Med. & Biol. Eng. & Comput., 1981, 19, 535–537

Measurement of the blood-pressure constant *k*, over a pressure range in the canine radial artery

M. Voelz

Potter Building, Biomedical Engineering Centre, Purdue University, West Lafayette, Indiana 47907

Abstract—*The value of the blood pressure constant k in the now known equation*

$$M = D+k(S-D)$$

was measured over a wide pressure range in the canine radial artery. This equation is used to estimate the value of the mean blood pressure from the measured values of the diastolic and systolic blood pressures. It was found that k varies widely. It is concluded that this equation cannot give an accurate estimate of the mean blood pressure from the systolic and diastolic pressure readings.

Keywords—*Diastolic blood pressure, Mean blood pressure, Systolic blood pressure*

1 Introduction

IN clinical practice, three arterial pressures, systolic, mean and diastolic, are important in the assessment of cardiovascular dynamics. Systolic blood pressure is the maximum and diastolic is the minimum pressure. Mean blood pressure is the average pressure forcing blood through the arteries. Because the blood pressure pulse is not symmetrical, about the time axis, the mean blood pressure is not the average of the systolic and diastolic pressures. The mean pressure is the area under one blood pressure pulse divided by the period of the same pulse (Fig. 1).

Mean blood pressure can be measured directly with a blood-pressure transducer coupled to an artery. The signal from the transducer can be processed using a long rise time constant which dampens out the pulsations of the signal, yielding the mean blood pressure.

Mean blood pressure can be calculated accurately using the following expression

$$M = 1/T\int_0^T \{P(t)\,dt\}. \qquad (1)$$

where M is the mean blood pressure, T is the period of one pressure pulse, and the integral of $P(t)\,dt$ is the area under the pressure pulse.

When the blood pressure is measured indirectly [GEDDES, 1970], it is often estimated using the following expression

$$M = D+k(S-D) \qquad (2)$$

where M is the mean blood pressure, S and D are the systolic and diastolic blood pressures, respectively, and k is a constant with values ranging from 1/2 to 1/4, depending on the site of measurement. In reality, k represents the fraction of the pulse pressure waveform above diastolic that identifies mean pressure.

If the pulse waveform was a sinewave, the mean value of the pressure pulse would be half way between the peak and the trough of the waveform (Fig. 2). Because the blood pressure waveform is broad at the base and narrow at the top, the mean pressure is

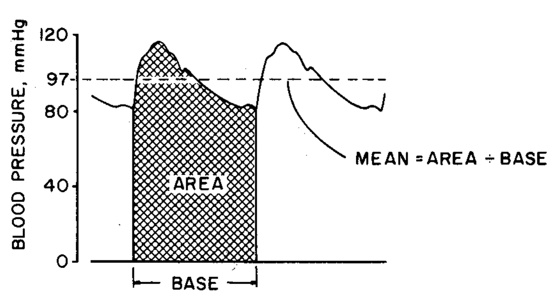

Fig. 1 *Mean blood pressure is not the average of the systolic and diastolic blood pressure; it is the area under one blood pressure pulse divided by the base or the period of the pulse*

First received 22nd August and in final form 4th November 1980
0140–0118/050535+03 $01·50/0

expected to be below half way between the peak and the trough of the pulse wave. If the pressure wave becomes more peaked, the mean pressure value moves toward diastolic pressure.

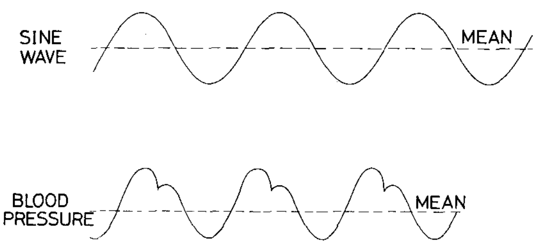

Fig. 2 *The mean of a sinewave is the average of the peak and the trough of the waveform. The mean of a blood pressure pulse is less than the average of the waveform peak and trough because of the asymmetry of the waveform.*

To date there is very little information on typical values of k. This report presents the values for k measured over a wide pressure range in the canine radial artery.

2 Methods and materials

Ten dogs, ranging in weight from 12 to 32 kg, were anaesthetised with sodium pentobarbital. The right radial artery was cannulated, with a stiff-walled catheter, and the blood pressure was recorded using a Microswitch blood pressure transducer (Microswitch, Model experimental) which had a uniform frequency response extending from 0 to 150 Hz when coupled to a 0·58 mm internal diameter catheter, 152 mm long. Hypertensive episodes were induced by the controlled intravenous administration of Levarterenol Bitartrate (8 μg per ml). Hypotensive episodes were induced by the controlled intravenous administration of sodium nitroprusside (100 μg per ml). To avoid the formation of a blood clot in the arterial cannula, heparin (2 mg per kg) was administered intravenously. The mean pressure ranged from 37 to 185 mm Hg.

Direct pulsatile arterial blood pressure was recorded simultaneously with the mean pressure obtained by processing the pulse pressure signal through a parallel resistive-capacitive circuit with a rise time constant of 825 ms. The reading on the mean pressure channel was verified by measuring the area under the blood pressure pulse recorded on a high-speed record.

Blood pressure measurements were made only when the blood pressure was stable. From the recorded systolic, diastolic, and mean pressure values, k was calculated using eqn. 2.

3 Results

Fig. 3 depicts the relationship between the diastolic blood pressure and k for a typical dog. This graph shows a scattered relationship, which is better visualised by combining the data from all ten dogs as shown in Fig. 4. The mean value of k for the entire pressure range is 0·310 with a standard deviation of 0·093.

It is important to note that the value of k varies widely throughout the pressure. In addition, the data points are fairly uniformly distributed around a mean value throughout the blood pressure range. This suggests that the value of k is not unique, even at the same pressure in the same artery.

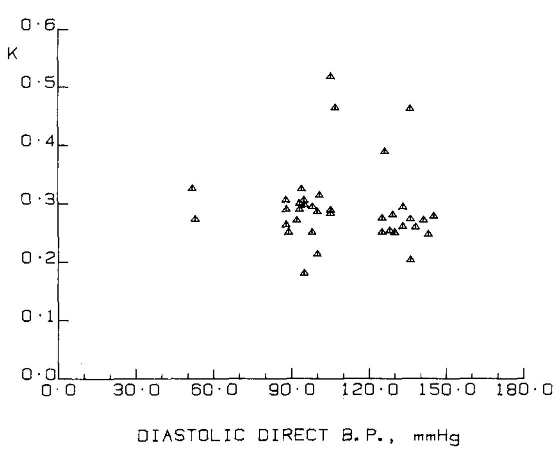

Fig. 3 *The value for the blood pressure constant k, for one typical dog, varies as the blood pressure changes and is varied at the same pressure*

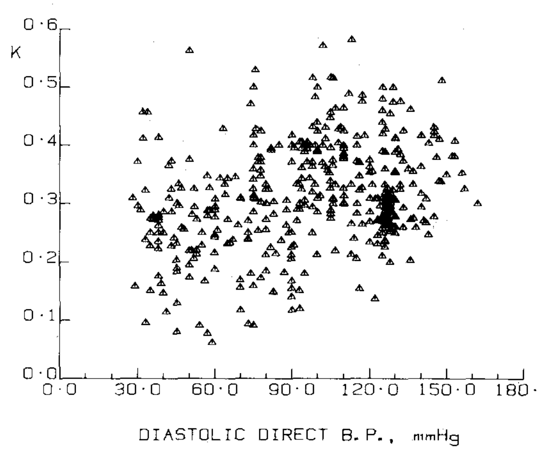

Fig. 4 *The large variation in the value of k is independent of the pressure over the range measured. This data is taken from all ten dogs using the same measurement site in the radial artery. The mean value of k is 0·31 with a standard deviation of 0·093 over the entire pressure range*

Fig. 5 presents the mean values of k plus and minus one standard deviation for pressure classes 20 mm Hg wide throughout the pressure range. Note that the value of k is not unique over the pressure range.

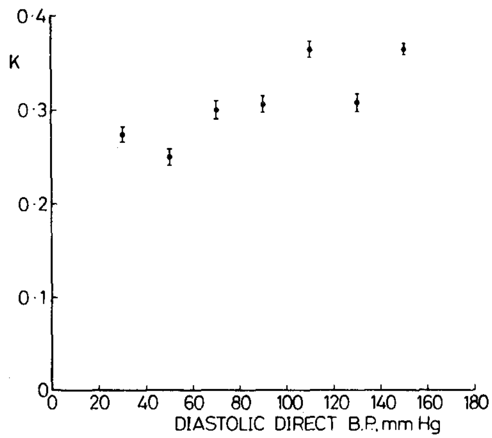

Fig. 5 *The data from ten dogs were separated into pressure classes 20 mm Hg wide and the mean and standard deviation of each class is shown. The circles are the mean of each pressure class and the vertical lines are plus and minus one standard deviation of each pressure class*

4 Summary

In the dog radial artery, the value for k was measured over a wide blood pressure range. It was found that k does not have a unique value at each pressure. Therefore, it is not possible to obtain an accurate value for the mean blood pressure using the systolic and diastolic pressures and selecting a single value for k.

Acknowledgments—The research was supported by grant HL18947-03 from the US National Heart Lung and Blood Institute, Bethesda, MD. Special thanks are due to Dr. L. A. Geddes, Director of the Biomedical Engineering Centre and to Debra Reiner, Brad Addison, and Connie Combs, undergraduate research assistants.

Reference

GEDDES, L. A. (1970) In *The direct and indirect measurement of blood pressure.* p 70. Year Book Medical Publishers, Inc., Chicago.