Neonatal Respiratory Care beyond the ventilator

Mike Phillips
Neonatal Pediatric Clinical coordinator
Women and Babies Hospital
Lancaster General PENN Medicine

Disclosures

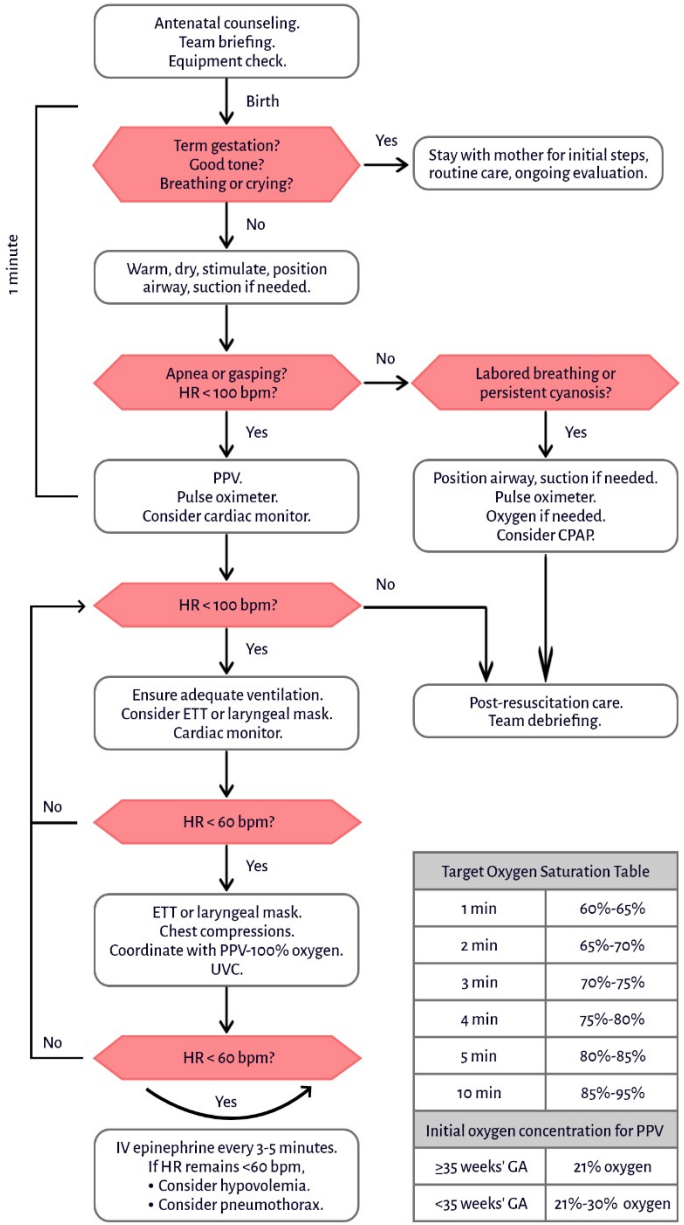
I have no financial disclosure.

Educational Points

- Attendees will be able to identify important of effective NRP care.
- Attendees will recall steps to help reduce risk factors of IVH.
- Attendees will be able to identify increasing trends in neonatal care.

Neonatal Resusitation

Epinephrine IV/IO Concentration: 0.1 mg/mL 1 mg/10 mL	0.02 mg/kg Equal to 0.2 mL/kg	IV Dose: 0.01 mg Volume: 0.1 mL	IV Dose: 0.02 mg Volume: 0.2 mL	IV Dose: 0.04 mg Volume: 0.4 mL	IV Dose: 0.06 mg Volume: 0.6 mL	IV Dose: 0.08 mg Volume: 0.8 mL	IV/IO rapid push Flush with 3 mL NS Repeat every 3-5 minutes if heart rate less than 60 bpm
Epinephrine ETT Concentration: 0.1 mg/mL 1 mg/10 mL	0.1 mg/kg Equal to 1 mL/kg	ET Dose: 0.05 mg Volume 0.5 mL	ET Dose: 0.1 mg Volume 1 mL	ET Dose: 0.2 mg Volume 2 mL	ET Dose: 0.3 mg Volume 3 mL	ET Dose: 0.4 mg Volume 4 mL	May administer while vascular access is being established ETT rapid push No need for flush. Provide PPV breaths to distribute into lungs.
Normal Saline IV 0.9% NaCl	10 mL/kg	5 mL IV	10 mL IV	20 mL IV	30 mL IV	40 mL IV	Give over 5-10 min



Target Oxygen Saturation Table	
1 min	60%-65%
2 min	65%-70%
3 min	70%-75%
4 min	75%-80%
5 min	80%-85%
10 min	85%-95%
Initial oxygen concentration for PPV	
≥35 weeks' GA	21% oxygen
<35 weeks' GA	21%-30% oxygen

T-piece resuscitator versus self-inflating bag

- Szyld E, Aguilar A, Musante GA, et al. Comparison of devices for newborn ventilation in the delivery room. J Pediatr 2014;165:234-9. PMID 24690329

- In infants ≥ 26 weeks gestation who require positive pressure ventilation (PPV) after birth during neonatal transition, which device: self-inflating bag (SIB) versus T-piece resuscitator (T-piece), more effectively establishes lung ventilation, indicated by heart rate (HR) ≥100 beats per minute (bpm) at 2 minutes of life?

- Design: Cluster randomized 2-period crossover trial. Cluster design chosen for 'ethical reasons'. Clinicaltrials.gov Identifier NCT00443118.
- Follow-up period: Until hospital discharge, or at least until 36 weeks postmenstrual age for infants <32 weeks gestational age (GA) and until 28 days of life for infants ≥32 weeks GA.
- ◦Setting: 11 centers from 5 countries (Argentina, Chile, Peru, Italy, and USA)
- ◦Patients: 1,032 newborns ≥ 26 weeks GA receiving PPV at birth with a facemask. Exclusion criteria included infants requiring immediate endotracheal intubation at birth, presenting with a major congenital malformation, or members of a multiple birth.
- ◦Intervention: At each site, providers were trained in the use of the first randomly assigned device: T-piece or SIB. Fifty infants were then enrolled and treated with that device. During a subsequent washout period, the health team was trained in the use of the alternative device. Fifty subjects were then enrolled and treated with the alternative device.

- Outcomes: ◦Primary outcome: Proportion of newborns with HR ≥100 bpm at 2 minutes of life.
- ◦Secondary delivery room outcomes: Time to HR ≥100 bpm, time to initiation of spontaneous breathing, oxygen saturation at 2 minutes of life, intubation after mask PPV failure, chest compressions or medication use, 1 and 5 minute Apgar scores, air leaks, and maximum ventilation pressures and FiO_2
- ◦Secondary hospital outcomes: Air leaks, use and duration of oxygen administration, duration of mechanical ventilation and/or continuous positive airway pressure, hypoxic ischemic encephalopathy, bronchopulmonary dysplasia (BPD)

CONCLUSION:

- There was no significant difference between the T-piece and SIB in establishing ventilation, as assessed by heart rate. However, the T-piece was associated with lower rates of intubation in the delivery room.

- The primary outcome did not significantly differ between intervention groups. Yet in the T-piece group, peak inspiratory pressures were lower and less variable, and significantly fewer infants were intubated in the delivery room. Finally, in post-hoc analysis of very low birth weight infants (VLBW), a higher proportion of infants in the T piece group had HR ≥100 bpm at 2 minutes while significantly fewer were intubated in the delivery room or developed BPD.

	T piece (n=511)	SIB (n=516)	OR (95% CI)	
Primary outcome:HR ≥100 bpm at 2 minutes	94%	90%	0.65 (0.41, 1.05)	0.08
Intubation in the delivery room	17%	26%	0.58 (0.4, 0.8)	0.002
Peak inspiratory pressure, mean +/- SD (cm H_2O)	26 +/-2	28 +/-5	N/A	<0.001

POST-HOC SUBGROUP ANALYSIS OF VLBW INFANTS

Outcome	T piece (n=85)	SIB (n=110)	OR (95% CI)	P value
HR ≥100 bpm at 2 minutes	88%	76%	0.43 (0.19, 0.95)	0.037
Intubation in the delivery room	53%	69%	2.01 (1.12, 3.60)	0.019
BPD	25%	40%	2.03 (1.09, 3.79)	0.036

2nd significant study

- T-Piece Resuscitator versus Self-Inflating Bag for Preterm Resuscitation: An Institutional Experience

- Archana Jayaram MBBS, Adam Sima MA, Gail Barker RN, and Leroy R Thacker PhD
- RESPIRATORY CARE • JULY 2013 VOL 58 NO 7

- OBJECTIVE: To compare the effect of type of manual ventilation device on overall response to resuscitation among preterm neonates born at < 35 weeks gestation.
- METHODS: Retrospective data were collected in 2 time periods. Primary outcome was overall response to resuscitation, as measured by Apgar score. Secondary outcomes were incidence of air leaks, need for chest compressions/epinephrine, need for intubation, and surfactant use.
- We identified 294 resuscitations requiring ventilation. SIB was used for 135 neonates, and T-piece was used for 159 neonates. There was no significant difference between the 1-min and 5-min Apgar scores between SIB and T-piece
- The rate of rise of Apgar score was higher, by 0.47, with T-piece, compared to SIB

Evidence based approach to decreasing risk factors of IVH

There are four types of IVH. These are called "grades" and are based on the degree of bleeding.

- Grades 1 and 2 involve a smaller amount of bleeding. Most of the time, there are no long term problems as a result of the bleeding. Grade 1 is also referred to as germinal matrix hemorrhage (GMH).

- Grades 3 and 4 involve more severe bleeding. The blood presses on (grade 3) or directly involves (grade 4) brain tissue. Grade 4 is also called an intraparenchymal hemorrhage. Blood clots can form and block the flow of cerebrospinal fluid. This can lead to increased fluid in the brain (hydrocephalus).

http://www.adhb.govt.nz/newborn/Guidelines/Developmental/Handling.htm

Timing of GM-IVH

- 0-90% of bleeds in the first 3 days.
- 7-20% in the next 4 days until <5% after 7 days.

Ventilation-Induced Brain Injury in Preterm Neonates: A Review of Potential Therapies

- Barton S.K.[a] · Tolcos M.[a-c] · Miller S.L.[a, b] · Roehr C.C.[a, d] · Schmölzer G.M.[e, f] · Moss T.J.M.[a, b] · Hooper S.B.[a, b] · Wallace E.M.[a, b] · Polglase G.R.[a, b]

- Neonatology 2016;110:155-162

- Mechanical ventilation is a risk factor for cerebral inflammation and brain injury in preterm neonates.
- Recent studies have shown that cerebral inflammation and injury can be initiated in the delivery room
- At present, initiation of intermittent positive pressure ventilation (IPPV) in the delivery room is one of the least controlled interventions a preterm infant will likely face
- Varying pressures and volumes administered shortly after birth are sufficient to trigger pathways of ventilation-induced lung and brain injury.
- The pathways involved in ventilation-induced brain injury include a complex inflammatory cascade and hemodynamic instability, both of which have an impact on the brain

The first pathway to brain injury from ventilation

- Is the initiation of a **pulmonary inflammatory cascade** which migrates systemically to the brain
- localized cerebral inflammatory response sufficient to increase markers of oxidative stress and apoptosis.

The second pathway

- Caused by over-distension of alveoli and compression of pulmonary capillaries, increasing pulmonary resistance and decreasing the cardiac output. Coupled with immature autoregulation and a permeable blood-brain barrier, this hemodynamic disturbance causes variable blood flow to the brain and cerebral protein extravasation.

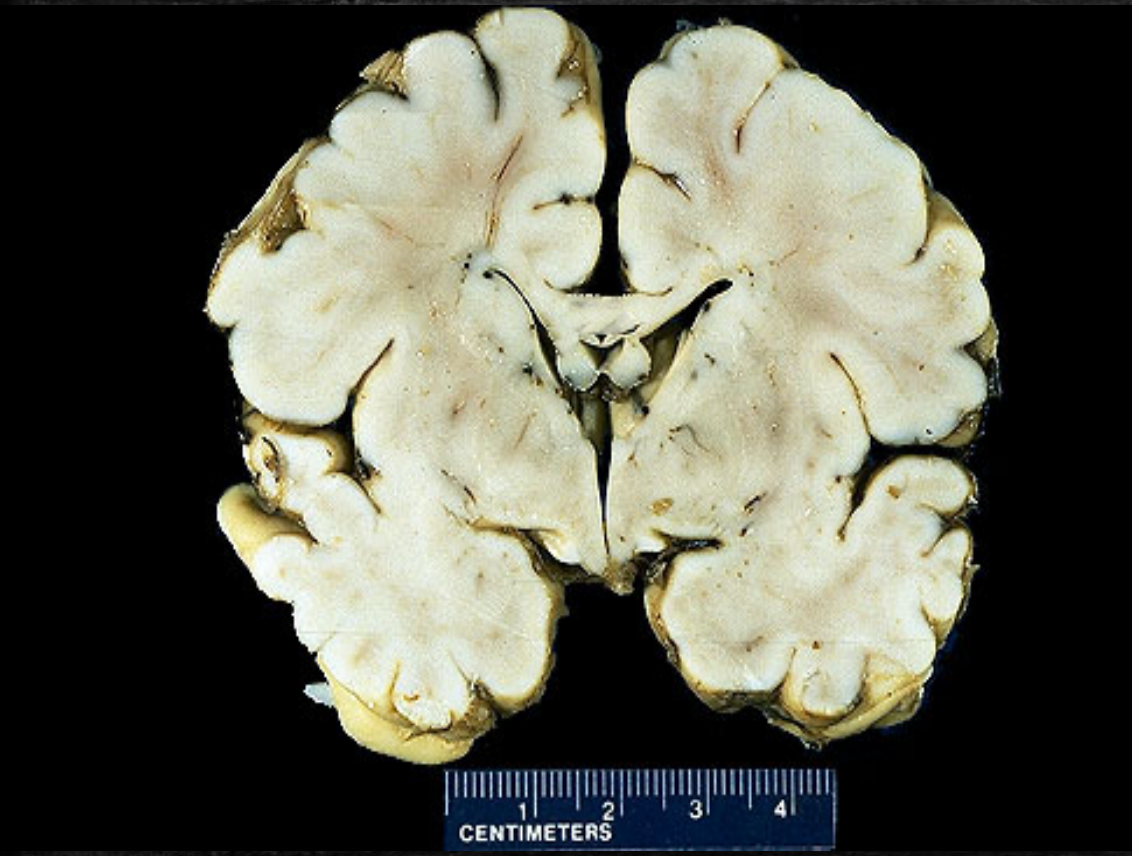
- These pathways are amplified when the initiation of ventilation encompasses a high V_T.
- While improving ventilation strategies can minimize some aspects of ventilation-induced lung and brain injury, it is not sufficient to mitigate injury.
- IPPV, irrespectively of the strategy, can increase brain injury and inflammation from as early as its initiation.

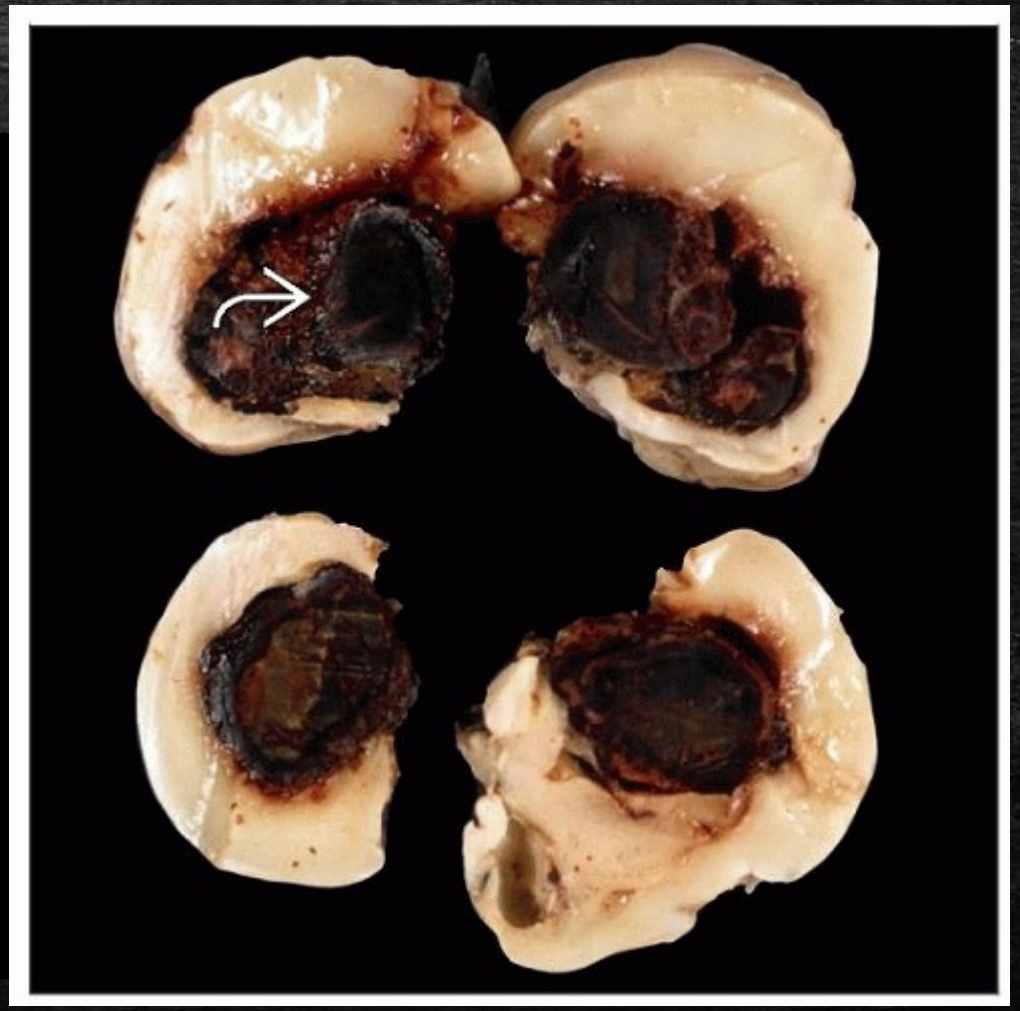
How to decrease the risk factors

Decrease stimulation
Infant Positioning
Blood Pressure Management
Control ventilation
Maintain FRC (control intrathoracic pressure changes)

- Not all IVH will stop occurring
- We can influence the outcome
- We need to “change the culture”

Final visual thought





Therapeutic Hypothermia from a Respiratory Therapist perspective

Pathophysiology

"Neonates: from birth through the first 28 days of life."

- FDA. (2014). *Guidance for Industry and FDA Staff*, 1-12.

BARD | MEDICAL

Global Ischemia

- Transient (5 – 30 minutes) complete or nearly complete lack of blood flow
- Lack of blood supply leads to ischemia
- If blood flow is not restored within 30 minutes, widespread necrosis occurs

Polderman, KH. (2004). *Int Care Med*. 30(4), 556-575

Gestational Age Plays an Important Role

- Complex negative cascade of reactions at cellular level
- Chain of events is called secondary injury or reperfusion injury
- May begin minutes after injury and continue up to 72 hours or longer

Polderman, KH. (2008). *Lancet.* 371, 1955-60.
Rocha-Ferriera. (2016). *N Plasticity*. 2016: 1-16.

Mechanism of Action

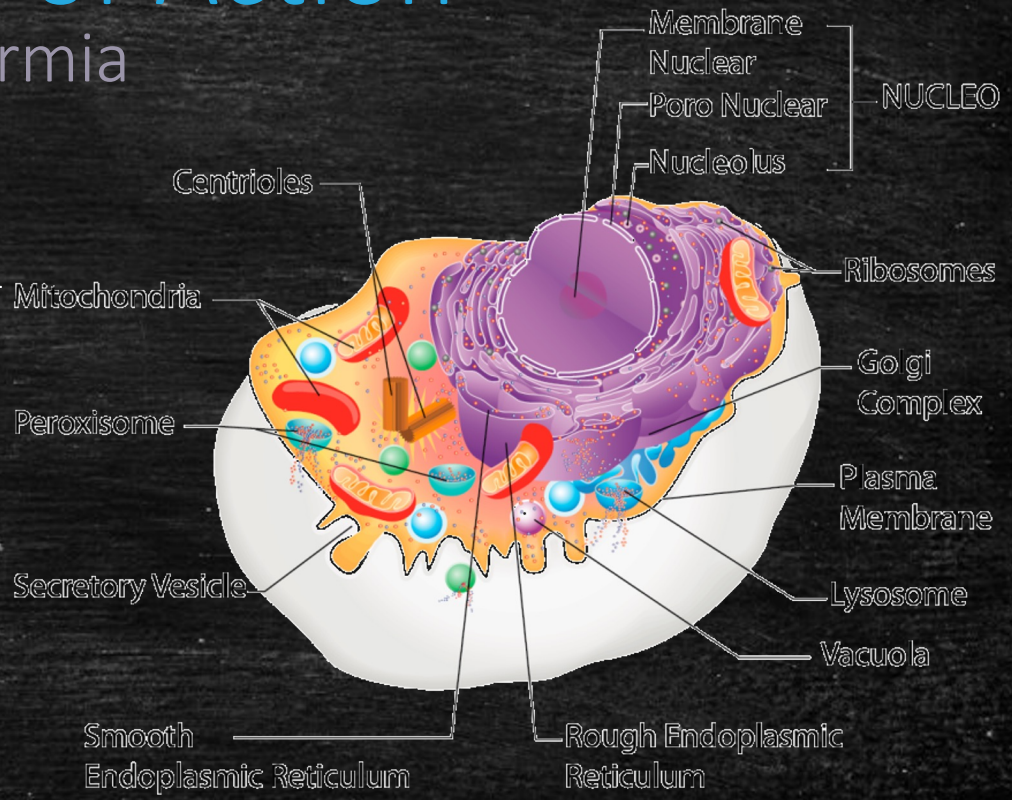
Hypothermia

Reduces

- Cytotoxic amino acid accumulation and nitric oxide[1]
- Secondary energy failure[1]
- Energy utilization[1]
- Metabolism[1]

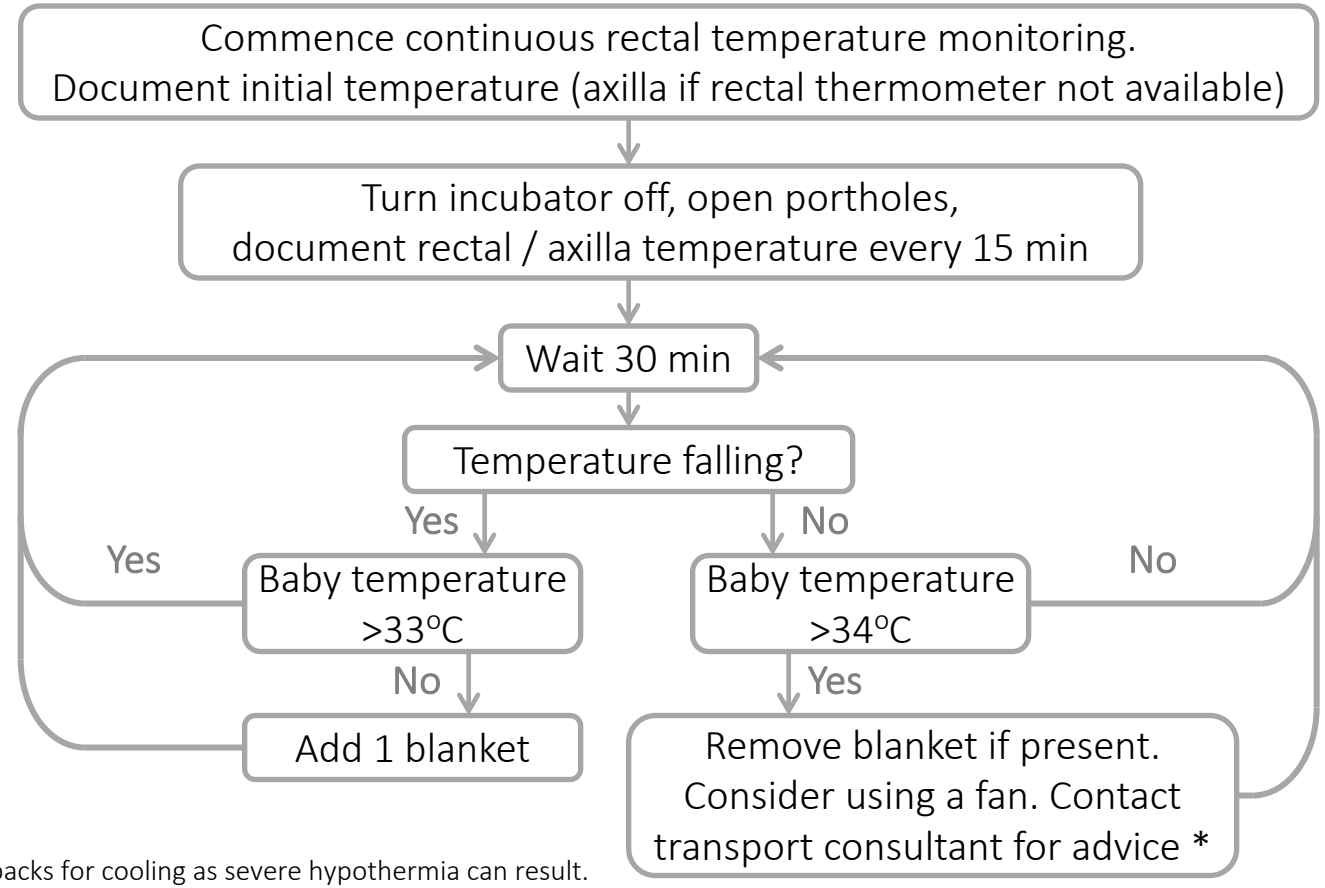
Inhibits

- Free radical activity[1,3]
- Cell death[2,3]



1. Wisnowski, JE. (2015). J *Cere Blood Flow and Metab.* 0, 1-12.
2. Newmyer. (2015). *Current Treatment Opt in Pediatrics,* 1: 38-47.
3. Jacobs, SE. (2013). *Cochrane Neonatal Review*. 1, 2.

Passive Cooling and Transport

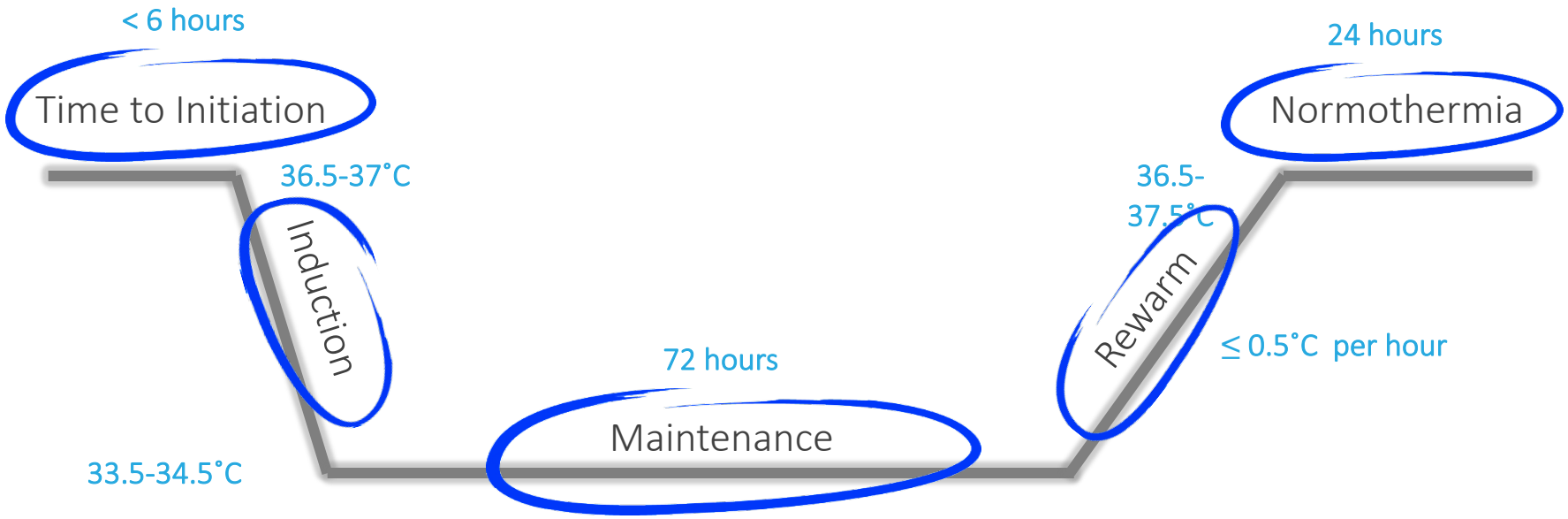


*Do not use ice packs for cooling as severe hypothermia can result.
Do not use active cooling (e.g. fan) unless rectal temperature is monitored.

NHS Networks, (2015-17). *Nat Assoc Neonatal Nurses*, (6), 75.

BMD/AS50/0916/0167

Four Phases*



*Duration to follow institutional and society guidelines

Antonucci. (2014). *Jour of Pediatr Neonat Individual Med,* 3(2), 1-14.
Mosalli, R. (2012). *Jour of Clinical Neonatology*, 1(2), 101–106.
NHS Networks, (2015-17). *Nat Assoc Neonatal Nurses*, (6), 73-364.
Shankaran, (2009). *Jour of Ntrauma*, 26(3): 437-443.

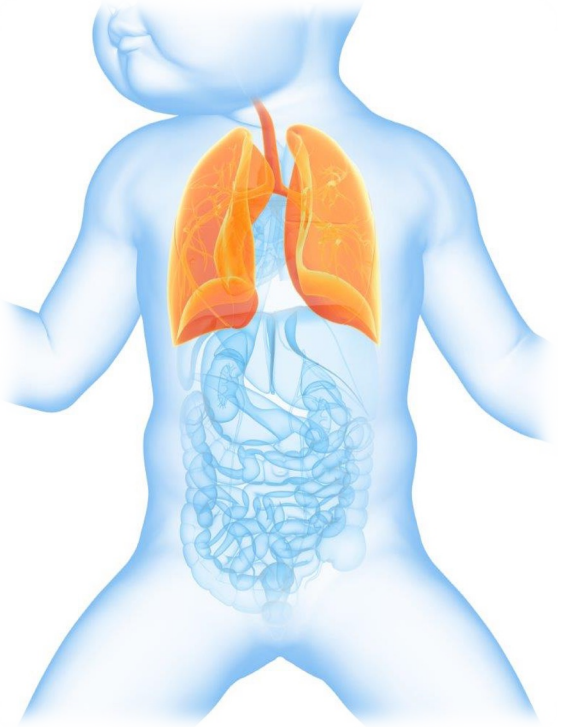
BMD/AS50/0916/0167

Physiological Effects of Cooling

and Nursing Considerations

Respiratory

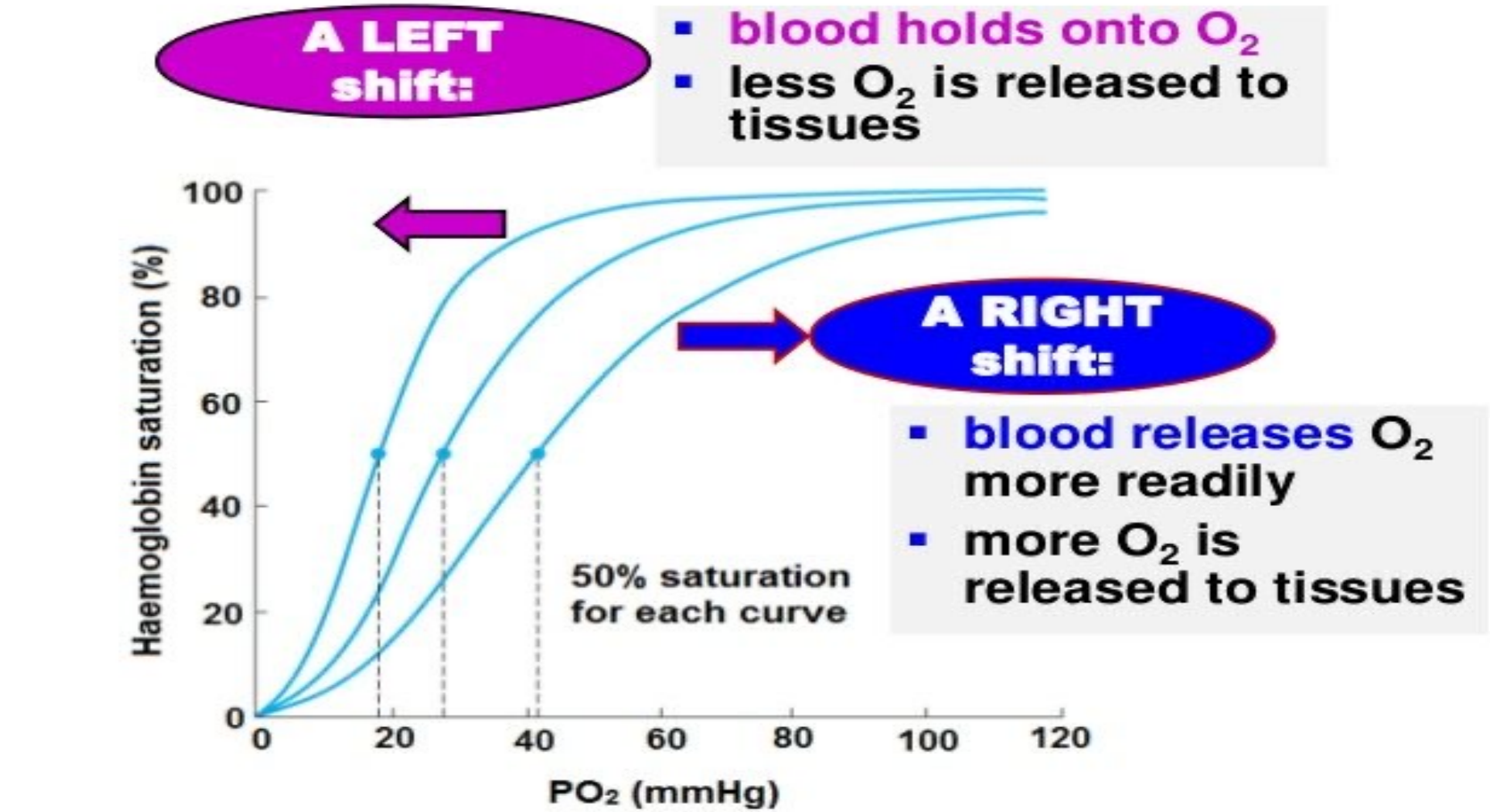
- Most infants will require assisted ventilation during cooling
- Secretions tend to be more “sticky”
- More frequent suction with saline and regular repositioning might be necessary
- ↓ O_2 consumption and CO_2 production

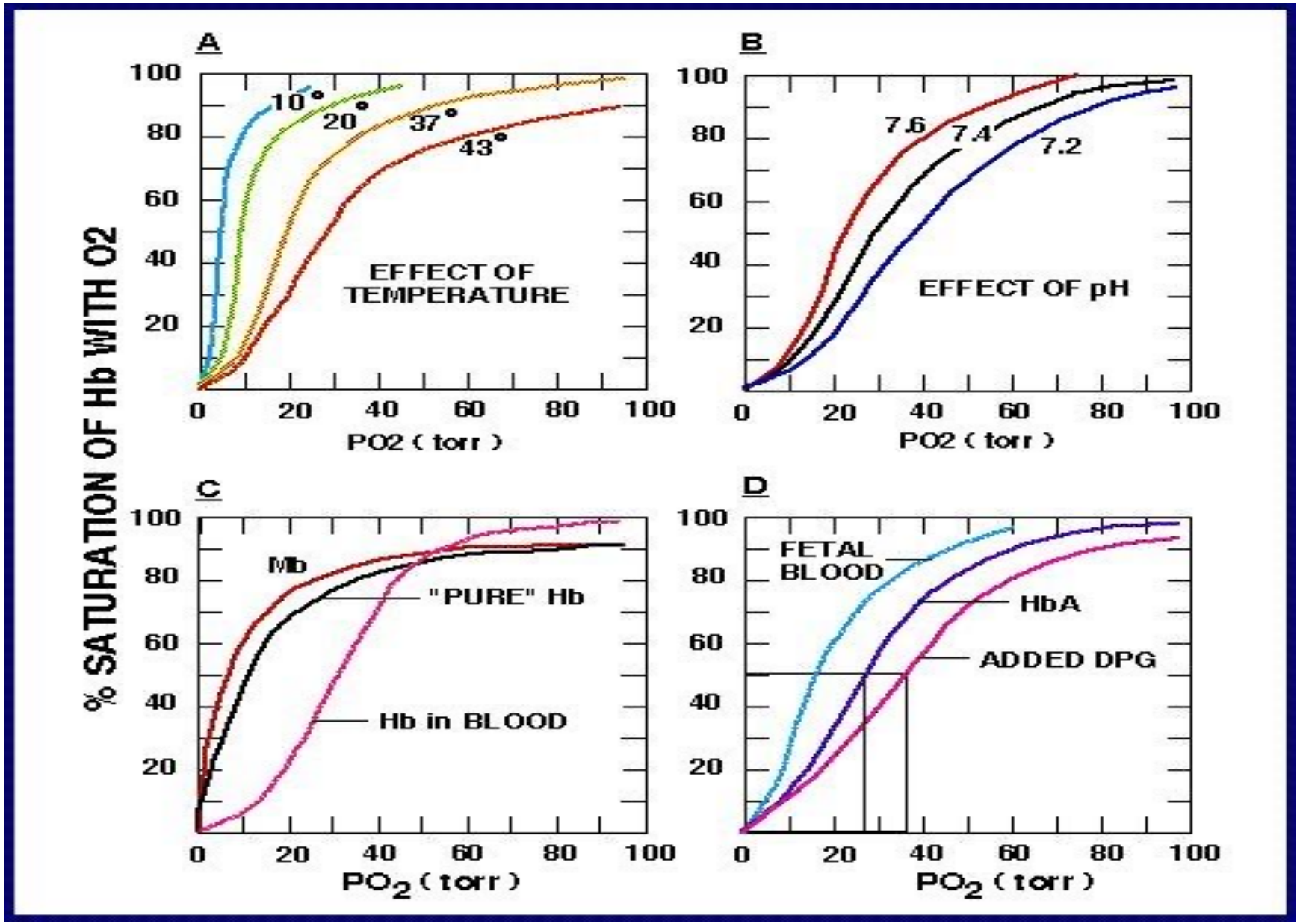


Mosalli, R. (2012). *Jour of Clinical Neonatology*. *1*(2), 101–106.

Measured values at 37 °C (NORMOTHERMIA)	Temperature-corrected values assuming a body temperature of 30 °C (HYPOTHERMIA)	Temperature-corrected values assuming a body temperature of 40 °C (HYPERTHERMIA)
pH 7.405	pH 7.508	pH 7.362
pCO_2 43.0 mmHg (5.72 kPa)	pCO_2 30.6 mmHg (4.07 kPa)	pCO_2 49.7 mmHg (6.6 kPa)
pO_2 94.2 mmHg (12.5 kPa)	pO_2 61.6 mmHg (8.2 kPa)	pO_2 112.8 mmHg (15 kPa)

In Body temp=Left shift




A
B
C
D
% SATURATION OF Hb WITH O2
100
80
60
40
20
0
20
40
60
80
100
10°
20°
37°
43°
EFFECT OF
TEMPERATURE
PO2 (torr)
7.6
7.4
7.2
EFFECT OF pH
PO2 (torr)
Mb
"PURE" Hb
Hb in BLOOD
PO2 (torr)
FETAL
BLOOD
HbA
ADDED DPG
PO2 (torr)

- As the baby cools there will have a decrease in PaC02 and Pa02 while having an increase in PH
- This metabolic change will require ventilation support to be adjusted

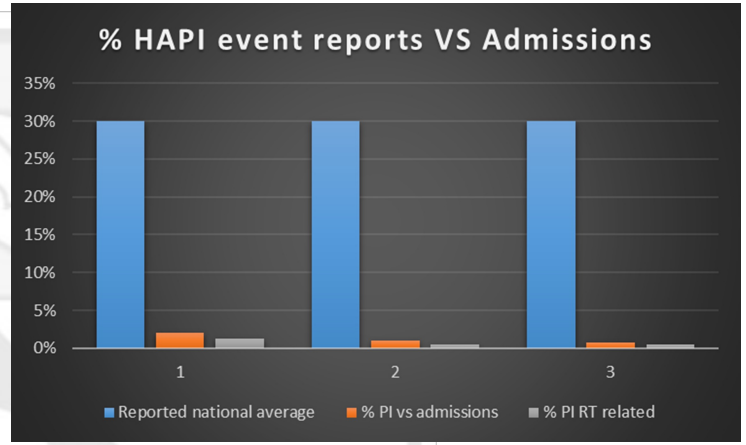
Collaborative effort to decrease pressure injuries in NICU

Michael Phillips, AS RRT, Respiratory Therapy Laura Maurer BSN, RNC-NIC NICU
Women & Babies Hospital Lancaster General PENN Medicine Lancaster, PA

Background: Working in collaboration with the NICU Skin team to evaluate pressure injury rates (HAPI Healthcare acquired pressure injury) it was discovered that a large amount of the injuries were related to respiratory therapy devices. With these results, a literature review was conducted to evaluate the findings compared to published results. The Journal of Neonatal Nursing found 247 neonatal patients were reviewed, of these infants 77 were identified as having a skin injury (a prevalence rate of 31.2%). The Respiratory therapy non-invasive CPAP delivery devices were associated with 14.0% of those HAPI(1). The mean gestational age was 28 weeks. A Literature review on prevention of HAPI found the use Hydrocolloid dressing to be beneficial in the preventing nasal trauma secondary to nasal CPAP in preterm infants. (2) Along with continuous education to nursing and respiratory therapy were found to be beneficial to decreasing the rate of HAPI events (3).

Methods: Continue to perform NICU skin assessments and collect data starting January 1st 2017 till April 2019 with a total of 812 babies assessed. Starting January 2017 event reports were completed for all issues including redness. Prior to 2017 multiple changes were implemented to include standardizing equipment to use only F&P Flexi trunk CPAP system. Starting simultaneous RN and RT skin assessment along with nasal prong and mask sizing any changes occurred at this time. The team instituted the use of Septal H, a hydrocolloid barrier device.

Results: The NICU HAPI rate was < 2% of annual admissions and assessments (15/812). The Respiratory Therapy related injuries were 1.3% (9/812) of the HAPI. The mean gestational age was 26 weeks. The HAPI rate remained stable, < 2% if NICU admissions. In 2017 with the introduction of Septal H there was 5 HAPI in a 2 month time frame. This was analyzed found not to be the product itself, but due to a deviation from traditional skin assessment technique. From September 2017 till March 2019 the HAPI rate remained less than 2%.



HAPI event reports are less than 1% of annual admissions

Conclusions: A Significant reduction in Neonatal HAPI can be achieved by strong nursing and respiratory therapy relationship. While there are many CPAP interfaces available, mastering proper fit and sizing along with attentive skin assessment will lead to reduction in HAPI. . While being successful in all of the previously mentioned changes, continuing education for RT and RN's had the largest impact on the reduction of HAPI.

References

(1)Journal of Neonatal Nursing Volume 20, Issue 3, June 2014, Pages 129-137
Pressure injuries to the skin in a neonatal unit: Fact or fiction
Author links open overlay panel Deanne L. August, Liza Edmonds, David K. Brown, Megan Murphy, Yogavijayan Kandasamy

(2) Hydrocolloid dressing in preventing nasal trauma secondary to nasal continuous positive airway pressure in preterm infants
World J Emerg Med. 2014; 5(3): 218–222

(3) Eliminating Device Related Hospital Acquired Pressure Injuries in the Neonatal Intensive Care Unit through Quality Improvement Methods
Anne Geistkemper, Sara Murphy, Kellianne Fleming, Christie Lawrence, Jean Silvestri and Laura Hernandez
Respiratory Care October 2018, 63 (Suppl 10) 3024435;

Acknowledgments

I would like to thank all the wonderful Women and Babies Respiratory Therapist and wonderful Nurses from NICU at Women & Babies Hospital Lancaster General Health Penn Medicine. Without their help this success would not have been possible.

2019 AARC Congress, New Orleans, LA
The authors have no relevant conflicts of interest to disclose

Penn Medicine
Lancaster General Health

Conclusions:

- Strong nursing and respiratory therapy relationship can achieve a significant reduction in Neonatal HAPI. While there are many CPAP interfaces available, mastering proper fit and sizing along with attentive skin assessment will lead to reduction in HAPI. . While being successful in all of the previously mentioned changes, continuing education for RT and RNs had the largest impact on the reduction of HAPI.

Intubated 31 days
CPAP interface 115 days
HFNC 12 days
N/C 6 days
Total days 164 days

Look into the future

Curosurf Delivery

Mr MIST **Mrs. LISA**

- M Minimal
- I Invasive
- S Surfactant
- T Therapy

- L Less
- I Invasive
- S Surfactant
- A Administration

Journal of Perinatology
https://doi.org/10.1038/s41372-020-0702-5

ARTICLE

Less invasive surfactant administration reduces incidence of severe intraventricular haemorrage in preterms with respiratory distress syndrome: a cohort study

A. Pérez-Iranzo[1] · A. Jarque[1] · J. D. Toledo[1] · R. Tosca[1]

Received: 10 November 2019 / Revised: 25 April 2020 / Accepted: 22 May 2020

Table 2 Details of postnatal respiratory management of study group compared with historical.

	LISA[a] group ($n = 109$)	Historical controls (n = 100)	P value
Timing (hours) of first Surfactant dose (Mean ± SD)	13.7 ± 16.9	7.8 ± 9.05	0.002
Fio2 along period of 1 h post treatment (Mean ± SD)	0.26 ± 0.07	0.29 ± 0.14	0.04
Max Fio2[b] along period of 24 h post treatment (Mean ± SD)	0.30 ± 0.12	0.37 ± 0.22	0.01
Max Fio2 along period of 72 h post treatment (Mean ± SD)	0.26 ± 0.1	0.33 ± 0.17	0.001
PCO2[c] (mmHg, capilar) 2 h after treatment (Mean ± SD)	48.3 ± 9	52,9 ± 15	0.01
PCO2 (mmHg, capilar) 24 h after treatment (Mean ± SD)	44.9 ± 6	46.1 ± 10	NS
Recurrent surfactant treatment, *n* (%)	24 (22)	18 (18)	NS
Any adverse event during surfactant administration[d]	37 (54)	35 (62)	NS
Sedative medication during surfactant administration	49 (45)	92 (92)	<0.001
Sedative medication, after surfactant administration (NICU stay)	35 (32.5)	69 (69)	<0.001
CPAP day 1, *n* (%)	100 (92)	28 (24)	<0.001
CPAP day 3, *n* (%)	83 (76)	13 (13)	<0.001
CPAP day 7, *n* (%)	41 (40.2)	14 (14)	0.004
Mechanical ventilation day 1, *n* (%)	6 (5.5)	72 (72)	<0.001
Mechanical ventilation day 3, *n* (%)	15 (13.8)	67 (67)	<0.001
Mechanical ventilation day 7 *n* (%)	10 (9)	27 (27)	<0.001
Any mechanical ventilation, *n* (%)	31(28.4)	100(100)	0.000
Total days of mechanical ventilation (Mean ± SD)	2.4 ± 5	6.9 ± 9.6	<0.001
Total days of CPAP[e] (Mean ± SD)	9.7 ± 11.7	4.3 ± 5.7	<0.001
Max Fio2 at 28 days post procedure (Mean ± SD)	0.23 ± 0.09	0.23 ± 0.08	NS
Total n° of O2[f] days (Mean ± SD)	14.2 ± 19	15.2 ± 21	NS

[a]LISA (Less invasive surfactant administration).

[b]Max Fio2: Maximum fraction of inspired oxygen required to reach minimal preductal Saturations of 90%.

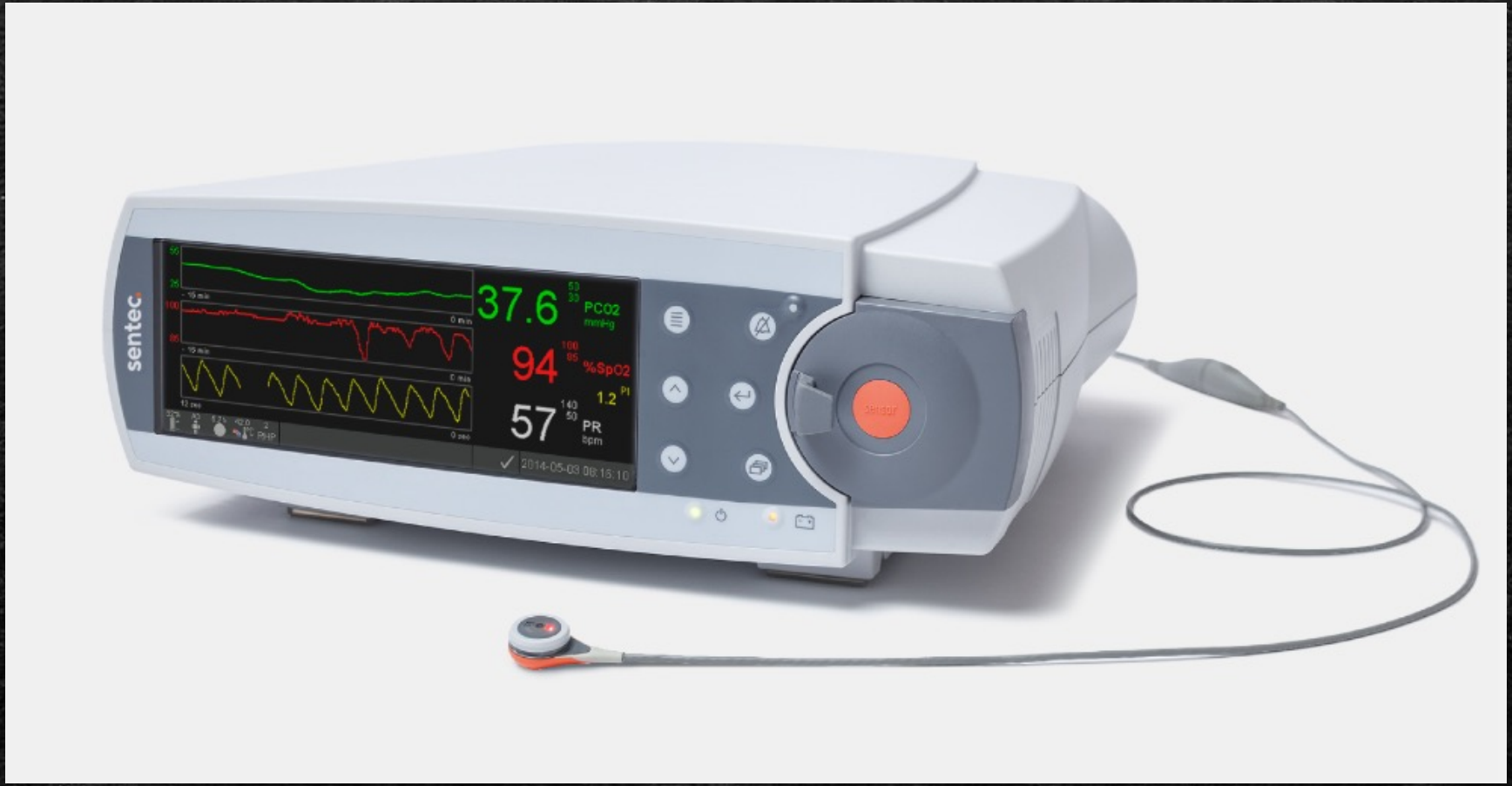
[c]PCO2 (partial pressure of carbon dioxide).

[d]Apnoea, bradycardia, preductal desaturation below <85, thorax rigidity, coughing/gagging/regurgitation and catheter dislodgement.

[e]CPAP (Continuous positive airway pressure).

[f]O2 (oxygen).

LISA- Angiocatheter


sentec
37.6
PCO2
94
%SpO2
1.2
PI
57
PR
bpm
2014-05-03 08:15:10

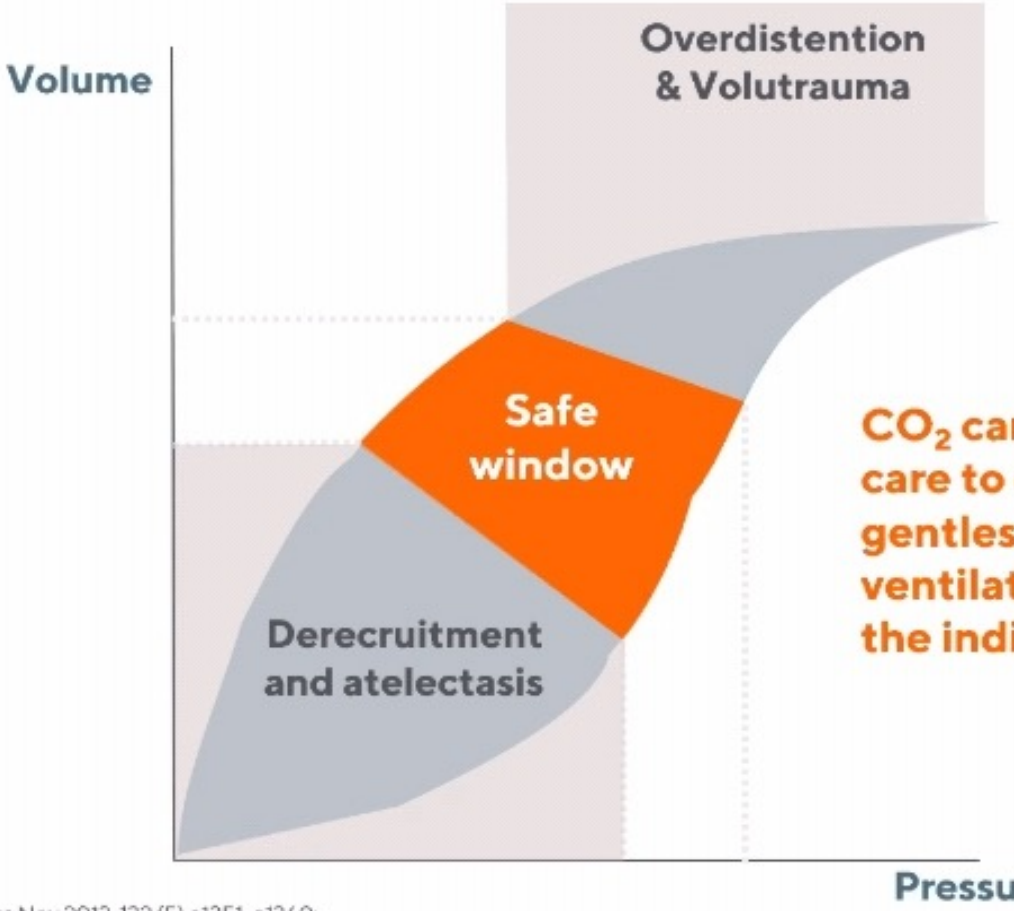
CO_2 & the Lungs

While ventilation support is crucial to protect the brain from hypercarbia, hypocarbia, and CO_2 fluctuations, ventilation itself can also cause lung damage in the absence of finely-tuned care.

Duration of mechanical ventilation in VLBW infants has been associated with:

- increased odds of **BPD**
- Increased odds of **Pulmonary Hypertension**
- increased risk of **neurodevelopmental impairment**[2]

Implementing strategies to **avoid endotracheal mechanical ventilation** has been shown to **reduce the incidence of BPD.**[1]



CO_2 can help titrate care to deliver the gentlest efficacious ventilatory support for the individual patient.

1. Fischer et al. Pediatrics Nov 2013, 132 (5) e1351-e1360;
2. Choi et al. The Journal of Pediatrics, 2017, Volume 194, 34 - 39.e3
3. Erickson et al. J Paediatr Child Health. 2002;38(6):560–562.


The most dangerous
phrase in the language is
"we've always done it this way."

Mike Phillips RRT

Respiratory Therapy Neonatal Pediatric Coordinator

Lancaster General PENN Medicine

Jmichael.Phillips@pennmedicine.upenn.edu