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Rethinking Cardiovascular Risk in Pediatric Sleep Apnea—Tissue Oxygen Delivery Matters

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As in adults, obstructive sleep apnea (OSA) is highly prevalent in children (3%-5%) and often underdiagnosed.[1] OSA in children is increasingly recognized as a condition with potential short-term and long-term cardiovascular consequences.[2] The presence of episodic increases in upper airway resistance and potential collapse during sleep disrupts both sleep continuity and normal ventilation and oxygenation, all of which can lead to sustained alterations in blood pressure regulation and early markers of cardiovascular dysfunction.[3,4] Although much of the attention in clinical practice has traditionally been focused on the apnea-hypopnea index (AHI) as a measure of disease severity, the AHI alone provides an incomplete picture since it quantifies only the frequency of events and fails to account for the physiological and homeostatic burdens imposed by each respiratory perturbation, particularly those events associated with hypoxemia. Recent advances in adult sleep medicine have highlighted the value of the hypoxic burden (HB)—a metric that quantifies the cumulative impact of oxygen desaturation during the night—as a factor associated with more accurate estimation of cardiovascular outcomes.[5] Similarly, principled oxygenation indices, such as the oxygen desaturation burden index, have recently been investigated in children and have shown promise regarding estimation of neurocognitive dysfunction.[6] However, the utility of HB in assessing cardiovascular comorbidity risk has not been explored in the pediatric population.

In this context, the study by Mediano et al,[7] derived from the prospective Kids Trial, represents a significant step forward in pediatric sleep research. The authors evaluated 190 children with suspected OSA who underwent overnight polysomnography and 24-hour ambulatory blood pressure monitoring. The primary objective was to determine whether HB, measured as the area under the oxygen desaturation curve per hour of sleep, correlates with nocturnal blood pressure patterns, particularly the nondipping pattern (NDP), which represents an additional cardiovascular risk marker. Children with higher levels of HB exhibited significantly less nocturnal decline in blood pressure values and a higher prevalence of NDP. Specifically, HB values higher than 22.53% min/h were independently associated with an odds ratio of 2.41 (95% CI, 1.00-5.79) for presenting with NDP, even after adjusting for confounders such as age, sex, and body mass index. This association was consistent across sleep stages, with rapid eye movement (REM) sleep and supine position unsurprisingly showing particularly elevated HB levels, underscoring the dynamic nature of HB across physiological contexts.

The implications of these findings are both clinically and conceptually important. First, the study reinforces the limitations of AHI as a stand-alone metric of disease severity, especially when cardiovascular risk is concerned. The association between HB and NDP suggests that the burden of hypoxemia—not merely the frequency of desaturation events—may be the key driver of downstream cardiovascular dysregulation. This supports a shift in focus from quantifying how often apneas and hypopneas occur, to assessing the severity of their physiological impact. HB captures a substantial component of this impact in a single, automated metric derived from oximetry, making it a practical tool for broader clinical applications. Importantly, the ease of calculating HB without the need for manual event scoring or sleep stage classification makes it well-suited for pediatric populations, where sleep studies are often more challenging and time-consuming to interpret. Notwithstanding, in light of the relatively less severe desaturations generally occurring in children, efforts to quantify the impact of sleep fragmentation and add it to the HB may further refine the estimation of cardiovascular morbidity.[8]

Second, the association between HB and NDP has potential implications for early intervention. In adults, the presence of a nondipping blood pressure pattern is a well-established risk factor for cardiovascular morbidity and mortality.[9] While similar longitudinal data in children are lacking, there is growing evidence that early-life blood pressure abnormalities track into adulthood and contribute to the development of hypertension and vascular disease, as shown in 2021 by Fernandez-Mendoza and colleagues.[10] By identifying children at higher risk through preferably multiple-night HB measurements to account for night-to-night variability, clinicians could prioritize follow-up, consider earlier therapeutic interventions such as adenotonsillectomy, and potentially mitigate long-term cardiovascular sequelae.

Furthermore, this study[7] provides insights into the variability of HB across sleep architecture and body position. That HB values were notably higher during REM sleep and when children were supine is consistent with findings of adult studies and reflects the known vulnerabilities of these sleep states to airway compromise. This highlights the importance of personalized assessment and suggests that HB could also be useful in evaluating positional or sleep-stage–dependent OSA severity, thus informing tailored treatment strategies.

Despite its strengths, the study also has limitations. It is based on a single cohort, and although the sample was well characterized and the methodology rigorous, external validation in larger and more diverse pediatric populations is needed. Moreover, while HB is associated with NDP, the prognostic significance of this pattern in children—particularly its long-term cardiovascular impact—remains to be determined through longitudinal studies. Also, while the study is based on a prospective cohort, the present analysis is cross-sectional, limiting causal inferences. Future research should also seek to establish normative HB thresholds in children and investigate whether reductions in HB following treatment correlate with improvements in blood pressure regulation and other cardiovascular outcomes.

Is HB a game changer in pediatric sleep apnea? We still do not know, as many questions remain unanswered. For example, is HB superior to AHI in the pediatric population? Why was an association between HB and systolic blood pressure not seen? Since NDP is a component of blood pressure variability, is the association between HB and NDP dependent on absolute blood pressure values? What is the impact of obesity on HB-cardiovascular relationships (eg, additive, synergistic, or none)? Is there a relationship between HB and plasma-derived biomarkers of cardiovascular risk?

Of course, more evidence is needed, but this secondary analysis of the Kids Trial offers timely and valuable evidence that the HB may provide a promising biomarker for short-term cardiovascular risk stratification in children with OSA. Its association with blood pressure abnormalities, particularly the NDP, positions HB as a clinically relevant metric that could reshape how pediatric sleep apnea is evaluated and managed. As the field moves toward more precise and personalized approaches to care, incorporating metrics like HB may help bridge the gap between diagnosis and meaningful cardiovascular prevention in this population.

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