

Reliability of Resting Blood Pressure Measurement and Classification Using an Oscillometric Device in Children with Chronic Kidney Disease

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Objective To compare the reliability of blood pressure (BP) readings obtained with an oscillometric device with those obtained by auscultation and assess for differences in BP status classification based on the 2 techniques.

Study design Resting BP was measured by auscultation and with an oscillometric device at the same encounter in 235 subjects enrolled in the Chronic Kidney Disease in Children study. Resting auscultatory BP values were averaged and compared with averaged oscillometric readings. BP agreement by the 2 methods was assessed using Bland-Altman plots, and BP status classification agreement was assessed by calculation of kappa statistics.

Results Oscillometric BP readings were higher than auscultatory readings, with a median paired difference of 9 mm Hg for systolic BP (SBP) and 6 mm Hg for diastolic BP (DBP). Correlation for mean SBP was 0.624 and for mean DBP was 0.491. The bias for oscillometric BP measurement was 8.7 mm Hg for SBP ($P < .01$) and 5.7 mm Hg for DBP ($P < .01$). BP status classification agreement was 61% for SBP and 63% for DBP, with Kappa values of .31 for SBP and .20 for DBP.

Conclusions Compared with auscultation, the oscillometric device significantly overestimated both SBP and DBP, leading to frequent misclassification of BP status. (*J Pediatr* 2012;160:434-40).

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Reference values for childhood blood pressure (BP) have been issued on four occasions since the 1970s by the National High Blood Pressure Education Program. These values are based on a database of BP readings obtained by auscultation in normal children from a nationally representative sample. Consensus recommendations for measuring BP and classifying hypertension status in children and adolescents state that auscultation is the preferred method of BP measurement in the young. It is further recommended that elevated BP values obtained by another method, such as an oscillometric device, should be remeasured by auscultation.¹

Despite this recommendation, many clinicians routinely use oscillometric devices for BP measurement in children and adolescents given their convenience and ease of use. Frequent use of oscillometric devices occurs even among pediatric nephrologists, 70% of whom stated that they routinely use oscillometric devices to measure BP.² At the same time, it has been shown that oscillometric devices may not yield BP readings that are as accurate or reproducible as those obtained by auscultation.³ This problem may be amplified in children who may not cooperate well with oscillometric devices, thus resulting in greater and more frequent inaccuracies.⁴

We have recently shown that among children with chronic kidney disease (CKD), elevated BP is common, is frequently missed, and is often undertreated.⁵ Although the reasons for this are unclear, it is important to understand whether the use of oscillometric devices rather than auscultation may introduce systematic errors in BP measurement, which may lead to misclassification of hypertension status. To the best of our knowledge, no data comparing BP measurement and classification by these 2 methods are available in children with CKD.

We therefore compared paired resting BP values obtained by auscultation and oscillometry in children enrolled in the Chronic Kidney Disease in Children

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ABPM	Ambulatory blood pressure monitoring	DBP	Diastolic blood pressure
BMI	Body mass index	GFR	Glomerular filtration rate
BP	Blood pressure	ICC	Intraclass correlation coefficient
CCC	Clinical Coordinating Centers	SBP	Systolic blood pressure
CKD	Chronic kidney disease	sHTN	Systolic hypertensive
CKiD	Chronic Kidney Disease in Children	sPHTN	Systolic prehypertensive

(CKiD) cohort study to better understand the comparability of BP values obtained by the 2 techniques, and the effect of these different techniques on classification of BP status.

Methods

The CKiD study is an observational cohort study of 586 children with CKD being conducted at 46 pediatric nephrology centers in North America; the study design and objectives have previously been published.⁶ The CKiD study protocol has been reviewed and approved by the institutional review boards of each participating center ([Appendix](#); available at www.jpeds.com).

Eligibility criteria for enrollment in CKiD include age 1-16 years, estimated glomerular filtration rate (GFR)⁷ of 30-90 mL/min/1.73 m², and signed written informed consent by a parent or guardian, plus signed assent according to local requirements. Exclusion criteria include solid organ, bone marrow, or stem cell transplant; dialysis within 3 months of enrollment; cancer/leukemia or human immunodeficiency virus treatment within the past year; pregnancy within the past year; inability to complete protocol procedures; enrollment in a randomized clinical trial in which treatment is masked; or plans to move away from the participating center in the near future.

The present study is a cross-sectional analysis of resting BP measurements obtained by a standard BP measurement protocol⁵ across all sites at follow-up visits at which subjects underwent resting BP measurement by auscultation and also with an oscillometric device. Analysis was restricted to children with both auscultatory and oscillometric BP measurements obtained on the same day.

Resting Blood Pressure

Auscultatory Measurement. The protocol for auscultatory BP measurement in the CKiD study has been described.⁵ Briefly, after 5 minutes of rest and after measurement of the child's upper arm, an appropriately sized cuff¹ is selected. Following this, the peak inflation pressure is determined and then 3 BP measurements at 30-second intervals are obtained by auscultation of the brachial artery using an aneroid sphygmomanometer (Mabis MedicKit 5; Mabis Healthcare, Waukegan, Illinois). The first Korotkoff sound is recorded for systolic BP (SBP) and the fifth Korotkoff sound for diastolic BP (DBP). All participating clinical sites have been provided the same aneroid device by the CKiD Clinical Coordinating Centers (CCCs). The CCCs also provide standardized training and certification in the auscultatory BP measurement protocol to all study personnel responsible for casual BP measurement. Recertification in auscultatory BP measurement technique and calibration of each center's aneroid device occurs annually.

For this analysis, auscultatory BP values (SBP and DBP, respectively) were calculated as the mean of the 3 auscultatory BP measurements.

Oscillometric Measurements. The CKiD study protocol includes ambulatory BP monitoring (ABPM) at the first follow-up study visit using a SpaceLabs 90217 oscillometric device (SpaceLabs Healthcare, Issaquah, Washington). Monitors are programmed centrally at the ABPM Center (University of Texas at Houston), shipped to the clinical sites, and placed on the subject's nondominant arm. The child's arm circumference is measured locally and an appropriately sized cuff is selected according to Fourth Report recommendations.¹ Monitor placement occurs at the end of the study visit, after the auscultatory readings have been obtained. All participating clinical sites receive annual training in monitor placement from the ABPM Center.

At the time of monitor placement, the CKiD protocol calls for 3 resting BPs to be obtained using the SpaceLabs device to ensure that the monitor is fitted and working properly. For the current analysis, oscillometric SBP and DBP measurements were calculated as the mean of these resting oscillometric BP measurements, excluding the first reading. The first reading was excluded to account for the fact that the cuff inflation process is automated and may overinflate on the first reading, leading to inaccurate BP measurements. The first auscultatory BP reading was not excluded because determination of the peak inflation pressure as previously described⁵ avoids overinflation.

Definitions/Classification of BP status

For this report, participants' SBP and DBP statuses, respectively, were classified according to the National High Blood Pressure Education Program Fourth Report on the diagnosis, evaluation, and treatment of high BP in children and adolescents¹: individuals with resting BP <90th percentile were categorized as normotensive, ≥90th and <95th percentiles as prehypertensive, and ≥95th percentile as hypertensive. This classification scheme was applied to resting BP values obtained by auscultation and by the oscillometric device. BP status categorization was applied to BP measurements whether children were taking antihypertensive medications or were BP medication naïve.

Other Variables

To describe the clinical characteristics of the study population, the following variables are also reported: age, sex, race, ethnicity, GFR, CKD diagnosis, body mass index (BMI) percentile, and use of antihypertensive medication. All clinical measurements and biologic samples were collected concomitantly at the time of the study visit. GFR was determined by plasma iothexol disappearance as previously described.⁸

Demographic and medical history information was collected at the participating clinical sites using standardized forms. Anthropometric measurements were obtained via a standardized physical examination. Age- and sex-specific height, weight, and BMI percentiles were calculated using standard growth charts for US children.⁹ Blood samples were analyzed at the CKiD central laboratory (University of Rochester, Rochester, New York).

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