Comparison of Airmod and Capnography for Pediatric Sedation Respiratory Rates

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ABSTRACT

Purpose: This study aimed to evaluate the accuracy of the Airmod device compared to capnography (Cap), the gold standard, in measuring respiratory rates (RR) in pediatric patients undergoing oral conscious sedation during dental procedures.

Methods: Fifty-nine pediatric patients aged 3-16 years, classified as ASA I or II, and scheduled for oral conscious sedation at the UT Health COHR Pediatric Dental Clinic, were recruited. RR was monitored using the Airmod device (an electronic stethoscope) and Cap concurrently. Patient behaviors, including talking and crying were documented throughout the procedure. Bland-Altman analysis, generalized linear mixed models, and Pearson correlation were used to assess agreement and variability between devices.

Results: Of the 59 recruited patients, 32 were evaluable. Airmod measurements consistently underestimated RRs compared to Cap, with a mean negative bias of 2.5 bpm. Bland-Altman analysis revealed limits of agreement from -5.8 to 0.8 bpm, with increased variability at higher RRs (>20 bpm). The Pearson correlation coefficient was 0.25, indicating weak agreement and substantial discrepancies at elevated RRs. Generalized linear mixed models confirmed significant underestimation at higher RRs (P<.001). Despite this, 85% of Airmod readings fell within clinically acceptable ranges at lower RRs.

Conclusion: While Airmod offers a promising non-invasive alternative for RR monitoring during mild to moderate sedation, its systematic underestimation highlights limitations at higher respiratory rates. Further refinement of the device is necessary to optimize its accuracy and reliability for pediatric use.

MATERIALS and METHODS

This prospective observational study was conducted over six months at the UT Health COHR Pediatric Dental Clinic to compare respiratory rates (RR) measured by the Airmod device and capnography, the gold standard. Data collection followed real-world clinical conditions to enhance external validity.

Study Population: Participants included pediatric patients aged 3–16 years with ASA I or II status, weighing at least 13 kg, and meeting specific airway assessment criteria. Exclusion criteria included recent respiratory illness, significant airway abnormalities, or language barriers. Parental informed consent was obtained, and parents were allowed to be present during procedures.

Interventions: RR was measured simultaneously using the Airmod device and capnography. The Airmod, featuring an AS-101 electronic stethoscope, was secured at the sternal notch with biocompatible tape. Capnography data was collected via a nasal cannula attached to the nitrous oxide hood. Both devices recorded continuously throughout sedation, with behavioral observations (e.g., talking, crying, movement) documented as potential confounders.

Informed Consent and Ethical Approvals: The study received IRB approval, ensuring compliance with ethical guidelines for research involving human subjects. IRB ID: STUDY00000375. Informed consent was obtained from parents or legal guardians in either English or Spanish, with opportunities for questions and thorough explanations provided before enrollment.

Data Collection & Management: Device data was automatically logged and securely stored, while behavioral observations were recorded manually. Data entry followed strict confidentiality protocols, limiting access to authorized personnel.

Statistical Analyses: Agreement between devices was assessed using Bland-Altman plots to evaluate bias and variability. Pearson correlation coefficients measured association strength, while generalized linear mixed models accounted for repeated measures and systematic bias. A sample size of 59 participants was determined via power analysis to ensure statistical rigor.

RESULTS

Patient Demographics: Of the 59 patients recruited, 32 completed the study. Ages ranged from 3-16 years, with diverse gender and ethnic representation. All participants met inclusion criteria, and no adverse events were reported during the study.

Agreement Between Airmod and Capnography: Airmod underestimated RRs compared to Cap (mean bias: -2.5 bpm; limits of agreement: -5.8 to 0.8 bpm). Variability increased at higher RRs (>20 bpm). The Bland-Altman plot (Figure 1) visually demonstrates this trend, showing tighter clustering of data points near the mean at lower RRs, with greater dispersion observed at higher rates. This highlights the need for further refinement of the Airmod device to improve its accuracy in higher RR ranges.

A Pearson correlation coefficient of 0.25 indicated weak agreement between Airmod and capnography. While Airmod performed adequately at lower respiratory rates, deviations increased at higher rates, as shown in the scatter plot (Figure 2). Within the linear range of Airmod readings (10–35 bpm), the slope was 0.3 (95% CI: 0.35–0.37) with an intercept of 8.8 bpm (95% CI: 6.9–9.8 bpm), indicating Airmod aligns with capnography at 12.6 bpm but increases only 0.3 bpm per unit of capnography. Airmod's repeatability was ±5 bpm.

Performance at Clinically Relevant Ranges: Despite systematic bias, 85% of Airmod readings were within clinically acceptable ranges at lower RRs (<20 bpm). However, its accuracy diminished as RRs exceeded 20 bpm, limiting its utility for detecting rapid respiratory changes.

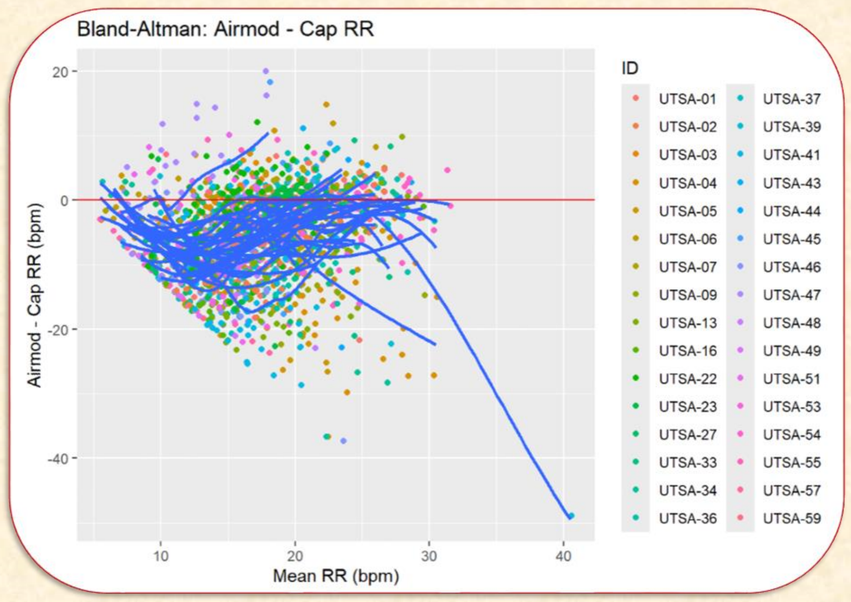

Figure 1: The Bland Altman plot (Difference Airmod - Cap RR vs Average Airmod vs Cap) are shown for each participant below. The Airmod appears to give lower estimates for much of the range. There is an outlier with a high >40 bpm.

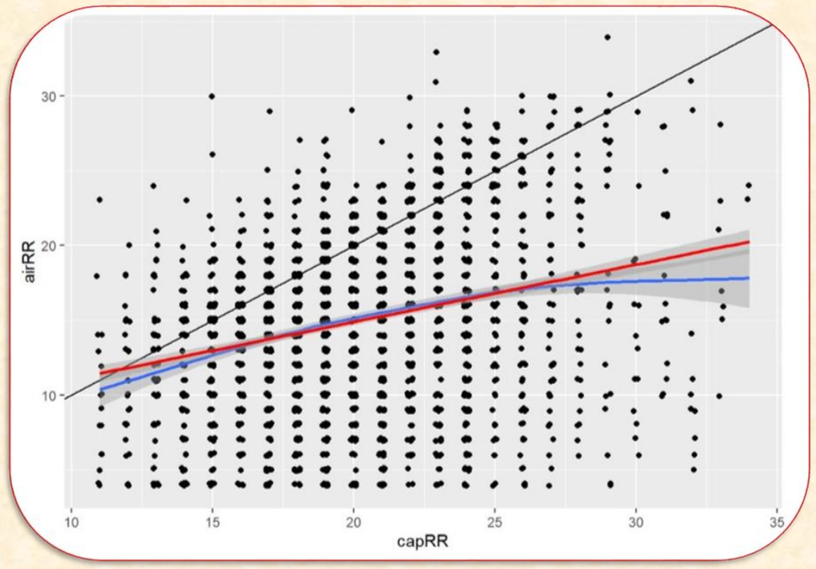

Figure 2: Pearson Correlation Coefficient

DISSCUSSION

This study evaluated the Airmod device's adaptability in pediatric sedation settings, revealing both its strengths and limitations. Originally designed for adults in controlled environments like operating rooms, Airmod demonstrated the ability to actively cancel noise and provide real-time respiratory feedback. This function is critical in procedural sedation, where early detection of respiratory changes enhances patient safety.

However, challenges emerged in pediatric use. External noise from crying and talking affected data accuracy, and the device underestimated higher pediatric respiratory rates due to calibration limitations. Additionally, practical issues such as the attachment of the stethoscope to children's smaller and more mobile anatomies required frequent reapplication, impacting data reliability. Despite these issues, Airmod reliably detected low respiratory rates, making it useful for identifying potential airway obstruction or oversedation.

Future research should focus on refining the device to better accommodate the unique characteristics of pediatric patients. With refinements, Airmod has the potential to serve as a valuable adjunct to traditional respiratory monitoring, advancing safety in pediatric sedation care.

CONCLUSIONS

- Airmod is a promising non-invasive tool for RR monitoring in pediatric sedation but underestimates higher RRs compared to capnography.
- Device refinements are necessary to optimize accuracy for pediatric use.
- Airmod's utility is strongest at stable, lower RRs, making it suitable for mild-to-moderate sedation scenarios

REFERENCES

- Coté, Charles J., et al. "Guidelines for monitoring and management of pediatric patients before, during, and after sedation for diagnostic and therapeutic procedures." *Pediatrics* 143.6 (2019).
- Wilson, S. "Patient monitoring in the conscious sedation of children for dental care." *Current Opinion in Dentistry* 1.5 (1991): 570-576.
- Dionne, Raymond A., et al. "Balancing efficacy and safety in the use of oral sedation in dental outpatients." *The Journal of the American Dental Association* 137.4 (2006): 502-513.
- Haberland, Christel M., Suher Baker, and Haibei Liu. "Bispectral index monitoring of sedation depth in pediatric dental patients." *Anesthesia progress* 58.2 (2011): 66-72.
- American Academy of Pediatric Dentistry. Use of anesthesia providers in the administration of office-based deep sedation/ general anesthesia to the pediatric dental patient. The Reference Manual of Pediatric Dentistry. Chicago, Ill.: American Academy of Pediatric Dentistry; 2024:430-4.

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