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ARAŞTIRMA/RESEARCH

Blood pressure monitoring in non-critically ill preterm neonates

Hasta olmayan preterm yenidoğanlarda kan basıncı monitörizasyonu

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Abstract

Purpose: The aim of this study was to provide normative blood pressure measurements during the first days of life of healthy preterm neonates admitted to our neonatal intensive care unit.

Material and Method: The representative study population consisted of 141 hemodynamically stable premature infants who were smaller than 34 gestational weeks admitted to the neonatal intensive care unit during the first hours of life.

Results: One hundred forty-one infants were studied. The mean birth weight and gestational weeks of the study group is 1437.45±445.8 (580-2400) gr and 31.04±2.1 (27-34) weeks respectively. Blood pressures differ from the universal norms in different groups of gestation and birth weight.

Conclusion: Despite the fact that neonatal blood pressures has been measured for decades, we are still in the early phase of identifying the normal patterns of infant blood pressure. There are still many physiological changes that need further investigation before definitive reference data can be generated.

Key words: Neonates, blood pressure, oscillometric method

Öz

Amaç: Bu çalışmada yenidoğan yoğun bakım ünitemize yatırılan sağlıklı preterm bebeklerdeki normal kanbasıncı değerlerini sağlamayı amaçladık.

Gereç ve Yöntem: Yaşamının ilk saatlerinde yenidoğan yoğun bakım ünitemize yatırılan 34 gestasyonel haftadan küçük hemodinamik olarak stabil 141 preterm bebek çalışmaya dahil edildi.

Bulgular: 141 bebek çalışmaya alındı. Ortalama doğum ağırlıkları ve gestasyon haftaları sırasıyla 1437.45±445.8 (580-2400) gr and 31.04±2.1 (27-34) hafta idi. Kan basıncı değerleri farklı gestasyon haftası ve doğum ağırlıklarına göre uluslararası değerlerden farklı idi.

Sonuç: Yüzyıllardan beridir yenidoğan kan basıncı ölçümleri yapılmasına rağmen, normal neonatal kan basıncı değerlerini belirlemede henüz daha çok yolumuz bulunmaktadır. Kesin değerleri belirlemeden önce hala birçok fizyolojik değişikliklerin araştırılması gerekmektedir.

Anahtar kelimeler: Yenidoğan, kan basıncı, osilatuar yöntem

INTRODUCTION

The neonatal period is a time of extensive hemodynamic changes. It is expected that these changes are most prominent in premature infants during the first week of life. Measuring blood pressure is an integral part of vital sign monitoring in neonates. Normal blood pressure (BP) measurements are required to diagnose and manage appropriately for both hypotension and hypertension in the neonates and infants.

In the first few days of life, infants of less than 28 weeks' gestation frequently receive treatment for hypotension. The large prospective cohort study, the Extremely Low Gestational Age Newborn (ELGAN) study showed that the lower the gestational age the higher the proportion of babies who received therapy for hypotension[1]. Analysis of these data showed enormous variation from one hospital to another that was not related to differences in patient characteristics but just variations in practice patterns and the approach of the individual neonatologist[2].

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Direct intra-arterial recordings are the "gold standard" for determination of BP in critically ill neonates whose condition is serious to justify arterial catheterization, and generally this method is used if arterial access is available[3,4]. The non-invasive methods of BP monitoring represent great progress in the care of non-critically ill neonates. The most common non-invasive method used in neonatal intensive care units (NICU) is automated measurement using oscillometric devices[5]. Studies have shown a good correlation between oscillometric and invasive umbilical or radial artery BP in neonates and young children[6, 7]. The method is based on the transmission of oscillations in the arterial wall to a cuff placed around a limb[8].

However, this blood pressure norms is rather complex because genetic factors could also play a significant role in regulation of blood pressure. Despite a large number of covering factors, family studies have shown significant genetic contributions to inter-individual differences in BP[9, 10].

The aim of this study was to provide normative BP measurements during the first days of life of healthy preterm population admitted to our neonatal intensive care unit (NICU), using an oscillometric method, to find out the national blood pressure limits in premature infants and the difference from international norms.

MATERIALS AND METHODS

This study was carried out prospectively over three years in the NICU of the Çukurova University Medical Faculty in Turkey. The representative study population consisted of 141 hemodynamically stable premature infants who were smaller than 34 gestational weeks (GW) admitted to the NICU during the first hours of life. The condition was considered stable based on the following criteria: normal hemoglobin; normal acid-base balance; no renal or renovascular anomalies; no congenital heart disease or patent ductus arteriosus; no chromosomal abnormalities; no usage of indomethacin, steroids, diuretics, muscle relaxants, narcotics; non-treatment for hypo/hypertension; and that the patients were accessible for investigation for at least the first 10 postnatal days. The patients did not receive any inotropic drug therapy, ventilator support (also including continuous positive airway pressure) or develop sepsis during the period of observation. Gestational age was estimated using clinical assessments[11]. They were categorized into ten according to the estimated gestational age of 27-34 gestational weeks. Additional classification was carried out according to birth weight: Group I (500-750 g), Group II (751-1000 g), Group III (1001-1250 g), Group IV (1,251–1,500 g), and Group V (1501-1750 g), VI (1751-2000 g), Group VII (2001-2500 g). The newborns whose mothers had chronic hypertension, as well as pregnancy-induced hypertension or any other confirmed pre-existing disease were excluded from this study.

All patients received routine postnatal care by the 10th day of age. Systolic BP (SBP), diastolic BP (DBP), and mean arterial BP (MBP) were measured indirectly using an oscillometric device (Viasys, Mindray VS 800, Germany). BP was measured in the supine position while the infant was asleep or was in a quiet awake state in random order at least 30 min after the last feed at 1st, 3rd, 7th and 10th day of life. An appropriate-sized cuff (covering at least two-thirds of the length of the limb segment and 85% of the limb circumference) was applied to the right upper arm. Three successive BP recordings were taken at 2-min intervals, and the mean of the last two measurements was used for all analyses.

This study was approved by Local Ethics Committee on April 2012. All parents were informed about the study and signed agreement was got from all parents.

Statistical analysis

SPSS 19.0 was used for data analysis. Categorical variables were summarized using counts and percents whereas continuous variables were summarized in mean ± standard deviation, median, minimum and maximum values.

RESULTS

One hundred forty-one infants were studied. The mean birth weight and gestational weeks of the study group is 1437,45+/-445,8 (580-2400) gr and 31,04+/-2,1 (27-34) weeks respectively. There were 10 premature in 27 GW group, 13 premature in 28 GW group, 12 premature in 29 GW group, 21 premature in 30 GW group, 21 premature in 31 GW group, 21 premature in 32 GW group, 20 premature in 33 GW group, 23 premature in 34 GW group. Systolic, diastolic and mean blood pressures of the infants according to gestational weeks are given in

Table 1. There were 6 premature in Group I, 25 premature in Group II, 24 premature in Group III, 24 premature in Group IV, 28 premature in Group V, 17 premature in Group VI, 17 premature in Group VII. Systolic, diastolic and mean blood pressures of the infants according to birth weight are given in Table 2.

DISCUSSION

Defining what is considered a normal blood pressure (BP) in premature infants is a complex task. There are few BP data reported for such infants after 24 h of life. Also comparison of these normative data on BP from various studies is difficult due to differences in methodology[12-16].

Although nearly half of the newborns admitted to neonatal intensive care units receive treatment for hypotension, the normal physiologic blood pressure range ensuring appropriate organ perfusion in the neonate is unknown. Thus, the decision to treat hypotension in the newborn is based on statistically defined gestational and postnatal age–dependent normative blood pressure values and beliefs of the clinician rather than on data bearing physiologic reference[17].

Table 1: Normal systolic, diastolic and mean blood pressures according to gestational weeks

	mm Hg	GW 27 n=10	GW 28 n=13	GW 29 n=12	GW 30 n=21	GW 31 n=21	GW 32 n=21	GW 33 n=20	GW 34 n=23
BW(gr) mean±SD min-max		850,5±17 3,5 580-1160	996,5±17 1,8 740-1220	1223,3±22 8,0 900-1640	1231,9±26 4,2 720-1750	1492,4±30 3,4 910-1910	1685,7±29 8,4 930-2360	1741,5±56 5,2 730-2400	1700,0±38 9,5 1000-2360
Day 1 mean±SD min-max	SBP	57±10 50-69	59±3 57-62	67±13 51-81	65±10 35-76	64±9 45-75	63±11 43-89	63±7 50-73	68±10 46-88
	DBP	29±3 26-33	36±5 32-42	42±9 31-52	41±8 29-55	39±8 23-54	37±8 24-55	38±6 29-53	39±8 24-53
	MBP	43±6 36-47	47±6 41-52	52±9 41-61	51±6 38-59	48±8 38-62	47±10 31-70	46±6 34-63	49±10 35-69
Day 3 mean±SD min-max	SBP	70±4 64-74	71±12 58-88	65±7 58-77	72±6 63-83	69±9 55-89	68±8 56-84	68±10 49-85	70±7 55-80
	DBP	42±3 38-46	47±9 36-62	41±6 35-52	43±6 34-54	43±7 29-56	42±6 33-57	50±6 30-48	42±9 27-57
	MBP	52±6 47-57	54±10 42-70	49±6 41-58	53±4 45-60	52±8 36-70	51±8 40-66	50±6 41-57	52±9 35-67
Day 5 mean±SD min-max	SBP	70±6 65-82	70±6 60-78	68±7 60-76	74±7 62-89	66±9 51-85	70±6 58-80	70±9 54-88	73±9 58-93
	DBP	34±6 21-41	42±6 34-52	40±11 24-61	44±8 30-66	40±8 25-60	43±8 24-62	40±6 29-50	44±10 29-67
	MBP	49±9 43-54	53±6 48-64	51±8 38-64	55±7 43-74	50±9 37-67	53±8 41-70	51±7 40-69	53±9 40-73
Day 7 mean±SD min-max	SBP	67±7 57-77	70±5 66-82	68±6 58-77	71±9 60-98	67±7 54-80	69±8 55-83	70±7 59-82	71±7 57-82
	DBP	40±12 27-56	43±6 38-57	44±9 29-59	42±7 30-59	38±6 26-50	43±7 30-54	43±7 33-56	40±6 28-50
	MBP	47±9 34-61	50±5 37-56	51±7 38-62	52±10 34-80	49±6 35-59	51±7 41-67	52±7 42-64	52±9 33-62
Day 10 mean±SD min-max	SBP	71±6 63-82	69±6 57-80	74±5 64-79	73±9 53-87	68±7 58-81	73±8 59-88	68±8 52-78	78±9 67-89
	DBP	41±9 26-58	40±5 30-47	41±7 35-58	40±8 30-58	39±6 29-48	41±8 32-54	37±7 28-48	44±6 39-52
	MBP	52±9 38-67	50±6 40-58	52±6 45-64	52±7 41-67	49±6 41-61	55±8 45-70	50±6 41-59	55±8 48-63

Table 2. Normal systolic, diastolic and mean blood pressures according to birth weight

	mmHg	Group I N=6	Group II N=25	Group III N=24	Group IV N=24	Group V N=28	Group VI N=17	Group VII N=17
GW(wk) mean±SD min-max		28,6±2,4 27-33	29,6±2,3 27-34	29,5±1,8 27-34	30,8±1,6 29-34	32,3±1,3 29-34	32,1±1,1 31-34	33,2±0,6 32-34
Day 1 mean±SD min-max	SBP	65±5 62-69	66±9 54-78	56±9 51-73	66±15 35-89	57±9 44-70	67±3 64-69	59±12 43-68
	DBP	32±9 26-39	43±8 32-55	33±5 29-41	41±7 32-52	37±6 29-48	34±9 23-41	39±5 33-45
	MBP	48±2 47-50	51±8 40-63	41±7 34-54	52±8 39-70	43±7 31-52	46±11 38-59	46±6 38-52
Day 3 mean±SD min-max	SBP	68±3 64-70	73±9 63-87	65±7 55-74	74±9 57-89	64±6 55-75	73±3 69-75	73±8 64-83
	DBP	38±7 30-46	45±6 37-53	41±4 35-47	47±6 36-54	40+/6 29-48	44±4 40-48	44±6 36-49
	MBP	48±5 41-52	54±4 50-62	47±7 41-57	57±6 48-66	50±8 36-62	53±1 52-54	52±6 44-57
Day 5 mean±SD min-max	SBP	67±2 65-69	76±4 70-80	67±8 55-79	72±11 57-89	67±5 62-78	62±5 56-65	69±8 59-78
	DBP	37±7 30-47	47±7 36-62	38±8 29-51	45±10 34-66	42±5 35-49	35+/9 25-44	37±7 31-46
	MBP	49±4 43-54	58±6 51-70	50±7 43-62	53±10 41-74	52±7 42-60	50±5 47-55	48±7 40-56
Day 7 mean±SD min-max	SBP	70±6 62-77	74±12 57-98	65±4 59-70	70±6 60-80	73±8 60-82	68±1 67-69	69±6 61-72
	DBP	44±8 32-54	45±8 33-59	40±9 30-52	40±6 34-50	43±6 34-52	39±5 34-43	43±7 33-50
	MBP	50±6 40-57	55±12 42-80	48±6 42-57	53±7 41-64	53±7 42-60	51±4 48-55	54±7 43-59
Day 10 mean±SD min-max	SBP	68±9 57-80	68±9 59-87	72±11 52-87	71±8 53-83	72±10 58-88	69±11 58-81	73±4 68-78
	DBP	35±6 26-44	38±9 30-58	38±5 30-42	41±7 30-52	42±8 28-54	38±9 29-48	43±6 35-48
	MBP	45±7 38-54	51±7 45-67	52±8 41-61	53±7 41-63	56±8 45-70	47±8 42-56	52±5 45-55

The automated oscillometric method detects the pressure oscillations within the artery, determines the mean arterial pressure, and then uses an algorithm which is specific to each manufacturer to establish the systolic and diastolic BP[19].

We used an oscillometric device as an alternative method of performing invasive intra-arterial BP measurement. This method is convenient and easy to use in younger children and neonates. Given that the oscillometric method is now frequently used to obtain BP measurements in neonatal intensive care units, emergency departments and pediatric units, normative values are required to assess both hypotension and hypertension appropriately in the infant with this method.

In a retrospective study examining the association between mean blood pressure and neonatal death and morbidity in preterm infants with a birth weight of less than 1500 g, the authors found no association between mean blood pressure and neonatal death, periventricular leukomalacia, and retinopathy of prematurity[20].

Since systemic blood pressure is the function of blood flow and systemic vascular resistance, blood pressure may not always appropriately reflect the status of organ blood flow in the nonacidotic preterm infants[21]. We could not evaluate organ perfusion in our babies. On our clinical follow up we found that the urination, cardiac functions, liver function test are all stable.

Accurate blood pressure measurement, especially in smaller babies, is important to avoid overtreatment as well as under treatment of circulatory failure. Hypotension may lead to impaired organ perfusion, including cerebral hypo perfusion, putting the neonate at risk of cerebral ischemic injury, periventricular leukomalacia and intraventricular hemorrhage. Hypertension may cause hypertensive encephalopathy and intracerebral and intraventricular hemorrhage. Both should be avoided by accurate monitoring of the hemodynamic status of the neonate, with blood pressure measurement being one of the most frequently used indirect hemodynamic variables. Namely, the most difficult part of this research was to form and follow up the groups of preterm neonates with very low BW, which would keep the physiology of the age (free from sepsis, intracranial hemorrhage, cardiopulmonary distress, and need for mechanical support) for a relevant period to monitor BP.

Postconceptional age was the primary determinant of BP in this population of infants. Zubrow et al.[22] reported the findings of a large multicenter study, which included data from 608 infants followed for 1 to 99 days after delivery. On day 1, birth weight and gestational age were strong correlates of SBP and DBP. During the first 5 days of life there was a progressive rise in SBP (2,23 to 2,67 mmHg/day) and DBP (1,58 to 2,02 mmHg/day) regardless of gestational age or weight at birth. After day 5 there was a more gradual increment in the daily SBP (0,24 to 0,27 mmHg/day) and DBP (0 to 0,15 mmHg/day). In our study we could not find such a linear relation between postnatal days and systolic or diastolic blood pressures. Our results about the BPs that is not increase with postnatal age, are not consistent with those in other reports[23- 25].

On the other hand, Hegyi et al.[26] studied blood pressure in the first hours of life in a cohort of 244 healthy preterm infants weighing 501–2,000 g over a 34-month period. This study showed that, in the healthy group during the first 3–6 h of life, minimum and maximum of SBP were 47 mmHg and 59 mmHg, while minimum and maximum for DBP were 24 mmHg and 35 mmHg respectively. In our study minimum and maximum of SBP were 31 mmHg and 78 mmHg, while minimum and maximum for DBP were 21 mmHg and 67 mmHg respectively. They found that in healthy premature infants the limits of SBP and DBP were independent of birth weight and gestational age. Similar to this study, we also could not demonstrate any relation between blood pressures and birth weight and gestational week.

The research base is not yet available to give a definite answer to the question regarding which BP is really normal in very preterm and very low birth weight infants. From the methodological point of view it is very difficult to include in a study a great number of stable or so-called "normal" very low birth weight premature infants who are free from pharmacological, ventilator or nutritional support.

Despite the fact that neonatal BPs has been measured for decades, we are still in the early phase of identifying the normal patterns of infant BP, and there are still many physiologic changes that need further investigation before definitive reference data can be generated. Further studies including more healthy premature infants are needed to determine normal blood pressure limits.

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