Non-Invasive Oxygenation and Ventilation in Acute Critical Illness

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Disclaimer

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Goals

Physiology

Evidence

Indications

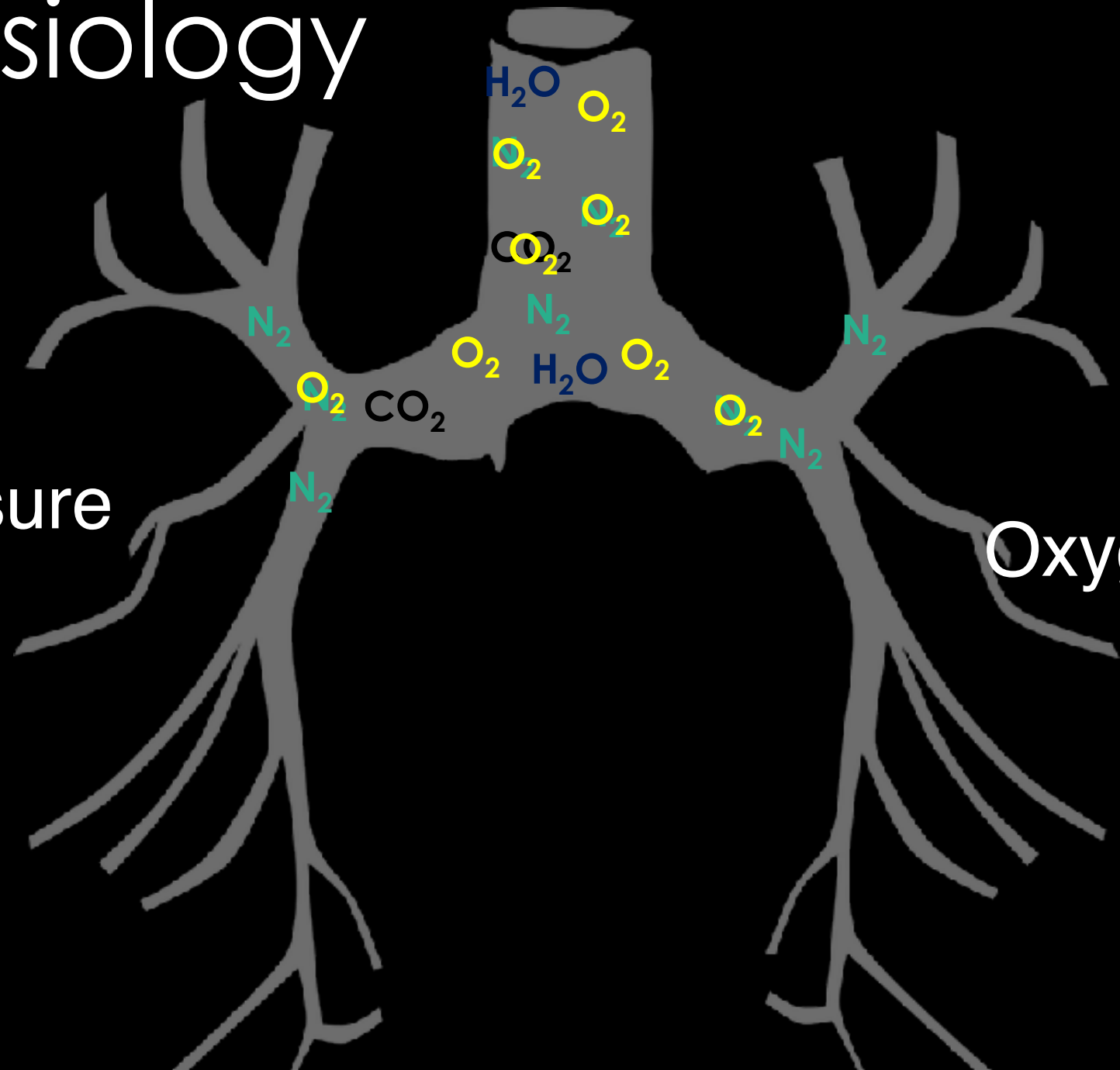
Questions To Answer

- Who does better on **CPAP vs. BPAP Vs. HiFlo O2?**
- **When should we intubate** people on NIV?
- Is NIV for Pts **with hypoxemic** respiratory failure?

Which Patients Can Get NIV

Memorial General Hospital Tracking Board				
Room	***Chief Complaint***	***Age***	***Sex***	***Triage***
1	HTN/CHF/SOB	55	M	2
2	DNR/DNI SOB from home	82	F	3
3	FEVER+SOB S/P lung Transplant	66	F	3
4	Fever/cough decreased feeding	8 MO	M	3
5	Fever SOB/CD4 <200	47	M	3
RESUS1	EMS: COPD/Resp distress	70	M	2
RESUS2	EMS: Sepsis/Resp distress	72	F	2
TRAUMA1	SOB multiple Rib fractures	64	M	3

The Physiology



Positive pressure

Oxygenation

NIV Comes in Different Flavors

CPAP/Bubble CPAP

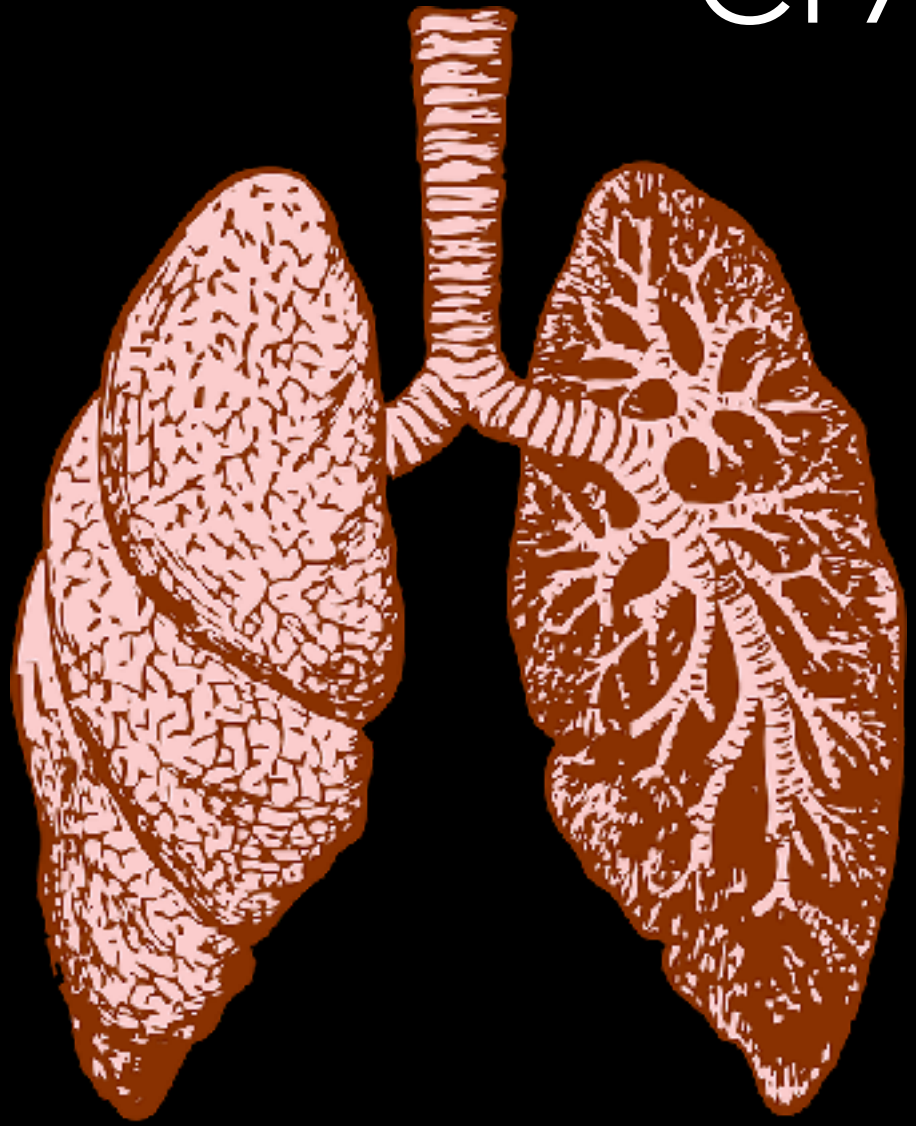
HiFlowO2

BiPAP

NIV Benefits

- ***Prevents:***
  - Ventilator related complications
  - Mortality In peds + adults
- ***Improves:***
  - Outcomes in COPD and CHF
- **Hypoxemic RF:**
  - Evidence supports HiFLO O2

CPAP: How it Works



Stented airways

↓

⇑Recruitment

↓

⇑FRC+Alveolar SA

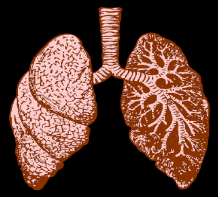
↓

⇑V/Q + ⇓WOB + ⇑O2

- CPAP=EPAP=PEEP

BPAP/Bi-Level vs CPAP

Inspiration



Expiratory PAP
(CPAP)

Inspiratory PAP
(PSV)

Expiration

IPAP-EPAP = Driving Pressure

What's different about BPAP/Bi-Level?

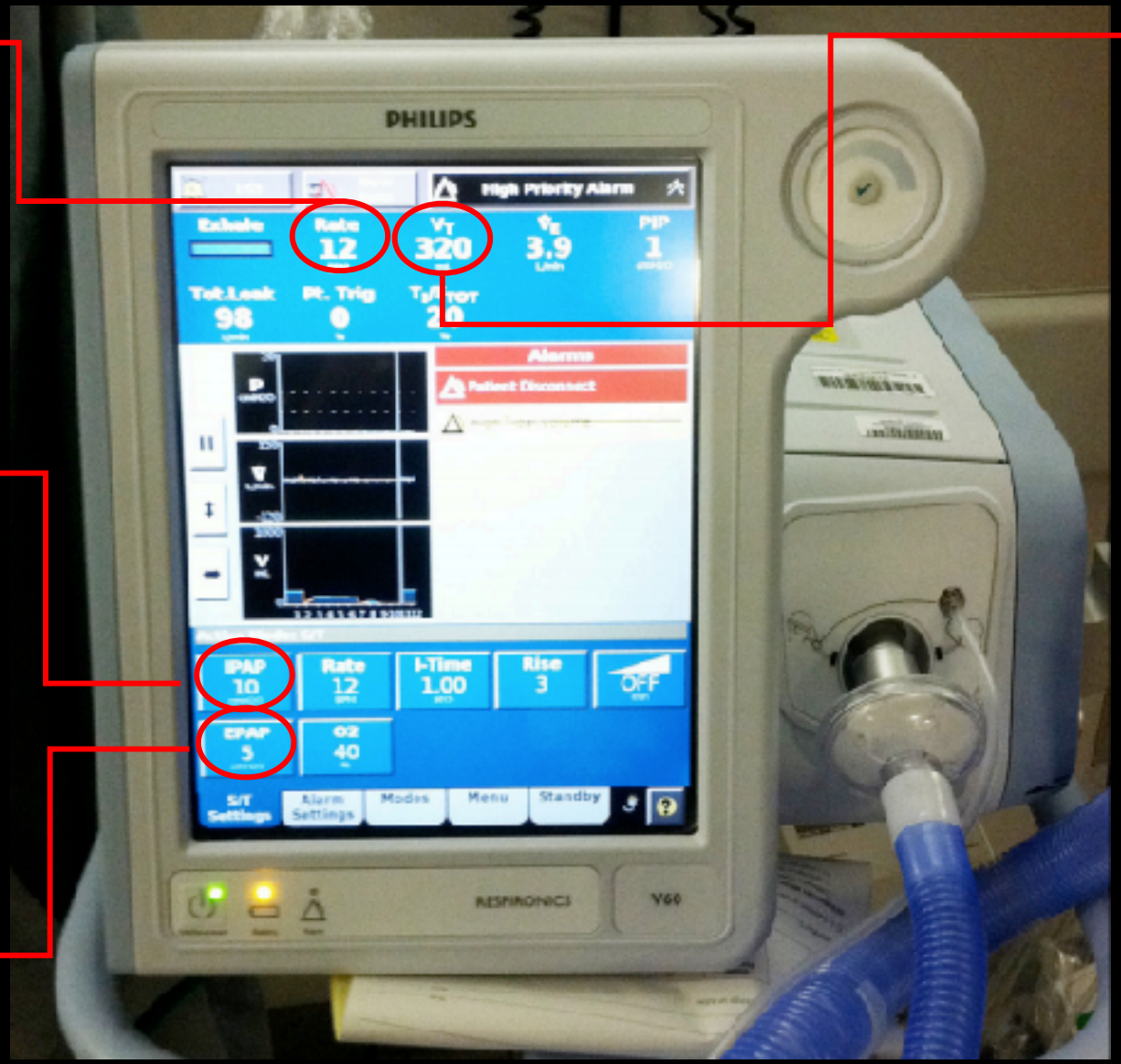
- Adds IPAP: pressure above PEEP
- Decreases dead space
- **Improves oxygenation and CO_2 clearance**

Torres, J and Radeos, M EMCC, 2011

Pressure Settings

- CPAP
  - Start 1cm H20/10Kg
- BPAP:
  - IPAP: 2X CPAP
  - IPAP Max: 25
- Repeat ABG in 1 hr :
  - + 2CmH2O if PaCO2 > 50

Equipment



Torres, J and Radeos, M EMCC, 2011

Equipment

Mask

Helmet

Boussignac

Torres, J and Radeos, M EMCC, 2011

Contraindications

Absolute

Relative

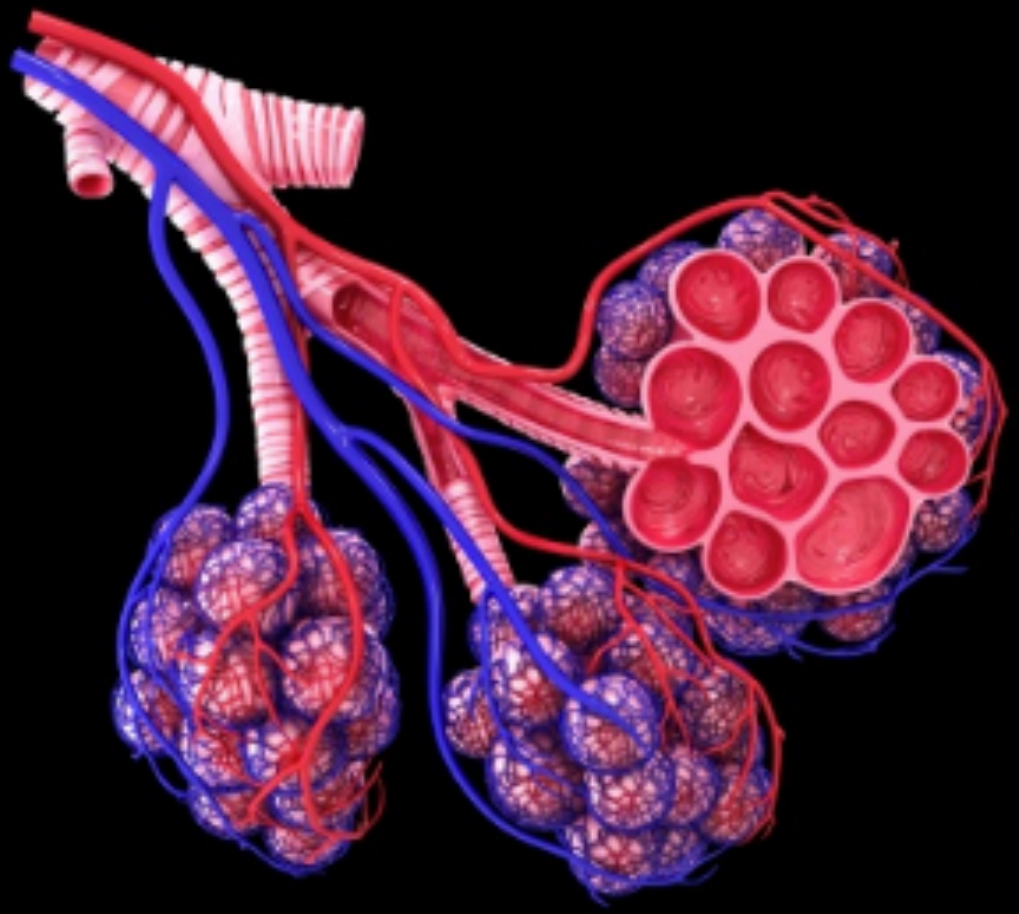
Low O_2

CPAP v. BiPAP: Disease Specific Pearls

- <u>CHF:</u>
  - CPAP better than BiPAP
- <u>COPD:</u>
  - BPAP preferred

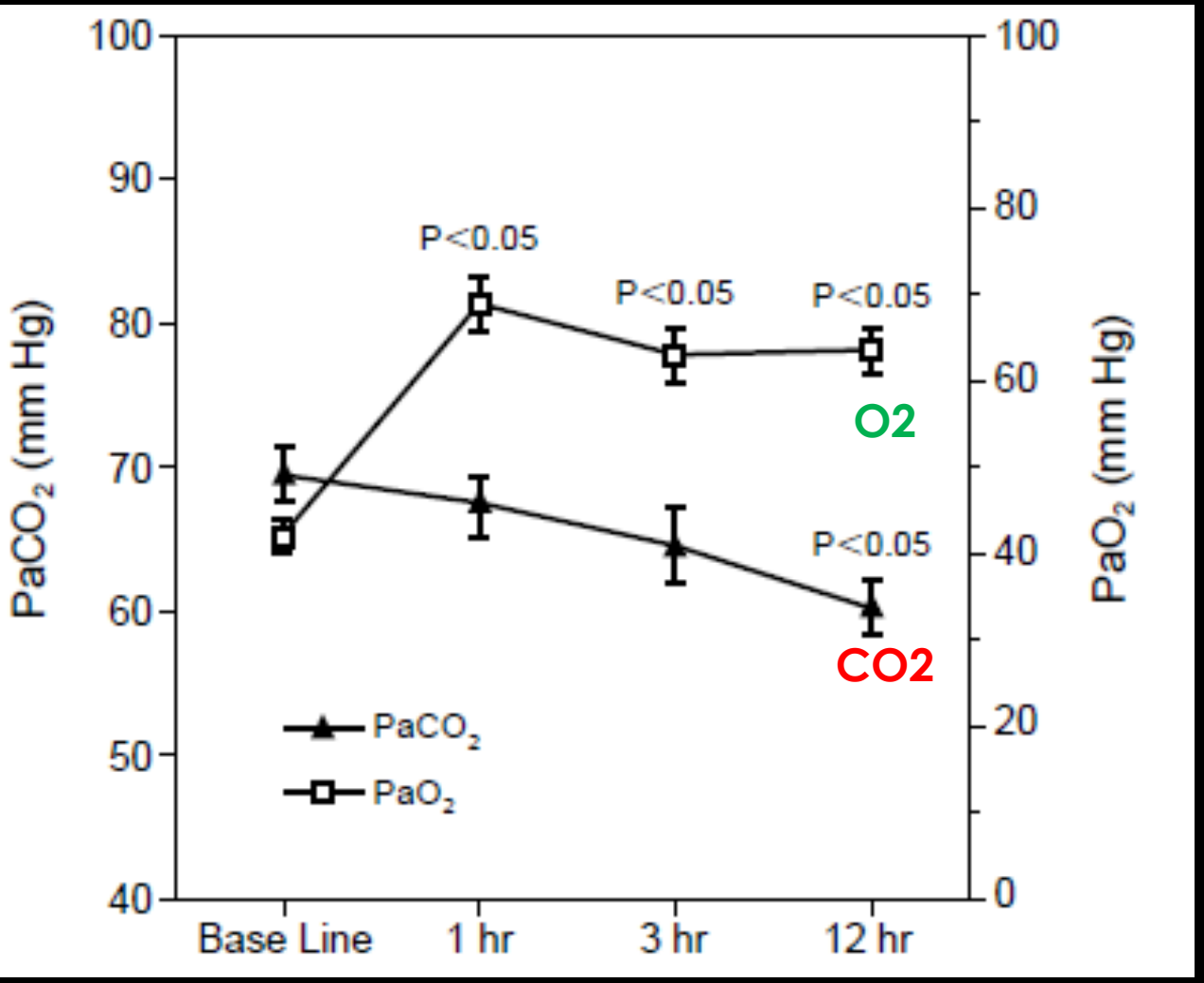
NIV IN COPD

How PAP Works in COPD



- Overcomes loss of pulmonary elasticity
- Improved gas exchange
- Less hypercapnia

BPAP in COPD: Decreased WOB



- **Reduces WOB** via:

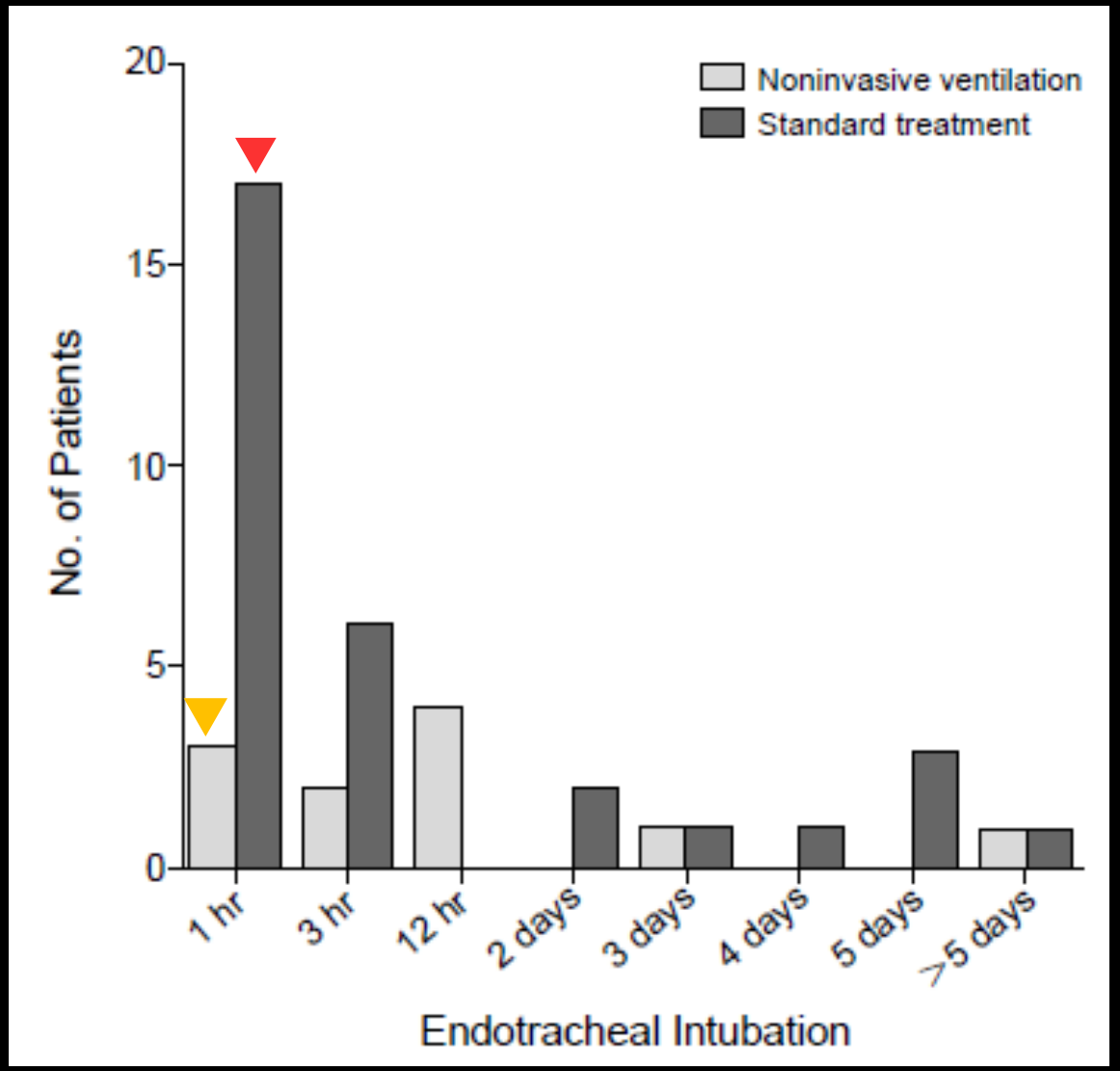
⇓⇓PaCO2

⇑⇑PaO2

⇓⇓RR

Brouchard et Al, NEJM 1995

Intubation in COPD: NIV Vs. O2 + RX



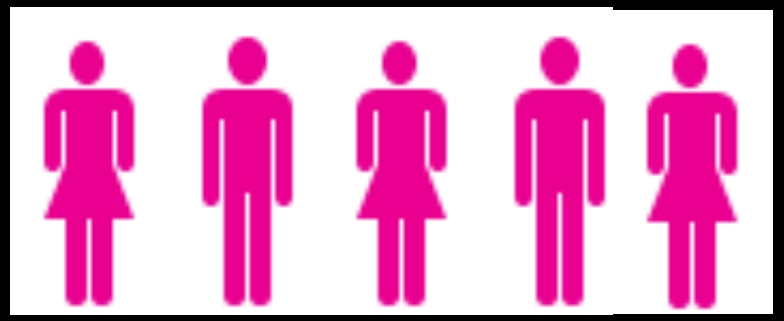
O2 +RX: **74%**

PAP+RX: **26%**

Brouchard et Al, NEJM 1995. Multicenter RCT

NIV Vs. Usual Care: Metadata

Treatment Failure
(N=529)



NNT=5

Mortality
(N=523)

NNT=8

Intubation
(N=546)

NNT=5

Lightowler et Al BMJ 2003

Predictors of Failure on BPAP

- At Presentation-1Hr: [1,2]
  - pH <7.25
  - HR > 120
  - RR>30

- Markers at > 1Hr:
  - Similar
  - Persistent RR >30[3]

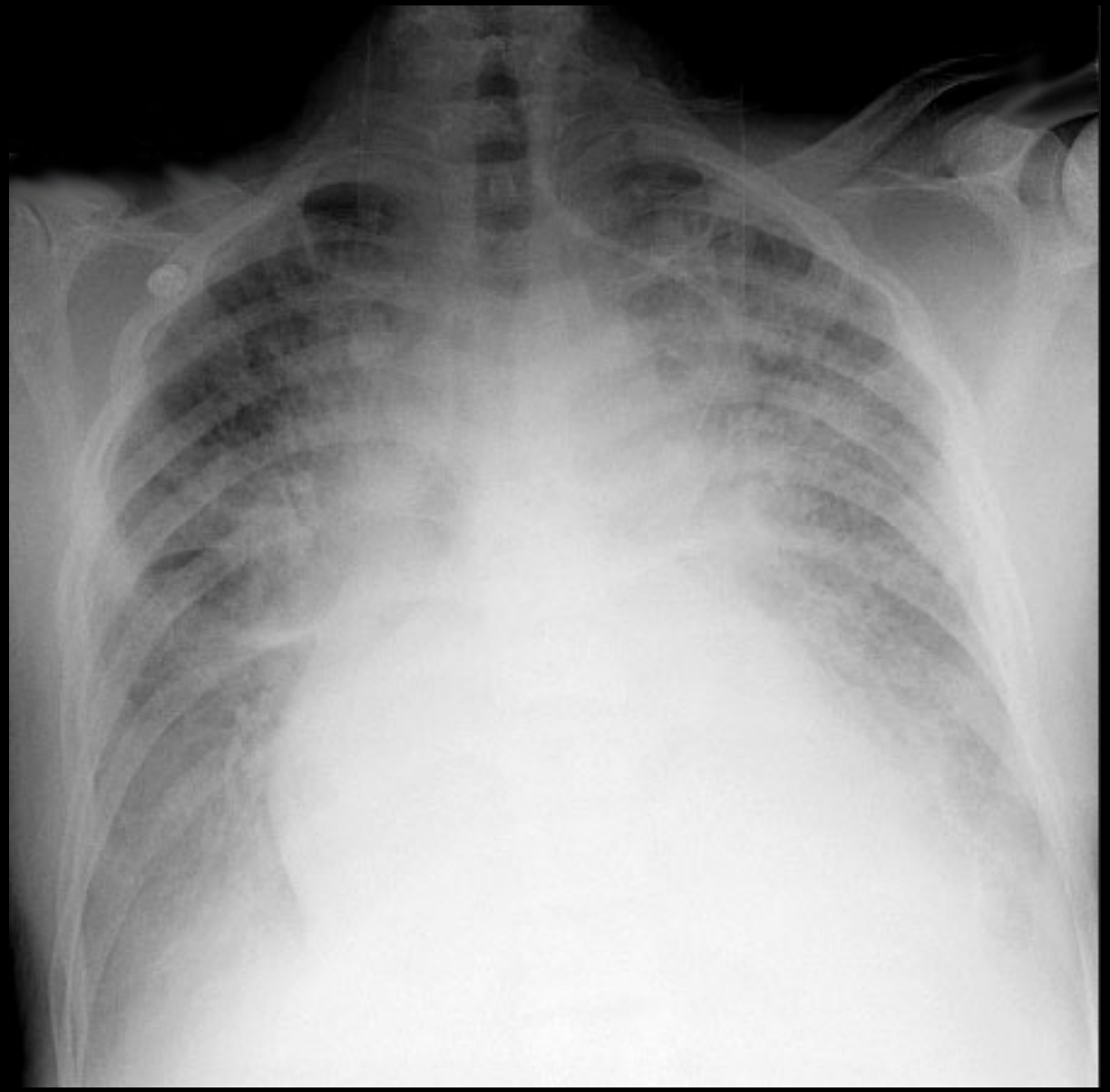
- At any time:
  - GCS <14/AMS[3]

1. Murugan Et al. IJSS 2015
2. Ko Et al. IEMJ 2015
3. Anton Et Al, 2003

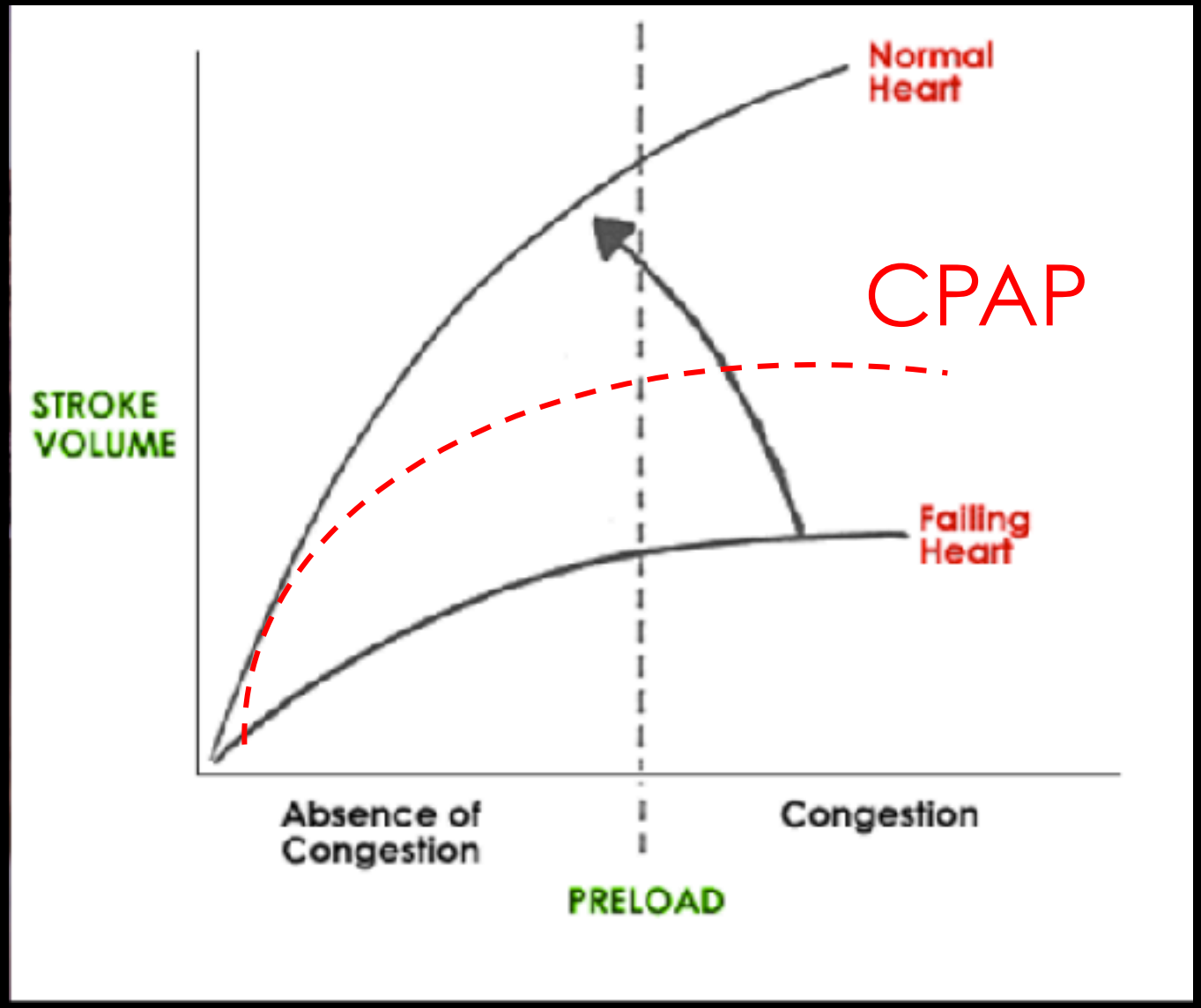
NIV in COPD

- Prevents
  - Intubation (NNT = 5)
  - Mortality (NNT=8)
- BPAP is Best
- Predictors of failure
  - PH < 7.25-7.3
  - AMS
  - RR>30-28

NIV for Heart Failure



NIV Indirectly Augments SV



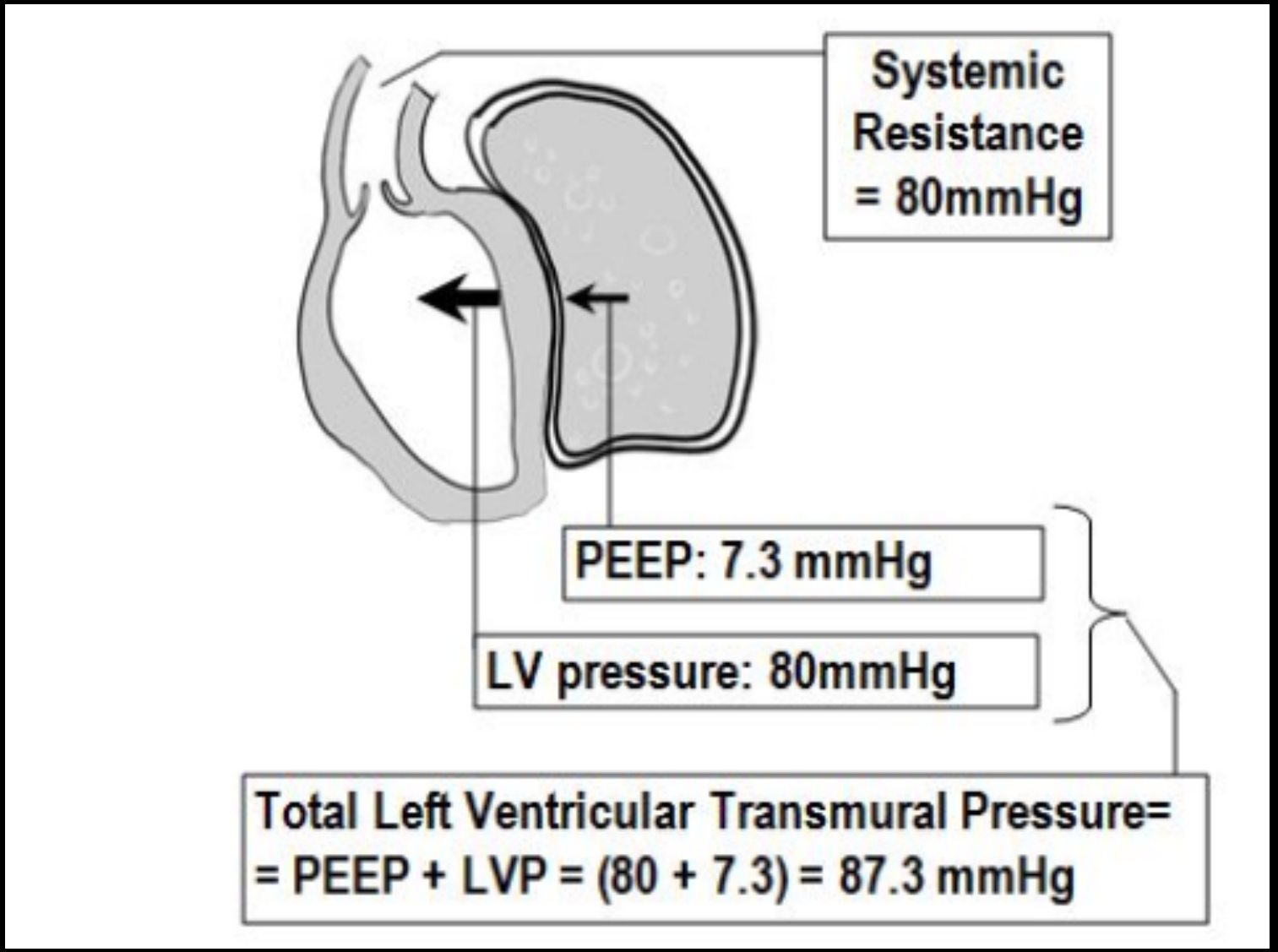
⇑⇑Intrathoracic pressure

⇓⇓Preload

⇓⇓Blood to LV

Optimized Frank-Starling

NIV and the Left Heart



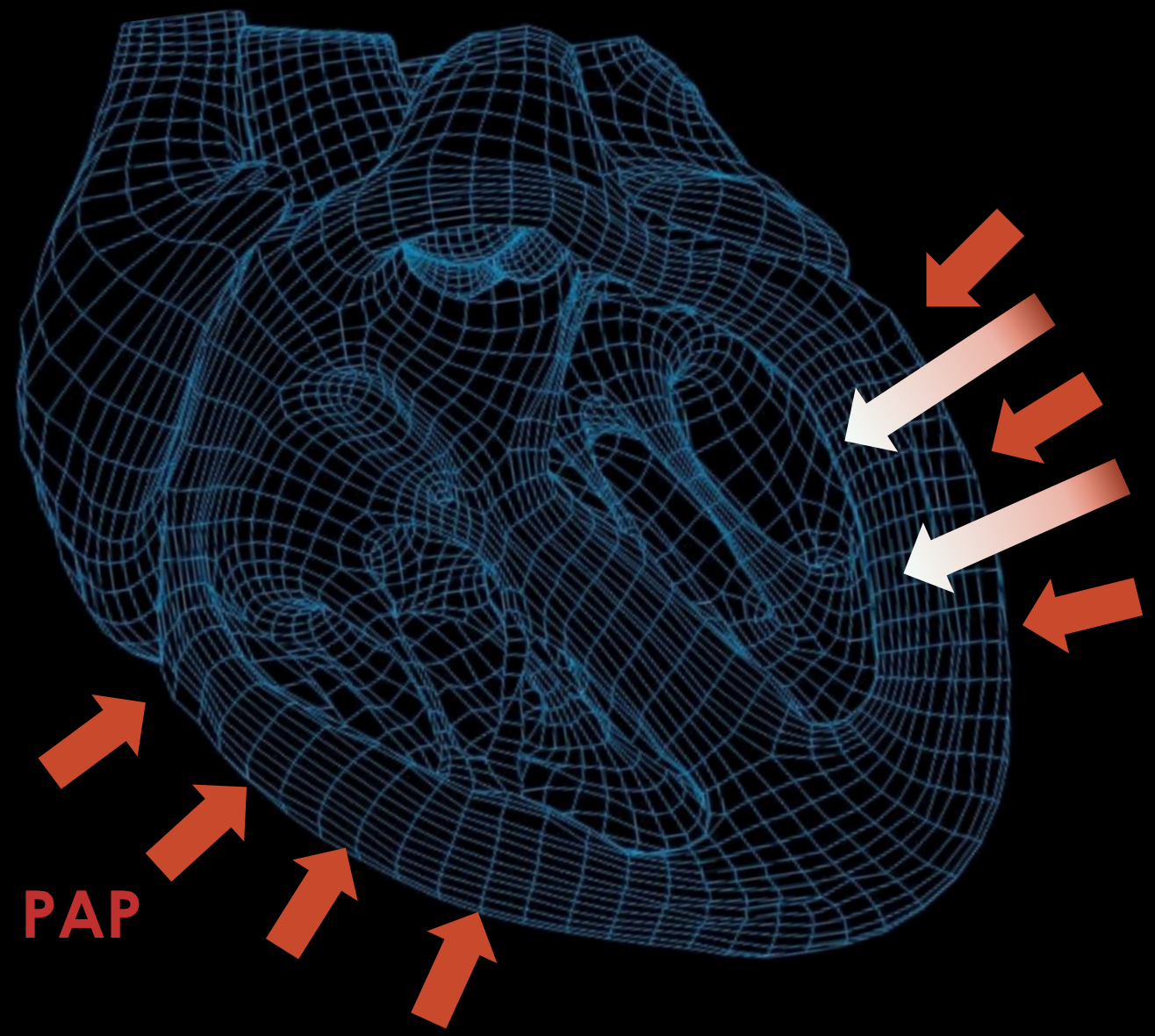
- ⇑PEEP = ⇑pTM

- **⇑pTM overcomes afterload**

NIV and Cardiogenic Pulmonary Edema

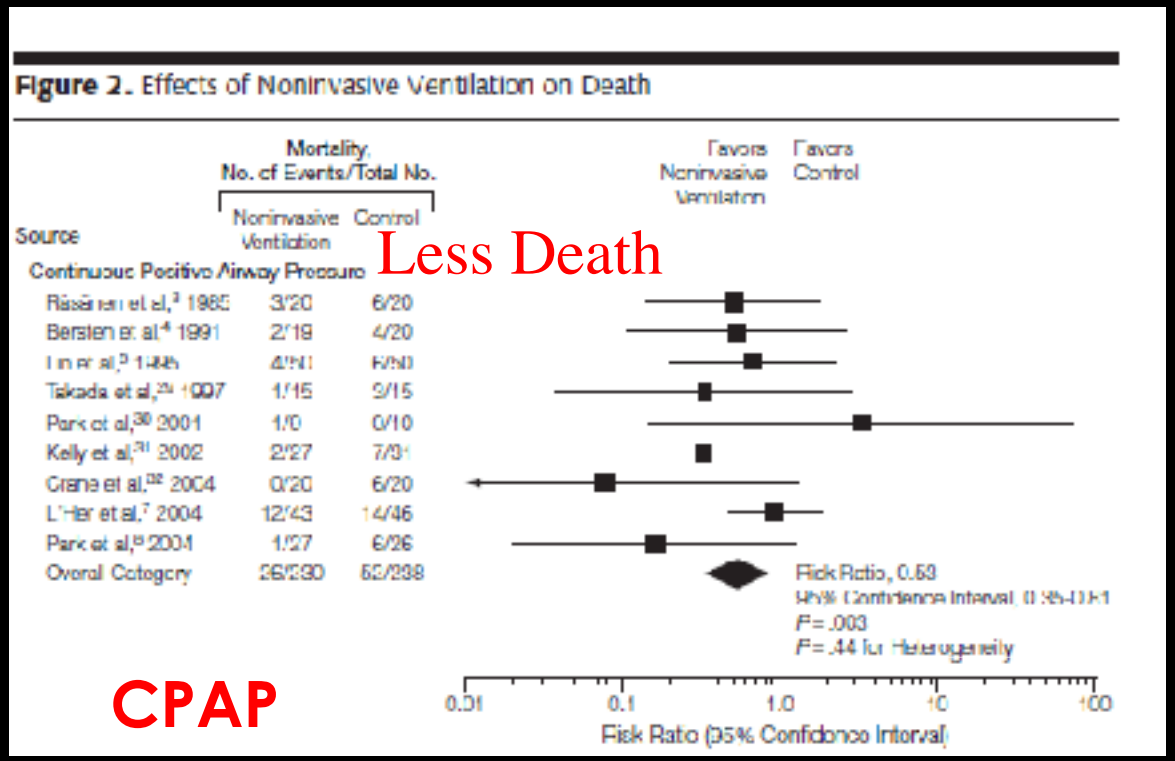
Decreased PHTN

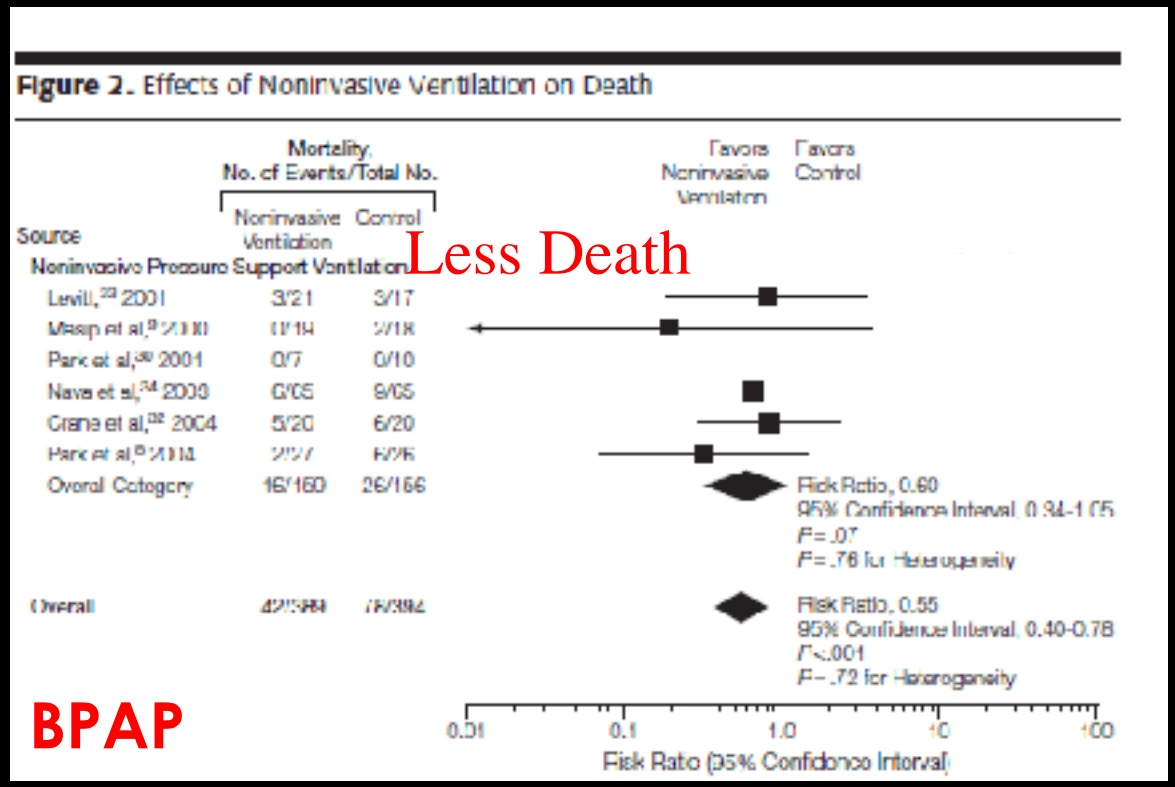
Decreased Preload



- **Afterload Reduction**
- **Decreased Work**

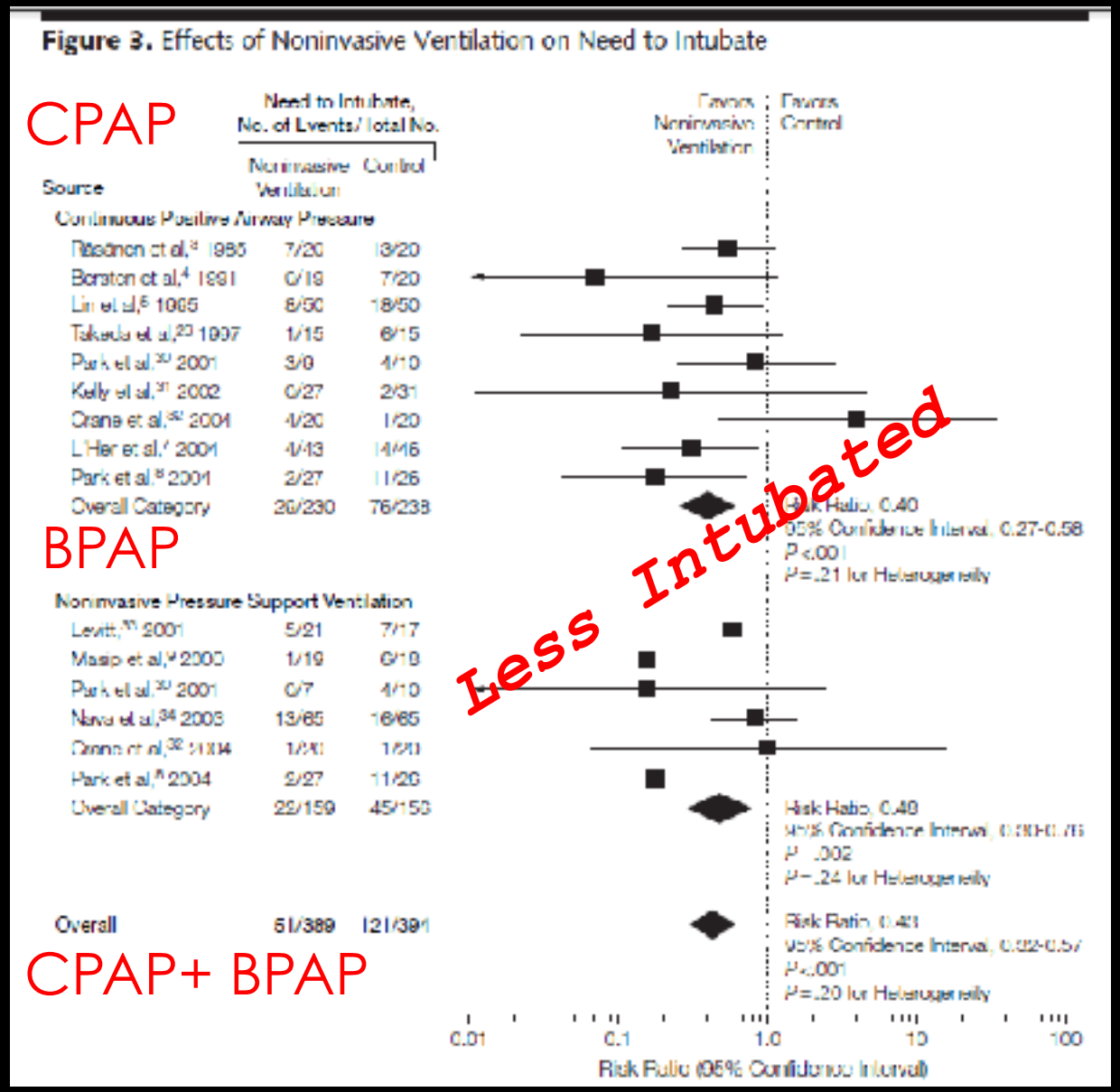
NIPPV Prevents Death in CHF





Masip et Al JAMA 2005

NIPPV Prevents Intubation in CHF



Masip et Al JAMA 2005

Is CPAP Safer Than BPAP in CHF?

- Increased mortality in B-PAP group 2/2 MI
- Issues in methodology and randomization

Mehta et Al 1997

BiPAP is safe in CHF

- RCT: No risk of MI vs. CPAP (1)
- Meta Analysis: No mortality difference (2)

1: Belone et Al CCM 2004
2: Li et Al AMJEM 2013

Conclusions: CHF

- B/CPAP may be used for acute heart failure
- BiPAP = MI have never been replicated in the literature
- CPAP = BiPAP w/ regard to mortality

Other Emergent Indications

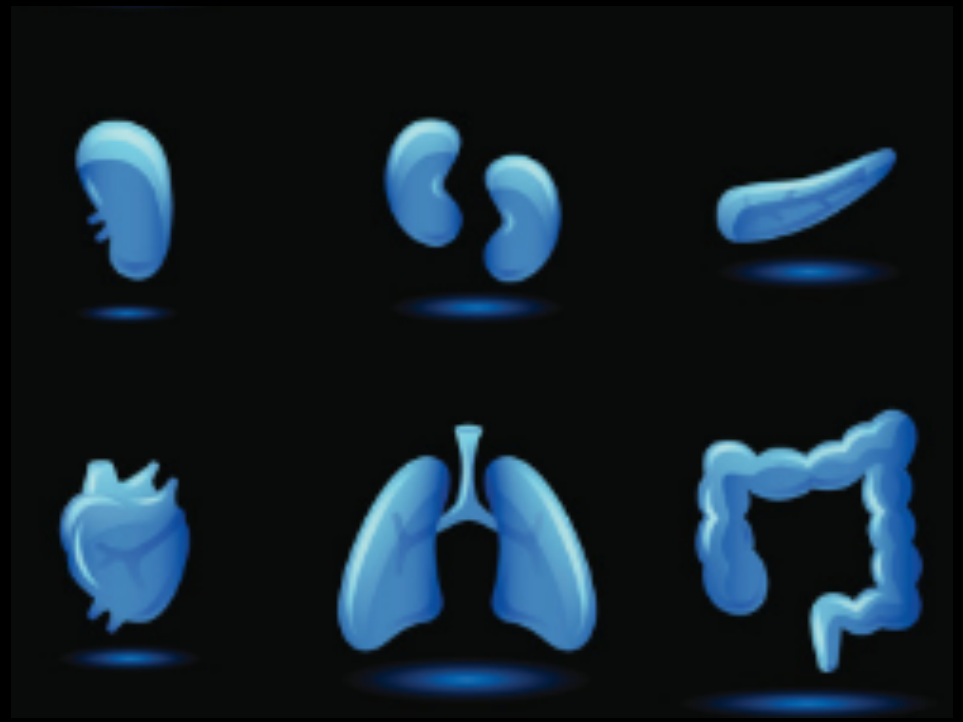
- Asthma
- Immunocompromised
- Palliative care
- PNA?
- Kids?

What About Asthma?

- BiPAP V. standard therapy for asthma
  - FEV1: 80% vs. 20% Improved
  - Hospitalization: 18% vs 63%
- Bottom Line: BiPAP is efficacious and safe but needs more research

Soroksky Et. al, Chest 2003

Reduced Intubation and Death in Immunocompromise



Antonelli Et al. 2000 JAMA

Hilbert Et al. 2001

What About NIV for ARF in kids

- 2 RCT's to date!
- Indications similar to adults
- Major issues:
  - "Mask fear"
  - Patient comfort

Bubble CPAP

- CPAP = tube depth
- "Oscillatory" CPAP
- Useful <12 months

https://www.youtube.com/watch?v=XlMituWYVxQ

BPAP vs. Standard [1]

BPAP: 32% fewer intubated*

- N=50 (0-13 YO)

1. Yanez Ped CCM 2008

Bubble CPAP vs HiFlo vs. O2 [2]

	BCPAP (%)	O2 (%)	NNT
Treatment Failure	6	24	**5.6**
Intubation	6	16	NS
Death	4	15	**9**

- N=255 (0-5YO)
- *Bubble CPAP = Hiflo*

2. Chisti Et. Al Lancet 2015

In Peds NIV is Superior to Standard O2

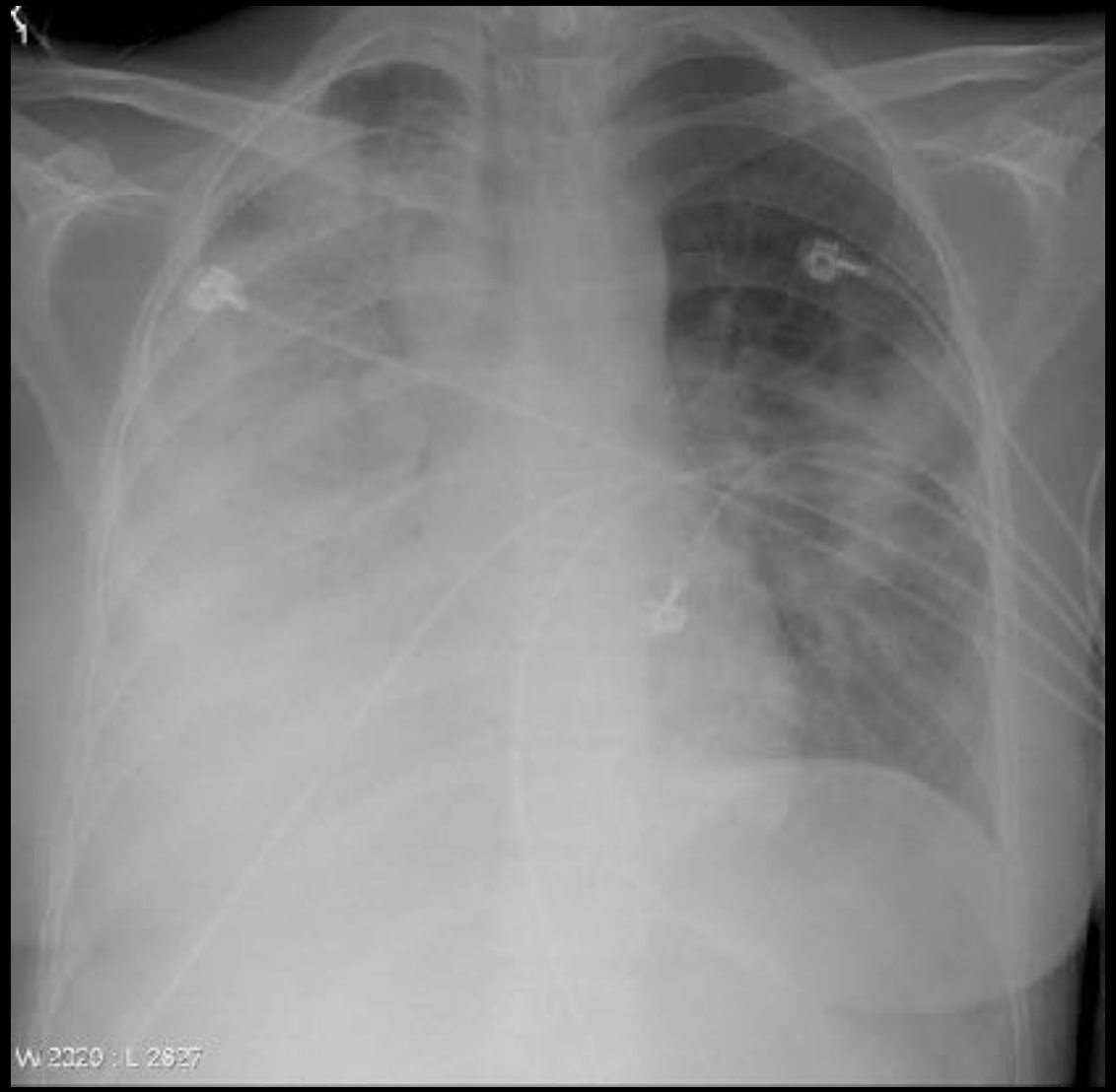
- BPAP decreases Intubations 1-13 YO

- Bubble CPAP <14 months of age Decreased:

    - Intubation
    - Treatment failure: **NNT 5.6**
    - Mortality: **NNT:9**

NIV In Hypoxemic Respiratory Failure?

Is NIV Indicated or Useful In PNA?



- IDSA and ATS:
  - Controversial
  - Avoid:
    - PaO2/FiO2 <150
    - B/L infiltrates

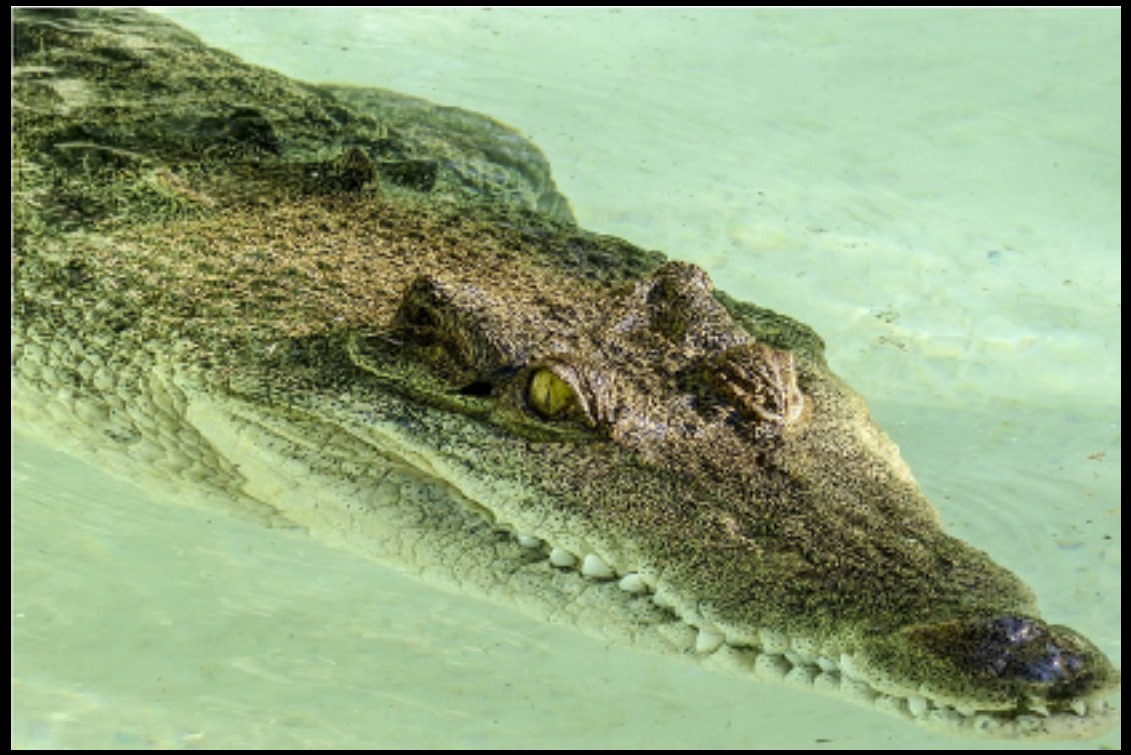
Image courtesy of Jack Ren, Radiopaedia.org, rID: 29090

NIV In Pneumonia: Who Fails

- NIV: 56% failure in CAP [1]
  - Who fails at1 Hr post NIV?
    - PH < 7.35, RR > 28, P:F < 177
- PNA may include 10% ARDS incidence[2]

1. *Carron et. AL JCC, 2010*
2. Bellani et Al 2016 JAMA

NIV In ARDS/Hypoxemic RF



- NIV Worse: isolated acute resp. failure (1)
- Failed NIV: 50% mortality (2)
- Failure ∝ ARDS severity

- 1: *Caroll Et al ICM, 2012*
- 2: Argawal et Al: 2010 JRCM
- 3: ARDS Definition Task force: 2012 JAMA

ARDS: Who Fails?

ARDS Grade	Mortality (%) + NIV [1]	Mortality (%) Usual care [2]
Mild (200-300)	22%	27
Moderate (100-200)	42%	32
Severe (<100)	47%	45

P:F < 150: Highest mortality

1: Bellani et al: LUNGSAFE ESCIM
2: ARDS Definition Task force: 2012 JAMA

Hypoxemic RF: Predictors of Failure?

- P:F <150, shock/MOSF[1]
- High Expired Tidal Vol: [2]
  - ETV > 9.5 ml/kg
  - >85% sens/spec
- High Driving Pressures[3]
  - PPLAT-PEEP

1: Chawala Et Al: JCC 2016
2: Carteaux Et Al: CCM 2016
3: Tucci Et Al: JTD 2016

Hypoxemic RF: Are We Doing it Wrong?

We use ARDSNET for MV why not for NIV?

Intubations: Facemask vs. Helmet

FM (n=44)

- Intubation: 61.5%*

Helmet (n=39)

- Intubation: 18.2%*

NNT: 2.3

Patel, B Et al, JAMA 2016

*P<0.005

Mortality: Facemask vs. Helmet

In Hospital:	48.7%	**27.3%***
90 Day:	56.4%	**34.1%***

Patel, B Et al, JAMA 2016

*P<0.005

Recruitment to Improve P:F

- Apply ARDSNET thinking…
- 40 cm H2O PSV X 40 s
- 50 % pts: >20% P:F improvement

Lovas: Front Med 2015

NIV In PNA and ARDS

- Not for: P:F <150 or B/L infiltrates

- 1 Hr Predictors of failure:

    - Higher RR
    - pH <7.35
    - P:F < 200

- Data shows that patients who fail do far worse

NIV in ARDS Toward an NIV Open Lung Model?

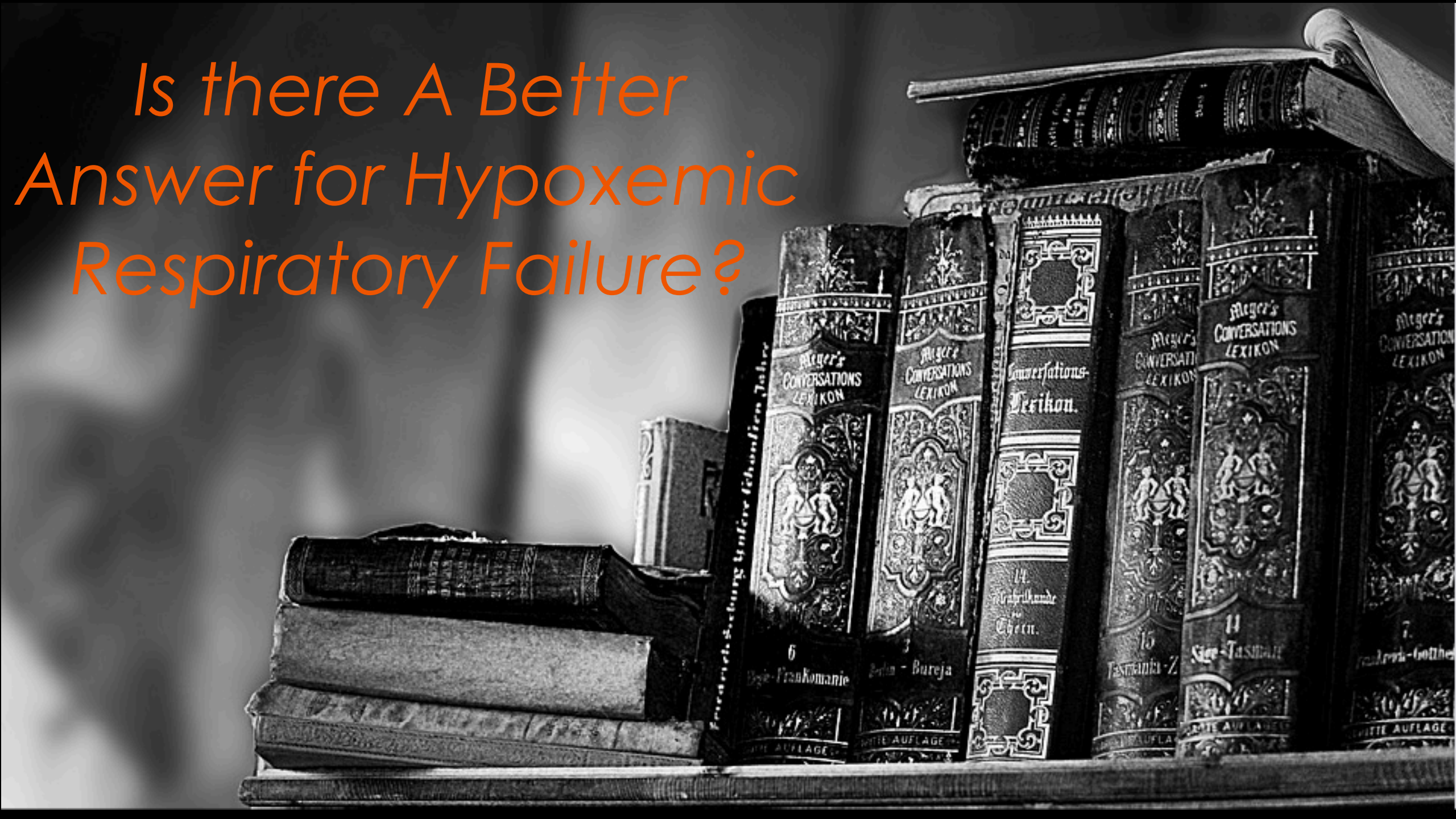
- Helmets? (1)
- If ETV > 9 intubate (2)
- Keep driving pressures low(3)
- Lung recruitment maneuvers(4)

- 1: Chawala Et Al: JCC 2016; 2: Carteaux Et Al: CCM 2016; 3: Tucci Et Al: JTD 2016; 4: Lovas: Front Med 2015

Is it Wrong to Try NIV in PNA/ARDS?

- Most trials involve **prolonged NIV use**
- Monitor closely **+ 0hr/1hr ABG**
- **Know who fails**
- Think of NIV as a **Pre-oxygenation method for intubation**

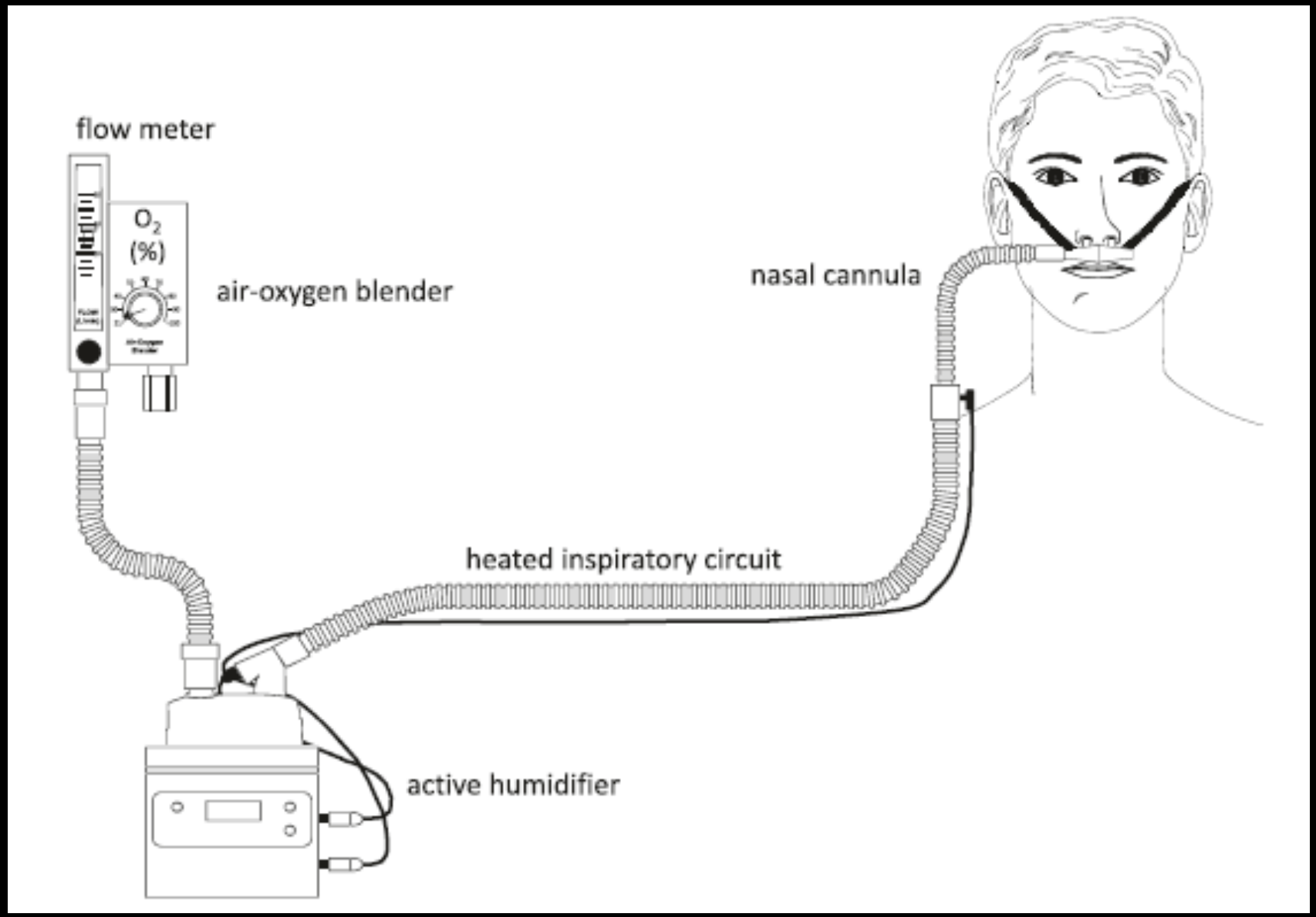
Is there A Better Answer for Hypoxemic Respiratory Failure?



Hi Flow Nasal Canula (HFNC)

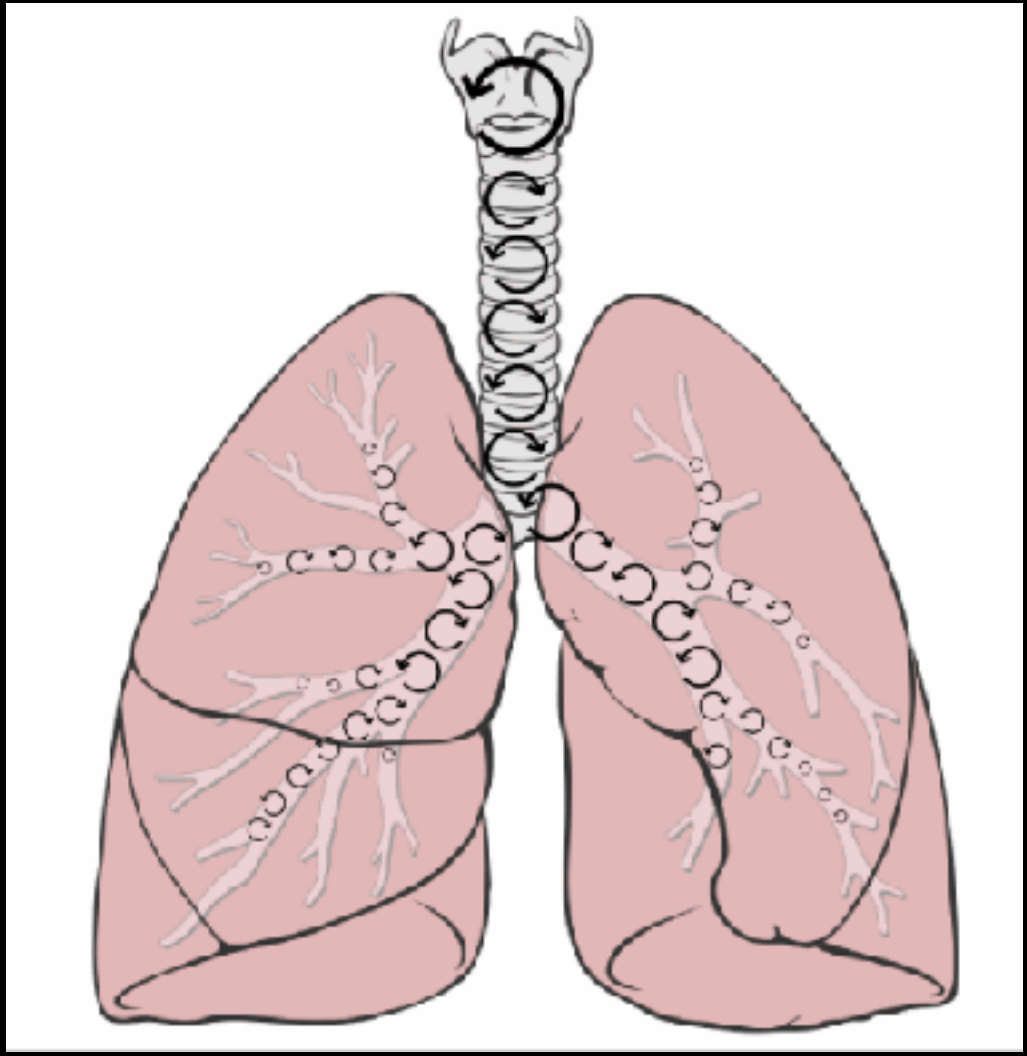
- Heated/Humidified
- FIO2: 20-100%
- Decreases air entrainment
- Flows: 20-60 LPM

Hi Flow Equipment



Nishimura Journal of Intensive Care 2015

Hi Flow O2: How it works

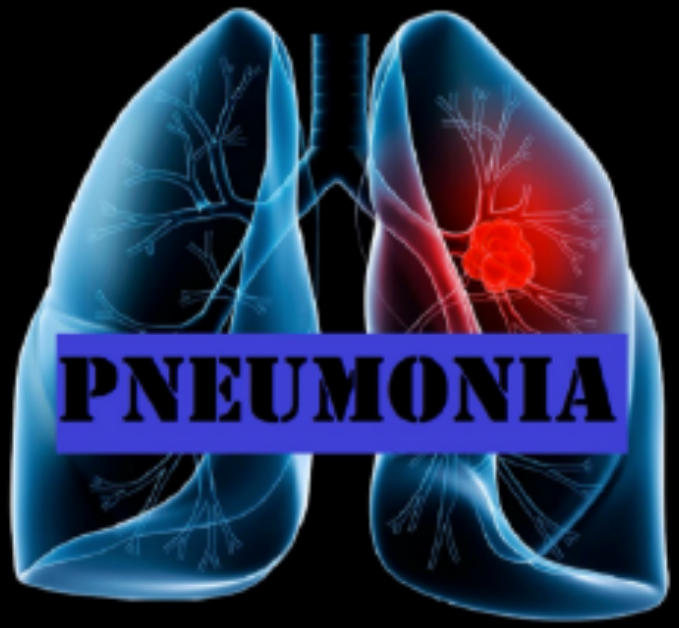


- Deadspace washout
- Decreased nasal resistance
- PEEP to 3cm
- Decreased WOB

https://emcrit.org/pulmcrit/high-flow-nasal-cannula-for-apneic-oxyventilation/

Hi Flow O2 Indications

Pediatric respiratory distress



Adult hypoxic respiratory failure

Pre-oxygenation for RSI

FLORALI[1]
HFNC in Acute Hypoxemic Resp. failure

NRB >10 LPM
N=94

NIV SpO2 92
N=110

HFNC 50 LPM
N=106

Frat, M Et al, NEJM 2015

*P<0.005

Intubated at 28 Days

	HFNC	NRB	NIV
			
All Pt's:	38%	47%	50%
P:F <200:	**35%***	53%	58%

Frat, M Et al, NEJM 2015

*P<0.005

Mortality at 90D

	HFNC	NRB	NIV
			
All Pt's:	12%*	23%	28%

Frat, M Et al, NEJM 2015

*P<0.005

Why Does HFNC Improve Outcome?

- Benefits of O2 w/ Hypoxia
- NIPPV may cause barotrauma
- HFNC allows secretion clearance

Frat, M Et al, NEJM 2015

Setting the Flow

Adult	60 LPM
Child	20 LPM
Infant	6 LPM
Neonate	2 LPM

Titration Tips

- Start at the max and decrease
- Avoid hyperoxia
- Infants: RR/HR is a good surrogate
- Beware the 60LPM/100%

Other Hi Flow Outcomes

- Immunocompromised Adults:
  - Reduced mortality and intubation[1]

- Kids:
  - 68% less intubations vs. standard in bronchiolitis over 1 yr period[2]

  - 30% reduction in intubation over 5 yr [3]

- 1. Huang, B Et Al *JCC* 2018
- 2. McKiernan *J Peds* 2010

Who To Beware of

- COPD/CHF
- Increasing RR/WOB
- Dropping PO2
- Max LPM/Sats
- Organ Dysfunction in PNA and PCP

Kim W Et al. JTD 2016

Conclusions

Conclusions: Benefits of NIV

- Highest benefit:
  - CHF
  - COPD
  - ARF in Immunocompromised

- Moderate benefit: Asthma

- No benefit/may be harmful:
  - Pneumonia → Hi flow O2 is better
  - Severe ARDS

Conclusions: Selecting Candidates

- What modality:
  - CPAP for O_2
  - BPAP for CO_2

- Know who fails:
  - Acidotic, High RR
  - No improvement at 1 Hr

- Kids:
  - Ages 1-13: standard NIV
  - < 14 MO: Bubble CPAP

Conclusions: NIV in ARDS

- Only for P:F >200
- Hi Flo or Helmets are best (1)
- Keep Driving Pressures Low(3)
- Lung recruitment maneuvers(4)
- Intubate If: ETV > 9, P:F < 200 (2)

1: Chawala Et Al: JCC 2016
2: Carteaux Et Al: CCM 2016
3: Tucci Et Al: JTD 2016
4: Lovas: front Med 2015

Conclusions: High Flow O2

- Improved outcomes in adults and children
- Best for hypoxemic respiratory failure vs NIV
    - Less intubation: NNT = 4.3
    - Less mortality: NNT = 6.2
    - Most dramatic in P:F <200 group
- Start high, titrate down

Conclusions: Just Remember This

Non-Invasive Ventilation Methods and Disease Specific Indications						
	CPAP	BPAP	NIV Helmet	Bubble CPAP	Hi Flow O2	Intubation
CHF	☑	☑				
COPD		☑				
Asthma		☑				
Immunocompromise		☑				
ARF Peds > 1YO		☑				
ARF Peds <1 YO				☑	☑*	
PNA Any P:F (no MOSF)					☑	
ARDS P:F >200			☑			
ARDS P:F <200			☑			☑
ARDS +MOSF						☑
PNA +MOSF						☑

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- 8.

So What do We do With PNA?

- Intial and 1 hr re-assessment are key!
    - Initial acidosis, AMS, Failure to improve → Intubate

- Know who fails: Low pH, High RR, Sicker patients

- Consider Hi Flow first instead of standard NIV unless:

    - Pre-existing COPD or pulmonary disease
    - Need for intubation
    - Shock