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XXVIII CONGRESSO NAZIONALE SIMRI

Il respiro: scienza e terapia per la salute del bambino

Torino, 10-12 ottobre 2024

Corso precongressuale

«IL PAZIENTE CON INSUFFICIENZA RESPIRATORIA CRONICA: dall'età pediatrica all'età adulta»

INTERFACCE NELLA VENTILAZIONE NON INVASIVA

Dott.ssa Maria Papale

Dirigente Medico Pediatra
UOC Broncopneumologia Pediatrica
Direttore Prof. Salvatore Leonardi
AOU Policlinico – San Marco - Catania

TOPICS

….beetween myths, evidence and clinical experience

- ✓Home noninvasive ventilation (NIV), including cPAP e Bilevel is increasingly used in children
- ✓Tolerance and adherence to treatment are necessary to guarantee the clinical efficacy of NIV
- ✓Adequate equipment, such as adapted interfaces and home devices, is one of the clues for the success of NIV
- ✓Practical and comprehensive summary of the equipment available for home NIV in pediatrics, their limits and pitfails

TOPICS

….beetween myths, evidence and clinical experience

There are limitations around the use of masks for NIV in children including:

1. Limited size and shape options that fit and adapt to growing faces
2. Limited headgear options in pediatrics
3. Potential and short and long-term interface related complication

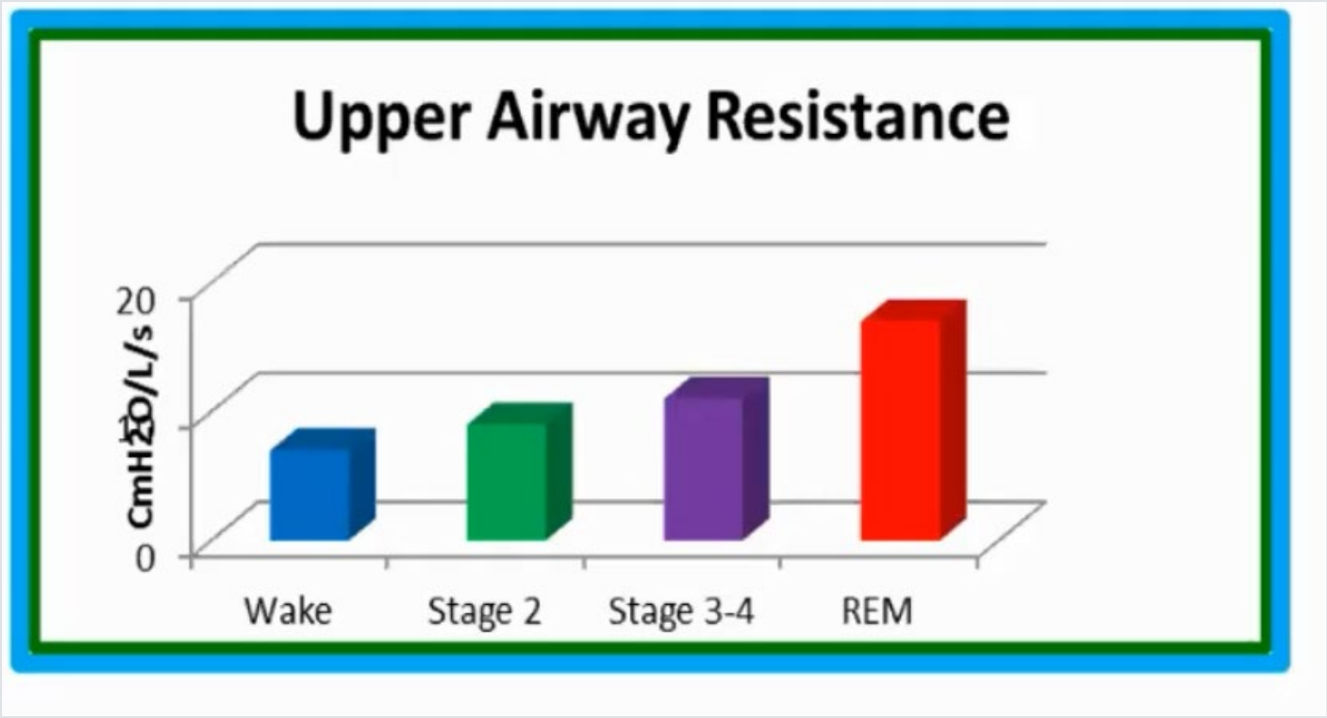
Castro-Codesal ML, Olmstead DL, MacLean JE. Mask interfaces for home non-invasive ventilation in infants and children. Paediatr Respir Rev. 2019 Nov

LONG-TERM VENTILATION AND SLEEP…..

The greater proportion of patients receiving ventilation use only nocturnal or nocturnal plus part-time diurnal NIV

In sleep the ventilatory balance is phisiologically unstable

- Changes in ventilatory patterns
- Respiratory drive
- Respiratory muscle activity



Sleep increases leaks and asynchronies during home noninvasive ventilation: a polysomnographic study

Sergi Martí, MD, PhD[1,2]; Alex Ferré, MD, PhD[3,4]; Gabriel Sampol, MD, PhD[1,2,3]; Mercedes Pallero, MD, PhD[1,2]; Odile Romero, MD[2,3,4]; Jaume Ferrer, MD, PhD[1,2]; Júlia Sampol, MD[1,2,3]

Table 4—Gas exchange data during nocturnal polysomnography with noninvasive ventilation, awake, and sleep.

	Awake	Sleep	*P* Value
Average $PtcO_2$, mm Hg	44 (40–46)	47 (42–49)	<.001
Time spent with $PtcO_2$ > 50 mm Hg, %	0 (0–7)	2 (0–40)	.002
Average SpO_2	94 (93–96)	93 (91–95)	<.001
Time spent with SpO_2 < 90%, %	0 (0–5)	1 (0–27)	.001
ODI 3%, events/h	0 (0–0)	11 (5–25)	<.001

Data are shown as median (interquartile range); n = 28. ODI = oxygen desaturation index, $PtcO_2$ = partial pressure of transcutaneous carbon dioxide, SpO_2 = oxygen saturation from pulse oximetry.

Table 5—Respiratory events during nocturnal polysomnography with noninvasive ventilation: awake vs sleep comparison.

	Awake	Sleep	*P* Value
Leaks, time (%)	1 (0–9)	10 (0–75)	<.001
Major leaks, time (%)	1 (0–6)	10 (0–52)	<.001
Upper airway obstruction, events/h			
Without reduction of ventilatory drive	—	1.8 (0.5–10.3)	
With reduction of ventilatory drive	—	0.1 (0–1.1)	
Asynchronies, % breaths			
Ineffective effort	1 (0–3)	12 (3–20)	<.001
Auto-triggering	0.1 (0–1)	1 (0–4)	<.001
Double triggering	1 (0–2)	4 (1–7)	<.001
Premature cycling	0.1 (0–1)	0.1 (0–1)	.71
Delayed cycling	0.2 (0–2)	0.4 (0–6)	.18
All asynchronies (triggering + cycling)	6 (2–14)	27 (16–39)	<.001

The changes during sleep may modify the interactions between the patient and the ventilator, thus inducing leaks, upper airway events, and patient-ventilator asynchronies (PVAs)

J Clin Sleep Med. 2022;18(1):225–233

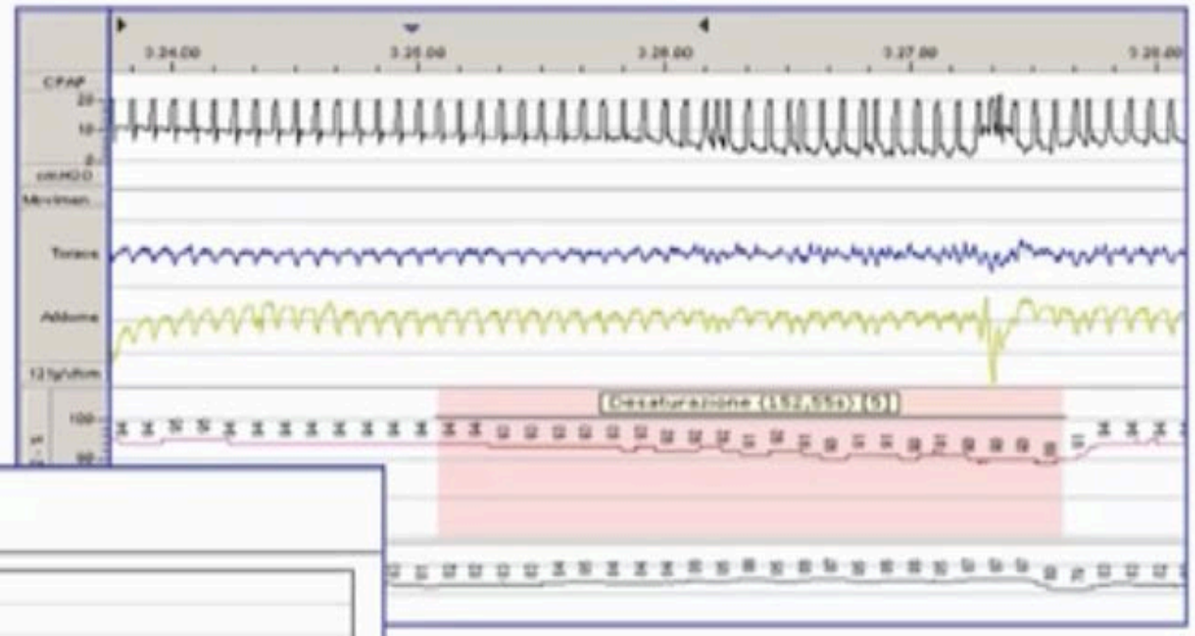
Air leaks may reduce the efficacy of NIV

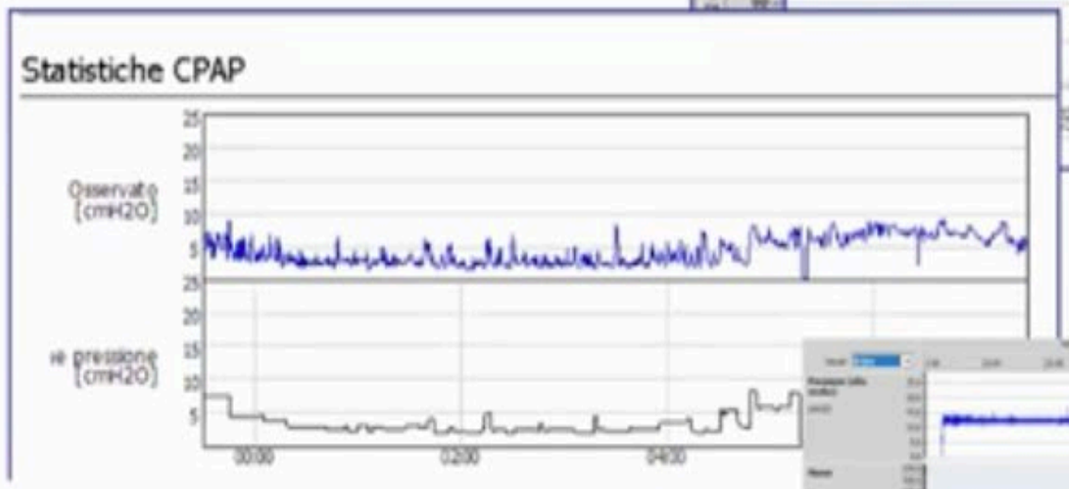
↑ patient-ventilator asynchrony in NIV (through loss of triggering sensitivity)

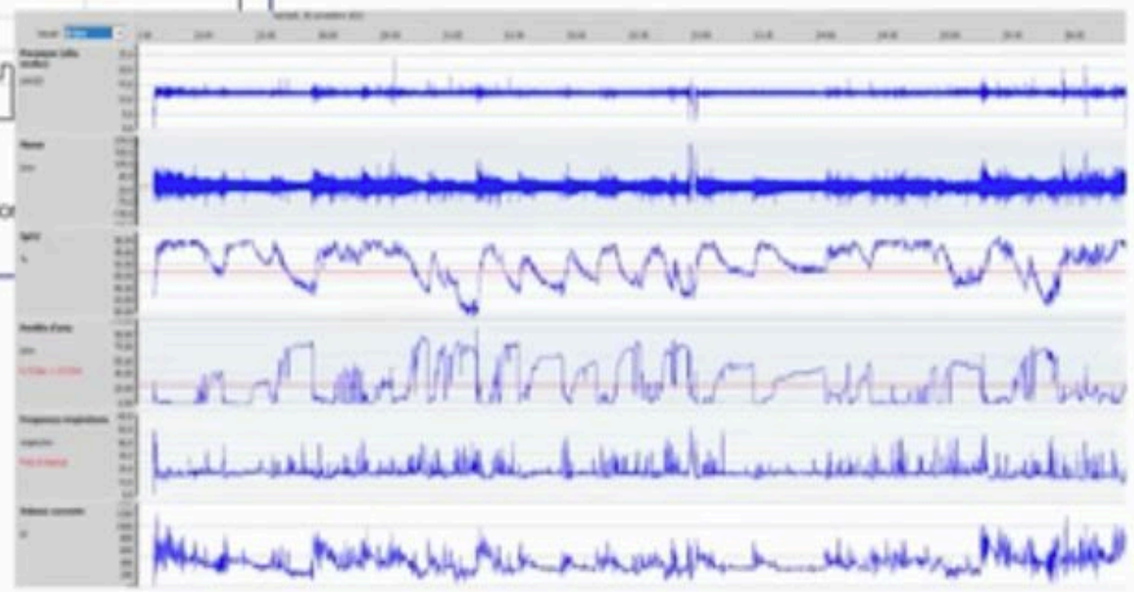
↑ awakenings and sleep fragmentation

↓ patient tolerance

↓ efficacy

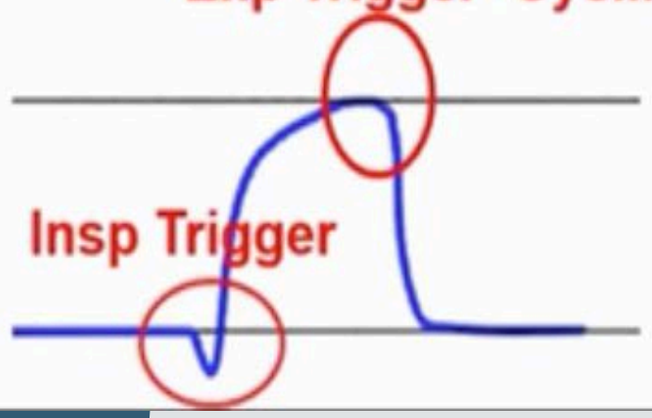






Exp Trigger- Cycling

Insp Trigger



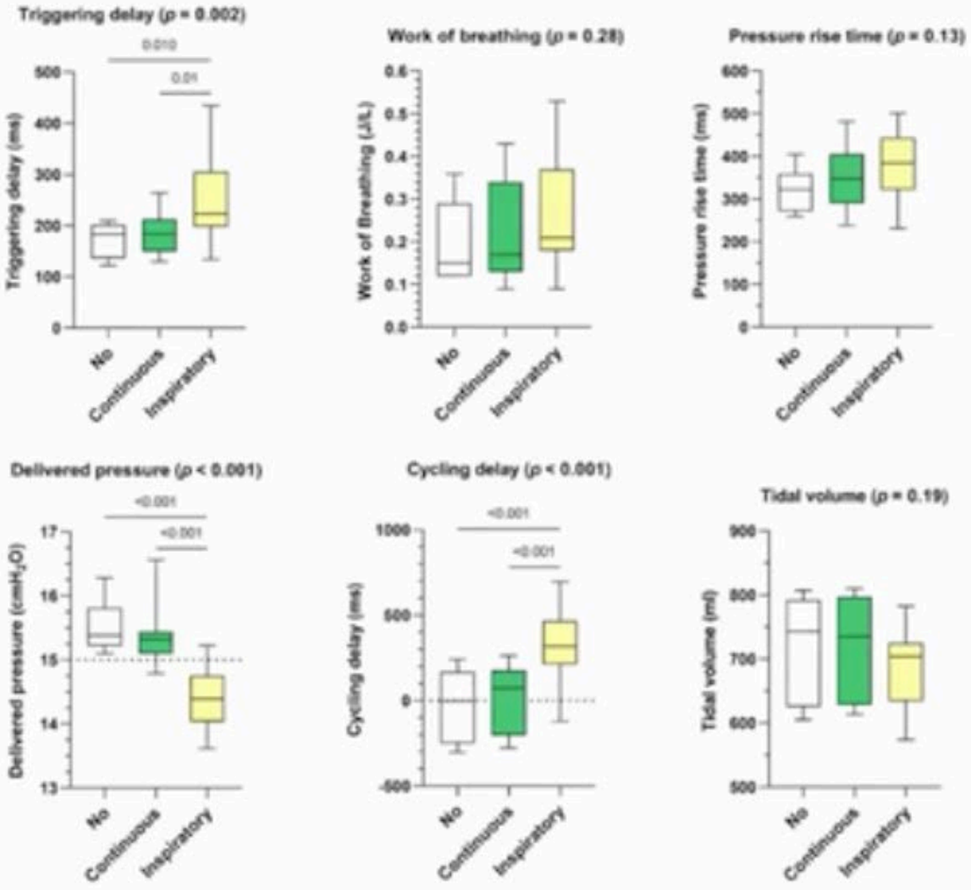
Responses of Bilevel Ventilators to Unintentional Leak: A Bench Study

Marius Lebret [1,2,*], Emeline Fresnel [3], Nathan Prouvez [1], Kaixian Zhu [1], Adrien Kerfourn [3], Jean-Christophe Richard [1,4] and Maxime Patout [5,6]

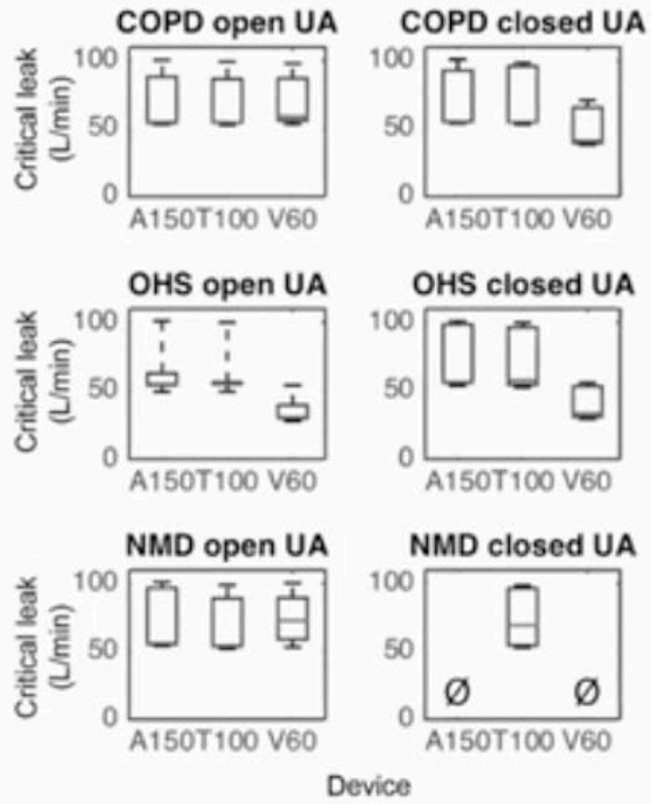
Lebret M. Healthcare 2022, 10, 2416

Combined effects of leaks, respiratory system properties and upper airway patency on the performance of home

To assess
- **the impac**
- models or
- available
- to find for

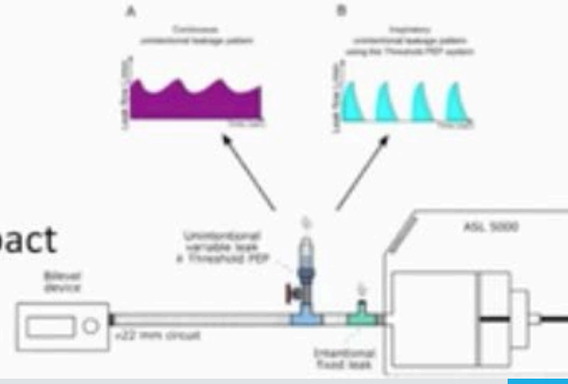


Lebret M. Healthcare 2022, 10, 2416



Zhu et al. BMC Pulmonary Medicine (2017) 17:145

MAIN RESULTS:
- A leak threshold of 24 L/min is probably clinically irrelevant
- There is **no generic threshold** of "critical leak"
- **The intermittent or polymorphic nature** of unintentional leakage has a **more deleterious** impact on device performance and synchronization, than the leak flow rate of continuous leakage.
- In case of **closed UA** this function is strongly compromised



Leak Monitoring in Noninvasive Ventilation

C.A. Rabec, O. Reybet-Degat, P. Bonniaud, A. Fanton, and P. Camus

Arch Bronconeumol 2004;40(11):508-17

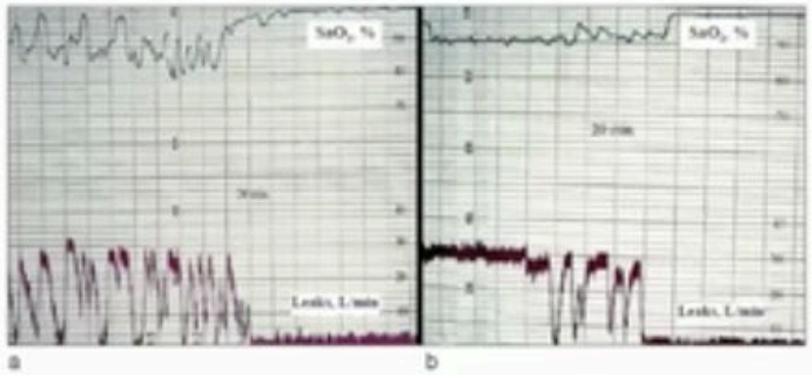
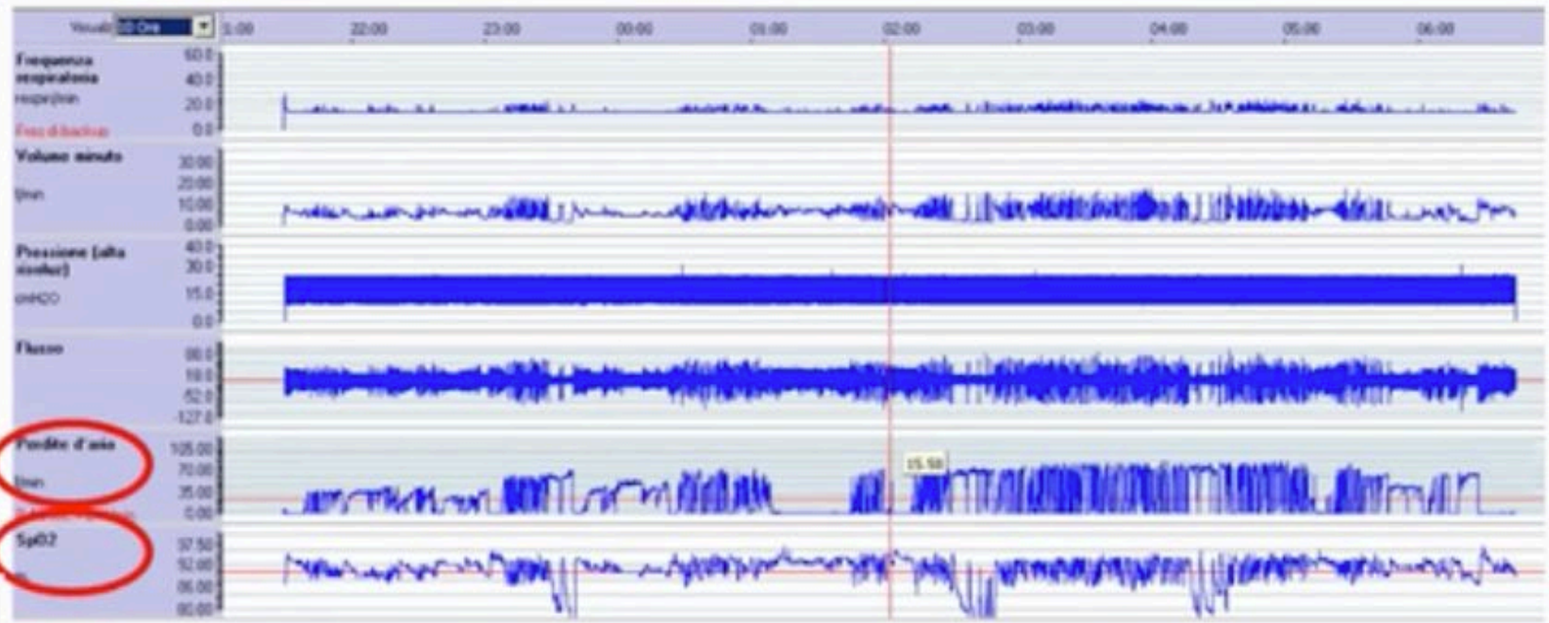


Figure 3. Simultaneous recording of leaks and arterial oxygen saturation (SaO_2) trace during sleep in patients on bilevel pressure nasal ventilation with a VPAP II ST device.
a) Desaturation peaks "mirroring" intermittent leaks; and *b)* regular desaturation resulting from a permanent leak. (The traces read from right to left.)

Leaks can arise due to passive mouth opening (known as "primary leaks" or "passive leaks") or as a result of an increase in airway resistance (known as "secondary leaks" or "reflex obstruction during ventilation").[21]



The first major challenge is **minimising leaks**

The second major challenge is finding an interface, which is **comfortable** and does not cause side-effects

Eur Respir J 2004;23:7-8

Review > Paediatr Respir Rev. 2019 Nov:32:66-72. doi: 10.1016/j.prrv.2019.03.004.
Epub 2019 Mar 23.

Mask interfaces for home non-invasive ventilation in infants and children

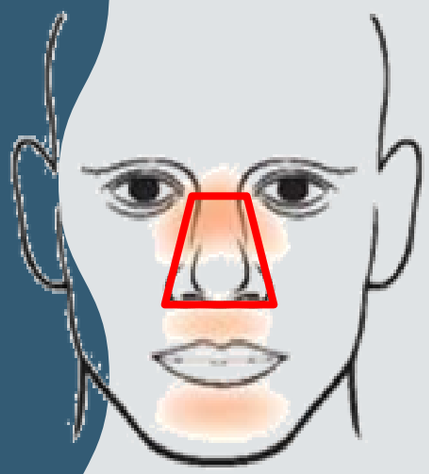
Maria L Castro-Codesal [1], Deborah L Olmstead [2], Joanna E MacLean [3]

Affiliations + expand

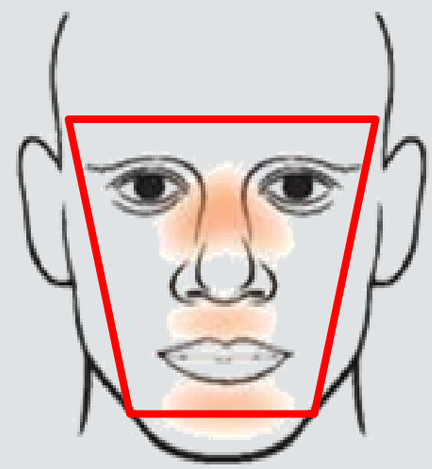
PMID: 31130424 DOI: 10.1016/j.prrv.2019.03.004

- ✓ Five Types of masks can be used for long-term nocturnal NIV
- ✓ Each mask has its own advantages and disadvantages
- ✓ May present with one of different size of cushion and/or headgears

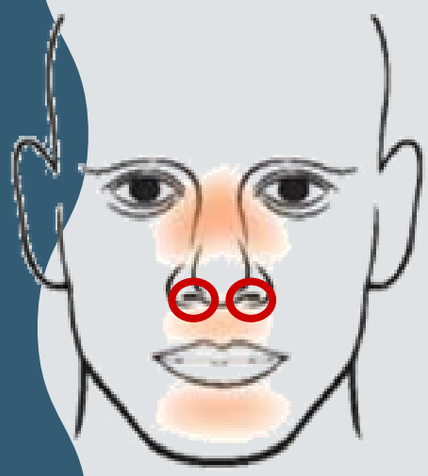
Nasal mask



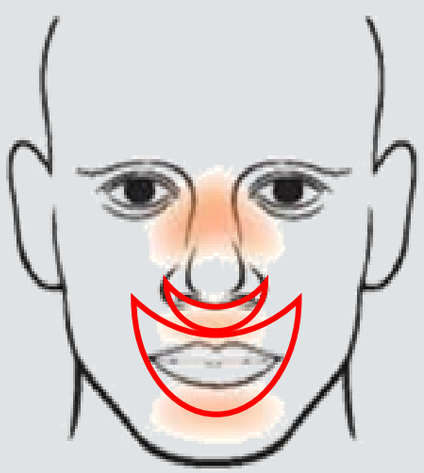
Total -Face



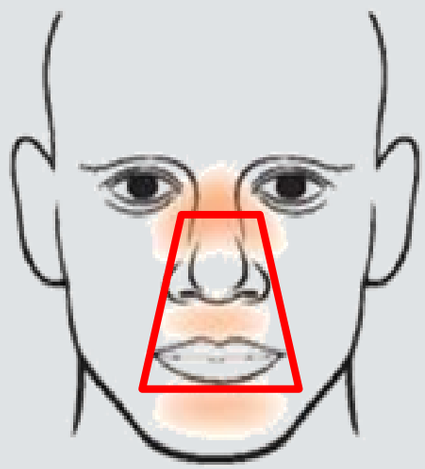
Nasal pillow



Oronasal-mask under-the-nose



Oronasal-Mask



NASAL MASK

- ✓ It is the most used interface both in adults and children
- ✓ In the last decade, manufactures have developed specific nasal masks for infants and toddlers
- ✓ Nasal masks are preferred to avoid the risk of aspiration with emesis or asphyxia

- ✓ Under-the-nose nasal mask have been developed for adults, and can be used in adolescents

Interface	Characteristics	Advantages	Disadvantages
NASAL MASK	Flow through the nose	Allows eating, speaking, secretion management, and using pacifier Several pediatric and infant models and sizes available No risk of aspiration	Risk of: • Nasal dryness and irritation • Mouth leaks • Skin lesion over the nasal bridge and face • Midfacial hypoplasia • Eye irritation in case of leaks Limit eating, speaking, secretion management

Interfaces, Circuits and Humidifiers
Rosario Ferreira, Frontiers in Pediatrics, 2020

NASAL PILLOW

- ✓ Nasal pillow which are minimal contact interfaces that insert into the nostrils
- ✓ Alternative masks that may be mainly posed in pre-adolescents and adolescents.
- ✓ Some nasal pillow are available in small sizes that may fit for older children

Interface	Characteristics	Advantages	Disadvantages
NASAL PILLOW	Flow through the nose	Minimal facial contact Allows eating, speaking, and secretion management Less risk of skin lesion No risk of aspiration	Limited domiciliary indications Risk of: • Nasal symptoms • Nostrils pain and lesions • Mouth leak

Interfaces, Circuits and Humidifiers
Rosario Ferreira, Frontiers in Pediatrics, 2020

UNDER -THE -NOSE NASAL MASK

- ✓Recently under the nose nasal mask with minimal contact surface and no support on the nasal bridge have been developed for adults and can be used in pre-adolescents and adolescents

- ✓They can be occasionally indicated in older children, as an alternative in case of intercurrent illness with nasal obstruction or intolerance of the regular nasale mask in this time period.

ORONASAL MASK

- ✓ Oro-nasal masks allow delivery of positive pressure through the nose and mouth
- ✓ Limited availability of commercially available oro-nasal masks for children
- ✓ Oro-nasal masks can be an appropriate interface choice for children who are unable to tolerate a nasal interface or where large mouth leak limits the efficacy of treatment.
- ✓ Important disadvantages include limited capacity to communicate and manage secretions, potential claustrophobia, and increased risk of aspiration in the event of vomiting

Interface	Characteristics	Advantages	Disadvantages
ORONASAL MASK	Rest on nasal bridge, nose and mouth sides and chin (±forehead) - Air flow through nose and mouth	No mouth leaks Less risk of midfacial hypoplasia	Limit eating, speaking, secretion management No use of pacifier Risk of: • Aspiration • Suffocation • Skin lesion over the nasal bridge and face • Eye irritation in case of leaks

Interfaces, Circuits and Humidifiers
Rosario Ferreira, Frontiers in Pediatrics, 2020

TOTAL-FACE MASK

- ✓ Rarely prescribed for home NIV,
- ✓ should be reserved to very particular cases:
  - patient with severe deformities or bilateral cleft lips with no possibility to adapt other types of interfaces
  - Severe skin injiury

Interfaces, Circuits and Humidifiers
Rosario Ferreira, Frontiers in Pediatrics, 2020

Interface	Characteristics	Advantages	Disadvantages
TOTAL-FACE MASK	- Covers the entire face - Air flow through nose and mouth	Less risk for skin injuries: no contact with nasal bridge and other sensitive skin areas - No mouth leaks	-Limits communication, use of pacifier, secretion management and eating - Risk for upper airway obstruction - Risk for aspiration - Risk for claustrophobia - Limited commercially available infant/pediatric sizes

MOUTHPIECE

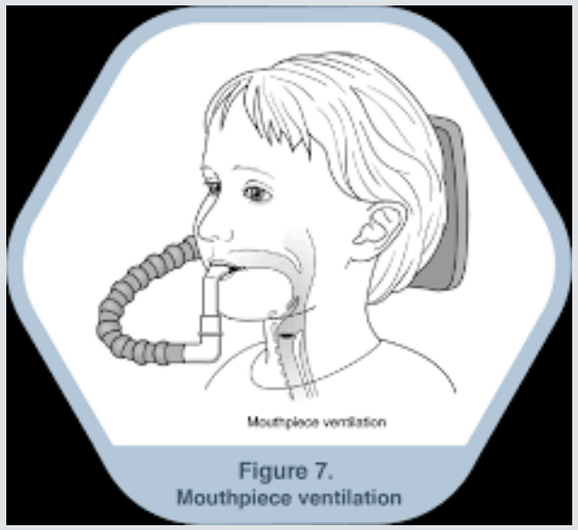


Figure 7.
Mouthpiece ventilation

- ✓ Mouth-only-masks may be used in very rare cases of complete nasal obstruction.
- ✓ Available literature on mouthpiece ventilation is limited to young adults with neuromuscular disorders and demonstrates reduced daytime dyspnea, and delay or even prevention of the need for tracheostomy

Interfaces, Circuits and Humidifiers
Rosario Ferreira, Frontiers in Pediatrics, 2020

Interface	Characteristics	Advantages	Disadvantages
MOUTHPIECE	- Patient's lips seal around it - Airflow through mouth only	- Free face and head - No risk for nasal symptoms - No risk for skin injury - No risk of aspiration - No risk of claustrophobia	- Requires volume-cycle ventilation - No leak compensation (adequate lips' sealing required) - No adequate for non-cooperative indi-viduals or during sleep

Castro-Codesal ML, Olmstead DL, MacLean JE. ***Mask interfaces for home non-invasive ventilation in infants and children****. Paediatr Respir Rev. 2019 Nov*

MASK INTERFACES FOR HOME NON-INVASIVE VENTILATION IN INFANTS AND CHILDREN

Maria L. Castro-Codesal, Deborah L. Olmstead, Joanna E. MacLean Paediatr Respir Rev. 2019 Nov

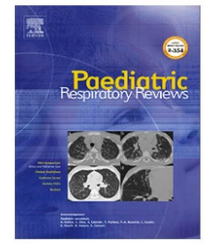


Table 1
Advantages and disadvantages of mask interfaces for home non-invasive ventilation in pediatrics.

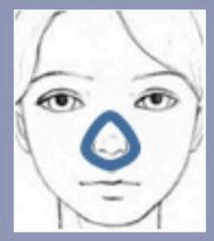
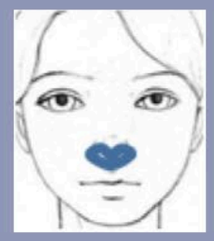
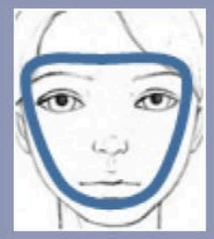
NIV interface	Contact area and air flow delivery	Advantages	Limitations and disadvantages	Image
Nasal mask	- Rest on nasal bridge and nose sides (±forehead) - Air flow through nose only	- Allow communication, use of pacifier, secretion management and eating - No risk for aspiration - Multiple options available - Infant sizes available	- Limited use if high nasal resistance - Risk for mouth leak - Risk for nasal dryness, bleeding - Risk for skin injury - Risk for BiPAP asynchrony	
Oro-nasal mask	- Rest on nasal bridge, nose and mouth sides and chin (±forehead) - Air flow through nose and mouth	- No mouth leak	- Limits communication, use of pacifier, secretion management and eating - Risk for skin injury - Risk for upper airway obstruction - Risk for aspiration - Risk for claustrophobia - No infant/pediatric sizes commercially available	
Nasal pillows	- Rest on inside the rim of nostrils - Air flow through nose only	- Allow communication, secretion management and eating - Less contact surface (allow wearing lenses) - No risk for aspiration - Less risk for skin injury: no contact with nasal bridge	- Limited use if high nasal resistance - Risk for mouth leak - Risk for nasal dryness, bleeding and nostril pain - Risk for BiPAP asynchrony - No infant/pediatric sizes commercially available	
Total-faced mask	- Covers the entire face - Air flow through nose and mouth	- Less risk for skin injuries: no contact with nasal bridge and other sensitive skin areas - No mouth leaks	- Limits communication, use of pacifier, secretion management and eating - Risk for upper airway obstruction - Risk for aspiration - Risk for claustrophobia - Limited commercially available infant/pediatric sizes	
Mouthpiece	- Patient's lips seal around it - Airflow through mouth only	- Free face and head - No risk for nasal symptoms - No risk for skin injury - No risk of aspiration - No risk of claustrophobia	- Requires volume-cycle ventilation - No leak compensation (adequate lips' sealing required) - No adequate for non-cooperative individuals or during sleep	

FIGURE
Top, from
(Maskme
Liquide);

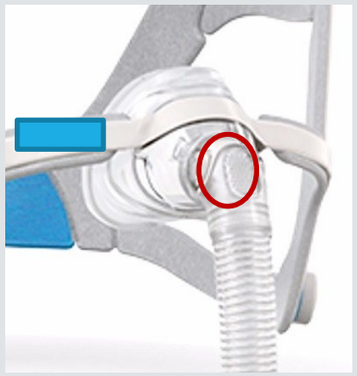
FIGURE 2 Specific NIV interfaces for toddlers and older children. Top, from left to right: Nonny large (AG Industries); Wisp Giraffe (Philips Respironics); Respireo Soft child (Air Liquide); Pixi (ResMed); SleepWeaver Advance Pediatric (Circadiance). Bottom, from left to right: Minime and Minime 2 (SleepNet); Nonny full face (AG Industries); Total full-face CPAP mask (Hsiner); FitMask CPAP Total face (Besmed); BiTrac® Select Pediatric MaxShield (Pulmodyne).

VENTED-MASK

Vented Masks are nowadays used predominantly for home NIV, and benefit from a larger choice than non-vented masks.

NONVENTED-MASK

INTENTIONAL LEAKS



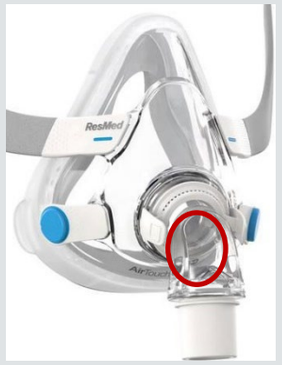


Table 3 Masks changes and reasons for change during the study period

Age (years)	Pathology	First mask	Second mask	Third mask	Fourth mask
Neuromuscular group					
7	Congenital myopathy	N Discomfort	NP NPPV mode change		
13	COPD	Discomfort N Discomfort + NPPV mode change	Discomfort NL Discomfort	NP	

CM custom made, *NL* nasal with manufacturer leak, *FL* facial with manufacturer leak, *NP* nasal prongs, *N* nasal leak, *F* facial without manufacturer leak, *NPmod* nasal prongs with obstruction of manufacturer leak, *NPPV* noninva ventilation, *OSAS* obstructive sleep apnea syndrome, *BPD* bronchopulmonary dysplasia, *COPD* chronic obstructi

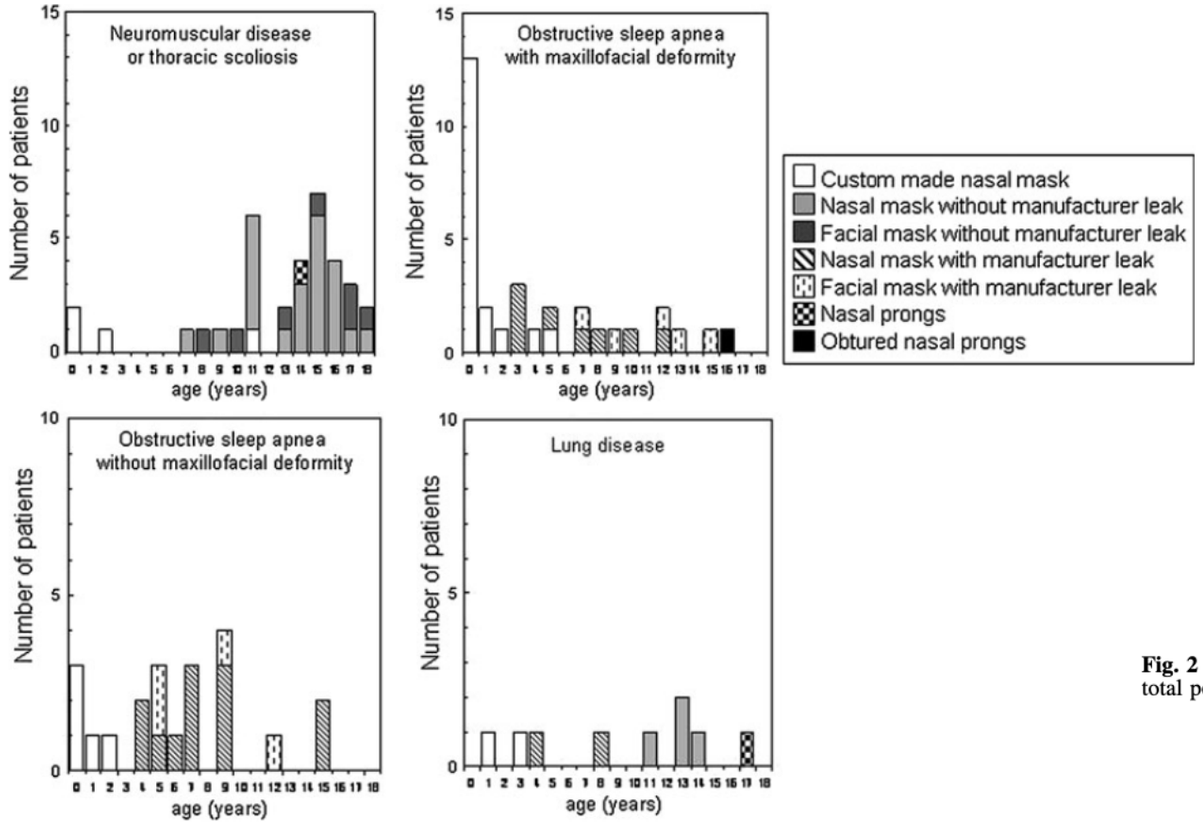
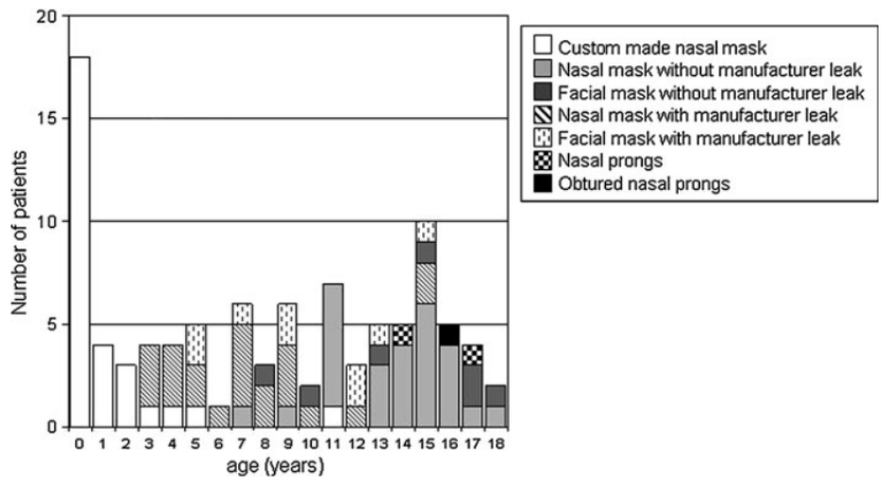


Fig. 3 Types of masks used according to the underlying disease

- 67 patients
- All patients>2 years old and four of the older children (two with maxillofacial deformity, one with OSAS, and one with spinal muscular atrophy)
- 49 used a nasal mask, 16 a facial mask, and 2 nasal prongs.
- Industrial masks with and without manufactured leaks were used in 33 (34%) and 35 (36%) children, respectively.

NL
NL
NL
FL

Fig. 2 First mask choice in the total population



- All patients with neuromuscular disease or thoracic scoliosis, with the exception of one patient, used interfaces without manufactured leaks.
- Interfaces with and without manufactured leaks were used equally in patients older than 2 years with lung disease.
- In 80% of the patients, the most appropriate interface could be determined after the first night.

Interfaces for long-term noninvasive positive pressure ventilation in children
Ramirez, Delord et all.

Intensive Care Med (2012) 38:655–662
DOI 10.1007/s00134-012-2516-1

Outpatient Utilization of the RAM Cannula for Nasal Noninvasive Ventilation in Children

Brittany A Truitt, Erin F Kallam, Eric W Price, Amit S Shah, Dawn M Simon and Ajay S Kasi

Department of Pediatrics, Division of Pediatric Pulmonology and Sleep Medicine, Emory University and Children's Healthcare of Atlanta, Atlanta, GA, USA.

Clinical Medicine Insights: Pediatrics
Volume 17: 1–6

DOI: 10.1177/11795565231192965
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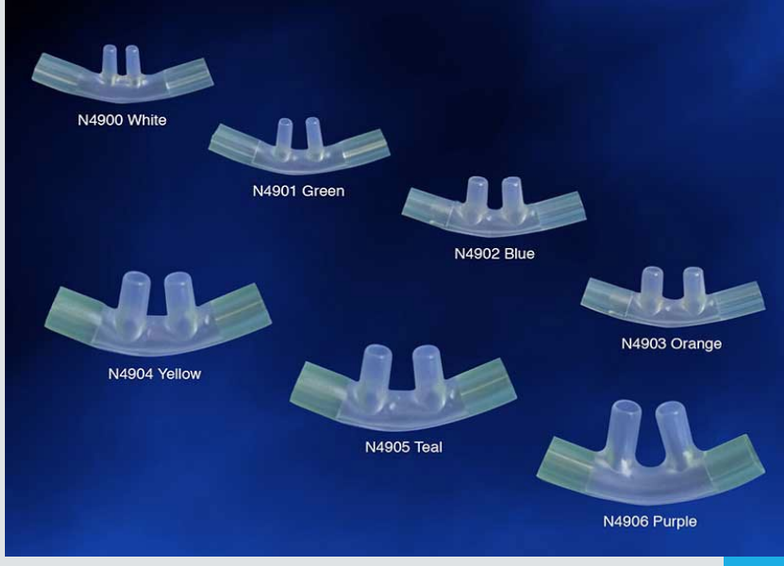
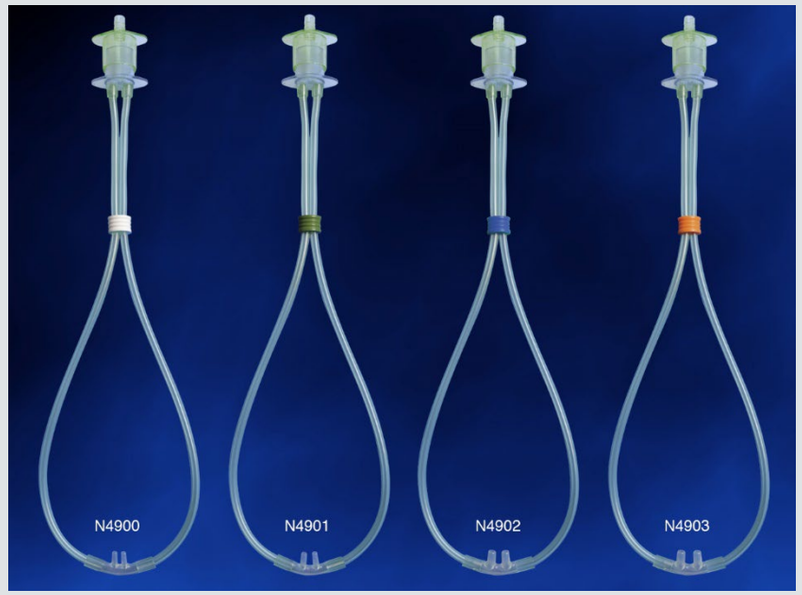


institution, the RAM cannula has been utilized for outpatient NIV in children with sleep-disordered breathing, chronic respiratory failure, and genetic conditions when conventional NIV interfaces were not tolerated either due to limited patient cooperation, lack of well-fitting interfaces (such as with craniofacial and genetic disorders), and for patients seeking comfort-based care without invasive ventilation via tracheostomy. Based on our experience with using the RAM cannula for outpatient NIV, we hypothesized that NIV via the RAM cannula can be used in the outpatient management of infants and young children. The aims of our study were to describe the clinical features and outcomes of infants and children who used outpatient NIV via the RAM cannula.



Results

We identified 20 patients who used outpatient NIV via the RAM cannula during the study period. Among patients using outpatient NIV via the RAM cannula, 18 (90%) patients started using NIV in the inpatient setting and were subsequently discharged home on NIV. Two patients started using

- ✓ The most common indication for utilizing the RAM cannula for NIV was intolerance of conventional NIV interfaces (80%).
- ✓ Other indications for using the RAM cannula were to alleviate dyspnea (60%) and to avoid tracheostomy (55%) based on parental preference or due to redirection of care to comfort-based care (n = 2, 10%).

Brief Communication

The Optiflow™ interface for chronic CPAP use in children

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- ✓ *Although this interface is efficient in delivering chronic CPAP, limited experience suggests that it should not be used for bilevel ventilation*
- ✓ These pilot data suggest that the Optiflow™ interface may be used for chronic CPAP use in infants and children. However, ***it should not be used for children who require bilevel ventilation because of insufficient triggering***

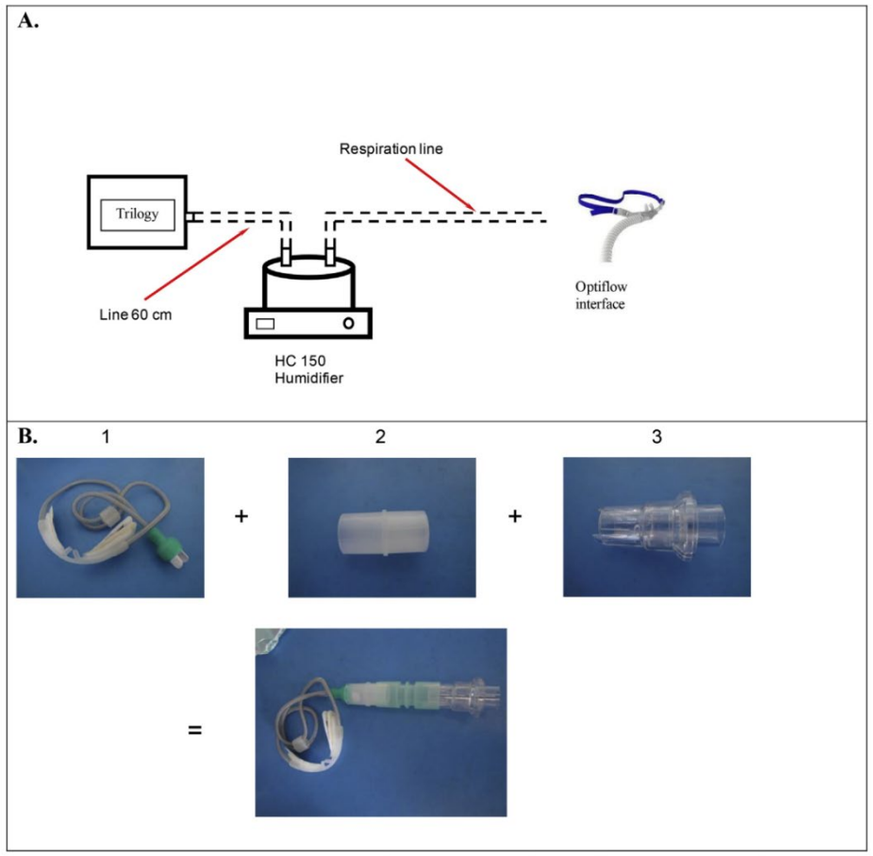

Fig. 1. Connecting the CPAP device to the Optiflow™ interface. **A.** A general outline is presented. **B.** The Optiflow™ interface (1) is connected to the ventilator tube by a straight connector 22M/22F (2) and a whisper swivel (3).

Table 1
Description of patients on chronic CPAP use treated with Optiflow™ interface.

Patient description	Effective CPAP pressure	Obstructive $AHI_{baseline}$ (n/h)	Obstructive AHI_{CPAP} (n/h)
Seven month-old girl with persistent tracheomalacia after correction of a double aortic arch	5 cmH_2O	20	3.2
Two year-old boy with OSAS and tracheobronchomalacia	7 cmH_2O	5.8	3.2
Four year-old boy with severe OSAS and partial trisomy 9	6 cmH_2O	99.3	7
Five year-old boy with REM-related OSAS and a chromosome Xp27.3-q28 duplication	8 cmH_2O	99.7	6.5
Five year-old boy with OSAS and Down syndrome	4 cmH_2O	6.5	0
Nine year-old boy with OSAS and Down syndrome	6 cmH_2O	70	22
15-year-old boy with OSAS and cerebral palsy	6 cmH_2O	16.6	4
Five year-old girl with OSAS due to tracheomalacia	5 cmH_2O	20	3.2
Four year-old boy with OSAS due to pharyngo-laryngomalacia	7 cmH_2O	40.5	6

3D-Printing Mask

FUTURO

- ✓ Although custom-made masks are nowadays mainly parts of the history of NIV in pediatrics, an increasingly interest for new Kinds of custom-made masks has emerged, with the widespread accessibility to 3D printing

- ✓ Indeed, with advancements in 3D technology, custom-made masks appear less challenging to be made, and may be of great utility in children with particular face shapes and /or anatomical features.

Short communication

A personalized approach to non-invasive ventilation masks in amyotrophic lateral sclerosis using facial scanning and 3D-printing

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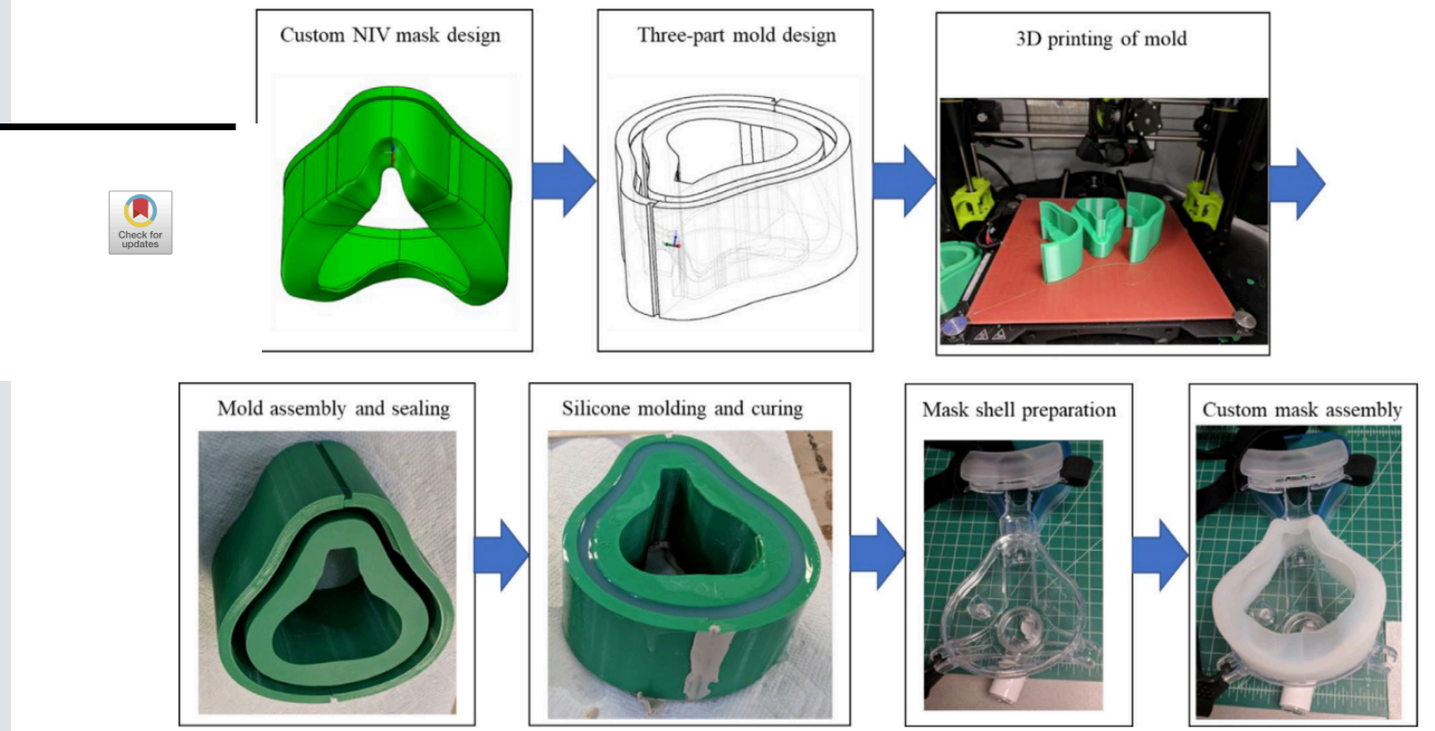

Fig. 3. Mask Workflow

Following facial scan, a custom mask insert was designed in CAD software. Next, a three-part mold (geometric negative) was then generated from the mask design and exported from the CAD software in STL format. From there, a 3D slicing program (Cura by Ultimaker BV) was used to generate a G-code toolpath which was imported into a 3D-printer (LulzBot TAZ 6 by Fargo 3D Printing, Fargo, ND) for material extrusion (MEX) with polylactic acid (PLA) as three independent parts. After printing, the three-part mold was assembled and sealed with modeling clay and clamps. Medical grade two-part room temperature vulcanizing (RTV) silicone with a Shore A 10 hardness and viscosity of 2500 cps (A-RTV-10: RTV-4410 Liquid Silicone Rubber, Factor II, Inc., Arizona, USA) was mixed and then degassed in a vacuum chamber to remove bubbles from the material. The degassed silicone was then poured into the mask mold and left to cure for 24 h. After curing, the three-part mold was taken apart to demold the mask interface. Silicone flashing was trimmed and the interface was then post cured for 4 h at 200 °C to achieve the final mechanical properties of the silicone material. The base of the molded mask interface was then attached to the ComfortGel mask frame using a medical grade silicone adhesive (A-100: Medical Silicone Adhesive, Factor II, Inc., Arizona USA); small holes were drilled in the frame to help the silicone adhesive form a mechanical connection.

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ORIGINAL ARTICLE

PEDIATRIC PULMONOLOGY WILEY

Predictors of NIV-related adverse events in children using long-term noninvasive ventilation

Prabhjot K. Bedi MBBS, MSc[1,2] | Kristie DeHaan BSc[3] | Daniel Ofosu MPhil[1] | Deborah Olmstead MN, NP[4] | Joanna E. MacLean BSc, MD, PhD[1,2] | Maria Castro-Codesal MD, PhD[1,2]

TABLE 3 Percentage of children with reported NIV-related complications at the initial follow-up visit within 12 months of NIV initiation and most recent follow-up visit after 12 months of NIV initiation.

NIV-related complication	Reported complications at initial follow-up visit *n* (%) Total *n* = 507	Reported complications at most recent follow-up visit *n* (%) Total *n* = 379	Percent change from initial to most recent follow-up visit (%)
Skin injury (persistent redness/skin breakdown)	103 (20.3)	44 (11.6)	−8.7*
Air leak (air blowing into eyes/red eyes)	95 (18.7)	38 (10.0)	−8.7**
Child sleep disruption	46 (9.1)	27 (7.1)	−2.0
Parent/caregiver sleep disruption	31 (6.1)	15 (4.0)	−2.1
Nasal symptoms (dryness/bleeding)	27 (5.3)	15 (4.0)	−1.3
Gastrointestinal symptoms/abdominal distension	20 (3.9)	9 (2.4)	−1.5
Midface hypoplasia	6 (1.2)	11 (2.9)	+1.7
Increased drooling	4 (0.8)	1 (0.3)	−0.5
Pneumothorax	1 (0.2)	0 (0.0)	−0.2

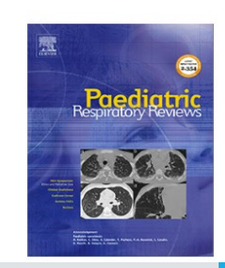
Note: McNemar's test.

Abbreviation: NIV, noninvasive ventilation.

*$p < .01$; **$p < .001$.

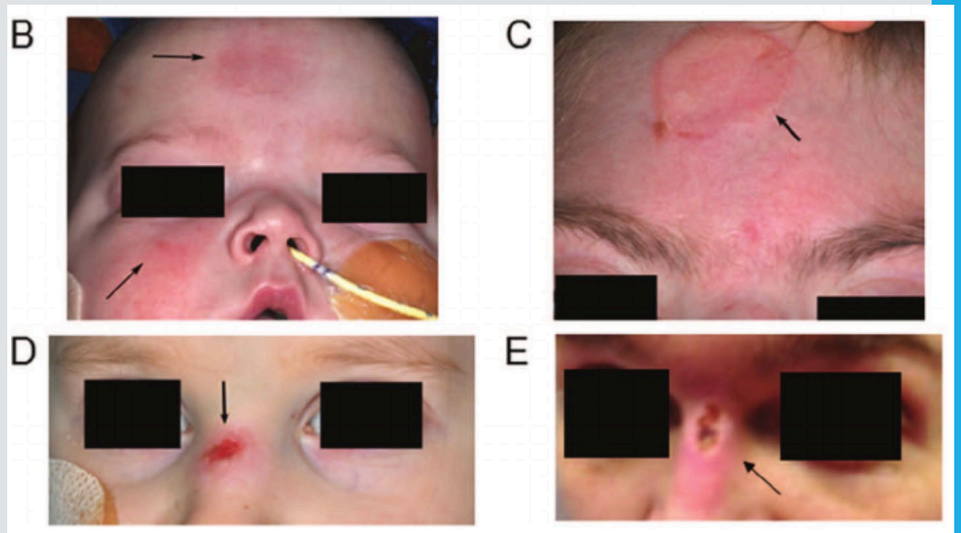
MASK INTERFACES FOR HOME NON-INVASIVE VENTILATION IN INFANTS AND CHILDREN

Maria L. Castro-Codesal, Deborah L. Olmstead, Joanna E. MacLean Paediatr Respir Rev. 2019 Nov



The most common side effects caused by the mask interface comprise skin irritation and/or injury due to pressure sores, eye irritation and mouth dryness due to air leaks, nasal symptoms and facial deformities in young children

❖ SKIN INJURY



Representative images of 5 subjects are shown. Panel A shows erythema on the nose immediately after the mask for overnight NIV was removed in the morning. Non-blanching erythema consistent with a stage I pressure ulcer persisted throughout the day. The subject in panel B has stage I pressure ulcers on the right cheek and forehead. Panel C shows a stage II ulcer on the forehead that developed over 1 night of wear. Panels D and E show stage II and stage III pressure ulcers, respectively, on the nasal bridge.

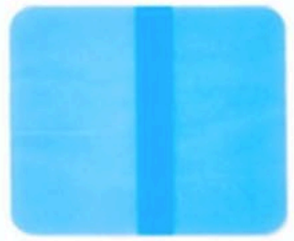
MAIN FEATURES	RECOMMENDATIONS
Skin injuries are still occurring, and are frequently reported. - nonblanchable erythema - severe pressure ulcers bridge, forehead, and cheeks.	• Re-assess fit and size of the mask • Re-assess integrity of the mask (might need replacement) • Re-assess fit of the headgear • Consider decreasing heated humidification • Consider switching mask interface

Khirani S, Ducrot V. ***Mask interfaces and devices for home noninvasive ventilation in children****. Pediatr Pulmonol. 2024 Jun*

Restorative cream

Gecko nasal pad
soft silicone strip

Silicone foam
dressing



Hydrogel sheet
dressing

Eye bubble chamber

cloth masks or foam masks

FIGURE 3 Possible solutions to prevent/treat skin irritation/injuries or ocular injury due to the NIV interface.

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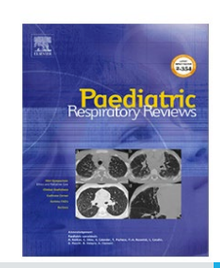

❖ EYES IRRITATION AND MOUTH DRYNESS

MAIN FEATURES	RECOMMENDATIONS
• Unintentional leaks due to an incorrect mask fit or the displacement by the child, may cause eye irritation • . Particular attention should be addressed to prevent or correct leaks in patients with eye sensitivity such as children with exorbitism	• Re-assess fit and size of the mask • Re-assess integrity of the mask and/or headgear (might need replacement) • Consider decrease and modify pressures

Khirani S, Ducrot V. ***Mask interfaces and devices for home noninvasive ventilation in children****. Pediatr Pulmonol. 2024 Jun*

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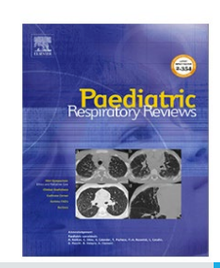

❖ NASAL SYMPTOMS

MAIN FEATURES	RECOMMENDATIONS
• Dryness, nasal congestion, nosebleeds, and even headaches • Lack of humidification and mouth leak may contribute to this process	• Increase heated humidity • Consider topical treatment with nasal rinses, steroids and/or decongestants • If no resolution of symptoms, consider switching to an oro-nasal interface

children

MDPI

Review

Maxillary Hypoplasia and Non-Invasive Ventilation: Literature Review and Proposed New Treatment Protocol

Maria Costanza Meazzini [1], Mattia Moretti [2,3,*], Gabriele Canzi [4], Davide Sozzi [2,5], Giorgio Novelli [2,5] and Fabio Mazzoleni [1,2]

MAIN FEATURES	RECOMMENDATIONS
• Midface hypoplasia and maxillary retrusion represent a major side effect of NIV interfaces. • Children should undergo regular evaluations of the maxilla- mandibular growth, with early referral to pediatric orthodontists and maxillo-facial specialists, in those requiring NIV for a long time period and in children at risk of major facial deformities	• Avoidance of excessive tightening of the headgear • Consider selection of lighter interfaces and rotation of interfaces with different pressure points • Periodic sleep studies to re-assess need for NIV and/or titration to determine the lowest efficacious pressure

This dysmorphism was partly due to the use of NIV during the night (Figure 3).

Figure 3. Frontal (**A**) and lateral (**B**) clinical images with NIV interface.

Khirani S, Ducrot V. ***Mask interfaces and devices for home noninvasive ventilation in children****. Pediatr Pulmonol. 2024 Jun*

Conclusion

It is important for the therapist to understand that the differences in the efficacy of positive airway pressure applied via nasal and oro-nasal masks may influence the effectiveness of NIV therapy.

Bahammam A.S. Respir Care 2018;63(2):227-237

"One size does not fit all"

Gozalez-Bermejo J. Eur Respir Rev 2019; 28: 190043

The little things do make a big difference during application of NPPV

Kacmarek R. Respir Care 2003; 48:10