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Review

Interfaces for noninvasive ventilation in the acute setting in children

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EDUCATIONAL AIMS

The reader will come to appreciate that in critically ill children:

- The ideal interface should be: small, inexpensive, comfortable, light-weight, easy to fit and remove.
- The interface should manufactured with non-allergenic material and have appropriate and well-adapted headgear.
- The choice of interface for NIV depends on patient's age, weight and clinical situation, facial anatomy the mode of ventilation and the type of circuit (vented or non-vented) and the risk of skin injury.

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SUMMARY

The use of noninvasive ventilation (NIV) is very specific in the acute setting as compared to its use in a chronic setting. In the Pediatric Intensive care Unit (PICU), NIV may be required around the clock and initiation has to be fast and easy. Despite the increasing use of non-invasive ventilation (NIV) and the larger choice of interfaces, data comparing the use of different interfaces for pediatric patients are scarce and recommendations for the most appropriate choice of interface are lacking. However, this choice in acute settings is crucial and a major contributor of the success of NIV. The aim of the present review was to describe the different types of interfaces available for children in the acute setting, their advantages and limitations, to highlight how to choose the optimal interface, and how to monitor the tolerance of the interface.

INTRODUCTION

Respiratory failure is the leading cause of hospital admissions in the pediatric intensive care unit (PICU) and nowadays noninvasive ventilation (NIV) represents the first-line treatment for acute respiratory failure [1,2]. NIV is increasingly used in acute or chronic respiratory failure with various etiologies [3]. NIV in acute settings has been shown to be useful in critically ill children with bronchiolitis [2,4], post extubation respiratory failure [5], pneumonia [6], acute chest syndrome [7], and status asthmaticus [8]. Moreover, findings regarding the benefits of NIV from clinical studies were confirmed by several physiological studies [9,10].

The use of NIV is very specific in the acute setting as compared to its use in a chronic setting [11]. Indeed, in the PICU, NIV may be required around the clock and initiation has to be fast and easy. Different types of interfaces should be immediately available and the medical team should be experienced with the choice and the use of the different interfaces. Several types of interfaces are currently available: nasal mask, nasal prongs, oronasal mask, full face mask, and the helmet. Interfaces are characterized by different

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shapes, sizes, and materials. However, despite the increasing use of NIV and the larger choice of interfaces, data comparing the tolerance or efficacy of different interfaces for pediatric patients are scarce and recommendations for the most appropriate choice of interface are lacking [12–15].

The aim of the present paper is to describe the different types of interfaces available for children in the acute setting, their advantages and limitations, to highlight how to choose the optimal interface, and how to monitor the tolerance of the interface.

VENTED OR NON-VENTED VENTILATION?

Interfaces can be vented or non-vented, i.e with or without intentional leaks. In PICU, due to the performance and availability of ICU ventilators, most patients are supported by non-vented NIV with closed double-limb respiratory circuits [3]. On the other hand, most home ventilators and CPAP devices use a single limb circuit with vented interfaces. The appropriate selection of equipment, including an appropriate mask, circuit, device and device settings is essential for the success of NIV. The choice between a vented or non-vented interface is mainly determined by the type and severity of the respiratory failure, including the degree of oxygen requirement, the type of ventilator and ventilator mode, and the experience and competency of the medical team. The choice of vented interfaces is now quite large, even for the youngest patients, as compared to the non-vented interfaces, where there is a paucity of industrial interfaces, especially for the younger patients.

TYPES OF INTERFACES

Nasal interface

Nasal masks cover solely the nose and differ with regard to the presence or not of a forehead support, internal flap and type of fixation. Nasals masks are available for all ages, from the newborn to the adolescent. They are usually chosen as a first choice and are preferred to nasobuccal or full face masks due to the small static dead space, especially in the younger patients [16,17]. Nasal masks are easy to apply and have the advantage of causing less anxiety, which may be a major issue in critically ill children (Table 1). Despite the lack of data in the literature, nasal masks also cause less gastric distension, therefore allowing a better tolerance of feeding. Due to the non-covering of mouth, nasal masks are safer regarding the risk of aspiration [18]. Mouth leaks and nasal obstruction (by adenoids, polyps or rhinitis) are limitations of nasal masks. Mouth breathing is common in infants, but the use of a pacifier may limit mouth leaks. Mouth breathing is also common in acute respiratory failure, which limits the use of this interface in the acute setting.

Nasal prongs

Nasal prongs, or pillows, or plugs, occlude the outer part of the nostrils. Nasal prongs are very comfortable but are available only for older (school-aged) children. They have the advantage of being "minimal-contact" interfaces but they are easier to displace and can't be used in case of mouth breathing. Moreover, the use of high pressures is often poorly tolerated with nasal prongs.

Oronasal masks

Oronasal masks cover the nose and the mouth and are commonly used in the PICU [19,20]. Oronasal masks can be used in cases of mouth breathing or nasal obstruction (Table 1). These interfaces have been shown to be more effective in improving arterial blood gas levels and minute ventilation in adults [21–24], but these findings have not been confirmed in other studies [25,26]. In children, studies are lacking but theoretically, mouth leaks are reduced with oronasal masks, which should translate into a better patient-ventilator interaction. The use of oronasal masks can be limited by the presence of (non-mouth) air leaks, discomfort, and the risk of aspiration (Table 1). Regarding comfort and tolerance, Schallom *et al* observed that oronasal masks were associated with a significantly higher risk of pressure ulcers in 200 adults, compared to total face masks [27]. However, studies comparing nasal masks to oronasal masks are controversial in term of tolerance [21,26].

Table 1
Advantages and disadvantages according of the different interfaces for noninvasive ventilation in the acute setting.

Type	Advantages	Disadvantages
Nasal	Easy fitting	Mouth leaks
	Allows coughing, eating, talking, use of a pacifier	Not indicated if mouth breathing
	No risk of aspiration	Not indicated if nasal obstruction
	Low risk of claustrophobia	Skin pressure ulcers
	Less gastric distension	
	Low risk of asphyxia in case of ventilator malfunction	
Nasal prongs	Minimal contact interface	Not indicated if mouth breathing
	Comfortable	Not indicated if nasal obstruction
Oronasal mask	Improved gas exchange	Risk of aspiration
	Improved minute ventilation	Claustrophobia
	No mouth leaks	Gastric distension
		Limit eating, talking
Full face	Less pressure ulcers	Gastric distension
	Comfortable	Claustrophobia
		Higher dead space
		Risk of aspiration
Helmet	Allows eating, coughing, talking, pacifier	Higher dead space
	No pressure ulcers	Ventilator adaptation
	Less resistance to flow, better tolerance to high pressure	Difficult humidification
	More comfortable	Claustrophobia, noise

Total face mask

In order to limit the side effects of oronasal masks, new interfaces such as total face masks have been developed. A total face mask, or cephalic mask, covers the entire anterior surface of the face, including the nose, the mouth and the eyes, delivering thus ventilation via the nasal and the oral route. Because mask-fit pressure is spread over a larger surface beyond the nose area, total face masks may be more comfortable than oronasal masks [28] (Table 1). In adults, the total face mask has shown to be as efficient as an oronasal mask in terms of breathing pattern, gas exchange and outcome [28–30]. However, a total face mask has a larger internal volume and therefore a larger anatomical dead space which may interfere with the efficacy of NIV [31]. Moreover, because the ratio between the tidal volume and the volume of the interface is important with regard to carbon dioxide (CO_2) rebreathing, the large volume of total face mask may limit CO_2 clearance.

In our experience, a total face mask may be used with success in children with acute respiratory failure when other interfaces have failed. However, published data is still scarce and future studies should assess its use and indications in children.