DETERMINANTS OF BLOOD PRESSURE IN NEWBORNS: AN OBSERVATIONAL STUDY CORRELATING BLOOD PRESSURE WITH GESTATIONAL AGE AND BIRTH WEIGHT

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Abstract:

Background

Blood pressure (BP) is an important physiological parameter in newborns and reflects cardiovascular adaptation during the neonatal period. Several factors influence neonatal blood pressure, among which gestational age and birth weight are considered major determinants. Establishing the relationship between blood pressure and these variables is essential for identifying neonates at risk of hypotension or hypertension and for guiding appropriate clinical management.

Objectives

To study the blood pressure profile of newborn babies and to evaluate its correlation with gestational age and birth weight.

Methods

This hospital-based observational study was conducted among newborn babies admitted to the neonatal unit and postnatal wards of a tertiary care hospital. Blood pressure measurements were obtained using an appropriate non-invasive method under standardized conditions. Gestational age was determined from maternal history and clinical assessment, while birth weight was recorded soon after delivery. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were analyzed and correlated with gestational age and birth weight using appropriate statistical tests.

Results

A total of 500 neonates were enrolled, including 366 (73.2%) term and 134 (26.8%) preterm infants. The mean systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were 68.08 ± 6.14 mmHg, 41.15 ± 4.11 mmHg, and 50.10 ± 4.53 mmHg, respectively. Term neonates had significantly higher SBP, DBP, and MAP than preterm neonates ($p<0.001$). Blood pressure showed significant positive correlations with gestational age ($r=0.679$–0.774), birth weight ($r=0.602$–0.734), crown–heel length ($r=0.479$–0.523), and head circumference ($r=0.480$–0.618) ($p<0.001$).

Neonates requiring resuscitation at birth and those with lower 1-minute APGAR scores had significantly lower blood pressure values ($p<0.001$). No significant differences in blood pressure were observed with respect to sex or maternal anaemia. Gestational age-specific percentile charts for SBP, DBP, and MAP were generated for neonates between 31 and 41 weeks of gestation.

Conclusion

Neonatal blood pressure is significantly influenced by gestational age and birth weight. Lower blood pressure values are commonly observed in preterm and low-birth-weight infants. These findings highlight the importance of considering gestational age and birth weight while interpreting blood pressure measurements in newborns and may aid in the early identification and management of hemodynamic abnormalities.

Keywords: Neonatal blood pressure, Newborn, Gestational age, Birth weight, Mean arterial pressure, Neonate.

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Introduction

Blood pressure (BP) is a fundamental physiological parameter that reflects cardiovascular adaptation during the neonatal period. As newborns transition from fetal to extrauterine life, rapid haemodynamic changes occur, making BP assessment an essential component of neonatal evaluation and monitoring, particularly in neonatal intensive care units (NICUs). Abnormal BP values may indicate underlying cardiovascular, renal, or systemic disorders requiring prompt intervention. [1,2]

The transition from fetal to neonatal circulation is characterized by a sharp decline in pulmonary vascular resistance following lung expansion and a simultaneous increase in systemic vascular resistance after placental separation. These physiological changes lead to closure of the fetal shunts and establishment of adult-type circulation, directly influencing neonatal blood pressure values. [3-5]

Among BP parameters, mean arterial pressure (MAP) is considered the most clinically relevant measure because it reflects tissue perfusion and organ blood flow. Adequate MAP is particularly important in preterm infants, whose autoregulatory mechanisms are immature and less capable of maintaining stable perfusion under haemodynamic stress. [6-8]

Neonatal blood pressure varies considerably with gestational age, birth weight, and postnatal age. Preterm and low birth weight infants generally have lower BP values because of immature myocardial function and reduced vascular tone. Blood pressure gradually increases during the first days and weeks of life as cardiovascular adaptation progresses. [9-11] Consequently, a single universal reference range is not applicable, highlighting the need for gestation- and weight-specific normative data. [12,13]

In routine neonatal practice, blood pressure is commonly measured using the oscillometric technique, which provides a safe, non-invasive, and reproducible method for estimating systolic, diastolic, and mean arterial pressures. Accurate measurement requires appropriate cuff selection and standardized measurement conditions to minimize variability. [14-16]

Both hypotension and hypertension are clinically significant neonatal conditions. Hypotension is particularly common among extremely preterm infants and has been associated with serious complications, including intraventricular haemorrhage, periventricular leukomalacia, necrotising enterocolitis, and acute kidney injury.[17,6,18] Although less common, neonatal hypertension can also result in significant cardiovascular and neurological morbidity if left undetected.[19–20] Because these conditions often present with subtle or nonspecific clinical manifestations, routine BP monitoring remains essential for early diagnosis and management.[21]

Most published normative blood pressure data originate from Western populations and may not accurately reflect the physiological characteristics of Indian newborns. Given the high burden of prematurity, low birth weight, and intrauterine growth restriction in India, region-specific reference values are required. Previous Indian studies have contributed important data; however, variations in population characteristics and regional factors limit their generalizability. [22-23] Establishing local normative blood pressure values is therefore important for improving clinical assessment and haemodynamic management of Indian neonates.

Review of Literature:

Neonatal blood pressure is determined primarily by cardiac output and systemic vascular resistance, both of which undergo rapid transitional changes after birth. In newborns, cardiac output is largely heart rate–dependent due to limited myocacontractile reserve, particularly in preterm infants. [5] Lower vascular tone and increased arterial compliance further contribute to reduced systemic vascular resistance compared with older children.[7]

Mean arterial pressure (MAP) is the most reliable indicator of organ perfusion in neonates. [2] Cardiovascular regulation is mediated by the autonomic nervous system and the renin–angiotensin–aldosterone system (RAAS), both of which are functionally active at birth but relatively immature in preterm infants, predisposing them to haemodynamic instability under stress conditions such as infection or fluid imbalance. [24-25]

Determinants of Neonatal Blood Pressure

Neonatal blood pressure is strongly influenced by gestational age, birth weight, and postnatal age. In term neonates, systolic, diastolic, and MAP values at birth typically range from 65–75, 40–50, and 50–

60 mmHg, respectively, with a gradual rise during the first days of life. [26] Preterm infants exhibit significantly lower values, with MAP commonly between 25–35 mmHg. [27]

Effect of Gestational Age

Gestational age is the strongest determinant of neonatal blood pressure, showing a consistent positive correlation with systolic, diastolic, and MAP values.[27-28] Increasing gestational maturity is associated with improved myocardial contractility, higher stroke volume, enhanced vascular tone, reduced arterial compliance, and better autonomic and RAAS responsiveness.[24-25]

Extremely preterm neonates (23–26 weeks) have the lowest MAP (23–33 mmHg) and a high incidence (>40%) of clinically significant hypotension.[29] Their fragile cerebral vasculature, particularly the germinal matrix, makes them highly susceptible to intraventricular haemorrhage (IVH) during blood pressure instability.[30] In contrast, late preterm infants show values closer to term neonates, though gestational age-specific references remain essential.[12-13]

Effect of Birth Weight

Birth weight correlates positively with neonatal blood pressure. Higher birth weight is associated with greater myocardial mass and stroke volume, contributing to higher pressures. [28] However, small-for-gestational-age (SGA) infants may exhibit relatively higher blood pressure due to intrauterine programming effects such as increased vascular tone and altered compliance, supporting the Developmental Origins of Health and Disease (DOHaD) hypothesis. [31-33]

Very low and extremely low birth weight infants are particularly haemodynamically vulnerable and require close monitoring using weight-adjusted reference standards for optimal management.[34]

Effect of Postnatal Age

Postnatal age independently affects blood pressure, with a progressive rise observed during early neonatal life.[9-10] Term infants may experience a transient early decline followed by stabilization and a 5–10 mmHg increase over the first week.[35] Preterm infants demonstrate a steeper rise (3–4 mmHg/day) in the initial days before gradually converging toward term values.[13] Blood pressure trends correlate more closely with postconceptional age than chronological age.[36-11]

Neonatal Hypotension

Neonatal hypotension is defined as MAP below the 10th percentile or more than two standard deviations below gestational age–specific norms.It is classified into hypovolaemic, cardiogenic, and distributive types.[17] Management is etiology-driven: volume expansion for hypovolaemia, dopamine as first-line vasopressor, dobutamine for myocardial dysfunction, and hydrocortisone for refractory cases.[37]

Neonatal Hypertension

Neonatal hypertension is defined as blood pressure above the 95th percentile for gestational age, birth weight, and postnatal age. [19-20] Although rare (0.2–3%), it can lead to significant morbidity. [21] Clinical features are non-specific and include irritability, tachycardia, respiratory distress, and seizures.

Common causes include renal disease, renovascular injury (especially catheter-related), aortic coarctation, endocrine disorders, and drug-induced hypertension.

Cerebral autoregulation maintains stable cerebral blood flow despite systemic blood pressure fluctuations, but is often impaired in preterm infants. In such cases, cerebral perfusion becomes pressure-dependent, increasing the risk of ischemia during hypotension and haemorrhage during hypertension. [8]

Several studies have consistently demonstrated that neonatal blood pressure is strongly influenced by gestational age, birth weight, and postnatal maturation, with progressive postnatal adaptation of cardiovascular function

Dore et al. (2024) [12] revealed a consistent positive relationship between gestational age and systolic, diastolic, and mean arterial pressures across the full neonatal spectrum. Postnatal age was also identified as an independent determinant, with a steady rise in blood pressure during early life. However, significant heterogeneity in measurement techniques, cuff sizes, devices, and timing was observed, emphasizing the need for population- and device-specific reference standards rather than universal cut-offs.

Kiss et al. (2023) [13] studied 629 neonates (25–42 weeks gestation) and found that blood pressure increased more rapidly in preterm infants than in term infants during the first few days of life. Blood pressure showed a positive correlation with birth weight, while term neonates demonstrated a transient initial decline before a gradual rise

Radha et al. (2023) [26] established normative blood pressure values in 400 Indian neonates and reported a significant increase in systolic, diastolic, and mean arterial pressures with advancing gestational age and birth weight. No significant sex-related differences were observed, while upper limb blood pressure readings were consistently higher than lower limb values.

Dionne et al. (2020) [14] reported significant variability in neonatal blood pressure measurements across different methods and devices. Compared with intra-arterial monitoring, oscillometric devices tended to overestimate higher blood pressure values and underestimate lower values. The study emphasized that neonatal blood pressure reference ranges are device-specific and require appropriate validation before clinical application.

Study conducted by Samanta et al. (2015)38 confirmed a strong positive correlation of blood pressure with both gestational age and birth weight, and established centile charts for Indian neonates, showing comparatively lower values in low birth weight infants relative to international references, reinforcing the need for population-specific standards.

Earlier studies established the fundamental determinants and developmental patterns of neonatal blood pressure. Versmold et al. [39] first demonstrated a strong positive relationship between gestational age and blood pressure in preterm infants, while subsequent studies confirmed that gestational age, birth weight, and postnatal age independently influence neonatal blood pressure values.[36-40]

Blood pressure rises progressively during the early postnatal period, particularly in preterm infants, and gradually stabilizes with advancing postconceptional age. [41-42]

Zubrow et al. [11] identified postconceptional age as the strongest predictor of neonatal blood pressure, integrating both prenatal and postnatal maturation.

These studies collectively provided the foundation for contemporary gestational age- and birth weight-specific reference standards used in neonatal practice.

Materials and Methodology:

This was an observational descriptive study conducted to evaluate neonatal blood pressure and its correlation with gestational age and birth weight.The study was carried out in the Neonatal Division, Department of Paediatrics, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala, a tertiary care teaching hospital providing comprehensive maternal and neonatal services over a period of 18 months, from September 2024 to February 2026.

Study Population

The study included newborns delivered at the institute during the study period who met the eligibility criteria and underwent blood pressure and anthropometric assessment.

Sample Size and Sampling Technique

A minimum of 500 neonates were included considering evidence from previous studies, including Zubrow et al. (1995), which demonstrated significant associations of gestational age and birth weight with neonatal blood pressure, this sample size was considered adequate for correlation analysis. Consecutive sampling was used, enrolling all eligible neonates until the required sample size was achieved.

Inclusion Criteria

- Neonates born at the study institution
- Clinically stable newborns at the time of assessment
- Neonates with informed parental consent

Exclusion Criteria

- Post-term neonates (>42 weeks gestation)
- Unknown gestational age (no reliable LMP)
- Birth asphyxia (APGAR <4 at 1 minute)
- Respiratory distress requiring mechanical ventilation
- Congenital malformations
- Exposure to vasoactive or cardioactive drugs (e.g., dopamine, dobutamine, corticosteroids, adrenergic agents, phenylephrine, theophylline)
- Capillary refill time ≥3 seconds
- Maternal history of substance abuse

Study Tools

- Pre-structured case record form
- Calibrated digital weighing scale (birth weight)
- Infantometer (length measurement)
- Non-stretchable measuring tape (head circumference)
- Multiparameter monitor (BPL) using oscillometric blood pressure measurement

Data Collection Procedure

After obtaining informed consent, demographic and clinical details were recorded in a structured proforma. APGAR scores at 1 and 5 minutes were extracted from delivery records. Gestational age was determined using maternal last menstrual period (LMP).

Anthropometric measurements were obtained on day one of life. Birth weight was recorded using a calibrated digital scale with the neonate undressed. Length and head circumference were measured using standard techniques.

Neonates were categorized by birth weight according to WHO classification: normal birth weight (2500–4000 g), low birth weight (1500–2499 g), very low birth weight (1000–1499 g), and extremely low birth weight (<1000 g).

Blood pressure was measured between 6 and 24 hours of life using a validated oscillometric device. An appropriately sized cuff was selected (covering approximately two-thirds of upper arm circumference), with sizes assigned based on limb circumference. Measurements were taken from the right upper arm with the infant in a supine, calm state. Three readings of systolic, diastolic, and mean arterial pressure were recorded at two-minute intervals, and the mean of the three was used for analysis.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 21. Descriptive statistics (mean ± standard deviation) were used for continuous variables. Correlation analysis was performed to assess relationships between blood pressure, gestational age, and birth weight. A p-value <0.05 was considered statistically significant.

Results:

Among the 500 neonates included in the study, 252 (50.4%) were males and 248 (49.6%) were females, resulting in an almost equal male-to-female ratio of 1.02:1. This indicates a balanced sex distribution within the study population.

The majority of neonates were born at term (≥37 weeks), accounting for 73.2% (n=366) of the study population. Preterm neonates constituted 26.8% (n=134), including 4.8% (n=24) early preterm and 22.0% (n=110) late preterm infants. This distribution provides adequate representation across different gestational age groups for evaluating blood pressure patterns as shown in Table1.

Table1: **Distribution of Study Participants by Gestational Age and Maturity Status (n = 500)**

Gestational Status	Number (n)	Percentage (%)
Term (≥37 weeks)	366	73.2
Preterm (<37 weeks)	134	26.8
Early Preterm (<34 weeks)	24	4.8
Late Preterm (34–36 weeks)	110	22.0
Total	**500**	**100.0**

Caesarean section was slightly more common than vaginal delivery, accounting for 53.0% (n=265) of births, while 47.0% (n=235) were delivered vaginally. Most mothers (97.2%, n=486) had regular antenatal care follow-up, with only a small proportion (2.8%, n=14) being unbooked.

Normal birth weight (2500–3999 g) was most prevalent, observed in 66.6% (n=333) of neonates. Low birth weight accounted for 31.8% (n=159), while very low birth weight (1.0%, n=5) and macrosomia (0.6%, n=3) were uncommon as shown in Table 2. The relatively high proportion of low-birth-weight infants highlighting the contribution of prematurity and intrauterine growth restriction in the cohort, which is relevant for analysing the relationship between birth weight and blood pressure.

Table 2**: Distribution of Study Participants by Birth Weight Category (n = 500)**

Birth Weight Category	Number (n)	Percentage (%)	Weight Range (g)
Very Low Birth Weight (VLBW)	5	1.0	<1500
Low Birth Weight (LBW)	159	31.8	1500–2499
Normal Birth Weight (NBW)	333	66.6	2500–3999
Macrosomia	3	0.6	≥4000

Birth Weight Category	Number (n)	Percentage (%)	Weight Range (g)
Total	**500**	**100.0**	–

About 69.8% (n=349) of neonates were Appropriate for Gestational Age (AGA), while 28.8% (n=144) were Small for Gestational Age (SGA) and 1.4% (n=7) were Large for Gestational Age (LGA).

The mean maternal age was 26.93 ± 4.97 years, with most mothers (64.6%) belonging to the 21–30-year age group. A high prevalence of maternal anaemia was observed, affecting 75.8% (n=379) of participants, with an overall mean haemoglobin level of 9.49 ± 2.07 g/dL as depicted in table 3. This significant burden of anaemia was documented as a relevant perinatal factor due to its potential impact on fetal circulation and neonatal blood pressure at birth.

Table 3: **Maternal Profile of Study Participants (n = 500)**

Maternal Variable	Category / Value	Number (n)	Percentage (%)
Age (years)	Mean ± SD: 26.93 ± 4.97	–	–
Age Group	18–20 years	50	10.0
	21–25 years	166	33.2
	26–30 years	157	31.4
	31–35 years	98	19.6
	≥36 years	29	5.8
Anaemia Status	Anaemic	379	75.8
	Non-Anaemic	121	24.2
Haemoglobin (g/dL)	Mean ± SD: 9.49 ± 2.07	–	–

Our study revealed that most neonates (97.6%, n=488) had 1-minute APGAR scores of 7–8 and did not require resuscitation, indicating good immediate postnatal adaptation. A small proportion (2.4%, n=12) required resuscitation and had APGAR scores of 5–6 at 1 minute. By 5 minutes, all neonates achieved APGAR scores ≥8, confirming adequate stabilization as shown in table 4. Neonates with APGAR scores <4 at 1 minute were excluded according to the study criteria to ensure inclusion of clinically stable infants only.

Table 4: **Neonatal Clinical Profile at Birth (n = 500)**

Neonatal Variable	Category	Number (n)	Percentage (%)
Resuscitation at Birth	Required (YES)	12	2.4
	Not Required (NO)	488	97.6
APGAR Score at 1 minute	5–6 (Moderate)	12	2.4
	7–8 (Good)	488	97.6
APGAR Score at 5 minutes	8	8	1.6
	9	492	98.4

The mean crown–heel length was 48.04 ± 2.03 cm, with most neonates (96.0%, n=480) within the normal 10th–90th centile range. The mean head circumference was 34.03 ± 1.25 cm, while 2.8% (n=14) of neonates had microcephaly. These anthropometric measurements further reflect fetal growth status and serve as additional parameters for assessing the relationship between body size at birth and neonatal blood pressure as shown in Table 5.

Table 5: **Neonatal Anthropometric Parameters of Study Participants (n = 500)**

Anthropometric Parameter	Mean ± SD	Range	10th–90th Centile
Birth Weight (g)	2682.3 ± 477.2	780–4096	–
Crown-Heel Length (cm)	48.04 ± 2.03	38.5–51.5	480 (96.0%)
Head Circumference (cm)	34.03 ± 1.25	29.0–37.5	–
Length Category			
<10th Centile	17	3.4%	–
10th–90th Centile	480	96.0%	–
>90th Centile	3	0.6%	–
HC Category			
Normal	486	97.2%	–
Microcephaly (<3rd centile)	14	2.8%	–

Across all 500 neonates, the mean systolic blood pressure (SBP) was 68.08 ± 6.14 mmHg, with a mean diastolic blood pressure (DBP) of 41.15 ± 4.11 mmHg and a mean arterial pressure (MAP) of 50.10 ± 4.53 mmHg. No significant differences in SBP, DBP, or MAP were observed between male and female neonates (p=0.938, 0.284, and 0.499, respectively), indicating that sex did not have a significant effect on blood pressure in this cohort

A highly significant difference was observed in all blood pressure parameters between term and preterm neonates (p<0.001). Term infants had higher SBP, DBP, and MAP compared to preterm neonates (70.31 vs 61.99 mmHg, 42.48 vs 37.52 mmHg, and 51.74 vs 45.62 mmHg, respectively) as shown in Table 6. The large t-values (>14) highlight a strong association between gestational maturity and blood pressure, consistent with the physiological increase in cardiovascular function with advancing gestational age.

Table 6: **Comparison of Blood Pressure Values in Term versus Preterm Neonates (Independent t-test)**

BP Parameter	Term (n=366) Mean ± SD	Preterm (n=134) Mean ± SD	t-value	p-value	Significance
SBP (mmHg)	70.31 ± 5.28	61.99 ± 3.73	16.778	<0.001	Significant
DBP (mmHg)	42.48 ± 3.16	37.52 ± 4.21	14.132	<0.001	Significant
MAP (mmHg)	51.74 ± 3.58	45.62 ± 3.74	16.724	<0.001	Significant

A significant progressive increase in SBP, DBP, and MAP was observed with advancing gestational age (p<0.001 for all, one-way ANOVA). The lowest blood pressure values were seen in neonates <32 weeks, while the highest values were recorded in those ≥37 weeks (SBP 60.33 vs 70.31 mmHg) as shown in Table 7. This graded rise highlights gestational age as the strongest determinant of neonatal blood pressure and represents a key finding of the study.

Table 7: **Blood Pressure Values Across Gestational Age Groups (One-Way ANOVA)**

BP Parameter	<32 wks (n=3)	32–33 wks (n=21)	34–36 wks (n=110)	≥37 wks (n=366)	p-value (ANOVA)	Significance
SBP (mmHg)	60.33 ± 2.	59.76 ± 3.0	62.45 ± 3.7	70.31 ± 5.28	<0.001	Significant

BP Parameter	<32 wks (n=3)	32–33 wks (n=21)	34–36 wks (n=110)	≥37 wks (n=366)	p-value (ANOVA)	Significance
	08	2	4			
DBP (mmHg)	33.00 ± 3.61	32.57 ± 3.40	38.59 ± 3.58	42.48 ± 3.16	<0.001	Significant
MAP (mmHg)	42.00 ± 3.00	41.57 ± 3.04	46.49 ± 3.30	51.74 ± 3.58	<0.001	Significant

Our study also demonstrates that a significant progressive increase in blood pressure was demonstrated across birth weight categories (p<0.001 for all parameters). VLBW neonates had the lowest mean SBP (57.20 mmHg), followed by LBW (63.87 mmHg) and NBW (70.22 mmHg). The large F-statistic values for SBP (F=59.4) and DBP (F=101.7) reflect a strong and consistent direct relationship between birth weight and neonatal blood pressure across all three blood pressure types, confirming birth weight as a major factor in neonatal blood flow and pressure as depicted in table 8.

Table 8: **Blood Pressure Values According to Birth Weight Category (One-Way ANOVA)**

BP Parameter	VLBW <1500 g (n=5)	LBW 1500–2499 g (n=159)	NBW 2500–3999 g (n=333)	p-value (ANOVA)	Significance
SBP (mmHg)	57.20 ± 1.30	63.87 ± 4.81	70.22 ± 5.52	<0.001	Significant
DBP (mmHg)	30.60 ± 0.55	37.95 ± 3.56	42.77 ± 3.05	<0.001	Significant
MAP (mmHg)	39.40 ± 0.55	46.55 ± 3.60	51.91 ± 3.60	<0.001	Significant

Our study also found that neonates with lower APGAR scores at 1 minute (5–6) had significantly reduced SBP, DBP, and MAP compared to those with higher APGAR scores (7–8), with all differences being statistically significant (p<0.001). Mean SBP was 60.00 mmHg in the lower APGAR group versus 68.28 mmHg in the higher APGAR group, indicating a clear association between early postnatal adaptation and neonatal blood pressure as shown in table 9.

Table 9: **Comparison of Blood Pressure by APGAR Score at 1 Minute (Independent t-test)**

BP Parameter	APGAR 5–6 (n=12) Mean ± SD	APGAR 7–8 (n=488) Mean ± SD	t-value	p-value	Significance
SBP (mmHg)	60.00 ± 4.30	68.28 ± 6.04	−4.709	<0.001	Significant
DBP (mmH	34.00 ±	41.33 ±	−6.340	<0.001	Significant

BP Parameter	APGAR 5–6 (n=12) Mean ± SD	APGAR 7–8 (n=488) Mean ± SD	t-value	p-value	Significance
g)	4.28	3.94			
MAP (mmHg)	42.67 ± 4.17	50.28 ± 4.37	−5.954	<0.001	Significant

Neonates who required resuscitation at birth (n=12) showed significantly lower SBP, DBP, and MAP compared to those who did not require resuscitation (60.00 vs 68.28 mmHg, 34.00 vs 41.33 mmHg, and 42.67 vs 50.28 mmHg, respectively), with all differences being highly significant (p<0.001) as shown in table10.

Table10: **Comparison of Blood Pressure Based on Need for Resuscitation at Birth (Independent t-test)**

BP Parameter	Resuscitation Required (n=12) Mean ± SD	No Resuscitation (n=488) Mean ± SD	t-value	p-value	Significance
SBP (mmHg)	60.00 ± 4.49	68.28 ± 6.04	−4.709	<0.001	Significant
DBP (mmHg)	34.00 ± 4.47	41.33 ± 3.94	−6.340	<0.001	Significant
MAP (mmHg)	42.67 ± 4.36	50.28 ± 4.38	−5.954	<0.001	Significant

Significant positive correlations were observed between all blood pressure parameters and gestational age, birth weight, crown–heel length, and head circumference (r=0.479–0.774; p<0.001). Gestational age showed the strongest association with SBP (r=0.774), while birth weight had the strongest correlation with DBP (r=0.734). Head circumference also demonstrated a relatively strong correlation with DBP (r=0.618), suggesting a link between somatic growth, neurodevelopment, and neonatal cardiovascular status as depicted in Table 11.

Table 11: **Pearson Correlation of Blood Pressure Parameters with Gestational Age, Birth Weight, Crown-Heel Length, and Head Circumference**

BP Parameter	r (GA)	p	r (Birth Weight)	p	r (Length)	p	r (Head Circumference)	p	Significance
SBP (mmHg)	0.774	< 0.001	0.602	< 0.001	0.508	< 0.001	0.480	< 0.001	Significant
DBP (mmHg)	0.679	< 0.001	0.734	< 0.001	0.479	< 0.001	0.618	< 0.001	Significant
MAP (mmHg)	0.764	< 0.001	0.720	< 0.001	0.523	< 0.001	0.596	< 0.001	Significant

Discussion:

In the present study, the mean SBP, DBP, and MAP were 68.08 ± 6.14 mmHg, 41.15 ± 4.11 mmHg, and 50.10 ± 4.53 mmHg, respectively, measured within 6–24 hours of life. These values are consistent with Indian studies such as Samanta et al. (2015) [38] (SBP 64–72 mmHg, MAP 45–52 mmHg) and

Radha et al. (2023)[26] (SBP 66–71 mmHg, MAP 48–54 mmHg), as well as international data showing similar neonatal BP trends across gestational ages.[13, 43] Minor variations across studies likely reflect differences in population characteristics and measurement timing.

A strong positive correlation was observed between gestational age and all BP parameters (r up to 0.774, $p<0.001$), with significantly higher SBP, DBP, and MAP in term compared to preterm neonates. This finding is well supported by previous studies demonstrating a consistent gestation-related rise in neonatal blood pressure.[43,41] The physiological basis includes progressive maturation of myocardial function, increasing vascular tone, and enhanced neurohumoral regulation with advancing gestation.[11]

Birth weight also showed a significant positive association with SBP, DBP, and MAP ($p<0.001$), with lowest values in VLBW and highest in normal birth weight neonates. Similar associations have been reported by Samanta et al. (2015)[38] and Zubrow et al. (1995) [11]. The mechanism is attributed to greater cardiac output, myocardial mass, and vascular development in larger infants.Although oscillometric values in the present study were slightly higher than invasive MAP references in VLBW infants, this difference is expected due to known methodological overestimation by oscillometric devices. [14, 40]

No significant sex-based differences were observed in neonatal blood pressure, consistent with Radha et al. (2023)[26] and Zubrow et al. (1995)[11], confirming that sex does not independently influence neonatal BP and is not included in standard reference charts.

Mode of delivery showed slightly higher SBP and MAP in vaginally delivered neonates compared to caesarean section ($p<0.05$), though the absolute difference was small and clinically insignificant. This likely reflects transient catecholamine surge during vaginal delivery, as previously described by Agata et al. (1991)[44] and Matsuoka et al. (1996)[35].

Despite a high prevalence of maternal anaemia (75.8%), no significant effect was observed on neonatal BP parameters, consistent with Nair et al. (2014) [22]. This suggests effective fetal compensation through maintained uteroplacental perfusion in mild-to-moderate anaemia.

No significant differences were found among AGA, SGA, and LGA neonates for SBP and MAP, while only a borderline difference in DBP was noted. This may reflect fetal adaptive vascular changes described in the DOHaD framework, where growth-restricted fetuses develop compensatory vascular tone that maintains BP despite lower body size. [32,33]

Overall, the study confirms gestational age and birth weight as the strongest determinants of neonatal blood pressure, while other factors such as sex, maternal anaemia, and mode of delivery have minimal clinical impact. The gestational age–specific percentile charts generated provide locally relevant reference standards for neonatal BP assessment in Indian settings and may aid in early identification of hypotension using the 10th percentile threshold. [45,46]

Conclusion:

The present study demonstrates that neonatal blood pressure is primarily influenced by gestational age, birth weight, and immediate condition at birth. Term and normal birth weight neonates exhibited higher SBP, DBP, and MAP compared to preterm and low birth weight infants, indicating a progressive rise in blood pressure with increasing fetal maturity and growth.

Neonates with lower APGAR scores and those requiring resuscitation at birth showed significantly lower blood pressure values, reflecting their reduced early haemodynamic stability. In contrast, factors such as sex of the neonate and maternal anaemia did not have a significant impact on blood pressure in this study population.

Overall, neonatal blood pressure should be interpreted in conjunction with gestational age, birth weight, APGAR score, and overall clinical status rather than as an isolated parameter. The findings provide useful baseline data for this region and may assist in early identification and monitoring of neonates at risk of haemodynamic instability.

Limitation:

This study was conducted in a single tertiary care hospital, which may limit the generalisability of the findings to the broader neonatal population. As the sample was drawn from a specific geographical region, regional and demographic factors may have influenced the results.

Blood pressure measurements were taken only during the early neonatal period; therefore, subsequent postnatal changes in blood pressure patterns could not be evaluated. The study primarily focused on associations with gestational age and birth weight, while other potentially relevant factors such as maternal medication use, antenatal steroid exposure, feeding status, sleep–wake state, and underlying neonatal illness were not assessed in detail.

References:

1. Guyton AC, Hall JE. Textbook of Medical Physiology. 14th ed. Philadelphia: Elsevier; 2021.
2. Kliegman RM, St Geme JW, Blum NJ, Shah SS, Tasker RC, Wilson KM. Nelson Textbook of Pediatrics. 21st ed. Philadelphia: Elsevier; 2020.
3. Heymann MA. Control of the pulmonary circulation in the perinatal period. J Dev Physiol. 1984;6(3):281-90.
4. Rudolph AM. The changes in the circulation after birth: their importance in congenital heart disease. Circulation. 1970;41(2):343-59.
5. Anderson PA. The heart and development. Semin Perinatol. 1996;20(6):482-509.
6. Volpe JJ. Neurology of the Newborn. 6th ed. Philadelphia: Elsevier; 2018.
7. Berne RM, Levy MN, Koeppen BM, Stanton BA. Physiology. 5th ed. St. Louis: Mosby; 2004.
8. Soul JS, Hammer PE, Tsuji M, Saul JP, Bassan H, Limperopoulos C, et al. Fluctuating pressure-passivity is common in the cerebral circulation of sick premature infants. Pediatr Res. 2007;61(4):467-73.
9. Batton B, Zhu X, Fanaroff J, Kirchner HL, Berlin S, Wilson-Costello D, et al. Blood pressure, anti-hypotensive therapy, and neurodevelopment in extremely preterm infants. J Pediatr. 2009;154(3):351-7.e1.
10. Laughon M, Bose C, Allred E, O'Shea TM, Van Marter LJ, Ehrenkranz RA, et al. Factors associated with treatment for hypotension in extremely low gestational age newborns during the first postnatal week. Pediatrics. 2007;119(2):273-80.
11. Zubrow AB, Hulman S, Kushner H, Falkner B. Determinants of blood pressure in infants admitted to neonatal intensive care units: a prospective multicenter study. Philadelphia neonatal blood pressure study group. J Perinatol. 1995;15(6):470-9.
12. Dore RR, Barnes K, Bremner S, Ishii Iwami H, Apele-Freimane D, Batton B, et al. Neonatal blood pressure by birth weight, gestational age, and postnatal age: a systematic review. Matern Health NeonatolPerinatol. 2024;10:9.
13. Kiss JK, Ganda A, Mari J, Nemeth J, Bereczki C. Oscillometric arterial blood pressure in haemodynamically stable neonates in the first 2 weeks of life. Pediatr Nephrol. 2023;38(11):3369-78.
14. Dionne JM, Bremner SA, Baygani SK, Batton B, Ergenekon E, Bhatt-Mehta V, et al. Method of blood pressure measurement in neonates and infants: a systematic review and analysis. J Pediatr. 2020;221:23-31.e5.
15. Nwanko MU, Lorenz JM, Gardiner JC. A standard protocol for blood pressure measurement in the newborn. Pediatrics. 1997;99(6):e10.
16. Birkbeck GL, Birch JR, Barrington KJ. Comparison of oscillometric and intra-arterial blood pressure measurements in critically ill neonates. Crit Care Med. 1992;20(12):1720-6.
17. Fanaroff AA, Fanaroff JM. Klaus and Fanaroff's Care of the High-Risk Neonate. 7th ed. Philadelphia: Elsevier; 2020.
18. Subhedar NV, Shaw NJ. Dopamine versus dobutamine for hypotensive preterm infants. Cochrane Database Syst Rev. 2003;(3):CD001242.
19. Skalina ME, Kliegman RM, Fanaroff AA. Epidemiology and management of severe symptomatic neonatal hypertension. Am J Perinatol. 1986;3(3):235-9.
20. Seliem WA, Falk MC, Shadbolt B, Kent AL. Antenatal and postnatal risk factors for neonatal hypertension and infant follow-up. Pediatr Nephrol. 2007;22(12):2081-7.
21. Dionne JM. Evidence-based guidelines for the management of hypertension in children with chronic kidney disease. Pediatr Nephrol. 2015;30(11):1919-27.
22. Nair S, Ahluwalia J, Jain S, Kumar P, Bhalla AK. Blood pressure in neonates: normative data from a cohort from North India. Indian Pediatr. 2014;51(8):631-5.
23. Joshi R, Kumar P, Kumar R, Bhalla AK. Non-invasive blood pressure norms in term neonates. Indian Pediatr. 2014;51(4):297-9.
24. Bhatt-Mehta V, Nahata MC. Dopamine and dobutamine in pediatric therapy. Pharmacotherapy. 1989;9(5):303-14.
25. Tufro-McReddie A, Gomez RA. Ontogeny of the renin-angiotensin system. Semin Nephrol. 1993;13(5):519-30.
26. Radha, Narayan J, Nishna, Jain AK. Normative blood pressure values in healthy Indian neonates and comparison between upper limb and lower limb blood pressures. Int J Pharm Clin Res. 2023;15(6):1019-24.
27. Sweet DG, Carnielli VP, Greisen G, Hallman M, Ozek E, Te Pas A, et al. European Consensus Guidelines on the Management of Respiratory Distress Syndrome: 2022 Update. Neonatology. 2023;120(1):3-23.
28. Gomella TL, Eyal FG, Bany-Mohammed F. Gomella's Neonatology: Management, Procedures, On-Call Problems, Diseases,

and Drugs. 8th ed. New York: McGraw-Hill Education; 2020.
29. Dempsey EM, Barrington KJ. Evaluation and treatment of hypotension in the preterm infant. Clin Perinatol. 2009;36(1):75-85.
30. Papile LA, Munsick-Bruno G, Schaefer A. Relationship of cerebral intraventricular hemorrhage and early childhood neurologic handicaps. J Pediatr. 1983;103(2):273-7.
31. Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in blood pressure among children and adolescents. JAMA. 2004;291(17):2107-13.
32. Eriksson JG, Forsén T, Tuomilehto J, Osmond C, Barker DJ. Early growth and coronary heart disease in later life: longitudinal study. BMJ. 2001;322(7292):949-53.
33. Law CM, de Swiet M, Osmond C, Fayers PM, Barker DJ, Cruddas AM, et al. Initiation of hypertension in utero and its amplification throughout life. BMJ. 1993;306(6869):24-7.
34. Stark AR; American Academy of Pediatrics Committee on Fetus and Newborn. Levels of neonatal care. Pediatrics. 2004;114(5):1341-7.
35. Matsuoka OT, Pinheiro AC, Pascuas DZP, Leone CR. Evolution of arterial blood pressure levels during the neonatal period in appropriate for gestational age term newborns. J Pediatr (Rio J). 1996;72(3):155-8.
36. Tin W, Milligan DW, Pennefather P, Hey E. Pulse oximetry, severe retinopathy, and outcome at one year in babies of less than 28 weeks gestation. Arch Dis Child Fetal Neonatal Ed. 2001;84(2):F106-10.
37. van der Hoeven MA, Wijnberger LD, Houben AJ, Blanco CE. Comparison of arm and calf blood pressure measurement during the first days of life in healthy term neonates. Acta Paediatr. 1999;88(9):1030-4.
38. Samanta M, Mondal R, Ray S, Sabui T, Kundu C, Hazra A, et al. Blood pressure variation with gestational age and birth weight in Indian newborn. J Trop Pediatr. 2015;61(3):197-205.
39. Versmold HT, Kitterman JA, Phibbs RH, Gregory GA, Tooley WH. Aortic blood pressure during the first 12 hours of life in infants with birth weight 610 to 4,220 grams. Pediatrics. 1981;67(5):607-13.
40. Cunningham S, Symon AG, Elton RA, Zhu C, McIntosh N. Intra-arterial blood pressure reference ranges, death and morbidity in very low birthweight infants during the first seven days of life. Early Hum Dev. 1999;56(2-3):151-65.
41. Kent AL, Kecskes Z, Shadbolt B, Falk MC. Normative blood pressure data in the early neonatal period. Pediatr Nephrol. 2007;22(9):1335-41.
42. Cordero L, Timan CJ, Waters HH, Sachs LA. Mean arterial pressures during the first 24 hours of life in extremely low birth weight infants. J Perinatol. 2002;22(5):348-53.
43. Pejovic B, Peco-Antic A, Marinkovic-Eric J. Blood pressure in non-critically ill preterm and full-term neonates. Pediatr Nephrol. 2007;22(2):249-57.
44. Agata Y, Hiraishi S, Oguchi K, Misawa H, Horiguchi Y, Fujino N, et al. Changes in left ventricular output from fetal to early neonatal life. J Pediatr. 1991;119(3):441-5.
45. Soothill P, Nicolaides KH, Bilardo CM, Campbell S. Relation of fetal hypoxia in growth retardation to the onset of fetal heart rate abnormalities. BMJ. 1987;294(6576):786-7.
46. Barker DJ, Osmond C, Golding J, Kuh D, Wadsworth ME. Growth in utero, blood pressure in childhood and adult life, and mortality from cardiovascular disease. BMJ. 1989;298(66*073):564-7.