# Blood pressure values in healthy term newborns at a tertiary health facility in Enugu, Nigeria

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## Abstract

**Background:** Blood pressure (BP) is a reflection of hemodynamic variables. It is an important vital sign and indicator of clinical stability. Accurate measurement of this physiological signal is essential for the optimal management of the ill infant. An increase in the awareness of hypertension among neonates has resulted to increased ability to diagnose neonates with the disease.
**Objectives:** This study aimed to determine BP values in apparently healthy term newborns in the first 48 h of life and evaluate the factors affecting BP at birth.
**Methods:** Three hundred and ten healthy appropriate for gestational age term newborns were consecutively recruited. BP measurements were determined using the oscillometric technique with the neonate supine after an appropriate size cuff was applied on the right arm. The monitor (Dinamap 8100) is switched on while the cuff inflation and deflation is automatically done by the instrument with subsequent display of the BP values on the screen. BP measurements were taken at age 0–24 h and 25–48 h. Their weight was measured with infant's weighing scale, and data analyzed with SPSS version 15.
**Results:** The mean systolic BP (SBP), diastolic and mean arterial BP at 0–24 h were 63.3 ± 5.5 mmHg, 36.8 ± 5.3 mmHg and 46.4 ± 5.2 mmHg respectively. There was a positive correlation between birth weight and SBP at birth. No significant correlation was found between BP and gender, mode of delivery or maternal age.
**Conclusion:** This study provides current normative BP values that can be used in neonatal Intensive Care Unit.

**Key words:** Blood pressure, healthy, newborns, term

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## Introduction

Blood pressure (BP) is a reflection of hemodynamic variables – cardiac output and peripheral vascular resistance. It is an important vital sign and an indicator of clinical stability.[1] In neonatal Intensive Care Unit (NICU), accurate monitoring of these physiological signals (BP, pulse rate, and respiratory rate) is essential for the optimal management of ill infants. BP readings considered to be abnormal have important implications and may form the basis for further investigations of other systems that are associated with alterations in the BP level.[2] Currently, there is an increased awareness of hypertension in modern NICU as a result of increased ability to diagnose neonates with the disease.[3]

Routine BP measurement though a common clinical practice among adult physicians, is not usually observed in the pediatric practice especially in the well newborn. This may be due to the relatively low incidence of hypertension in the pediatric age group.[4] Indirect BP measurement was not routinely done in newborn infants before the development of oscillometric technology.[1] This may be partly because

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of the recommendation that universal screening of BP in neonates was not necessary and partly due to unavailability of appropriate equipment for the measurement of neonatal BP.[5,6] This probably, has led to the paucity of normative data and standard BP values for neonates and infants. Reliable diastolic blood pressure (DBP) recording has been documented only for the Dinamap oscillometric unit.[7] The accuracy of the instrument meets the standard (i.e., mean error of ±5 mmHg and standard deviation of 8 mmHg) proposed by the American National Standard for manual, electronic and automated instrument when compared with intra-arterial BP measurement.[8]

Blood pressure measurement is not only very important in assessing the cardiovascular status of the newborn but is also important in the fetal origin of the cardiovascular and metabolic diseases in adulthood.[9,10] There are genetic and hereditary predispositions to essential hypertension. This makes the early determination of BP in life imperative especially among blacks where hypertension is very common. Sadoh *et al*. found mean systolic BP (SBP), DBP and mean arterial pressure (MAP) of 66.8 ± 7.7, 38.5 ± 6.3 and 47.9 ± 6.3 mmHg, respectively, on day 1. However, this study cannot be used as a reference standard for appropriate for gestational age newborns as it included both small and large for gestational age neonate as well as postterm newborns. The mean of the BP values of these classes of newborns was used to generate the study's percentile chart. It has been documented that birth weight affects neonatal BP. In spite of its importance, however, there is a paucity of data on normative BP in term neonates in our environment. Such data will be very useful to the neonatologist who is faced with either hyper/ or hypotension in a neonate.

The aims of this study therefore are to determine BP values in apparently healthy term newborns within the first 48 h of life, to determine factors affecting BP at birth, to correlate BP with weight and generate percentile of age/sex-specific SBP and DBP.

## Methods

This study was carried out at the University of Nigeria Teaching Hospital, Ituku-ozalla in Enugu, South East of Nigeria. Ethical clearance was obtained from the Ethics Committee of the hospital. Details of the study and extents of involvement of each subject were clearly explained to the mother or both parents as the case may be, and informed consent was obtained before enrolling their baby into the study.

The study was cross-sectional in which 310 healthy newborns in the postnatal ward after physical examination including modified Ballard assessment were consecutively recruited. Included were all births between 37 and 41 completed weeks of gestation as determined by maternal dates and early first trimester ultrasonography, weighing between 2.5 and 4.0 kg. All ill and asphyxiated babies, those whose mothers were on antihypertensive drugs or used illicit drugs or did not consent as well as those who have obvious cardiac or renal malformations were excluded.

Neonatal demographic data recorded included the gestational age, birth weight, mode of delivery, APGAR score at 1 and 5 min, and maternal age. BP measurement was determined using the oscillometric technique (Dinamap 8100). An appropriate size cuff was chosen after the infant's arm circumference was measured at the midpoint of the limb (between olecranon and acromion processes). This was compared with the circumference marked on the cuff to ensure that the ratio of the cuff width to arm circumference is between 0.45 and 0.70.[11] A single BP measurement was determined on each neonate with the neonate in the supine position, either awake and quiet or during sleep, after an appropriate size cuff was applied on the right arm. The newborn was left for 10–15 min after cuff application to ensure quietness. This procedure was adopted from the standard protocol for assessment of BP measurement in newborns.[12,13] The monitor is switched on while the cuff inflation and deflation is automatically done by the instrument with subsequent display of the BP values (systolic, diastolic and MAP) on the screen. If any movement occurred during the measurement, the result was disregarded. Measurements were taken at age 0–24 h and 25–48 h. The infant's weight was measured with the baby naked using an infant's weighing scale (sensitivity − 0.05 kg, Docbel, Braun). In doing it, the baby was placed on the weighing scale, and the weight read off. The scale was checked for zero error before and after each reading.

Data analysis was done with Statistical Package for social sciences (SPSS) version 15 (Johnson and Johnson, Florida, USA). Means were calculated and compared with Student's *t*-test or analysis of variance where applicable. BP measurements (systolic, diastolic, and MAP) were also correlated with birth weight, gender, mode of delivery, and maternal age. Percentile charts were generated for age and sex.

## Results

Three hundred and ten healthy term babies were recruited in the study. This is made up of 182 (58.7%) males and 128 (41.3%) females with M: F ratio of 1.4:1. Three hundred and six subjects were singletons while four subjects were twin deliveries.

Two hundred and thirty-eight (76.8%) babies were delivered through spontaneous vertex delivery (SVD); 69 (22.3%) deliveries were by cesarean section (CS) and 3 (0.9%) by instrumental delivery (vacuum extraction). The majority of the mothers were within 21–30 years of age with mean maternal age being 29.3 ± 4.6 years [Table 1].

The mean SBP, DBP, and MAP for males in the first 24 h of life were 63.3 ± 5.7 mmHg, 36.6 ± 4.2 mmHg and 46.2 ± 5.4 mmHg, respectively. For females, the corresponding values were 63.4 ± 5.1 mmHg, 37.1 ± 4.4 mmHg and 46.6 ± 5.0 mmHg, respectively. There was no significant statistical difference observed between BP readings among males and females ($P = 0.78$, 0.32, 0.51 for SBP, DBP, and MAP, respectively). However, the mean values for all subjects irrespective of gender were 63.3 ± 5.5 mmHg (SBP), 36.8 ± 4.3 mmHg (DBP), and 46.4 ± 5.2 mmHg (MAP) [Table 2].

The mean SBP, DBP, and MAP for males in the second 24 h of life were 65.5 ± 5.5 mmHg, 39.7 ± 4.6 mmHg and 49.6 ± 5.4 mmHg, respectively. In the females, the mean SBP is 65.8 ± 5.0 mmHg, mean DBP is 40.4 ± 5.0 mmHg while the mean MAP is 49.9 ± 5.5 mmHg. There was also no significant statistical difference in BP values between males and females ($P = 0.61$, 0.22, and 0.59, respectively, for SBP, DBP, and MAP). Overall, the mean SBP, DBP, and MAP values for all subjects irrespective of gender were 65.6 ± 5.3 mmHg, 40.0 ± 4.7 mmHg, and 49.7 mmHg, respectively.

Comparing mean SBP, DBP, and MAP between 0–24 h and 25–48 h of life, BP values at 25–48 h were higher than values at 0–24 h. The observed increase in diastolic ($t = 8.84$, $P = 0.00$) and MAP ($t = 7.75$, $P = 0.00$) were statistically significant, although the increase in mean SBP was not significant statistically ($t = 1.65$, $P = 0.10$), [Figure 1].

There is a positive correlation between birth weight and SBP at 0–24 h ($r = 0.37$, $P = 0.00$) and 25–48 h of life ($r = 0.29$, $P = 0.00$), and between birth weight and MAP at 25–48 h ($r = 0.16$, $P = 0.00$). There was no such correlation between DBP and birth weight as shown in Table 3. There was also no statistically significant correlation between maternal age, different modes of delivery, and BP values ($P > 0.05$) [Table 4].

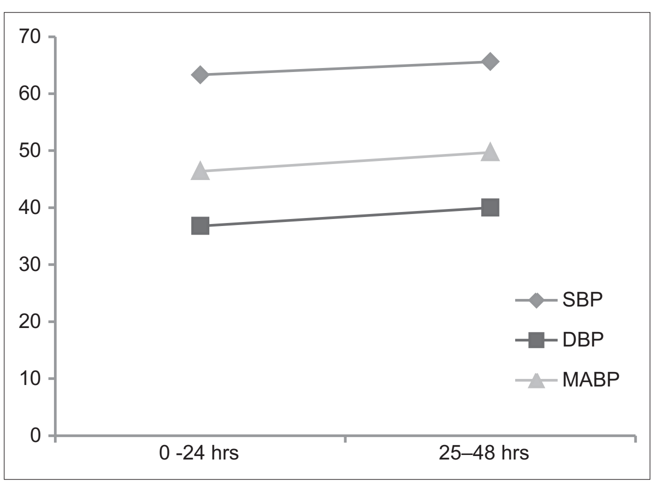


**Figure 1:** Graphic representation of the distribution of the mean systolic blood pressure, diastolic blood pressure, and mean arterial pressure values obtained at 0–24 h and 25–48 h

The 5th, 50th, and 95th percentile of BP values at 0–24 h were: SBP (54, 64, and 72 mmHg), DBP (30, 37, and 44 mmHg), and MAP (38, 46, and 55 mmHg). By 25–48 h, there was a

**Table 1: Distribution of subjects by gender, mode of delivery, and maternal age**

| | Number of subjects (*n*) | Percentage |
|---|---|---|
| Gender | | |
| Male | 182 | 58.7 |
| Female | 128 | 41.3 |
| Mode of delivery | | |
| Spontaneous vertex | 238 | 76.8 |
| Cesarean section | 69 | 22.3 |
| Vacuum extraction | 3 | 0.9 |
| Birth weight | | |
| <3.0 | 63 | 20.3 |
| 3.0-3.5 | 156 | 50.3 |
| >3.5 | 91 | 29.4 |
| Maternal age range | | |
| <20 | 8 | 2.6 |
| 21-30 | 186 | 60.0 |
| 31-40 | 113 | 36.4 |
| 41-50 | 3 | 1.0 |

*Note that lowest weight recorded is 2.5 kg while the largest weight is 4.0 kg

**Table 2: Mean blood pressure at early post natal age by gender**

| | Total (*n*=310) | Males (*n*=182) | Females (*n*=128) | *t* | *P* |
|---|---|---|---|---|---|
| 0-24 h | | | | | |
| SBP | 63.3±5.5 | 63.3±5.7 | 63.4±5.1 | −0.28 | 0.78 |
| DBP | 36.8±4.3 | 36.6±4.2 | 37.1±4.4 | −0.99 | 0.32 |
| MAP | 46.4±5.2 | 46.2±5.4 | 46.6±5.0 | −0.66 | 0.51 |
| 25-48 h | | | | | |
| SBP | 65.6±5.3 | 65.5±5.5 | 65.8±5.0 | −0.51 | 0.61 |
| DBP | 40.0±4.7 | 39.7±4.6 | 40.4±5.0 | −1.22 | 0.22 |
| MAP | 49.7±5.4 | 49.6±5.4 | 49.9±5.5 | −0.55 | 0.58 |

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure

**Table 3: Factors affecting BP**

| | *R* | *P* |
|---|---|---|
| Birth weight versus SBP (0-24 h) | 0.37 | 0.00 |
| Birth weight versus SBP (25-48 h) | 0.29 | 0.00 |
| Birth weight versus DBP (0-24 h) | 0.04 | 0.48 |
| Birth weight versus DBP (25-48 h) | 0.10 | 0.09 |
| Birth weight versus MAP (0-24 h) | 0.10 | 0.07 |
| Birth weight versus MAP (25-48 h) | 0.16 | 0.00 |

*R*=Pearson's correlation coefficient; *P*=Significance level ($P \leq 0.05$). SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure; BP=Blood pressure

**Table 4: Mean BP measures for different modes of delivery and birth weight**

| | 0-24 h (mmHg) | | | *F* | *P* | 25-48 h (mmHg) | | | *F* | *P* |
|---|---|---|---|---|---|---|---|---|---|---|
| | SBP±SD | DBP±SD | MAP±SD | | | SBP±SD | DBP±SD | MAP±SD | | |
| Mode of delivery | | | | | | | | | | |
| SVD (283) | 63.3±5.4 | 36.9±4.3 | 46.5±5.2 | 0.48 | 0.62 | 65.7±5.3 | 40.1±4.7 | 49.8±5.3 | 0.18 | 0.84 |
| ID (3) | 60±9.7 | 37.0±3.6 | 46.3±7.6 | 0.19 | 0.83 | 67.3±7.2 | 40.7±2.1 | 52.7±3.5 | 0.30 | 0.74 |
| CS (69) | 63.5±5.5 | 36.5±4.4 | 46.0±5.5 | 0.33 | 0.72 | 65.5±5.5 | 39.6±5.0 | 49.2±5.8 | 0.83 | 0.44 |
| Birth weight (kg) | | | | | | | | | | |
| <3 | 59.6±5.4 | 35.9±4.9 | 44.6±5.2 | | | 62.4±4.9 | 38.4±4.2 | 47.2±4.9 | | |
| 3.0-3.5 | 63.9±5.2 | 37.2±3.7 | 47.0±4.7 | | | 66.4±4.7 | 40.8±5.0 | 50.5±5.4 | | |
| >3.5 | 64.9±4.8 | 36.6±4.7 | 46.7±5.8 | | | 66.6±5.7 | 39.8±4.4 | 50.1±5.3 | | |

*F*=Analysis of variance; *P*≤0.05; SVD=Spontaneous vertex delivery; ID=Instrumental delivery (vacuum extraction); CS=Cesarean section; BP=Blood pressure; SBP=Systolic blood pressure; SD=Standard deviation; DBP=Diastolic blood pressure

**Table 5: Distribution of abnormal BP values using the cut-off**

| SBP (mmHg) ≥95th percentile | Frequency (*n*) | Percentage |
|---|---|---|
| 0-24 h | | |
| 72 | 11 | 3.5 |
| 73 | 4 | 1.5 |
| 74 | 5 | 1.6 |
| 76 | 1 | 0.3 |
| 78 | 1 | 0.3 |
| 25-48 h | | |
| 4 | 10 | 3.2 |
| 75 | 2 | 0.6 |
| 77 | 1 | 0.3 |
| 78 | 2 | 0.6 |
| 79 | 3 | 1.0 |
| 80 | 1 | 0.3 |
| 83 | 1 | 0.3 |

BP=Blood pressure; SBP=Systolic blood pressure

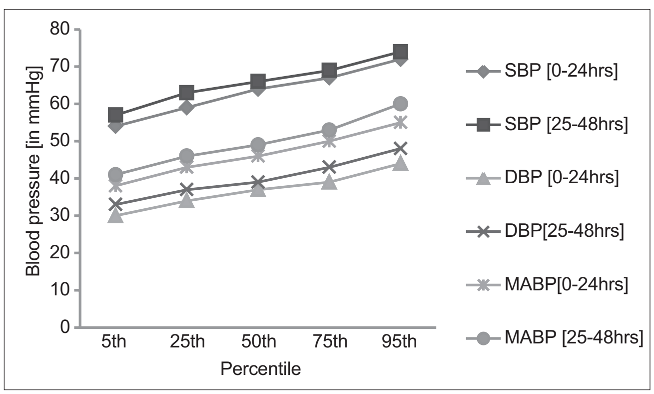


**Figure 2:** Percentile chart of systolic blood pressure, diastolic blood pressure, and mean arterial pressure

rise in BP values such that the 5th, 50th, and 95th percentile of these BP values were: SBP (57, 66, and 74 mmHg), DBP (33, 39, and 48 mmHg), and MAP (41, 49, and 60 mmHg), respectively [Figure 2]. Between 0 and 24 h of life, 22 newborns had SBP values above the 95th percentile while 20 had values above the 95th percentile by the 25–48 h. Nine of the 22 newborns were among those who had raised SBP by 25–48 h of life [Table 5].

## Discussion

In this study, current normative BP values of a group of healthy term newborn in the first 48 h of life are provided. This much-needed information is important in evaluating the cardiovascular system. The values in this study are comparable to that recorded within the first 36 h of life by Park and Lee,[14] and also that of Hulman *et al.*[1] in USA. The values are also similar to those of normal term infants recorded by Pejovic *et al.*[15] in Montenegro and Hwang and Chu[16] in Taiwan. The similarities between these studies may suggest that race may not affect BP in the neonate. However, the values are lower than that recorded in a previous Nigerian study.[5] The difference may be due to the study characteristics of the subjects (the study included SGA and LGA babies as well as postterm babies).

What is clear from this study is that birth weight affects BP in the early neonatal life. A significant but weak positive correlation was found between SBP and birth weight at 0–24 h and 25–48 h. There is an increase in BP in subjects with birth weight from 2.5 to 3.5 kg. However, beyond this birth weight there appears to be a plateau. This observation which is in agreement with the report of other workers may suggest that at term birth weight is a significant determinant of SBP.[14,17-19]

The postnatal age also affected both the SBP and DBP. There was also increase in BP from day 1 to day 2. This may be due to a rise in systemic vascular resistance as the cord is clamped, and the pulmonary vascular resistance falls following lung expansion. This study agrees with the findings of Hulman *et al.*[1] and Zubrow *et al.*[20] in US, and Tan[21] in Singapore. Tan in a study of cohorts of healthy full term Asian newborn demonstrated that SBP and DBP rise in the first 3 days of life.[21] Similar rise in the first 3 days of life was also documented by Hulman *et al.*[1]

The mean SBP, DBP, and MAP for females were higher than that of the males both at 0–24 h and 25–48 h of life, respectively. However, these differences in mean BP values between males and females were not statistically significant. Similar findings have been documented by other workers.[5,22] From this, it may be implied that normative values can be used interchangeably for both males and females at birth among term babies. However, although there was no statistical difference in BP on day 1 and 2, there appears to be a consistent higher BP values among the female neonates compared with the males even though the mean weight of the males was higher than the females. This finding was also noted by Gemelli *et al.*,[22] who noted that females have higher BP values in the 1st days of life. This finding may suggest that sex has some influence on neonatal BP.

Mode of delivery was not significantly associated with BP in this study. This is similar to the findings of Nascimento *et al.*[23] and Earley *et al.*[24] However, it differs with that of Holland and Young[25] who found that SBP was lower among CS delivered infants compared with those by SVD. It also contradicts earlier reports that the more trauma the head of a newborn passes through (e.g. during normal delivery and also during forceps delivery) the higher the BP.[25]

In the newborn, only the SBP is used to define hypertension.[4,26] BP values ≥72 mmHg and ≥74 mmHg for 0–24 h and 25–48 h, respectively, which are the 95th percentile values may necessitate a thorough investigation for hypertension. From this study, the newborns that developed hypertension between 0 and 24 h require only further observation, but in the second 24 h of life, subjects who still have or develop hypertension may require further investigation.

## Conclusion

The study provided normative BP values among full term healthy neonates in the first 48 h of life. These values are recommended for use in the evaluation of BP in newborns in our environment. There was also a positive correlation between SBP and birth weight.

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