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Original research article

Distribution of blood pressure and selected clinico-epidemiological correlate among normal newborns in a tertiary care health centre in South India

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Abstract

Background: BP monitoring is mandatory in all newborns to find out the cardiac as well as renal diseases. Premature infants have a limited ability to auto regulate cerebral blood flow when compared to full-term infants and hypotension is a major concern in them. Measures should be taken to detect neonatal hypotension and hypertension as earlier as possible and thereby they can be managed well.
Aim: To determine the normative distribution of blood pressure in healthy newborns in the tertiary care setting in 1st 48 hours of life. To find out the factors affecting blood pressure in healthy newborn and to find out relationship between blood pressure distribution and anthropometric measurements of neonates.
Materials and Methods
Study design: This is a descriptive cross sectional study was conducted in the post-natal ward of DR.SMCSI Medical College Hospital, Karakonam, Kerala, India.
Study population: Newborns in the postnatal ward after physical examination including modified Ballard assessment and APGAR score at 1 and 5 minutes were selected for the study.
Study size: Study consisted of 400 Newborn.
Study tools and Data collection procedure: Blood pressure measurements were taken at age 0–24 hours and 25-48 hours, three times at five minutes interval to get average values. BP measurement was performed with the neonate in the supine position, either awake or quiet or during sleep. The newborn was left for 10-15 min after the application of appropriate size cuff to the right arm to ensure quietness [12]. The automatic cuff inflation and deflation by the instrument rendered display of the BP values (systolic, diastolic and MAP) on the screen. Values are disregarded if any movement occurred during the measurement. The entire procedure was repeated twice as a standardization procedure for deriving on a single valid measurement. Weights of infants were measured by placing the baby naked on an infant's weighing scale and length of the newborn was measured using an Infantometer.
Results: The mean SBP, DBP and MAP for term babies in the first 24 hours of life were 70.7±14 mmHg, 39.1±11 mmHg and 49.6±11 mmHg respectively. For preterm, the corresponding values were 70.1±21 mmHg, 36.5±12 mmHg and 47.7±13.8 mmHg respectively. A significant positive correlation (p value<0.05) was observed between heart rate and blood pressure values of newborns both at 0-24 and 25-48 hours of life.
Conclusion: The normative distribution of mean arterial pressure in the term neonates in the first 48 hours of life was 49±9 mmHg. The normative distribution of mean arterial pressure in the preterm neonates in the first 48 hours of life was 47±13 mmHg. All three parameters (SBP, DBP, and MAP) were lower in preterm neonates compared to term neonates. DBP and MAP values significantly rose with increase in the birth weight of neonates at 0- 24 hours. Blood pressure values of neonates are also influenced by gestational diabetes mellitus and use of antenatal steroid. Maternal age and maternal BMI were found to have a significant influence in the blood pressure values of their babies.
Keywords: Neonatal Hypotension, Neonatal hypertension, Systolic Blood Pressure, Diastolic Blood

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Pressure, Mean Arterial Pressure.

Introduction

Blood pressure (BP), being a reflection of hemodynamic variables is an important vital sign and an indicator of vital stability [1]. Owing to the relatively low incidence of hypertension in the pediatric age group, routine BP measurement is not usually observed in the paediatric practice especially in the well newborn [2]. Blood pressure measurement is very important in assessing the cardiovascular status of the newborn as well as the fetal origin of the cardiovascular and metabolic diseases in adulthood [3-4]

Blood pressure (BP) among newborn infants varies considerably in the immediate postnatal period and hence the accurate measurement of BP is essential for the optimal management of the sick neonates thereby ensuring optimal provision of hemodynamic support in the immediate postnatal period. Since the etiology of essential hypertension in adults is not known and it is impossible to pinpoint accurately the onset of this disease, it is logical to examine early in life those factors that relate to BP. Several studies in adults have suggested that blood pressures in the third and fourth decades are predictive of BP in later life, and these observations have been extended into childhood [5-6]. Hence it is necessary to have more appropriate reference values for blood pressure of newborns.

Our intensive search of literature rendered less data about blood pressure readings in normal neonates in Kerala and hence it is assumed that there is a paucity of data on normative distribution of blood pressure in term neonates in our setting. Such data will be very useful to the neonatologist who is facing with either hyper or hypotension in a neonate. The current study is aimed to determine the distribution of BP values in apparently healthy term newborns within the first 48 hours of life and to determine factors affecting BP at birth. Even though more accurate, invasive BP monitoring is associated with complications such as infection, vasospasm and thrombus formation [7-9], non-invasive methods are opted for the measurement of blood pressure in the current study and are shown to be reliable and consistent if conducted under standardized conditions [10]. Also, an attempt was made to find the correlation between blood pressure distribution and anthropometric parameters like birth weight, length and head circumference in neonates.

Materials and Methods

The current descriptive cross sectional study was conducted in the post-natal ward of DR.SMCSI Medical College Hospital, Karakonam, Kerala, India. The study was approved by Institutional Human Ethics Committee on 13.12.2015 (No. SMCSIMCH/EC(PHARM)37/2015).

Study population

Inclusion criteria: 400 newborns in the postnatal ward after physical examination including modified Ballard assessment and APGAR score at 1 and 5 minutes were selected for the study.

Exclusion criteria: Ill and asphyxiated babies, very sick neonates and newborns on ventilator were excluded from the study.

Collection of Primary Data

Consents were obtained from the parents of the newborns enrolled for the study. Data regarding maternal factors were obtained by one-to-one interview as well as questionnaire methods.

Anthropometry of infant

Weights of infants were measured by placing the baby naked on an infant's weighing scale (sensitivity − 0.05 kg) which was checked for zero error before and after each reading. Length of the newborn was measured using an Infantometer.

Measurement of blood pressure

The infant's arm circumference was measured at the midpoint of the limb (between olecranon and acromion processes) and an appropriately sized cuff was chosen accordingly by ensuring the ratio of the cuff width to arm circumference should lie between 0.45 and 0.70 [11].

Blood pressure measurements were taken at age 0-24 hours and 25-48 hours, three times at five minutes interval to get average values. BP measurement was performed with the neonate in the supine position, either awake or quiet or during sleep. The newborn was left for 10-15 min after the application of appropriate size cuff to the right arm to ensure quietness [12]. The automatic cuff inflation and deflation by the instrument rendered display of the BP values (systolic, diastolic and MAP) on the screen. Values are disregarded if any movement occurred during the measurement. The entire procedure was repeated twice as a standardization procedure for deriving on a single valid measurement.

Data Analysis

All data were entered in MS Excel and analyzed using Statistical Package for Social Sciences (SPSS)

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version 20. Descriptive statistics were used to compute frequency, percentile, mean and median of different variables followed by t- test or analysis of variance where ever applicable. BP measurements (systolic, diastolic, and MAP) were also correlated with postnatal age, heart rate, length, and head circumference of the neonates. A p value <0.05 is considered to be significant.

Results

Out of 400 study subjects, 337 were term babies which constitute 52.2% males and 47.8% females. 173 (51.3%) babies were delivered through spontaneous vertex delivery; 154 (45.7%) deliveries were by LSCS (lower segment caesarean section) and 10 (3%) deliveries by vacuum assisted vaginal delivery. Maternal ages of the term babies were in between 21and 30 years with mean maternal age being 25.8+3.6 years.

Out of sixty-three preterm babies, thirty-five babies were males and twenty-eight babies were females. 18 were delivered through spontaneous vertex delivery; 43deliveries were by LSCS and 2 were by vacuum assisted vaginal delivery. The mean SBP, DBP and MAP for term babies in the first 24 hours of life were 70.7±14 mmHg, 39.1±11 mmHg and 49.6±11 mmHg respectively. For preterm, the corresponding values were 70.1±21 mmHg, 36.5±12 mmHg and 47.7±13.8 mmHg respectively. (Table: 1) No significant statistical differences were observed between BP readings of term and preterm babies at 24 hours after their birth. Similarly, there were no significant statistical differences between the BP values of term and preterm neonates at 48hrs of their life.

Table 1: The normative distribution of blood pressure in newborns at first two days of their life

Gestational Age (Hrs)	Blood Pressure (mmHg)	Total Study subjects (*n*=400)	Term Neonates (*n*=337)	Preterm Neonates (*n*=63)	T	P
0-24 hrs	SBP	70.6±15.5	70.7±14	70.1±21	0.29	0.76
	DBP	38.7±11.9	39.1±11	36.5±12	1.57	0.11
	MAP	49.3±12.2	49.6±11.0	47.7±13.8	1.14	0.25
25-48 hrs	SBP	70.3±11.3	70.5±10	68.7±15	1.14	0.25
	DBP	38.9±9.4	39.1±9.4	38.1±9.4	0.78	0.43
	MAP	49.4±9.2	49.6±8.8	48.3±10	1.01	0.31

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure. All values are expressed as Mean ± SD.

The 5th, 50th, and 95th percentile of BP values at different gestational age of the study subjects were tabulated (Table: 2). In both term and preterm study population, the SBP values of 4 neonates were above 95th percentile between 0 and 24 hours of life and while 5 neonates from each section had SBP values above the 95th percentile by the 25-48 hours.

An attempt was made to correlate the blood pressure of the newborns with several parameters like their gestational age, post-natal age, sex, heart rate, mode of delivery, maternal age and maternal risk factors.

Table 2: Percentile distribution of blood pressure in neonates

Percentile	Blood Pressure (mmHg)											
	Term Neonates						Preterm Neonates					
	0-24hours			25-48hours			0-24hours			25-48hours		
	SBP	DBP	MAP	SBP	DBP	MAP	SBP	DBP	MAP	SBP	DBP	MAP
5th	52	24	36	56	30	40	38	14	23	42	20	28
25th	64	32	43	64	32	43	57	30	40	60	34	42
50th	69	36	46	70	36	46	68	34	44	66	36	46
75th	76	43	53	75	44	54	76	44	51	73	44	52
95th	108	59	74	90	58	66	129	61	77	108	59	73

There were no significant statistical differences observed in all three BP readings (SBP, DBP, and MAP) between the term and preterm babies at 0-24hrs and 24-48hrs. However, the mean values for all subjects irrespective of gestational age were observed as 70.6±15 mmHg (SBP), 38.7±11.9 mmHg (DBP), and 49.3±12.2 mmHg (MAP) at 0-24hrs and 70.3±11.3 mmHg (SBP), 38.9±9.4 mmHg (DBP), and 49.4±9.2 mmHg (MAP) at 24-48hrs. There is no difference between postnatal day first and second, but these values have significant positive correlation with BP (Table: 3). The mean SBP, DBP and MAP values of male and female term neonates didn't show any significant differences at the 24hrs and 48hrs of their life, while significant differences were observed between BP readings of preterm male and female newborns at 24hrs and 48hrs of their life.

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 01, 2023

Table 3: Correlation between mean blood pressure and postnatal age of study subjects

Blood pressure (mmHg)	Mean	Postnatal age (hours)		R	P
	Total (*n*=400)	0-24hours	25-48hours		
SBP	70.6±15.5	70.7±14	70.5±10	0.91	0.000
DBP	38.7±11.9	39.1±11	39.1±9.4	0.89	0.000
MAP	49.3±12.2	49.6±11.0	49.6±8.8	0.89	0.000

BP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure, R=Pearson's correlation coefficient; P=Level of Significance ($p \leq 0.05$).

Table 4: Correlation of mean blood pressure values of neonates with their mode of delivery

Postnatal age (Hours)		Mode of delivery		t	p
		NVD + ID (173+10)	LSCS (154)		
0-24hrs	SBP	71.4±14.6	69.9±13.8	0.94	0.3
	DBP	38.5±11.5	39.7±12.3	0.92	0.35
	MAP	49.5±11.6	49.8±12.3	-0.23	0.81
24-48hrs	SBP	71.1±10.6	69.9±10.1	1.123	0.262
	DBP	38.4±9.3	39.8±9.5	-1.311	0.191
	MAP	49.3±8.7	49.8±9.0	-0.488	0.626

There were no significant statistical differences observed between BP values of newborns born by Normal Vaginal Delivery (NVD) and lower segment Caesarean section (LSCS)(Table: 4). A significant positive correlation (p value<0.05) was observed between heart rate and blood pressure values of newborns both at 0-24 and 25-48 hours of life (Table:5). Statistically significant increases in the BP values (SBP, DBP and MAP) were noted with decrease in maternal age (Table 6). All three parameters of blood pressure of female babies were lower than that of male babies both at 0-24 hours and 25-48 hours of life (Table 7).

Table 5: Correlation of heart rate with the blood pressure parameters of neonates during first 48 hours of their life

Age of Neonates	BP Parameters	R	P
	Heart rate versus SBP	- 0.16	0.003
0-24 HOURS	Heart rate versus DBP	- 0.17	0.002
	Heart rate versus MAP	- 0.17	0.001
	Heart rate versus SBP	- 0.15	0.004
24- 48 HOURS	Heart rate versus DBP	- 0.20	0.000
	Heart rate versus MAP	- 0.20	0.000

Table 6: Effect of maternal age on the blood pressure values of newborns

Age of Neonates (Hours)	BP Parameters	Age of mothers (Years)			F	P
		<20yr (n=20)	21-30yr (n=350)	31-40yr (n=30)		
0-24 hours	SBP	81.3±28	70.3±14	67.0±8	5.68	0.004
	DBP	45.4±19	38.2±11.5	39.1±9.7	3.39	0.034
	MAP	57.3±22	48.9±11.6	48.4±8.7	4.59	0.011
25-48 hours	SBP	76.1±20	70.1±11.2	68±6.7	3.22	0.041
	DBP	45.4±14.6	38.4±8.9	40.9±9.6	6.01	0.003
	MAP	55.6±15	48.9±8.7	49.9±8	5.04	0.007

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure F=Analysis of variance; P=Level of significance ($p \leq 0.05$).

Table 7: Gender wise distribution of blood pressure at different post natal ages

Postnatal age (hours)		Mean	Gender of Neonates		t	P
		Total (*n*=337)	Males (*n*=176)	Females (*n*=161)		
Term babies 0-24 hours	SBP	70.7±14.3	69.3±13.1	72.2±15.4	−1.86	0.06
	DBP	39.1±11.8	38.6±11.1	39.6±12.7	−0.74	0.45
	MAP	49.6±11.9	48.8±11.0	50.4±12.8	−1.23	0.21
Term babies 25-48 hours	SBP	70.5±10.4	70.1±9.6	71.1±11.1	−0.92	0.35
	DBP	39.1±9.4	38.8±8.8	39.4±10.1	−0.56	0.57
	MAP	49.6±8.8	49.2±8.3	49.9±9.5	−0.76	0.44
Preterm babies	SBP	70.1±21.1	73.2±22.6	66.2±18.8	1.30	0.19
	DBP	36.5±12.4	38.6±11.1	39.6±12.7	2.88	0.00

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0-24 hours	MAP	47.7±13.5	48.8±11.0	50.4±12.8	2.30	0.02
Preterm babies	SBP	68.7±15.6	71.2±18.0	65.7±11.6	1.405	0.16
	DBP	38.1±9.4	40.8±10.4	34.7±6.7	2.65	0.01
25-48 hours	MAP	48.3±10.8	50.9±12.4	45.0±7.5	2.20	0.03

Table 8: Effect of maternal body mass index on the blood pressure values of their neonates

Age of Neonates (Hours)	BP Parameters	Body Mass Indices of Mothers (Kg/m^2)				F	P
		<18.5 kg/m^2 N=43	18.5-25 kg/m^2 N=259	26-30 kg/m^2 N=66	>30 kg/m^2 N= 32		
0-24 hrs	SBP	70.9±13	69.1±14	70.5±11	82.5±25	7.37	0.00
	DBP	39.5±12	37.9±11	39.4±10	41.8±15	1.21	0.30
	MAP	50±12	48.3±11	49.8±10	55.3±17	3.27	0.02
25-48 hrs	SBP	71.6±9	68.9±10	70.4±8.2	79.7±20	9.33	0.00
	DBP	39.7±9	37.8±8.8	41.6±9.4	41.6±12	4.11	0.007
	MAP	50.3±8.3	48.1±8.5	51.2±8.1	54.3±14	5.81	0.001

Maternal BMI could elicit a significant impact on the BP values of infants. BP values of neonates of obese mothers were significantly increased (Table 8). Among the 400 mothers 27 had gestational hypertension; but the current study couldn't correlate gestational hypertension and BP values of their respective newborns at their early 48 hours of life (Table 9) and 47 mothers had gestational diabetes mellitus, out of which 35 were on diet control 12 were under insulin therapy. Though there were increase in the BP values of newborns of diabetic mothers when compared to that of newborns of mothers under insulin therapy, the values were statistically not significant (Table: 10). Use of antenatal steroids could elicit significant increase in the BP values of newborns (Table: 11).

Table 9: Effect of gestational hypertension on neonatal blood pressure

Age of Neonates (Hours)	BP Parameters	BP Values of Mothers (mmHg)			t	P
	SBP	Total (*n*=400)	Normal (n=373)	Hypertensive (*n*=27)		
0-24 hrs		70.6±15.5	70.4±14	73.6±27	-1.04	0.54
	DBP	38.7±11.9	38.7±11	38.3±20	0.16	0.87
	MAP	49.3±12.2	49±11.3	50±21	-0.33	0.84
25-48 hrs	SBP	70.3±11.3	70.4±20	70±20	-0.47	0.97
	DBP	38.9±9.4	38.9±8.9	39±15	-0.09	0.95
	MAP	49.4±9.2	49.3±8.5	49.5±16.3	-0.89	0.96

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure, P=Level of significance ($p \leq 0.05$).

Table 10: Effect of gestational diabetes on the neonatal hypertension

Age of Neonates (Hours)	BP Parameters	BP Values of Mothers (mmHg)			t	P
		Normal (no=353)	Diabetic (n=47)			
			Diet controlled (n=35)	Insulin treated (n=12)		
0-24 hrs	SBP	70.3±16	73.6±8.3	70.9±12	0.84	0.49
	DBP	38.6±12	39.6±6.7	36.9±2.5	1.35*	0.05
	MAP	49.2±12	50.9±6.3	48.2±4.3	1.35	0.18
25-48 hrs	SBP	70±11	73.1±5.7	69.9±6.9	1.61	0.16
	DBP	38.7±9.7	41.0±7.3	38.5±2.7	1.13	0.10
	MAP	49.1±9.6	51.7±5.9	49.0±3.5	1.50	0.06

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure. * P=Level of significance ($P \leq 0.05$).

Table 11: Effect of use of antenatal steroids on the blood pressure values of their neonates

Age of Neonates (Hours)	BP Parameters	BP Values of Mothers (mmHg)			t	P
		Total (*n*=400)	Normal (n=389)	Under Steroid treatment (*n*=11)		
0-24 hrs	SBP	70.6±15.5	69.6±14	104±23	-7.85	0.001
	DBP	38.7±11.9	38.1±10.9	60±23	-6.25	0.012

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	MAP	49.3±12.2	48.6±11	74.8±22	-7.44	0.003
25-48 hrs	SBP	70.3±11.3	69.7±10.5	91.6±18	-6.62	0.003
	DBP	38.9±9.4	38.5±8.9	54.7±12.4	-5.84	0.001
	MAP	49.4±9.2	48.9±8.5	67±14	-6.77	0.002

A significant increase in SBP, DBP and MAP values were observed with increase in birth weight of the term babies at 0–24 hours, but the same results were not replicated at 2nd 24 hours of life (Table:12). In the case of preterm babies, only the SBP values were significantly increased at 0-24 hours of life (Table 13). The increases in the BP parameters with increase in the birth weights of the neonates at 24-48 hours were not statistically significant. There was also no statistically significant correlation between blood pressure and length of the baby while there was a positive correlation between head circumference of the baby and SBP at 0-24 hours of life(r=o.13, p=0.01) and there were no correlation between head circumference and SBP at 25-48 hours of life; DBP (0-24hrs and 25-48 hours) and MAP (0-24hrs and 25-48 hours) (Table 14).

Table 12: Correlation between birth weight and blood pressure values in term babies during first 48 hours of their life

Age of Neonates (Hours)	BP Parameters	Birth Weight of Term Neonates					F	P
		<1.5 kg N=2	1.5-2.5kg N=56	2.5-3kg N=119	3-3.5kg N=111	>3.5kg N=49		
0-24 hours	SBP	56	66.8±14.4	71.2±14.9	71.7±13.8	72.3±13.3	1.92	0.10
	DBP	27	35.9±13	40.2±12	40.7±12.0	36.6±7.1	2.91	0.02
	MAP	36	46±12.8	50.6±12.6	51.0±12.2	48.5±7.6	2.45	0.041
25-48 hours	SBP	80	68.8±9.4	70±11	71.5±9.8	70.7±10.3	1.19	0.31
	DBP	44	36±9.5	40.5±10.2	39.6±8.8	38.2±8.4	1.87	0.11
	MAP	56	47.2±8.6	50.1±9.6	50.3±8.6	49.1±7.3	1.61	0.16

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure, F=Analysis of variance; $P \leq 0.05$

Table 13: Correlation between birth weight and blood pressure values in preterm babies during first 48 hours of their life

Age of Neonates (Hours)	BP Parameters	Birth Weight of Term Neonates			F	P
		>2.5kg N=19	1.5-2.5kg N=42	<1.5kg N=2		
0-24 hours	SBP	81±20	64±20	73	4.56	0.01
	DBP	38.5±13	36.1±11.8	24	1.30	0.27
	MAP	52±15	45.7±13	40.3	2.10	0.13
25-48 hours	SBP	75.4±14	65.5±15	74	2.87	0.06
	DBP	39.0±12	37±8.1	44	0.72	0.48
	MAP	51±12.6	46±9.9	54	1.53	0.22

SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure, *F*=Analysis of variance; $p \leq 0.05$

Table 14: Correlation of head circumference with the blood pressure values of neonates

Age of neonates (Hours)		*R*	*P*
	HC versus SBP	0.13	0.01
(0-24 hrs)	HC versus DBP	0.06	0.22
	HC versus MAP	0.09	0.07
	HC versus SBP	0.10	0.06
(24-48 hrs)	HC versus DBP	0.04	0.45
	HC versus MAP	0.06	0.21

R=Pearson's correlation coefficient; *P*=Level of significance ($P \leq 0.05$). SBP=Systolic blood pressure; DBP=Diastolic blood pressure; MAP=Mean arterial pressure; BP=Blood pressure; HC=head circumference

Discussion

In the current study, the normative distributions of SBP, DBP, and MAP of the term neonates in the first 48 hours of life were 70.5±10 mmHg, 39±10 mmHg and 49.6±9 mmHg respectively and were higher than the findings of Nwokoye *et al.*, [13]. Maternal risk factors may account for these elevated blood pressures, and were excluded in their study.

The normative distributions of SBP, DBP, and MAP of the preterm neonates in the first 24 hours of life were 70±21 mmHg, 36±12 mmHg and 47±13 mmHg respectively. The mean values in the 24-48 hours of life were 68.7±15 mmHg, 38±9.4 mmHg and 48±13 mmHg respectively. However, all three parameters were lower in preterm neonates compared to term neonates. This result is analogous to the

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findings of Samanta *et al*., [14] in Indian neonates. The day wise increment in mean arterial pressure was also reported by Cunningham [15] *et al*., and Kent *et al*., [16]. BP of preterm babies continued to rise and stabilize by a post-conceptional age of 44-48 weeks [17].

Current study couldn't correlate gestational age with BP readings of neonates. Conflicts in results were observed among different studies. Hernández *et al*., [18] also reported absence of significant difference in Mean Blood Pressure in the first 3 days after birth was recorded between neonates born to pre-eclamptic mothers compared to normotensive mothers. In the light of identified studies, Rabe *et al*.,[19] also supports the uncertainty in the influence of BP reading of mothers in the BP values of their babies.

Similarly, the present study couldn't justify the insignificant increase in the BP values of newborns of diabetic mothers when compared to that of newborns of mothers under insulin therapy. In contrast to this Kent *et al*., [16] reported no difference in SBP, DBP or MBP at 14 days post-delivery between term neonates born to mothers with diabetes compared with healthy mothers. At the same time, significantly higher BP readings for preterm neonates born to diabetic mothers were observed at 28 days for SBP. A significant increase in the neonatal BP values with respect to maternal BMI was noted in the present study. Very few studies show the association of maternal BMI and neonatal BP in early life. In a cohort of 473 Nigerian infants [20], the mean SBP of infants of mothers with BMI < 30 was reported to be significantly lower than that of infants whose mothers had BMI > 30 ($p = 0.031$). Even in the absence of hypertension or diabetic mellitus, neonates of obese mothers are at increased risk for hypoxic ischemic encephalopathy, sepsis, and needing hypothermia treatment [21]. The current study also supports the increase in the BP values of newborns with the use of antenatal steroids.

A significant increase in SBP, DBP and MAP values were observed with increase in birth weight of the term babies at 0–24 hours and in the case of preterm babies, only the SBP values were significantly increased at 0-24 hours of life and this findings well correlate with the findings of Park *et al*., [3], and Nwokoye *et al*., [13] suggesting that term birth weight is a significant determinant of SBP. Rise in SBP with increasing birth weight at first 24 hours of life was also reported by Rosner *et al*.,, Nuntnarumit P, Yang W *et al*., Alves *et al*., [22-24].

In contrast to the report of Hulman *et al*., in USA [1] and Zubrow *et al*., and Tan *et al*., [25-26] in Singapore, the findings of the current study did not support of increasing trend of BP values in the first two days of the life of neonates. Similar results were also reported in Boston cohort [27].

It was observed that irrespective of weight of the neonates, SBP, DBP, and MAP for females were higher than that of the males in the first 48 hours of life, This finding was supported by Gemelli *et al*., [28] who also noted that females have higher BP values in the 1st days of life suggesting that sex might have some influence on neonatal BP. However, these differences in mean BP values between males and females were not found to be statistically significant. Similar findings have been documented by Nigerian study and other studies. [28, 20] From this, it may be seen that normative values can be used interchangeably for both males and females for term babies. In contrast, blood pressure values for female preterm neonates were found to be significantly lower than that of males at the first 48 hours of life. It was in contrast to the findings of Harlan *et al*., [5] where the sex of the baby had no significant role in the BP values.

The present study also supports finding of insignificant association between mode of delivery and blood pressure parameters by Nascimento *et al*., and Earley *et al*.,. [29-30]. Higher values of SBP in normal vaginal delivered infants when compared to that in caesarean delivered infants found in the study may be due to increased catecholamine concentrations and cord blood arginine vasopressin and adrenocorticotrophin hormone levels. [31-32]. similarly, length and head circumference of the baby had no significant correlation with blood pressure. This finding was supported by the study done by Matthew *et al*., [33]. The positive significant correlation of increased BP parameters with increased heart rate suggesting higher heart rate leads to higher blood pressure. These findings well match up to the findings of Petkins *et al*., [34].

Not much information is available about the parameters which influence the blood pressure values of healthy neonates while that of sick neonates were extensively studied [34]. In the developing countries, including India, the major preventable causes of neonatal mortality are neonatal sepsis and shock and can be managed by prompt and judicious use of fluid & inotropes, guided by adequate BP recordings. The Neonatal period, being the most vulnerable time of a child; a sick neonate needs constant monitoring of various parameters which includes blood pressure. Hence it is necessary to undertake extensive epidemiological researches to bring about a normogram depicting the blood pressure values. Mothers who were younger and who have associated co-morbidities can be identified from the history and the neonates can be monitored serially by using the given BP parameters to reduce the Neonatal Mortality and Morbidity. The data derived from this study can be used to diagnose hypotension and hypertension in the regional geographic area and monitor blood pressure of sick neonates.

Limitations

The limitations of the study include small sample size for preterm neonates when compared to term neonates. All sick newborns were excluded while maternal risk factors were not excluded.

Conclusion

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In the analysis of blood pressure values of 337 term healthy neonates and 63 preterm healthy neonates, the normative distribution of mean arterial pressure in the term and preterm neonates in the first 48 hours of life were 49±9 mmHg and 47±13 mmHg respectively. All three parameters (SBP, DBP, and MAP) were lower in preterm neonates compared to term neonates. DBP and MAP values significantly rose with increase in the birth weight of neonates at 0- 24 hours. Blood pressure values of neonates are also influenced by gestational diabetes mellitus and use of antenatal steroid. Maternal age and maternal BMI were found to have a significant influence in the blood pressure values of their babies.

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