A Standard Protocol for Blood Pressure Measurement in the Newborn

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ABSTRACT. ***Objectives.*** **Improvements in neonatal care have resulted in increasing survival of extremely premature infants whose hospital course often runs into weeks or months. Some interventions during the acute care of these neonates, such as umbilical catheterization and use of steroids, not infrequently result in elevation of blood pressure (BP). It is, therefore, essential that these infants be monitored accurately for possible hypertension during their convalescence. Unfortunately, normative data on BP in this population are scant and comparison of data from various studies is hampered by methodologic differences in design. Studies in adults address the necessity for a restful state, adopting a comfortable position, and attempts to reduce the startle response to initial cuff inflation. Studies in the newborn using the oscillometric technique have not addressed these concerns. A standard BP measurement protocol was studied to determine the effect of ensuring a restful state, startle response to cuff inflation, and infant position on BP in clinically stable low birth weight infants after the first week of life.**

Study Design. **The Dianamap oscillometer was used to measure BP in infants with a birth weight <2500 g between 7 and 42 days postnatal age. Each infant was studied only once when they were clinically stable. BP was measured in two positions, prone and supine, in random order. Infants were studied at least 1½ hours after their last feeding or medical intervention. An appropriate sized cuff was applied to the right upper arm and the infant was positioned according to randomization. The infant was then left undisturbed for at least 15 minutes or until the infant was sleeping or in a quiet awake state. Three successive BP recordings were taken at 2-minute intervals. The infant's position was then reversed and another 15 minutes of quiet time was allowed. Thereafter, a second set of three successive BP recordings were obtained. The most recent routine nursing BP measurement was also recorded. Data were analyzed using analysis of variance and are presented as means and standard errors of the mean.**

Results. **Sixty-four infants were studied. Birth weights ranged from 901 to 2423 g and gestational ages from 26 to 37 weeks. Overall, mean BP was significantly lower in the prone than supine positions (45.7 ± 0.7 vs 47.8 ± 0.8 mm Hg, *P* < .002). In either position, the first measurement was significantly higher than the third (average difference was 3 mm Hg, *P* < .003). In general, the relationships among position and order of measurement were similar for systolic and diastolic BP. Mean BPs obtained by routine nurse measurements were significantly higher than those in either position using our standard protocol (54.4 vs 47.0 or 49.1 mm Hg, *P* < .003). Moreover, the routine nurse measurements varied more widely than did those obtained using the standard protocol. The standard deviation for the routine mean BP measurements by nurses was 11.4 compared with 6.8 and 8.2 for the first measurements in the prone and supine positions, respectively, with the standard protocol. The mean BP measurements made in the supine position (the highest measurements obtained) using the standard protocol were also significantly lower than published values: 57 of 64 measurements were less than the average mean BP for age described by Tan (*J Pediatr*. 1988; 112: 266–270).**

Conclusion. **The statistically significant difference between the prone and supine position and among successive measurements in each position are not clinically relevant. The clinically significant differences between measurements obtained with this standard protocol and routine nursing measurements or published data are the result of ensuring a restful state after cuff application. We believe that measurements thus obtained are more representative of true resting BPs in these infants. We propose that a single measurement obtained after a restful state has been assured after cuff application would be practical for routine newborn care and be more representative of basal BP than that obtained immediately after cuff application. Normative data in convalescing low birth weight infants should be generated using a protocol that emphasizes a rest period after cuff application.** ***Pediatrics*** **1997;99(6). URL: http://www.pediatrics.org/cgi/content/full/99/6/e10;** ***newborn, low birth weight, blood pressure.***

ABBREVIATION. BP, blood pressure.

Blood pressure (BP) monitoring is an important part of neonatal intensive care both for the acutely ill and the convalescing neonate. The most accurate method of measuring BP is by direct intraarterial recordings.[1] However, this method is associated with serious complications related to arterial catheterization[2,3] and the procedure itself may be technically difficult, especially in low birth weight infants. Therefore, direct intraarterial recordings are usually reserved for those infants whose conditions are sufficiently serious to justify arterial catheterization.

Of the noninvasive methods of BP recordings, the oscillometric technique is the most widely accepted method in current use. The oscillometric technique is based on the fact that pulsatile blood flow sets off oscillations in the arterial wall that are transmitted to a cuff placed around the limb.[4] When used correctly, BPs obtained by this method correlate well with

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intraarterial recordings.[4–6] The most common factors that affect the reliability of this technique are cuff size and fit,[7–9] as well as the state of alertness and agitation of the subject.[10,11]

Improvements in neonatal care have resulted in increasing survival of extremely premature infants whose hospital course often runs into weeks or months. Some interventions during the acute care of these neonates, such as umbilical catheterization and use of steroids, not infrequently result in elevation of BP. It is therefore essential that these infants be monitored accurately for possible hypertension during their convalescence.

Unfortunately, normative data on BP in the convalescing preterm newborn are scant[12,13] and comparison of data from various studies is hampered by methodologic differences in design. In most BP studies in adults, the protocol designed for the multiple risk factor intervention trials[14] is the gold standard for BP recording. This protocol addresses the necessity for a restful state, adopting a comfortable position, and attempts to reduce the startle response to initial cuff inflation. Studies in the newborn using the oscillometric technique have not addressed these concerns. Although cuff sizes and position are specified, no attempts are described to ensure a restful state or to reduce the startle effect to cuff inflation. There is no information regarding the effect of position on BP in newborns. We report here a protocol that was designed to standardize the recording of BP in the newborn.

MATERIALS AND METHODS

All newborn infants with a birth weight <2500 g were eligible for the study, if parental consent could be obtained. Infants were enrolled between 7 and 42 days postnatal age. Babies with major congenital anomalies were excluded. Each infant was studied only once during their hospital stay when they were clinically stable. The study was approved by the Institutional Review Board of Sparrow Hospital.

The Dianamap oscillometer (Critikon, Inc) was used to determine systolic, diastolic, and mean BPs. Critikon infant BP cuffs were used (sizes 2 to 4). The smallest cuff size that covered at least two thirds of the right upper arm and encompassed the entire arm was selected. BPs were measured in two positions: prone and supine. The position for the first series of measurements was assigned randomly using a table of random numbers.

One of the investigators (M.U.N.) performed all of the BP measurements using a standardized protocol. Infants were studied at least one and one-half hours following their last feeding or medical intervention. An appropriate sized cuff was applied to the right upper arm and the baby was positioned according to randomization. The baby was then left undisturbed for at least 15 minutes or until the infant was sleeping or in a quiet awake state. Three successive BP recordings were taken at 2-minute intervals. The infant's position was then reversed and another 15 minutes of quiet time was allowed. Thereafter, a second set of three successive BP recordings were obtained.

TABLE 1. Characteristics of Study Sample

	Range	Mean	Standard Deviation
Gestational age, wk	26–37	31.6	2.5
Birth weight, g	901–2423	1652	386
Postnatal age, days	7–41	12.5*	
Body weight, g	937–2537	1750	342

* Median.

TABLE 2. Mean Blood Pressure (mm Hg): Mean ± Standard Error

	Prone	Supine	Routine Nurses'
First measurement	47.0 ± 0.8	49.1 ± 1.0	54.4 ± 1.4
Second measurement	45.6 ± 0.9	48.1 ± 1.0	
Third measurement	44.4 ± 0.7	46.3 ± 0.9	

TABLE 3. Systolic Blood Pressure (mm Hg): Mean ± Standard Error

	Prone	Supine	Routine Nurses'
First measurement	65.2 ± 1.0	66.3 ± 1.1	73.1 ± 1.4
Second measurement	63.2 ± 0.9	65.7 ± 0.8	
Third measurement	62.8 ± 0.9	64.5 ± 0.9	

TABLE 4. Diastolic Blood Pressure (mm Hg): Mean ± Standard Error

	Prone	Supine	Routine Nurses'
First measurement	36.1 ± 0.8	37.9 ± 0.9	41.7 ± 1.3
Second measurement	34.5 ± 0.9	36.2 ± 0.8	
Third measurement	34.6 ± 0.8	35.0 ± 0.8	

Nurses measured BP as part of routine assessment of vital signs. This was usually done just before infant feeding. The nurses employed the same Dianamap oscillometer and the same criteria in selecting cuff size as did the standardized protocol. Only a single reading was obtained. No attempt was made to influence or modify the technique of nurse recordings during the study period.

Using data generated in an earlier pilot study, we determined that a sample size of 40 patients would be sufficient to detect a 5-mm Hg difference in mean BPs between prone and supine positions at the .05 level of significance with 80% power. Mean BP was chosen as the primary variable because it represents the most accurate reading by the oscillometric technique.[4]

Data were analyzed using repeated measures analysis of variance to assess the effect of position and measurement order. Comparisons among the initial measurements made in each position using the standard protocol and the routine measurements by the nurse were made using within subject analysis of variance. In both analyses, if the F value obtained exceeded the critical value for the .05 level, then the least significant difference method was used to test for differences between cells.

RESULTS

Sixty-four infants were studied. There were 36 males and 28 females. The characteristics of the study population are shown in Table 1. Cuff sizes used ranged from 2 to 4.

Table 2 shows the mean BP, our primary outcome variable. Overall, mean BP in the prone position was significantly lower than in the supine position (45.7 vs 47.8 mm Hg, $F = 10.8$, $P < .002$). Also, each successive measurement in prone position was significantly lower than the corresponding one in the supine position. In the prone position, the first measurement was significantly higher than the second and the third. However, the second and third measurements were not different. In the supine position, the first measurement was not significantly different from the second, but was significantly higher than the third.

Table 3 and Table 4 show systolic and diastolic BP, respectively, in the prone and supine position for the first, second, and third measurements. In general, the results mirrored those for mean BP.

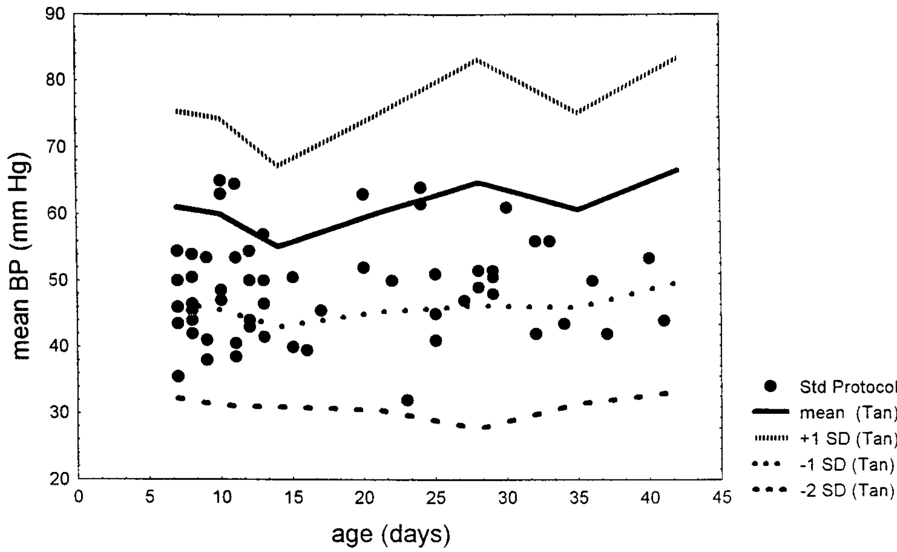

Fig 1. Scatterplot of the first mean blood pressure measured in the supine position using our standard protocol versus the normative data of Tan.[12]

We then compared routine nurse readings with the first readings in prone and supine positions, the highest measurements using our standard protocol. Mean BPs obtained by routine nurse measurements were significantly higher than those in either position using our standard protocol. Moreover, the routine nurse measurements varied more widely than did those obtained using our standard protocol. The standard deviation for the routine mean BP measurements by nurses was 11.4 compared with 6.8 and 8.2 for the first measurements in the prone and supine positions, respectively, with our standard protocol.

We then compared our results with those published by Tan,[12] who used the Dianamap oscillometer to study BPs in low birth weight infants in the first 10 weeks of life. Tan studied infants with birth weights <1500 g, whereas we included babies with birth weights of <2500 g (range, 901 to 2423 g). The mean birth weight in our study was 1652 ± 386 g, compared with 1221 ± 171 g in Tan's study. Figure 1 shows a scattergram of the first mean BP readings in the supine position by our standard protocol (the highest measurement we obtained) compared with data of Tan.[12]

DISCUSSION

Our data indicate that BP measurements using our protocol were significantly lower than those recorded as part of routine nursing care and lower than those previously reported by Tan.[12] We believe that these clinically significant differences are the result of assuring a restful state in the subjects after cuff application. Although BPs were lower in the prone position than in supine, this difference was of low magnitude and, therefore, of little clinical relevance. We used the mean BP measurements in the supine position (the highest values using our protocol) in comparing our data with the nurses' readings and published data[12] to underscore the effect of assuring a restful state after cuff application on the newborn infant. Also remarkable is the fact that the infants in our study were of a larger mean birth weight and still had lower BP than did those reported by Tan. Moreover, the variance of measurements obtained using our standard protocol was significantly less than in routine measurements and less than those of Tan.[12]

Our data also confirms earlier reports by Park and Menard[13] that BPs tend to decrease with repeated measurements. The first BP measurements were significantly higher than the second or third, but these differences were of small magnitude. Findings such as this have led some to the suggestion that the average of two or three readings be used for BP measurements in children. However, we believe that these differences, although statistically significant, are not of clinical relevance. We propose that a single measurement obtained after a restful state has been assured after cuff application would be practical for routine newborn care and be more representative of basal BP than that obtained immediately after cuff application. It must also be emphasized that selecting an appropriate-sized cuff remains a key requirement for any indirect method for BP measurement.

In conclusion, we suggest that normative data in convalescing low birth weight infants should be generated using a protocol like this one, which emphasizes a rest period after cuff application. We have demonstrated that this protocol results in lower BPs with less variance. We believe that measurements thus obtained are more representative of true resting BPs in these infants.

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