

## ORIGINAL ARTICLE

## Variability of four limb blood pressure in normal neonates

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**Aims:** To assess the variation in blood pressure (BP) between limbs in normal neonates. To assess whether comparison of arm and leg BP in neonates is reproducible enough to allow the difference to raise suspicion of coarctation of the aorta.

**Methods:** Infants recruited from the postnatal wards and the postnatal murmur clinic underwent echocardiography and BP measurement in each limb using a Dinamap Compact T 482210. The method of BP measurement was guided by a telephone survey of 40 UK neonatal units.

**Results:** Forty healthy neonates underwent echocardiography and all had a normal aortic arch. BP was measured in 39. In three, BP in the arms was 20 mm Hg higher than in the legs. This gave a specificity of comparison of the upper and lower limb BPs of 92 (36/39) or a false positive rate of 8% (3/39). The standard deviation in BPs was 15.7 mm Hg between arms, 14.5 mm Hg between legs, and 11 mm Hg when the nearest arm and leg were compared.

**Conclusions:** With current measurement techniques, normal neonates may have a wide variation in BP between limbs. A difference of 20 mm Hg in isolation is more likely to be due to random variability in measurement than to coarctation of the aorta. If coarctation of the aorta is suspected, it can only be excluded or confirmed by echocardiography.

Comparison of upper and lower limb blood pressure (BP) is recommended by standard paediatric cardiology textbooks to aid the clinical diagnosis of coarctation of the aorta (CoA).<sup>1,2</sup> A BP 20 mm Hg higher in the arms than in the legs in neonates with CoA or interrupted aortic arch is widely reported, although there is concern about the possibility of false negative testing.<sup>2–4</sup>

Reports of an observed difference between upper and lower limb BP in neonates give conflicting results.<sup>5–11</sup> None of these series has confirmed normal cardiovascular anatomy. The device used for BP measurement as well as the number of times the BP is measured in each limb varies between studies. To our knowledge, there are no specific guidelines on measuring BP in all four limbs in neonates in whom CoA is suspected.

From the available data, it is not clear whether the difference between arm and leg BP readings can be used in assessment of suspected coarctation. We set out to establish the specificity of this test in neonates with a normal aortic arch and a closed duct using a method commonly used in UK neonatal units.

## METHODS

### Subjects

Babies were recruited from the postnatal wards. They included babies with or without a murmur at the postnatal examination and babies undergoing echocardiography for a family history of congenital heart disease.

### Procedure

Babies underwent cross sectional echocardiography (conducted by MAH). BP was then measured in all four limbs using a Dinamap XL 9300 automated oscillometric machine. The largest standard cuff that fitted the upper arm or calf was used (if necessary changing the cuff size between arm and leg readings). Each infant was settled and kept still while a single reading in each limb was taken. Limb order was random. The measurements were performed in a quiet room with no disturbance except a feed if this was required to settle the infant. A positive test was defined as a difference of

more than 20 mm Hg between the nearest arm BP and the nearest leg BP. The device used and the number of times the BP was taken was guided by our telephone survey. BP was then measured in some babies in all limbs using a Doppler device with the same size cuff as the oscillometric readings. Repeating the BP measurements in this manner was discontinued because the time taken to measure the BP eight times in a completely settled baby proved too long for some parents.

### Telephone survey

A telephone survey of 40 UK neonatal intensive care units with four or more intensive care cots was carried out. The senior nurse on duty was asked whether he/she could recall, in the previous six months, BP being measured in all four limbs because of suspicion of congenital heart disease. Those who could recall the investigation being carried out were asked how many times BP would usually be measured in each limb and which device was used.

### Statistical analysis

SPSS for windows version 10.1 was used for the analyses. The Shapiro-Wilk test was used to test distributions, and the Student's *t* test to compare matched pairs.

### Ethics

The Sunderland local research ethics committee approved the study, and written consent was obtained from the parents.

## RESULTS

Forty infants aged 2–21 days were recruited. Echocardiography showed a small ventricular septal defect in one infant. The remainder had normal hearts: the duct was closed and the aortic arch was normal. The femoral pulses were clinically normal in all 39 infants. Oscillometric BP was recorded in four limbs of 38 infants. It was impossible to settle one baby to allow the BP to be measured. Another became unsettled and a reading could not be taken in the

**Abbreviations:** BP, blood pressure; CoA, coarctation of the aorta

right leg. This infant was included in the calculation of specificity as a true negative with the reading from the leg being within 20 mm Hg of that in the arms.

Three of 39 babies (8% (95% confidence interval (CI) 2 to 21%) had a difference in BP of 20 mm Hg or more between the upper and lower limbs (table 1). This gives a specificity (for normality) of the test of 92% (95% CI 79 to 98%) or a false positive rate of 8% (95% CI 2 to 21%). Comparing the right arm and right leg only (n = 38), there were six infants with a difference of 20 mm Hg or more between readings (specificity 84% (95% CI 69 to 94%), false positive rate 16% (95% CI 6 to 31%)).

Oscillometric BP in each limb was normally distributed across our series. Table 2 shows the wide variation in BP difference between limbs. Figure 1 illustrates this range of difference between right arm and right leg BP. The scatter is similar whichever two limbs are chosen for comparison. Although, as expected, the differences are less pronounced when the values for the nearest arm and leg are compared, the scatter remains obvious (fig 2). The mean difference between any two limbs was small, with a highest mean difference of 1.5 mm Hg when the left arm and right leg are compared.

BP measurements were repeated in 17 babies using a Doppler device. In 2, the reading in the arms was 20 mm Hg higher than in the legs (specificity 88% (95% CI 64 to 99%), false positive rate 12% (95% CI 1 to 36%)). One of these babies had also had a positive result with the oscillometric device. He was reviewed a week later, at which time his femoral pulses remained normal and he was normotensive in his right arm. There was a wide scatter of differences in Doppler BP when any two limbs were compared and when nearest arm was compared with nearest leg (right arm versus right leg, mean difference 6 mm Hg, range -62 to 80 mm Hg; nearest arm and leg comparison, mean difference 2 mm Hg, range -20 to 37 mm Hg). There was also poor agreement between oscillometric and Doppler values for BP across the 68 comparable measurements (mean difference 2.5 mm Hg, range -103 to 55 mm Hg, standard deviation 25 mm Hg).

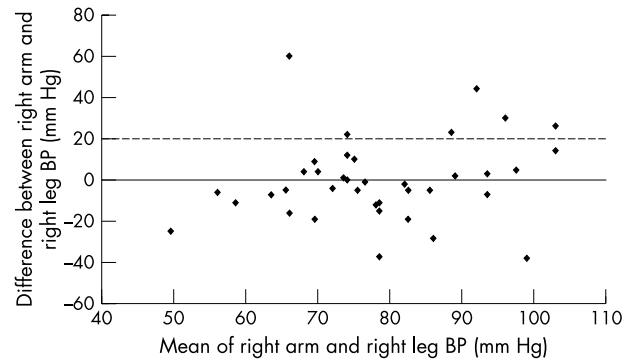
The senior nurse on duty at 39 of 40 units contacted could recall four limb BPs being measured in the preceding six months. Thirty eight used an oscillometric technique (Dinamap or Hewlett-Packard), and the other used a Doppler device. Thirty three measured the BP once in each limb. Two took two measurements in each limb, and recorded the lowest. Two performed three measurements and recorded the median. One performed three measurements and recorded the lowest.

**DISCUSSION**

Measurement of BP in all four limbs is still widely practised in UK neonatal units, with most using oscillometric devices and measuring the BP once in each limb. Guidelines for accurate BP measurement recommend several and repeated readings but do not include recommendations for measurement of BP in four limbs.<sup>12 13</sup> The difference in size between the calf and upper arm will result in falsely raised leg BP if

**Table 1** Systolic blood pressure (mm Hg) in each limb of the three neonates with false positive results

Patient	Right arm	Left arm	Right leg	Left leg
1	111	102	81	81
2	100	105	77	65
3	114	126	70	71

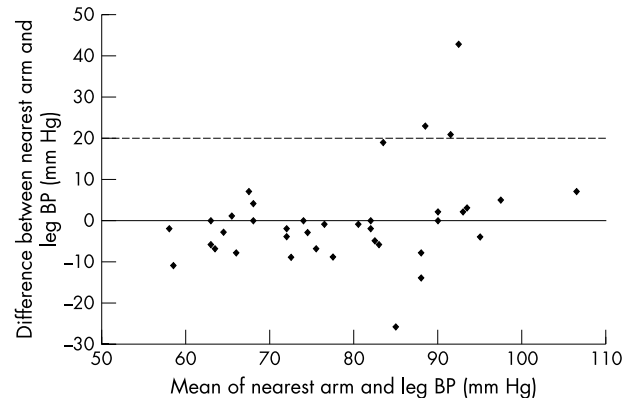


**Figure 1** Comparison of right arm and right leg blood pressure (BP) measurements. The mean of the arm and leg BP is plotted against the difference between the measurements (right arm - right leg).

the same size cuff is used for both. With the need for early diagnosis and treatment for neonates with CoA, repeated measurements over a period of time in an effort to obtain consistent readings is impractical and potentially dangerous.

This is the first study to compare the BP in four limbs in babies in whom Doppler echocardiography confirmed closure of the arterial duct and a normal aortic arch. There is a wide variation in BP between limbs when single readings are taken using oscillometric or Doppler devices. This variation is enough to suggest CoA in a proportion of normal babies. Explanations for the variation in BP readings between limbs include the fact that single BP readings are not sufficiently reproducible or that there is a genuine variation in BP between the limbs. In our series the mean oscillometric difference between any two limbs was 1.5 mm Hg or less making the former of these explanations most likely. The wide variation between oscillometric and Doppler readings is also probably a reflection of comparing only one measurement by each method in each limb.

Comparison of arm and leg BP is not used for routine screening of neonates for CoA although this has been suggested.<sup>14</sup> The prevalence at live birth of CoA is 1 per 4000.<sup>15</sup> With a false positive rate of 8% for the technique, 300 babies would yield a positive result in this test for each true case—that is, conceivably 300 urgent tertiary cardiac opinions for each correct diagnosis. Comparison of arm and leg BP is often suggested as a useful technique for the further investigation of babies in whom a CoA is suspected clinically. Our data suggest that the variation inherent in the measurement of



**Figure 2** Comparison of nearest arm and leg blood pressure (BP) measurements. The mean of the two measurements is plotted against the difference between the measurements (arm - leg). All those with a difference of more than 20 mm Hg are considered positive results.

**Table 2** Comparison of blood pressures (mm Hg) between selected limbs

Limbs compared	Right arm v left arm	Right leg v left leg	Right arm v right leg	Nearest arm and leg
Number compared	39	38	39	38
Mean difference	-1.3	-0.5	0.2	0.03
Standard deviation	15.7	14.5	20.0	11.3
Range of difference	-44 to 45	-38 to 31	-38 to 60	-26 to 43

four limb BP is significant, and, if CoA is suspected, the information gained will not be of sufficient quality to confirm the diagnosis. Others have observed a difference of less than 20 mm Hg between arm and leg BP in infants with CoA.<sup>4</sup> In our opinion, clinical findings, particularly weak or absent femoral pulses, should raise suspicion of CoA sufficiently to prompt referral for specialist assessment, and four limb BP measurement does not help to confirm or exclude CoA.

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