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Original Article

Blood Pressure Trends and Influencing Factors in the First Week of Life: A Prospective Study in Healthy Term Turkish Newborns

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ABSTRACT

Aim: To establish descriptive reference blood pressure (BP) values in healthy full-term Turkish newborns during the first seven postnatal days and to identify associated perinatal factors.

Materials and Methods: In this prospective observational study (April-September 2012), 419 healthy term newborns (≥37 weeks of gestation) underwent daily BP measurement using the oscillometric method. Exclusion criteria included neonatal intensive care unit admission, low 5th minute Apgar scores (<7), congenital anomalies, maternal pregnancy complications, or chronic disease.

Results: The newborns' mean birth weight, length, and gestational age were 3,302±398 g, 48.95±1.9 cm, and 39.28±1.19 weeks, respectively. The mean BP increased significantly from Day 1 to Days 5-7 (48.10±7.35 mmHg → 59.23±6.79 mmHg; p<0.0001). Sex and parity were not associated with BP. Caesarean delivery was linked to lower Day 1 BP. Birth length, the five-minute Apgar score, and maternal systolic BP were positively correlated with Day 1 BP, although correlation coefficients indicated weak associations (r<0.3).

Conclusion: This study provides descriptive early postnatal BP values for healthy Turkish newborns. Maternal BP, neonatal length, and Apgar score influence first-day BP, but their clinical relevance is limited due to weak correlations and the low explanatory power of regression models.

Keywords: Newborn, blood pressure, reference range, perinatal factors, term infants, Turkey

Introduction

Blood pressure (BP) monitoring plays a critical role in the management of sick newborns, both for detecting hypotension and recognizing hypertension. Accurate interpretation requires knowledge of normal BP values stratified by gestational age, postnatal age, sex, race/ethnicity, and other relevant factors (1,2).

Historically, various methods have been used to assess BP in newborns (3). Currently, oscillometric devices are the most commonly employed non-invasive method in neonatal units. However, intrinsic and extrinsic factors, such as software miscalculations, incorrect cuff size, and movement artefacts, may affect accuracy. In order to minimize these errors, several guidelines have been published (4,5).

Most neonatal reference ranges reported in textbooks are derived from the multicenter study by Zubrow et al.

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(6), which used oscillometric measurements. That study included neonatal intensive care unit (NICU) patients across a wide range of gestational ages, potentially influencing the reported values. In order to reduce such bias, subsequent investigators focused on healthy, term newborns in well-baby nurseries (7,8).

Compared with adults and older children, percentile curves for neonatal BP remain scarce. This may reflect the rarity of cardiovascular disease in the newborn period or historical limitations in measurement techniques. An increasing recognition that adult cardiovascular diseases may have origins in early life, or even in the fetal period, has shifted attention toward the neonatal stage (9). Careful evaluation of BP, one of the earliest parameters affected by a newborn's health status, allows for the early detection and management of septic, metabolic, or hemodynamic disturbances.

To date, no study has established reference BP values specifically for healthy term Turkish newborns. Previous reports from Türkiye have focused on NICU populations or preterm infants, limiting their applicability to healthy infants (10,11). The aim of the present study was therefore to provide descriptive BP values in healthy Turkish term newborns during the first seven postnatal days, to compare these values with previously published international data, and to examine the influence of perinatal factors on early postnatal BP.

Materials and Methods

Study Population

This prospective observational study was conducted between April and September 2012 at a tertiary hospital. A total of 419 healthy term newborns (≥37 weeks of gestation) were consecutively recruited. Ethical approval was obtained from the University of Health Sciences Türkiye, Şişli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee (approval no.: 33, date: 10.04.2012), and informed parental consent was secured. Exclusion criteria included maternal chronic or acute diseases, pregnancy complications, congenital anomalies, NICU admission, low 5th minute Apgar scores (<7), low birth weight (<2,500 g), fetal malnutrition (CAN score <26), or non-Turkish ethnicity.

Data Collection

Demographic and perinatal data were obtained from medical records and parental interviews. Variables included infant sex, gestational age, birth weight, birth length, Apgar scores, and maternal characteristics. Maternal weight was measured with a digital scale, and BP was assessed by the auscultatory method.

Blood Pressure Measurements

Neonatal BP was measured using an oscillometric device (DRÄGER Siemens SC 6002 XL, Siemens Co., NY, USA), calibrated according to manufacturer's recommendations. The first BP measurement was performed 12-24 hours after birth, followed by daily measurements between 9:00 AM and 12:00 PM while the infants remained hospitalized. After discharge, additional measurements were obtained during routine outpatient follow-up visits within the first week. The measurements were obtained while the infant was quietly awake or asleep, at least one hour after feeding, using the right upper arm. Cuff size was selected so that the inflatable bladder width was at least 40% of the mid-arm circumference and its length covered 80-100% of the arm circumference (3). Each measurement was repeated three times, and the average was used for analysis.

Statistical Analysis

Analyses were performed using NCSS 2007 (Number Cruncher Statistical System, Utah, USA). Continuous variables are expressed as mean ± standard deviation, median, and range; categorical variables as counts and percentages. Percentiles for systolic, diastolic, and mean BP (SBP, DBP, MBP) were calculated for each day.

Days 5-7 were combined due to the small number of infants measured on each of these days in order to ensure a sufficient sample size for statistical analysis. Repeated measurements were analyzed with paired variance analysis, and subgroup comparisons were made using the Newman-Keuls multiple comparison test. Independent t-tests were used to compare two continuous variables and chi-square tests were used for categorical variables. Correlations were assessed using Pearson's correlation coefficient. Multivariate linear regression analysis was performed in order to identify independent predictors of neonatal BP. Statistical significance was defined as $p<0.05$.

Results

A total of 419 healthy term newborns were enrolled. The number of infants with valid BP measurements declined from Day 1 to Days 5-7 (Figure 1) (401, 287, 169, 85, and 100, respectively). Baseline demographic and maternal characteristics are summarized in Table I. The mean gestational age was 39.3±1.2 weeks, and 51.3% of the infants were male. The mean birth weight and length were 3,302.2±397.8 g and 49.0±1.9 cm, respectively. Cesarean delivery accounted for 49% of births, of which 65% were elective. Mean maternal age was 27.7±6.3 years, parity ranged from one to seven, and 15% of mothers reported smoking during pregnancy.

The percentile distributions of systolic, diastolic, and mean BP are illustrated in Figures 2-4. As shown in Table II, MBP values increased significantly across the first seven postnatal days (p=0.0001). Post-hoc pairwise comparisons (Table III) demonstrated significant differences between Day 1 and all subsequent days (p<0.05), indicating a rapid early rise. Beyond Day 2, significant increases were generally observed only on alternate days.

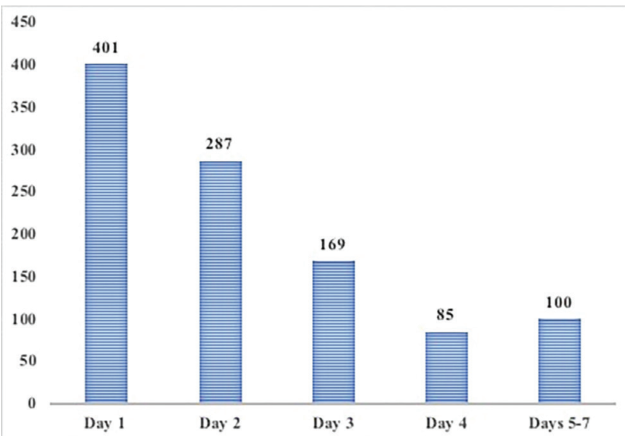

Figure 1. Number of infants measured per day (Days 5-7 combined)

Table I. Demographic and maternal characteristics of the study population (n=419)		
Variable	**Value**	**Min-Max**
Neonatal characteristics		
Birth weight (g)	3,302.2± 397.8	2,520-4,580
Birth length (cm)	49.0±1.9	44-56
Male sex, n (%)	215 (51.3)	-
Gestational age (weeks)	39.3±1.2	37-42
1-min Apgar score	7.8±0.8	4-9
5-min Apgar score	9.4±0.6	7-10
Maternal characteristics		
Caesarean section, n (%)	209 (49.9)	-
Age (years)	27.8±6.2	15-50
Parity	2.1±1.1	1-7
Weight in the 1st trimester (kg)	65.1±25.6	40-120
SBP in the 1st trimester (mmHg)	103.3±10.5	70-140
DBP in the 1st trimester (mmHg)	65.2±9.2	50-110
Weight near delivery (kg)	76.0±12.2	45-120
SBP near birth (mmHg)	114.4±12.6	80-180
DBP near birth (mmHg)	72.9±9.4	37-120
Smoking during pregnancy, n (%)	61 (14.6)	-
SBP: Systolic blood pressure, DBP: Diastolic blood pressure		

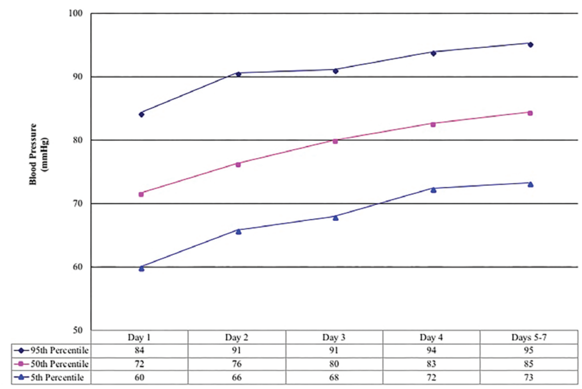

Figure 2. Systolic blood pressure percentiles of healthy term Turkish newborns during the first week of life

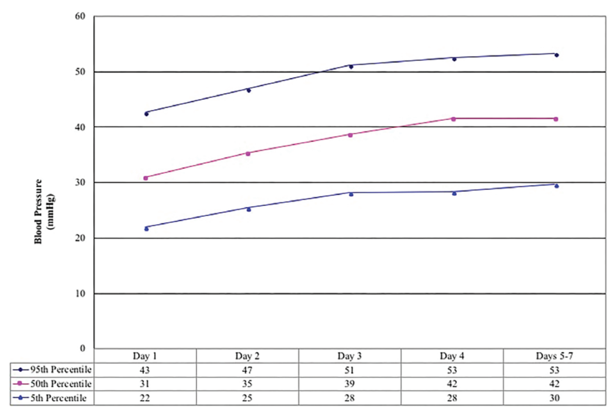

Figure 3. Diastolic blood pressure percentiles of healthy term Turkish newborns during the first week of life

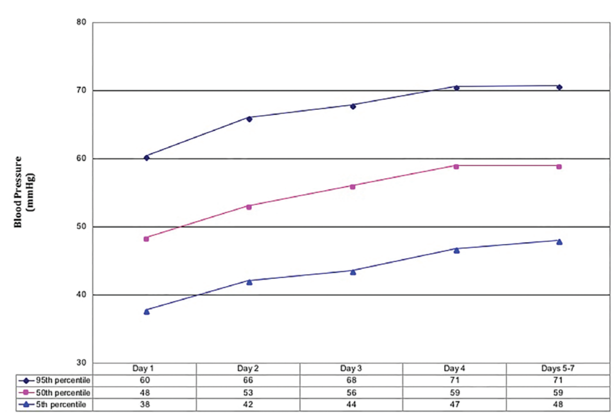

Figure 4. Mean blood pressure percentiles of healthy term Turkish newborns during the first week of life

Table II. Changes in mean blood pressure over the first five postnatal days

Day	Mean±SD (mmHg)	Median (IQR) (mmHg)
Day 1	48.1±7.35	48.33 (43.67-52.67)
Day 2	53.02±7.78	53.00 (48.33-57.67)
Day 3	55.91±7.52	56.00 (50.33-61.33)
Day 4	58.84±6.90	59.00 (54.17-63.84)
Days 5-7	59.23±6.79	59.00 (55.00-64.00)

Mean blood pressure increased significantly over the first five postnatal days (repeated measures ANOVA, F=12.27, p<0.001)
SD: Standard deviation, IQR: Interquartile range

Table III. Pairwise comparisons of mean blood pressure across postnatal days

Comparison	p value
Day 1 vs. Day 2	**0.013**
Day 1 vs. Day 3	**0.017**
Day 1 vs. Day 4	**<0.001**
Day 1 vs. Days 5-7	**<0.001**
Day 2 vs. Day 3	0.785
Day 2 vs. Day 4	**0.026**
Day 2 vs. Days 5-7	**0.003**
Day 3 vs. Day 4	0.056
Day 3 vs. Days 5-7	**0.002**
Day 4 vs. Days 5-7	0.358

Pairwise comparisons were performed using the Newman-Keuls multiple comparison test. Bold values indicate statistically significant correlations (p<0.05)

No statistically significant differences in MBP were detected by mode of delivery, sex, parity, or maternal smoking status. However, those infants born vaginally tended to have slightly higher MBP (by 1-2 mmHg) than those who were delivered by cesarean section on Days 1 and 2 (48.72±8.22 vs. 47.49±6.34 mmHg, p=0.09; and 54.13±7.37 vs. 52.33±7.97 mmHg, p=0.05, respectively).

Pearson correlation analyses revealed significant associations between neonatal MBP and several perinatal factors on Days 1 and 2 (Table IV). On Day 1, MBP correlated positively with birth weight (r=0.138, p=0.006), length (r=0.172, p=0.001), maternal near-birth SBP (r=0.259, p<0.001), maternal near-birth DBP (r=0.244, p<0.001), and 5th minute Apgar score (r=0.141, p=0.005). On Day 2, significant correlations persisted with gestational age (r=0.212, p<0.001), birth weight (r=0.165, p=0.005), and maternal near-birth SBP (r=0.132, p=0.032). From Day 3 onward, correlations weakened and lost statistical significance.

Multivariate stepwise linear regression analysis (Table V) identified maternal SBP near birth (β=0.143, p<0.001), birth length (β=0.605, p=0.001), and 5th minute Apgar score (β=1.26, p=0.007) as independent predictors of neonatal MBP on Day 1. Although statistically significant, the model explained only 0.1% of the variance (Adjusted R2=0.001), indicating that these predictors account for a minimal proportion of BP variability and have limited clinical relevance.

Table IV. Correlation between neonatal mean blood pressure and perinatal variables (r, p)

Variable	Day 1	Day 2	Day 3	Day 4	Days 5-7
Birth order	-0.008, 0.880	0.013, 0.827	0.005, 0.951	-0.063, 0.566	-0.040, 0.690
Birth weight	**0.138, 0.006**	**0.165, 0.005**	0.026, 0.737	0.013, 0.908	0.093, 0.359
Length	**0.172, 0.001**	0.095, 0.109	0.011, 0.886	0.017, 0.881	0.015, 0.885
Gestational age	0.043, 0.395	**0.212, <0.001**	0.125, 0.104	0.065, 0.553	-0.025, 0.808
Pre-delivery weight	0.081, 0.123	**0.135, 0.028**	0.038, 0.646	0.013, 0.910	0.029, 0.778
Pre-delivery SBP	0.098, 0.064	0.119, 0.056	-0.108, 0.185	-0.005, 0.964	0.110, 0.296
Pre-delivery DBP	**0.169, 0.001**	0.107, 0.085	-0.003, 0.968	0.086, 0.450	0.178, 0.089
Delivery weight	0.090, 0.089	**0.170, 0.006**	0.018, 0.826	0.096, 0.391	0.009, 0.928
Near birth SBP	**0.259, <0.001**	**0.132, 0.032**	**0.170, 0.035**	0.161, 0.152	0.166, 0.111
Near birth DBP	**0.244, <0.001**	0.074, 0.228	**0.196, 0.015**	0.139, 0.215	0.093, 0.374
Maternal age	0.091, 0.100	-0.020, 0.757	0.031, 0.727	-0.089, 0.483	0.071, 0.532
Apgar score (1 min)	0.023, 0.652	-0.005, 0.930	-0.015, 0.851	-0.112, 0.307	-0.025, 0.809
Apgar score (5 min)	**0.141, 0.005**	0.063, 0.293	-0.019, 0.810	-0.028, 0.797	0.019, 0.848

Bold values indicate statistically significant correlations (p<0.05)
SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table V. Multivariate stepwise linear regression analysis of day 1 mean blood pressure and perinatal parameters

Predictor variable	β coefficient	t value	p value
Constant	9.92	5.07	**0.0001**
Mothers' near birth SBP	0.143	4.95	**0.0001**
Birth length	0.605	3.21	**0.001**
5^{th} minute Apgar score	1.26	2.74	**0.007**

Adjusted R^2=0.001, overall model p=0.001
SBP: Systolic blood pressure

Discussion

This single-center study provides preliminary reference ranges for BP in healthy term Turkish newborns during the first week of life, which may contribute to future multicenter studies. These values are broadly comparable to those reported in previous studies conducted in different ethnic populations. Notably, we observed a significant increase in BP, particularly between the first and second days of life. While maternal near-birth SBP, neonatal birth length, and 5^{th}-minute Apgar scores were associated with MBP on the first day, these associations diminished in the subsequent days.

BP monitoring is one of the cornerstones of neonatal care, yet interpretation remains challenging due to variability in gestational age, birth weight, sex, and methodological differences. Only a limited number of studies have focused specifically on healthy term neonates (7,8,12). Kent et al. (7) reported median MBP values of 48-54 mmHg across the first four days in Australian infants, while Sadoh (8) found mean values of 48-52 mmHg in Nigerian neonates. Samanta et al. (12) reported a mean MBP of 60 mmHg on day 4 in a large cohort of term infants. Our values (48, 53, 56, and 59 mmHg) were slightly higher than those of Sadoh (8), but comparable to Samanta et al. (12). Differences may reflect ethnicity, maternal BP, environmental conditions, or device selection.

Consistent with prior research (6-8,12), we observed a significant rise in MBP during the early neonatal period, especially between the first and second days. Zubrow et al. (6) demonstrated a continuous increase in BP over the first five days across a range of gestational ages, independent of birth weight. This trend likely reflects the physiological transition from fetal to extrauterine circulation.

Although our data suggested a trend toward lower MBP in those infants born via cesarean section, this difference was not statistically significant. This contrasts with the findings from Salihoğlu et al. (11), who reported lower BP in neonates assessed within minutes of birth, likely reflecting the transient effects of anesthesia. In order to minimize confounding from perinatal asphyxia, we included only those infants with 5^{th} minute Apgar scores ≥7. Interestingly, we found a correlation between 5^{th}-minute Apgar scores and MBP on the first day. Given that Apgar scoring reflects neurobehavioral and physiological adaptation to extrauterine life, this association may reflect individual variability in neonatal cardiovascular responsiveness. However, we found no comparable data in the literature to support or refute this finding.

Sex-based differences in BP are well-documented in older populations, but remain inconclusive in neonates. While some studies have reported higher values in female newborns (11,13), others found no significant differences (6-8). The absence of pronounced hormonal influences in the neonatal period may explain the lack of consistent sex-related differences.

We identified a significant correlation between birth length and MBP on the first day. Kent et al. (7) did not report any associations between birth weight or length and BP, possibly due to their use of categorical variables. Sadoh (8) similarly categorized birth weights and found that large-for-gestational-age infants had higher BP than their small-for-gestational-age counterparts. Zubrow et al. (6) demonstrated that gestational age and birth weight were associated with SBP and DBP on day one, but post-conceptional age emerged as the primary determinant over time. Salihoğlu et al. (11) also found associations between BP and anthropometric measures including birth weight, length, and head circumference. In our study, birth length was significantly associated with MBP only on the first day. The lack of association with gestational age in this study may be due to our exclusive focus on term infants. We hypothesize that while maturation plays a role, other anthropometric or physiological factors may contribute to BP variability in healthy neonates.

In order to minimize confounding from maternal health conditions, we excluded those infants born to mothers with any known disease. We found a significant association between maternal near-birth SBP and neonatal MBP on the first day. Although BP tracking from infancy to adulthood has been documented (14-16), neonatal BP has not been shown to predict values at 6 months or 1 year (17). Neonatal BP appears to be more closely linked to perinatal and prenatal factors. Gillman et al. (18) described this as a "neonatal phenomenon," highlighting the influence of maternal age, third-trimester BP, birth weight, and postnatal age. They speculated that advanced maternal age may be associated with cardiovascular risk factors which affect placental and fetal vascular development. Our findings support this hypothesis, demonstrating a link between maternal BP and neonatal MBP.

We used oscillometric devices, consistent with standard neonatal practice. While these devices have known limitations (2,19), invasive measurement was not ethically feasible in healthy infants. Adherence to published guidelines (4,5) minimized error, and our results remain clinically relevant given the widespread use of oscillometry.

Study Limitations

Several limitations should be acknowledged. First, attrition reduced sample size after Day 2, thus limiting generalizability. Second, the data were collected in 2012. No newer Turkish neonatal BP data exist, and many NICUs still rely on reference curves from 1995 (6). Thus, our findings remain valuable for current practice. Third, correlation coefficients were consistently below 0.3, indicating weak associations with perinatal factors. Finally, our descriptive percentile tables provide practical insight but lack the robustness of advanced modeling approaches (e.g., GAMLSS).

Conclusion

We present descriptive BP values for healthy term Turkish newborns during the early neonatal period. Maternal and perinatal factors influenced BP, particularly on the first day, but their clinical impact appears limited. Future multi-center studies with larger, contemporary cohorts and advanced statistical modeling are needed in order to establish robust reference curves and clarify long-term implications.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the University of Health Sciences Türkiye, Şişli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee (approval no.: 33, date: 10.04.2012).

Informed Consent: Informed parental consent was secured.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Ö.G., Concept: Ö.G., S.U., A.B., Design: Ö.G., S.U., A.B., Data Collection or Processing: Ö.G., E.K.B., M.Ç., U.Z., Analysis or Interpretation: Ö.G., E.K.B., M.Ç., U.Z., Literature Search: Ö.G., Writing: Ö.G., S.U., A.B.

Conflict of Interest: The authors declare no conflicts of interest.

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