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DELIMITATION OF BLOOD PRESSURE IN HEALTHY NEWBORNS

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ABSTRACT

Blood pressure (BP) is one of the four vital signs that best reflect cardiovascular status during the physical examination of newborns. Adequate monitoring of vital signs is essential to optimize the management of neonates; therefore, BP measurements should be obtained and recorded throughout their ongoing care. A prospective observational study was carried out, selecting 836 healthy full-term newborns in a maternity hospital in the Federal District. Blood pressures were measured in the delivery room within the first two hours of life using an MX-600 GE automatic oscillometric device, following the hospital's standard care protocol. Maternal and neonatal data were measured to correlate systolic, diastolic, and mean blood pressure percentiles. The measurements obtained were systolic BP 64.89 ± 10.7 mmHg and diastolic BP 37.60 ± 11.7 mmHg in males and systolic BP 66.46 ± 10.9 mmHg and diastolic BP 39.52 ± 12.3 mmHg in females. This article strengthens neonatal care by establishing normative blood pressure values.

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INTRODUCTION

Blood pressure (BP) is extremely important for diagnostic investigation and clinical evaluation, as it is a parameter capable of defining the force that the blood exerts against a unit area of the vascular wall. Furthermore, it is the result of cardiac output multiplied by peripheral vascular resistance (Guyton, 2017), which can have repercussions on perfusion, fluid states, and cardiac and endocrine bodily functions (Dionne *et al*., 2020). Blood pressure is one of the four vital signs that best reflect cardiovascular status during the physical examination of newborns (NBs), and it is essential for the management of high-risk neonates (Kent and Chaudhari, 2013; Salihoğlu *et al*., 2012). Thus, BP measurements should be obtained and recorded throughout the NBs continuous clinical care, increasing the chances of survival of the critically ill. An example of this is children who develop severe arterial hypotension, which can lead to complications from ischemic brain injury if not treated early, or reduced oxygenation in body tissues due to severe arterial hypertension (Kelly *et al*., 2017), causing heart failure, pulmonary edema and renal dysfunction (Kliegman *et al*., 2020).

Despite this importance, BP is rarely measured in the delivery room, and most established normative data on newborn BP were collected from sick NBs in neonatal units after 12 to 24 hours of birth (Samanta *et al*., 2015; Hulman *et al*., 1991). The incidence of arterial hypertension in newborns varies widely in the literature, as reported by Ribeiro *et al*. (2007) in up to 3% of neonates. This difference in incidence reflects the difficulty of defining neonatal hypertension due to numerous factors, such as the absence of large-scale prospective studies that determine universally accepted reference values, variability of blood pressure measurement techniques and conditions, and influence on normal blood pressure values at gestational age, birth weight, sex, pathological history, and use of maternal medications. The Brazilian literature has only two studies that demonstrated possible BP reference values for term neonates. These studies are by Matsuoka *et al*. (1996), which investigated the evolution of BP in 35 full-term neonates, and by Vilarim and Alves (2000), involving 624 NBs from Recife in 2000. Due to the scarcity of studies to define BP levels in neonates, the parameters currently accepted to define neonatal arterial hypertension may be similar to those of older children, with systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) persistently equal or higher than the 95th percentile for gestational age, sex, and height (Starr and Joseph,

2019). These values can be used to guide the clinical management of these patients, suggesting that persistent BP values above the 95th percentile should be closely monitored, while values above the 99th percentile require investigation and possible treatment depending on the underlying cause (Starr and Joseph, 2019). In addition, the most accepted curves of blood pressure values in full-term newborns for consultation were published by Kent and Chaudhari (2013). The study obtained the largest sample of serial BP measurements by oscillometry between the first and fourth days of life in healthy full-term NBs, with no associated maternal or neonatal risk factors. Therefore, this research aimed to determine systolic, diastolic and mean BP levels to estimate blood pressure ranges of healthy full-term newborns in the first and second hour of life, born in a private maternity hospital in the Federal District.

MATERIAL AND METHODS

This is research involving newborns treated at the Neonatology Unit of Hospital Santa Lúcia Sul do Distrito Federal, from August 2019 to August 2020. The research was approved by the Ethics Committee under number 20237919.1.0000.0023. To compose the sample universe, 836 healthy full-term newborns, between 37 and 42 weeks of gestational age, were selected. Exclusion criteria excluded neonates with congenital anomalies, premature infants, those undergoing neonatal resuscitation with or without tracheal meconium aspiration, admitted to the neonatal intensive care unit and classified as small for gestational age according to the Margotto curve (Margotto, 2001). These parameters were selected to acquire a normal value of BP data in healthy NBs, excluding any variables that would allow changes in the data. The gestational age considered was provided by the date of the last menstrual period or early obstetric ultrasound in the first 12 weeks of gestation and confirmed by the New Ballard Score. Newborns were classified as small for gestational age, appropriate for gestational age, or large for gestational age based on the norms of Margotto's intrauterine growth curves (Margotto, 2001).

The maternal and neonatal variables investigated were gestational age, head circumference, weight ratio, heart rate (HR), length, sex, mode of delivery, SBP, DBP, and mean blood pressure (MAP) values. BP measurements were performed between the first and second hours of life by an automatic oscillometer MX-600 GE. The standard hospital care protocol for BP measurement was followed, with a selection of the measurement site, comfortably positioning the NB and the limb supported on a surface, free of clothes, placing a cuff on the limb so that the mark of the artery of the cuff was aligned with the neonate's artery, confirming that the hoses were not bent, twisted or compressed, connecting with the multi-parameter monitor cable, pressing the specific BP measurement button and waiting for the cuff to deflate completely for removal. The records of the variables collected were analyzed using the SPSS statistical program for Windows, version 23.0. This platform statistically defined BP values in percentile curves. A table was constructed showing data that could influence the BP of neonates, such as weight, HR, gestational age, head circumference, and length.

RESULTS

The study selected parameters from 836 healthy neonates to corroborate the prediction of normal blood pressure values and their variations depending on intrapartum and immediate postpartum conditions. The most common route of delivery was a cesarean section, corresponding to 85.8% of births. Among the newborns, 50.9% were male, the mean gestational age was 38.7 weeks ± 1.7, weight was 3191.1 grams ± 445.9, head circumference was 34.6 cm ± 1. 4, and heart rate of 154.3 ± 13.4 beats per minute (Table 1). Blood pressure measurements were obtained in the right upper limb in 97.9% of the cases. The values found in the mean of SBP were 64.89 ± 10.7 mmHg and DBP of 37.60 ± 11.7 in males, while in females they were 66.46 ± 10.9 for SBP and 39.52 ± 12.3 for DBP (Table 2).

The 10th percentile of SBP corresponded to 50.34 mmHg and that of DBP to 25.0 mmHg, while the 90th percentile had 80 mmHg of SBP and 52.6 of DBP mmHg. Among the 836 newborns, 48 were allocated between the 90th and 95th percentile with a MAP of 60 to 66 mmHg, 30 on the 95th to 99th percentile with MAP between 67 and 88 mmHg, and 7 on the 99th percentile with MAP greater than or equal to 89 mmHg (Graph 1). The 95th percentile greater than or equal to arterial hypertension was present in 4.4% of the newborns in the study, but these blood pressure levels did not change the prognosis due to the absence of hospitalizations in the neonatal intensive care unit, with hospital discharge between 24 and 48 hours after birth. In addition, the 36 NBs who had hypotension, considered MAP lower than 30 mmHg (Ribeiro *et al*., 2007), also did not require hospitalization in a neonatal care unit or prolonged hospital stay after birth, with no complications due to the decrease in blood pressure. Furthermore, there was a correlation between weight, blood pressure range, and heart rate at birth. Newborns with lower birth weights had lower BP and HR levels when compared to those with higher birth weights. In the sample, the 5th percentile of blood pressure was born weighing 2,481 grams and showing HR of 133 beats per minute, while the 95th percentile had 3,911 grams and HR of 176 beats per minute (Table 3).

DISCUSSION

In the last 30 years, few scientific materials have documented BP values related to gestational age during the first hours of life in full-term newborns. Among these studies, the references showed considerable variations in neonatal BP data. This can be the result of numerous situations, such as small sampling, BP measurement by oscillometric and intra-arterial methods, and lack of identification of factors that may influence BP levels, such as mode of delivery, gestational age, and birth weight (Lalan, 2014; Lalan and Wardy, 2015). Thus, there are many controversies regarding the assessment of BP and the need to treat the observed abnormalities of these physiological variables (Kent and Chaudhari, 2013). The aforementioned problem resulted in the development of a variety of techniques for measuring BP in recent years. The first neonatal BP study was published by Holland and Young in 1956, having performed palpation of the brachial artery below an inflatable cuff for data measurement. This study compared SBP at the birth of neonates in various conditions, such as abnormal delivery, abnormal pregnancies, prematurity, and twin pregnancies, indicating a mean SBP of 69 mmHg at birth. However, no diastolic or mean BP values were determined in the article. Another example was the study carried out by Samanta *et al*. (2015), who investigated non-invasive BP in term and preterm newborns up to the fourteenth day. Measurements were repeated three times at two-minute intervals, indicating MAP in 1617 full-term and preterm neonates on the fourth day of life of 59.3 mmHg and 66.4 mmHg on the fourteenth day.

The data found showed that full-term NBs have higher SBP, DBP, and MAP than preterm infants (Samanta *et al*., 2015). These findings were similar to those observed in studies conducted by Kent and Chaudhari (2013). Furthermore, in an attempt to define BP parameters in newborns, Zubrow *et al*. (1995) reported BP reference ranges for neonates born over 36 weeks of gestational age who were admitted to a neonatal intensive care unit. Another study by Paliwoda *et al*. (2018) evaluated vital signs in NBs older than 34 weeks. In this systematic review study, four primary studies were selected that reported BP between various periods from the first to the fourteenth day of life (Paliwoda *et al*., 2018). In Brazil, the literature review showed only two studies on BP assessment values in neonates, one by Matsuoka *et al*. (1996), which investigated the evolution of BP in 35 full-term neonates, and the other in Vilarim and Alves, involving measurement in 624 NBs from Recife in 2000. In the first one, SBP, DBP, and MAP were measured at five different intervals, indicating that in the first three days of life there is a significant increase in BP (Matsuoka *et al*., 1996). In the second study, systolic and diastolic blood pressure values were collected from the NB, which contributed to determining cut-off values for hypertension with SBP of 82.0 + 7.5 mmHg and DBP of 41.7 + 5.8 mmHg considered within the normal

Table 1. Data on gestational age (GA) in weeks, weight in grams (g), length in centimeters (cm), brain circumference (BC) in centimeters, and heart rate (HR) in beats per minute (bpm) of 836 newborns - healthy newborns treated at Hospital Santa Lúcia-DF

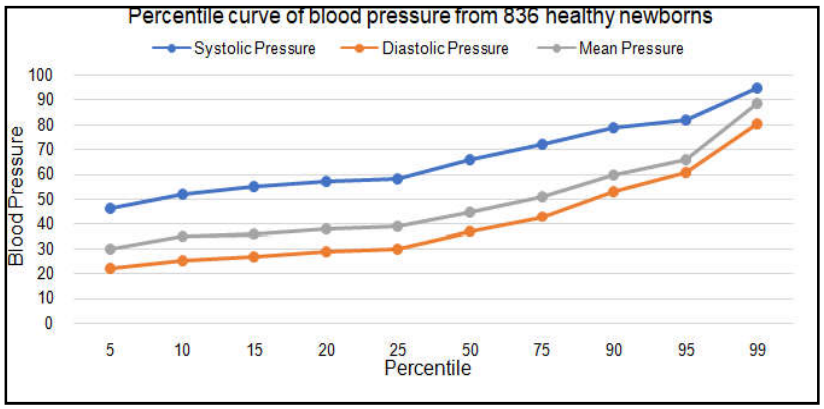
	GA (weeks)	Weight (g)	Length (cm)	BC (cm)	HR (bpm)
Mean (DP)	38.7 ± 1.7	3191.1± 445.9	48.6 ± 2.2	34.6 ± 1.4	154.3 ± 13.4
Median	39	3195	49	33.5	154

Table 2. Systolic, mean, and diastolic blood pressure levels in 836 healthy newborns treated at Hospital Santa Lúcia – DF

Blood Pressure	Percentile 10	Percentile 25	Percentile 50	Percentile 75	Percentile 90	Percentile 95	Percentile 99
Systolic	52	58	66	72	79	82	95
Diastolic	25	30	37	43	53	61	81
Mean	35	39	45	51	60	66	89

Table 3. Mean arterial pressure (MAP) percentile related to weight in grams, and heart rate (HR) in beats per minute of 836 neonates up to two hours after birth

	Percentile 10	Percentile 25	Percentile 50	Percentile 75	Percentile 90	Percentile 95	Percentile 99
MAP	35	39	45	51	60	66	89
Weight	2624	2900	3193	3499	3770	3911	4171
HR	138	145	154	164	172	176	188



Graph 1. Blood pressure percentile curve of 836 healthy newborns treated at Hospital Santa Lúcia - DF

range and values above 95 mmHg of SBP and 52 mmHg of DBP as arterial hypertension (Vilarim and Alves, 2000). These data differ from the present study, which obtained a mean SBP of 65.5 + 10.9 mmHg and a mean DBP of 38 + 12.02 mmHg from 836 healthy full-term newborns. Currently, accepted parameters to define neonatal arterial hypertension are SBP and/or DBP persistently at or above the 95th percentile for gestational age, sex, and height (Starr and Joseph, 2019). The study by Kliegman *et al.* (2020) corroborates this definition, indicating that arterial hypertension would be the mean SBP and/or DBP greater than or equal to the 95th percentile measured on three occasions in children; however, these values were not standardized for term birth neonates. Regarding BP measurement methods, auscultation is the preferred method, while intra-arterial blood pressure monitoring is the gold standard, and is used for severe cases because it is invasive (Dionne *et al.*, 2020). Furthermore, another way of measuring BP is the oscillometric method, which consists of identifying, quantifying, and analyzing oscillometric pulses, based on an average of three BP readings. Oscillometric BP levels have a greater relationship with intra-arterial pressures than the auscultatory method when used in neonates (Dionne *et al.*, 2020). It should be noted that to carry out an adequate BP measurement using the oscillometric method, it is necessary to pay attention to the ideal cuff size, location, and measurement method. The cuff can be chosen using a ratio of approximately 0.5 between cuff size and width to arm circumference (Dionne *et al.*, 2020). The oscillometric measurement method detects the amplitude of pulsations within the artery, determining the MAP value as the cuff gradually deflates with arterial pulsations, which in turn increases the amplitude to maximum extension.

The proper measurement technique is even more important in NBs, because expected MAP values are generally lower than in older children, and can be in the range of 30-50 mmHg (Dionne *et al.*, 2020). Observing these aspects, it is necessary to have a parameter that allows for identifying changes related to BP, since arterial hypertension in children can persist and progress to systemic arterial hypertension in adulthood (Hao *et al.*, 2017). Meanwhile, BP values considered below the lower limit of the mean should be confirmed by the correct measurement technique to avoid unnecessary conduct, such as volume infusion or inotropic drugs (Kent and Chaudhari, 2013). Thus, the correct control of BP should be performed from the beginning of life. The present study stands out from the others for measuring BP in the first two hours of life, in addition to correlating it with parameters of NBs capable of influencing their levels, such as sex, mode of delivery, gestational age, heart rate, head perimeter, weight, and length. In addition, other conditions of this study that confer reliability are measurement method by automatic oscillometry, exclusion of certain variables that would allow changes in the data, and greater sample space when compared to other studies in the literature review. Thus, the work was able to delimit the range of systolic, diastolic, and mean blood pressures in healthy neonates. However, it is necessary to carry out multicenter studies to allow greater amplitude for the results found; these, as well as subsequent studies, should overcome the current limitations in this work, such as BP measurement performed under the supervision of multiple professionals and a greater proportion of NBs born from cesarean delivery, which can interfere with fetal hemodynamics. In this way, it will become possible to diagnose and treat early, if necessary, changes in BP in neonates, avoiding the development of cardiovascular pathologies and other secondary complications.

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