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Research Article

Comparison between oscillometric and intra-arterial blood pressure measurements in ill preterm and full-term neonates

Shwetal Lalan, MD* and Douglas Blowey, MD

Division of Pediatric Nephrology, Children's Mercy Hospitals and Clinics, University of Missouri-Kansas City, Kansas City, MO, USA

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Abstract

Conflicting data exist regarding the accuracy of the oscillometric method of blood pressure (BP) measurement in neonates. There is limited data regarding intra-arterial BP trends in neonates. We aimed to determine the accuracy of oscillometric BP measurements and to evaluate the BP distributions in ill neonates. A total of 1492 simultaneously obtained oscillometric and intra-arterial (umbilical arterial [UAC] or radial arterial) BP measurements were used for comparisons and 125,580 intra-arterial BP readings were used to the evaluate BP distribution. There was a statistically significant difference ($P < .0001$) between the oscillometric and radial mean arterial BP (MAP) 4.8 ± 9.8 mm Hg, systolic BP 8.3 ± 11.6 mm Hg, diastolic BP 4.3 ± 9.3 mm Hg and between the oscillometric and UAC systolic BP 5.2 ± 11.9 mm Hg and diastolic BP −0.8 ± 10.4 mm Hg. The MAP increased with increases in weight (35.3 ± 4.92 mm Hg/kg), post-menstrual age (−0.29 ± 1.41 mm Hg/week) and advanced gestational age at birth (13.12 ± 0.90 mm Hg/week). Oscillometric BP measurements are not equivalent to the intra-arterial (UAC or radial arterial) BP in ill neonates. The BP increases with increase in weight, gestational age at birth, and post-menstrual age in ill neonates. J Am Soc Hypertens 2014;8(1):36–44. © 2014 American Society of Hypertension. All rights reserved.

Keywords: Accuracy; invasive blood pressure; non-invasive blood pressure.

Introduction

In the neonatal intensive care unit (NICU), the decision to initiate inotropic therapy, provide volume support, or initiate antihypertensive therapy is often guided by the blood pressure (BP) measurements.[1,2] Accurate BP measurements are essential for the optimal management of hypotension and hypertension in neonates.

BP measurements in neonates can be performed by the invasive intra-arterial method or by the non-invasive oscillometric method. Intra-arterial BP measurements can be performed through umbilical arterial catheters (UAC) or peripheral arterial catheters such as radial arterial catheters.[3] For the non-invasive BP monitoring, the oscillometric method is most frequently employed because of its ease of use compared with the auscultatory or Doppler methods.

Intra-arterial BP monitoring is considered the gold standard for neonatal BP measurements. Prior studies comparing the oscillometric and intra-arterial BP measurement methods in neonates have provided conflicting results.[2,4–8] The accuracy and reliability of the oscillometric method remains questionable.

There are substantial data regarding the BP trends obtained by the oscillometric method in neonates with respect to the gestational age (GA) at birth, the birth weight, and the post-menstrual age (PMA).[9–14] The data obtained by the intra-arterial method, which is considered a more accurate method to assess the neonatal BP, are limited.[4,10,15]

The aim of our study was to compare the oscillometric and intra-arterial BP measurements, as obtained by either UAC or radial arterial catheters, in pre-term and term neonates hospitalized in a tertiary care NICU. We assessed the impacts of such variables as the weight, GA at birth, PMA, extremity of BP measurement, low BP, inotropic and ventilator support on the comparisons between the BP measurements obtained by these two methods. We evaluated the intra-arterial BP distribution with respect to the GA at birth, daily weight, and PMA over a period of several weeks.

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*Corresponding author: Shwetal Lalan, MD, Children's Mercy Hospitals, 2401 Gilham Road, Kansas City, MO 64108. Tel.: 816 234 3010.

E-mail: shwetal_lalan@hotmail.com

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Methods

In this prospective, single center study, we evaluated neonates admitted to our NICU during the period of July 2012 and October 2012 who had UAC or radial arterial lines for intra-arterial BP measurements. The patients with coarctation of the aorta or lethal congenital anomalies were excluded.

Based upon the weight of the neonates, 3.5 F to 5.0 F UAC and 22 G to 24 G radial arterial catheters were used for intra-arterial BP measurements. The intra-arterial BP obtained by the UAC or radial arterial catheters were recorded every minute. These BP readings were averaged in 5-minute increments for subsequent analyses. The intra-arterial BP measurements were obtained using the GE TRAM (X51 Modules; GE Healthcare, Waukesha, WI). Per our NICU protocol, the system was calibrated every 8 hours or if there were findings of air bubbles or an absence or distortion of the dicrotic notch. The UAC or radial arterial catheters for continuous intra-arterial BP monitoring were placed per our NICU protocol for the neonates with unstable conditions, such as lethargy, perfusion changes, or unstable respiratory conditions, clinical sepsis or proven sepsis, or severe cardiovascular disease.

The oscillometric BP measurements were obtained per our NICU protocol, which is to measure the oscillometric BP every 8 hours, attempting to avoid the measurements within 30 minutes of any procedures or activities. The measurements were obtained in either the upper arm in the upper extremity or the thigh in the lower extremity, based upon ease of access and the need to avoid peripherally placed intravenous catheters. The cuff sizes were used per the manufacturer's recommendations. When two or more oscillometric BP readings were obtained within a 5-minute interval, these readings were averaged. The oscillometric BP measurements were recorded using the DINAMAP technology.

The simultaneously obtained and averaged (over a 5-minute interval) intra-arterial (UAC or radial arterial) and oscillometric BP measurements were used for the comparisons. To assess the impact of the PMA and weight on the agreement of BP by the two methods, the following subgroups were used: PMA groups $\leq$32 weeks and $>$32 weeks and weight groups $\leq$1.5 kg and $>$1.5 kg. The PMA was calculated by adding the GA and the day of life. A low BP was defined as an intra-arterial mean arterial pressure (MAP) $<$30 mm Hg.

For each study subject, the GA, the daily weight, and the day of life were recorded. For each BP measured, the presence or absence of inotropic support, presence or absence of ventilator support, the extremity of the oscillometric BP measurement, and the location of the intra-arterial access were recorded. To assess the impact of the GA on the distribution of BP, neonates who had UAC or radial arterial lines within the first 24 hours of life were included, and the BP readings from first 24 hours of life for each patient were averaged. To assess the impact of the PMA on the distribution of BP, the UAC or radial arterial BP measurements averaged over 5-minute intervals were charted against the PMA on a weekly basis. The impact of the daily weight (kg) on the distribution of BP was assessed using the UAC or radial arterial BP readings averaged over 5-minute increments, charted against the weight in kilograms (kg). We did not include the BP readings in our weight analysis if we did not have a corresponding daily weight.

Statistical Analysis

We used a paired *t*-test to compare the difference between the two methods of BP measurements. Agreement between the oscillometric versus the UAC BP and oscillometric vs radial arterial BP are graphically depicted as scatter plots and Bland-Altman plots. The univariate and multivariate linear regression analyses were performed using the General Linear Model (GLM) PROC MIXED repeated measures procedure using SAS to assess the impact of the GA, PMA, weight, inotropic support, ventilator support, and the extremity of the BP measurement on the agreement between the BP obtained by the two methods. The GLM PROC MIXED procedure for repeated measures was performed to assess the effect of the PMA and weight on the UAC, radial arterial and combined UAC, and the radial intra-arterial BP. Repeated measures analysis of variance GLM procedure were performed to compare the difference between the impact of the GA, PMA, and weight on BP measurements obtained by the UAC and radial arterial methods. A linear regression using GLM was performed to assess the effect of the GA groups (23–27 weeks, 28–32 weeks, 33–36 weeks, and $\geq$37 weeks) on the UAC, radial arterial, and combined intra-arterial BP measurements in the first 24 hours of life. The SAS GLM PROC MIXED repeated measures takes in to account the BP as a repeated variable for a patient during the analysis. The distribution profile for the intra-arterial BP is charted as the fifth percentile, the mean, the 95th percentile, and linear regression lines for average MAP. Statistical significance was defined as $P < .05$. All statistical analyses were performed using SAS 9.2 (Cary, NC).

The study was approved by the local institutional review board.

Results

We studied 101 neonates between the GA of 24 to 40 weeks admitted to our tertiary care NICU who had intra-arterial BP monitoring performed by either UAC or radial arterial lines. Of the 101 neonates, 63 neonates had intra-arterial BP measurements taken during the first 24 hours of life, and these patients were included in the