

## **A Study of Normative Blood Pressure Values in Healthy Indian Neonates and Comparison Between Upper Limb and Lower Limb Blood Pressures**

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### **Abstract:**

**Objective:** To provide current normative BP values for healthy neonates without any confounding maternal or neonatal factors during the first week of life using an oscillometric method and to compare BP recordings between upper limb and lower limb.

**Study design:** Hospital based prospective longitudinal study.

**Setting:** Neonatal unit of a tertiary care teaching hospital in north India between December 2021 and December 2022.

**Participants:** 400 healthy neonates with gestational age between 34 and 41 weeks and birth weight between 1500 g and 4000 g were enrolled in the study. Neonates with congenital anomalies, sick neonates requiring intensive care, mothers with hypertension, gestational diabetes or substance use were excluded from the study.

**Procedure:** For all neonates, four limb BP (SBP, DBP and MBP) was measured at four time points i.e., within 1<sup>st</sup> hour of birth, at 24 hours, at 48 hours and on 7<sup>th</sup> postnatal day by oscillometric method.

**Results:** Normative BP charts (including 5<sup>th</sup>, 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, 95<sup>th</sup>, 99<sup>th</sup> percentile values) were developed based on the gestational age. SBP, DBP and MBP values increased with birth weight, gestational age, and postnatal age. SBP, DBP and MBP recordings were significantly higher in upper limbs as compared to lower limbs. However, there was no difference in BP recordings between male and female.

**Conclusion:** This study provides normative BP charts as well as gestational age wise percentile charts of BP values in healthy term and preterm neonates without any neonatal or maternal confounding factors which is helpful in the definition of hypotension and hypertension in this population.

**Keywords:** blood pressure, neonate, percentile, normative.

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## Introduction

Neonates can develop hypotension or hypertension requiring early detection and

careful management as it can lead to both short-term and long-term problems [1].

**Table 1: Oscillometric neonatal blood pressure recordings stratified by gestational age (Weeks) at birth**

Week	BP %	1 hour			24 hours			48 hours			7 days		
		SBP	DBP	MAP	SBP	DBP	MAP	SBP	DBP	MAP	SBP	DBP	MAP
34	5	51	30	37	53	31	39	56	33	41	59	35	43
	10	51	30	37	53	31	39	57	33	41	59	35	43
	25	51	30	37	54	31	39	57	33	41	59	35	43
	50	53	32	39	56	33	41	59	35	43	60	35	43
	75	53	32	39	58	34	43	61	38	46	63	42	50
	90	56	36	41	58	38	46	62	41	47	68	47	54
	95	57	38	43	58	40	49	66	44	51	68	48	55
35	5	51	33	40	54	34	41	57	33	41	60	35	43
	10	52	33	40	54	34	41	57	33	41	60	35	43
	25	54	33	40	56	35	41	57	36	44	61	38	46
	50	55	34	41	58	36	43	61	37	45	65	39	48
	75	55	35	42	58	37	44	61	39	46	65	41	49
	90	56	38	43	59	40	45	62	44	49	68	47	52
	95	56	39	43	59	42	48	63	44	50	70	47	55
36	5	55	36	42	58	37	44	60	38	46	65	40	48
	10	55	36	43	58	37	44	61	38	46	65	40	48
	25	56	36	43	58	38	45	63	40	47	67	42	50
	50	57	37	44	60	39	46	64	41	49	68	44	53
	75	58	38	45	60	40	47	69	42	50	73	45	54
	90	62	41	47	64	42	48	69	44	52	73	48	55
	95	64	42	48	66	44	52	70	47	55	75	51	59
37	5	58	39	46	62	40	48	65	41	49	65	42	51
	10	61	39	46	62	40	48	66	41	49	65	42	51
	25	61	39	46	63	40	48	66	41	49	65	42	51
	50	62	40	47	65	42	50	68	43	51	69	44	53
	75	62	41	48	66	43	51	69	46	54	71	48	54
	90	63	41	48	66	43	51	69	47	54	71	50	57
	95	63	42	48	66	44	51	69	47	54	72	52	58
38	5	59	37	44	61	40	47	64	42	50	72	44	53
	10	61	40	48	62	42	50	69	43	52	72	45	54
	25	64	41	49	67	42	50	70	45	54	73	47	55
	50	65	42	50	68	44	52	70	47	55	75	49	58
	75	65	43	51	68	44	52	71	47	55	75	49	58
	90	66	43	51	69	46	53	72	49	57	76	54	61
	95	66	44	51	70	46	53	72	50	57	76	55	62
39	5	65	35	45	67	37	47	70	41	51	72	46	55
	10	65	39	47	67	43	51	70	45	54	74	49	57
	25	67	44	52	70	46	54	72	48	56	75	52	60
	50	68	45	53	71	46	54	73	49	57	76	52	60
	75	69	46	54	72	47	55	74	50	58	79	53	60
	90	69	47	54	72	49	56	76	52	60	79	56	63
	95	69	47	54	72	50	56	76	52	60	80	56	64
40	5	64	38	47	67	40	48	69	43	52	74	45	56

	10	66	39	47	68	41	50	72	44	53	76	48	56
	25	68	46	54	72	47	55	75	49	58	78	51	56
	50	70	47	55	73	49	57	76	50	59	79	53	56
	75	71	48	56	74	49	58	77	51	60	80	53	57
	90	71	49	56	74	50	58	77	52	60	80	56	64
	95	71	49	56	74	51	58	78	53	61	81	57	65
41	5	67	38	48	68	40	47	70	44	53	74	46	56
	10	69	45	53	68	44	51	70	45	53	74	46	56
	25	71	49	56	68	47	54	70	46	54	74	47	56
	50	71	49	56	68	47	54	70	46	54	74	47	56
	75	71	49	56	70	48	55	72	47	55	77	48	57
	90	73	51	58	76	52	60	79	53	62	82	55	64
	95	74	52	59	77	53	61	80	54	63	83	56	65

Blood pressure (BP) increases with gestational age, postnatal age, and birth weight [2]. There is paucity of normative data of BP in Indian healthy neonates without any confounding maternal or neonatal factors. The invasive BP measurement method is highly accurate however, it has been associated with infection, arterial spasm, or thrombus formation [3]. Although there is some controversy regarding the accuracy of the oscillometric method, it has been shown to correlate more closely with intra-arterial measurements than the sphygmomanometer [4,5]. Major limitations of normative BP studies include small sample size, retrospective design and infrequent measurements for few hours after birth. This study was planned to provide current normative BP values for healthy neonates without any confounding maternal or neonatal factors during the first week of life using an oscillometric method.

### Methods

This hospital based prospective longitudinal study was conducted on healthy term and preterm neonates born at a tertiary care teaching facility between December 2021 and December 2022. Ethical approval was obtained from the institute ethics committee.

After obtaining parental consent, healthy neonates with gestational age between 34 and 41 weeks and birth weight between 1500 g and 4000 g were enrolled in the

study. Neonates with congenital anomalies, sick neonates requiring intensive care, mothers with hypertension, gestational diabetes or substance use were excluded from the study. However, healthy preterm neonates with birth weight more than 1500 g requiring intensive care admission only for the establishment of enteral feeding were included. Healthy neonates with abnormal BP as per the existing guidelines and attribution to a cause after evaluation were also excluded.

All neonates underwent examination based on a study proforma including physical examination and anthropometric measurements. Gestational age was determined either from the last menstrual period dates or by new Ballard score if the dates were not known. For all neonates, BP was measured at four time points i.e., within 1<sup>st</sup> hour of birth, at 24 hours, at 48 hours and on 7<sup>th</sup> postnatal day. Mother was asked to come for follow-up on 7<sup>th</sup> postnatal day in case of early discharge. BP was measured by a validated multi-para monitor (Schiller multi-para Truscope ultra Q7 monitor®) by oscillometric method. Disposable infant BP cuffs (sizes 6-11 cm, 4-6 cm, and 1-4 cm) were used. The smallest cuff size that covered at least two-thirds of the limb length and encompassed the entire limb circumference were selected for measurements. The investigator performed

all BP measurements using a standardized protocol. The average of three successive systolic BP (SBP), diastolic BP (DBP) and mean BP (MBP) readings, rounded off to nearest mm of Hg taken at 2 minutes interval was recorded for further analysis.

IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, N.Y., USA) was used for the analysis. Independent t test was used to compare means between the

**Table 2: Oscillometric neonatal blood pressure recordings stratified by gestational status and comparison between right upper limb and right lower limb**

Site		1 hour			24 hours			48 hours			7 days			
		SBP	DB P	MB P	SB P	DB P	MB P	SB P	DB P	MB P	SB P	DB P	M BP	
RUL	Pret erm	Mean	56	35	42	58	37	44	62	39	47	66	41	49
		SD	3	3	3	3	3	3	3	4	3	5	4	4
		Median	55	36	43	58	37	44	61	39	46	65	42	50
	Ter m	Mean	66	44	51	69	45	53	71	47	55	75	49	58
		SD	4	4	4	4	3	3	4	3	3	4	4	4
		Median	67	44	52	68	46	53	71	47	55	75	50	58
RLL	Pret erm	Mean	52	33	40	55	35	42	58	37	44	58	37	44
		SD	5	4	4	5	4	4	5	5	5	5	5	5
		Median	52	34	40	55	35	42	58	38	45	58	38	45
	Ter m	Mean	63	42	49	67	44	51	69	46	54	69	46	54
		SD	5	4	5	5	4	4	5	5	5	5	5	5
		Median	64	42	48	67	44	51	69	46	54	69	46	54

two groups. Pearson's correlation was used to find the correlation between two continuous variables.

### Results

A total of 400 neonates were included in the study. There was female preponderance (218 females (54.6%) and 182 males; Female: Male ratio = 1.20). The gestational age ranged from 34 weeks to 41 weeks. There were 136 preterm neonates (<37 weeks; 34%) and 264 term neonates (≥37 weeks; 66%).

Mean gestational age was 37 weeks (SD=2). Mean birth weight was 2619 gram (SD=385).

The BP recordings within the 1st hour, at 24 hours, at 48 hours and on 7<sup>th</sup> postnatal day have been displayed in table I.

Blood pressure recordings were significantly lower in preterm as compared to term neonates (all p values <0.001) at each time point of examination. There was no statistically significant difference in mean SBP, DBP and MAP recordings between males and females.

Mean SBP, DBP and MBP recordings were increasing as birth weight increased (all p values <0.001). Similarly, mean SBP, DBP and MBP recordings increased as gestational age progressed (all p values <0.001).

Mean SBP, DBP and MBP recordings were significantly higher in upper limbs as compared to lower limbs (all p values <0.001) (table II). Thirteen neonates had a difference of more than 20 mm of Hg in systolic BP. All these 13 neonates had normal echocardiography.

RUL: right upper limb, RLL: right lower limb, SD: standard deviation

## Discussion

This study provides current normative BP values for healthy neonates without any confounding maternal or neonatal factors during the first week of life using an oscillometric method.

In the current study, blood pressure recordings were significantly lower in preterm as compared to term neonates (all p values <0.001) at each time point of examination. There was no statistically significant difference in mean SBP, DBP and MAP recordings between males and females. Samanta et al reported similar results as SBP, DBP and MAP showed a steady rise from day 4 to day 14, and were comparable between males and females, but were significantly lower in preterm than in term neonates [6]. The day wise increment in MAP as seen in our study was also reported by Cunningham, et al [7].

Similar trend of increase in BP associated with advancing birth weight, gestational age and postnatal age has been reported in various studies [8,9]. The relation between weight, gestation, and blood pressure at birth has been reported before [10]. A progressive rise in systolic pressure during the first week of life in the very preterm baby has also been documented in some [10,11], but not all [12], previous studies.

The association between advancing birth weight, gestational age, and postnatal age and increases in BP is not understood completely. A discussion of the complex neural, hormonal, and vascular mechanisms that control BP is beyond the scope of this

article, but their maturation is a significant consideration.

There was significant difference in SBP, DBP and MBP between upper limb and lower limb (mean difference of 2.4 mm of Hg in MBP). Comparison of upper and lower limb blood pressure (BP) is recommended by standard paediatric cardiology textbooks to aid the clinical diagnosis of coarctation of the aorta (CoA) [13]. A BP 20 mm Hg higher in the arms than in the legs in neonates with CoA or interrupted aortic arch is widely reported, although there is concern about the possibility of false negative testing [14,15]. A total of 13 neonates had difference of more than 20 mm of Hg between upper and lower limbs. However, all these neonates had normal echocardiography.

Normative BP values for healthy neonates without any confounding maternal or neonatal factors during the first week of life, oscillometric method of BP measurement and comparison of BP values between four limbs were strengths of the current study. Small sample size and non-inclusion of preterm infants less than 34 weeks of gestation were the limitations.

## Conclusions

This study provides normative BP values for healthy neonates up to one week of age. Blood pressure recordings were significantly lower in preterm as compared to term neonates at each time point of examination. SBP, DBP and MBP recordings were increasing as birth weight, gestational age and postnatal age increased. Mean SBP, DBP and MBP recordings were significantly higher in upper limbs as compared to lower limbs. However, there was no difference in BP recordings between male and female.

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