



Acute Non-invasive Ventilation in Pediatrics

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Dr Peter Skippen
De Jenny Retallack
Rachel Chung (RT)

Learning Objectives

Identify acute indications for pediatric non-invasive ventilation

Discuss initiation of BIPAP in a Pediatric Patient

Review management strategies for patients on acute BIPAP



What is Non-Invasive Ventilation

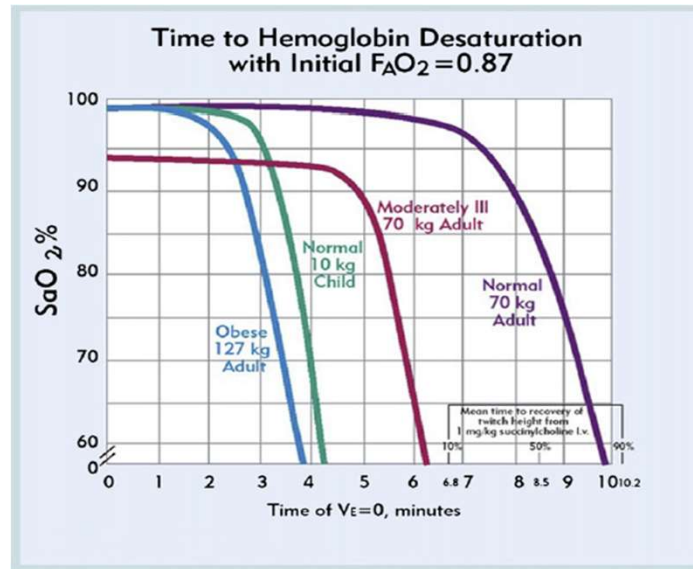
- Delivery of positive pressure ventilation
- Without the need for an endotracheal tube, tracheostomy, or laryngeal mask airway
- To promote improved oxygenation and ventilation

Basic Physiology

Children more prone to respiratory failure

- Smaller airways/greater airways resistance
- Pliable chest walls predispose to reduced FRC and atelectasis
- Desaturate rapidly with apnea – airways close above functional residual capacity (FRC)

Less Time



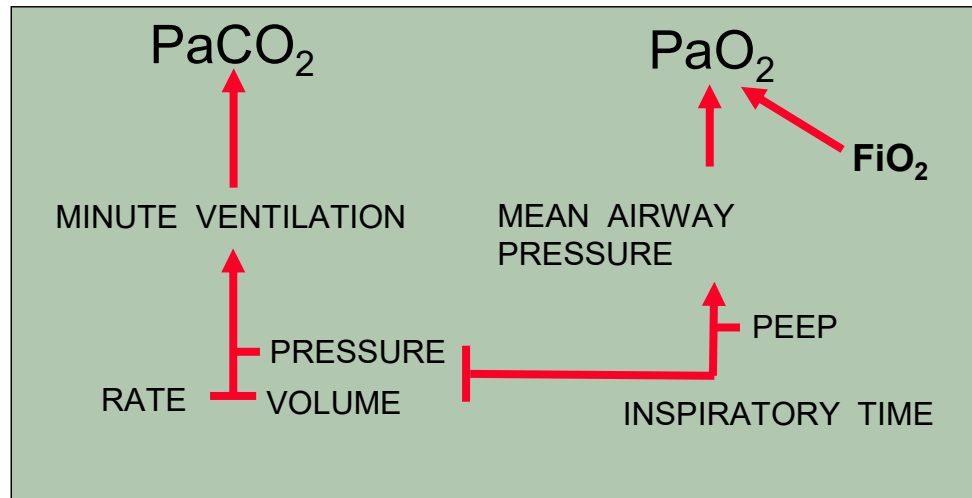
Types of Respiratory Failure

**Ventilation
failure**

**Oxygenation
failure**

JR1

Basic Concepts



Options for Oxygenation/Ventilation

Oxygenation

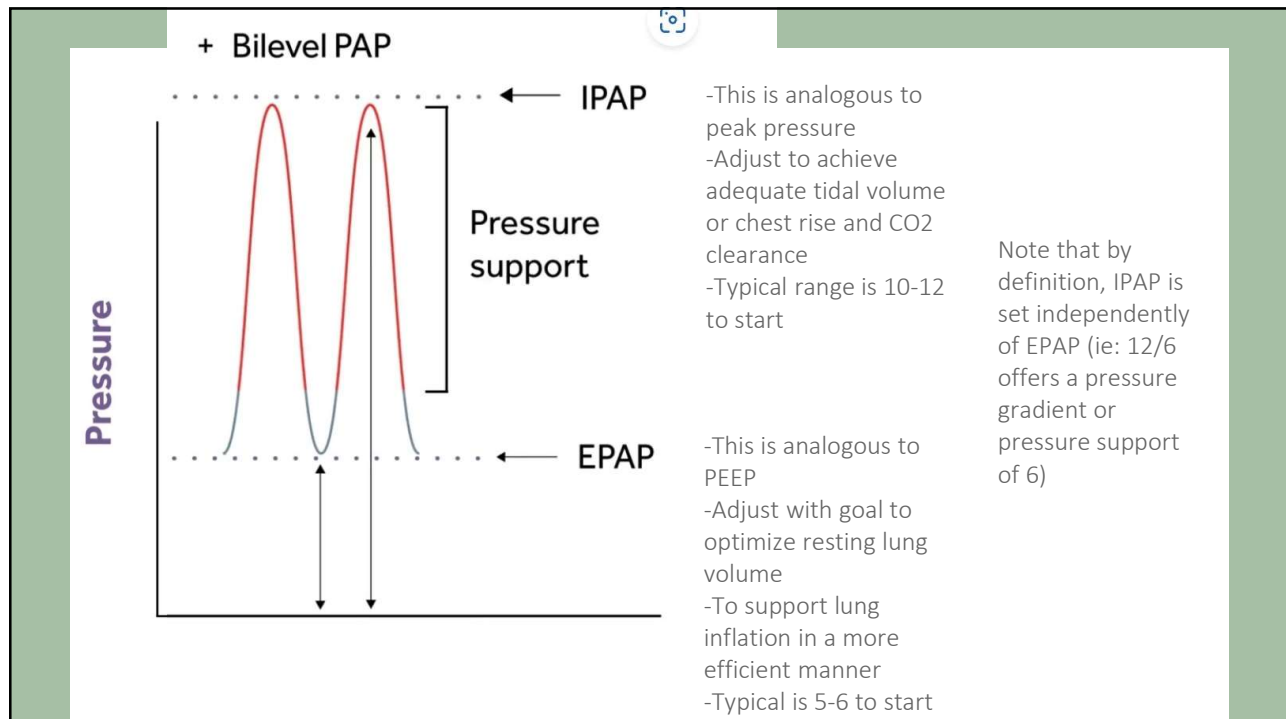
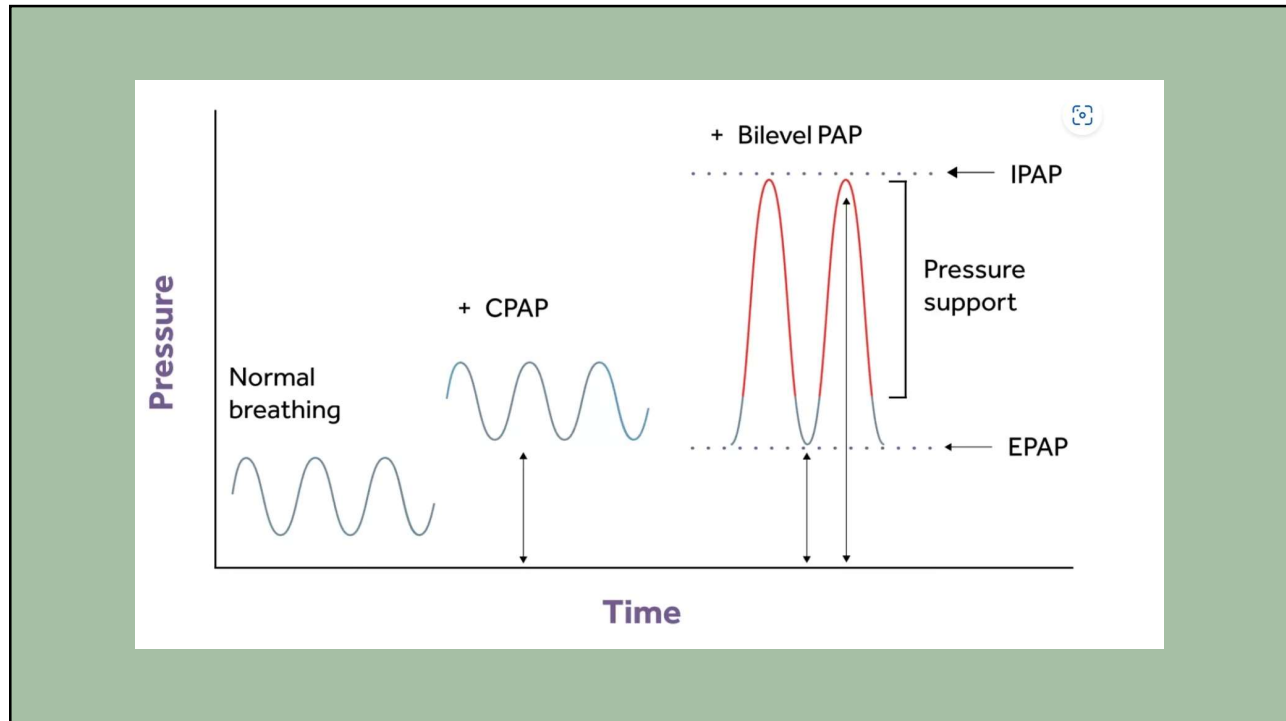
- Low flow oxygen
- Heated humidified high flow nasal cannula oxygen therapy (HHHFNC)
- BiPAP (Bi-level positive airway pressure) – oxygen/ventilation support
- Invasive mechanical ventilation – oxygen/ventilation support

Ventilation

- BiPAP (Bi-level positive airway pressure) – oxygen/ventilation support
- Invasive mechanical ventilation – oxygen/ventilation support

Slide 7

JR1 Consider switching it around to focus on CO₂ clearance vs PaO₂ support. I just flipped the diagram you had
Jenny Retallack, 2023-12-11



Heated Humidified High flow Oxygen

- Establishes control of inspired oxygen delivery by matching patient inspiratory flow rate with oxygen flow rate
- Reduce WOB by supporting inspiratory flow demand
- Warmed Humidification optimizes secretion clearance/reduces heat loss
- ?Reduction of dead space (enhances upper airway clearance reducing rebreathing of CO₂)
- ?Dynamic PEEP
- Does NOT support ventilation

- **Bronchiolitis**
- **Asthma**
- Pneumonia
- Medical complexity with hypoxia and increased secretions

Typical Clinical
Scenarios for
acute NIV in
Children

- **Bronchiolitis**

Typical Clinical

**Call PICU for Advice for
Other Clinical Scenarios**

-
-
-
- Medical complexity with hypoxia and increased secretions

Children

BiPAP support for asthma/bronchiolitis?

- Unloads inspiratory muscles
 - Decreasing work of inspiratory/expiratory accessory muscles
 - Reduces effort to initiate inspiratory flow
 - Matching CPAP to autoPEEP creates a driving pressure to support inspiratory muscles
 - May improve delivery of inhaled medication



Interfaces and Mask Ranges



- Nasal mask**
- For patient who requires NIV support at home
 - Transition to a nasal mask as part of their weaning plan as patient improves in hospital



- Total face mask**
- Cover the whole face to deliver adequate ventilation
 - Peds XXS (>3kg)/ Peds XS/ Adult S/ Adult L
 - Sizing: Depends on patient face size



- Full face mask**
- Same as adult NIV mask
 - S/M/L

Mask Fit



Choose the appropriate mask and bonnet for the patient. Ensure the mask sits around the face, not covering the mouth or eyes and is midline



An appropriate size bonnet is important for mask fit. Ensure the bonnet covers from top of the head to nape of the neck



Make sure the mask remains midline when you adjust the straps

Mask sizing

XXS

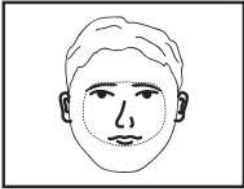


Figure 1

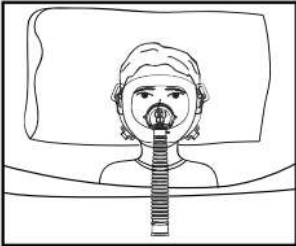


Figure 2

XS

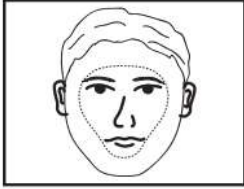


Figure 1

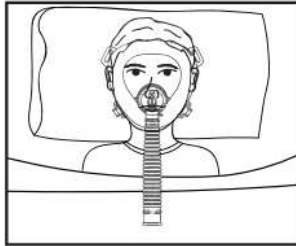


Figure 2



Trilogy 202
Single limb circuit for BiPAP



Hamilton T1
Dual limbs for BiPAP.
Can be used for HF/
BiPAP/invasive ventilation



PICU Servo U
Dual limb circuit.
Can be used for HF/
BiPAP/invasive
ventilation

Home Ventilators



Resmed Aircurve

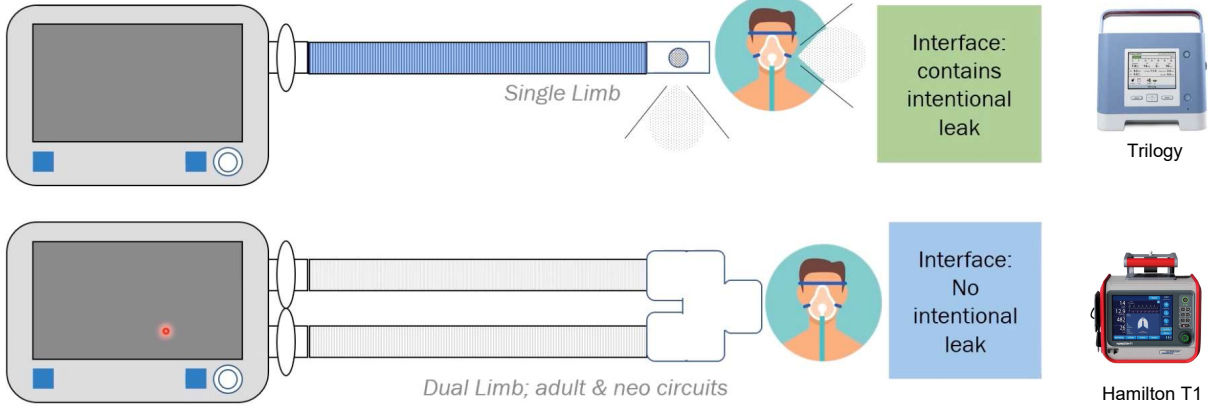


Resmed Stellar



Phillips A40 Pro

Single vs Dual Limb Circuits



Dual limb NIV set up



Case

5mo previously healthy male

Presents with 3 days of URTI symptoms, poor feeding, decreased U/O

In ER:

RR 90, HR 180, Sats 81% RA and severe WOB

Saturations improved to 95% on face mask O₂

Significant nasal secretions and coarse crackles throughout chest

IV Access achieved

Decision to start BIPAP

Initial Settings

Spontaneous Mode: primary mode of choice

Essentially pressure support mode

➤ IPAP delivered with each spontaneous breath

➤ No rate, no inspiratory time (Ti)

NIV mode on T1 ventilator

Controlled mode: considered in infrequent cases with:

Persistent ventilation/oxygenation issues despite

High BiPAP settings

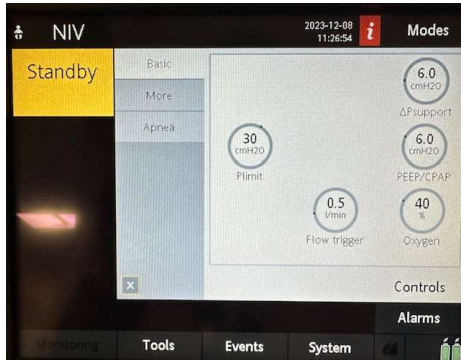
High FiO₂ requirements

➤ Set Rate

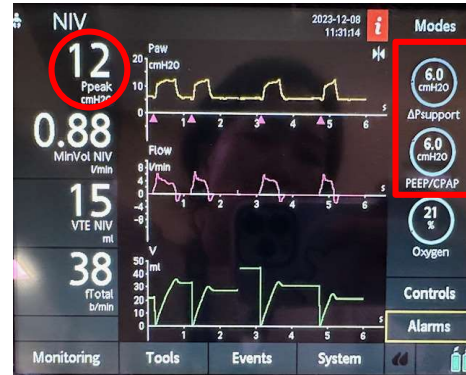
➤ Set Ti -> this will increase mean airway pressure to support recruitment

NIV-ST mode on T1 ventilator

Spontaneous Mode on T1 Ventilator (NIV)



No RR, No inspiratory time



Ppeak = Pressure Support (ΔP) above PEEP

SP19

Escalation

Common example of increasing BiPAP pressure
12/6 -> 14/7 -> 16/8 -> 18/8 -> 20/10

Max IPAP likely to be 20 cmH₂O before considering more advanced therapy

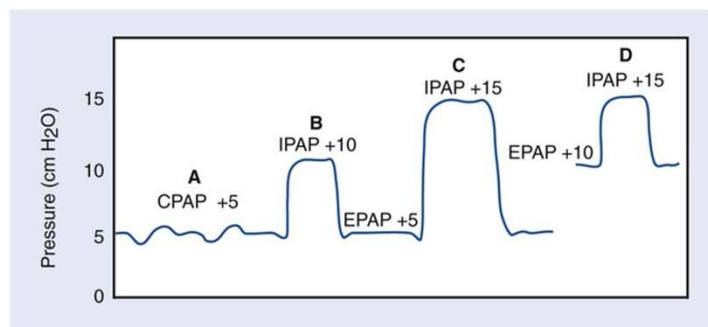
If patient has difficult oxygenation or requires lung recruitment	Increase FiO ₂ Increase PEEP
If patient has ventilation issue or increased in WOB	Increase ΔP (IPAP – EPAP) by increasing IPAP for CO ₂ clearance
Difficult oxygenation and ventilation	Consider adjusting IPAP and EPAP Maintain/ Increase ΔP

Slide 26

SP[9] emphasize the spontaneous mode, and that if a controlled mode is considered required, a video call should be established and we can walk them through the steps...

Skippen, Peter [CWBC], 2023-12-08

Titration of Pressures



SP18

To Start BiPAP

Appropriate Care Area

- Location
- Human Resources – EYES ON THE PATIENT
- Monitoring

Planning for next steps

- Contingency planning
 - Escalation to intubation
- Transfer Plan
 - PICU video consult
 - Interdisciplinary review

Slide 28

SP[8] emphasise eyes on patient best method of monitoring....

Skippen, Peter [CWBC], 2023-12-08

Risks associated with NIV - uncommon

- Aspiration
- Skin injury/breakdown (longer term use)
 - Face care q4hrs
 - suctioning
- Hemodynamic instability – uncommon
 - potential increased intrathoracic pressure may impact preload
 - Likely require intubation

Markers of Success

Patient Synchrony

Identified immediately

Regularly reassessed

Improved work of breathing

Seen within first minutes once settled

Improvement in vital signs

Should see gradual improvement in HR and RR

Follow trajectory over hours

Challenges

- Mask/Bonnet Fit
- NIV tolerance
 - Non-pharmacologic
 - Pharmacologic supports
- Gastric Distension
- Hunger



Non-Pharmacologic Support

- Bundling Patient
 - Neonate/infant
- Bundling Care
 - NG insertion
 - NPW/bloodwork
- Distraction
- Timing of re-assessment
- Parental Support

Intranasal Medication Options

To take Control

Fentanyl

- 1-2mcg/kg
- Onset 2-3 min

Ketamine

- 4mg/kg
- Onset 3-10 minutes

Midazolam (stings)

- 0.3-0.5mg/kg
- Onset 10 minutes

Dexmedetomidine

- 2-3mcg/kg
- Onset 20-30 min



Dexmedetomidine

- Selective alpha-2 adrenergic receptor agonist
- **Sedative and Anxiolytic**
- Mild analgesia
- **IV continuous Infusion** (range 0.2-1mcg/kg/hr)
- Maintained respiratory drive and airway tone
- Risks/Side effects
 - Bradycardia
 - Hypotension

Ketamine

- Dissociative Agent
- **Sedative and Analgesia**
- Bronchodilation

- **IV Bolus dose for initiation** 0.5-1mg/kg
- **IV continuous Infusion** (range 5-20mcg/kg/min)
- Potential for significant sedation

- Risks/Side effects
 - Increased Secretions
 - Nausea/Vomiting

Common Clinical Scenarios

6 week old with
bronchiolitis

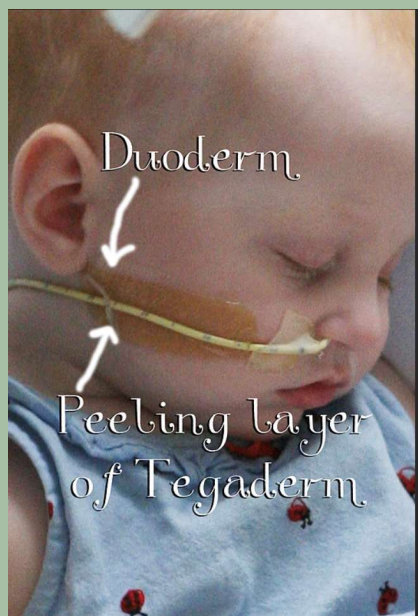
Trial bundling

10 mo with bronchiolitis
with severe WOB but
not lethargic

Dexmedetomidine
infusion preceding
BIPAP initiation

8 yo with severe
asthma who
needs BiPAP **now**

Ketamine bolus
then
dexmedetomidine
infusion



NG insertion

- Decompression
- Eventual feeding once stabilized

The child on home BiPAP

- Consider using nasal mask?
- May use home machine?
- May need increased pressure?
- Beware of the weak child
 - May not show WOB
 - Consider O₂ requirements and RR

Case

8 yo known asthmatic on baseline Flovent with Ventolin prn
2 previous admissions to hospital with asthma
Presents with 3 days of URTI symptoms, worsening WOB and Ventolin use
4x/day x 2 days

In ER:

RR 36, HR 130, Sats 84% RA and severe WOB

Saturations improved to 95% on face mask O₂

Very tight with limited AE and faint wheeze

Prolong expiratory phase

Received back to back 3 Ventolin/Atrovent with minimal change

IV access with methylprednisone and MgSO₄

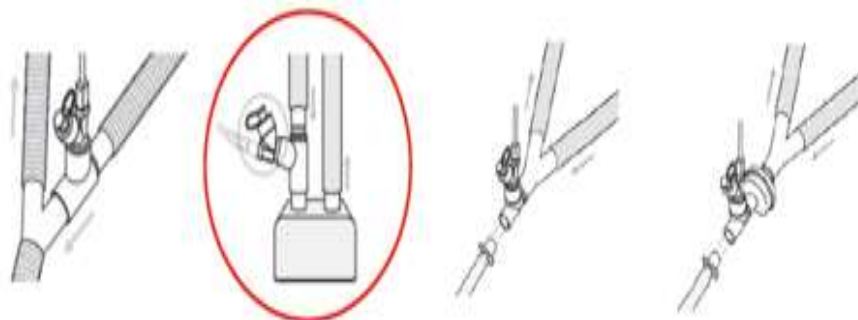
Decision BiPAP initiation

Best Practice for Inhaled Medication Delivery

- High flow
- BiPAP



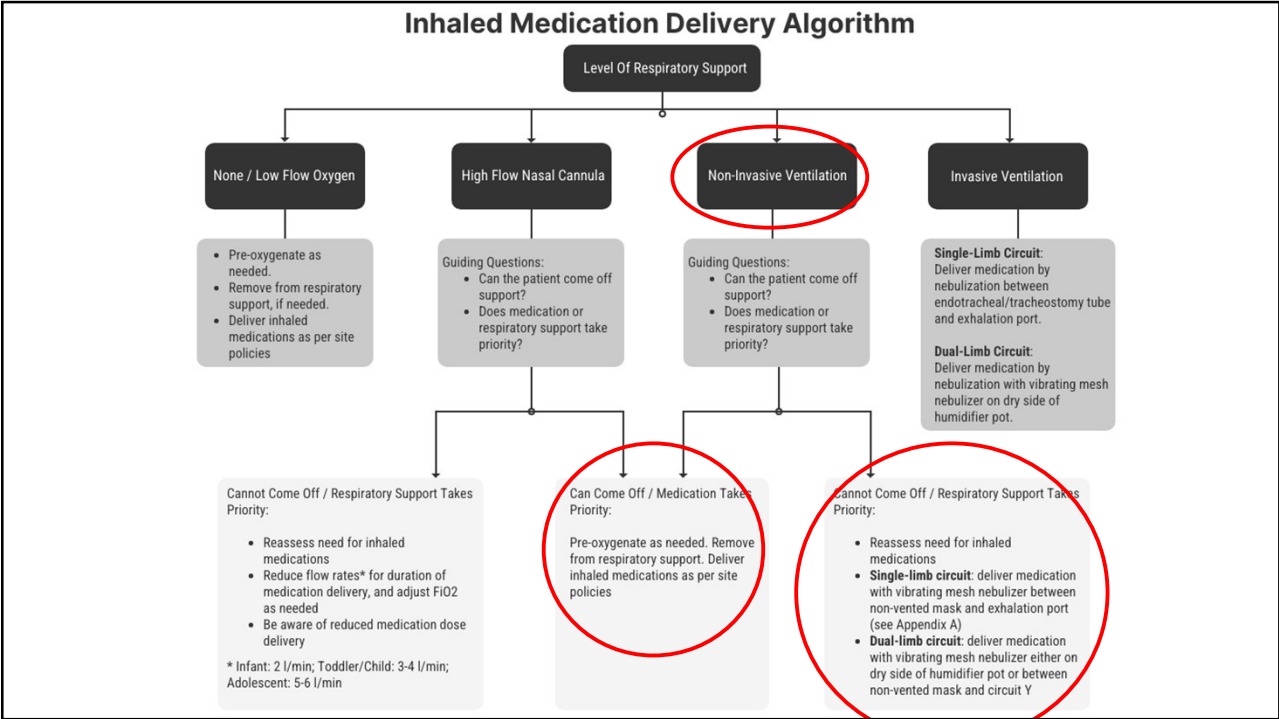
Inhaled Medication via Mesh Nebulizer (Aerogen)



Dual limb circuit set up for aerogen

Do you have mesh nebulizer (Aerogen) available at your hospital?

If yes, raise your hand on Zoom



Continuous Nebulization of Salbutamol

Drug Dosage	20 mg/h
Amount of 0.9% NS to add to Aerogen 60 mL syringe	36 mL
Amount of drug (5 mg/mL salbutamol inhalation solution) to add to 60 mL syringe	24 mL (120 mg)
Approximate total solution in syringe	60 mL
Approximate final concentration of solution	2 mg/mL
Alaris pump flow rate	10 mL/h



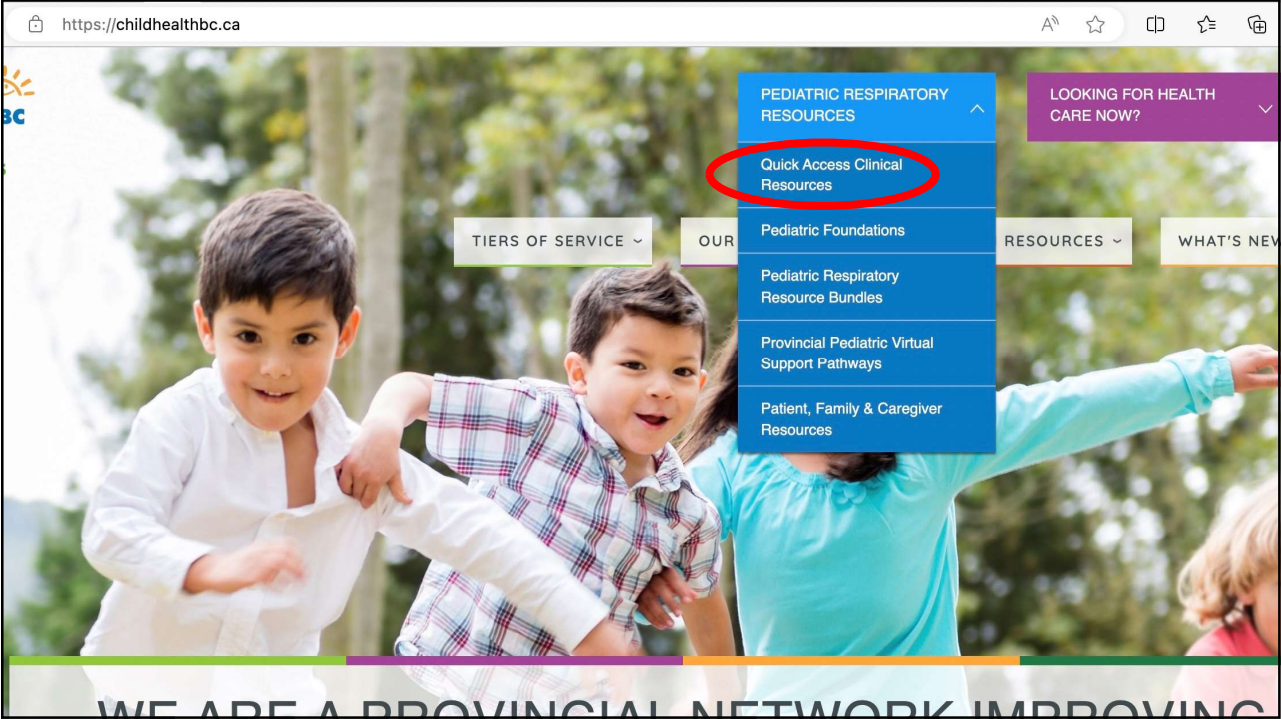
HFNC vs. NIV in Pediatric Asthma

HFNC

- HFNC for **Oxygenation failure** -> **NOT** a primary issue in Asthma
- **No reduction** in physiologic dead space after the toddler years
- **Provide minimal CPAP**
- **Longer hospital LOS** in comparison to NIV
- **Does not prevent escalation** of therapy to NIPPV in pediatric asthmatic patients
- **Lacking data** supporting it's use in pediatric status asthmaticus
- **Considered for stabilization prior to transfer in BC centers that do not have NIV capability**

NIV

- **Addresses** both key physiologic challenges in asthma
 - **lower airway obstruction**
 - **dynamic hyperinflation**
- Provides **PEEP** to allow improved air flow into airways by matching autoPEEP
- Creates **Driving Pressure** to allow delivery of an efficient tidal volume at a faster rate
- **Clinical improvement usually seen within 1-2 hrs** of initiation



GENERAL MEDICATIONS:

- [BC Children's Hospital Formulary](#)
- [BC Children's Hospital Continuous Infusion Guidelines](#)
- [Low Dose Push Epinephrine \("Spritzer Epi" severe hypotension – non-arrest\)](#)

RESPIRATORY SUPPORT:

- [BC Children's Hospital Intubation checklist \(PAGE 6\)](#)
- [BC Children's Hospital Intubation Guideline \(Equipment list PAGE 6\)](#)
- [BC Children's Hospital High Flow Nasal Prongs Procedure](#)

ASTHMA:

- [CHBC Asthma Urgent Care Practical Summary](#)
- [BC Children's Hospital Continuous Ventolin Nebulization Guideline](#)

BRONCHIOLITIS:

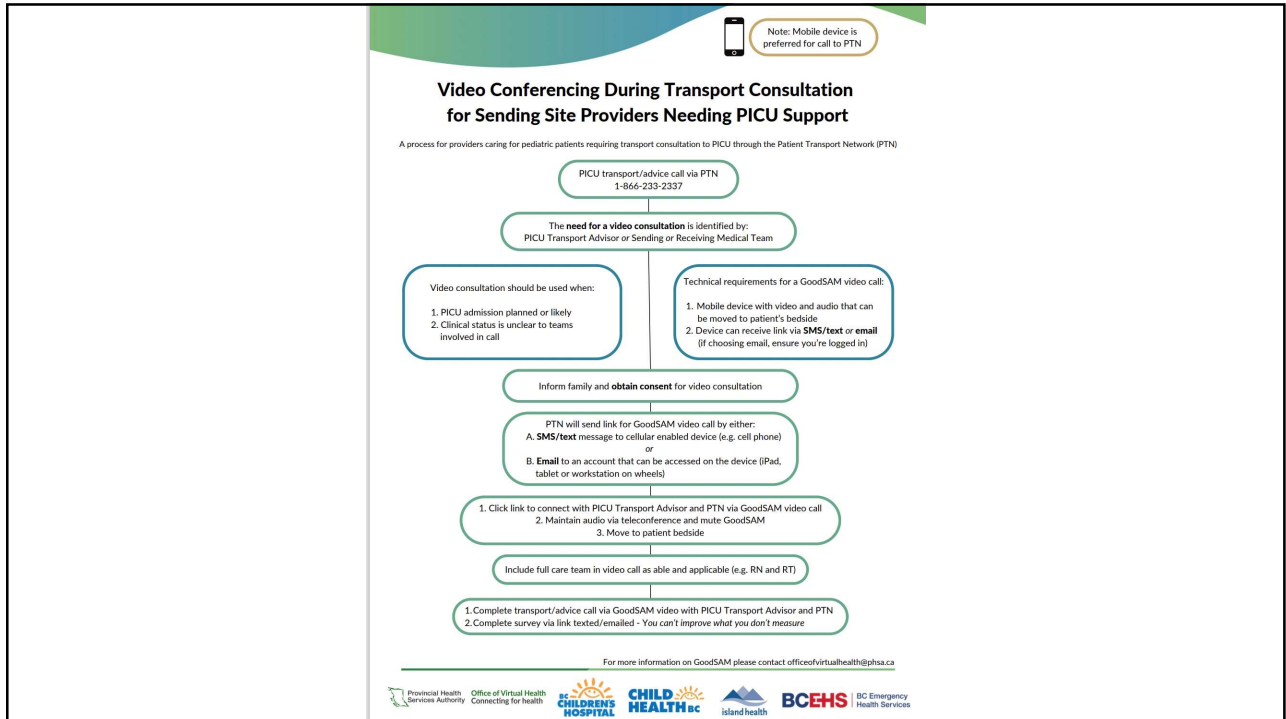
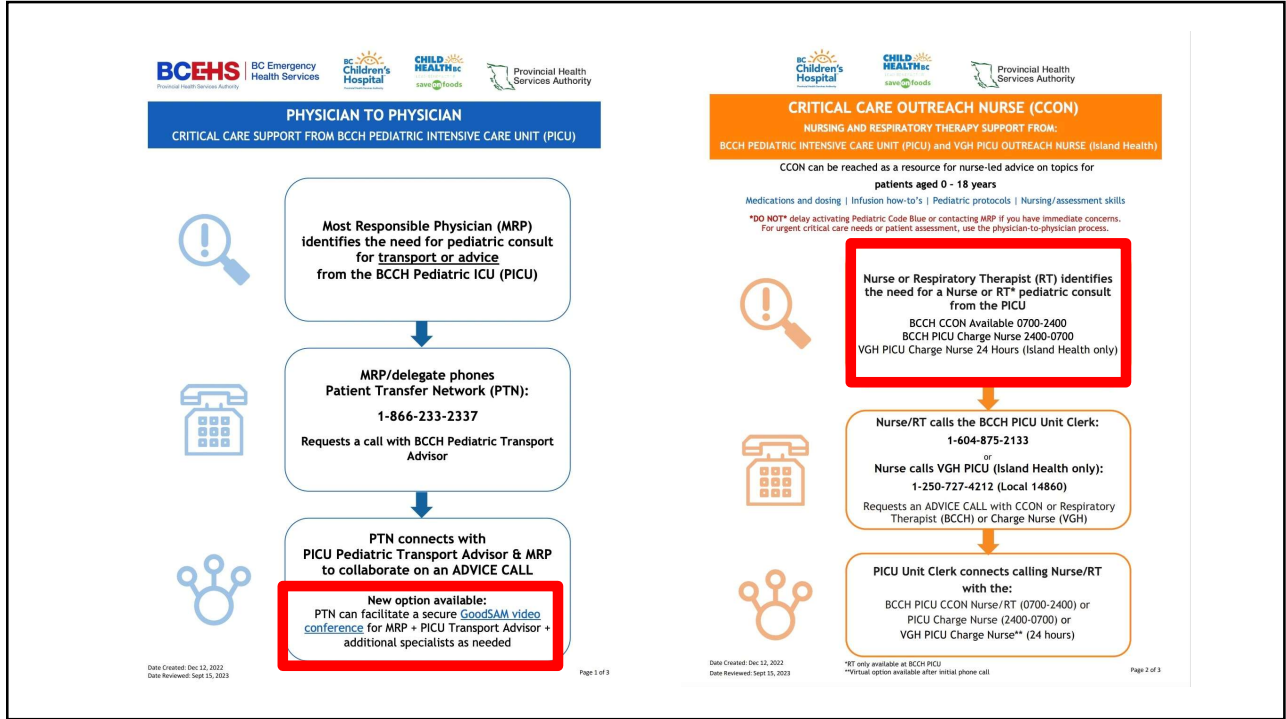
- [Choosing Wisely Bronchiolitis \(Summary Page 6\)](#)

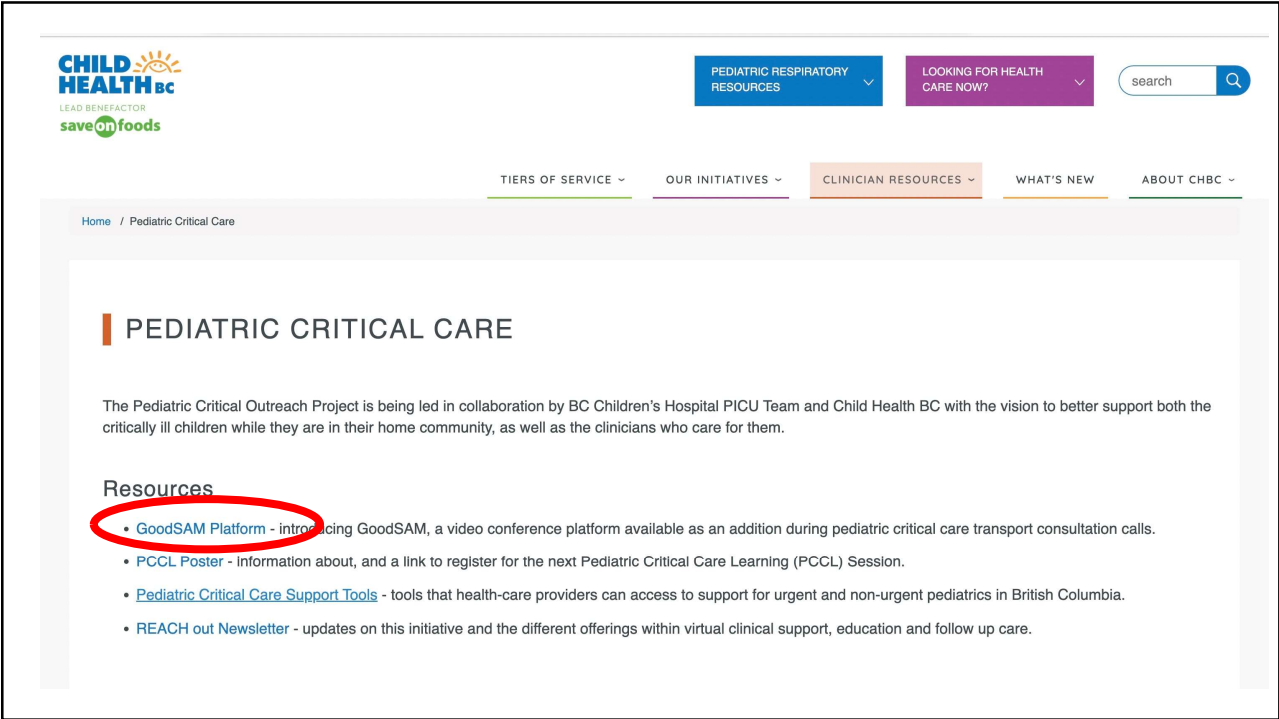
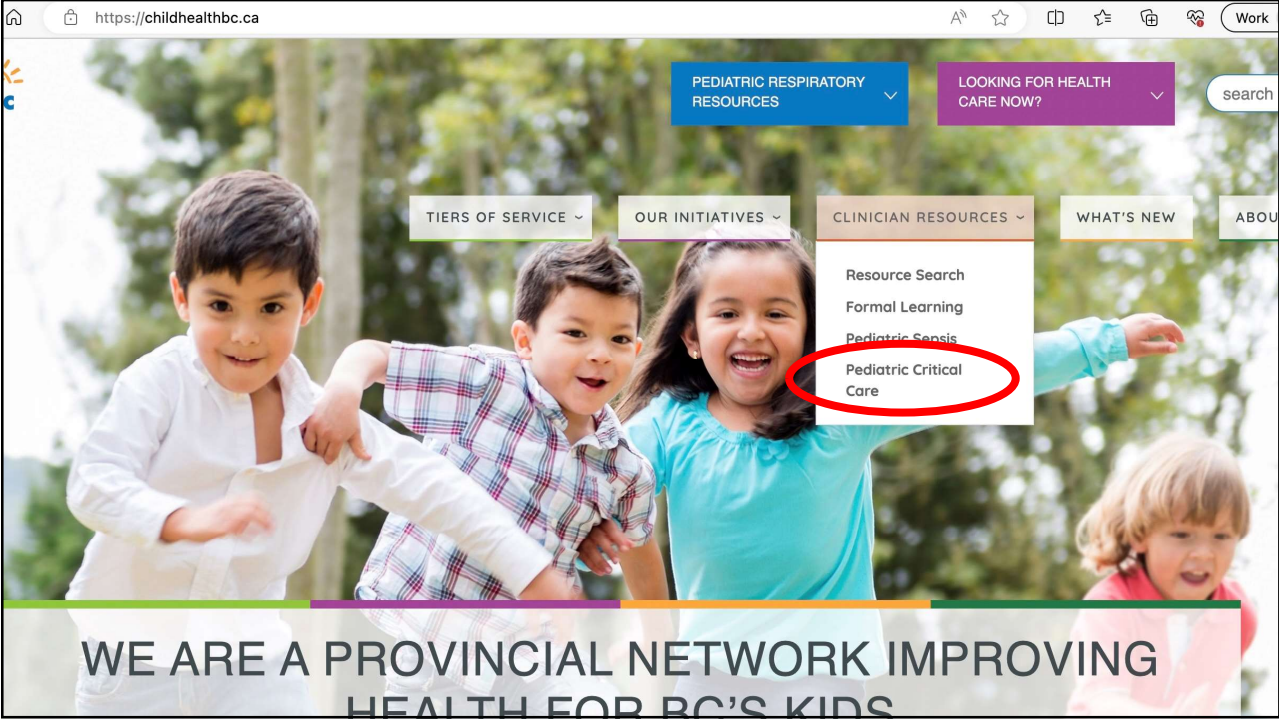
[BC Children's Hospital Bronchiolitis High Flow Nasal Prongs Guideline](#)

The screenshot shows the website <https://childhealthbc.ca>. The main navigation menu is open, displaying the following items:

- PEDIATRIC RESPIRATORY RESOURCES (with an upward arrow)
- Quick Access Clinical Resources
- Pediatric Foundations
- Pediatric Respiratory Resource Bundles
- Provincial Pediatric Virtual Support Pathways** (highlighted with a red circle)
- Patient, Family & Caregiver Resources

Other visible elements include a purple button labeled "LOOKING FOR HEALTH CARE NOW?", a search bar, and a banner at the bottom that reads "WE ARE A PROVINCIAL NETWORK IMPROVING".





The image shows a YouTube video player interface. At the top, the YouTube logo and a search bar are visible. The video thumbnail features an illustration of a hospital building with a red cross on its facade. The text 'Access to PICU Video Consultation' is overlaid on the right side of the thumbnail. Below the video player, the channel name 'GoodSAM Platform' is displayed, along with 'Unlisted' status and 'Provincial Health Services Authority (PHSA)' with '13.9K subscribers'. A 'Subscribe' button is present. Below the channel information, there is a light blue banner with a plus icon and the text 'From a provincial health authority of Canada' and a link to 'Learn how health sources are defined by the World Health Organization'.

This slide features a green background with the word 'Questions?' centered in a large, black, sans-serif font. On the left side, there is a small image of a red and white medical device, likely a patient warming unit, with a digital display showing various vital signs. On the right side, there is a photograph of a young child lying in a hospital bed, wearing a yellow gown and receiving oxygen therapy through a clear plastic mask held by a healthcare professional wearing blue gloves.

References

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- Williams, Alicia; Dhar, Archana. Differences and similarities in severe bronchiolitis and status asthmaticus. *Journal of Pediatric Critical Care* 10(3):p 94-100, May–Jun 2023.
- Li J, Tu M, Yang L, Jing G, Fink J, Burtin C, et al. Worldwide clinical practice of high-flow nasal cannula and concomitant aerosol therapy in the adult ICU setting. *Respir Care*. (2021) 66:1416–24.
- Poonai N, Canton K, Ali S, Hendrikx S, Shah A, Miller M, Joubert G, Rieder M, Hartling L. Intranasal ketamine for procedural sedation and analgesia in children: A systematic review. *PLoS One*. 2017 Mar 20;12(3):e0173253.
- Parashchanka, Aliaksandra; Schelfout, Sam; Coppens, Marc. Role of novel drugs in sedation outside the operating room: dexmedetomidine, ketamine and remifentanyl. *Current Opinion in Anaesthesiology*. 27(4):442-447, August 2014
- Pansini V, Curatola A, Gatto A, Lazzareschi I, Ruggiero A, Chiaretti A. Intranasal drugs for analgesia and sedation in children admitted to pediatric emergency department: a narrative review. *Ann Transl Med*. 2021 Jan;9(2):189.