An Auscultatory Recording Method for Blood Pressure Measurement during Exercise

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Summary For inspective determination of blood pressure at rest and during exercise, simultaneous recordings of cuff pressure, Korotkov's sounds, and ECG by an electromagnetic oscillograph were necessary. We devised an apparatus in line with the requirement. Results obtained using this apparatus demonstrate that the auscultatory recording method is suitable to determine the blood pressure during submaximal bicycle exercise.

Key words: blood pressure, exercise, Korotkov's sound.
Sphygmomanometer

Cuff Pressure

Amp

Korotkov's Sound

Amp

ECG

Amp

Data Recorder

Electromagnetic Oscillograph

Artificial Signal

Fig. 1. An apparatus for measuring blood pressure by auscultatory recording method. 
1, pressure transducer; 2, microphone; 3, microswitch (see text for details).

enclosed in a glass tube connected to a sphygmomanometer with rubber tubes. ECG was determined through a bipolar lead, whose electrodes were placed on chest (left and right V5). A microphone normally utilized for phonocardiogram recording was placed on the left antecubital artery, and used to determine Korotkov's sounds of the blood vessel. All of the parameters mentioned above were recorded by an electromagnetic oscillograph (visigraph, NEC-San-ei Co., Ltd.) and by a data recorder (A-44, SONY). The filter used for the phonocardiogram was a high pass filter and that for the oscillograph was a low pass filter, whose cut-off frequencies were 10 and 500 Hz, respectively. The output of the pressure transducer was amplified by a strain amplifier (DPM-310B, Kyowa Electric Co., Ltd.) and calibrated against reading of the sphygmomanometer. There was a linear relation between the output of pressure transducer and height of mercury of the manometer (data not shown). The regression line calculated by the least squares method was proved to pass the origin of the coordinate. Actual reading of the sphygmomanometer did not deviate more than 1 mm from the regression line. In addition to the recordings mentioned above, we added artificial signals on the strip chart by a microswitch. The signals indicated time points approximately corresponding to 10 mmHg decrements in sphygmomanometer readings and were useful for giving us values of the BP's in real time, leading to safe performance of the experiment.

Examples of recordings of cuff pressure, ECG, and Korotkov’s sounds at rest and during exercise are shown in Fig. 2A and B. Although many noises were recorded together with Korotkov’s sounds, we could clearly discriminate Korotkov’s sounds from the noises in most cases because, (1) signals of Korotkov’s sounds have far larger amplitudes than those of noises and (2) Korotkov’s sounds appear close to the peaks of T waves of ECG. Systolic BP can be determined from recorded cuff pressure curve in accordance with the first appearance of Korotkov’s sounds, while diastolic BP is measured at the time point of the last Korotkov’s sounds.
For a case where Korotkov’s sounds were recorded up to extremely low BP during exercise, diastolic BP was not determined only from the recorded Korotkov’s sounds. However, we could discriminate a transition point from Swan’s IV to V by hearing the sounds with an earphone during later playback from the data recorder. The change in Korotkov’s sounds would be related to the difference of their amplitudes, as shown in Fig. 2B.

We compared values of the BP’s at rest which were measured simultaneously in 7 trials by the two methods, i.e. the traditional auscultatory method and the
auscultatory recording method proposed in the present study. Similarly, the BP's during Valsalva maneuver were also compared in 3 trials. Discrepancy of values of systolic BP determined by the two methods was $-2\pm2$ mmHg and that of diastolic BP was $-2\pm5$ mmHg in both conditions. The difference of 2 mmHg is equivalent to only one scale of the sphygmomanometer and is regarded as an error of reading in the auscultatory method, whereas 5 mmHg may occur due to mishearing of the last or one before the last Korotkov's sound. The results demonstrate that almost similar systolic and diastolic BP values were obtained by both the traditional auscultatory method and the auscultatory recording method.

In the present study, we proposed an auscultatory recording method for inspective determination of BP at rest and during submaximal bicycle exercise.

REFERENCES


