INDIRECT ANKLE, BRACHIAL AND DIRECT INTRA-ARTERIAL BLOOD PRESSURE MEASUREMENTS

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SYNOPSIS

The purpose of this study was to compare the accuracy of indirect ankle and brachial blood pressure measurements in a group of neurosurgical patients. Intra-radial cannulation was used for direct arterial pressure measurement. The correlations of the systolic and diastolic pressure between the indirect ankle and direct intra-arterial blood pressure was good. The coefficient of correlation for systolic and diastolic pressure were 0.95 and 0.81 respectively. The correlation between the indirect brachial blood pressure and direct intra-arterial blood pressure was also good. The coefficient of correlation for systolic and diastolic pressures were 0.94 and 0.87 respectively. It was concluded that the indirect ankle blood pressure measurement was a good method of assessing the blood pressures and should be used when the upper limb measurements were not possible.

INTRODUCTION

In clinical practice, the commonest method of measuring blood pressure is by means of auscultation using a sphynomanometer at the upper limbs. However, there are occasions when this is not possible. Such situations are encountered in patients with bilateral upper limb injuries or bilateral extensive burns of the upper limbs. It is usually difficult to take the brachial blood pressure in surgical patients when the operations are carried out around the head, neck and shoulder regions. Intra-arterial blood pressure monitoring is invasive, technically more difficult and requires more sophisticated equipments. When it is not possible to use the upper limbs or when direct arterial blood pressure monitoring is not warranted, the lower limbs become the alternative site for blood pressure assessment. The purpose of the study is to evaluate the accuracy of ankle blood pressure measurement in relation to indirect brachial blood pressure and direct intra-arterial blood pressure monitoring.

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MATERIAL AND METHODS

This study was conducted over a 2 month period in the Neurosurgical Theatre of Tan Tock Seng Hospital. 15 consecutive patients given general anaesthesia by one of the authors (Koay) were included. Patients with known coarctation of aorta or vascular disease of the lower limbs were excluded from the study. There were 10 males and 5 females. Their ages ranged from 15 years to 84 years with a mean of 45 years.

All the patients had continuous intra-arterial blood pressure monitoring indicated for the neurosurgical procedure. Cannulation of the radial artery was done by means of a gauge 23 or 27 cannula with a 60 inch pressure tubing which was connected to a continuous flush system and a strain gauge transducer. The recording machine used was Physio-Control VSM 1. The machine was zeroed and calibrated. Readings were taken with the transducer at the level of mid-axillary line with the patient in the supine position. The intra-arterial blood pressure was recorded for each brachial and ankle readings.

For brachial BP measurement, the standard cuff (ACCOSON 22 cm long and 14 cm wide) was used for all patients. The cuff bladder was applied at the inner aspect of the arm with its lower margin about 2 cm above the antecubital fossa. Similar cuff was used for ankle blood pressure measurement. The cuff bladder was applied on the medial aspect of the lower limb with its lower border just above the medial malleolus. The brachial artery and dorsalis pedis artery were used for the upper limb and lower limb pressure measurement respectively. The systolic pressure was recorded when the korotkoff sound was first heard and the diastolic pressure was taken when the sound ceased to be tapping in quality.

RESULTS

The results of this study were shown in Tables I and II. The correlation between ankle and intra-arterial blood pressures was shown in Figures 1 and 2. Analysis of the data gave a regression line of $Y_1 = 1.05x_1 - 11$ ($r = 0.95$) when X_1 was the intra-arterial systolic pressure and Y_1 was the ankle systolic pressure. As for diastolic pressure, the regression equation was $Y_2 = 0.64x_2 + 39$ ($r = 0.81$) where X_2 and Y_2 were the intra-arterial and ankle diastolic pressures respectively.

Similary, the correlation between the direct intra-arterial and indirect brachial pressure measurements was shown in Figures 3 and 4. For the systolic pressure, analysis of the data gave the following regression line of $Y_3 = 0.85x_3 + 13.7$ ($r = 0.94$) and X_3 and Y_3 represent the intra-arterial and brachial systolic pressures respectively. The regression equation for the diastolic pressure was $Y_4 = 0.56x_4 + 40$ ($r = 0.87$) where X_4 and Y_4 were the intra-arterial diastolic and brachial diastolic pressure respectively. The coefficient of correlation is denoted by r in each case.

TABLE 1: DIRECT INTRA-ARTERIAL AND INDIRECT ANKLE BLOOD PRESSURE IN STUDIED PATIENTS

Patients	Intra-arterial blood pressure (mm Hg)		Ankle blood pressure (mm Hg)	
	Systolic	Diastolic	Systolic	Diastolic
1	146	86	140	90
2	108	70	120	100
3	117	70	118	90
4	114	79	100	90
5	147	95	130	100
6	150	96	134	100
7	138	90	130	90
8	182	82	180	90
9	158	80	158	90
10	167	80	160	85
11	129	64	125	70
12	114	67	100	85
13	170	102	180	110
14	165	106	170	110
15	105	66	100	80

TABLE II: DIRECT INTRA-ARTERIAL AND INDIRECT BRACHIAL BLOOD PRESSURE IN STUDIED PATIENTS

Patients	Intra-arterial blood pressure (mm Hg)		Brachial blood pressure (mm Hg)	
	Systolic	Diastolic	Systolic	Diastolic
1	146	86	130	90
2	120	84	115	90
3	130	86	120	90
4	90	57	105	70
5	119	68	110	80
6	118	70	120	80
7	150	90	140	85
8	192	87	180	80
9	83	40	80	60
10	144	76	140	90
11	120	63	120	80
12	151	78	160	90
13	130	80	110	80
14	123	85	110	90
15	110	60	110	70

FIGURE 1: THE CORRELATION BETWEEN INTRA-ARTERIAL AND INDIRECT ANKLE SYSTOLIC BLOOD PRESSURES.

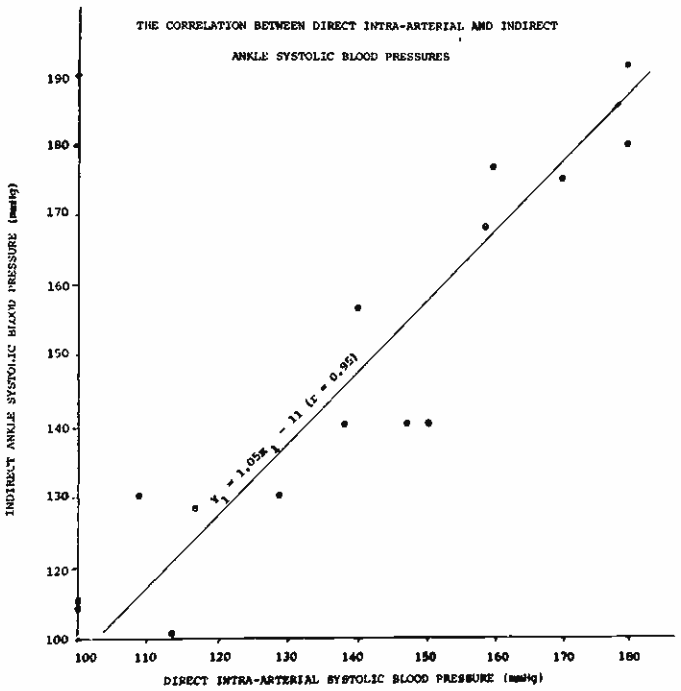


FIGURE 2: THE CORRELATION BETWEEN INTRA-ARTERIAL AND INDIRECT ANKLE DIASTOLIC BLOOD PRESSURES

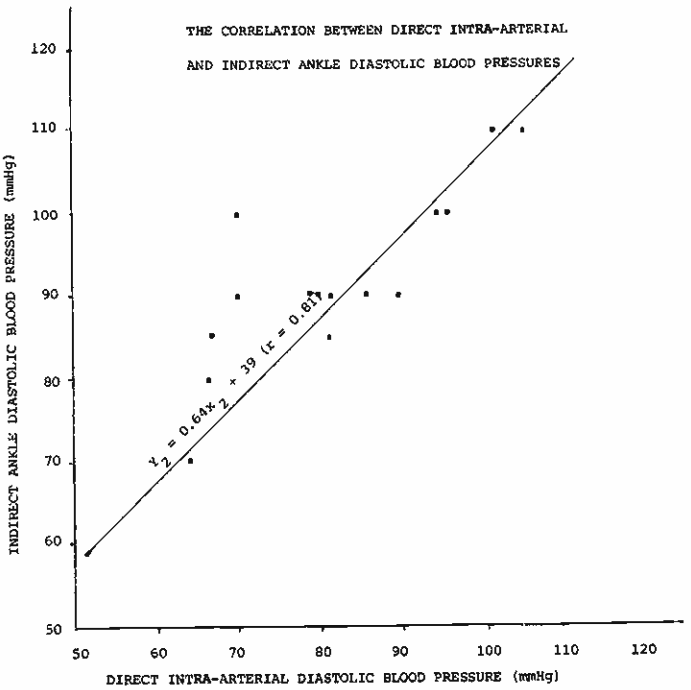


FIGURE 3: THE CORRELATION BETWEEN INTRARTERIAL AND INDIRECT BRACHIAL SYSTOLIC BLOOD PRESSURES.

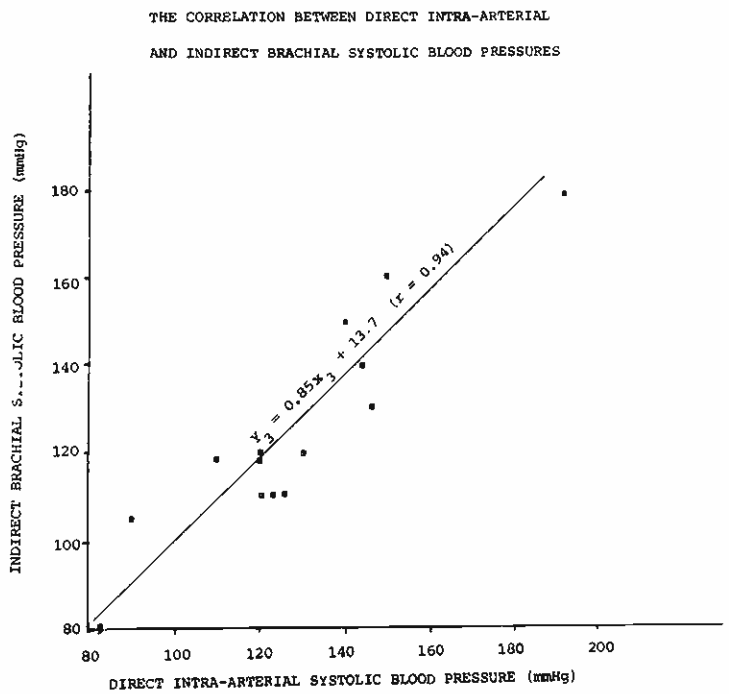
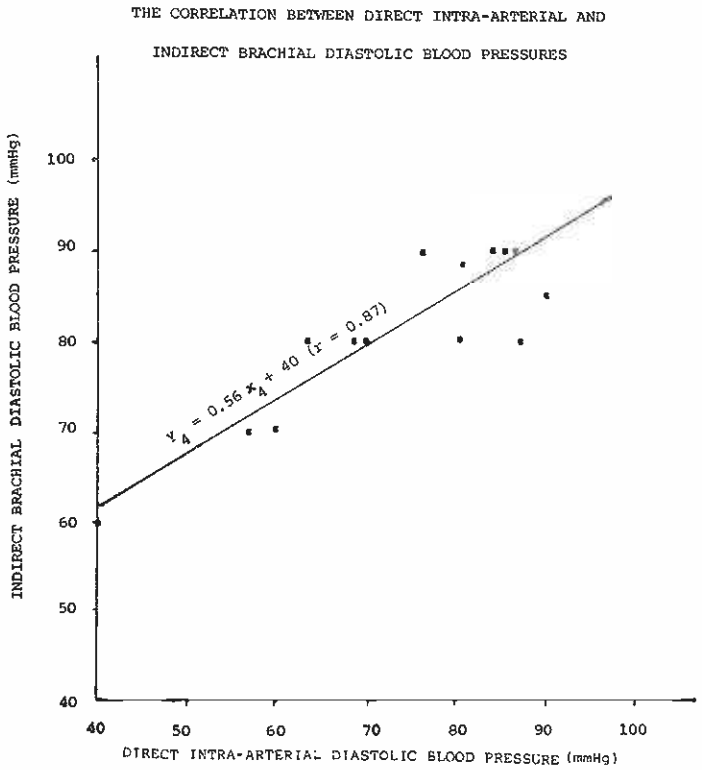


FIGURE 4: THE CORRELATION BETWEEN INTRA-ARTERIAL AND INDIRECT BRACHIAL DIASTOLIC BLOOD PRESSURES.



DISCUSSION

It has been shown by many workers that indirect blood pressure measurements are imprecise and that both systolic and diastolic measurements could be in error by up to +20 and —30 mmHg (1, 2). Observers also differ widely in their estimations of blood pressure. Errors in indirect blood pressure measurements can be due to improper application of cuffs (3). The deflated cuff should be applied with the bladder bag over the area of the limb where the artery runs; ie. over the inner aspect of the upper arm for a brachial blood pressure measurement. Inappropriate cuff size can also give rise to inaccurate measurements. Various recommendations have been made regarding the choice of correct length or width of cuff in relation to the limb length or circumference. The American Heart Association (1967) recommends a cuff width 20 per cent greater than the diameter of the limb on which it is to be used. For children, the association recommends that the cuff should cover two-thirds length of the upper arm. However, recent studies suggest that length of the bladder cuff should completely encircle the limb so that the intra-bladder pressure is transmitted with least decay to the underlying compressible artery (4, 5). Park, Kawabori and Guntheroth suggested that the practice of selecting the cuff size based on the length of the arm should be discontinued and that the standard recommended by the American Heart Association Subcommittee for adults should be adopted for children as well (6, 7).

The different interpretation of korotkoff sounds also gives rise to variation in indirect blood pressure measurement. In this article, the onset of tapping sounds heard through the stethoscope is taken as systolic pressure and cessation of the tapping sound or muffling of the sounds is the sign for end of diastole (Phave IV). Interpretation of phase IV diastolic point is a common cause of difficulty (8).

The same criterias were also used during the indirect blood pressure measurement on the lower limbs.

Blood pressure measurement in the thigh is inconvenient for routine theatre use because a prone position is required and besides that, a much larger cuff is needed.

This study has shown that both indirect brachial and ankle blood pressure measurements correlates well with intra-arterial pressure readings. In fact, both the systolic and diastolic of either the brachial or ankle blood pressure have a coefficient of correlation of more than 0.8 with the respective intra-arterial pressure. It might be due to the fact that in most cases, the circumference of the arm is about the same size as that of the ankle. The dorsalis pedis being a more superficial artery than the brachial artery, its pulsation is then more easily felt in normal circumstances. The disadvantage of taking measurement around the ankle is that under certain circumstances, the pulse becomes unrecordable. Dorsalis pedis artery being a smaller and a more superficial artery than the brachial artery, is more

susceptible to vasocontriction in severe cold, stress or shock.

In conclusion, the ankle blood pressure measurement can serve as an alternative in some situations when the routine method of brachial blood pressure monitoring becomes impossible or inconvenient. It is adequate for following changes in blood pressure in patients who are not in shock or criticaly ill in the theatre.

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