NON-INVASIVE VENTILATION (What Are The Evidences)

مستشفى الرحبة
AL RAHBA HOSPITAL
IN AFFILIATION WITH JOHNS HOPKINS MEDICINE

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SEHA صحة
A SEHA Healthsystem Facility

First Use

- **"And the God formed man of the dust of the ground and breathed into his nostrils breath of life, and man became a living soul"**

Genesis 2:7

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Introduction

Perhaps the only consensus about mechanical ventilation of infants is that, all else being equal, avoidance of mechanical ventilation is the best way to avoid lung injury.

Jobe A, Journal of Pediatrics, September 2006

Introduction

Therefore,

strategies to minimize this lung injury, such as nasal CPAP, could lower the incidence of BPD.

Bancalari and del Moral , Journal of perinatology, 2006

Bancalari et al, Semin neonatology, 2003

Mechanisms of Damage to the Immature Lung

- Over distension

Excessive VT : PIP – PEEP

Prolonged inspiratory time

PEEP, gas trapping

- Insufficient FRC: Low PEEP
- Infection-Inflammation
- Oxygen toxicity
- Improper conditioning of the inspired gas: Temperature, humidity
- Increased pulmonary blood flow - PDA

What’s wrong with Ventilation?

Doctor’s don’t know:

- When to start
- How to prevent lung damage
- How to wean or when to stop

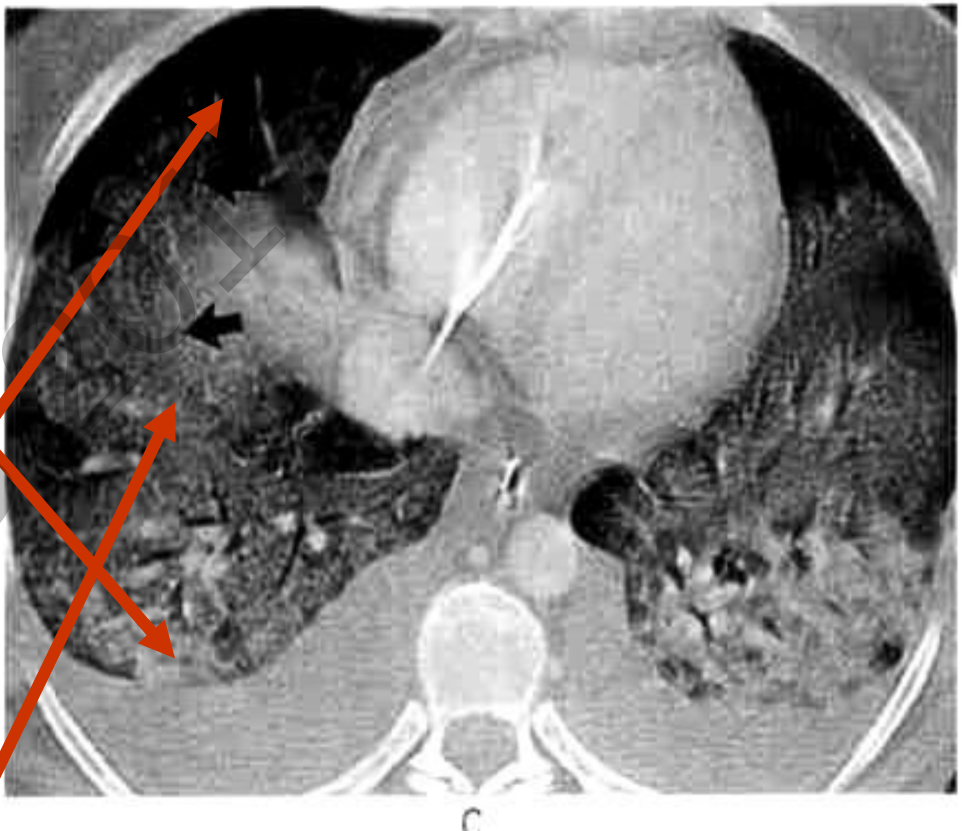
Dr. Alan H. Jobe,

"The Journal of Pediatrics" 2005

"There is perhaps nothing more dangerous for the preterm lung than an anxious physician with an endotracheal tube and a bag".

Acute Lung Injury

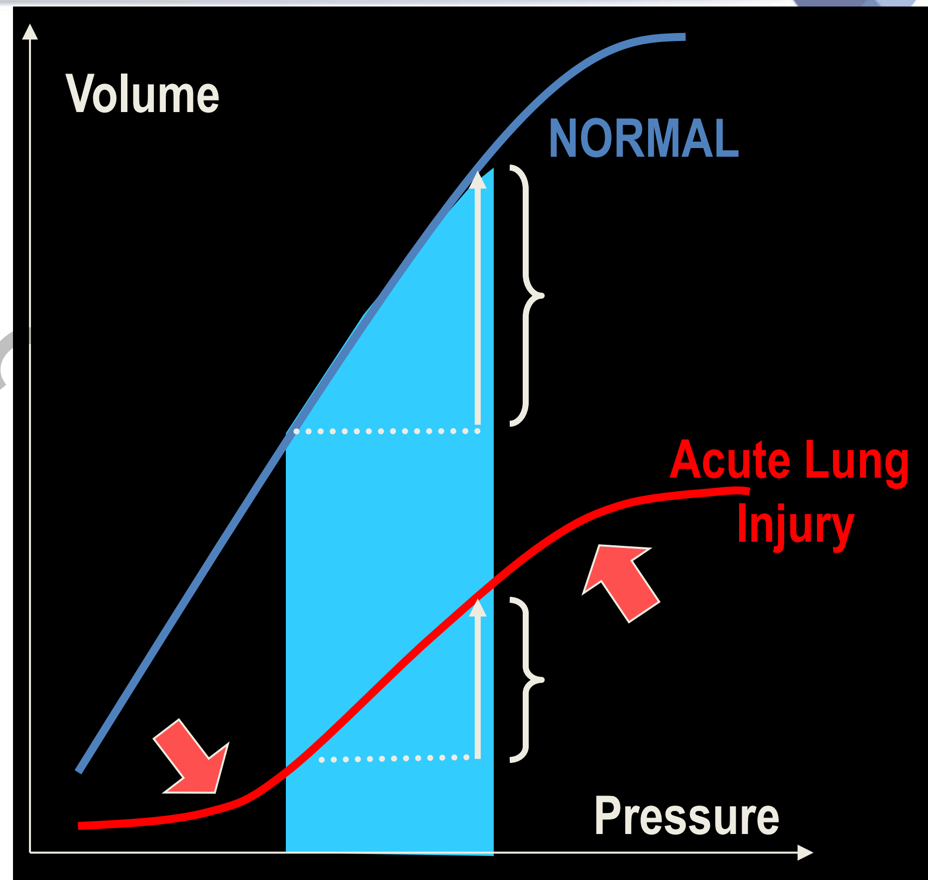
- In acute lung injury (ALI) there are 3 regions of lung tissue:
  - Severely diseased regions with a limited ability to "safely" recruit.
  - Uninvolved regions with normal compliance and aeration. Possibility of overdistension with increased ventilatory support.
  - Intermediate regions with reversible alveolar collapse and edema.



Ware et al., NEJM, 2000

Respiratory Mechanics

- ALI is associated with a decrease in lung compliance.
  - Less volume is delivered for the same pressure delivery during ALI as compared to normal conditions.
- Lower and upper inflection points:
  - At the lower end of the curve, the alveoli are at risk for derecruitment and collapse.
  - At the upper end of the curve, the alveoli are at risk of alveolar overdistension.



Ventilator Associated Lung Injury

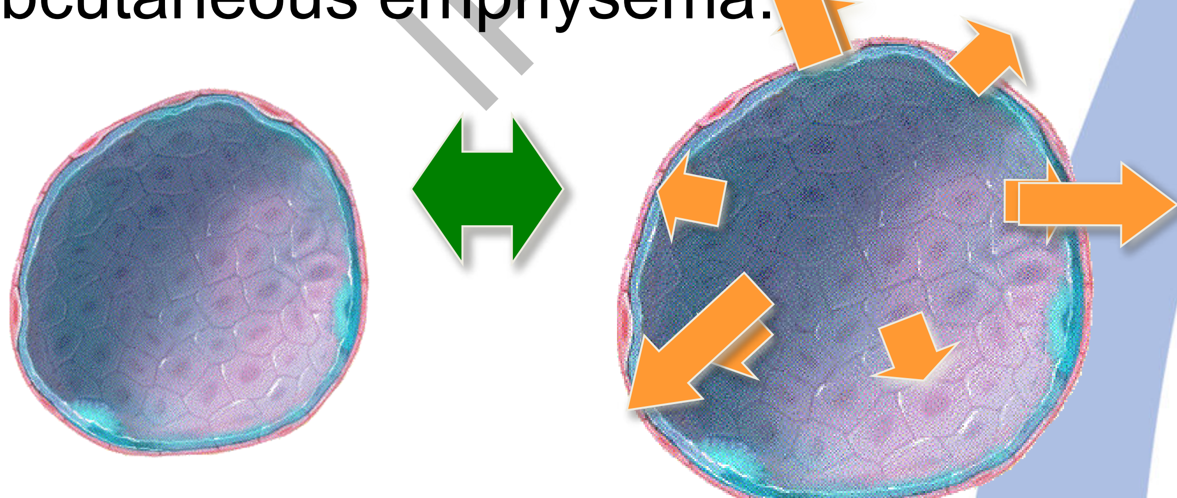
- All forms of positive pressure ventilation (PPV) can cause ventilator associated lung injury (VALI).

- VALI is the result of a combination of the following processes:
  - Barotrauma
  - Volutrauma
  - Atelectrauma
  - Biotrauma

Slutsky, Chest, 2005

Barotrauma

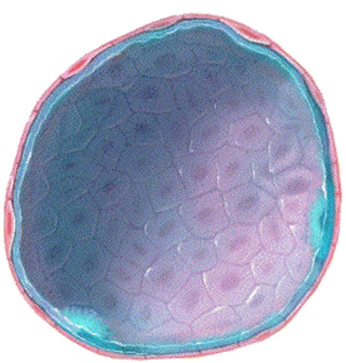
- High airway pressures during PPV can cause lung overdistension with gross tissue injury.
- This injury can allow the transfer of air into the interstitial tissues at the proximal airways.
- Clinically, barotrauma presents as pneumothorax, pneumomediastinum, pneumopericardium, and subcutaneous emphysema.

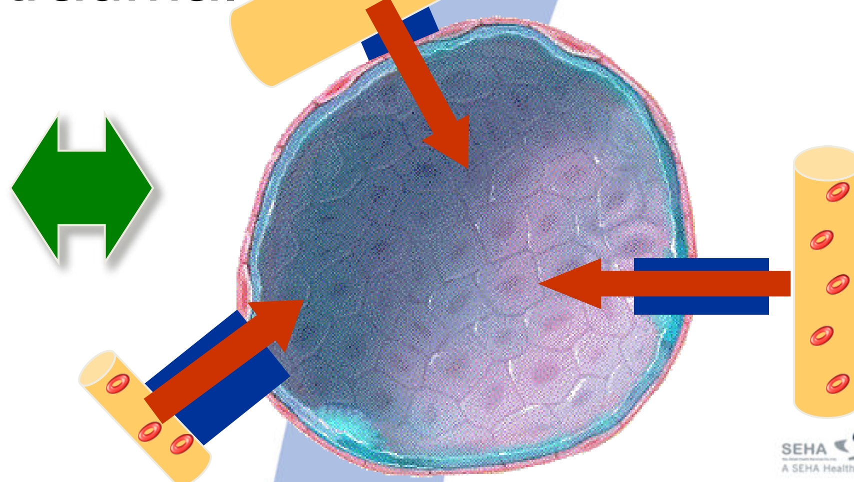


Slutsky, Chest, 1999

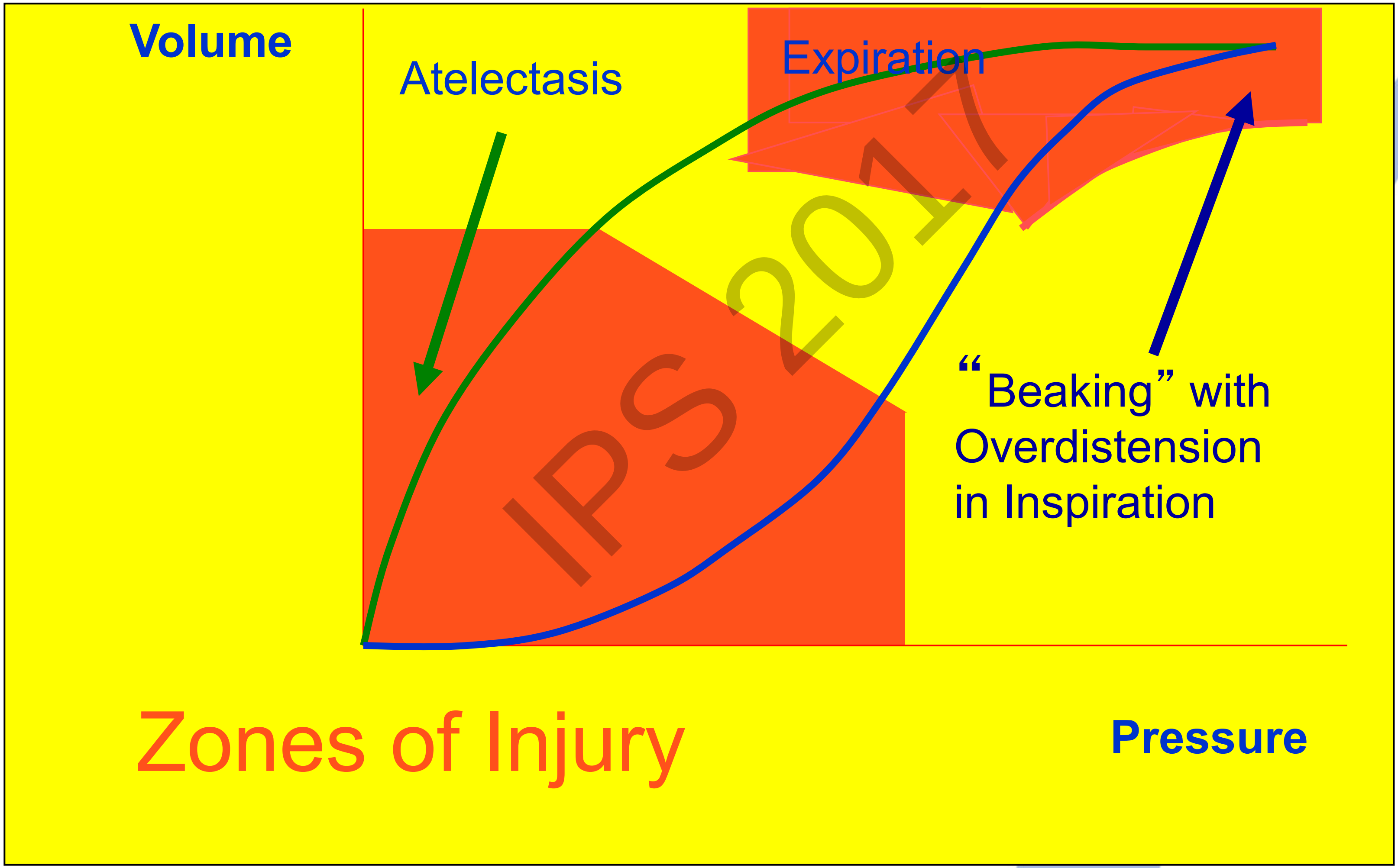
Volutrauma

- Lung overdistension can cause diffuse alveolar damage at the pulmonary capillary membrane.
- This may result in increased epithelial and microvascular permeability, thus, allowing fluid filtration into the alveoli (pulmonary edema).
- Excessive end-inspiratory alveolar volumes are the major determinant of volutrauma.

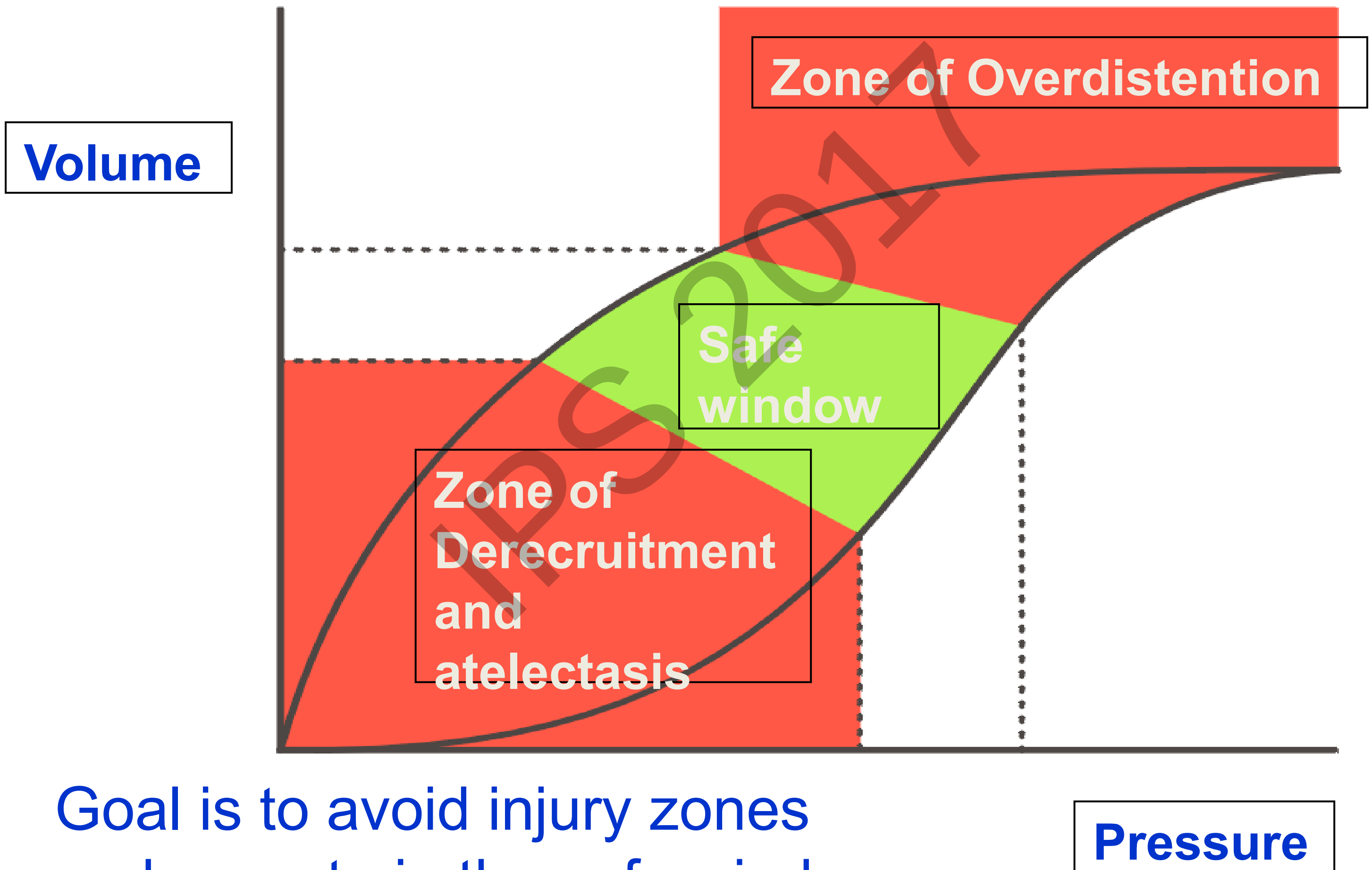




Pressure-Volume Loop



Open Lung Ventilation Strategy

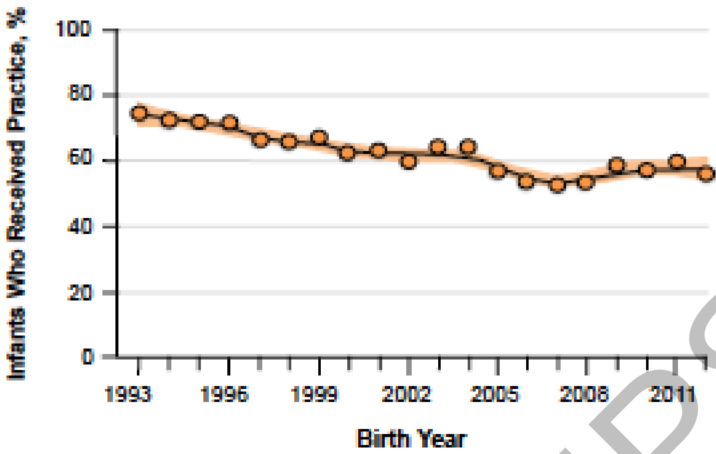


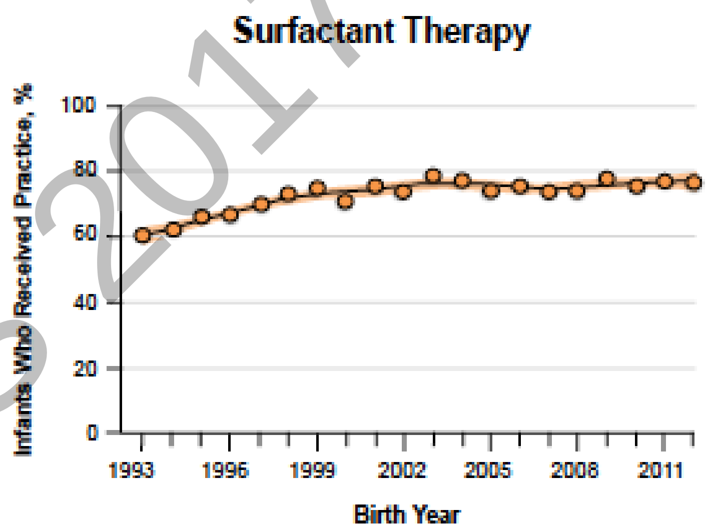
Goal is to avoid injury zones and operate in the safe window

Respiratory support for infants 22-28 weeks gestation surviving more than 12 hours of life

	2003-2007 N =8546	2008-2012 N=8034	2012 N=1756
Any conventional ventilation	82%	87%	83%
Any non-invasive ventilation	80%	96%	100%
CPAP highest	8 %	9%	11%

Stoll JAMA 2015


Infants Who Received Practice, %
100
80
60
40
20
0
1993
1996
1999
2002
2005
2008
2011
Birth Year


Surfactant Therapy
Infants Who Received Practice, %
100
80
60
40
20
0
1993
1996
1999
2002
2005
2008
2011
Birth Year

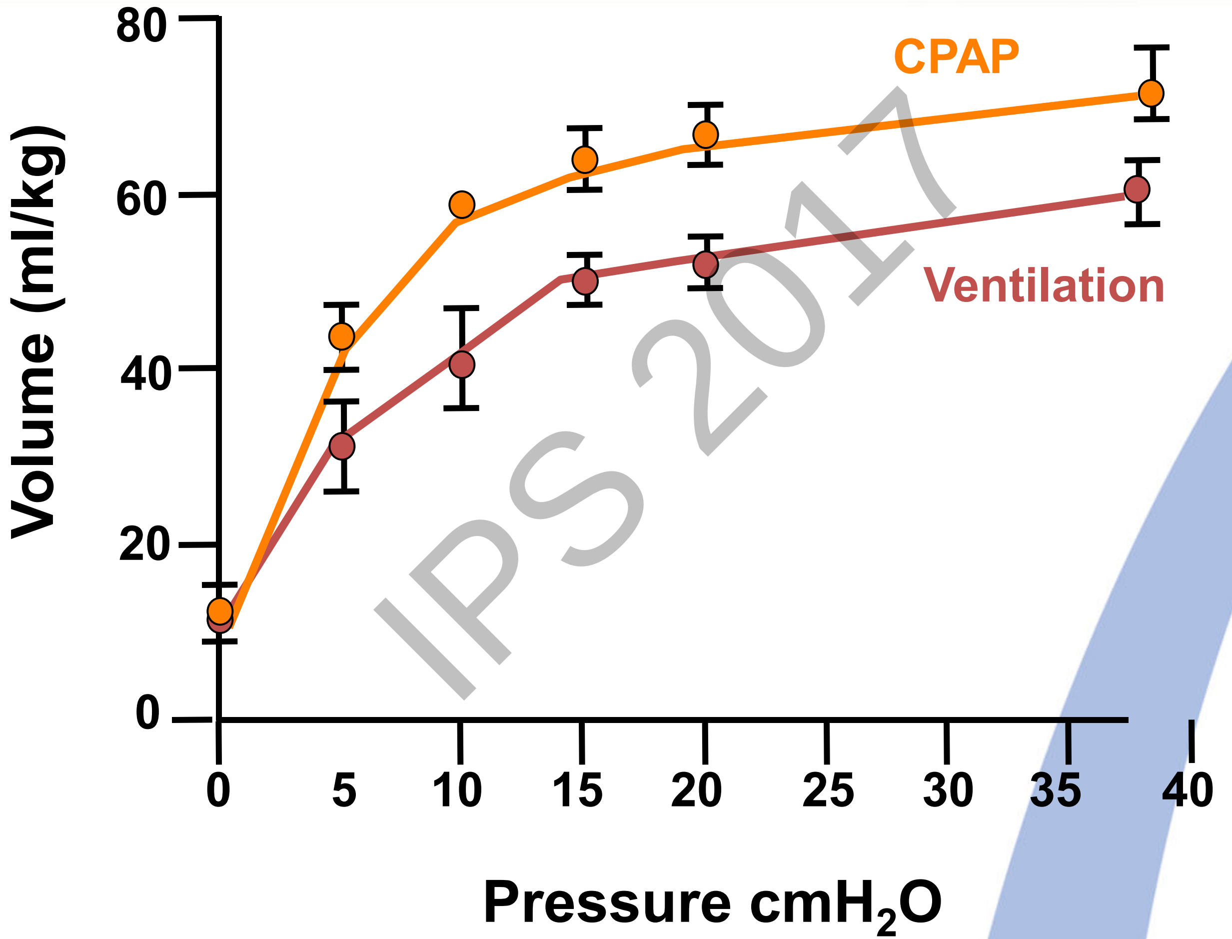
Surfactant

	RR	95%CI	NNT	95% CI
Natural surfactant	0.86	0.76-0.98	50	20-1000
Multiple doses	0.63	0.39-1.02	14	7-1000
Prophylaxis	0.61	0.48-0.77	20	14-50
Early	0.87	0.77-0.99	33	17-1000

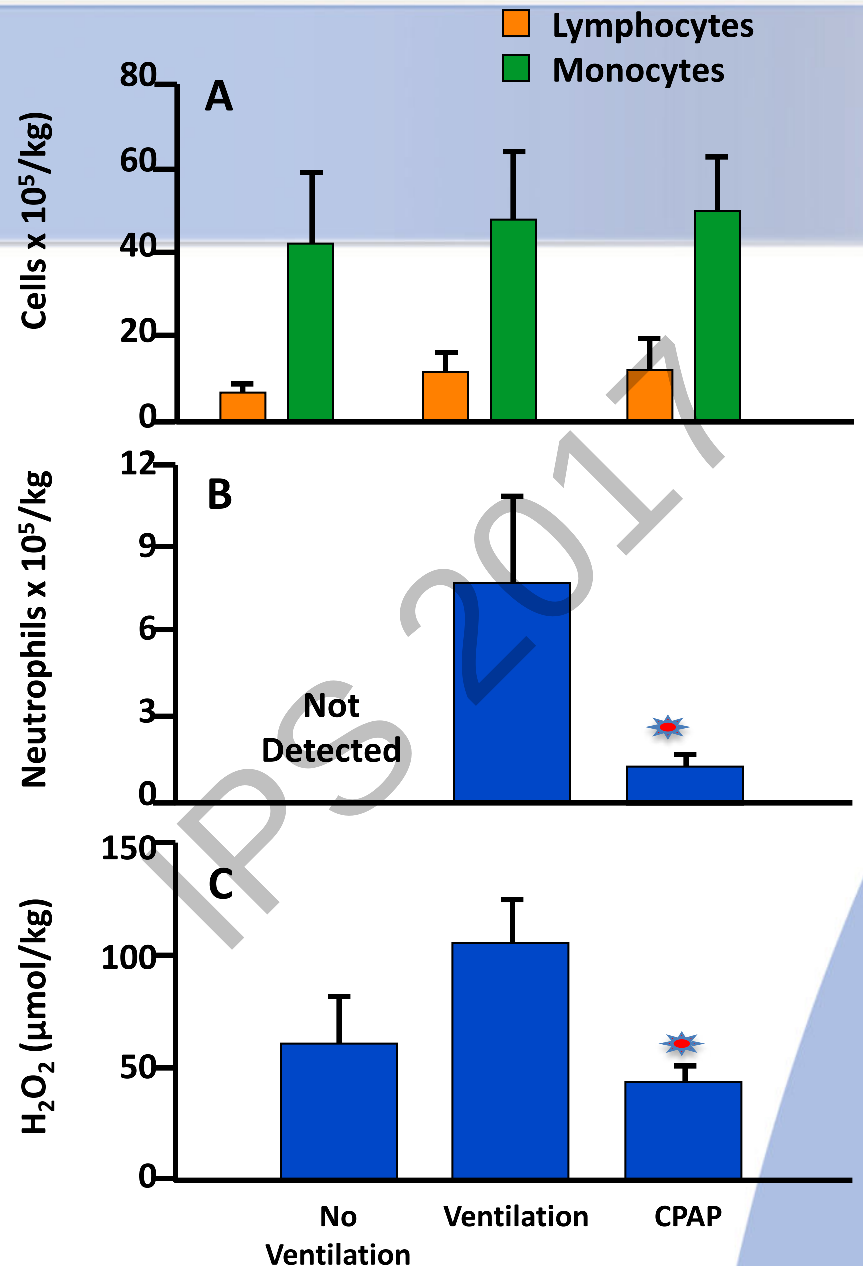
HL Halliday Journal of Perinatology 28: s47, 2008

CPAP Decreases Acute Lung Injury in Preterm Lambs

CMV vs. Bubble CPAP x 2 hours



(Jobe AH: Pediatr. Res. 2002)



L.Merino, J.Perinatology 2006

Do clinical markers of barotrauma and oxygen toxicity explain interhospital variation in rates of chronic lung disease

Case-cohort study to evaluate the relationship between NICU practices and the occurrence of BPD

	Babies	*Boston*
BPD	4%	22%*
CPAP	63%	11%*
Ventilation	29%	75%*

Van Marter et al Pediatrics: 105, 1194, 2000

Controversies

- Early vs. late Surfactant
- Clinical Practices and Biases
- Ventilatory Stability

European consensus guidelines on management neonatal RDS

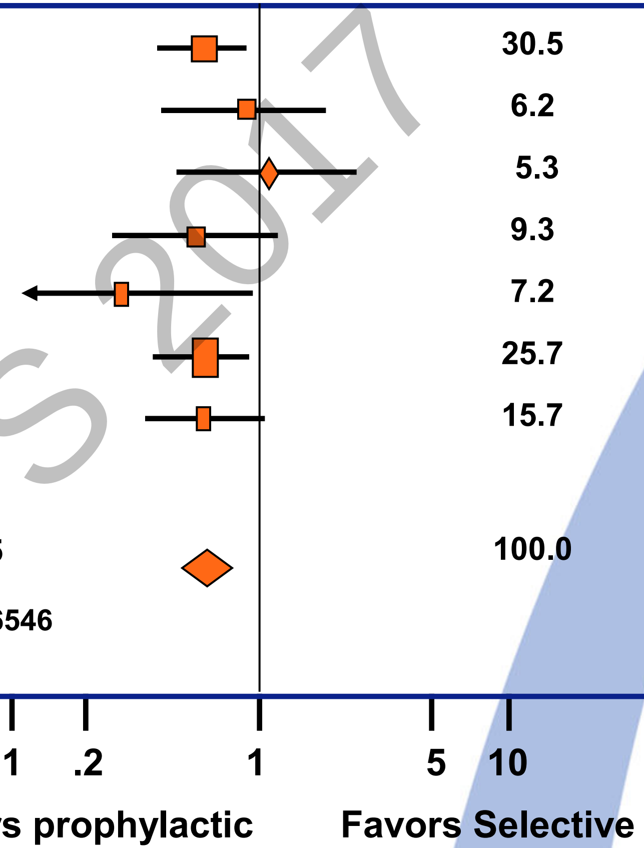
Sweet D, Bevilacqua, Carnielli V, Greisen G, Plavka R, Saugstat OD,Simeoni U, Speer CP, Valls-i-Soler and Halliday H

- PROPHYLACTIC SURFACTANT (within 15 ´ of birth) should be given to almost all babies under 27 weeks ´ gestation, and should be considered for all babies over 26 week but <30 weeks ´ gestation if intubation is required in the delivery room or if the mother has not received prenatal corticosteroid (A)
- CPAP should be initiated in all babies at risk of RDS, such as those <30 weeks ´ gestation until their clinical status can be assessed (D)

J.Perinat.Med 2007, 35:175-186

Prophylaxis vs. Selective SRT: Mortality

Study	Prophylactic n/N	Selective n/N	Relative Risk (fixed) 95% CI	Weight (%)	Relative Risk (fixed) 95% CI
Bevilacqua 1996	28/136	46/132		30.5	0.59 [0.39, 0.89]
Bevilacqua 1997	9/49	9/44		6.2	0.90 [0.39, 2.06]
Dunn 1991	9/62	8/60		5.3	1.09 [1.45, 2.63]
Egberts 1993	8/75	14/72		9.3	0.55 [0.24, 1.23]
Kattwinkel 1993	3/627	11/621		7.2	0.27 [0.08, 0.96]
Kendig 1991	23/235	40/244		25.7	0.60 [0.37, 0.97]
Walti 1995	15/134	23/122		15.7	0.59 [0.33, 1.08]
Total (95% CI)	95/1318	151/1295		100.0	0.61 [0.48, 0.77]

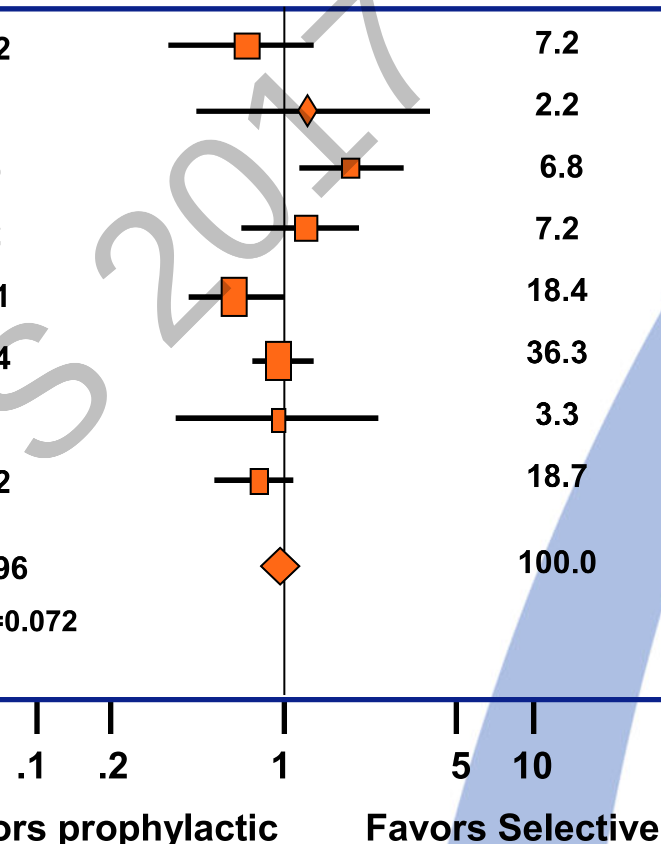


Test for heterogeneity chi-square=4.16 df=6 p=0.6546
Test for overall effect = 4.12 p=0.0000

Prophylaxis Vs. Selective SRT: BPD

Study	Prophylactic n/N	Selective n/N	Relative Risk (fixed) 95% CI	Weight (%)	Relative Risk (fixed) 95% CI
Bevilacqua 1996	12/136	17/132		7.2	0.69 [0.34, 1.38]
Bevilacqua 1997	7/49	5/44		2.2	1.26 [0.43, 3.68]
Dunn 1991	31/62	16/60		6.8	1.88 [1.15, 3.05]
Egberts 1993	22/75	17/72		7.2	1.24 [0.72, 2.14]
Kattwinkel 1993	29/627	44/621		18.4	0.65 [0.41, 1.03]
Kendig 1991	85/235	89/244		36.3	0.99 [0.78, 1.26]
Merritt 1991	8/102	8/101		3.3	0.99 [0.39, 2.54]
Walti 1995	38/134	43/122		18.7	0.80 [0.56, 1.15]
Total (95% CI)	232/1420	239/1396		100.0	0.96 [0.82, 1.12]

Test for heterogeneity chi-square=13.01 df=7 p=0.072
Test for overall effect = 0.57 p=0.6



CURPAP Study

(R Plavka, U Simeoni et al. ESPR: ARCH Dis Child 2008;93 (Suppl II):A34

Nasal CPAP or Intubation at Birth for Very Preterm Infants

Colin J. Morley, M.D., Peter G. Davis, M.D., Lex W. Doyle, M.D., Luc P. Brion, M.D., Jean-Michel Hascoet, M.D., John B. Carlin, Ph.D., for the COIN Trial Investigators

Support Trial

(Finer, NEJM, 2010)

Early CPAP vs. IPPV in extremely low gestational age newborns

	Death/BPD		IPPV		Surfactant	
	CPAP	MV-Surf	CPAP	MV-Surf	CPAP	MV-Surf
COIN 25-28 wks	34%	39%	58.7%	100%	38%	77%
SUPPORT 24-28 wks	49%	54%	83.1% 24.8 d	99.7% 27.7d	67%	99%
VON (CPAP) 26-30 wks	31%	37%	52%	96%	46%	99%
VON (ISX)	29%	37%	59%	96%	98%	99%

Early CPAP vs. ventilation trials in extremely low gestational age newborns complications

Trial	Pneumothorax		Severe IVH		PVL	
	CPAP	Surfactant	CPAP	Surfactant	CPAP	Surfactant
COIN	9%	3%	9%	9%	3%	4%
SUPPORT	7%	7%	14%	11%	--	--
VON	5%	3%	3%	4%	--	--

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IFDAS trial and outcomes

Merran Thomson 2014

- Infants 27-29 wks randomised before birth to one of 4 regimes

	CPAP + Surf (50)	CPAP (63)	IPPV + Surf (55)	Conventional (69)
O_2 at 36 w – survivors	25%	22%	24%	30%
O_2 at 36 w + Died	30%	25%	31%	38%

Conclusions

- CPAP without surfactant does not appear to be harmful
- CPAP seems to be as effective as ventilation

Summary of Recent Trials

	Gestational Age	Enrollment, *n*	Surfactant Treated, %	BPD or Death, *n/N* (%) CPAP	BPD or Death, *n/N* (%) Control	Risk Ratio (95% Confidence Interval)
SUPPORT	24^{0}–27^{6}	1,316	67	323/663 (49)	333/653 (54)	0.91 (0.83–1.01)
COIN	25^{0}–28^{6}	610	38	104/307 (34)	118/303 (39)	0.80 (0.58–1.12)
VON	26^{0}–29^{6}	432	15	68/223 (31)	76/209 (37)	0.83 (0.64–1.09)
CURPAP	25^{0}–28^{6}	208	74	23/105 (22)	22/103 (21)	1.03 (0.61–1.72)
Neocosur	800–1,500 g	256	37	18/131 (14)	24/125 (19)	0.72 (0.41–1.25)
Total		2,822		539/1,429 (38)	573/1,393 (41)	0.92 (0.84–1.00)

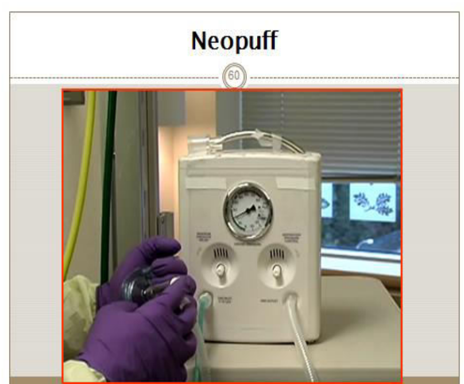
COIN=Continuous Positive Airway pressure or Intubation at Birth trial; CURPAP=Efficacy of Combining Prophylactic Curosurf With Early Nasal CPAP in Delivery Room study; Neocosur=South American Neocosur Network trial; SUPPORT=Surfactant Positive Airway Pressure and Pulse Oximetry trial; VON=Vermont Oxford Network Delivery Room Management trial.

How do the results of these trials help US ?

- NCPAP is effective in the initial management of RDS and can be used starting in the delivery room to avoid IPPV in infants with good respiratory effort
- NCPAP is more successful in infants over 26-27 wks
- NCPAP is effective after extubation to prevent respiratory deterioration and apnea

CPAP Pressure Generators

- Ventilator CPAP
- Flow Driver CPAP
- “Bubble Bottle” CPAP
- Others



BNCPAP

Bubble CPAP vs IFD / Vent.-CPAP

- Gupta, Sinha, Donn; J Perinatol 2009

Early bubble CPAP and outcomes in ELBW preterm infants.

- Narendran V, Donovan EF, Hoath SB, Akinbi HT, Steichen JJ, Jobe AH. 2009

Bubble- and vent.-derived NCPAP – work of breathing & gas exchange

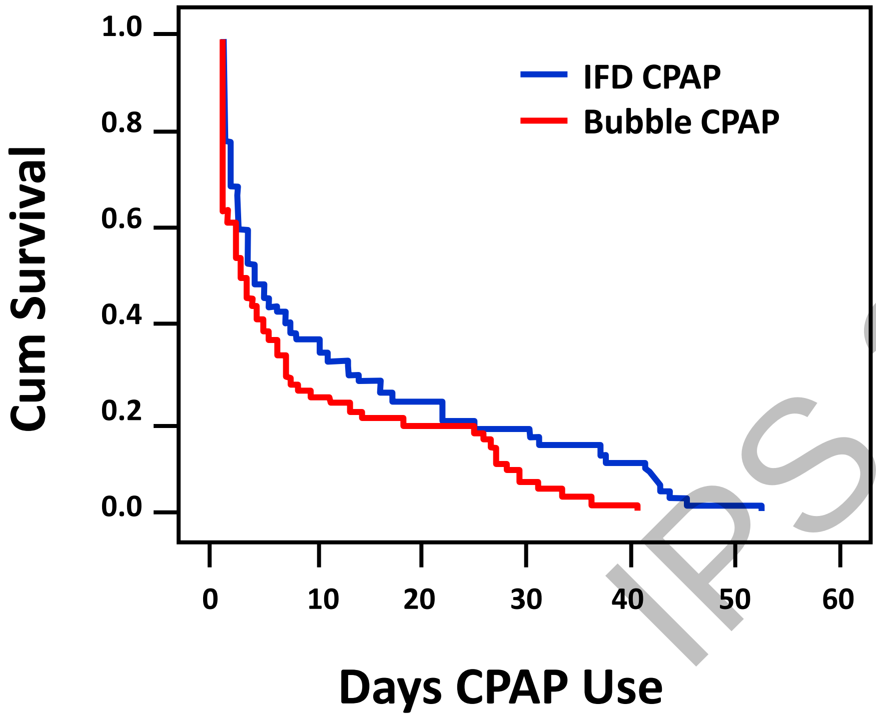
- Courtney SE et al., J Perinatol 2010

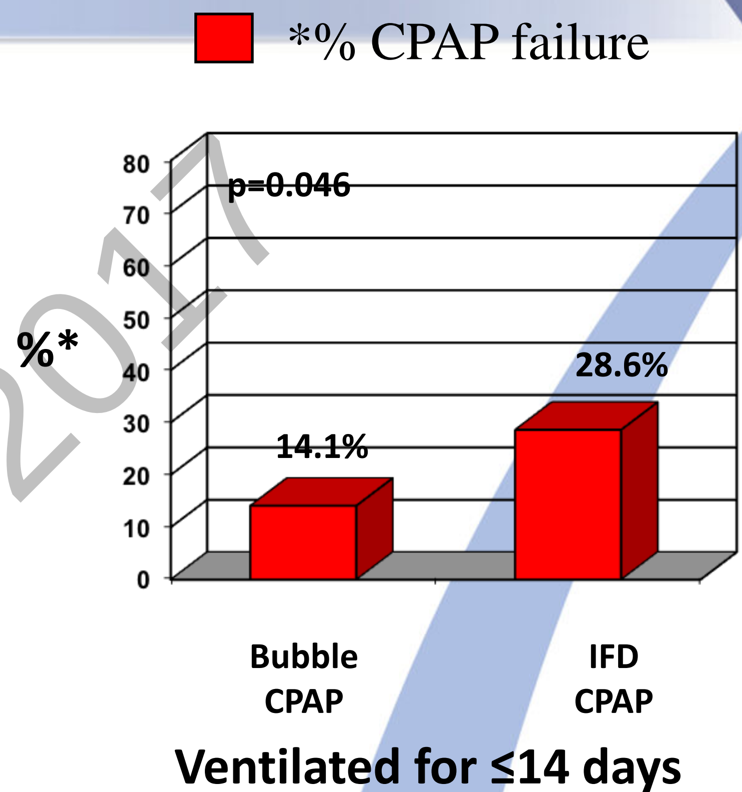
Physiological Explanation of the Advantages of Bubble CPAP

- The increased area under the flow-volume curve and the more efficient utilization of inspired O_2 in the bubble CPAP groups are suggestive of *increased airway patency*.
- "Promotion of airway opening events likely explains the short term improvement in respiratory physiology".

Randomized controlled Trial of Post-Extubation

Bubble CPAP vs. Infant Flow Driver in Preterm Infants with RDS





Gupta S et al J Pediatr. 154: 645, 2009

Is Nasal Ventilation a Better Alternative?

- **Possible mechanisms of action:**
  - Increase in Vt and Ve
  - Upper airway stimulation may reduce apnea
  - Higher mean airway pressure: Better lung stability and gas exchange
  - Reduced dead space: Clears exhaled gas from proximal airway

NIPPV: Efficacy and lung pressure transmission

- An *in vitro* study using short bi-nasal prongs (SBP) or a small caliber cannula (RAM)
- Using the lung model, a small amount of CO2was infused and the amount remaining after 100 seconds was determined.
- Pressure transmission to the "lung" and tidal volume were also measured.

Mukerji and Belik J Perinatology 2015

NIPPV: Physiologic Principles

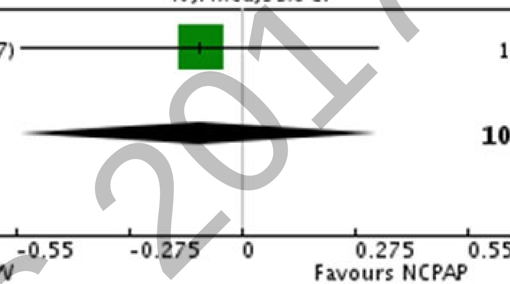
- In awake and sleeping adults, NIPPV produces vocal cord adduction and glottal narrowing resulting in lower tidal volumes and apneic episodes.
- Data suggest that using higher peak pressures does not consistently increase the likelihood of chest inflation.

NIPPV vs NCPAP for Apnea

Review: Nasal intermittent positive pressure ventilation (NIPPV) versus nasal continuous positive airway pressure (NCPAP) for apnea of prematurity
Comparison: 1 NIPPV vs NCPAP
Outcome: 2 Rate of apnea (events/hr)

Study or subgroup	NIPPV N	Mean(SD)	NCPAP N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Ryan 1989	20	0.5 (0.7)	20	0.6 (0.7)		100.0 %	-0.10 [-0.53, 0.33]
Total (95% CI)	**20**		**20**			**100.0 %**	**-0.10 [-0.53, 0.33]**

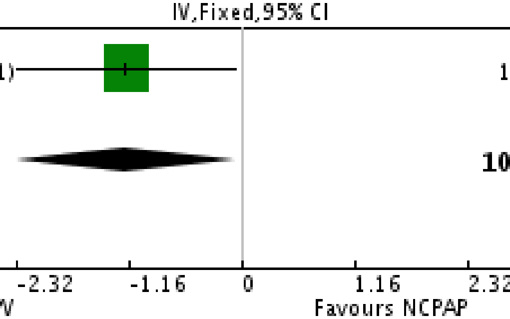
Heterogeneity: not applicable
Test for overall effect: Z = 0.45 (P = 0.65)



Review: Nasal intermittent positive pressure ventilation (NIPPV) versus nasal continuous positive airway pressure (NCPAP) for apnea of prematurity
Comparison: 1 NIPPV vs NCPAP
Outcome: 3 Change in rate of apnea (events/hr)

Study or subgroup	NIPPV N	Mean(SD)	NCPAP N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Lin 1998	18	-2.75 (2.06)	16	-1.56 (1.21)		100.0 %	-1.19 [-2.31, -0.07]
Total (95% CI)	**18**		**16**			**100.0 %**	**-1.19 [-2.31, -0.07]**

Heterogeneity: not applicable
Test for overall effect: Z = 2.08 (P = 0.038)



Lemyre B, Davis PG, De Paoli AG. *Cochrane Database of Systematic Reviews* 2002

	N	Mean GA (weeks)	No	Benefit
Kugelman	86	30.6 / 31.1	Yes	Significant
Bisceglia	88	30.6 / 29.8	No	No
Kishore	76	28-34	No	Significant
Meneses	200	30.1 / 29.0	No	No
Shi	179	24-32	No	Significant
Kirpilani	200	26.2 / 26.1	Both	No

Outcome: respiratory failure or need for intubation/surfactant

N-IPPV vs. N-CPAP in RDS Failure: Need for intubation

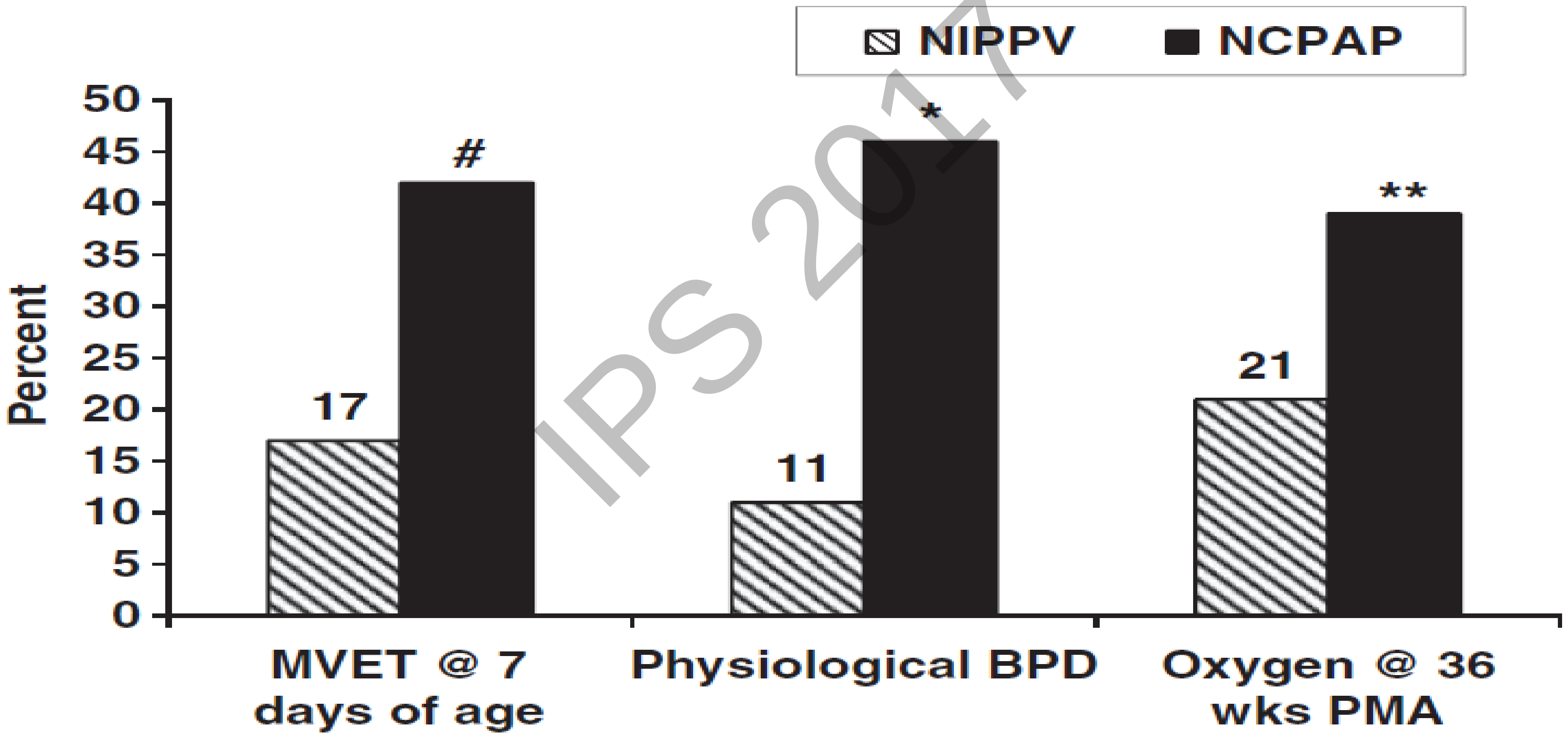
	Population	N-CPAP	N-IPPV	p
Kugelman A. 2007	n = 84 GA: 24-34 w	49 %	25 %	0.04
Sai Sunil Kishore M. 2011	n = 76 GA: 28-34 w BW: ≥ 750 g	41 %	19 %	0.036
Lista G. 2010	n = 40 GA: 28-34 w	15 %	10 %	NS
Meneses J. 2011	n = 200 GA: 26-33 w	34 %	25 %	NS

N-IPPV vs. N-CPAP in RDS BPD: O2 at 36 wks

	Population		N-CPAP	N-IPPV	p
Kugelman A. 2007	n = 84 GA: 24-34 w	BPD:	17 %	2 %	0.04
Sai Sunil Kishore M. 2011	n = 76 GA: 28-34 w BW: ≥ 750 g	BPD: Death or BPD:	10 % 31 %	3 % 16 %	NS* NS*
Lista G. 2010	n = 40 GA: 28-34 w	BPD:	0	0	NS
Meneses J. 2011	n = 200 GA: 26-33 w	BPD: Death or BPD:	5 % 42 %	11 % 40%	NS* NS**
Kirpalani H. 2012	n = 493 (on non-invasive support, ≤7 days) GA: < 30w BW: < 1000 g	Death or BPD:	29 %	30 %	NS

*: Estimated from published data; **: Author's personal communicatio

NIPPV after surfactant treatment for RDS in preterm infants <30 weeks' gestation: a randomized, controlled trial



Ramanathan, R et al. J Perinatol 2012; 32: 336-343.

RCTs: NIPPV or CPAP for Post-extubation Failure

	N	Synchronized	Benefit
Khalaf	32	Yes	Significant
Friedlich	41	Yes	Significant
Barrington	54	Yes	Significant
Khorana	48	No	No
Moretti	63	Yes	Significant
Kirpilani	845	Both	Marginal
O'Brien	133	No	No

Outcome: respiratory failure or need for intubation

What Settings to Use with NIV?

After Extubation

- PIP: 2-4> on ventilator
- PEEP: 4-6 cm H2O
- RR: 10-25
- IT: 0.3-0.5
- Flow: 8-10 l/min

Rx of RDS

PIP:	18-20
PEEP:	4-6
RR:	40
IT:	0.4-0.5
Flow:	8-10

Neo- Review 2015

BiPAP

- **Nasal continuous positive airway pressure (CPAP) versus bi-level nasal CPAP in preterm babies with respiratory distress syndrome: a randomised control trial**

Gianluca Lista, NICU, ‘V.Buzzi’ Children's Hospital, Milan, Italy;

Arch Dis Child Fetal Neonatal Ed 2010;95:F85-F89
doi:10.1136/adc.2009.169219

Humidified High Flow Nasal Cannula (HHFNC)

- Used when weaning off NCPAP
- Used when a baby does not tolerate or has complications of NCPAP
- Used as an alternative to NCPAP

HHFNC – Advantages and Disadvantages

- Simple
- More comfortable
- Less labor intensive, both nursing and RT
- Easier to provide developmentally directed care
- Kangaroo care

- The pressure being delivered to the baby is unregulated
- Actual pressure delivered is not known
- Difficult to provide heat and humidity
- No safety relieve valve if pressure is too high

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NIV-NAVA

- New modality
- More Physiological
- Exact Pressures giving to the baby is in control and known
- No errors due to leakage
- More studies needed

Minimally Invasive Surfactant Therapy (MIST)

Conclusions

- Surfactant can be effectively delivered via a vascular catheter, and this method of MIST deserves further investigation.

Dargaville PA, Aiyappan A, Cornelius A, Williams C, De Paoli AG.
Arch Dis Child Fetal Neonatal Ed doi:10.1136/adc.2010.192518

Aerosolized Surfactant Administration Aerosurf

- Aerosolized, synthetic, protein containing surfactant (Lucinactant)
- No intubation required for administration
- Delivered through nCPAP
- Survives the aerosolization process
- May significantly expand the clinical utility of surfactants through and beyond the neonatal period

AEROSURF

- Data from Pilot Phase 2 trial are encouraging
- Acceptable safety profile
- Justification for next trial
- Potential to revolutionize the management of RDS in the neonatal intensive care unit

CONCLUSION

- Many very premature infants can be managed with NCPAP or NIPPV from birth
- Difficult to predict which infants will fail and require intubation and mechanical ventilation
- Success depends on gestational age, degree of lung disease, respiratory drive, and team's attitude and skills

CONCLUSION

- Use of NIPPV instead of CPAP may reduce the number of infants that need intubation and shortens the duration of MV
- There is no clear evidence that non invasive respiratory support improves short or long term outcome in ELBW infants

Recommendation

- Preterm infants with RDS weighing < 1500 gms. should be allowed time to demonstrate if they can achieve acceptable ventilation and oxygenation on CPAP.
- During that time period, these infants must be monitored closely. If ventilation is not improving or oxygenation is worsening, or inadequate with an FiO2of 60%, these infants should be intubated.

ALGORITHM

Targeted O2 sat 90-95%

Preterm > 26 wk in Resp Distress

↓

BNCPAP 5 cm H2O

↓

- **O2 > 40%, CO2 > 60 PEEP > 7**
  → **Intubate and give Surfactant, extubate and start on CPAP** (can go up to 7)
- **In CV compromise, frequent apneas**
  → **Intubate and give Surfactant, cont. mech. vent. and try to wean as soon as possible**
- **O2 < 40%, CO2 < 60 PEEP 5**
  → **Cont. CPAP With close monitoring**

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Minimally-Invasive Ventilation Workshop

Continuous positive airway pressure ventilation

By

Dr Junaid Muhib Khan.

Introduction

√ Progress in neonatal intensive care is closely linked to improvements in the management of respiratory failure in small infants.

√ Current modalities of ventilatory assistance range from more benign continuous positive airway pressure (CPAP) to various modes of mechanical ventilation (including high frequency ventilation).

polin and Sahni, Seminars in Neonatology, 2002

Introduction

√ The advent of less invasive methods of delivering CPAP has permitted earlier treatment of infants with RDS and avoided the need for mechanical ventilation.

polin and Sahni, Seminars in Neonatology, 2002

Introduction

√ The early initiation of nasal CPAP in combination with a tolerance to elevated PCO_2 levels has reduced the incidence of BPD…… in many centers.

Kamper et al , 2004 (the ETFOL study)

√ BPD is a complex pulmonary disease, characterized by inflammation and abnormal lung repair.

Reese et al 2001, polin and Sahni 2002

<u>While prenatal, natal and postnatal events are important in its pathogenesis, Ventilation is thought to be a major contributing factor.</u>

Jobe and Ikegami 2001

Effects of CPAP in the infant with respiratory distress

1. Reduces upper airway occlusion by decreasing upper airway resistance and increasing the pharyngeal cross sectional area.

2. Reduces right to left shunting.

3. Reduces obstructive apneas.

4. Increases the FRC.

5. Reduces inspiratory resistance by dilating the airways. This permits a larger tidal volume for a given pressure, so reducing the work of breathing.

6. Reduces the compliance of very compliant lungs and, in these lungs, reduces the tidal volume and minute volume.

7. Increases the compliance and tidal volume of stiff lungs with a low FRC by stabilizing the chest wall and counteracting the paradoxical movements.

8. Regularizes and slows the respiratory rate.

9. Reduces the incidence of apnea.

10. Increases the mean airway pressure and improves ventilation perfusion mismatch.

11. Conserves surfactant on the alveolar surface.

12. Diminishes alveolar edema.

13. The increased pressure helps overcome the inspiratory resistance of an endotracheal tube.

- Nasal CPAP after extubation reduces the proportion of babies requiring re-ventilation.

- Oxygenation is related to the surface area, and carbon dioxide elimination is related to the minute volume. Normalizing lung volume improves oxygenation and carbon dioxide elimination.

Indications for CPAP

1. Spontaneously breathing babies with respiratory distress at birth.

2. Increased work of breathing indicated by: recession, grunting, nasal flaring, increased oxygen requirements or increased respiratory rate.

3. Poorly expanded or infiltrated lung fields on chest *x*-ray.

4. Atelectasis.
5. Pulmonary edema.
6. Pulmonary hemorrhage.
7. Apnoea of prematurity.
8. Recent extubation.
9. Tracheomalacia or other abnormalities of the airways, predisposing to airway collapse.

10. Phrenic nerve palsy.

Contraindications to CPAP

1. The need for ventilation because of ventilatory failure—inability to maintain oxygenation.

2. Upper airway abnormalities (cleft palate, choanal atresia).

3. Tracheo-oesophageal fistula.

4. Diaphragmatic hernia.

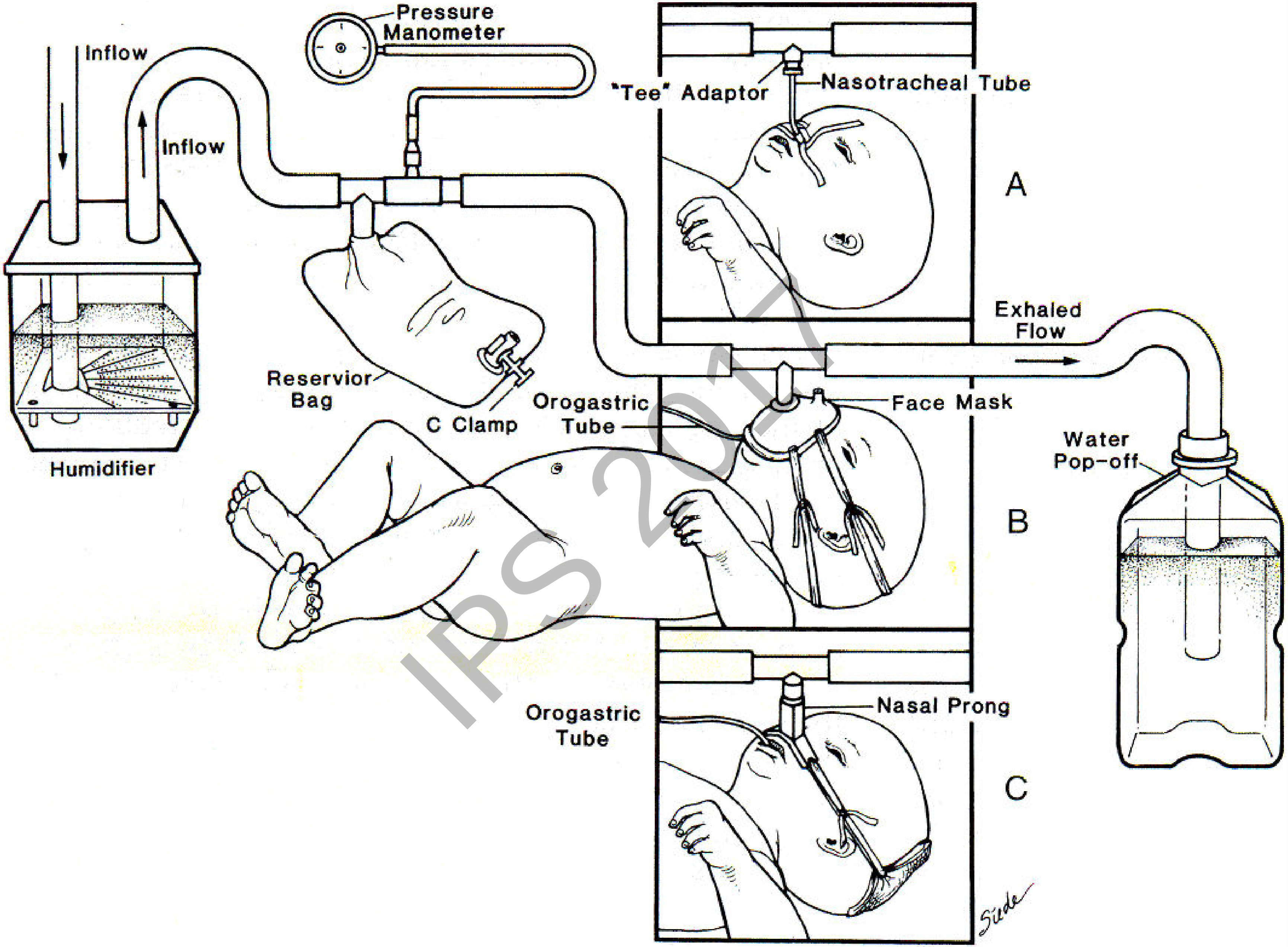
5. Severe cardiovascular instability.

"Bubble" nasal continuous positive airway pressure system

CPAP delivery systems

The CPAP delivery system consists of three components:

the *circuit* for continuous flow of inspired gases, the *interface* connecting the CPAP circuit to the infant's airway, and a *method of creating positive pressure* in the CPAP circuit.



Pressure Manometer
Inflow
Inflow
"Tee" Adaptor
Nasotracheal Tube
A
Humidifier
Reservior Bag
C Clamp
Orogastric Tube
Face Mask
Exhaled Flow
Water Pop-off
B
Orogastric Tube
Nasal Prong
C

The amount of CPAP may be varied by a change in the amount of gas flow into the system or by the amount of obstruction to the outflow (5 cm of fluid level in the case of bubble nasal CPAP).

Many techniques are available to deliver CPAP

Nasal cannulae

Face masks

Nasal prongs

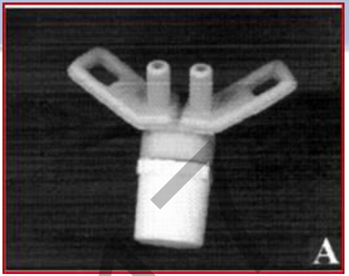
Nasopharyngeal tubes

Head box with nasal seal

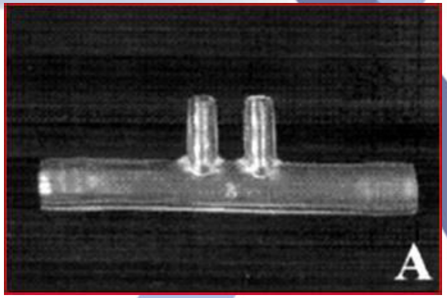
& Endotracheal tubes.

Types of prongs

- Argyle



- Hudson



- Inca

- Fisher & Paykel

- EME

- Others

CPAP Pressure Generators

- Ventilator CPAP
- Flow Driver CPAP →
- "Bubble Bottle" CPAP →
- Others

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Bubble Nasal CPAP

Why "Bubble" Bottle CPAP?

- Cheap
- Readily available
- Effective Oscillation/vibration may contribute to effect (15-30 HZ)*

***Nekvasil et al, 1992. Pillow and Travadi, 2005. Lee et al, 1998**

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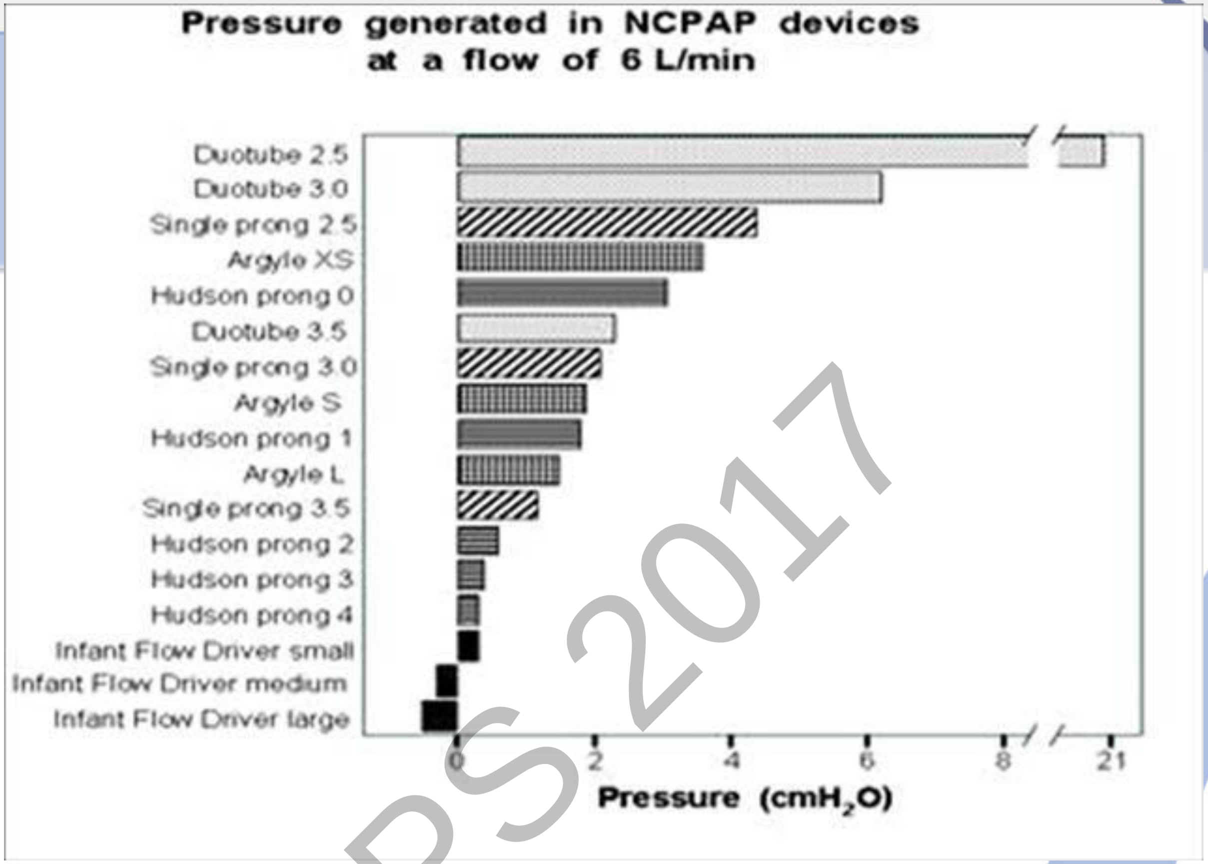
Nasal Prong Interface

What to use?



De Paoli et al, Arch Dis Child Fetal Neonatal Ed 2002

- The higher the resistance, the lesser the pressure transmitted through the prongs to the nose of the baby.
- Hudson prongs and the infant flow driver have the least resistance to flow.

Advantages and disadvantages of Nasal Prongs CPAP

Advantages	*Disadvantages*
Easy to apply; flexible and enable change in infant's position; low airway resistance, easily controlled, stabilized and eliminates need for intubation.	Nasal septal erosion or necrosis; nasal obstruction from secretions or improper position of CPAP prongs; abdominal distension from swallowing air.

Polin and Sahni, Seminars in neonatology 2002

- Building the Bubble Bottle NCPAP Delivery System
- Initiating Bubble Bottle NCPAP Delivery System
- Care of the Infant on NCPAP

Building the bubble CPAP apparatus

Bubble CPAP Delivery System

Preparation (1)
Gather the following equipment

- Oxygen/Air flow sources
- Oxygen blender with flow meter
- Oxygen tubing to lead from the blender to the humidifier
- Oxygen analyzer (optional)
- Humidifier filled to the appropriate level with sterile water
- Corrugated circuit tubing with humidifier connections
- Humidifier temperature probe
- Nasal prong CPAP set

Preparation(2)
Gather the following equipment

- 500-1000 cc bottle of 0.25% acetic acid or sterile water
- 10cc syringe / 3 cc syringe
- Luer plug/prn adapter/Pressure tubing
- 4 small safety pins
- 2 small rubber bands
- Tegaderm
- Gauze swabs
- Paper measuring tape
- Tape- adhesive

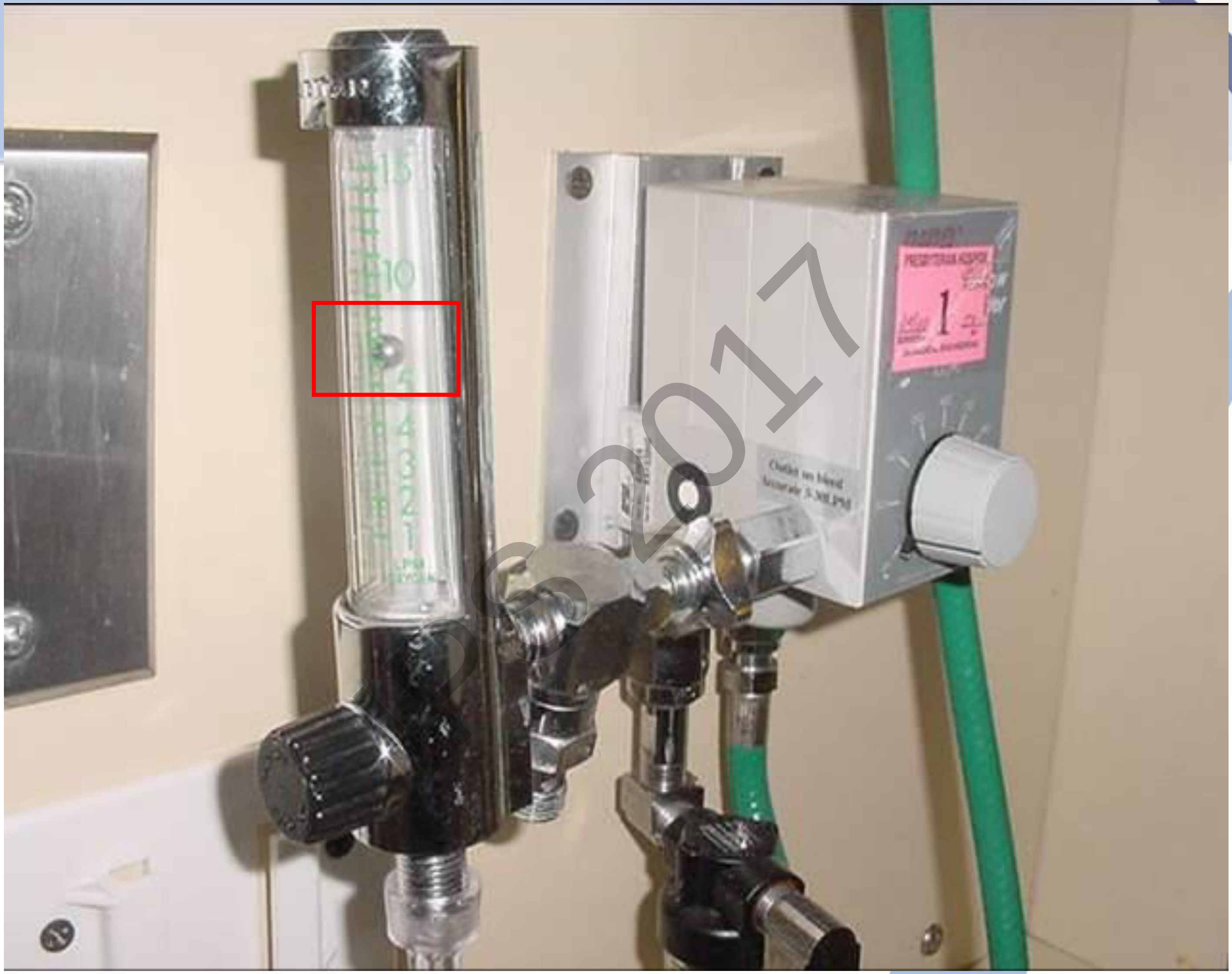
NASAL PRONG SIZE

size 0 for < 700 g
size 1 for 700-1000 g
size 2 for 1000-2000 g
size 3 for 2000-3000 g
size 4 for 3000-4000 g
size 5 for > 4000 g

For infants at the high end of any of the weight ranges, consider using the larger prongs appropriate for the next higher weight range

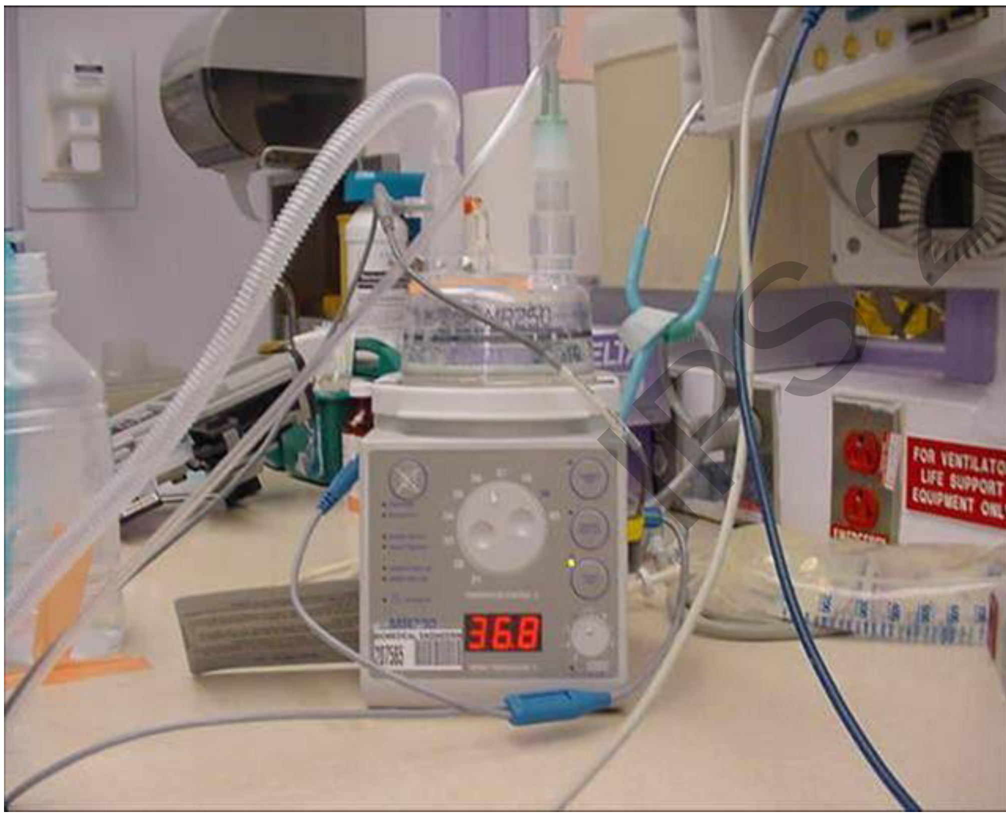
Nasal CPAP
Set up (1)

1. Attach the oxygen tubing to the flow meter and blender, and connect the tubing to the humidifier
2. Set the flow meter to deliver 5 – 10 liters per minute



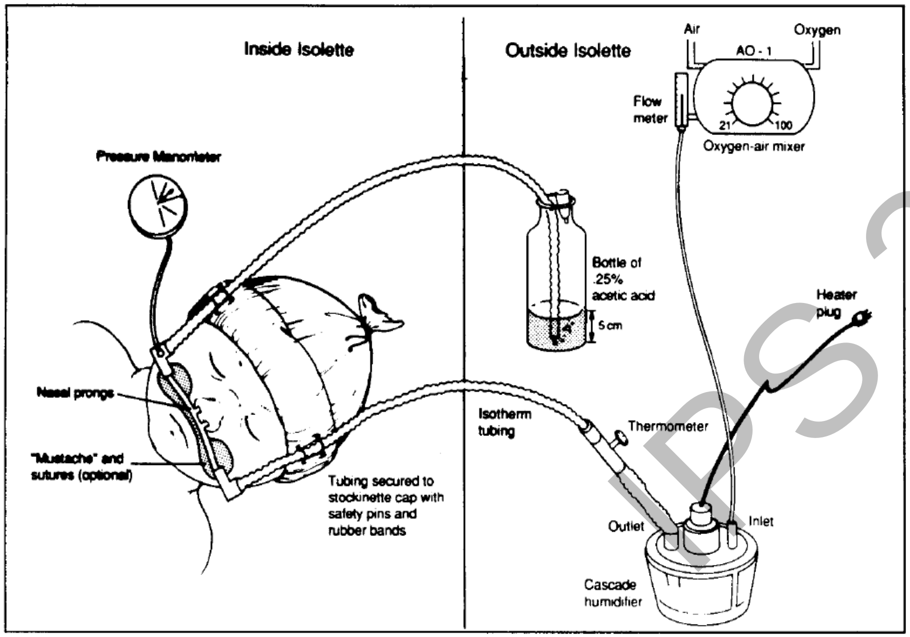
Flow 5 – 10 lpm

Nasal CPAP
Set up (2)



3. Turn on the humidifier, set the temp at 36.8 – 37.3 ^{o} C, and chamber temp.(-2)
4. Attach one corrugated tube to the humidifier

Nasal CPAP
Set up (3)



5. Connect the humidifier tube temperature probe to the corrugated tubing going to the baby
6. Choose appropriate size nasal prongs and attach them to the corrugated tubing

Nasal CPAP
Set up (4)

7. Attach corrugated circuit tube to the other side of prongs. Fix the Luer plug in place over the opening in the elbow of the prongs

Nasal CPAP
Set up (5)

7. Secure measuring tape to the outlet bottle containing 0.25% acetic acid or sterile water, with the 7 cm mark at the base
8. Empty fluid to the 0 mark

Nasal CPAP
Set up (6)

9. Place the end of the corrugated tube into the water to a depth of 5 cm to create 5 cm of CPAP
10. Fix the tubing in place by sliding the 10cc/3cc syringe (plunger removed) into the neck of the bottle


Colleague

KEY POINTS FOR MAINTAINING OPTIMAL NCPAP

- Correctly set up and maintain low resistance delivery circuit
- Securely attach interface
- Assure minimal pressure leaks
- Maintain optimal airway
- Prevent nasal septal injury
- Provide meticulous attention to details
- Resist the temptation to 'improve' the system
- Encourage committed and skilled caregivers

CIRCUIT MAINTENANCE

- Flow between 5-10 l/m (7-8 l/m)
- Humidification
- Corrugated tubing clear of excess rain out
- 5cm water pressure
- Change circuit (less nasal prongs) weekly.

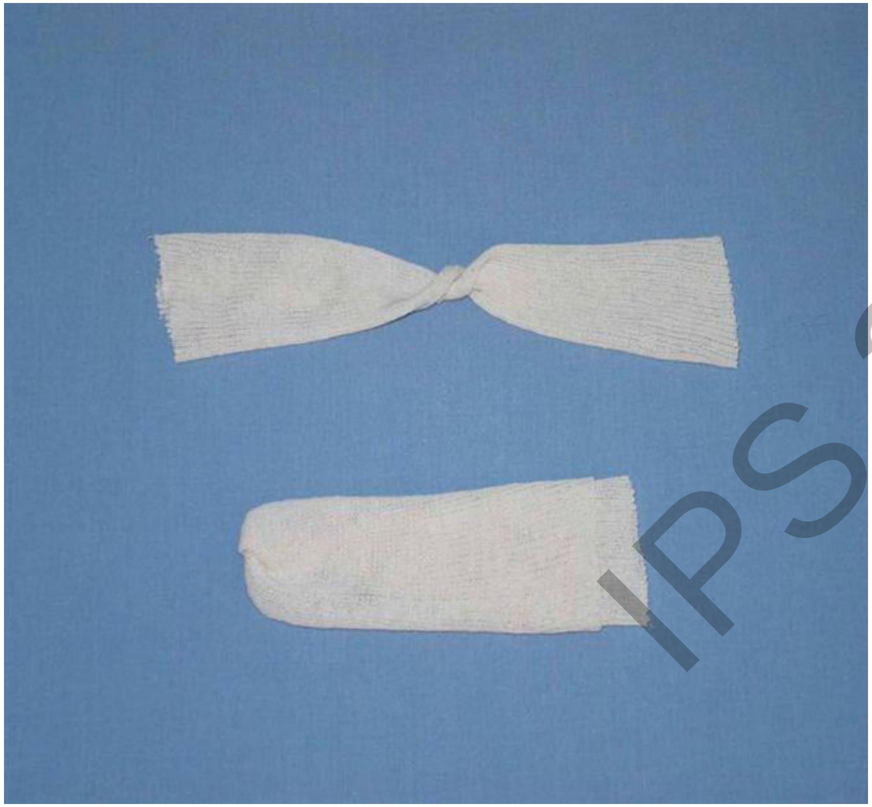
Maintaining Optimal Airway Care: Humidification

- Maintain adequate humidification of the circuit to prevent drying of secretions.
- Adjust settings to maintain gas humidification at or close to 100%.
- Set the humidifier temperature to 36.8-37.3° C.

Securely attached interface

- Snug fitting hat
- Snug fitting nasal prongs
- Velcro moustache
- Chin strap

STOCKINETTE HAT



SECURING THE HAT

VELCRO MOUSTACHE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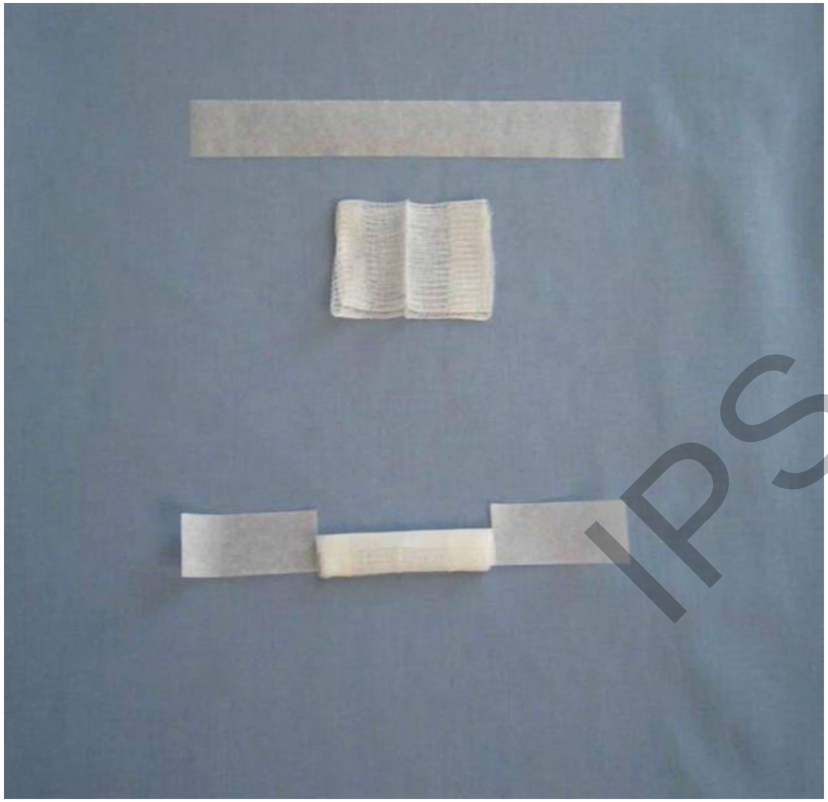
MINIMIZE PRESSURE LEAKS

- Snug fitting prongs
- Closed mouth
- Velcro moustache

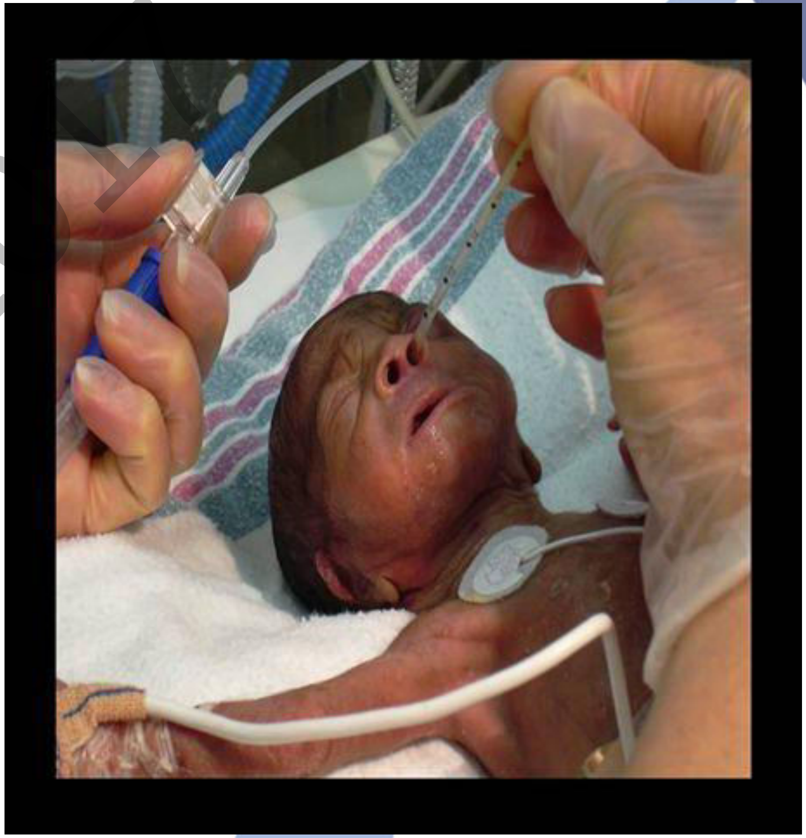
CHIN STRAP



OPTIMAL AIRWAY

- Effective upper airway clearance
- The 'sniff' position
- Suction
- Humidification
- If in doubt, Suction!

SUCTION



Maintaining Optimal Airway Care: Suctioning

- Suction the mouth, nose and pharynx

q 3 hr

- For symptomatic infants more frequent suctioning may be needed

Maintaining Optimal Airway Care: Suctioning

- Moisten the nares with normal saline or sterile water to lubricate the catheter and loosen dry secretions.
- It may be necessary to pass the suction catheter more than once to ensure adequate airway clearance.

PREVENT NASAL SEPTAL INJURY

Nasal Septal Injury Is Absolutely Preventable

- Snug fitting prongs
- Secure hat
- Correct positioning and attachment of corrugated tubing
- Velcro moustache
- Careful, frequent observation
- Avoid gels, creams, shields
- Careful positioning of the infant

A CUSHION OF AIR IS THE BEST PROTECTION'

NASAL SEPTUM

METICULOUS ATTENTION TO DETAILS

- Use the checklist
- Start with a great hat
- Keep the airway clear
- Avoid shortcuts
- Think 'low resistance'
- Clinical assessment vs. lab values
- Monitor pre-ductal saturation

Care of the Infant on NCPAP

Success with NCPAP

NCPAP is successful when meticulous attention is paid to both the infant and to the NCPAP Delivery System. This involves vigilance in:

- Monitoring the infant' s condition
- Maintaining an optimal airway
- Maintaining a patent CPAP delivery circuit
- Prevention of complications which may arise from NCPAP

Monitoring the Infant's Condition

- Once NCPAP is applied, the infant's condition must be monitored frequently
- Observe the infant q 1 hr over the first 4 hours of life, and then q 3-4 hr thereafter while on NCPAP.
- Any infant experiencing significant respiratory distress while on NCPAP requires closer observation for change in condition.

Monitoring the Infant's Condition

Recommended monitoring:

- Respiratory status (RR, work of breathing)
- Pre ductal oxygen saturation
- Cardiovascular status (HR, BP, perfusion)
- GI status (abdominal distention, bowel sounds)
- Neurological state (tone, activity, responsiveness)
- Thermoregulation (temp)

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Prevent Complications

Complications associated with bubble nasal CPAP

Pneumothorax / PIE

- more in the acute phase

- not a contraindication for continuing CPAP

Nasal obstruction

-Remove secretions and check for proper positioning of the prongs

Nasal septal erosion or necrosis

-Keep prongs away from the septum

Gastric distension

Intermittent or continuous aspiration of the stomach

Feeding intolerance

Preventing Complications: Nasal Septal Injury

- Septal injury is preventable
- Damage to the septum arises when poorly fitted or mobile prongs cause pressure and/or friction.
- Excess moisture from gels, lubricants or duoderm-like products undermines the skin integrity.
- Avoiding these factors will maintain an intact septum

Preventing Complications: Nasal Septal Injury

To prevent damage to the nasal septum:

- Evaluate the nasal septum q 30-60 min.
- Use correct prong size
- Secure prongs in place correctly
- Use Velcro mustache

Preventing Complications: Nasal Septal Injury

To prevent damage to the nasal septum:

- Maintain distance of 2-3 mm between bridge of prongs and septum
- Avoid twisting of prongs
- Do not use creams, gels, ointments or adhesive barriers (Duoderm) on the septum


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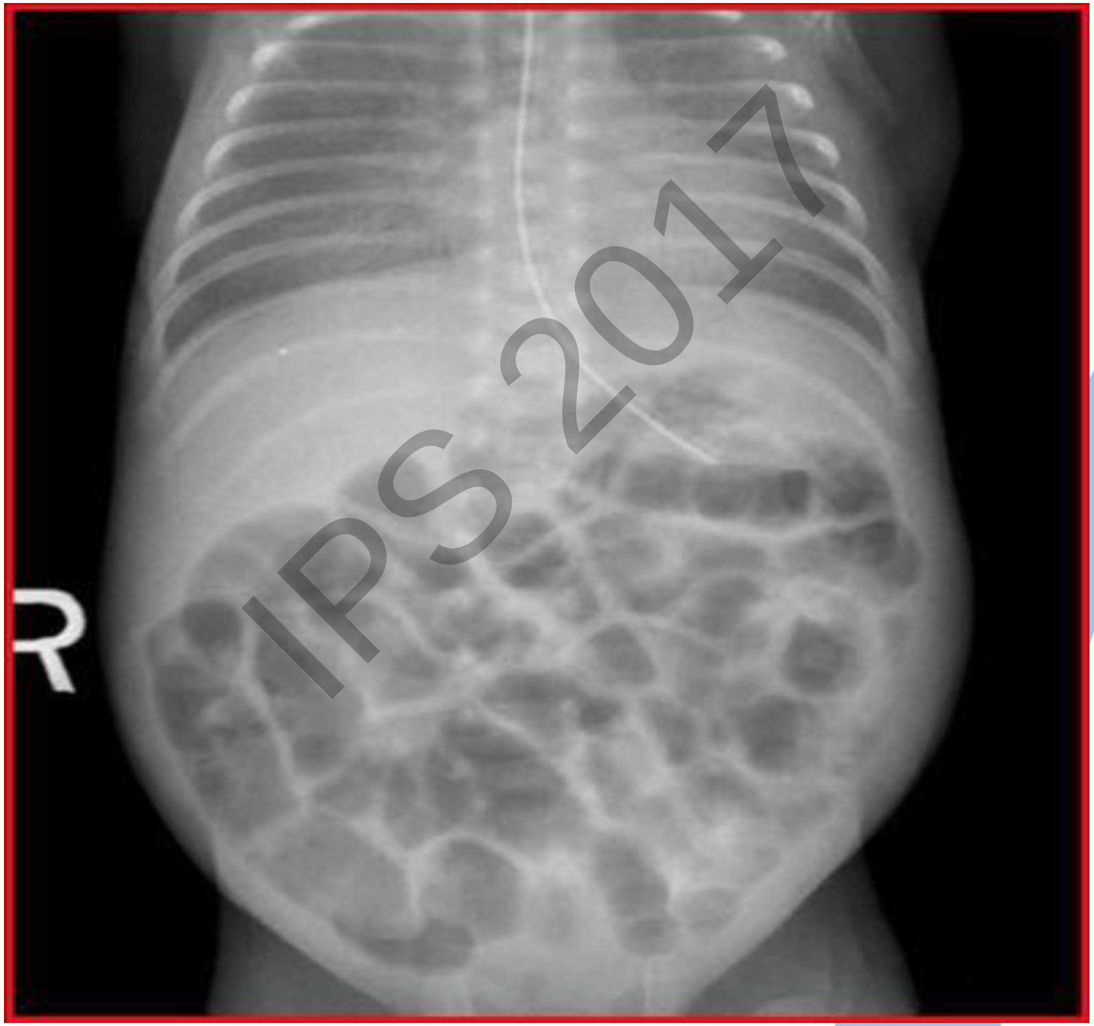
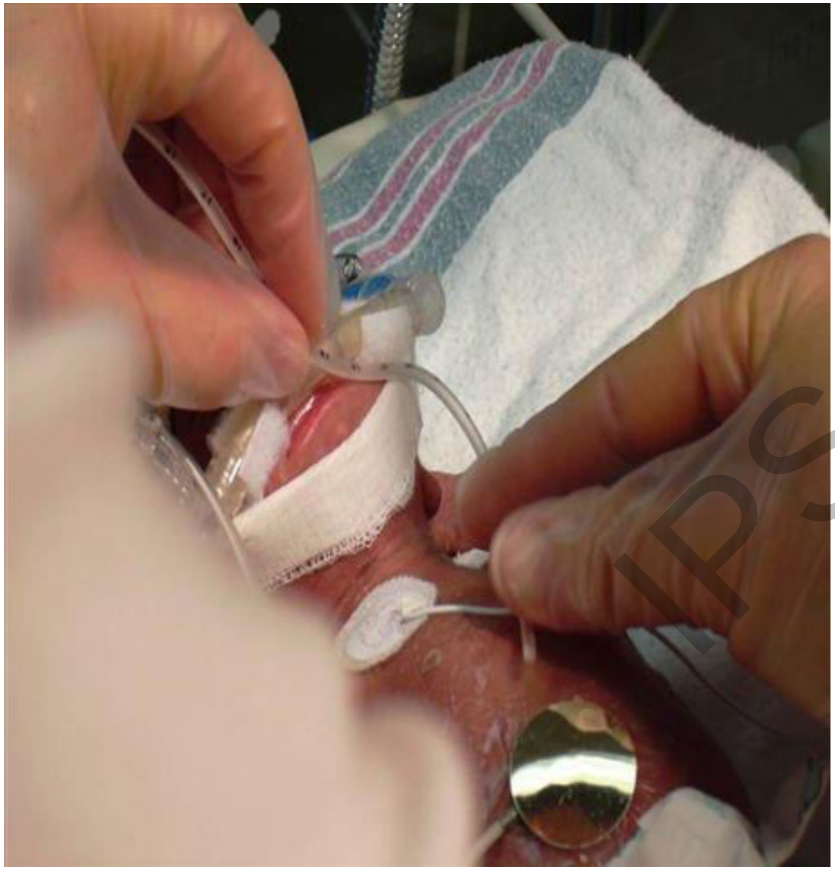
Preventing Complications: Gastric Distention

- NCPAP is not a contraindication to enteric feeding.
- Infants may experience mild abdominal distention during NCPAP delivery from swallowing air.

CPAP Belly



Preventing Complications: Gastric Distention



To prevent gastric distention:

- Assess the infant's abdomen regularly
- Pass an oro-gastric tube to aspirate excess air before feeds q 2-4 hr
- An 8 Fr oro-gastric tube may be left indwelling to allow for continuous air removal

Preventing Complications: Gastric Distention

To prevent gastric distention:

- If feeding continuously consider venting the tube q2hr.
- Place the infant prone with knees under the chest to relieve gastric pressure and encourage passing of stools and flatus.

Preventing Complications: Pneumothorax

- Pneumothorax, if occurs, is likely to occur during the acute phase of respiratory distress
- Pneumothorax is usually not due to NCPAP and is not a contraindication to continuing NCPAP

Positioning While on NCPAP

- The infant on NCPAP may be positioned supine, prone, or side lying
- When positioning supine or side lying support airway alignment with a neck roll.

Positioning While on NCPAP

- When positioning prone place a chest pad under the infant.
- Make a firm pad using linen which is the same size as the infant's chest
- Do not use beanbags or gel pillows under the chest as these will not provide adequate support

Phototherapy While on NCPAP

- The infant may receive phototherapy while on NCPAP
- Place the eye patches over the eyes and secure them with paper tape to the tubing or hat
- Do not allow the eye patches to obstruct your view of the nasal septum and prongs

Evaluating the Performance of the NCPAP Delivery System

- The NCPAP system must be evaluated for optimal performance
- From the flow meter to the nasal prongs to the bubble bottle; check the entire delivery circuit
- Evaluate the system q2-3 hr

Evaluating the Performance of the NCPAP Delivery System

CHECKLIST FOR MAINTAINING CPAP

This checklist may be used daily to check the performance of the NCPAP delivery system.

Criteria	Criteria Met/Not Met	Additional Information
CIRCUIT AND BUBBLER:		
Blended air/oxygen gas supply		
Flow between 5-10 liters/min		
Humidifier temperature correct (36.8-37.3)		
Humidifier water level correct		
Oxygen analyzer correctly set		
Corrugated tubing correctly placed		
Excess rainout (afferent tubing) drained		
Excess rainout (efferent tubing) drained		
Gas bubbling continuously		
Water level at 5 cm H_2O		
INTERFACE:		
Nasal prong size correct		
Nasal prongs positioned correctly		
Hat fits snugly		
Mustache suitable and effective (if > 4 hr of age)		
Chin strap correct size and position		
Septum intact		
POSITIONING:		
Head position correct (if prone)		
Neck roll correct size and position if supine or sidelying		
MONITORING/SUCTIONING:		
Preductal oxygen saturation probe		
Documentation in nurse's record of q3-6 hourly nasal/oral suction as appropriate		

- Use a bedside Checklist that lists the key points necessary to maintain effective CPAP.

Respiratory Failure on NCPAP

If an infant develops symptoms of respiratory failure on NCPAP then one or more of the following may apply:

- The infant is not receiving effective CPAP
- CPAP is not sufficient to treat the infant's respiratory disease
- An underlying condition is contributing to the infant's respiratory failure

Respiratory Failure on NCPAP

Take the following steps PRIOR to intubation:

- Evaluate the infant's condition
- Check that the CPAP delivery system is functioning correctly
- Optimize the airway (suction, reposition)
- Consider contributing factors
- ? Increase CPAP pressure to 7cm water

Respiratory failure on CPAP

1) Symptoms:

- Significant apnea
- Respiratory failure (PCO_2 >65 mmHg)
- Progressive hypoxemia
- Severe respiratory distress

Procedures prior to intubation:

- Evaluate the infant's clinical condition: Is the clinical condition compatible with the blood gas evaluation?
- Check the NCPAP delivery system for proper functioning: Is the system bubbling properly? Are air leaks by mouth and nose minimized?
- Suction the infant and reposition the nasal prongs: Are the nares obstructed? Are the prongs the correct size and position?
- Increase the CPAP to 7 cm H20: Does the infant respond to higher pressure?

If the infant continues to show evidence of respiratory failure.........then, intubate.

CHECKLIST FOR EVALUATING CPAP DELIVERY SYSTEM DURING RESPIRATORY FAILURE

Please complete this checklist on all study infants receiving bubble NCPAP who are experiencing respiratory distress and failure. This checklist must be completed prior to removing the infant from NCPAP for intubation.

Date: Time: Name: [redacted]

Criteria	Criteria Met/Not Met	Additional Information
Nasal prong size correct		
Nasal prongs positioned correctly		
Hat fits snugly		
Corrugated tubing correctly placed		
Mustache suitable and effective (if > 4 hr of age)		
Neck roll correct size and position if supine or sidelying		
Chin strap correct size and position		
Head position correct (if prone)		
Gas bubbling continuously		
Airway suctioned		
PEEP increased to 7 cm H_2O		
Infant's clinical condition consistent with definition of respiratory failure AFTER these measures taken		
Oxygen requirement: **Blood Gas Values:** **Date/Time Obtained:**	FiO2: __________ PH: __________ PaO2: __________ PaCO2: __________ Date/time: ________________	

WEANING FROM CPAP

When to Wean

- If less than 7 days old, must meet all of the following criteria:
  - F_iO_2 0.21
  - No respiratory distress
  - No significant apnea/bradycardia episodes
- If more than 7 days old
  - At discretion of the neonatal team

WEANING FROM CPAP

How to Wean

- Strategy (none tested/proven to date)
  - Remove from CPAP…..??
  - Cycle off (e.g. 1 hour off, 2 hours on, increase time off progressively)

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Bubble nasal CPAP is to be removed completely and not weaned when the infant has met the criteria for removing the CPAP

Indications for removal from NCPAP are:

- Infant is > 72 hours post extubation
- Infant is stable in room air with oxygen saturations >90%
- Infant has no evidence of tachypnea or retractions
- Infant has minimal to no apnea or bradycardia events

Procedures for removal of NCPAP

* The infant's nose and mouth should be suctioned thoroughly prior to, and after removal of NCPAP.

* The infant is carefully monitored after removal of the NCPAP for evidence of tachypnea, retractions, or increased apnea and bradycardia.

* The infant is suctioned every 6 hours for the first 24 hours after the removal of NCPAP.

Indications for reintroducing NCPAP

If the infant develops frequent apnea and bradycardia episodes, tachypnea or retractions, the nasal CPAP is reintroduced.

The more you do it, the better you get at it. And the better you get, the easier you will feel.

Intubating them is easy. Getting and keeping them off the ventilator is the challenge!

THANKS

Any Questions


Thank You
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Any Questions?