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Critical Care Management of Bronchiolitis, Asthma, and ARDS

November 17, 2022

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Hospital for Sick Children



Outline/Objectives

- Review medical approach to:
 - Asthma
 - Bronchiolitis
 - Pneumonia/ARDS
- How we do it: non-invasive ventilation in children (Katie Reise, RRT)
- Q+A

Current Situation

Critical Care Services Ontario (CCSO) COVID-19 Daily Report

Paediatric Critical Care Units (combined L3 and L2 ICU)

Source: Critical Care Information System (CCIS)

16th Nov 2022 (23:59:59)



Critical Care Census

114

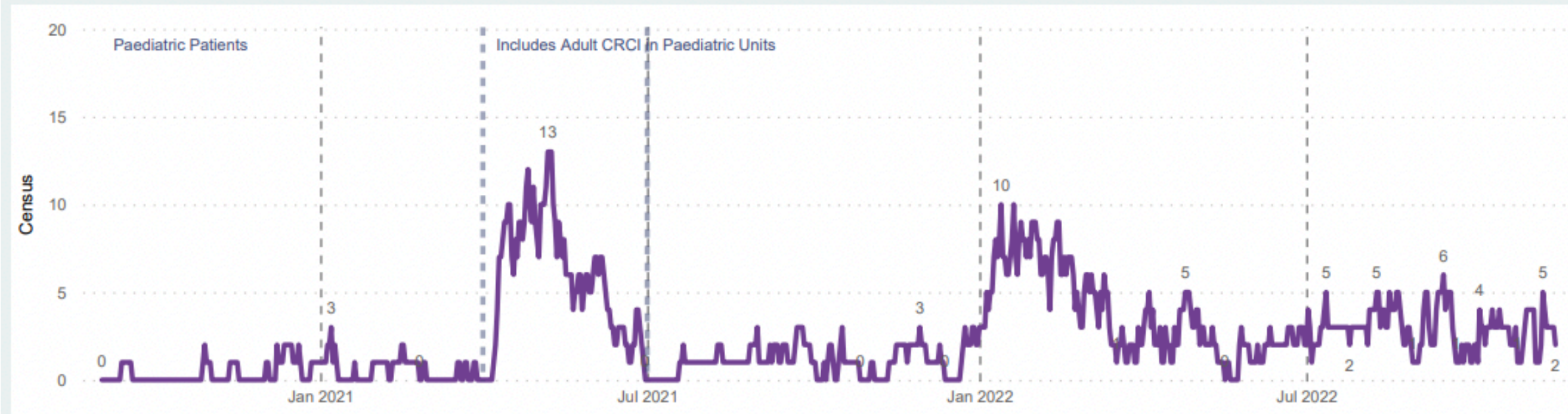
COVID Related Critical Illness (CRCI) Census

2

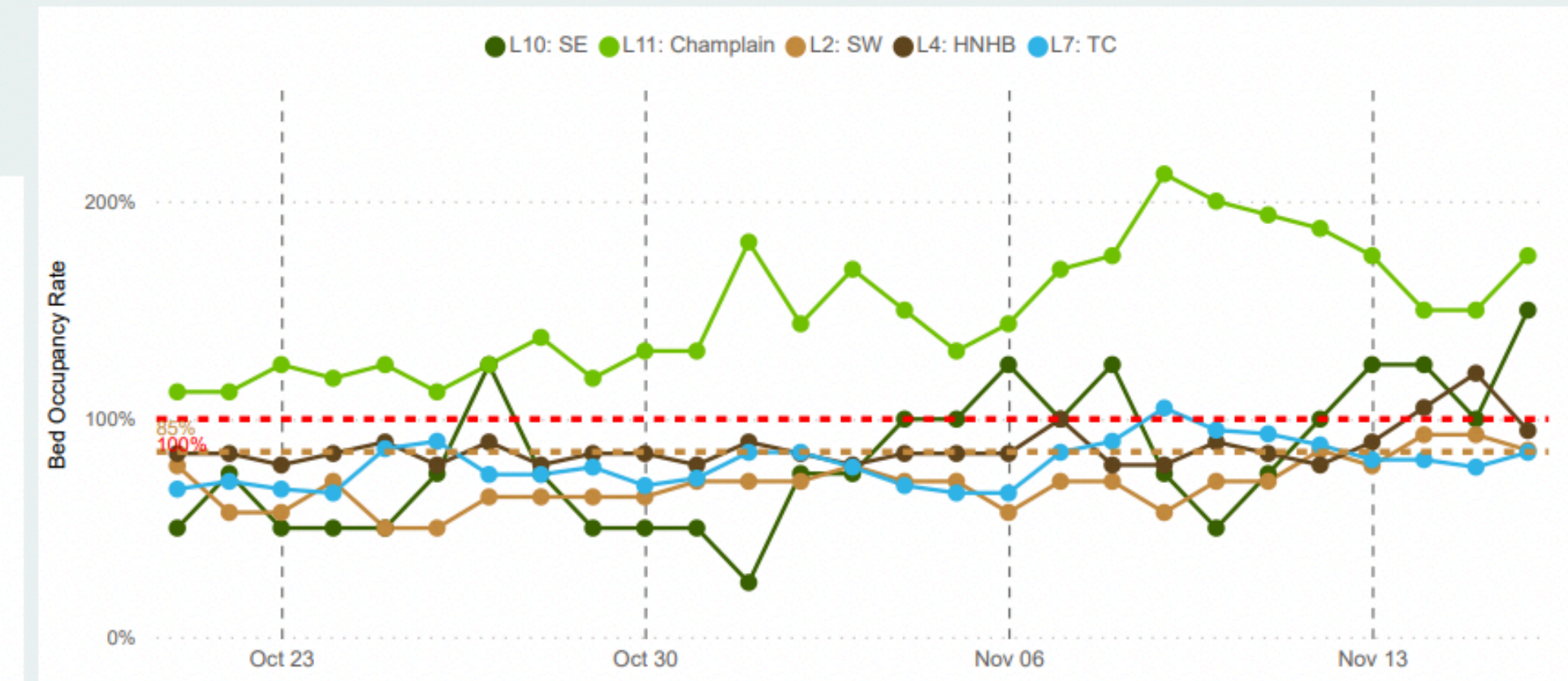
New CRCI Census

0

Daily Trend of Critical Care COVID *



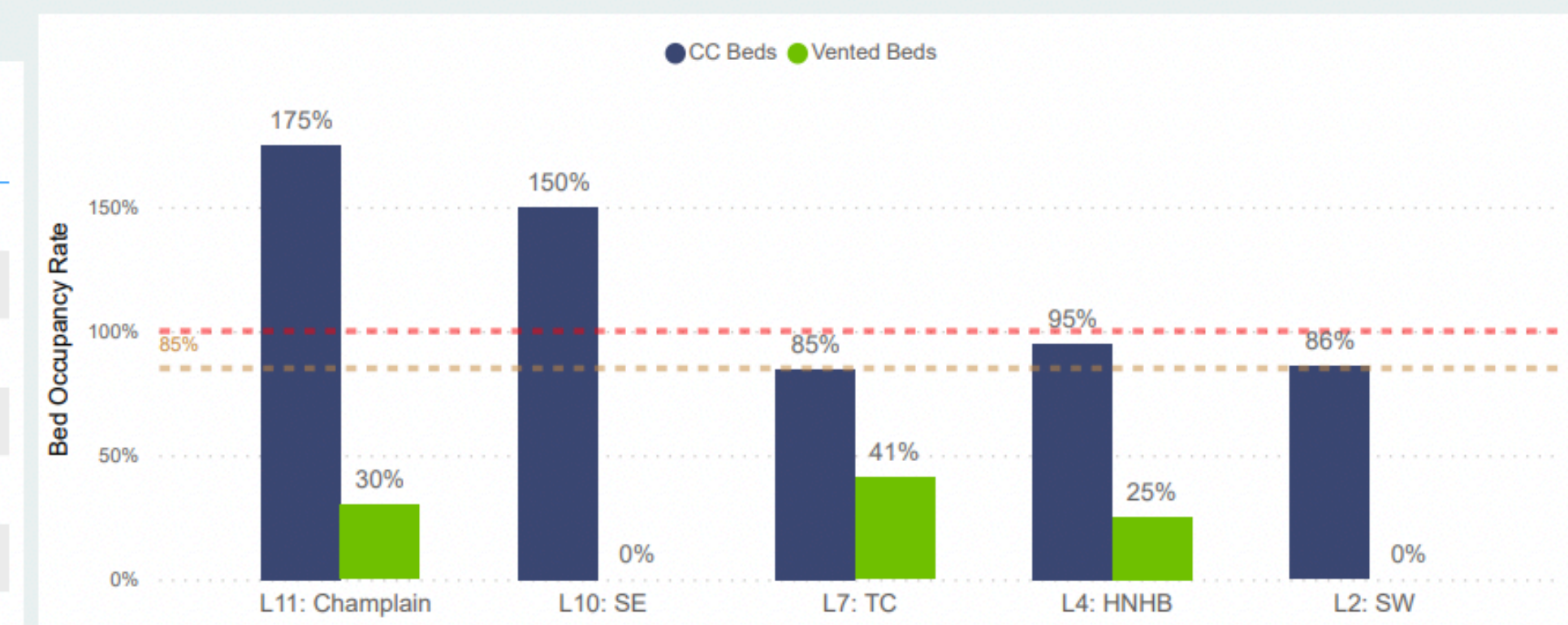
Daily Trend of Critical Care Bed Occupancy Rate for Baseline Capacity (4-week trend)



Region/LHIN Bed & Vented Bed Capacity vs. Census

Region	LHIN Code	Baseline* Critical Care Beds	Critical Care Census	Baseline Vented Beds	Critical Care Census Vented	CRCI	CRCI Vented	New CRCI Census
West	L2: SW	14	12	12	0	0	0	0
	L4: HNHB	19	18	12	3	0	0	0
Toronto	L7: TC	59	50	44	18	2	1	0
East	L10: SE	4	6	4	0	0	0	0
	L11: Champlain	16	28	10	3	0	0	0
Total		112	114	82	24	2	1	0

Critical Care Bed and Vented Bed Occupancy Rate for Baseline Capacity



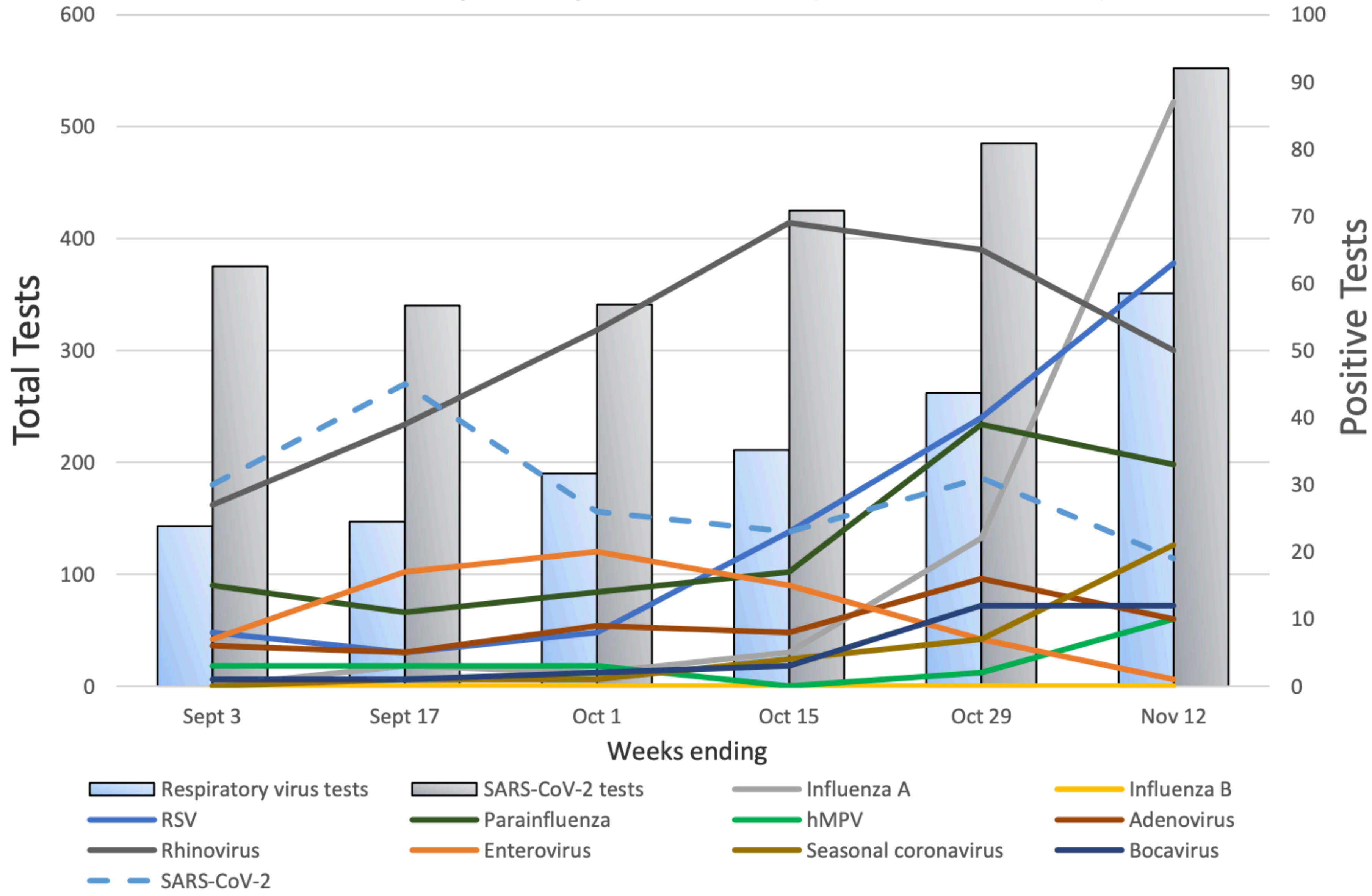
Champlain Children's Hospital of East Ontario received 2 expanded capacity beds not included in the Baseline Critical Care Beds column

* Between April and June 2021, the report included adults in paediatric units.

** Baseline includes pre-pandemic CCIS beds and additional investments made since Fall 2020. Incremental inclusion of beds into baseline will be directed by OCCCCC (The Ontario Critical Care COVID-19 Command Centre).

CCSO is responsible for providing strategic oversight to CCIS. CritiCall Ontario houses CCIS and is responsible for technical implementation. To obtain more information or provide feedback about the reports, please contact info@ccso.ca

SickKids Respiratory Virus Watch (with SARS-CoV-2)



Viral Respiratory Mapper - ACES Admissions

Last update (at midnight): 16-Nov-22



Hospital Admissions 7-Day Moving Average - Pandemic (2020+) vs. Pre-Pandemic Historical (2015-2019)* for:

Date Range

2/1/2020

11/16/2022

Main page

Data by syndrome (excluding COVID)

*Not all hospitals have historic data from 2015.

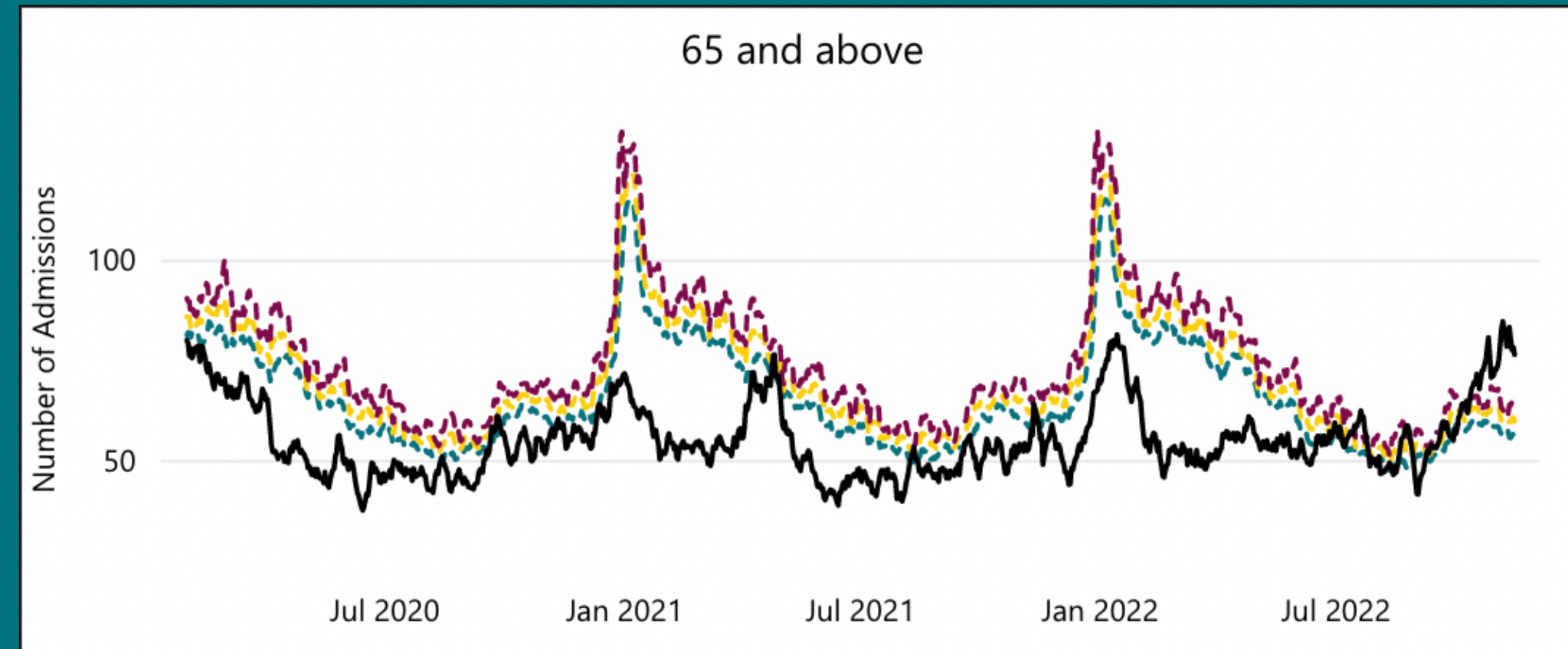
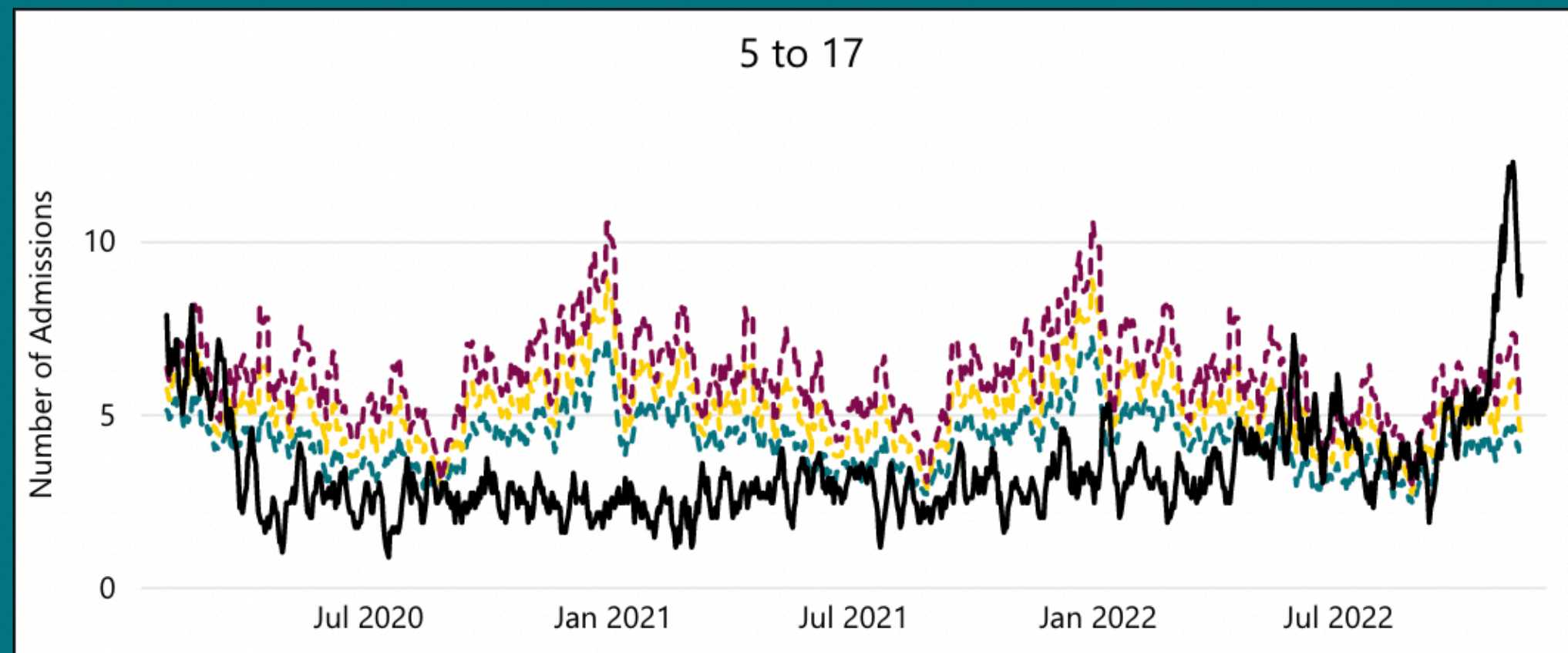
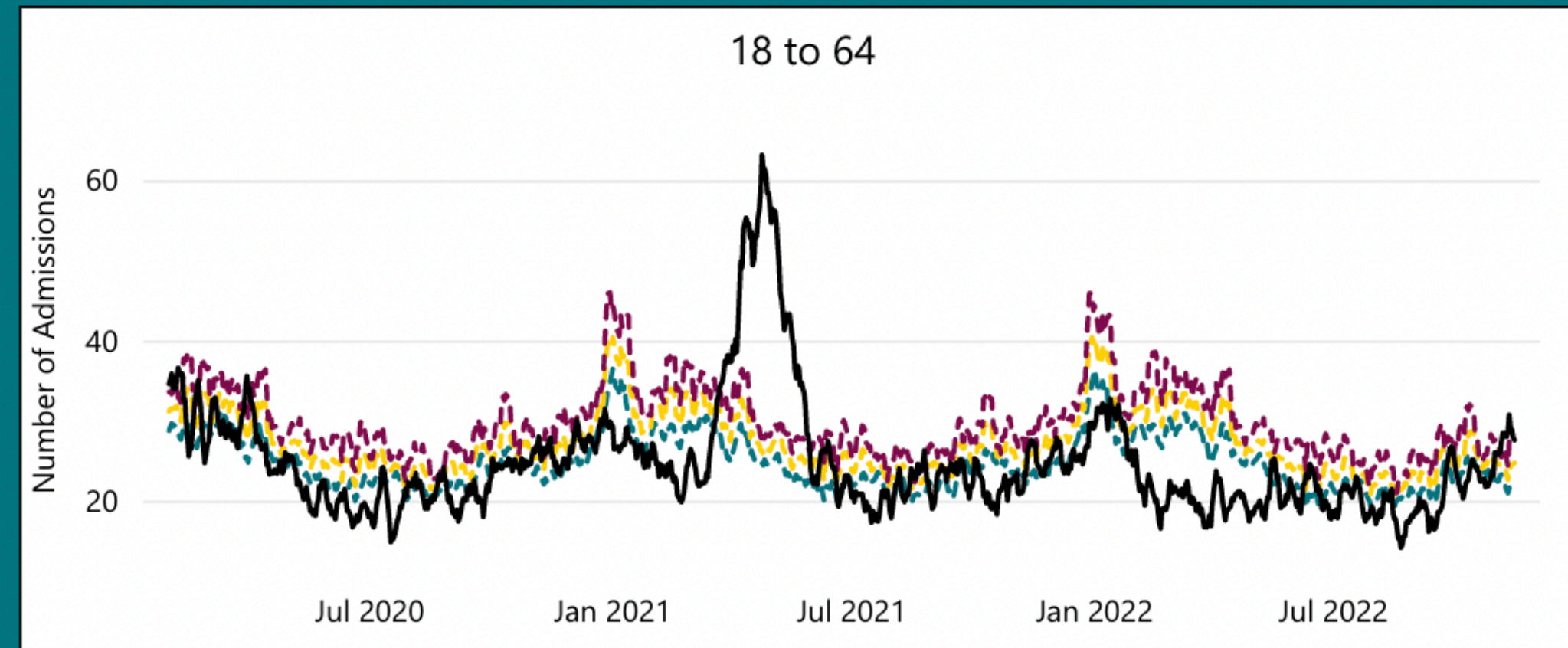
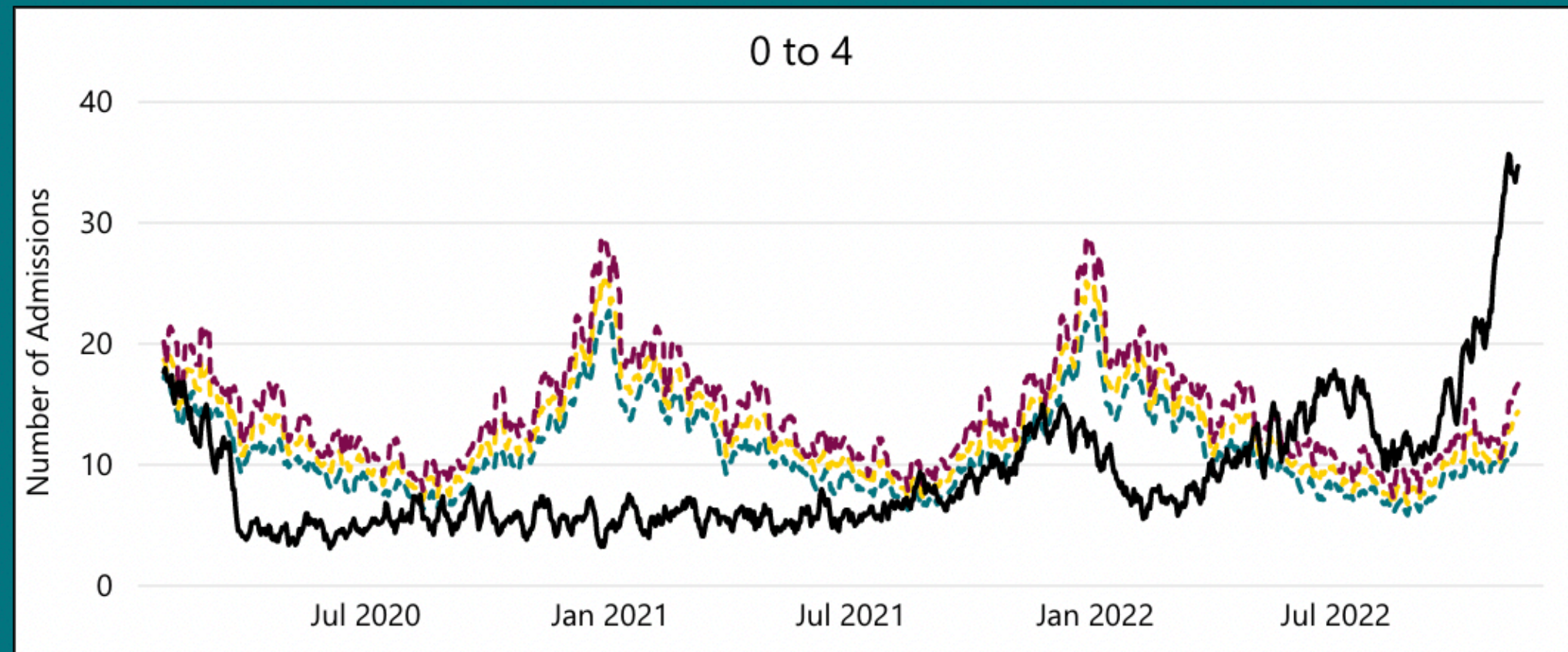
Pneumonia and Influenza-like Illness Only

7-Day Moving Average

Historical 7-Day Moving Average + 1 Standard Dev

Historical 7-Day Moving Average

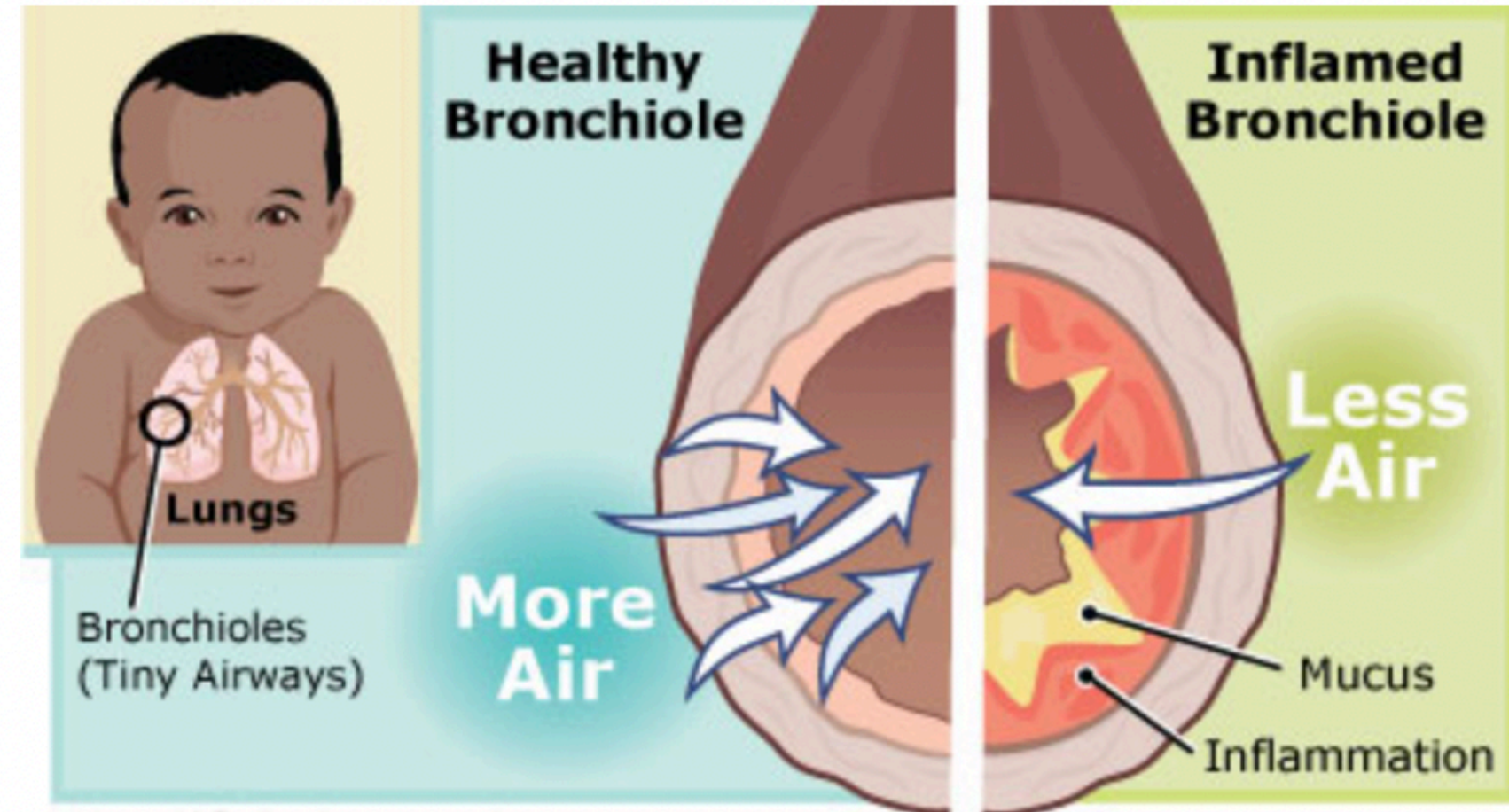
Historical 7-Day Moving Average + 2 Standard Dev



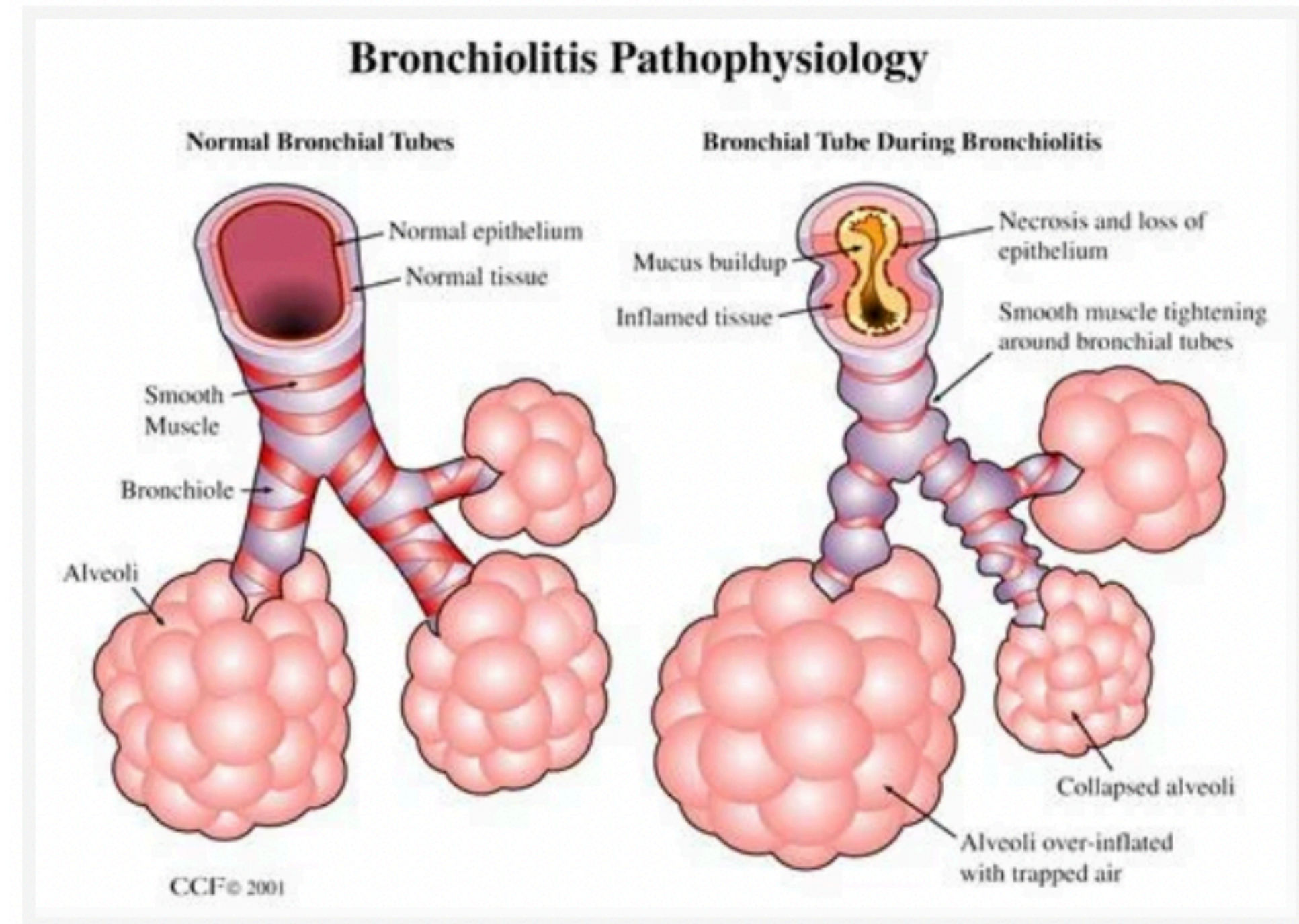
Current Situation

- Significant increase in volume of sick children presenting throughout region
- RSV and Influenza A driving many PICU admissions, including many co-infections (*S pneumoniae*, *S aureus*)
- Provincial PICU occupancy is very high
- Prudent to review/stock equipment to temporize (e.g. NIV masks for pediatric patients), and to adopt equipment changes that might simplify stabilization (e.g. Aerogen system for nebulization in acute asthma management)
- BUT we are not asking (or planning to ask) that community sites admit patients on NIV (exception being neonatal patients but only when already within site scope)

Bronchiolitis



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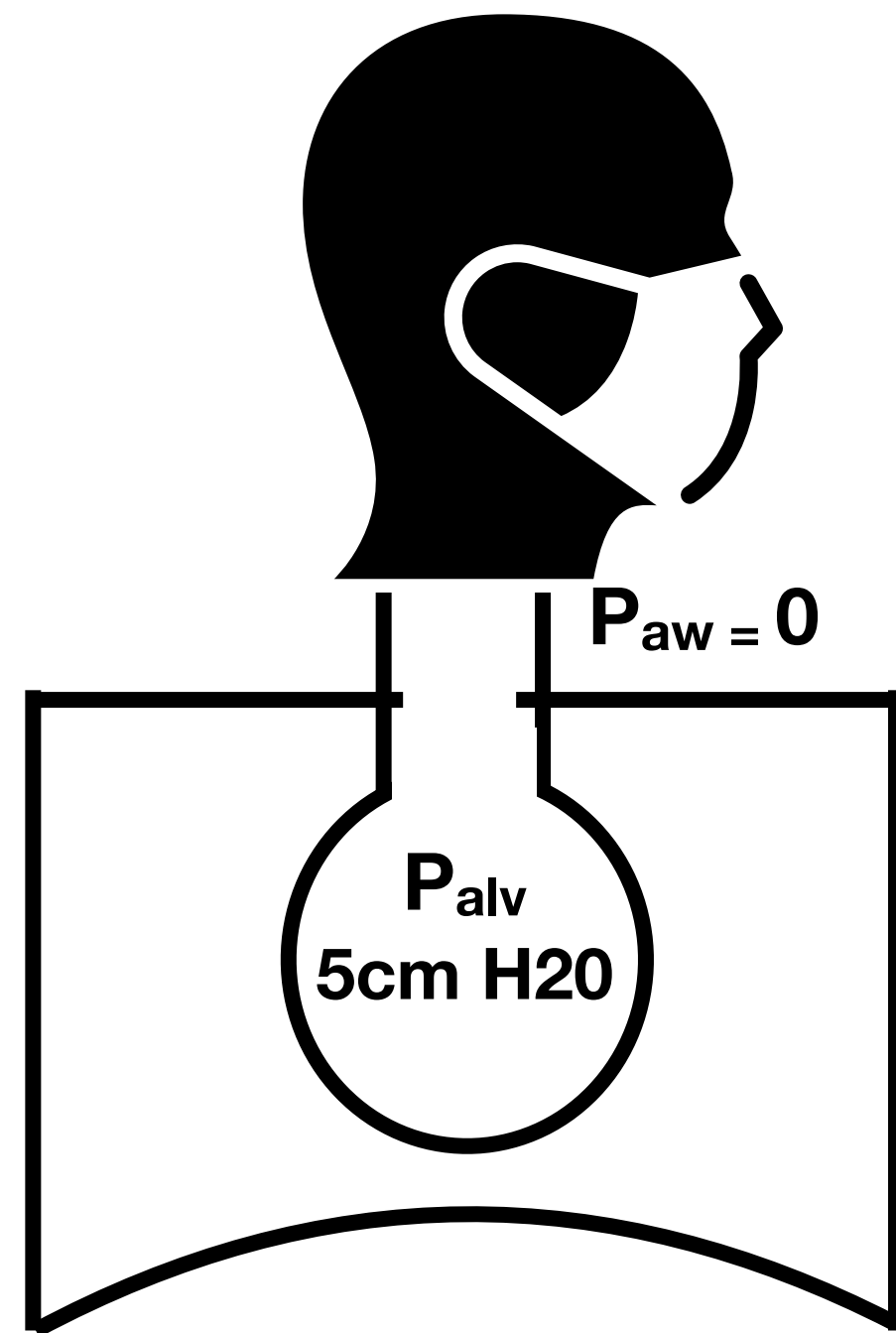
Bronchiolitis

Management for children with increasing acute care needs:

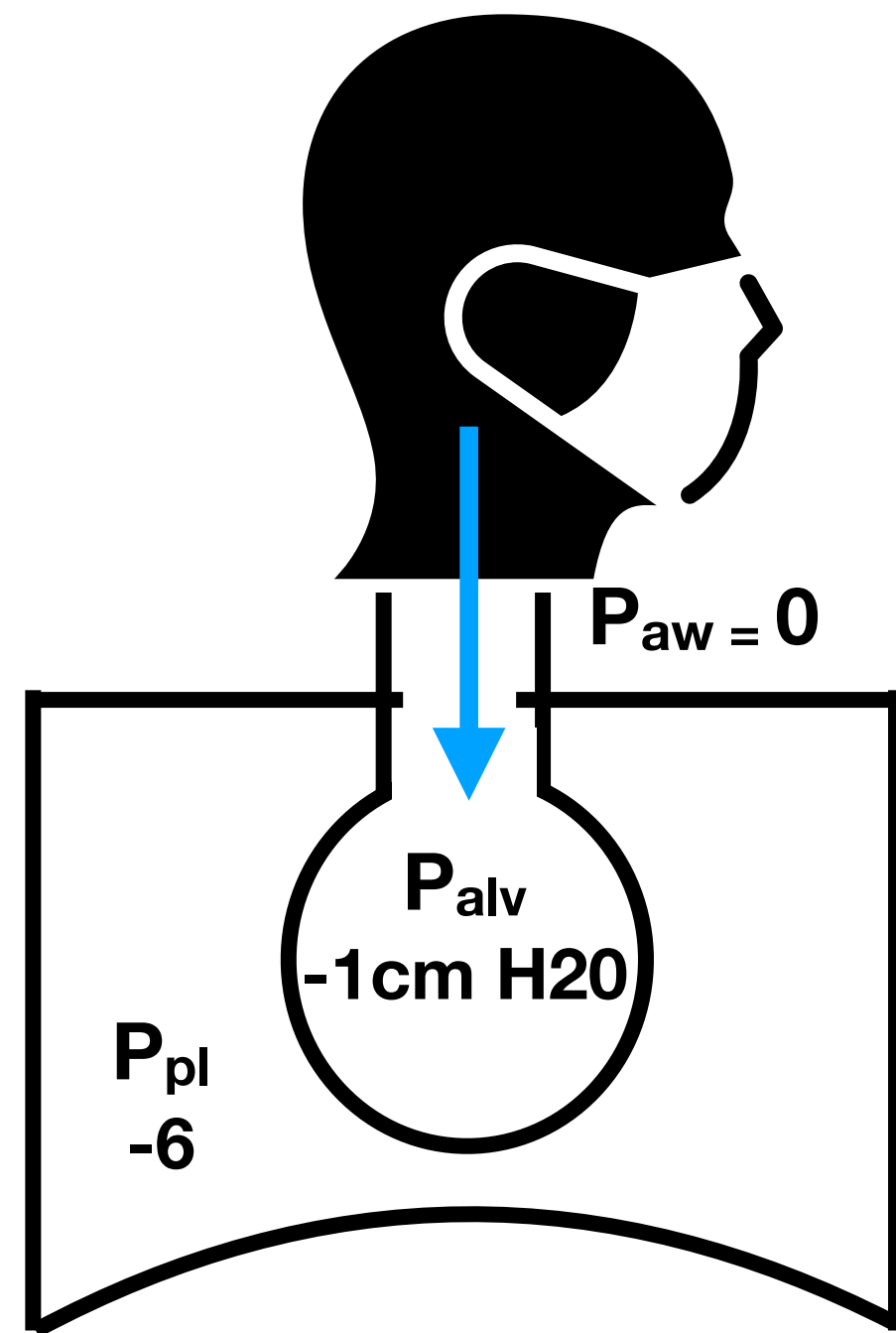
- “deep suctioning”, i.e. nasopharyngeal suctioning
 - a good reference: <https://starship.org.nz/guidelines/nasopharyngeal-suction/>
- HHFNC tips: prong sizing, start at 2L/kg/min, little merit in going much above that (Katie has more tips!)
- Move to NIV if persistent WOB (grunting, retractions, nasal flaring, tracheal tug...): more on this later
- OK to stray from guidelines in patients with whom you are peri-intubation
 - be wary of how easy Aerogen can make nebulizations...need to reassess and stop if these aren't helping
- Indications for intubation: severe WOB in spite of adjuncts (HHFNC, NIV), refractory hypoxia or hypercarbia, persistent apnea...

Asthma

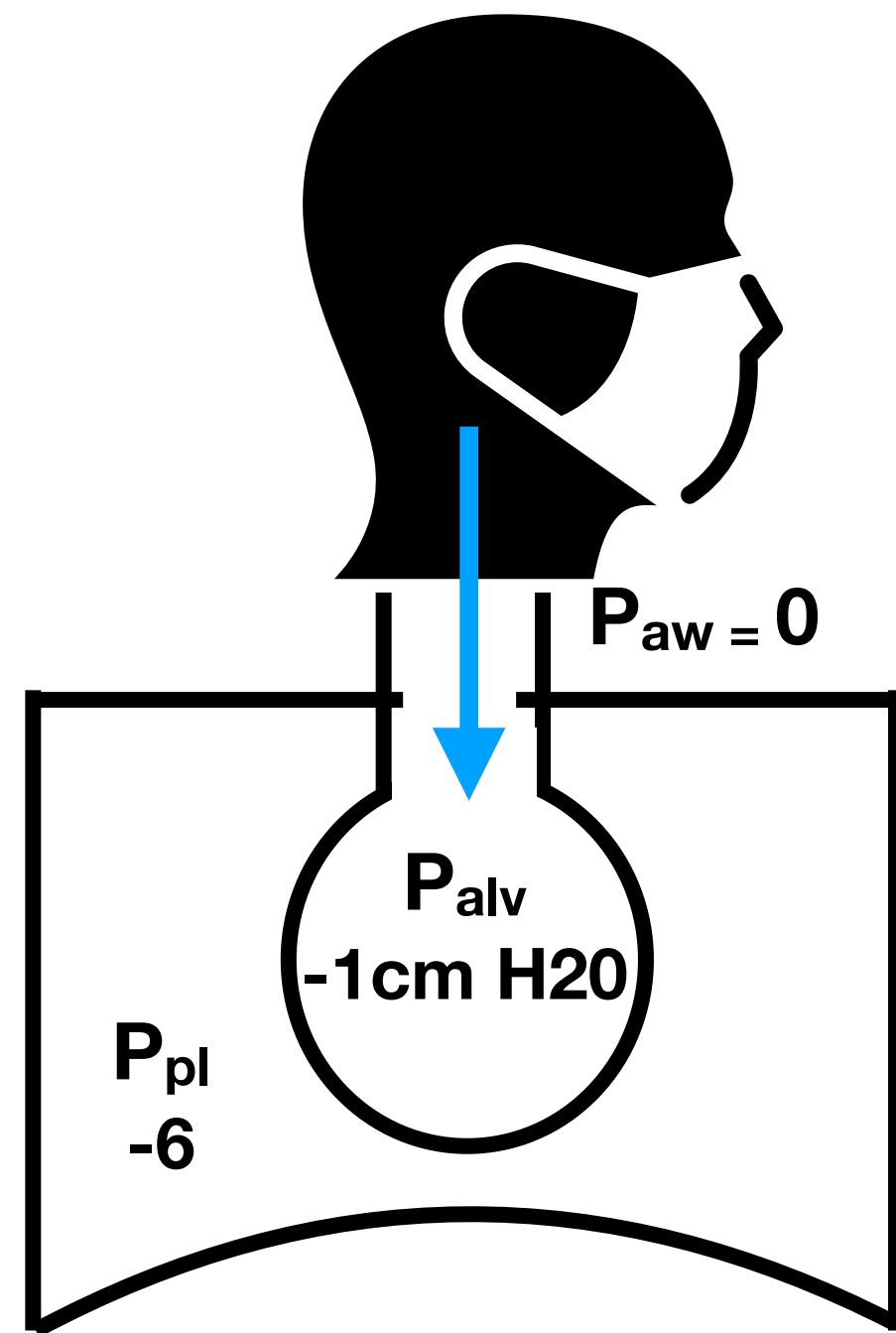
Usual



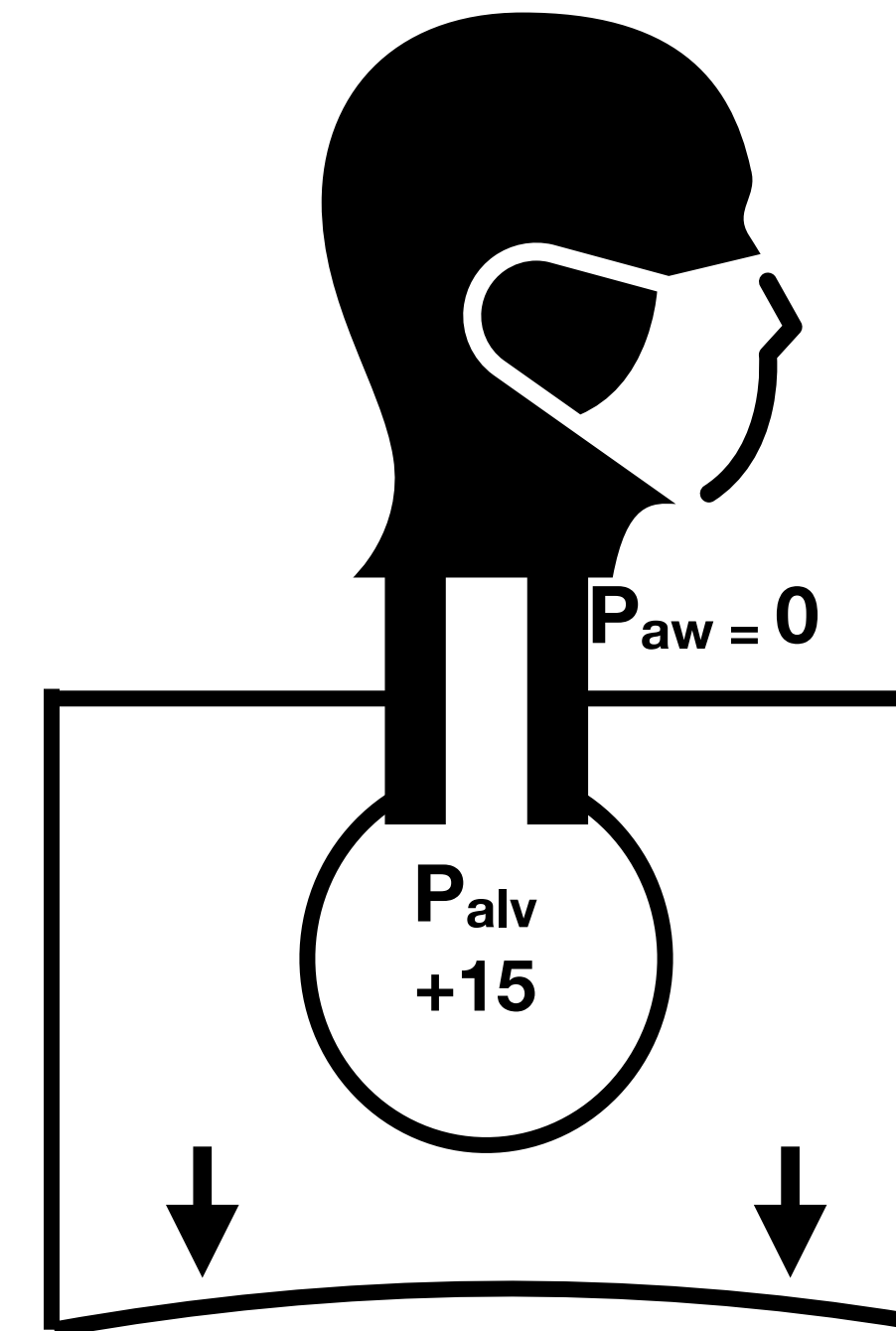
Usual



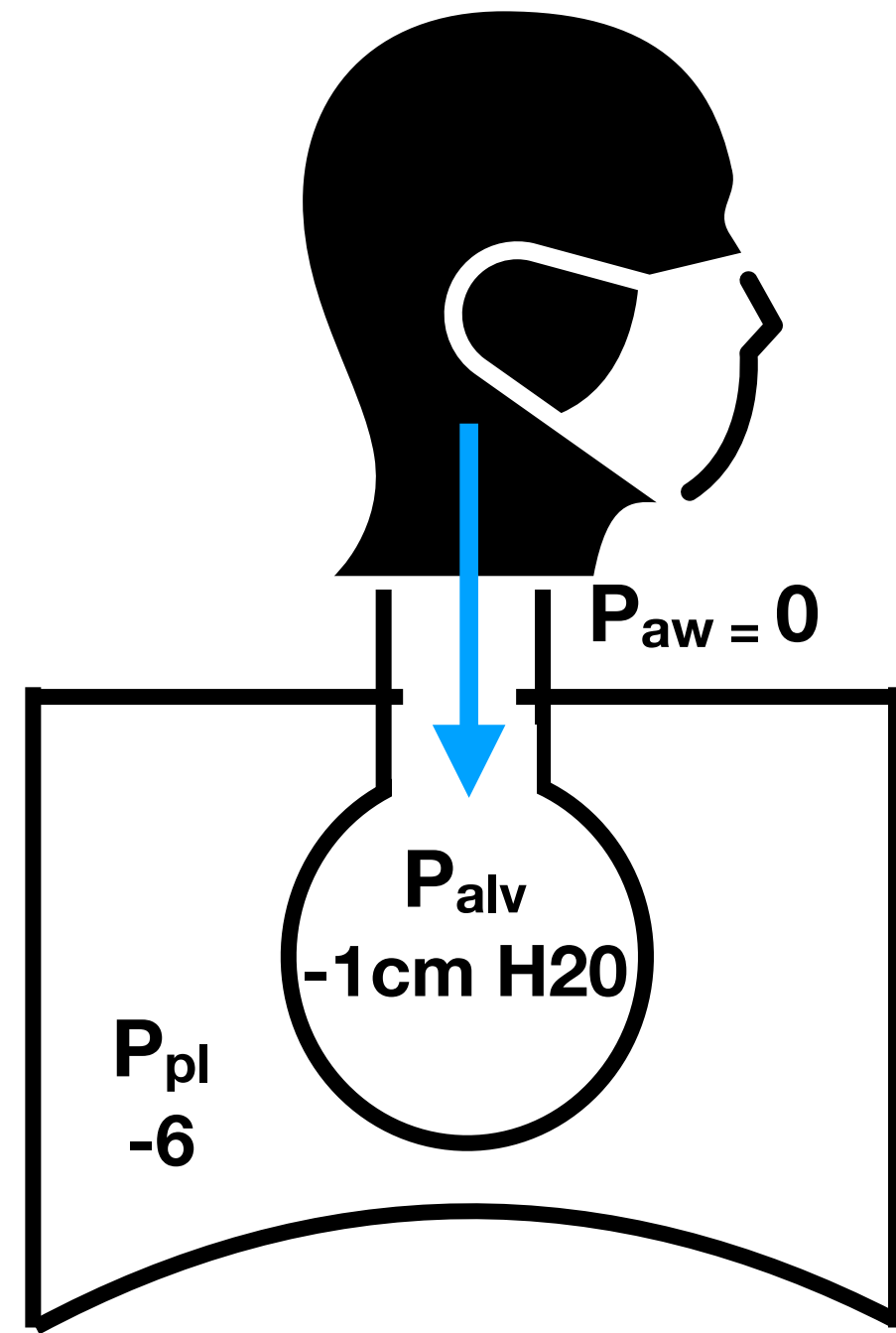
Usual



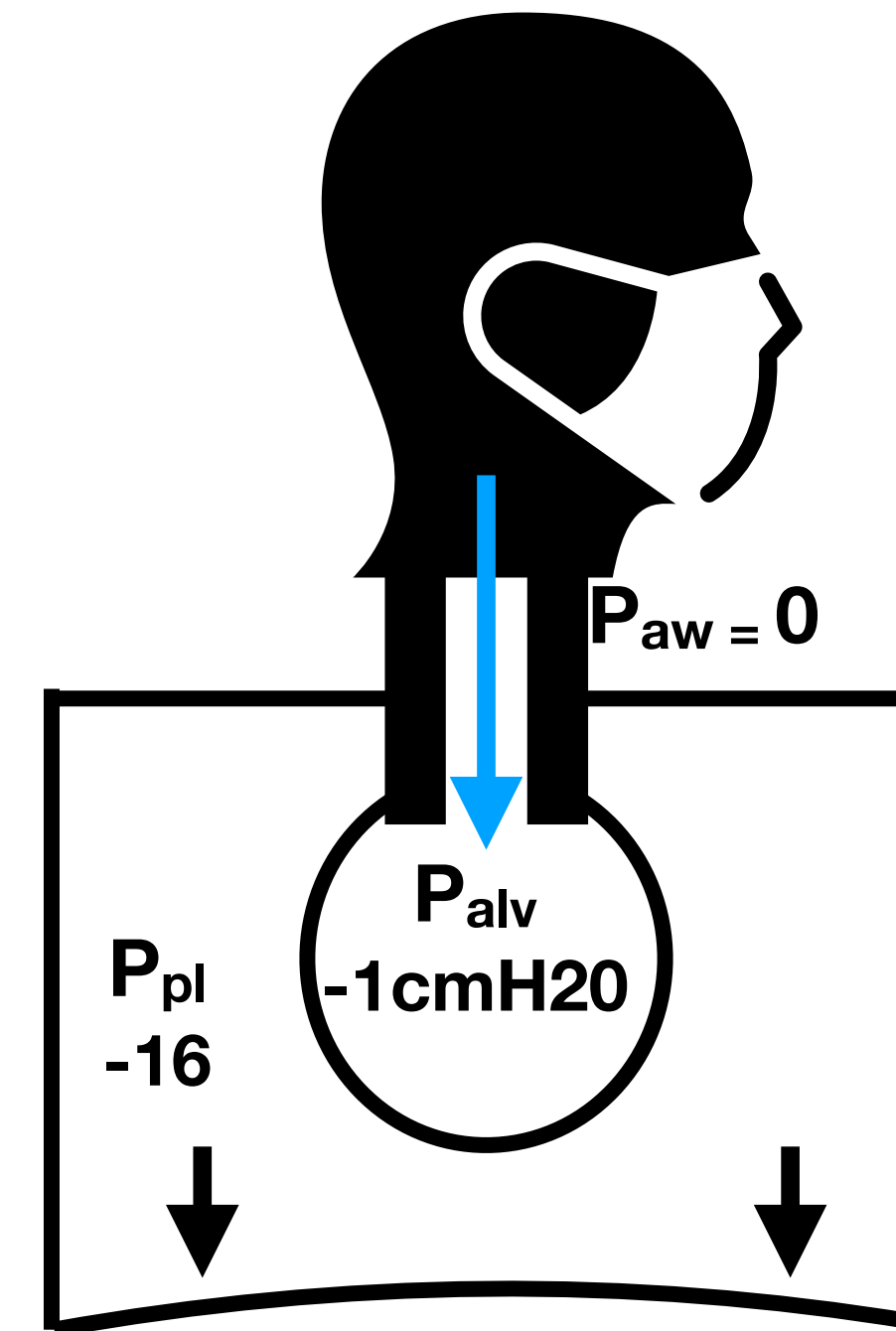
Asthma



Usual



Asthma

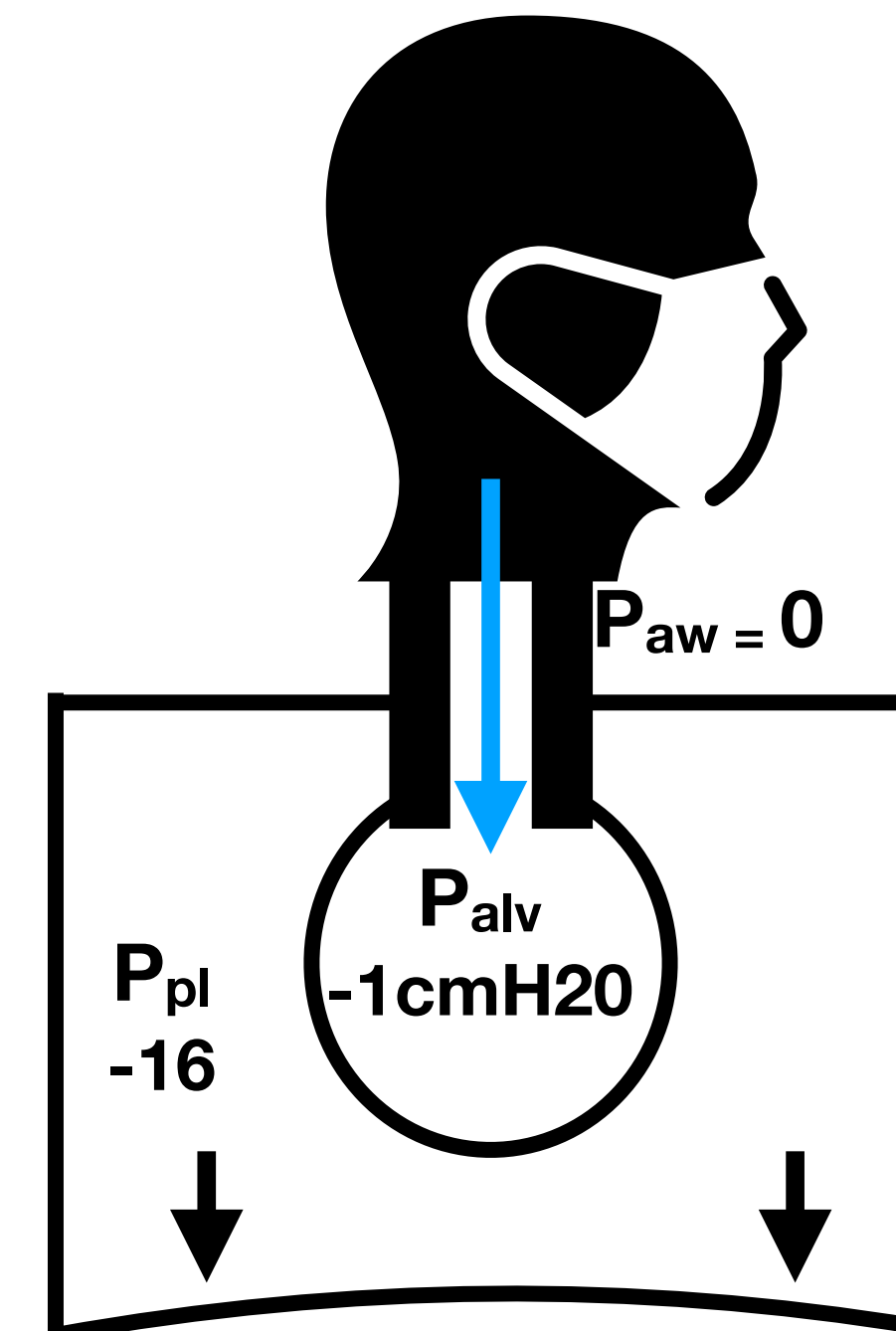


Role for NIV in reducing this work!

- minimize the pressures (both EPAP and IPAP)
- higher risks of air leak
- sedation (more on this later)



Asthma





POSITION STATEMENT

760
Shares



Managing an acute asthma exacerbation in children

Posted: Nov 5, 2021

Considerations

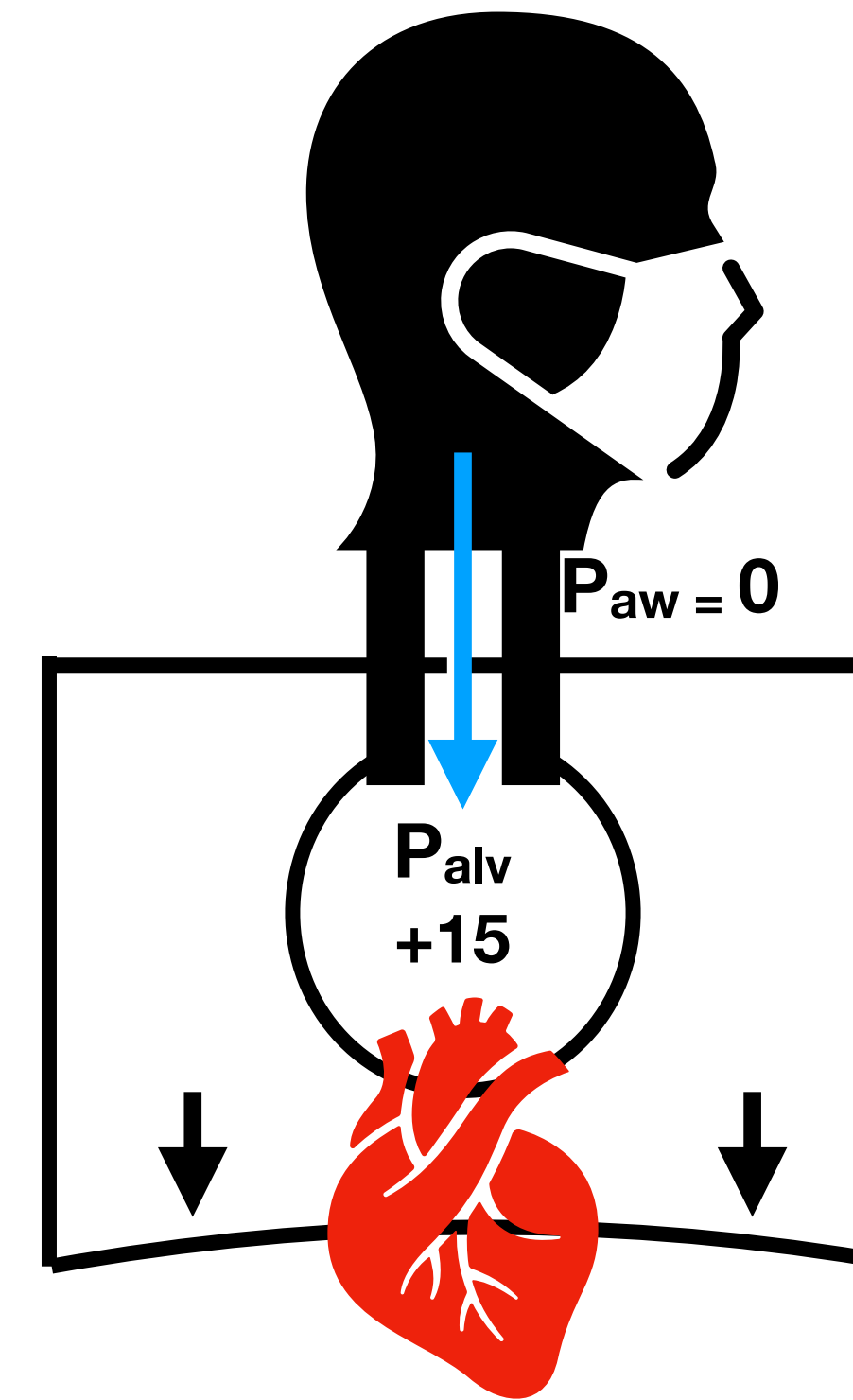
- Interventions for status asthmaticus:
 - MgSO₄ (50mg/kg)
 - Methylpred (1mg/kg q6h)
 - *Nebulized* ventolin (titrate to effect, we will run up to 20mg per hour continuous) and atrovent
 - IV ventolin (starting dose 1mcg/kg/min; NB for older children consider maximum 20mcg/min)
 - aminophylline (load and then infusion)
 - HHFNC or NIV (with Aerogen for nebulization)

Intubation & Asthma

- Pre-existent positive intrathoracic pressure is made even more positive by the change from negative-pressure to positive-pressure ventilation (and the loss of active exhalation)
- This brings a further drop in preload (venous return) and further adds to RV afterload
- Pts with acute asthma exacerbation are also volume-deplete
- Very high risk of cardiac arrest

If compelled to intubate...call a friend!

- Ketamine can be a good adjunct due to bronchodilator properties
- RSI with experienced operator
- may need to actively assist exhalation
- set low rate on ventilator, watch for air-trapping, and focus on hypoxia rather than hypercarbia



Acute Respiratory Distress Syndrome (ARDS)

[Pediatr Crit Care Med.](#) Author manuscript; available in PMC 2017 Jan 22.

PMCID: PMC5253180

Published in final edited form as:

NIHMSID: NIHMS840146

[Pediatr Crit Care Med. 2015 Jun; 16\(5\): 428–439.](#)

PMID: [25647235](#)

doi: [10.1097/PCC.0000000000000350](#)

Pediatric Acute Respiratory Distress Syndrome: Consensus Recommendations From the Pediatric Acute Lung Injury Consensus Conference

The Pediatric Acute Lung Injury Consensus Conference Group

Acute Respiratory Distress Syndrome (ARDS)

Age	Exclude patients with peri-natal related lung disease			
Timing	Within 7 days of known clinical insult			
Origin of Edema	Respiratory failure not fully explained by cardiac failure or fluid overload			
Chest Imaging	Chest imaging findings of new infiltrate(s) consistent with acute pulmonary parenchymal disease			
Oxygenation	Non Invasive mechanical ventilation	Invasive mechanical ventilation		
	PARDS (No severity stratification)	Mild	Moderate	Severe
	Full face-mask bi-level ventilation or CPAP ≥ 5 cm H ₂ O ² PF ratio ≤ 300 SF ratio ≤ 264 ¹	$4 \leq OI < 8$	$8 \leq OI < 16$	$OI \geq 16$
		$5 \leq OSI < 7.5$ ¹	$7.5 \leq OSI < 12.3$ ¹	$OSI \geq 12.3$ ¹
Special Populations				
Cyanotic Heart Disease	Standard Criteria above for age, timing, origin of edema and chest imaging with an acute deterioration in oxygenation not explained by underlying cardiac disease. ³			
Chronic Lung Disease	Standard Criteria above for age, timing, and origin of edema with chest imaging consistent with new infiltrate and acute deterioration in oxygenation from baseline which meet oxygenation criteria above. ³			
Left Ventricular dysfunction	Standard Criteria for age, timing and origin of edema with chest imaging changes consistent with new infiltrate and acute deterioration in oxygenation which meet criteria above not explained by left ventricular dysfunction.			

Acute Respiratory Distress Syndrome (ARDS)

Table 2 Berlin criteria for ARDS

Time	Chest X-ray	Oedema	Oxygenation (with PEEP/CPAP >5 cmH ₂ O)
Acute onset, <1 week before insult	Bilateral opacities (exclude pleural effusions, lung collapse, nodules)	Exclude cardiac failure/fluid overload	Mild: PaO ₂ /FiO ₂ 200–300 Moderate: PaO ₂ /FiO ₂ 100–200 Severe: PaO ₂ /FiO ₂ <100

- Airspace disease: pulmonary edema, inflammatory exudates
- Grunting, tachypnea, WOB
- BIPAP with a higher EPAP setting

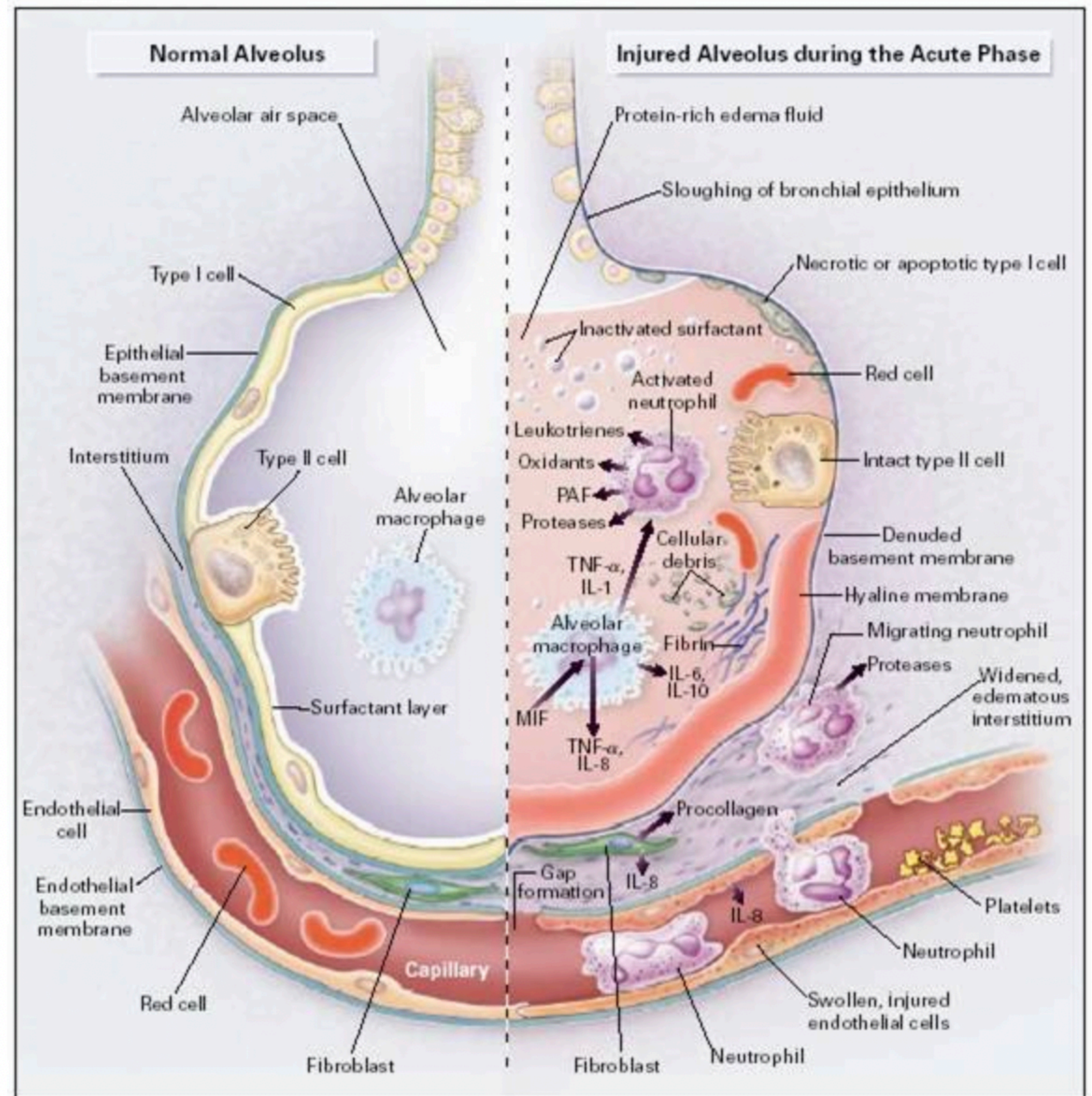


Figure 1: Pathophysiology of ARDS (Ware et al, NEJM 2000)

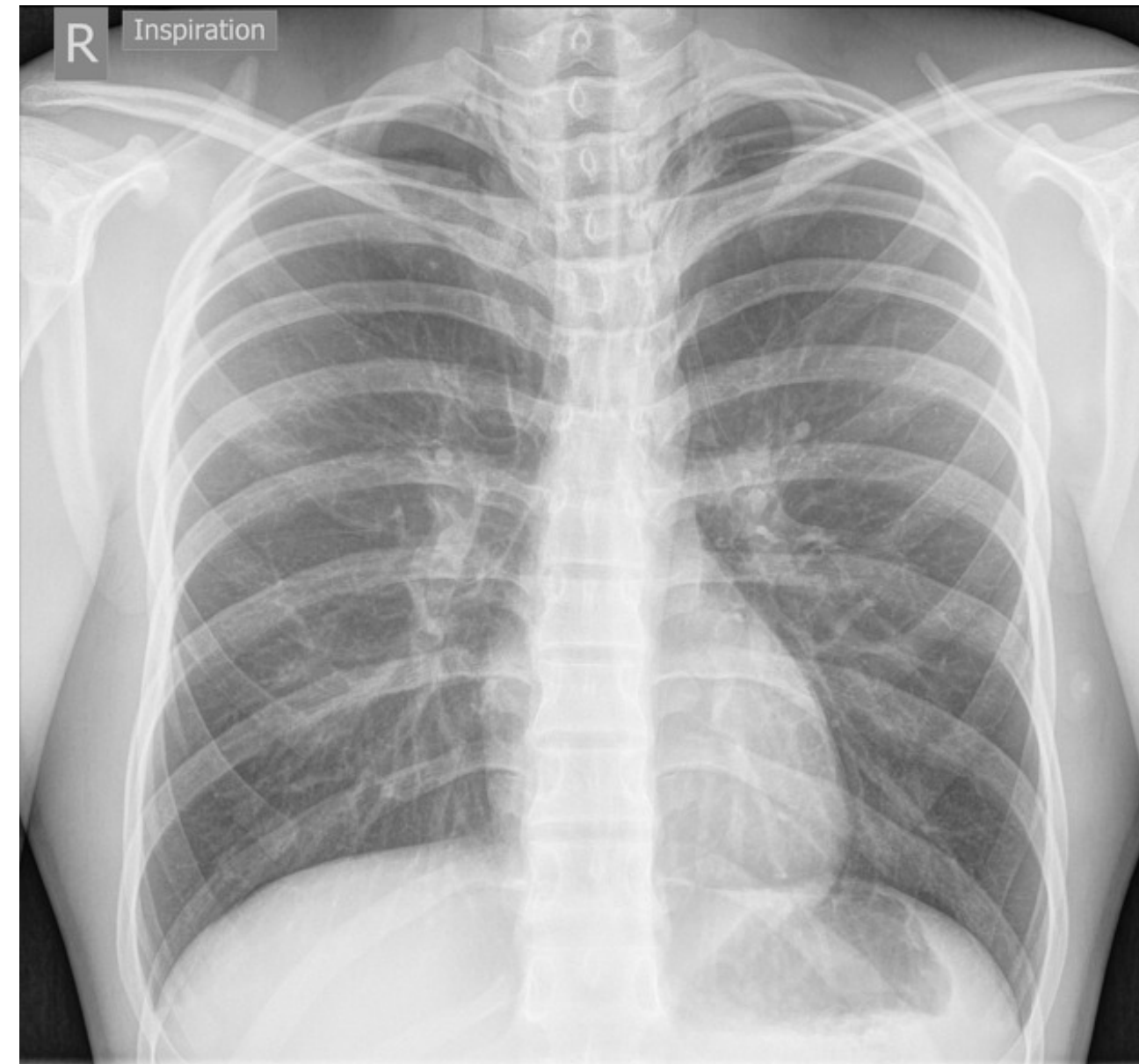
Acute Respiratory Distress Syndrome (ARDS)

- Can sometimes temporize with NIV (especially if rapid transport available) if oxygenation and WOB allow, but generally need intubation
- high-risk intubation:
 - hypoxia +/- volume depletion, combined with change from ++negative pressure ventilation to ++positive pressure ventilation
 - pre-brief, have pre-arrest epinephrine (1:100,000, 0.1ml/kg/dose), volume, assigned roles
- Strategies: iNO (available with ACTS), prone positioning; HFOV, ECMO only in PICU

Investigations: CXR



Bronchiolitis



Asthma



ARDS

Investigations: labs

- Gas (arterial, capillary, venous) is mainstay
- Decision for HHFNC, NIV based largely on clinical signs but gas can help guide this
 - e.g., in child whose baseline sensorium makes it difficult to assess degree of hypercarbia
 - e.g., in distinguishing whether a child needs support with ventilation (bi-level) and/or oxygenation (cpap)
- Close attention to lactate, bicarbonate...metabolic disease (including DKA), septic shock, myocarditis...all can masquerade as or coexist with viral pneumonia
- NB: viral swabs can be ++ helpful in allowing us to cohort patients!

Use of NIV in children: Risks, Contraindications, and Challenges

Risks

- Pneumothorax/pneumomediastinum
- Agitation
- Aspiration
- Hemodynamic instability (to the extent that intrathoracic pressure might be increased further and impact preload)
- (with longer usage): skin injury

Contraindications

- Not absolute: air leak
- Recent upper airway surgery (depending on situation) or upper GI tract surgery (this would be a rare thing, as generally relevant, e.g. in esophageal atresia surgery, during the time when the patient is still in hospital post-op)
- Use with caution in patients with an altered level of consciousness, especially when degree of obtundation compromises airway reflexes such that aspiration risk is ++ high. However, does not need to be perfect, e.g. will often invoke NIV when there is a degree of CO₂ narcosis in pts with asthma

Challenges

- Agitation: judicious management is key, as there are important risks of hypotension and hemodynamic collapse in patients with asthma (volume depletion, diminished preload from positive intrathoracic pressure) or ARDS (hypoxic stress, movement onto NIV brings a degree of positive intrathoracic pressure and preload compromise while worsening RV afterload)...thus making these patients sensitive to agents that lower SVR
- Dexmedetomidine (starting dose 0.5 mcg/kg/hr; avoid if any concern re: bradycardia) and ketamine (titrate to effect in 0.5mg/kg IV boluses) can be helpful adjuncts
- If compelled to use benzodiazepine err on lower end of dosing (e.g. use 0.05mg/kg midazolam instead of 0.1), and be prepared to respond to hypotension with volume

Challenges

- Trouble-shooting the interface: will leave this to Katie!

Key points

- Some patients who traditionally would be transferred we will ask to remain at referral site (or move to alternate community site) where appropriate, e.g. certain DKA patients
- Some patients clearly need acute care transport and likely PICU/CCU disposition, please activate CritiCall for these cases as usual
- Please let me know if any concerns/ideas/feedback and if any particular case is complicated by a delay in transport (especially a delay that is not communicated)
- We can always be reached at 416-813-6486 after the initial CritiCall

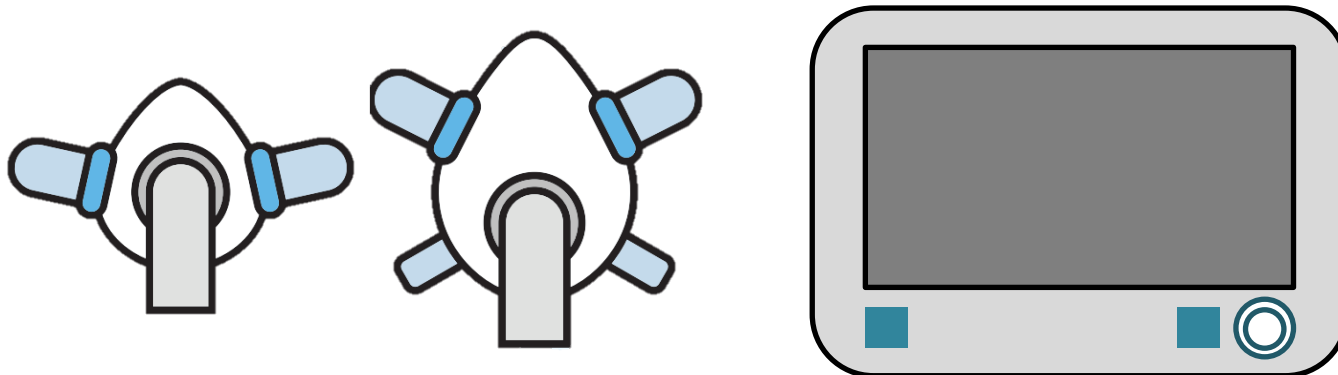
Key points

- For some cases there is a need to transfer due to risk of deterioration, scope of practice at referral site, level of care best met in tertiary centre, but no imminent ICU need...
- CritiCall is overwhelmed by requests to disposition pediatric patients who do not need a critical care bed; work ongoing with Julia et al, but fundamentally would encourage that a bed destination be established (when clearly isn't for PICU/CCU) before activating CritiCall for transport resources, as we currently struggle to solve beds that on the bridge (if tertiary bed, would be via Pediatric Consults through locating 416-813-7500)
- caveat: when in doubt, and when need for ACTS support is urgent, please do not hesitate to activate CritiCall for help. Our philosophy remains “**patient first, bed second**”, and **real-time advice** and team dispatch is always available even when destination bed is unknown! Call us back (direct line is 416-813-6486) if you've been promised a team and haven't heard back an ETA

Thank you!

andrew.helmerts@sickkids.ca

How we approach it: Acute Non-invasive & Mechanical Ventilation in Pediatrics



Katherine Reise, RRT, MScCH
Clinical Educator, CCU
(PICU/CCCU)

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Three Topics I'll try to cover

1

Discuss
Equipment
options in
pediatrics

2

Highlight
challenges we
have with NIV
in pediatrics

3

Offer a
general
approach to
settings &
management



NIV/MV Devices can Likely Support Children-Adults (and maybe smaller)



>20kg and greater
(≈ 6 years old)

> 5 kg
(≈ 1-2 months)

Neonatal: 0.2-30 kg
Pediatric/Adult:
>3 kg/30 cm

Neo 2 - 50 mL
Ped 10 - 350 mL
Adult 100 - 4000 mL

Encourage you to work with your RRT team/clinical support specialists for the devices that you have

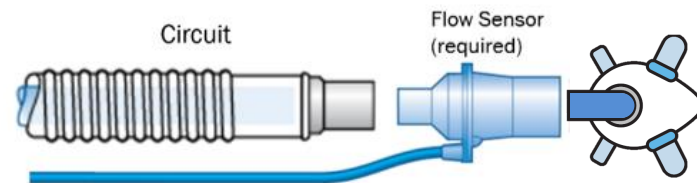


The Department of
Respiratory Therapy

Create a reference for Staff for Set-Up

Configurations for Hamilton Ventilators

Patient Size	Exp. Valve	VTR Patient Category	Circuit Type	Flow Sensor (deadspace)
<10 kg	**Neonatal Valve - Blue	NEONATAL	F-P Neo Circuit	Infant (1.3 mL)
>10 kg	**Adult/Ped Valve - Navy	ADULT/PED	Co-axial Circuit (or other adult)	Adult/Ped (9mL)
For NIV, same recommendations for Hamilton valve, circuit, flow sensor pt. category.				Non-leaking mask (blue connector)

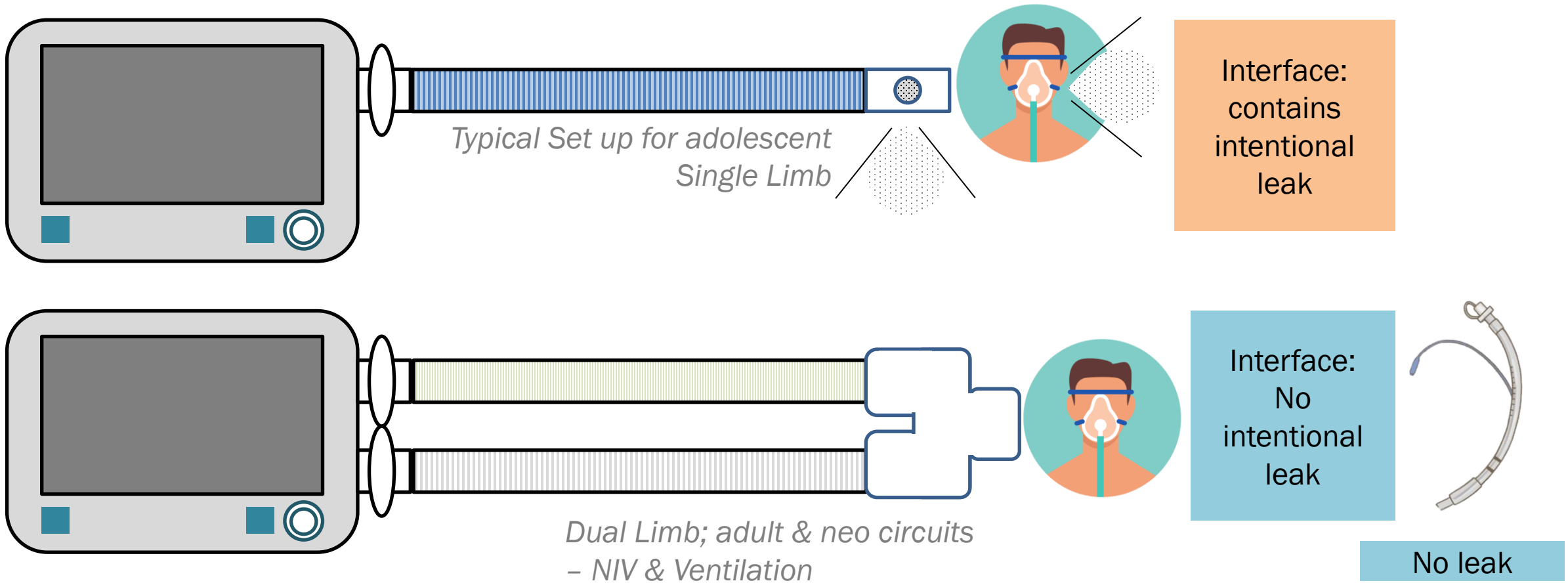


Sample reference for Hamilton T1 use in CCU

- Reduce your cognitive load
- Make it straightforward
- Consider deadspace, ranges, etc.



SickKids uses both NIV single-limb and dual-limb systems; adult and infant/neo interfaces



NIV Mask sizing is always finicky (an RT guesstimate of where mask ranges*)

**Consult product info*



Neonatal prongs/mask



Nasal Masks with Leak (pediatric sizes)



Nasal Masks with Leak (petite adult)

Nasal masks without Leaks (pediatric sizes)

4 kg

10 kg

20 kg

30 kg

Total face mask pediatric XXS/XS



Total face masks (S)



Total face mask pediatric XXS/XS



Total face masks (S)

Full face masks (adult S)

Full face masks (adult S)



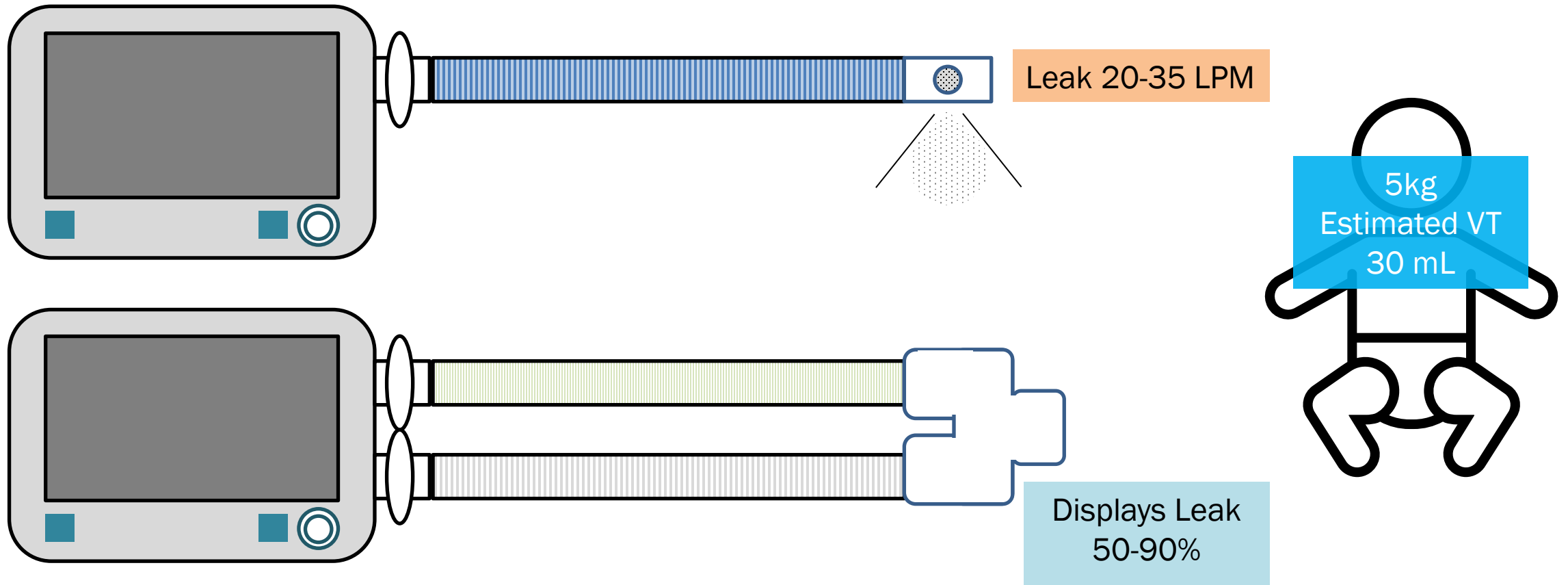
DO not use a nasal adult mask as a full face mask

Images: various sites

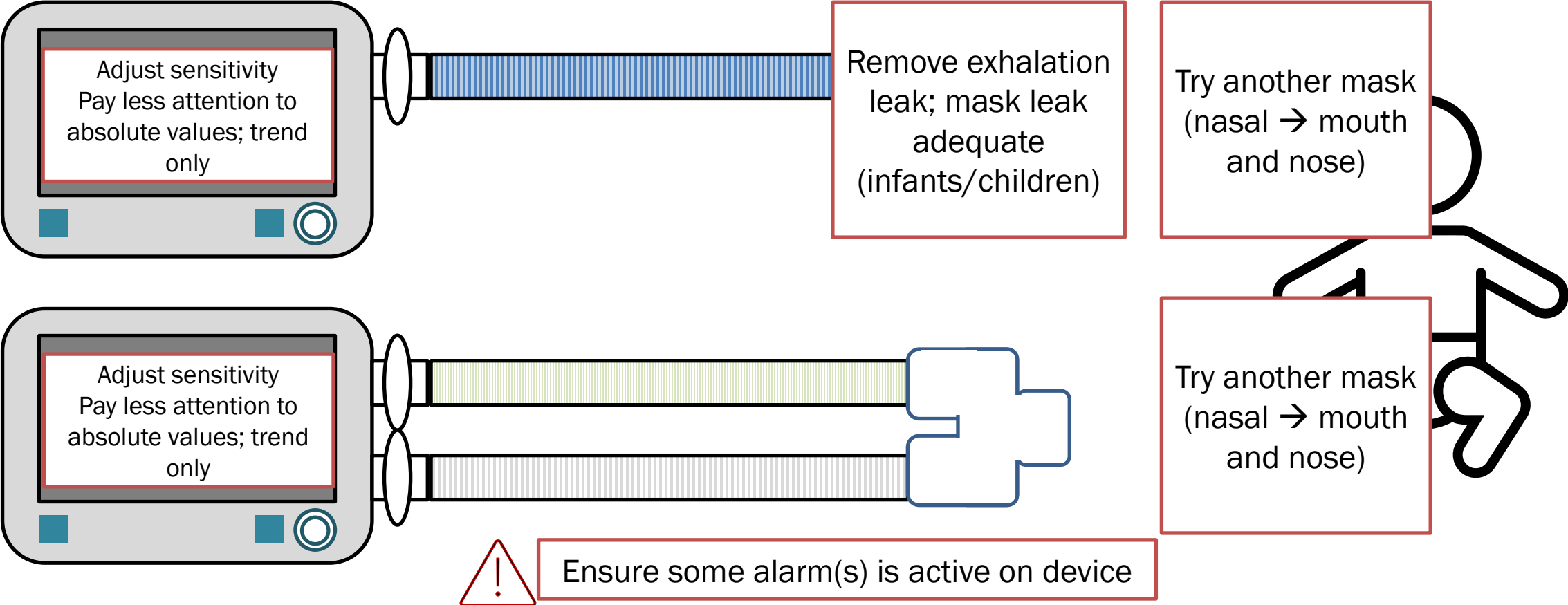


The Department of
Respiratory Therapy

NIV Tidal Volumes/Leak ratio make synchrony challenging in smaller patients



Addressing NIV asynchrony/leak: minimize unnecessary leak, and look at your patient



NIV Compliance/Tolerance Can be Tough



Addressing Patient Comfort

- Prepare and engage parents, child
 - Bundle cares, bundle infants (after stabilization)
 - Provide comforts to toddlers & children (blankets/stuffed animals, parents)
- Start low (5cmH₂O); work up on settings
- **NG/OG to vent the stomach**
- Consider patient tolerance/risk – is HFNC adequate?



Consider if maximizing HFNC is an option, given NIV challenges

Figure 1. Initiation of HHFNC

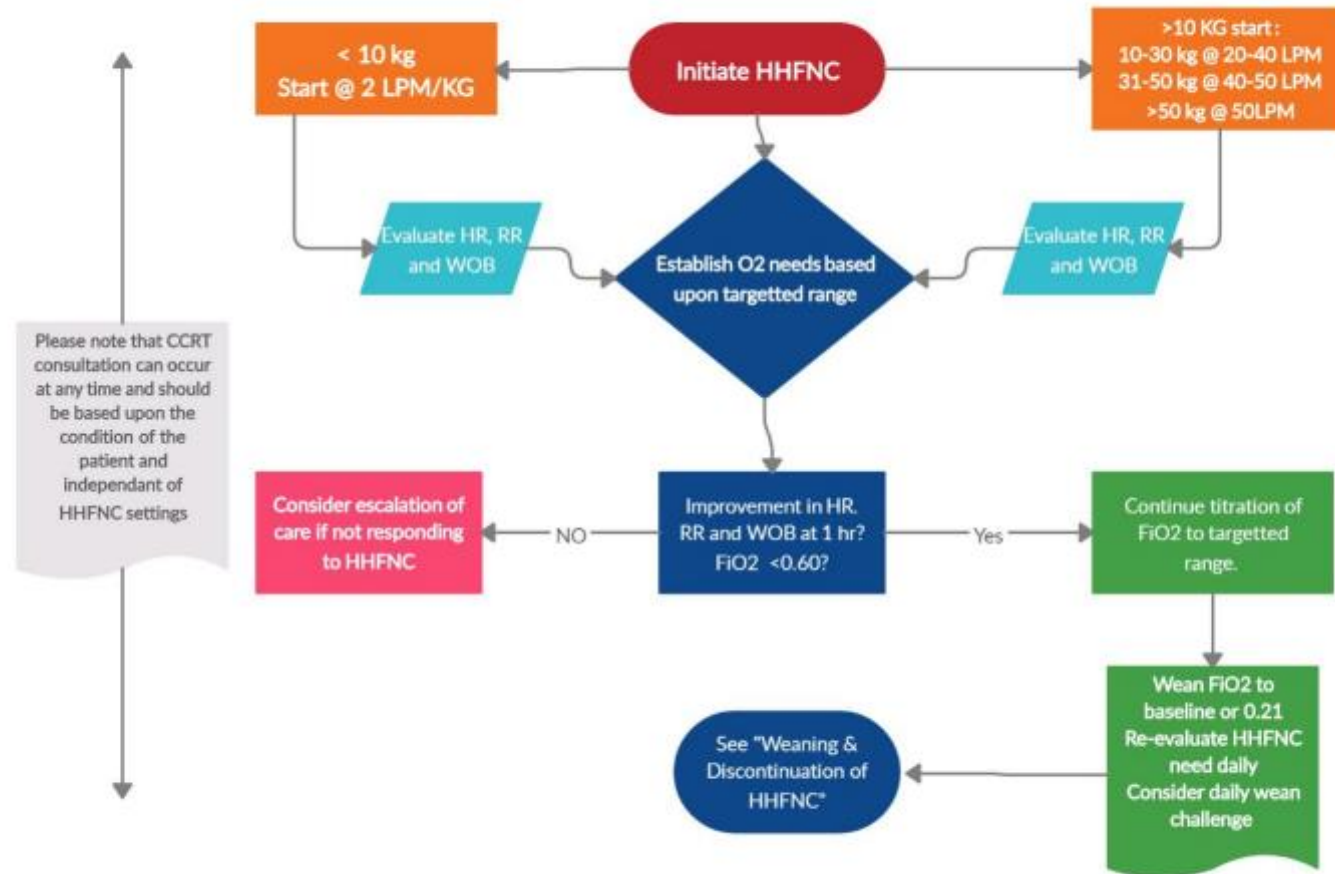


Table 3

Applied nasal high-flow rates

Weight	High-flow rates
0–12 kg	2 L/kg/min Max 25 L/min
13–15 kg	30 L/min
16–30 kg	35 L/min
31–50 kg	40 L/min
>50 kg	50 L/min

PARIS 2 protocol initiation flowrates



Trial of >2LPM/kg is acceptable, assess tolerance and patient comfort.



Choosing acute NIV settings: Mode

- Consult CritiCall Ontario for assistance and guidance

	Favours CPAP	Favours BiLevel (S/T, NIV, NIV-PC)
HFNC	Smallest Infants (<5 kg)	Children and Adolescents
	Too much asynchrony	Good triggering possible
	Normal CO ₂	Hypercapnia
	Exclusive oxygenation challenges	Hypercapnia + oxygenation challenges
	--	Neuromuscular Weakness
	--	Significant Respiratory Distress/WOB
	Device Limitations (i.e. CPAP only)	--
	Apnea primary concern (in small infant)	--

Limited use of Asynchronous BiLevel

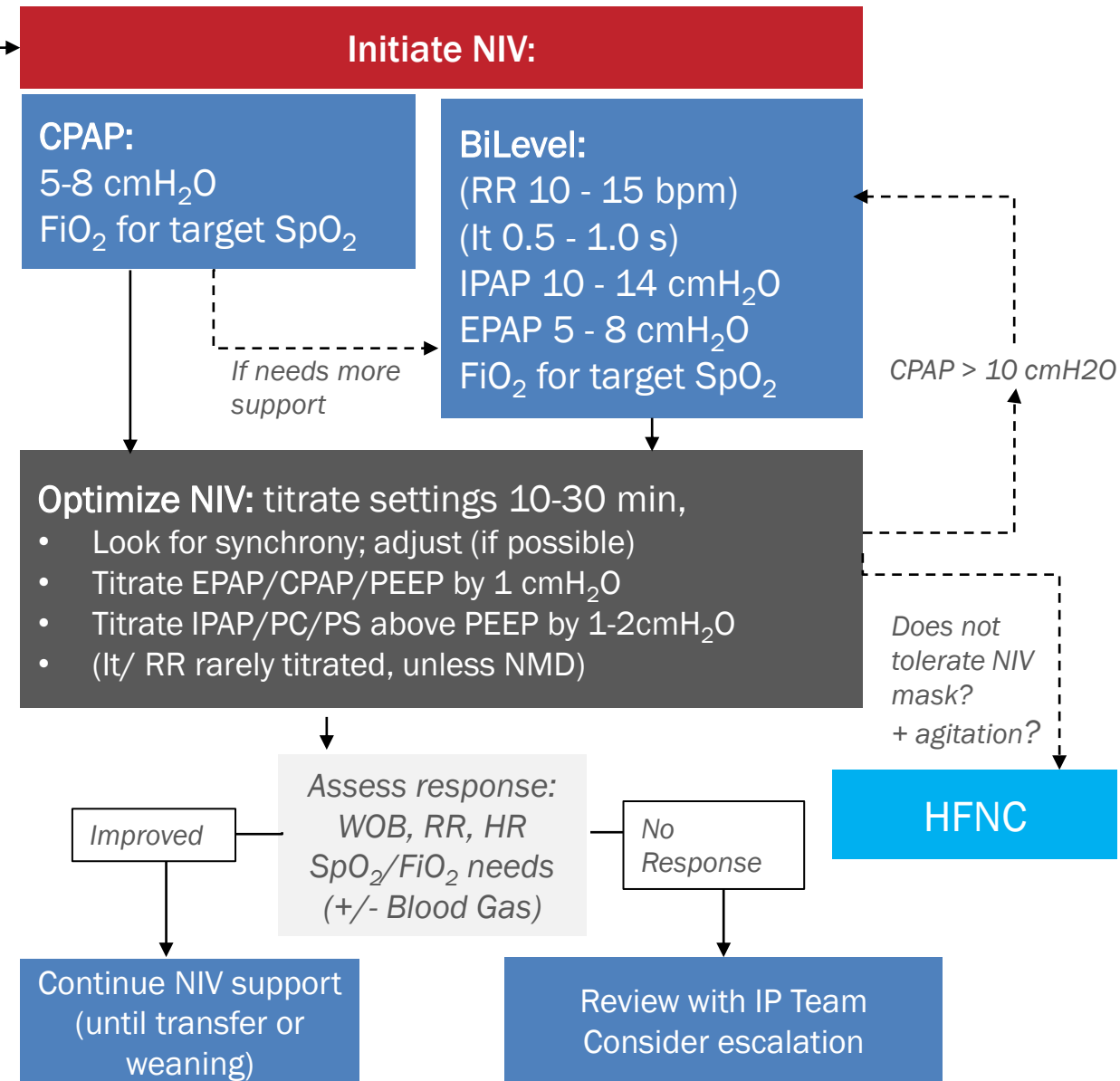


Is Acute NIV appropriate?

- 1) Is NIV indicated and no contraindications?
- 2) NIV is only supportive: has the appropriate medical therapy been provided?
- 3) Are appropriate consultations to CritiCall Ontario occurring/started?
- 4) Has a medical order and discussion of settings occurred?

Are you ready to start?

- 1) Is the patient in a safe, monitored clinical environment? (if no, is transfer happening to this area?)
- 2) Has NIV been explained to the child and family or caregiver?
- 3) Is there an understanding of next steps should it fail?
- 4) Have you gathered the right equipment options (mask, device)?



Ongoing therapy – Maintaining

- Skin assessment q4h (off)

- Humidity for all patients long-term

Hourly visual assessments	Every 4-6 hours timed with handling
P: Patient positioned to prevent pressure on face	Skin assessment
I: Interface in proper position and is neither too tight or too loose	Skin integrity score
N: Nares are not obstructed by protective barrier	Gentle massage
C: Circuit is not causing traction on the interface	Alternate between mask and prongs for all patients < 2kg
H: Hat in recommended position	

NICU Skin integrity Quality initiative



Example of mask too tight; early injury



Humidifier on infant nCPAP

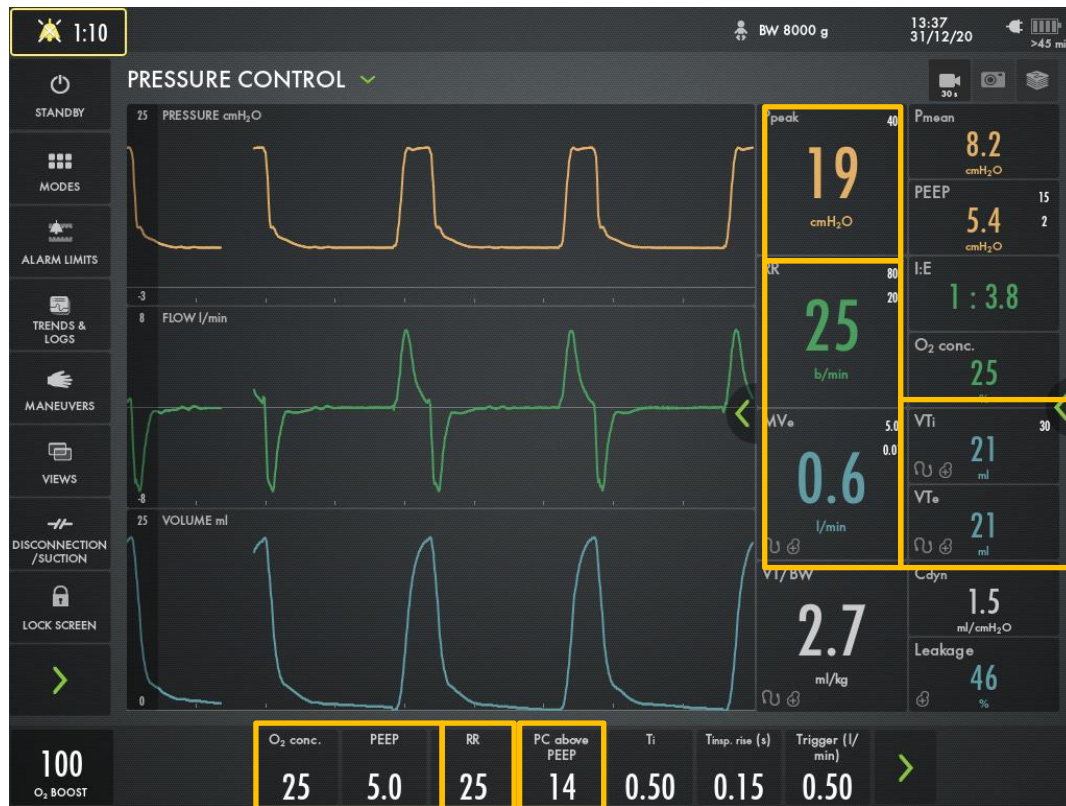


So it happened... you need to intubate



Setting a ventilator: talk through with the RT

- Two common options to inflate the lungs: Pressure or Volume



1. Are you able to achieve adequate tidal volumes?
2. Is ventilation okay?
3. Is the Peak pressure or P_{plat} below 28 cmH₂O
4. Are you having any challenges oxygenating?



Common Ventilation Settings

- For pediatrics, use either Braslow, or absolute weight for calculation
 - If you don't have any of these $kg = (Age \times 2) + 8$
- Target tidal volumes 6-8mL/kg; move to 4-6 mL/kg if lung protective strategies necessary
 - PC > 16-18cmH₂O
 - Pplat <28 cmH₂O
- RR & It for age
- Max PEEP ranges differ
 - Principle: recruitment

Age	RRset	Inspiratory Time	PEEP range* (*assess individually)
Term Neonate/Infant (0-<1 month)	25 - 40	0.35 - 0.5	5 - 10
Infant (1m-<12 m)	20 - 35	0.5 - 0.7	5 - 10
Toddler-Small Child (1-6 year)	18 - 30	0.6 - 0.8	5 - 12
Older Child (>6y-12 y)	15 - 30	0.6 - 0.9	5 - 14
Adolescent (>12 y)	12 - 30	0.7 - 1.0	5 - 18



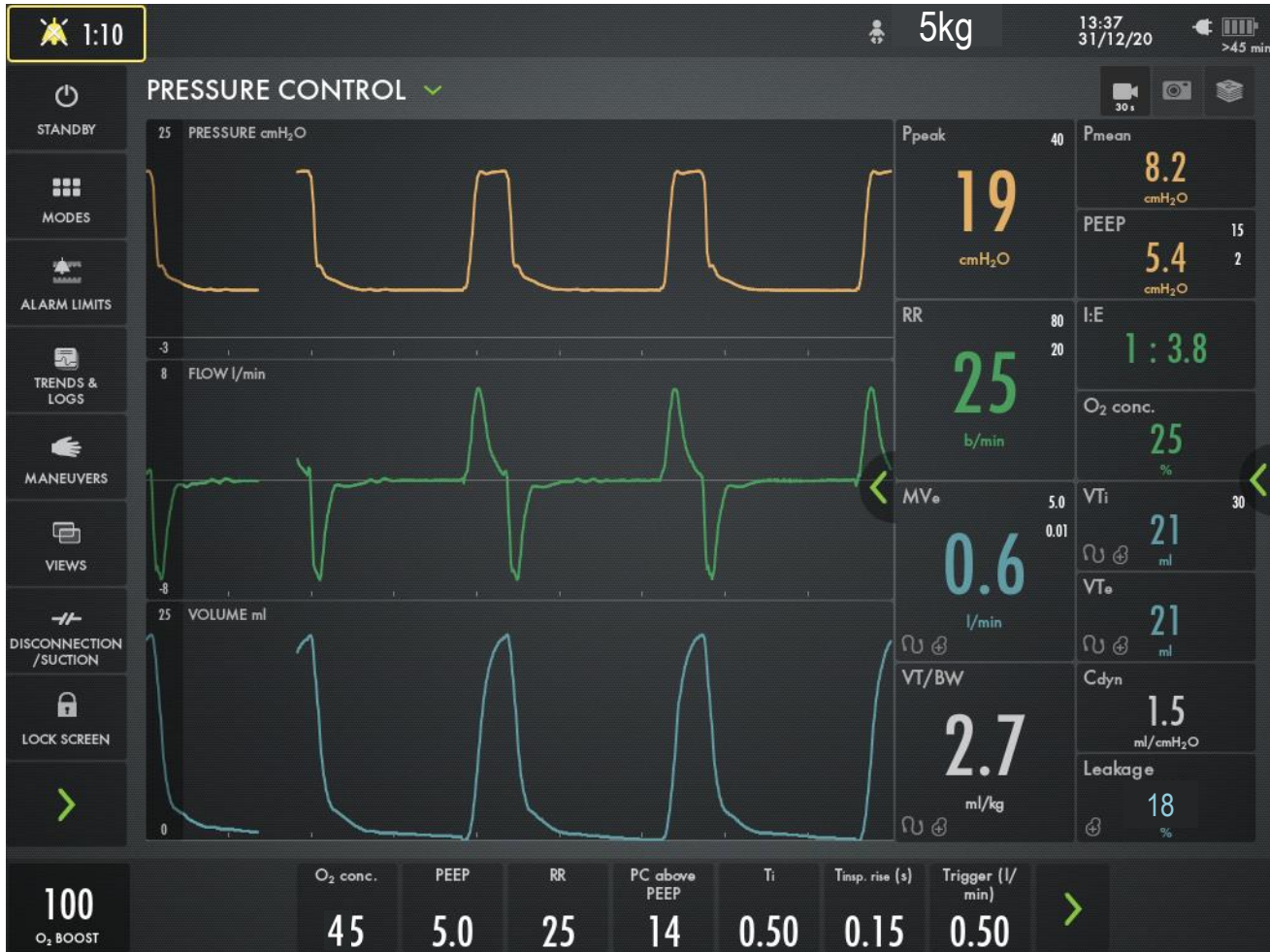
Mode Selection

- We use a lot of SIMV PC/PS (culture, not necessarily needed)
- Most ventilation in adults is PCV/VCV or PSV

Condition	Rationale for Mode
<i>Neurological concerns for raised ICP</i>	<i>Typically, volume-targeted ventilation (PRVC, VCV) to provide consistent minute ventilation and more consistent PaCO₂</i>
<i>Asthma</i>	<i>Volume-targeted (VCV), watching Pplateau and to avoid overdistension if resistance suddenly changes</i>
<i>Large leak</i>	<i>Pressure ventilation (PCV), look for chest rise and appreciate that tidal volumes (inspiratory versus expiratory).</i>
<i>Awake, spontaneously breathing</i>	<i>Pressure support ventilation (PSV), as tolerated</i>



The Bronchiolitis Patient in ER (5kg)



- Tried HFNC, Apneic, hypoxic bronchiolitis (4m, 5 kg)
- Intubated with a #3.5 ETT
- Post-intubation, sedated
- iSTAT/CBG:
 - 7.23/62/52/23/-2
 - SPO2 98%; EtCO2 54mmHg



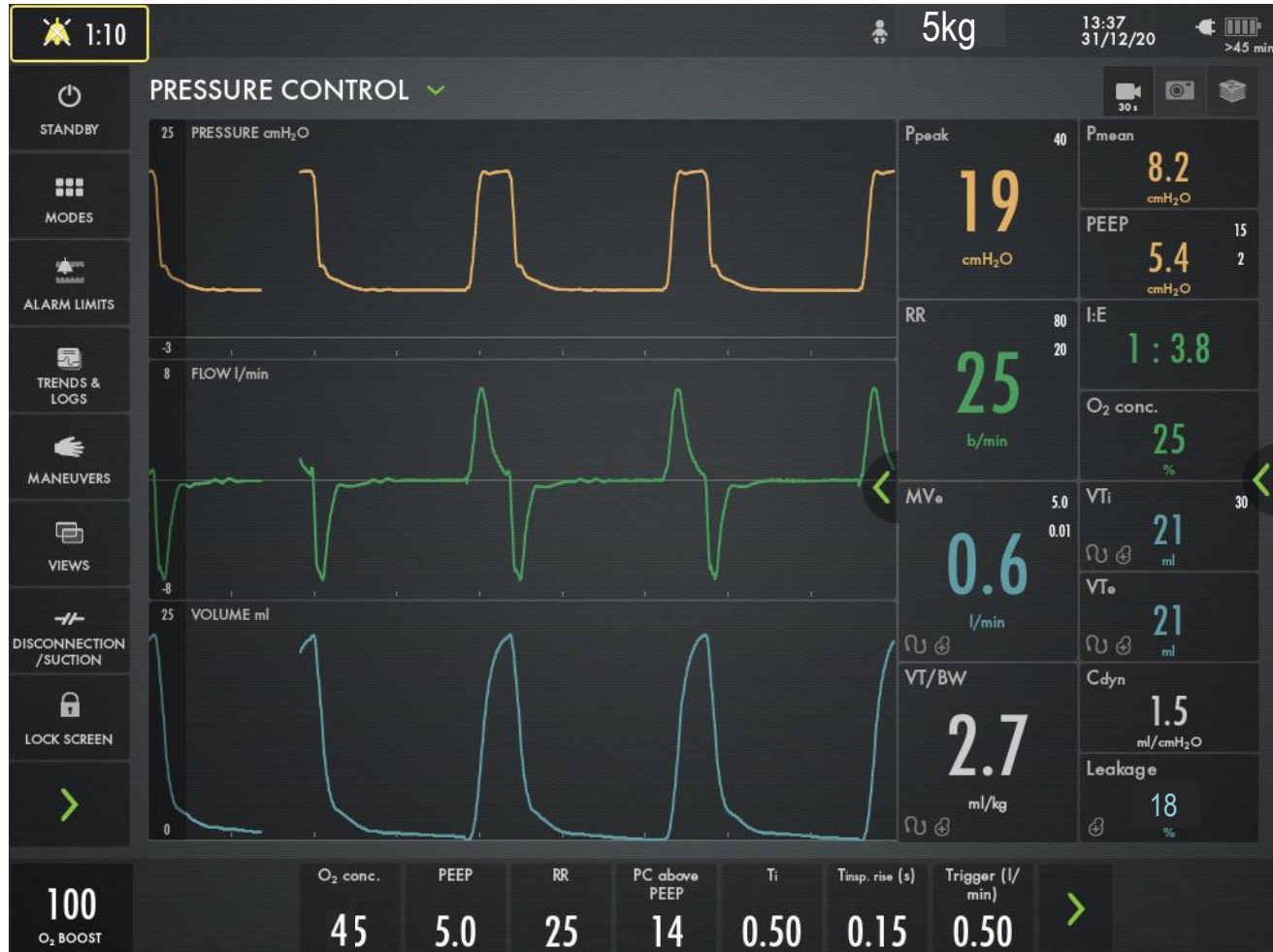
The Bronchiolitis Patient in ER (5kg)



1. Are you able to achieve adequate tidal volumes?
 - 21mL/5kg = 4 mL/kg
2. Is ventilation okay?
 - 7.23/62/52/23/-2
1. Is the Peak pressure or Pplat below 28 cmH₂O
 - 19 cmH₂O
2. Are you having any challenges oxygenating?
 - SpO₂ 98%



The Bronchiolitis Patient in ER (5kg)

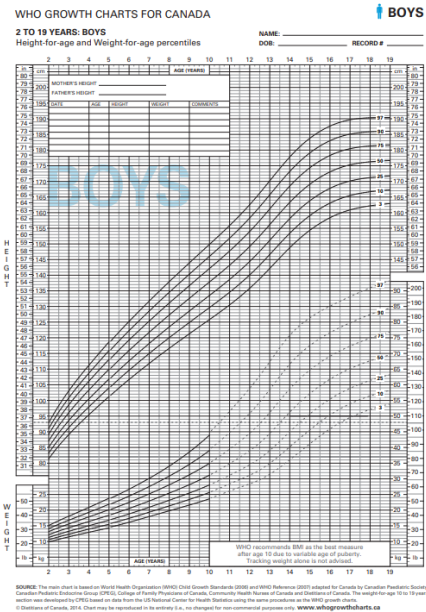


- Tried HFNC, Apneic, hypoxic bronchiolitis (4m, 5 kg)
 - 7.23/62/52/23/-2
 - SpO₂ 98%
- Okay, but not optimized.
 - Increase RR 28-30
 - VT low end, could increase
 - Blood gas not ideal, but not bad, no compensation



Adolescents and NIV/MV

Approaches would be the same as adult patients.



In summary

1

Use the equipment you'll be familiar with; talk with your RTs about options

2

Mask fit, Leak/Synchrony, Compliance are all challenges in NIV for pediatrics

3

CPAP & BiLevel Used, Titrate to response (WOB/RR/SpO₂)

4

Both CritiCall & RRTs will be able to support you with MV



- Open Pediatrics: Ventilator Simulator





Online evaluation form will be sent after the session or scan the QR Code to complete now.

We appreciate your feedback.

<https://skconnect.typeform.com/to/jmP9E8IZ>

