Noninvasive ventilation with helium-oxygen in children

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Abstract

Most existing literature on noninvasive ventilation (NIV) in combination with helium-oxygen (HELIOX) mixtures focuses on its use in adults, basically for treatment of acute exacerbations of chronic obstructive pulmonary disease. This article reviews and summarizes the theoretical basis, existing clinical evidence, and practical aspects of the use of NIV with HELIOX in children. There is only a small body of literature on HELIOX in pediatric NIV but with positive results. The reported experience focuses on treatment for patients with severe acute bronchiolitis who cannot be treated with standard therapies. The inert nature of helium adds no biological risk to NIV performance. Noninvasive ventilation with HELIOX is a promising therapeutic option for children with various respiratory pathologies who do not respond to conventional treatment. Further controlled studies should be warranted.

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1. Introduction

The interest in noninvasive ventilation (NIV) is rapidly growing, but the evidence from the literature is still scarce, and it is coming at a slower pace than the spread of its practical use [1]. Children receiving NIV may simultaneously need supplementary techniques either at the onset of treatment or throughout the progression of their pathology [1]. These techniques may be complementary to NIV and may even enable synergistic effects [1]. One of these applications is its use in combination with helium.

The use of helium-oxygen (HELIOX) mixtures in the pediatric setting has gained interest in the last few years for the treatment of different respiratory entities, mainly croup, asthma, and bronchiolitis [2,3]. Its use in combination with noninvasive positive pressure has been more selective. Most existing articles on NIV in combination with HELIOX focus on use in adults, basically for treatment of acute exacerbations of chronic obstructive airways disease [4-10]. This article reviews and summarizes the theoretical basis, existing clinical evidence, and practical aspects of the use of NIV with HELIOX in children.
2. Fundamentals of HELIOX

Helium, a noble gas, is inert, colorless, and odorless and has very low density [3]. If the nitrogen in inspired air (composed of 78% N\textsubscript{2} and 22% O\textsubscript{2}) is replaced with helium—that is 7 times less dense—a mixture (78% He and 22% O\textsubscript{2}) is obtained that is 3 times less dense than normal air [3]. The therapeutic use of HELIOX mainly lies in this significant difference in density; when a patient breathes HELIOX instead of air-oxygen, airway resistance to gas flow is reduced leading to a reduction in respiratory work. Furthermore, HELIOX also improves gas exchange, above all, in alveolar ventilation; in small airways where elimination of CO\textsubscript{2} is facilitated by diffusion, this diffuses 4 to 5 times faster in HELIOX than in air-oxygen mixture [3].

Helium was first introduced into the medical arena in the 1930s by Barach [11], who showed that when it was combined with oxygen, the resulting mixture (which he dubbed “HELIOX”) improved airflow in patients with obstructive laryngeal, tracheal, or lower airway lesions. Since then, studies on the pediatric use of HELIOX have demonstrated its use and efficacy for treatment of various conditions, including upper airway obstruction caused by diverse pathologies as well as asthma and acute bronchitisit [2,3].

3. Clinical applications of HELIOX

Helium-oxygen lacks any intrinsic therapeutic effect because of the inert nature of helium [3]. However, it can act as a “therapeutic bridge” maintaining the patient in improved conditions, delaying onset of muscle fatigue and respiratory failure, and obviating the use of more aggressive treatments until either other therapies can be administered or the patient’s condition spontaneously resolves itself [3]. Furthermore, this absence of any potential biological interaction provides an excellent safety profile for its clinical use, being a therapy without inherent risks; using HELIOX does not mean taking any biological risk for our patient [3].

Helium-oxygen is most effective at the highest possible concentrations of helium (typically, 60%-80%); nevertheless, there may be beneficial effects at much lower concentrations, although with proportionately lower effectiveness [3]. Given its physical properties, the main clinical uses of HELIOX predominantly relate to obstructive respiratory problems, those that pathophysiologically have both raised airway resistance and increased respiratory work, and also where alveolar ventilation is compromised to a greater or lesser extent. Table 1 summarizes the main pediatric clinical indications for the use of HELIOX. According to most existing studies of HELIOX use in children, usual practice is in those breathing spontaneously or, if in intubated patients, by adaptation of conventional mechanical ventilation systems [3].

### Table 1 Main clinical uses of HELIOX in children

<table>
<thead>
<tr>
<th>Obstruction mainly of the upper airway</th>
<th>Infectious etiology (eg, laryngitis, epiglottitis, tracheitis)</th>
<th>Inflammatory etiology</th>
<th>Postextubation subglottic edema</th>
<th>Postradiotherapy edema</th>
<th>Angioedema</th>
<th>Edema through inhaled injury</th>
<th>Recurrent or spasmodic croup</th>
<th>Mechanical etiology</th>
<th>Foreign body</th>
<th>Vocal chord paralysis</th>
<th>Subglottic stenosis</th>
<th>Laryngotracheomalacia</th>
<th>Neoplastic etiology</th>
<th>Laryngeal or tracheal growths</th>
<th>Extrinsic compression of the larynx, trachea, or bronchi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstruction mainly of the lower airways</td>
<td>Acute asthmatic crisis</td>
<td>Bronchiolitis</td>
<td>Bronchial hyperreactivity</td>
<td>Neonatal respiratory distress syndrome</td>
<td>Bronchopulmonary dysplasia</td>
<td>Driving gas for drug nebulization</td>
<td>Fiberoptic bronchoscopy and/or instrumental manipulation of the airway</td>
<td>Other indications</td>
<td>Hyperammonaemia</td>
<td>Pneumothorax</td>
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</table>

3.1. Helium-oxygen therapy in the spontaneously breathing infant

For patients with spontaneous breathing, the preferred method is via nonrebreathing mask with reservoir and unidirectional low pressure valves at flows of 10 to 15 L/min [3,12,13]. If required, supplementary oxygen can be delivered through nasal cannulae but at the lowest flow possible (always <2 L/min) because a higher flow could reduce the helium concentration excessively [3,12,13]. Warming and humidification of HELIOX, which are especially important for very small children, can readily be achieved by modifying standard equipment used for air-oxygen mixtures. Oxygen hoods or tents are not ideally suited to HELIOX therapy because mixture with room air is greater, with the helium (less dense) going to the top and the air (more dense) going to the bottom, close to the patient’s airway [14]. Simple face masks or nasal cannulae may be amenable to HELIOX therapy; however, they too tend to cause dilution of the HELIOX flow with external air, thereby markedly reducing the chances of a successful treatment [14].

3.2. Helium-oxygen as nebulization source

A further application for which significant evidence exists in both children and adults is to use HELIOX to nebulize...
medicines [2,3,15-17]. For this use, gas flow is usually increased by 20% to 25%, ensuring that minimum flow is not below 10 to 12 L/min. Note that the nebulization time of any particular volume of solution is much longer than with air or oxygen at a similar flow. To obtain the maximum benefits, a nebulization system with reservoir (such as the nonrebreathing reservoir face mask with a “Y” piece) should be used, ensuring that patient’s minute volume demands are covered with HELIOX. Alternatively, an ultrasonic nebulizer can be used, intercalated in the HELIOX flow to the patient [3,18].

3.3. Helium-oxygen therapy in the intubated child

When used invasively, the method depends upon the type of respirator. Helium-oxygen is usually introduced via the pressurized air input of the respirator; however, given its physical properties, it can interfere with a wide range of key functions (volume settings, levels of FiO₂, trigger sensitivities, flow rates, etc) [3,19-23]. Therefore, it is necessary to check before use that the ventilator is compatible with HELIOX and to consider specific correction factors. In general, the safest form of patient ventilation with HELIOX is to use a pressure-controlled ventilatory mode using pressure goals as a guide (see references [19-23] for details) and ensuring expiratory times long enough for adequate lung emptying. Presently, there are ventilators available specifically designed—and Food and Drug Administration cleared—to be used with HELIOX mixtures, although they are not widely distributed yet. Helium-oxygen has also been used with other invasive ventilatory modes such as high-frequency jet, high-frequency percussive ventilation, and high-frequency oscillatory ventilation [3,24,25].

4. Rationale for using HELIOX in NIV and clinical experience

Based on the studies published in the late 1990s by the Swiss group Jolliet et al [10], interest rose in the combination of NIV and HELIOX in the treatment of acute exacerbations in patients with chronic pulmonary disease, even showing its efficiency [5-10]. The use of NIV with HELIOX in place of air-oxygen occurred for the first time (successfully) in children in the mid 1970s in weaning off small children from mechanical ventilation after cardiac surgery [26]. However, this practice was not repeated (as few used NIV in children at that time), and there are no earlier publications on NIV with HELIOX in children before those of our own group on use in young infants with refractory acute bronchiolitis [27-30]. More recently, the use of helmet-delivered HELIOX continuous positive airway pressure (CPAP) has also been reported in small infants with bronchiolitis as an alternative mode of NIV with HELIOX [31].

Both experimental models and clinical data on adults demonstrate that, at a given target pressure, HELIOX provides greater minute volumes—and therefore, better alveolar ventilation—than air-oxygen mixtures [32]. Increasing the expiratory flow reduces air trapping and generation of auto–positive end-expiratory pressure, thereby improving lung compliance, restoring the mechanical advantage to inspiration, and decreasing work of breathing. This, in turn, expands the tidal volume generated per centimeter H₂O of pressure used. Moreover, NIV with HELIOX improves the patient’s elimination of CO₂ and reduces their sensations of dyspnea [32].

Helium-oxygen has complementary effects when used with NIV; indeed, the combination of HELIOX and NIV can even be considered synergistic. As positive pressure, NIV can help reduce the load on respiratory muscles, prevent or correct atelectasis, prevent airway collapse, and promote and facilitate distribution of HELIOX throughout obstructed airways. Helium-oxygen can further reduce work of breathing and improve CO₂ elimination. It can also provide higher expiratory flow than air-oxygen mixtures at the same pressure, which, in turn, can help improve passive expiratory lung mechanics, reducing the risk of barotrauma by gas trapping and thereby limiting any deleterious side effects from CPAP in obstructed airways [32].

Application of continuous positive pressure can lower the patient’s FiO₂ requirements, enabling them to be treated with a higher concentration of helium and, consequently, increasing the likelihood of treatment success. The reduction in the oxygen requirements further protects the lung.

Hypoxia secondary to development of atelectasis has been described in patients treated with HELIOX [33]. Neonates and small infants are at especially high risk for this complication. However, this potentially serious side effect—although anecdotaly reported and debatably related to HELIOX—can easily be prevented through concomitant use of CPAP.

Given that HELIOX can reduce the pressure gradient required to maintain a given flow, less pressure can be used to obtain the target tidal and minute volumes, which, in turn, diminishes peak pressures and minimizes the risk of barotrauma or volutrauma. By substituting air-oxygen for HELIOX, NIV may be performed in a more lung protective fashion: for a given target pH/CO₂ level, lower pressure swings and even lower volumes will be required [32].

Lastly, HELIOX delivered by NIV can delay or even obviate endotracheal intubation of the patient and subsequent invasive mechanical ventilation, each of which carries its respective complications. Although endotracheal intubation is the preferred method for airway isolation, it can produce local inflammation, ischemia of the mucosa, subglottal edema, and/or stenosis [34,35]. Likewise, invasive positive pressure ventilation can cause lung damage by altering lung mechanics, specifically, barotrauma, volutrauma, atelectrauma, and biotrauma [34,35].

Based on the experience of the author’s unit, HELIOX in combination with nasal CPAP (nCPAP) is a safe and effective treatment in unresponsive severe acute bronchiolitis...
as measured clinically or by tcPCO\textsubscript{2} and by satO\textsubscript{2} values [27-30]. Furthermore, nCPAP with HELIOX in place of an air-oxygen mixture is clearly more efficacious, as shown by approximately twice the level of improvement in clinical scores and tcPCO\textsubscript{2} levels after 30 minutes of therapy [28]. Between 1999 and 2010, only 1 (0.28%) of 352 patients admitted to our unit with moderate to severe acute bronchiolitis and managed according to our protocol—centered in the use of HELIOX alone or in combination with NIV—has needed intubation and mechanical ventilation (95% confidence interval, 0.01%-1.12%). Although this is a single-center experience and that there may be influencing factors other than HELIOX and nCPAP treatment in intubation practices (etiology, admission-discharge criteria, RSV season, etc), such low incidence is in stark contrast to the levels noted in a literature review suggesting that 25% to 60% of infants with bronchiolitis admitted to a pediatric intensive care unit may need intubation and ventilatory support [28,36-38]. Importantly, in our experience, there were no adverse effects related to HELIOX, and the technique used was tolerated well in all of the patients.

5. Indications of NIV with HELIOX in pediatric patients

No well-established indications of NIV with HELIOX in children exist. The author of this review has compiled a list of potential indications of HELIOX used with NIV for pediatric patients based on the physical properties of HELIOX, published data from experimental reports and clinical studies on adult patients, as well as—and mainly—his personal accumulated and reported experience. These comprise (Table 2):

<table>
<thead>
<tr>
<th>Indications of NIV with HELIOX instead of air-oxygen</th>
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<tbody>
<tr>
<td><strong>Children already receiving HELIOX therapy(^a) with inadequate oxygenation</strong></td>
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<tr>
<td>Not meeting their oxygenation goals-requirements</td>
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<tr>
<td>Whose FiO\textsubscript{2} requirement is either (&gt;0.40) or increasing</td>
</tr>
<tr>
<td><strong>Children already receiving NIV with inadequate ventilation</strong></td>
</tr>
<tr>
<td>Ventilation level achieved is inadequate according to pH/pCO\textsubscript{2}</td>
</tr>
<tr>
<td>Require high or increasing pressure levels (PIP/IPAP)</td>
</tr>
<tr>
<td>Show insufficient improvement (or worsening) in dyspnea</td>
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<tr>
<td>Show insufficient improvement (or worsening) in clinical respiratory score</td>
</tr>
<tr>
<td><strong>Children receiving NIV whose underlying pathology or illness requires protective ventilatory strategy (ie, the lowest possible pressure/volume swing [amplitude/IPAP-EPAP] for achieving a target pH/CO\textsubscript{2} level)</strong></td>
</tr>
</tbody>
</table>

\(^a\) Helium-oxygen therapy defined as HELIOX mixture (60%-80% helium proportion) administered to a spontaneously breathing child through nonrebreathing reservoir facemask with adequate HELIOX flow (usually about 10 L/min). PIP, peak inspiratory pressure; IPAP, inspiratory airway pressure; EPAP, expiratory airway pressure.

1. Children already receiving HELIOX therapy who are not achieving adequate levels of oxygenation. The positive pressure will enhance alveolar recruitment/oxygenation, allowing us to reduce FiO\textsubscript{2} (and thus to increase FiHe); and
2. Children already on NIV with inadequate ventilation according to pH/pCO\textsubscript{2} levels, dyspnea, or clinical score. The effect of HELIOX on alveolar ventilation not only through higher expiratory flows but also over CO\textsubscript{2} may resolve the situation without further increase in the NIV parameters.

One further indication, at least from the theoretical perspective, would be in those children receiving NIV whose underlying pathology or illness requires protective ventilatory strategy (ie, the lowest possible pressure-volume swing [amplitude/inspiratory airway pressure - expiratory airway pressure] for achieving a target pH/CO\textsubscript{2} level). From the practical point of view, infants with severe unresponsive bronchiolitis and children with status asthmaticus are the most frequent clinical indications of NIV with HELIOX.

6. Practical guide for using HELIOX with NIV

6.1. Equipment designed for HELIOX delivery

Currently, there are 6 commercially available ventilators designed for HELIOX delivery: Aptaer HELIOX Delivery System (GE Healthcare, Buckinghamshire, United Kingdom), Inspiration (E-Vent Medical Ltd, Galway, Ireland), Avea (Viasys Healthcare, Loma Linda, CA), Helontix Vent (Linde Gas Therapeutics, Höllriegelskreuth, Germany), G5 (Hamilton, Reno, NV), and Servo-I (Maquet, Rastatt, Germany). The main characteristics of these machines are summarized in Table 3. Their distribution and use remain limited; indeed, none of these devices have appeared in any of the few works on pediatric patients published to date. The Aptaer features inspiratory and expiratory triggers, enabling use of pressure support with HELIOX. The Inspiration is a conventional ventilator that includes an option for NIV delivery of HELIOX. The Avea offers all the standard modes used for invasive ventilation plus the option for invasive or NIV with HELIOX. The Helontix Vent was specifically developed for HELIOX therapy. It allows use of pressure support and only comes in a single model for adults and older children. To properly work with HELIOX, both the Inspiration and G5 devices require a specific module/software that needs to be purchased separately.

6.2. Equipment adapted for HELIOX delivery

Helium-oxygen can be safely delivered by modifying standard NIV ventilators according to literature guidelines. However, as with use of any equipment beyond its manufacturer’s indications, extreme caution must be applied.
when using this approach [3,32,39]. Hospital staff must have technical expertise in both the ventilator and in HELIOX therapy to minimize any potential risks in this method. In these cases, we should consider the following:

1. When HELIOX is used with NIV, the average flow and volume readings are not reliable unless an external pneumotachograph (which is not influenced by gas density) is used. Hence, ventilation should be programmed and controlled as a function of the programmed pressures (which are not affected by HELIOX) and the resulting blood gas values (arterial \(O_2\) saturation and \(CO_2\) levels);

2. Noninvasive ventilation with HELIOX instead of air-oxygen mixture generates greater inspiratory and expiratory flows at the same pressure and provides far superior \(CO_2\) diffusion. In terms of protecting the patient’s lungs, this implies that the pressure gradient required to reach a given target \(CO_2\) level will be lower with HELIOX than with an air-oxygen mixture.

3. If pure helium is used—which is generally not recommended and is prohibited by legislation on therapeutic gases in most European countries—then the patient must be continuously monitored by oximetry to prevent hypoxic conditions. Nonetheless, the safest and most practical clinical option is to use HELIOX mixtures at predetermined concentrations (typically, 80:20 or 70:30) and then add any required supplemental oxygen according to the patient’s needs.

There are 2 ways of adapting standard NIV equipment for delivery of HELIOX: predilution connection and postdilution connection (Figs. 1-3).

### 6.2.1. Predilution connection

In this approach, HELIOX is directly connected to the ventilator through a pressurized-gas inlet or a blender. It can be used with the BiPAP Vision (Respironics/Philipps, Amsterdam, The Netherlands), and the Infant Flow, Infant Flow Advance and SiPAP (EME/Viasys, Loma Linda, CA) systems (Figs. 2 and 3). The helium or HELIOX source is connected to the ventilator’s air inlet (probably the best option) or oxygen inlet. In the former case, the \(FiO_2\) is regulated using the ventilator’s \(FiO_2\) control, whereas in the latter case, the \(FiO_2\) control is set to 1.0 to ensure that only HELIOX is being delivered. If supplementary oxygen is required, it can be added through a T piece attached to the respiratory circuit. Alternatively, an oxygen blender can be attached to the ventilator’s air inlet or oxygen inlet so that helium and oxygen can be added simultaneously before entering the ventilator.

For cases in which the gas flow is directly regulated (eg, in the Infant Flow System), the following factors are used to convert flow meter readings from air-oxygen values to HELIOX values: for 80% He and 20% \(O_2\), multiply by 1.7; for 70% He and 30% \(O_2\), multiply by 1.7; and for 60% He and 40% \(O_2\), multiply by 1.4. These conversions enable determination of the real amount of HELIOX required to maintain the target pressure. If HELIOX is introduced through the air inlet, then the automatic limits of the alarm should be adjusted by first temporarily setting the \(FiO_2\) control to the same percentage as the oxygen in the HELIOX used and then resetting it to 0.21. The aim of this technique is to avoid false alarms caused by discrepancy between the concentration set on the oxygen blender and the concentration detected by the oximeter (whose minimum value is the percentage of oxygen in the HELIOX introduced at the air inlet).

Noninvasive ventilations delivery of HELIOX using the BiPAP Vision ventilator has been validated in an experimental model[39]. However, if this device is used, the initial leakage test of the expiratory valve should not be performed; paradoxically, this will provide better functioning of the ventilator, including greater accuracy of the trigger. Using this method with the \(FiO_2\) set at 1.0 enables safe and accurate administration of helium at concentrations higher than 60%.

The NIV ventilators best suited to modification for HELIOX delivery (ie, those for which HELIOX causes the least interference in functioning, including in measurements) comprise, in decreasing order of preference: Servo 300 (Rastatt, Germany), Galileo (Reno, NV), Galileo Gold...
(Reno, NV), and Veolar FT (Reno, NV). For volume-controlled ventilation, there are specific correction factors for tidal volume and FIO2 to be used with the most popular NIV ventilators (see references for more detailed data).

6.2.2. Postdilution connection

In this method, the HELIOX is introduced directly into the respiratory circuit tubing after the ventilator and ideally as close to the patient (interface) end as possible. In this setup, the concentration of helium that the patient receives is primarily dictated by the flow of helium used. Thus, it requires external oximetry to guarantee adequate FIO2 delivery. Furthermore, because the parameter values registered by the ventilator are not reliable, external pneumotachography is also needed. This setup is 1 option in some ventilators (eg, BiPAP Vision), whereas it is the only option in others, which generates pressure by drawing in ambient air (eg, BiPAP S/T-D30 [Respironics/Phillips, Amsterdam, The Netherlands]).

**Fig. 1** Modes of adaptation of standard NIV equipment for delivery of HELIOX. Both predilution connection and postdilution connection modes are detailed in the text.

**Fig. 2** BiPAP Vision noninvasive ventilator adapted for HELIOX delivery; the HELIOX is introduced through the device’s pressurized-oxygen inlet.
Netherlands], Knightstar 335 [Mallinckrodt/Puritan-Bennet, Mansfield, MA], Quantum PSV [Respironics/Phillips, Amsterdam, The Netherlands], and Sullivan VPAP II ST [ResMed, San Diego, CA]). Analogously to the case in standard NIV of trying to increase the $F_{O_2}$ by introducing oxygen in the circuit or interface, this approach is limited by the fact that the operator cannot determine exactly how much helium is being introduced into the circuit (and therefore, delivered to the patient), which carries a risk of affecting ventilator function. Nonetheless, it has been validated experimentally (39). Using any of the aforementioned ventilators with HELIOX (80% He and 20% $O_2$) flows of 18 L/min ensures delivery to the patient of helium at concentrations higher than 60%. Furthermore, at this flow rate, HELIOX only causes minimal interference (BiPAP S/T-D30 and the Quantum) with ventilator function or does not interfere at all (Knightstar, Sullivan, and BiPAP Vision) nor does it alter the programmed inspiratory or expiratory pressure in any of these models. Logically, with this HELIOX delivery approach, the final concentration of helium delivered to the patient is influenced by the tidal volume obtained: higher inspiratory pressure and greater tidal volume at a constant HELIOX flow correlate with a lower concentration of helium administered to the patient.

7. Side effects and drawbacks

7.1. Side effects

Although HELIOX is inert (nontoxic), when used with NIV, it may lead to certain side effects, namely,

- **hypoxemia**
  - The primary side effect is insufficient oxygenation because this treatment implies use of the lowest $F_{O_2}$ possible to maximize the positive effects of helium. Hence, strongly hypoxemic patients who are characterized by high oxygen requirements cannot be treated with HELIOX (at least not at any well-proven therapeutically significant concentration of helium). Hypoxemia can also be caused by inadvertent use of a hypoxic mixture ($F_{O_2} < 21\%$) in cases in which the helium and oxygen are mixed manually. This can be avoided by using tanks of premixed HELIOX at known concentrations or by using continuous oximetric monitoring (with an alarm) of the mixture delivered to the patient.

- **hypothermia**
  - One of the most therapeutically important physical properties of HELIOX is its high thermal conductivity (6–7 times that of air); hence, prolonged HELIOX treatment at temperatures under 36°C carries a risk of hypothermia. Neonates and small infants are at the highest risk for this side effect, which can be prevented by ensuring proper warming and humidification of the HELIOX and by carefully monitoring the patient’s body temperature. In our experience, this side effect has been only a theoretical concern.

7.2. Drawbacks

- **Cost**
  - There have not been any studies on the cost effectiveness of NIV HELIOX treatment in children. Compared with other clinically used gases, HELIOX is quite...
8. Conclusions and future perspectives

In conclusion, HELIOX is complementary to NIV, and together, they may even have synergistic effects. There is only a small body of literature on HELIOX in pediatric NIV —focusing on treatment for patients with severe acute bronchiolitis who cannot be treated with standard therapies —but the results are positive. Helium-oxygen and NIV may provide time for other therapeutic agents to work or for the disease to resolve naturally and might help to avoid more aggressive intervention such as endotracheal intubation and invasive mechanical ventilation. The ideal ventilators for HELIOX delivery are devices that are specifically designed for this task. Alternatively, other ventilators can be modified to administer HELIOX in NIV, although these must be used with extra precautions. Theoretically, NIV with HELIOX represents a new strategy for lung treatment and protection, and the inert nature of helium adds no biological risk to NIV performance.

Using HELIOX with NIV is a promising therapeutic option for children with various respiratory pathologies who do not respond to conventional treatment. According to the author’s experience, HELIOX in combination with CPAP is a safe and effective tool to be considered for the management of infants with severe acute bronchiolitis. However, this technique must be further evaluated in this and other settings and in both experimental and clinical studies. Noninvasive ventilation with HELIOX indications and treatment guidelines (ideal initial and maintenance settings, duration of treatment) must be more clearly established. Furthermore, NIV with HELIOX theoretically embodies a new strategy for lung treatment and protection, and studies exploring this possibility should be warranted.

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