Tailoring ventilation and respiratory management in pediatric critical care: optimizing care with precision medicine

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Purpose of review
Critically ill children admitted to the intensive care unit frequently need respiratory care to support the lung function. Mechanical ventilation is a complex field with multiples parameters to set. The development of precision medicine will allow clinicians to personalize respiratory care and improve patients' outcomes.

Recent findings
Lung and diaphragmatic ultrasound, electrical impedance tomography, neurally adjusted ventilatory assist ventilation, as well as the use of monitoring data in machine learning models are increasingly used to tailor care. Each modality offers insights into different aspects of the patient's respiratory system function and enables the adjustment of treatment to better support the patient's physiology. Precision medicine in respiratory care has been associated with decreased ventilation time, increased extubation and ventilation wean success and increased ability to identify phenotypes to guide treatment and predict outcomes. This review will focus on the use of precision medicine in the setting of pediatric acute respiratory distress syndrome, asthma, bronchiolitis, extubation readiness trials and ventilation weaning, ventilation acquired pneumonia and other respiratory tract infections.

Summary
Precision medicine is revolutionizing respiratory care and will decrease complications associated with ventilation. More research is needed to standardize its use and better evaluate its impact on patient outcomes.

Keywords
acute respiratory distress syndrome, pediatric intensive care, precision medicine, respiratory care, ventilation

INTRODUCTION

Pathological processes affecting the lung's function are frequent in the pediatric intensive care unit (PICU) [1]. Patients are diagnosed using clinical, biochemical and radiological data and are treated following the same standardized clinical guidelines or evidence-based practices. However, the wide range of ages in pediatric practice combined with the diversity of complex and heterogeneous pathologies makes this approach unsuitable for every individual patient.

With the increased use of new bedside imaging modalities [2,3,4▪,5,6], monitoring devices and electronic medical records giving access to larger amount of data per patient, we are seeing a shift towards tailoring the treatment specifically based on the patient's characteristics [7,8,9▪▪,10▪▪]. This approach is referred to as precision or personalized medicine [11]. This review will focus on the use of precision medicine to improve respiratory care in the PICU in the setting of pediatric acute respiratory distress syndrome (PARDS), severe asthma, bronchiolitis, extubation readiness trials and ventilation weaning, ventilation acquired pneumonia (VAP) and other respiratory tract infections. Technologies presented in this review, their advantages, their drawbacks and the important parameters are displayed in Tables 1 and 2, respectively.

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KEY POINTS

- Lung and diaphragmatic ultrasound, electrical impedance tomography (EIT) and neurally adjusted ventilatory assist (NAVA) are improving ventilation and weaning strategies and have a positive impact on patient outcomes.
- Machine learning models and CDSS will optimize diagnosis, the adherence to treatment guidelines and lung-diaphragmatic protective ventilation strategies in the PICU.
- The diagnosis and management of respiratory muscle weakness can be personalized to accelerate weaning and extubation and improve long-term respiratory function in critically ill children.
- Racial bias in pulse oximetry readings underscores the need for careful interpretation in diverse patient populations and highlights the importance of skin tone in machine learning models.

ACUTE RESPIRATORY DISTRESS SYNDROME

PARDS is a heterogeneous and severe disease process that is still associated with high morbidity and mortality [12–14]. The most recent pediatric guidelines (PALICC 2023) [14] recommend adjusting the positive end-expiratory pressure (PEEP) according to the fraction of inspired oxygen (FiO_2) using the table from the ARDS Network as it has been associated with reduced mortality. However, clinicians tend to use lower than recommended pressures because elevated ventilatory pressures can be detrimental to the lung and diaphragm function [15,16]. Precision medicine tools allow clinicians to collect personalized data on patients and tailor treatment and ventilation strategies to optimize care while limiting adverse events.

Esophageal pressure, mechanical power, driving pressure and alveolar dead-space fraction

Transpulmonary pressure evaluated by esophageal pressure [17,18,19▪], driving pressure [20–22,23▪], mechanical power [24,25▪] and alveolar dead-space fraction [26,27] are all parameters that affect outcomes in ARDS populations. Esophageal pressure can give information on the pressure-time product (PTP) and pressure-rate product (PRP) which can be used to help determine the optimal level of ventilatory support [28–30] and predict the risk of extubation failure [31]. PTP is a measure of the effort of breathing, and it is calculated by integrating the pressure generated by respiratory muscles over the inspiratory time. PRP is the product of the respiratory rate and the change in esophageal pressure during a respiratory cycle. Transpulmonary pressure guided ventilation has been linked to increased oxygenation in a pediatric population with moderate to severe ARDS [19▪]. In adults, transpulmonary pressure guided ventilation is associated with reduced mortality and mechanical ventilation days when compared to traditional lung protective strategies [18,32,33].

Getting all these parameters at the bedside will allow to optimize oxygenation and limit ventilator-induced injury, patient-induced injury, atelectasis and overdistension.

Data science and clinical decision support systems

Diagnosing PARDS requires meeting various clinical and radiological criteria which can lead to delays in identification and worse outcomes [34,35]. The widespread use of electronic medical records and the development of databases are allowing for the creation of machine learning models that facilitate timely diagnosis and the creation of clinical decision support systems (CDSS) to guide ventilation and to ensure adherence to guidelines [10▪▪]. Adult studies have shown that automated ARDS diagnostic tools are more efficient and have a higher specificity and sensitivity than clinicians [36,37]. To our knowledge, there are no similar pediatric studies on this topic to date.

A multinational study demonstrated that only 40% of patients with PARDS had an arterial gas when diagnostic criteria were met [12]. When no arterial samples are available, guidelines recommend the use of pulse oximetry (SpO_2) to estimate the hypoxemia severity using the oxygenation saturation index (OSI) or the saturation index (SF) depending on the context [14]. A pediatric equation has been developed to convert SpO_2 to PaO_2 to infer the oxygen index (OI) and the PF ratio with a higher accuracy than the OSI or SF ratios [38,39]. Pulse oximetry is a way to continuously monitor for hypoxemia and expedite diagnosis or assess the impact of ventilatory changes on oxygenation.

Other teams have focused their work on the radiological criteria for the diagnosis. A web-based platform was developed using artificial intelligence on patients' chest radiography for ARDS diagnosis with a recall rate of 95% and precision of 88% [40]. The use of machine learning tools on chest radiography is important as a meta-analysis of adult studies found an association between the radiological findings and the alveolar recruitment potential [41].

Table 1. Advantages and drawbacks of technologies used in respiratory precision medicine

Technique	Description	Advantages	Drawbacks
Clinical decision support systems (CDSS)	-Advance information systems using algorithms, patient data and a medical knowledge base to assist in clinical decisions -These systems can provide real-time, evidence-based recommendations, alerts to help diagnosis and to identify complications or high-risk patients, help monitor patient progress, etc.	- Enhances decision-making; provides evidence-based recommendations - Enables personalized care by analyzing patient-specific data trends - Facilitates standardized care across providers - Improves efficiency, timely diagnosis and management - Can reduce cognitive load and allow clinician to have more time with patients	- Reliance on data quality and volume - High initial costs for implementation and training - Risk of over-reliance; potentially reducing clinical intuition - Data security and privacy concerns - Limited flexibility - Needs explainability and clinical studies to ensure appropriate clinical management -Requires medical knowledge base updates with ever changing literature
Machine learning models	-Computational algorithms designed to identify patterns, make predictions or provide insights based on data -These models train on available patient data and database to provide predictions on new unseen data	-Can analyze large amounts of different types of data (lab results, imaging, text, etc.) - Enables personalized care by analyzing patient-specific data trends -Can predict diseases and patient deterioration and lead to proactive interventions -Can automate repetitive tasks	-Highly dependent on data quality: if data is incomplete, biased or not diverse, the model may produce inaccurate or biased predictions -Lack of transparency of certain models if no explainability behind predictions -Data privacy and security –Integration of such models can be complex and expensive
Ultrasound	-Imaging technique that uses high-frequency sound waves to produce real-time images and evaluate the pleura, lung parenchyma, and diaphragm	-Portable, available at bedside - Quick and accessible - No radiation, noninvasive - Provides immediate and real time information; can assess dynamic processes	- Operator dependency - Requires specialized training to use effectively and expertise to interpret images accurately - Limited availability - Expensive technology - Physical and environmental challenges - Artifact generation from implanted devices; can complicate accurate image interpretation
Electrical impedance tomography (EIT)	-Noninvasive imaging technique that reconstructs tomographic images of a body region by measuring its electrical conductivity, permittivity, and impedance through surface electrodes	- Individualized assessment leading to personalized care - Portable, available at bedside - No radiation; noninvasive - Provides immediate and real time information; can assess dynamic processes - Minimal patient discomfort - Allows for advance respiratory monitoring	- Low spatial resolution - Sensitive to noise and patient movement; can lead to artifacts. Requires precise electrode placement for accurate results - Limited to specific applications - Requires specialized training to use effectively - Variability in measurements due to individual anatomy and physiology - Limited availability - Relatively new technology with limited research
Neurally Adjusted Ventilatory Assist (NAVA)	-Ventilation mode that uses the patient's diaphragm electrical activity to generate synchronized and adjusted breaths in both invasive and noninvasive ventilation. -Technology can be used to evaluate diaphragmatic activity for ventilation weaning	- Improved synchrony between patient and respirator; enhance comfort -Minimally invasive - Provides an objective measure of respiratory effort - Allows for personalized, self-adjusting ventilation	- Requires specialized equipment, expensive technology - Set up may be more complex (i.e. nasogastric tube) - Requires trained staff for usage - Risk of technical problems with electrode performance or signal disruption; requires close monitoring -Noise by cardiac activity can complexify its use
Phenotypes and biomarkers	- Measurable characteristics or biological markers used to classify patients into different groups (phenotypes)	- Enables personalized care; can guide therapy selection - Facilitates risk stratification - Advances understanding of pathophysiology; advancing research - Provides objective data; complements clinical assessments	- Limited availability - High cost - Requires advanced lab equipment and training - False negative and false positive could lead to inaccurate interventions - Time consuming

Table 2. Key parameters and bedside applications of technologies

Technology	Parameters	Bedside applications
Lung Ultrasound	Lung-ultrasound score: A score done by scanning up to 6 zones per hemithorax. Adapted scores exist with fewer zones for critically ill supine patients. Score 0: A-lines or presence of rare (≤ 2 B-lines) Score 1: Presence of scattered B-lines Score 2: Presence of coalescent B-lines Score 3: Lung consolidation	Guide PEEP selection and recruitment maneuvers Estimation of extravascular lung water Diagnosis: Pneumonia, pleural effusion, pneumothorax, bronchiolitis Predicting outcomes and invasive ventilation in bronchiolitis patients and ventilation wean failure
Diaphragm Ultrasound	DE: Distance representing movement of the diaphragm between its position during end-expiration and end-inspiration DT: Perpendicular distance between the pleural and peritoneal layers of the diaphragm. Must be acquired in end-expiration and end-inspiration. DTF: 100 x ((End-inspiratory DT – End-expiratory DT)/ End-expiratory DT)	Guide a diaphragm-protective ventilation, help limiting ventilation diaphragmatic injuries Diagnosis: Diaphragm paralysis, diaphragmatic weakness Help in predicting severity and outcomes in bronchiolitis and asthmatic patients. Help in predicting ventilation wean failure or guide ventilation wean Help guide respiratory muscle training and identifying patient who would benefit from such treatments
NAVA ventilation	EADI: Maximal diaphragmatic electrical activity measured with esophageal catheter. Tonic EADI: Minimal diaphragmatic electrical activity measured with esophageal catheter.	Can optimize the level of support, detection of over and under assistance Limit ventilator-patient asynchrony Help in weaning patient from ventilatory support
Thoracic EIT	EELI: Lung impedance measured by EIT at end-expiration. EELV: Lung volume estimated by EIT at end-expiration. Overdistension and collapse curves: During ventilator pressure change, based on impedance and compliance measurements, curves showing degree of both overdistension and collapse are plotted. Optimal PEEP is thought to be at the intersection of the curves or where collapse is ≤ 5%. Δ Z: Variation overtime of the sum of all pixels in a region of interest. Represents the tidal volume. GI index: Index comparing the difference in impedance of each pixel between end-inspiratory and end-expiratory to its surroundings. It is a measure of heterogeneity.	Can optimize the level of support, personalized PEEP titration Detection of atelectasis and overdistension Identification of patients who could benefit from: recruitment postsuctioning, recruitment maneuvers, prone positioning, etc. Guide ventilation wean and help predict weaning failure

ΔZ, delta impedance; DE, diaphragm excursion; DT, diaphragm thickness; DTF, diaphragm thickening fraction; EADI, electrical activity of the diaphragm; EELI, end-expiratory lung impedance; EELV, end-expiratory lung volume; EIT, electrical impedance tomography; GI, global inhomogeneity; NAVA, neurally adjusted ventilation assist; PEEP, positive end-expiratory pressure.

Machine learning models are also used for mortality prediction and for significant risk factors identification, such severe hypoxemia, a history of cancer or hematopoietic stem cell transplant [42]. This can help guide discussions with parents and guide ventilation strategies or high-risk interventions like the use of extracorporeal membrane oxygenation.

Finally, CDSS have been developed to improve adherence to best practices. Most CDSS have been studied in adult populations and focus on low tidal volume ventilation strategy compliance [43–45,46▪]. It is yet to be determined if such CDSS will impact pediatric patients' outcomes or even if the model recommendations will influence ventilation management at the bedside as the agreement with models can be low [47]. However, a phase-1 clinical trial conducted on children with ARDS evaluated a CDSS prioritizing a lung and diaphragm protective ventilation strategy and compared the outcomes with an historical cohort. Patients ventilated with the CDSS guidance received lower delta pressure, lower tidal volumes, higher PEEP in hypoxemic patients and had more ventilator-free days and fewer days on mechanical ventilation [48].

Ultrasound

Ultrasound guided ventilator parameter changes have been more extensively studied in the adult and neonatal populations. Lung ultrasound (LUS) is correlated with respiratory system compliance in both infants and adults [49]. Observational studies

in adults showed a significant correlation between pressure-volume loops and LUS [50–52] and a meta-analysis in adults demonstrated that a high LUS score in ARDS was associated with higher mortality [53▪]. The study PEGASUS, an international randomized controlled trial, is currently enrolling patients to compare ultrasound-guided management to standard of care in adult patients with moderate to severe ARDS [54].

There are reports of the use of LUS to guide alveolar recruitment and PEEP selection in ARDS [55,56▪▪,57]. The technique requires the identification of lung consolidation and B-lines and the increase of PEEP in a stepwise manner until the apparition of A-lines, which suggests that the lung tissue is reaerated. However, studies in adults are inconsistent for the use of LUS to guide recruitment [51,57–59]. One limitation is that it is difficult to assess lung overdistension with ultrasound, but experimental studies are showing promising results by using the quantification of lung sliding [60,61] and lung strain to assess overdistension [62].

The evaluation of pulmonary hypertension and right ventricle (RV) dysfunction has also been studied in PARDS [63,64]. New or persistent right systolic dysfunction was associated with greater number of ICU days, less ventilator-free days and higher ICU mortality [64]. Nonsurvivors in this study did not improve their RV function overtime in comparison to the survivors. Moreover, a pediatric prospective study showed that the LUS score was correlated with the dynamic compliance, the OI and that the score was higher in children requiring continuous renal replacement therapy while decreasing overtime with fluid removal [65].

Electrical impedance tomography

Thoracic electrical impedance tomography (EIT) utilizes thoracic electrodes to measure conductivity variations, capitalizing on the differing electrical conductivities of air and water. Thoracic EIT allows for a live bedside evaluation of ventilation distribution and the balance between overdistension and atelectasis. The use of EIT is useful to increase compliance, reduce mechanical power, lower driving pressure and it has been associated with more ventilator-free days and lower mortality [65–69,70▪,71].

Pediatric cases have been reported where EIT was used to find optimal PEEP while limiting overdistension and driving pressures [72–74]. This technology can also identify patients in which recruitment maneuvers could be beneficial. Effectively, patients with more atelectasis in dependent areas were more likely to have a positive answer to stepwise recruitment maneuvers [75]. EIT measurements were also proportional to esophageal pressure in one pediatric study [76].

Phenotypes and biomarkers

There are distinct phenotypes in ARDS, each with different characteristics and outcomes [77,78,79▪▪, 80,81]. A subtype is characterized by elevated pro-inflammatory biomarkers, more frequent concomitant sepsis diagnosis and increased vasoactive requirements. This group is associated with longer ventilation duration and higher mortality [80]. Survivors and nonsurvivors have different biomarkers trajectories [81]. Finally, Yehya *et al.* [82▪▪] analyzed genes expression in a cohort of pediatric patients and found three distinct transcriptomic subtypes with a significant difference in hypoxemia evolution, biological signature, underlying diagnosis and mortality rate. The development of rapid phenotype classification and biomarkers analysis will enable the study of the impact of ventilation strategies and specific therapies, allowing for treatment to be tailored to the patient's characteristics.

SEVERE ASTHMA

There is very limited evidence on the use of precision medicine for severe asthma. Ultrasound diaphragm thickening (DT) and diaphragm thickening fraction (DTF) have both been correlated with asthma severity [83]. Additionally, EIT-based flow-volume curves showed strong correlation with spirometry values in noncritical pediatric patients [84]. There are case reports in adults that describe the use of EIT to determine optimal PEEP based on the intrinsic PEEP to avoid air trapping and air leak syndromes [85]. Finally, phenotype study can tailor patient's management with new biologic therapeutic agents for severe asthma [86,87].

BRONCHIOLITIS

Bronchiolitis diagnosis is based on medical history and physical examination as the disease lacks pathognomonic radiological pattern. Chest X-rays provide limited diagnostic value, often leading to unnecessary antibiotic use. The use of precision medicine tools to tailor ventilation and management remains limited.

Ultrasound

A systematic review suggests that LUS may aid in diagnosis and anticipating the need for PICU admission, and respiratory support requirements [88]. Specifically, predictive findings include posterior

or paravertebral consolidation >1 cm or lung derecruitment assessment using different LUS scores. The recent clinical practice guidelines on management of severe bronchiolitis suggest that LUS could be an alternative to chest radiography for descriptive purposes [89]. Moreover, LUS has shown promise in differentiating bacterial pneumonia from viral bronchiolitis, potentially aiding in the timely identification of patients who may benefit from antibiotic therapy [90]. The DTF has also been used successfully to identify patients with moderate to severe bronchiolitis that needed ventilatory support or invasive mechanical ventilation [91–93]. Further prospective studies are essential to validate the use of LUS, define its role in managing children with bronchiolitis, and establish standardized scores.

Neurally adjusted ventilation assist

Neurally Adjusted Ventilation Assist (NAVA) is a technology able to capture electrical activity of the diaphragm to improve ventilator support. The use of NAVA is associated with improved patient-ventilator synchrony and a decrease in respiratory effort [94,95,96▪]. A study demonstrated that elevated tonic diaphragmatic activity, representing a sustained contraction of the diaphragm muscle during expiration, is frequent in patients with bronchiolitis [97▪]. There is a possibility that this represents an effort to maintain a certain level of end-expiratory lung volume and that it could guide the PEEP selection in this population.

VENTILATOR ASSOCIATED PNEUMONIA AND OTHER RESPIRATORY TRACT INFECTIONS

A machine learning model has been used to predict VAP in a PICU population with a sensitivity of 79.7% and a specificity of 72.7% using the PEEP and the variation of the PEEP level, oxygenation markers, the variation of pulmonary compliance, minute ventilation, and ventilatory median pressures from a high-resolution database. [98]. This is useful as delayed antimicrobial treatment is associated with worse outcomes [99,100]. Another team developed a multivariable model to predict prolonged hypoxemia in pediatric influenza patients, using oxygenation markers, blood gas data, ventilation pressures, demographic data and mortality score components [101]. Early identification of these patients is crucial, as prolonged hypoxemia is linked to longer ICU stay and higher mortality [102,103]. Implementing these predictive models in clinical practice can enhance patient management and improve overall outcomes [9▪▪].

VENTILATION WEANING AND EXTUBATION READINESS

In adults, the use of weaning protocols has been shown to reduce the duration of mechanical ventilation, weaning duration, and ICU length of stay [104]. In pediatric populations, similar benefits have been observed. A study in PARDS demonstrated that implementing a ventilator-weaning pathway reduced the median duration of invasive ventilation by 3.6 days without increasing reintubation rates [105]. Another randomized clinical trial in PICU found that sedation and ventilator liberation protocols reduced the time to first successful extubation by a median of 6.1 h compared to usual care [106]. However, other studies in both populations showed no significant change in extubation failure rates, weaning duration and duration of mechanical ventilation, suggesting that a personalized approach may be more beneficial than a standardized protocol [107–109].

Data science and clinical decision support systems

A review and meta-analysis comparing automated weaning protocols to standard of care or nonautomated weaning protocols in adults and children showed that automatic systems reduced weaning duration by 30% [110], ventilation time by 10% and ICU length of stay (LOS) by 8% [111].

Another team predicted respiratory support escalation or re-intubation following extubation [112]. The variables predicting extubation failure included nonminimal ventilatory parameters during the spontaneous breathing trial (SBT), >3 ventilator days, an occlusion pressure (P0.1) $\geq$9 cmH_2O at 30 min and $\leq$ 8 ml/kg of exhaled tidal volume at 120 min.

Ultrasound

Mechanical ventilation can cause respiratory muscle weakness and diaphragm atrophy [113]. LUS enables clinicians to observe the effects of mechanical ventilation on the diaphragm size and function and to study the impact of these changes on extubation and ventilation weaning outcomes [114]. In a study of 47 children, diaphragm atrophy during mechanical ventilation was associated with prolonged noninvasive ventilation following extubation [115]. Diaphragm measurements are also added to other variables like expiratory tidal volumes or hypoxemia severity to improve extubation readiness prediction [116]. The most studied measurements are DTF and diaphragmatic excursion (DE), both associated with extubation failure in pediatric studies (Table 3). Even if there is variability in the threshold values,

Table 3. Diaphragmatic ultrasound to predict weaning failure

Study	Threshold values	Ability to predict weaning failure
Xue *et al.* (2019) [120]	DTF: 21%	AUROC: 0.89
Abdel Rahman *et al.* (2020) [117]	DTF: 23.175% DE: 6.2 mm LUS score: 12	AUROC: 0.932 AUROC: 0.876 AUROC: 0.934
Arslan *et al.* (2022) [118]	DTF: 40.5% DE: 12.15 mm	AUROC: 0.962 AUROC: 0.880
Subhash *et al.* (2023) [119]	DTF: 20%	AUROC: 0.77

AUROC, area under receiver operator characteristic; DE, diaphragm excursion; DTF, diaphragm thickening fraction; LUS, lung ultrasound.

both DTF and DE are promising tool to evaluate weaning readiness, extubation readiness and to predict noninvasive ventilation needs following extubation.

Neurally adjusted ventilation assist

NAVA ventilation has been linked to better decreased sedation requirements and reduced ventilation time. There is growing evidence that diaphragmatic activity can be monitored as a good weaning predictor. A study showed that children who failed extubation had higher diaphragm activity measured both pre and postextubation [121]. The advantages of NAVA during ventilation wean were further illustrated in difficult to wean PARDS patients and was associated with better synchrony and significant improvement in oxygenation compared to pressure support ventilation [122].

Electrical impedance tomography

In adults, studies have shown that EIT can be a valuable tool to monitor regional ventilation distribution and to predict the success of SBTs. Bickenbach *et al.* [123] demonstrated that EIT could help deciding if a SBT will be beneficial for difficult to wean patients on prolonged invasive ventilation courses. Similarly, Wisse *et al.* [124▪] found that a high lung inhomogeneity was associated with SBT failure. A pediatric case is described in a review where tidal volume changes were monitored following a ventilation pressure wean to assess the patient's readiness [125].

RESPIRATORY MUSCLE WEAKNESS AND WORK OF BREATHING

Respiratory muscle weakness can be acquired due to prolonged mechanical ventilation or ICU stay, or due to a congenital neuromuscular disease. Advanced breathing monitoring with 3D cameras has been investigated in a PICU [126]. It allowed for the precise estimation of tidal volumes and the continuous evaluation of the work of breathing. Ultrasound has been used not only to detect diaphragm weakness and paralysis, but also to evaluate the impact of assistance devices such as a pneumatic abdominal-diaphragmatic belt on DE or mechanical insufflation-exsufflation for airway clearance [127–129].

Prompt diagnosis of respiratory muscle weakness enables early inspiratory muscle training which can lead to earlier successful weaning [130,131]. Long-term inspiratory muscle training after diaphragmatic hernia surgery was associated with increased exercise capacity, improvement in respiratory function and better quality of life [132].

SpO_2 AND SKIN COLOR

A systematic review examined how skin tone influences the accuracy of pulse oximetry in estimating arterial oxygen saturation (SaO_2) [133]. The review found that pulse oximeters tend to overestimate SaO_2 in patients with darker skin tones, especially at lower oxygen saturation levels. This overestimation could lead to undetected hypoxemia and delayed interventions. It emphasizes the importance of considering skin tone when interpreting pulse oximetry readings and when using this parameter in machine learning models and CDSS to limit racial bias.

CONCLUSION

Precision medicine is set to revolutionize pediatric critical care by providing a more individualized approach to respiratory management. By incorporating advanced monitoring tools, machine learning models and the personalization of specific parameters, clinicians can optimize ventilation strategies, reduce complications associated with mechanical ventilation and improve patient outcomes. Further studies are necessary to refine these approaches and validate their impact on long-term outcomes.

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Conflicts of interest

There are no conflicts of interest.

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