



Evidence-based Practice for Improving Quality

Strategies to reduce the rate of pneumothorax associated with CPAP failure and mechanical ventilation in preterm infants:

A Quality Improvement project



Hôpital général juif
Jewish General Hospital

*Centre intégré
universitaire de santé
et de services sociaux
du Centre-Ouest-
de-l'Île-de-Montréal*

Québec 

Dr Julie Bartholomew

JGH Target Morbidities

Pneumothorax in preterm infants



Pneumothorax in Preterm Infants

- Summer of 2019, we noted a cluster of 9 neonates developed one or more pneumothoraces
- A task force was created: 2 nurses, 2 RTs, 2 neonatologists in addition to the Head nurse and Head RT
- Each case was reviewed very carefully:
 - Management of each patient (orders, medications, xrays)
 - Complications associated with the pneumothorax
 - Nursing management, respiratory therapy management (especially around surfactant administration),
 - Surfactant lots and asked the company to evaluate,
 - Geographical location of the babies and equipment malfunction
 - How did trainees fit into these events

Pneumothorax in Preterm Infants

- This is a feared complication in preterm infants
- It is associated with higher rates of severe IVH, BPD and even death^{1,2}
- Despite quality initiatives³ and less aggressive ventilation strategies⁴, Incidence is 4% in preterm infants and unchanged^{5,6}

2019 Pneumothorax cases

GA	Age/ PNX	CPAP failure?	Excessive WOB?	# BLES	Outborn	Peak Pressure/ mode	IVH	BLES down 1 lung	death
31	42 hrs	yes	?	2	yes	31 on AC/VG	normal		
29+4	27 hrs	yes	yes	1	n	22 on AC/VG	B/L grade III		
25	30 hrs	no	no	4	yes	26 on AC/VG	left grade III	y	
27	12 hrs	yes	yes	2	n	32 on AC/VG	B/L grade III		
25	72 hrs	no	no	3	n	MAP 13 HFOV	normal	y	22 days /NEC
28+4	60 hrs	yes	yes	2	n	26 AC/VG	normal		
30+2	30 hrs	yes	yes	1	n	PNX while on CPAP	left grade I-II		
23+3	48 hrs	no	no	2	n	MAP 11 on HFOV	B/L grade II		
23+3	72 hrs	no	no	3	n	MAP 12 on HFOV	R grade IV, L grade II		Palliation

Pneumothorax in Preterm Infants

9 cases of Pneumothorax in < 31 weeks

1. More than 1 dose of surfactant in most cases
2. Peak Pressures were high on ventilator after surfactant and prior to the PNx
3. Some continued on AC/VG after the diagnosis of a PNx without a trial of HFOV
4. Several cases of CPAP/NIPPV failure and excessive WOB documented before the PNx
5. A few babies got BLES down one lung because Xray was delayed

- EPIQ Target: Reduce rates of Pneumothorax in Preterm Infants

1-Bundle of care was introduced for those placed on CPAP initially for <31 weeks:

- Indication: Maximum of CPAP 6, fio2 35-45%
- May not use NIPPV to provide higher MAP
- Introduction of the Silverman score⁷⁻⁹ as an independent indication for intubation and surfactant if patient has RDS and is < 31 weeks:
 - Score of 5 → patient's WOB must improve within 4 hours
 - Score of 6 → patient's WOB must improve within 1 hour
 - Score of 7+ → intubate + Surfactant

UPPER CHEST MOVEMENT LOWER CHEST RETRACTIONS XIPHOID RETRACTIONS NARES DILATATION EXPIRATORY GRUNT

♂
NORMAL

GRADE 0



SYNCHRONIZED NONE NONE NONE NONE

GRADE 1



LAG ON INSPIRATION JUST VISIBLE JUST VISIBLE JUST VISIBLE HEARD WITH STETHOSCOPE

GRADE 2



SEE-SAW EASILY SEEN EASILY SEEN EASILY SEEN HEARD BY EAR

INSPIRATORY EXPIRATORY



+ + + + =

Pneumothorax in Preterm Infants

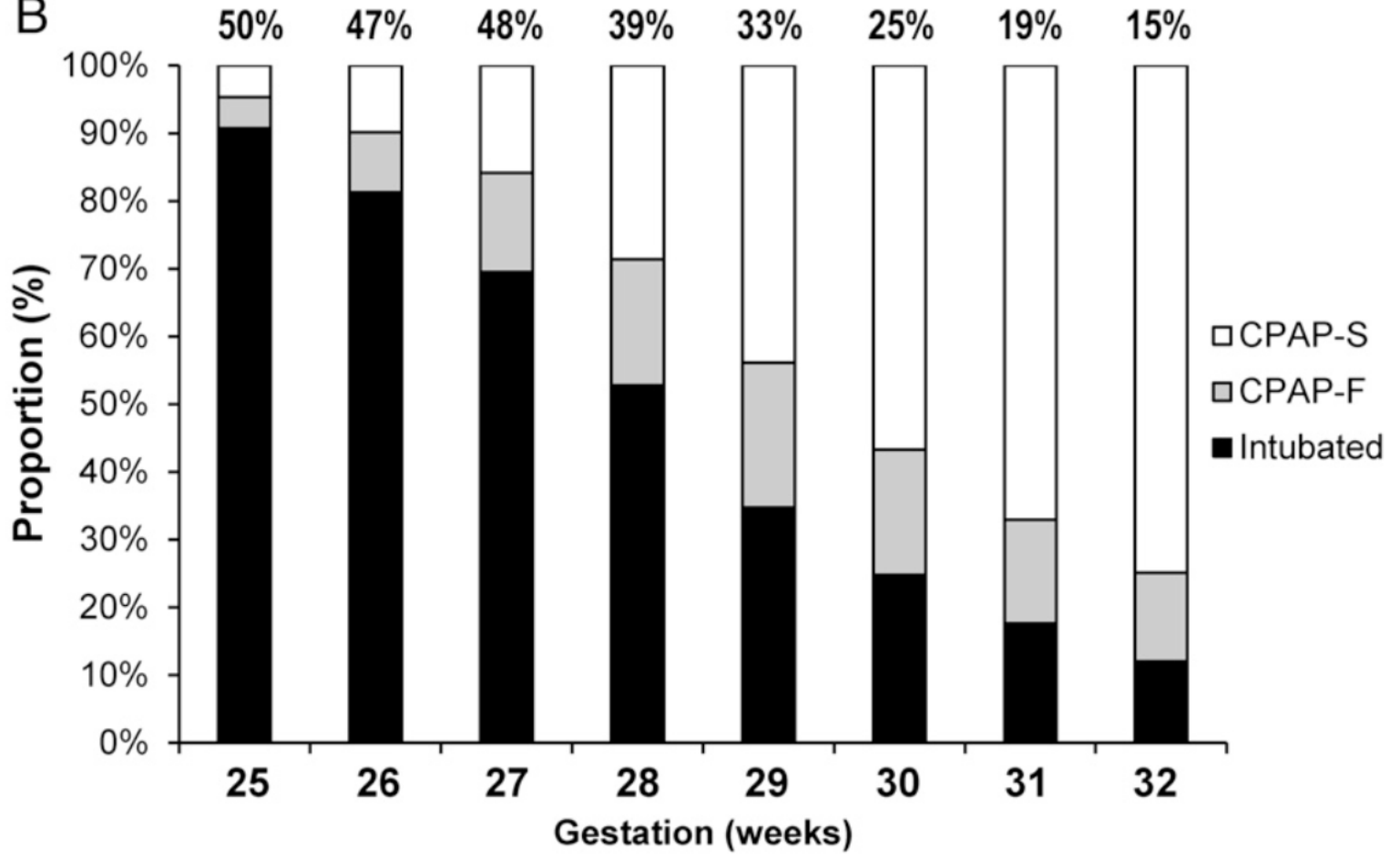
Bundle of care part 1:

<31 weeks placed on CPAP at birth

Goal: Identify CPAP failure earlier

- Many studies show that neonates who are managed on CPAP do better than those who are intubated¹⁰⁻¹²
- CPAP has become an important tool in the stabilization process¹³
- Of concern, many will experience **CPAP failure**¹⁴ which is strongly associated with pneumothorax^{15,16}

B



Pneumothorax in Preterm Infants

Bundle of care part 1:

<31 weeks placed on CPAP at birth

Goal: Identify CPAP failure earlier

- Patients with CPAP failure are intubated at a median time of 4-6 hours¹⁵:
 - Our patient population was intubated later (10-24 hours)
- Introduction of the Silverman Score:
 - Observation of intubating a few babies who were in CPAP 6 21-25% but had significant WOB and xrays confirming RDS
 - I am currently reviewing our patient population before and after to see if we are just identifying CPAP failure earlier and or if we are having more CPAP failure
 - We introduced the Seattle-PAP to our unit which is associated with significantly less WOB when compared standard BCPAP or ventilator CPAP^{17,18}

EPIQ Target: Reduce rates of Pneumothorax in Preterm Infants

2- Bundle of care for patients who are intubated and given surfactant:

Goal:

 **Volutrauma and Barotrauma post surfactant**¹⁹⁻²¹

1. Max PIP must be prescribed along with other parameters (20 for < 1000 g and 25 for > 1000g). If peak pressures surpass, change to HFOV
2. After surfactant, decrease TV to 4 ml/kg
3. For subsequent doses of surfactant, strongly recommend a discussion between 2 neonatologists
4. The golden hour must be a priority

EPIQ Target: Reduce rates of Pneumothorax in Preterm Infants

2- Bundle of care for patients who are intubated and given surfactant:

Goal:

 **Volutrauma and Barotrauma post surfactant**¹⁹⁻²¹

- Observation: We had not been prescribing PIP max in the past but following the review of cases, setting the PIP max really helped identify neonates who needed closer attention and those who may benefit from HFOV

EPIQ Target: Reduce rates of Pneumothorax
in Preterm Infants

Results:

After 16 months
of
implementation



2020 Pneumothorax cases

GA	Dol of PNX	CPAP failure?	Excessive WOB?	#BLES	Outborn	Peak Pressures	IVH	BLES down 1 lung	death
27+4	30 hrs	yes	no	2	n	AC/VG	normal		

What did we learn with this exercise?

- CPAP is a great alternative to stabilize premature infants but we should make every effort to recognize **CPAP Failure quickly**
- Volume Guarantee is a great way to manage intubated babies but **1 size does not fit all** and these fragile babies need close monitoring after surfactant
- Caution when giving surfactant (subsequent doses, ETT placement)

1. Linder N, Haskin O, Levit O, et al. Risk factors for intraventricular hemorrhage in very low birth weight premature infants: a retrospective case-control study. *Pediatrics* 2003;111:e590-5.
2. Bhatia R, Davis PG, Doyle LW, Wong C, Morley CJ. Identification of pneumothorax in very preterm infants. *J Pediatr* 2011;159:115-20.e1.
3. Walker MW, Shoemaker M, Riddle K, Crane MM, Clark R. Clinical process improvement: reduction of pneumothorax and mortality in high-risk preterm infants. *J Perinatol* 2002;22:641-5.
4. Sahni R, Schiaratura M, Polin RA. Strategies for the prevention of continuous positive airway pressure failure. *Semin Fetal Neonatal Med* 2016;21:196-203.
5. Duong HH, Mirea L, Shah PS, Yang J, Lee SK, Sankaran K. Pneumothorax in neonates: Trends, predictors and outcomes. *J Neonatal Perinatal Med* 2014;7:29-38.
6. Boo NY, Cheah IG. Risk factors associated with pneumothorax in Malaysian neonatal intensive care units. *J Paediatr Child Health* 2011;47:183-90.
7. Nanda D, Nangia S, Thukral A, Yadav CP. A new clinical respiratory distress score for surfactant therapy in preterm infants with respiratory distress. *Eur J Pediatr* 2020;179:603-10.
8. Hedstrom AB, Gove NE, Mayock DE, Batra M. Performance of the Silverman Andersen Respiratory Severity Score in predicting PCO₂ and respiratory support in newborns: a prospective cohort study. *J Perinatol* 2018;38:505-11.
9. Setty SG, Batra M, Hedstrom AB. The Silverman Andersen respiratory severity score can be simplified and still predicts increased neonatal respiratory support. *Acta Paediatr* 2020;109:1273-5.

10. Morley CJ, Davis PG, Doyle LW, Brion LP, Hascoet JM, Carlin JB. Nasal CPAP or intubation at birth for very preterm infants. *N Engl J Med* 2008;358:700-8.
11. Rojas-Reyes MX, Morley CJ, Soll R. Prophylactic versus selective use of surfactant in preventing morbidity and mortality in preterm infants. *Cochrane Database Syst Rev* 2012:Cd000510.
12. Schmölzer GM, Kumar M, Pichler G, Aziz K, O'Reilly M, Cheung PY. Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis. *Bmj* 2013;347:f5980.
13. Respiratory support in preterm infants at birth. *Pediatrics* 2014;133:171-4
14. Fuchs H, Lindner W, Leiprecht A, Mendler MR, Hummler HD. Predictors of early nasal CPAP failure and effects of various intubation criteria on the rate of mechanical ventilation in preterm infants of <29 weeks gestational age. *Arch Dis Child Fetal Neonatal Ed* 2011;96:F343-7.
15. Dargaville PA, Gerber A, Johansson S, et al. Incidence and Outcome of CPAP Failure in Preterm Infants. *Pediatrics* 2016;138.
16. Ammari A, Suri M, Milisavljevic V, et al. Variables associated with the early failure of nasal CPAP in very low birth weight infants. *J Pediatr* 2005;147:341-7.
17. Welty S, Rusin C, Stanberry L et al. Short term evaluation of respiratory effort by premature infants supported with bubble nasal continuous airway pressure using Seattle-PAP and standard bubble devices. *Plos one* 2018
18. Diblasi RM, Zignego JC, Tang DM, Hildebrandt J, Smith CV, Hansen TN, et al. Noninvasive respiratory support of juvenile rabbits by high amplitude bubble continuous positive airway pressure. *Pediatr Res.* 2010;67:624-9
19. Alkan Ozdemir S, Arun Ozer E, Ilhan O, Sutcuoglu S. Impact of targeted-volume ventilation on pulmonary dynamics in preterm infants with respiratory distress syndrome. *Pediatr Pulmonol* 2017;52:213-6.

20. Peng W, Zhu H, Shi H, Liu E. Volume-targeted ventilation is more suitable than pressure-limited ventilation for preterm infants: a systematic review and meta-analysis. Arch Dis Child Fetal Neonatal Ed 2014;99:F158-65.
21. Keszler M. Volume-targeted ventilation: one size does not fit all. Evidence-based recommendations for successful use. Arch Dis Child Fetal Neonatal Ed 2019;104:F108-f12.

- Special Thanks to the Task Force who made this Quality Initiative a true success:
 - Valerie Malone, RN
 - Marie Garabedian, RN
 - Lyne Charbonneau, Head Nurse
 - Caroline Dupont, RRT Educator
 - Angie Spiropoulous, Head RRT
 - Nina Nouraeyan, Neonatologist

Please direct all questions to:
Dr Julie Bartholomew
julie.bartholomew@mcgill.ca