated MAP is calculated by the one – third equation and measured MAP is measured by this algorithm. All of unit is mmHg.

Subject	SBP	DBP	Calculated MAP	Measured MAP	difference
01	110	64	79	84	-5
02	108	66	80	82	-2
03	108	75	86	86	0
04	122	78	93	89	4
05	120	74	89	88	1
06	115	69	84	80	4
07	112	79	90	91	-1
08	110	79	89	87	2
09	110	78	89	86	3
10	112	68	83	81	2
11	116	70	85	77	8

value that is calculated by one-third equation among traditional and other MAP estimating method that were introduced in many physiology books. In oscillometric method, one of the most important works is to find the MAP. The proposed method is to provide the easy and the correct way for finding the MAP and blood pressure in oscillometric method. Hence, the study will be progressed for increasing the accuracy of MAP estimation using the invasive method as a standard factor.

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