EDITORIAL

Blood Pressure Measurement in Critically-ill Children: Where do we Stand?

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There has been a steady increase in the admissions to pediatric and neonatal intensive care units (ICUs) worldwide [1,2]. In an acute clinical setting of critically ill children, blood pressure (BP) measurement is a crucial vital sign to assess their hemodynamic stability. Accurate measurement of blood pressure is essential for the diagnosis of hypertension as well as of hypotension, including various categories of hemodynamic shock [3,4]. Recent reports have shown that hypertension is relatively common in pediatric ICUs with prevalence of 19-25% [5,6], and is associated with increased length of stay and hospital expenses [7]. An abnormal blood pressure measurement is often the primary trigger for initiating therapeutic interventions, and therefore the accurate measurement of blood pressure is critical for appropriate decisions regarding the fluid volume, inotropes and vasoconstrictors [4,6].

We have come a long way since the auscultatory technique of BP measurement was first described by Korotkoff in 1905 [8]. Despite technological advancement in methods of measuring BP, including the automated BP monitors, the auscultatory method still remains the gold standard for measuring BP in different clinical and laboratory settings [9]. As per the latest European and American guidelines for pediatric hypertension, auscultatory BP measurement remains the recommended method for diagnosing hypertension in children [10,11]. However, there are considerable limitations regarding auscultatory measurements in children. These include smaller elastic arteries, shorter waveforms, a large discrepancy between the central aortic pressure and peripheral brachial pressure, and dependency on 4th Kortakoff sound in some cases [12]. Additionally, there are inherent obstacles to the auscultatory technique such as inaccurate cuff size, noisy background, observer error and bias; and observer characteristics such as digit preference, hand-eye coordination and hearing and visual acuity [8,12].

Some of the caveats of auscultatory techniques can be addressed with the routine use of automated oscillometric devices, especially in adult clinical settings. The advantage of this attractive alternative includes full automation, less dependency on specialist training for its use, and the low inter-rater variability [13]. However, the published evidence regarding the accuracy of these devices in children is limited [12,13]. Only a few devices available in the market have been successfully and properly validated for their use in children, with a very limited evaluation of proprietary algorithms required for estimating systolic and diastolic BP from the mean BP [14]. In addition, overinflation of automated cuff can cause significant discomfort and the child movement, resulting in inaccurate measurements [13]. Most studies assessing the accuracy of oscillometric devices have shown an overestimation of systolic BP by these devices in comparison to the "gold standard" mercury sphygmomanometer [13].

In view of these limitations of non-invasive methods of BP measurement and the absolute requirement of accurate measurement to guide the management, the intra-arterial BP is still considered as the standard of care in critically ill children. However, this technique of beat-to-beat arterial pressure measurement can be difficult to employ in some young patients and has the inherent risk of hemorrhage, vessel injury and infection [15]. In addition, absence of optimally dampened arterial system has the theoretical risk of overestimation or underestimation of the invasive BP [4,16]. Therefore, there has been an ongoing impetus to evaluate the accuracy of different non-invasive BP techniques in comparison to the invasive method, enabling the transition to a more convenient but still reliable method of BP measurement in this group.

In this issue of *Indian Pediatrics*, Krishna, *et al.*[17] report the correlation and reliability of non-invasive BP obtained by auscultatory (ABP) and oscillometric (OBP) methods compared to invasive BP (IBP) in 50 critically-ill

children, aged 1-12 years. Both non-invasive methods significantly underestimated systolic (SAP) and overestimated diastolic (DAP) compared to the invasive BP. In comparison, the difference between mean arterial pressure (MAP) of both auscultatory and oscillometric BP with invasive BP was insignificant. Additionally, they observed a significant correlation between SAP, DAP and MAP measurements of invasive BP versus auscultatory BP, with Pearson's coefficients for SAP, DAP and MAP as 0.914, 0.920, 0.944, respectively. A similar result was noticed between invasive BP versus oscillatory BP (0.908, 0.866, 0.916). It was concluded that the mean arterial pressure obtained by non-invasive methods is more reliable than systolic or diastolic pressures when compared with invasive BP. The results of the study are encouraging regarding the applicability of non-invasive methods of BP measurement in critically-ill children, especially for the measurement of the mean BP. However, some caution should be exercised in interpreting the results. First, although the mean difference between the mean BP was minimal and there was a significant correlation between the measurements by different techniques, wide variability in individual differences was observed as evidenced by the wide limits of agreement (IBP-ABP: 12.6; -15 and IBP-OBP:16.4; -17.4). Secondly, there was a significant underestimation of systolic BP and overestimation of diastolic BP between the auscultatory and invasive methods. Since mean BP is derivative of these two variables in auscultatory technique, observation of an insignificant difference in mean BP could potentially have arisen from the opposite trends in the systolic and diastolic BP and therefore might not generate the similar results in other studies where the significant variation observed in only the systolic or diastolic component.

There is limited literature available regarding the accuracy of non-invasive BP (NIBP) measurements in critically-ill patients, with only a handful of systematic studies conducted in till date. Joffe, *et al.* [4] demonstrated a minimal mean difference between the NIBP and IBP measurements as well a good correlation between the two techniques. However, they observed wide variability in their difference as demonstrated by wide standard deviation and limits of agreement. Therefore, it was concluded that there is a clinically significant difference between IBP and NIBP measurements in critically-ill children and therefore NIBP may not be accurate enough to replace IBP as the preferred method to guide diagnosis and the management. Similarly, Holt, *et al*. [6] showed that outside the normotensive BP range, the automated oscillometric method was not reliable as it underestimated the BP during hypertension and overestimated during hypotension, potentially delaying the commencement of the treatment. Auscultatory method of NIBP was not employed in this study.

Overall, this study is a welcome addition to the available scant data on non-invasive BP monitoring in critically-ill children. However, further systematic multicentric studies are required to confirm these findings.

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