Determinants of early Post-natal Blood Pressure among Term Healthy Babies Seen in A Tertiary Hospital in Southwest Nigeria

Ezra O. Ogundare, Adekunle B. Taiwo, and John A. Okeniyi

ABSTRACT

Background: Neonatal blood pressure varies considerably in the early days of life. To correctly interpret blood pressure measurements or predict the expected blood pressure of a newborn, the factors that influence neonatal blood pressure must be taken into consideration.

This study aimed to identify the factors that influence blood pressure (BP) in the early neonatal period.

Method: This is a sub-analysis of research work on the blood pressure pattern of asphyxiated neonates and apparently healthy neonates. It is a hospital-based observational study that was conducted at the Ekiti State University Teaching Hospital [EKSUTH], Ado-Ekiti, Nigeria. 12 blood pressure readings were taken serially from each baby in the first 24 hours after birth using oscillometric device. Relationships between blood pressure and physical parameters were established using regression analysis. Differences in blood pressure with respect to gender, gestational age, weight categorization, maturity for age, socio-economic status, and civil status were established using independent t-test and analysis of variance where appropriate.

Result: 1476 blood pressure readings from 123 healthy newborns were analyzed. The mean (standard deviation) (SD) BP in mmHg on day 1 were 69.5 (6.5), 39.2 (5.1), and 49.3 (4.6) for Systolic blood pressure (SBP), Diastolic blood pressure (DBP) and Mean Arterial pressure (MAP) respectively. Systolic blood pressure showed a positive linear relationship with weight (R=0.488, P=0.000) and length (R =0.304, P=0.001). There were also significant differences in the mean (SD) of SBP with respect to gender (P = 0.015), civil status (P = 0.023), and maternal hypertension (P = 0.043). DBP (P= 0.001) and MAP(P=0.001) also had significant differences with respect to Maternal hypertension.

Conclusion: Systolic blood pressure correlated significantly with birth weight and length. Only maternal hypertension had a significant effect on diastolic blood pressure.

Keywords: Blood pressure, determinants, physical factors, social factors.

I. INTRODUCTION

Blood Pressure (BP) is an important index of well-being, and it indicates the level of perfusion of body organs [1]-[4]. The interpretation of blood pressure readings in the early neonatal period is as important as its accurate measurement. Several factors interplay to determine blood pressure in early neonatal life [5]-[7]. Dionne, in a review article, grouped these factors into the method of measurement, antenatal factors, perinatal factors, and intrinsic factors [5].

The importance of knowing neonatal BP goes beyond the immediate diagnosis of blood pressure abnormalities in neonates, to tracking blood pressure from neonatal life to childhood and adulthood, especially in those in which neonatal risk factors have been identified [8], [9]. Studies have shown that metabolic syndromes could originate from foetal life and early recognition, monitoring, and modification of the factors on which it depends e.g., hypertension and weight (obesity) may help to prevent its occurrence [10]-[12].

Most studies carried out worldwide including Nigeria agreed that neonatal weight is a major determinant of neonatal systolic blood pressure [13]-[15]. The role of other physical factors, especially length has been inconsistently reported [16], [17]. Data about the effects of social factors on early neonatal blood pressure are scarce. In Nigeria, reports on neonatal blood pressure are generally scanty. The available ones focused on the development of nomograms and factors that determine systolic blood pressure. This write-up hopes to add to the understanding of the effects of both the physical and social factors on early neonatal blood pressure.

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II. MATERIAL AND METHODS

A. Study Setting

This is a sub-analysis of research work on blood pressure patterns among asphyxiated neonates and apparently healthy neonates. It was a hospital-based, observational study conducted at the post-natal ward of Ekiti State University Teaching Hospital (EKSUTH), Ado-Ekiti, South-west Nigeria. Formal approval of the Ethics and Research Committee of Ekiti State University Teaching Hospital with protocol number EKSUTH/ A67/ 2018/ 012/ 09 was obtained before the commencement of the study. Written informed parental consent was obtained before the recruitment of all study participants.

All consecutive-term neonates delivered in EKSUTH whose parents gave consent were recruited. Exclusion criteria included the presence of a murmur, obvious structural congenital anomaly, birth injuries such as a fracture to the humerus, and a significant disparity in BP measurement from both arms [18].

Data was collected using proforma designed for the study. Information obtained included the parental socio-demographic characteristics, babies’ gender, and mode of delivery. Mother’s co-morbidities, use of anti-hypertensives, steroid use, cigarette smoking, and alcohol consumption were also recorded. The weight, length, temperature, and systemic examination findings were also recorded in the proforma.

The study Examination and BP measurements were taken with negligible discomfort to the participants.

The BP was measured using an oscillometric device; the Welch Allyn™ Propaq Encore 206EL ©, serial number DA108534 with the babies laid quietly and calmly in the supine position. The appropriate cuff was chosen (with the length of the bladder covering 80 - 100% of the arm circumference, and the width-to-arm circumference ratio of 0.45 - 0.55) [19]. After the cuff had been wrapped around the mid-portion of the arm (halfway between the acromion and olecranon process), babies were allowed to rest for 15 minutes following which three BP measurements were taken within an hour at least two minutes apart [19]. The mean of the last three BP measurements was used as the reading for that hour.

Babies’ BP measured within an hour of birth, at the 6th, 12th, and 24th hours were used in this analysis as opposed to the 48 hours used for other analyses because the focus of this paper is to determine factors that affect the newborn’s blood pressure in the early hours of birth. If a baby was noticed to be unduly agitated as evidenced by crying or jitteriness during a BP measurement, the reading was suspended and repeated after the baby had been calm for at least five minutes.

The weight was measured using Seca™ digital weighing scale 354, serial number 571015. Subjects were weighed to the nearest 0.01 kg while completely naked (without diapers). The scale was standardized with a mass of known weight after every ten babies weighed.

The weight of the participants was classified as LBW, macrosomia, and normal [20]. Lubchenco chart [21] was used to classify the weight based on appropriateness for gestational age.

The length was measured with a Seca™ Infant meter Model 2101821009. Each subject was laid supine while naked, feet together, upper limbs by the side of the body. Trained assistants helped to stabilize the feet and the head of each baby. Measurements were made to the nearest 0.1 cm.

B. Statistical Analysis

Data analysis was done using the software Statistical Package for the Social Sciences (SPSS) version 25.0 [22]. Means with their standard deviations (SD) were reported for continuous data that were normally distributed. Results are presented in prose, tables, and figures. Statistical significance was established when the probability value (p) was less than 0.05 and a 95% confidence interval (CI) excluded unity. T-test was used to test for differences in BP across gender, mode of delivery, and the mother’s marital status. ANOVA was used to test the differences in blood pressure across socioeconomic statuses, estimated gestational age, and different weight classifications. Correlation and regression analysis were used to test for the relationship between blood pressure, estimated gestational age, and length.

III. RESULTS

One hundred and twenty-three (99.2%) of the 124 participants recruited met the requirement for analysis. Participants’ median estimated gestational age at birth was 38 (37-40) weeks. There were more females 69 (56.1%). The median maternal age was 31 (27-33) years; 37 (30.1%) of the babies were delivered via vaginal delivery, and the remaining 86 (69.9%) were delivered via caesarean session. Majority 90 (73.2%) of the participants belong to social class II, 32 (26%) belong to class III and 1 (0.8%) belongs to class I. Four (3.3%) of the mothers were unmarried, and 119 (96.7%) were married. Two (1.6%) of the mothers were hypertensive. None of the mothers had alcohol, used steroid, or smoked cigarette during pregnancy.

The mean (SD) weight of the participants was 3.1 (0.7) kg; the males weighed more with an average weight of 3.3 (0.7) kg versus an average weight of 3.0 (0.7) kg among females (p> 0.05). The mean (SD) length of the babies was 47.9 (3.1) cm. The mean (SD) length of the males was 48.5 (3.4) cm while that of the females was 47.4 (2.8) cm (p = 0.053).

A total of 1476 BP readings were taken. The mean (SD) BP in mmHg were 69.5 (6.5), 39.2 (5.1), and 49.3 (4.6) for SBP, DBP, and MAP respectively. The male participants had a significantly higher mean (SD) in mmHg SBP 71.1 (5.7) than the females 68.2 (6.8) (p=0.015). No significant difference in the mean (SD) in mmHg of DBP and MAP with respect to gender. There were no significant differences in the average BP readings with respect to the mode of delivery and parental socioeconomic status (Table I).

Babies of mothers who were unmarried had a significantly lower mean (SD) SBP and MAP compared to babies of married mothers, p= 0.023 in both cases, the mean (SD) DBP did not differ significantly with respect to maternal civil status. Further analysis showed that babies of unmarried women had significantly lower birthweight 1.7 (0.0) kg compared to 3.2 (0.7) kg (p=0.000) for babies of married mothers.

Babies whose mothers were hypertensive had significantly higher SBP, DBP, and MAP, P= 0.043, 0.001, and 0.001 respectively (Table I).
Concerning the estimated gestational age, one-way ANOVA showed significant disparity in the mean (SD) SBP \( P = 0.029 \). However, no significant difference was found when post-hoc analysis was done. No significant difference in DBP and MAP was found with respect to gestational age \( P = 0.612 \) and 0.382 respectively (Table II).

Using linear regression analysis, there was no relationship between the SBP (R=0.135, P=0.137), DBP (R=0.026, P=0.775), MAP (R = 0.044, P= 0.630), and babies estimated gestational age at birth.

The mean (SD) SBP of the babies differs significantly with respect to the weight class \( P<0.001 \), and weight appropriateness for age \( P < 0.001 \). Also, the mean (SD) MAP differs significantly with respect to the weight class \( P = 0.014 \). No significant difference was observed in the mean (SD) MAP when compared to the appropriateness of weight for age of the babies \( p = 0.114 \). No significant difference exists in mean (SD) DBP with respect to both the weight class and weight appropriateness for age (Table III).

### Table I: Blood Pressure Differences across Socio-demographic Factors

<table>
<thead>
<tr>
<th>Social factors</th>
<th>Mean (SD) SBP</th>
<th>P-value</th>
<th>Mean (SD) DBP</th>
<th>P-value</th>
<th>Mean (SD) MAP</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of the Babies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>71.5(5.7)</td>
<td>0.015*</td>
<td>38.5(5.1)</td>
<td>0.486*</td>
<td>49.5(4.5)</td>
<td>0.543*</td>
</tr>
<tr>
<td>Female</td>
<td>68.2(6.8)</td>
<td></td>
<td>39.4(5.0)</td>
<td></td>
<td>49.0(4.7)</td>
<td></td>
</tr>
<tr>
<td>Mode of Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>69.5(6.2)</td>
<td>0.994*</td>
<td>39.3(5.4)</td>
<td>0.547*</td>
<td>49.4(4.7)</td>
<td>0.658*</td>
</tr>
<tr>
<td>CS</td>
<td>69.4(6.2)</td>
<td>0.014*</td>
<td>39.3(5.4)</td>
<td>0.547*</td>
<td>49.4(4.7)</td>
<td>0.658*</td>
</tr>
<tr>
<td>Parental Socioeconomic Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>64.8</td>
<td></td>
<td>34.3</td>
<td></td>
<td>44.4</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>69.5(6.6)</td>
<td>0.767*</td>
<td>39.3(4.6)</td>
<td>0.610*</td>
<td>49.4(4.4)</td>
<td>0.569*</td>
</tr>
<tr>
<td>Maternal Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>69.7(6.5)</td>
<td>0.023*</td>
<td>39.3(5.1)</td>
<td>0.096*</td>
<td>49.4(4.6)</td>
<td>0.023*</td>
</tr>
<tr>
<td>Unmarried</td>
<td>62.3(0.0)</td>
<td></td>
<td>35.0(0.0)</td>
<td></td>
<td>44.1(0.0)</td>
<td></td>
</tr>
<tr>
<td>Maternal Hypertension</td>
<td>Yes</td>
<td>78.6(13.2)</td>
<td>51.0(6.0)</td>
<td>0.001*</td>
<td>60.2(2.9)</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>69.3(6.9)</td>
<td>39.0(4.5)</td>
<td></td>
<td>49.1(4.4)</td>
<td></td>
</tr>
</tbody>
</table>

*= independent t-test was used, #=analysis of variance was used, CS= caesarean section, VD= vaginal delivery, SBP = systolic blood pressure, MAP= mean arterial pressure, DBP= diastolic blood pressure, bold = significant findings.

### Table II: Variation of Blood Pressure across the Gestational Ages

<table>
<thead>
<tr>
<th>Estimated gestational age (weeks)</th>
<th>Systolic blood pressure (mmHg)</th>
<th>Diastolic blood pressure (mmHg)</th>
<th>Mean arterial pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>68.1(6.9)</td>
<td>39.0(6.1)</td>
<td>48.7(5.1)</td>
</tr>
<tr>
<td>38</td>
<td>71.3(4.9)</td>
<td>39.0(3.3)</td>
<td>49.3(3.6)</td>
</tr>
<tr>
<td>39</td>
<td>67.2(6.6)</td>
<td>40.0(5.9)</td>
<td>49.1(5.0)</td>
</tr>
<tr>
<td>40</td>
<td>68.5(6.7)</td>
<td>40.2(4.2)</td>
<td>49.6(4.4)</td>
</tr>
<tr>
<td>41</td>
<td>71.6(6.6)</td>
<td>36.8(6.1)</td>
<td>48.4(6.1)</td>
</tr>
<tr>
<td>42</td>
<td>75.5(4.3)</td>
<td>37.4(6.1)</td>
<td>50.1(5.5)</td>
</tr>
<tr>
<td>P- values*</td>
<td>0.029</td>
<td>0.509</td>
<td>0.910</td>
</tr>
</tbody>
</table>

*= analysis of variance was done, std = standard, SBP = systolic blood pressure, MAP= mean arterial pressure, DBP= diastolic blood pressure. mmHg= millimeter of mercury

### Table III: The Average Blood Pressure Differences across the Weight Classifications in the First Day of Life

<table>
<thead>
<tr>
<th>BP (mmHg)</th>
<th>Weight Appropriateness for Age</th>
<th>P-value*</th>
<th>Weight Class</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(SD) SBP</td>
<td>SGA</td>
<td>AGA</td>
<td>LGA</td>
<td>LBW</td>
</tr>
<tr>
<td>M(SD) DBP</td>
<td>40.3(5.3)</td>
<td>38.8(5.1)</td>
<td>39.5(5.1)</td>
<td>0.457</td>
</tr>
<tr>
<td>M(SD) MAP</td>
<td>48.8(4.3)</td>
<td>48.8(4.5)</td>
<td>50.9(4.9)</td>
<td>0.114</td>
</tr>
</tbody>
</table>

BP= Blood pressure, (M(SD) = mean (standard deviation), LBW= low birth weight, SGA = small for gestational age, AGA = appropriate for gestational age, LGA = large for gestational age, SBP = systolic blood pressure, MAP= mean arterial pressure, DBP= diastolic blood pressure, *= analysis of variance, mmHg= millimetres of mercury

Fig. 1. Relationship between weight and systolic blood pressure in the first 24 hours of life.
The weight of the babies also showed a positive and significant relationship with systolic blood pressure $R=0.488, P<0.000$ (Fig. 1). The regression equation shows that for every 1 kg rise in weight, the blood pressure increases by over 10 mmHg. Also, a significant relationship exists between the MAP ($R=0.261, p=0.003$) and the weight of the babies. However, DBP ($R=0.043, P=0.500$) showed no significant relationship with the birthweights of the babies.

The length of the babies also showed a positive, but weak and significant relationship with systolic blood pressure $R=0.304, P=0.001$ (Fig. 2). No relationship exists between the length and the MAP ($R=0.084, P=0.335$) and the DBP ($R=0.079, P=0.384$).

IV. DISCUSSION

The available neonatal blood pressure charts have their drawbacks; some were derived from extrapolation and research on ill children admitted to hospitals [4], [14]. The others that are derived from BP readings from healthy neonates, arrived at their values by checking blood pressure one or two times daily [17], [23]. The current study arrived at the day-one blood pressure of term neonates by averaging several blood pressure readings in the first 24 hours of life. Given that most neonatal admission occurs during this period, the values provided herein are useful for interpretations of blood pressure within this period. Nonetheless, these values are similar to that provided by [17].

This study revealed that the systolic blood pressure (SBP) of neonates increased significantly across the different weight groups from low-birth-weight babies to normal weight and to macromomic babies. Similarly, the small for gestational age (SGA) babies had lower blood pressure compared to the AGAs and LGA babies. These findings are similar to the findings of [13]. Previous studies have also shown that birthweights in the categories of LGA and Macrosomia predispose to childhood obesity [24], [25], however, whether this could lead to hypertension is yet to be proven [26]. Conversely, babies who were SGA or who suffered intrauterine growth restrictions have been proven to develop metabolic syndrome including hypertension later in life [10]-[12].

The SBP in the first day of life in this study correlated significantly with the babies’ birth weights and a useful equation for estimation of SBP was derived from the birthweight using a regression equation; $Y= 10x + 40$. where $x$ and $Y$ are the birth weight and blood pressure respectively.

For every 1 kg rise in weight, the BP increases by 10 mmHg. The correlation of systolic blood pressure with birthweight in this study is like the findings of some other authors [7], [14], [17]. The MAP also correlated significantly with birthweight which is similar to studies in India and USA [14], [15].

The SBP on the first day of life also showed a positive correlation with the birth length of the baby. Though this was a weak relationship, a similar finding was reported by [17]. Contrastingly, Nascimento in Brazil found no relationship between birth length and systolic blood pressure [16].

The SBP had no significant correlation with the gestational age at birth and there were no significant differences in the SBP with respect to different estimated gestational ages of the babies at birth as already observed by some authors who worked similarly on healthy term neonates [16], [17].

Similar to previous research on this topic, diastolic blood pressure had no significant relationship with any of weight, length, or EGA [7], [16], [17], [23].

Concerning the socio-demographics, SBP differs significantly in relation to gender and maternal civil status. In most studies, no significant differences have been found in SBP with respect to genders [7], [17], [23]. The reason for a significant difference in this study may be related to the higher average birthweight seen in males in this study since weight is a major determinant of blood pressure in early neonatal life. The mode of delivery of the babies had no significant effects on their blood pressure as earlier found by some authors [23], [27], [28]. Studies on Civil status and blood pressure in neonates are scarce, however, [13] had explored the relationship between parental socio-economic status and neonatal blood pressure. Reference [13] found out that babies of mothers in the low social class are likely to have significantly higher SBP compared to babies of mothers in the lower social class, the findings of the current study showed a similar trend though the differences were insignificant. Data on the effects of maternal hypertension on neonatal blood pressure are scarce, in this study babies of mothers who were hypertensive had higher SBP, DBP, and
MAP compared to babies of mothers who were not hypertensive, though their sample size was small. This finding corroborated earlier finding by [29] that neonates of preeclamptic mothers have higher odds of developing elevated blood pressure.

In conclusion, it can be inferred from this study that while the diastolic blood pressure of a newborn is rarely affected by physical and social factors at birth, the SBP is significantly influenced by physical factors, majorly the birth weight and to a lesser extent birth length. The social factors relating to the socioeconomic status of the parent and the civil status of the mother may be a subject for more research as they were observed to influence systolic blood pressure in this study.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

REFERENCES