TO INTUBATE OR NOT TO INTUBATE

ACUTE RESPIRATORY FAILURE MANAGEMENT FOR THE NON-INTENSIVIST

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DISCLOSURES

- None

OBJECTIVES

- Define acute respiratory failure
- Compare and contrast high flow nasal cannula (HFNC), CPAP, BIPAP and mechanical ventilation
- Distinguish key features of common ventilator modes including volume control, pressure control and pressure support
- Determine appropriate ventilatory support and management for representative clinical scenarios

ACUTE RESPIRATORY FAILURE

You are called to the bedside of a 65 y/o male who feels short of breath and is tachypneic

HOW FAST DO YOU NEED TO ACT?

INITIAL ASSESSMENT

- Vitals (RR, O_2 Sat, BP, Pulse)
- Work of breathing
- ABG
  - (pH / PaCO2 / PaO2 / Bicarb)
- CXR
- ECG

ABG

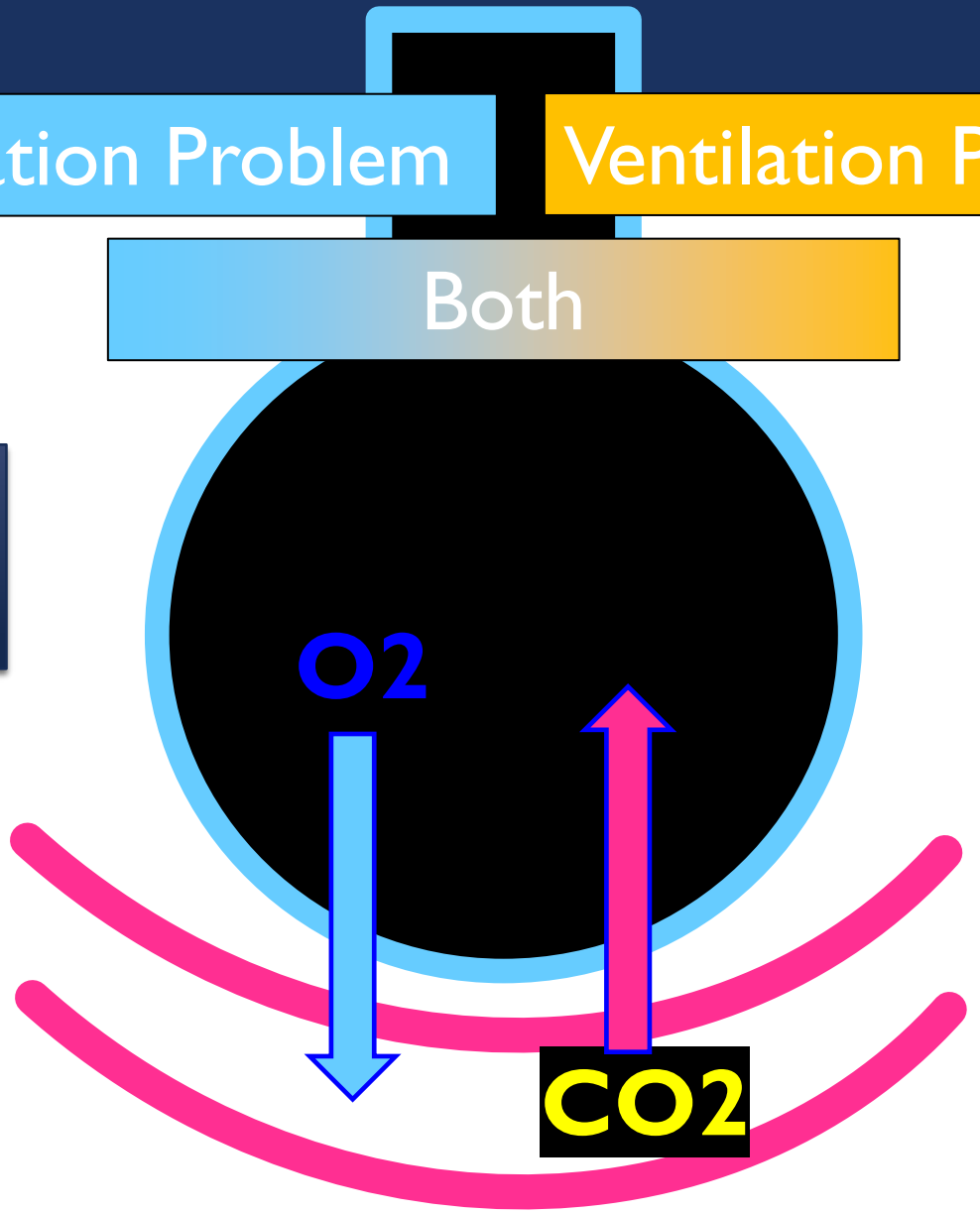
Oxygenation Problem

Ventilation Problem

Both

7.43 / 39 / 55 / 26
on 100% FiO2

7.13 / 89 / 105 / 29
on 100% FiO2



ABG

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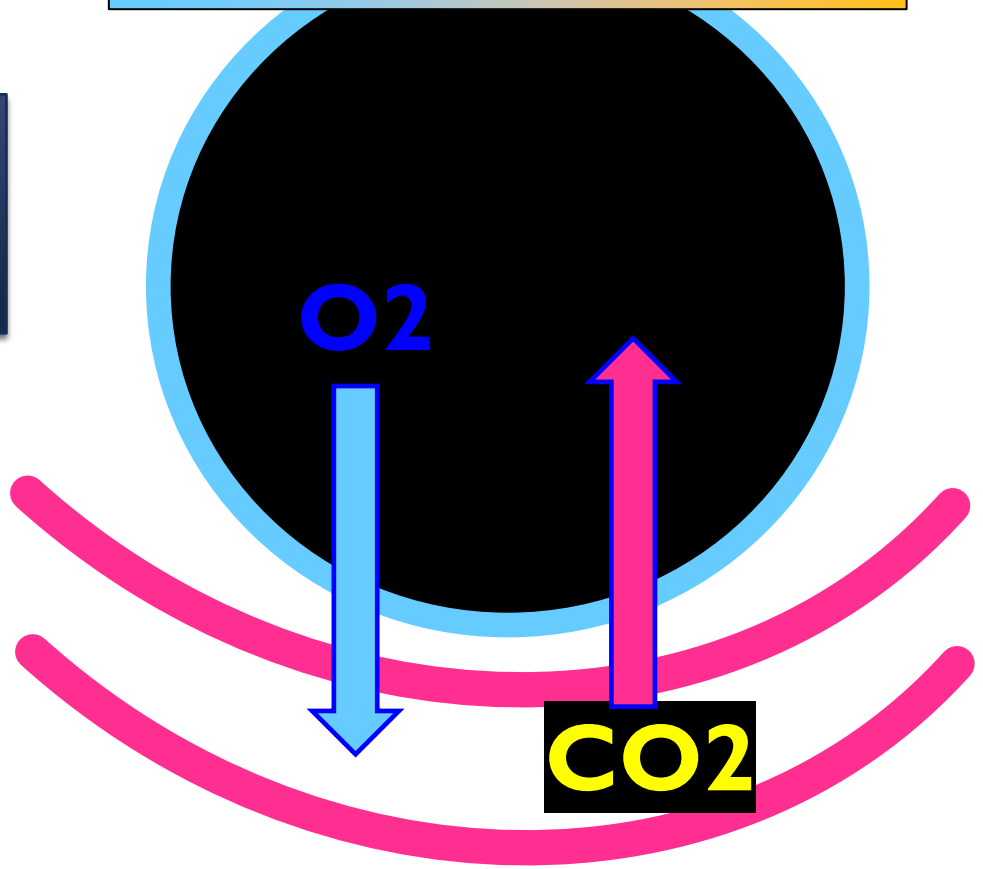


DEFINITIONS

Type I (Hypoxemic)

- $PaO_2 \leq 60$ mmHg
- Normal or decreased $PaCO_2$
- A-a gradient normal or increased

Type II (Hypercapnic)

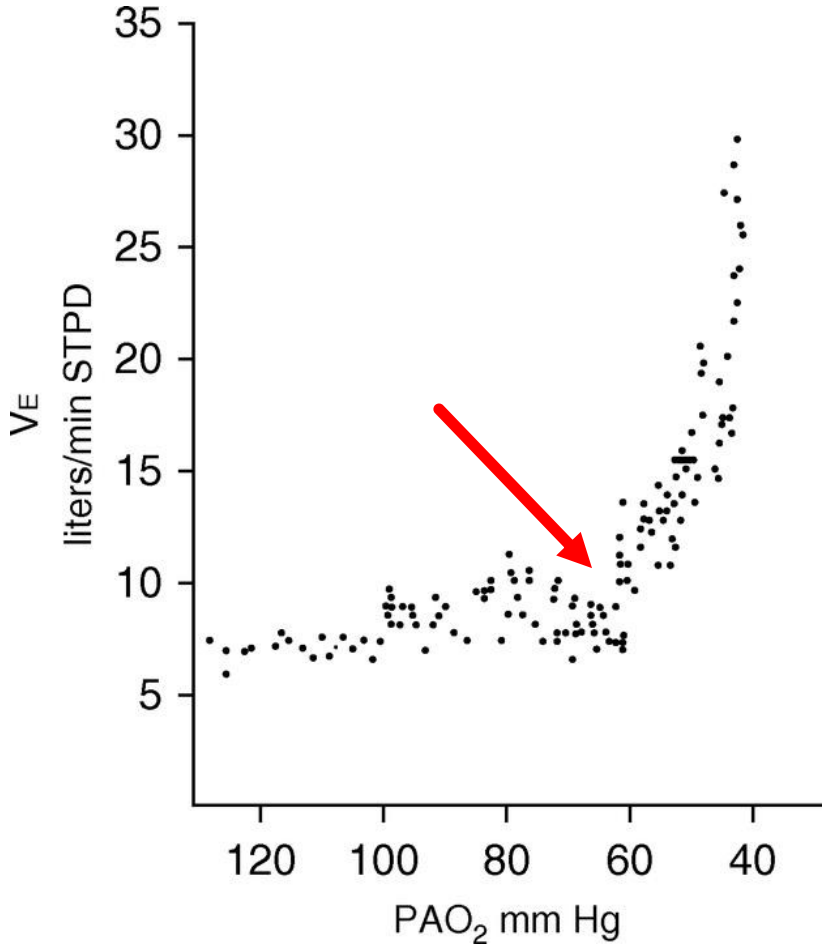
- $PaCO_2 \geq 45$ with a pH < 7.35
- PaO_2 normal or low
- *REMEMBER: chronic CO_2 retainers may have a high $PaCO_2$ but a compensated pH ≥ 7.35*

TYPE I (HYPOXEMIC) RESP. FAILURE

Normal A-a Gradients		Increased A-a Gradients		
Alveolar Hypoventilation Can progress to Type II Resp Failure	**Low Inspired FiO2**	**Diffusion Defect** Think about changes to alveolar capillary membrane	**V/Q Mismatch** Most common Type I Resp Failure	**Shunt** Occurs when VQ ratio = 0
CNS Depression (meds, hypothyroid) Decreased chest wall compliance (kyphoscoliosis) Neuromuscular disease (GBS, ALS)	High altitudes	Emphysema Edema Exercise Interstitial lung disease	ARDS Atelectasis COPD CHF PE Pneumonia	AVM Complete atelectasis Severe pulmonary edema Severe pneumonia

HYPOXEMIA & RR

- Hypoxemia rarely increases the RR assuming PaCO2 is unchanged
- Once the PaO2 falls < 60 mmHg the RR starts to increase



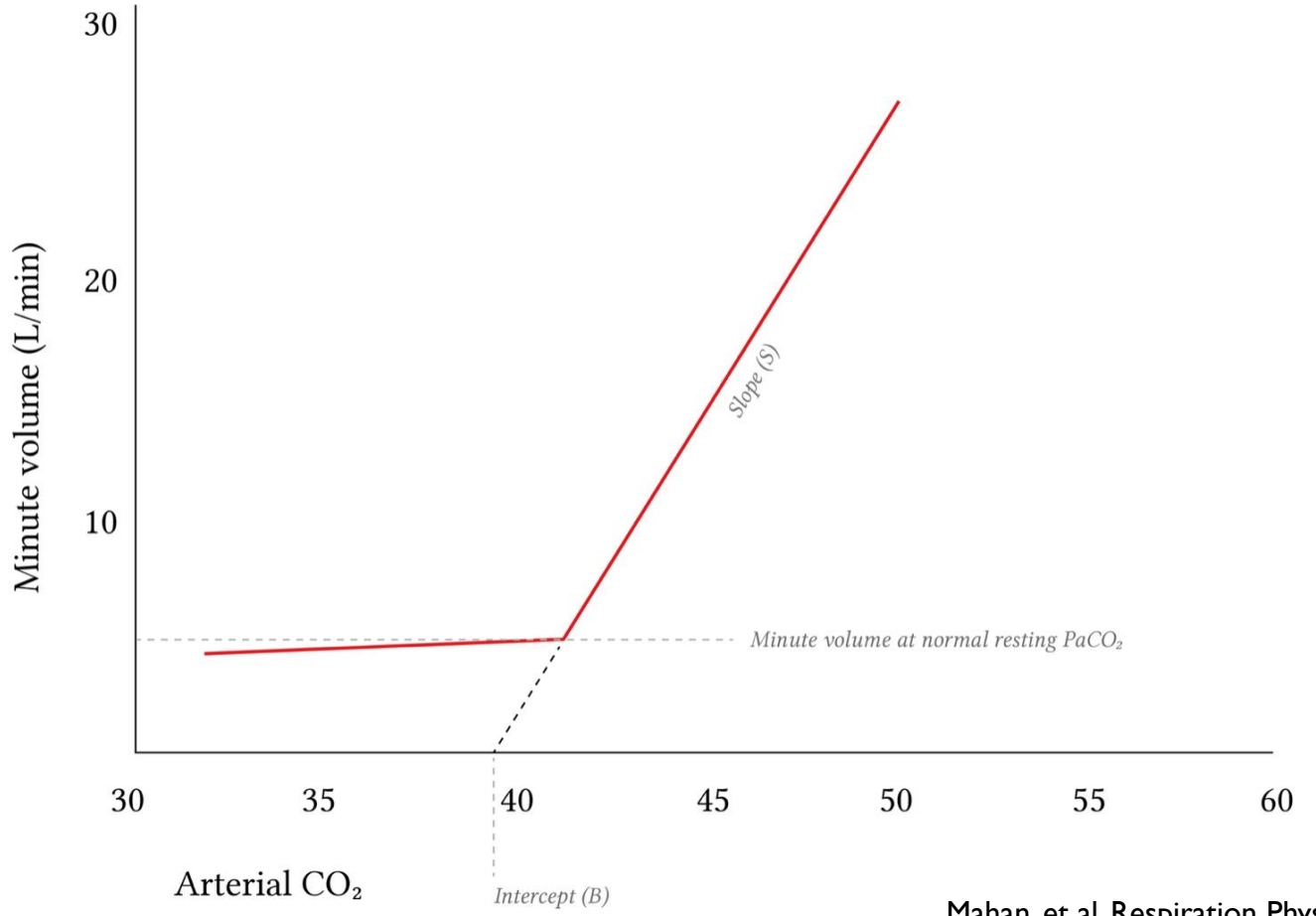
Martin J. Tobin; Franco Laghi; Amal Jubran; *Am J Respir Crit Care Med* 202356-360.

TYPE II (HYPERCAPNIC) RESP. FAILURE

Respiratory Pump Failure					Increased CO2 Production
Altered Neural & Neuromuscular Transmission	Chest wall/Pleural Disorders	Dead Space Ventilation (Increased VQ ratio)	Decreased Central Drive	Muscle Abnormalities	
ALS GBS Myasthenia gravis Transverse myelitis Botulism Spinal cord injury Organophophate poisoning	Kyphoscoliosis Obesity Large pleural effusions	ARDS Bronchiectasis Emphysema PE	Sedatives Encephalitis Stroke	Diaphragm Paralysis	Increased in fever, exercise, sepsis, thyrotoxicosis
**Respiratory Pump = chest wall, lung parenchyma, muscles of respiration, nervous system (central and peripheral)					

HYPERCARBIA & RR

- Hypercarbia causes a rapid rise in RR once PaCO2 ≥ 40



Mahan, et al. Respiration Physiology 108; 1997: 101-115.
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SIGNS OF IMPENDING RESPIRATORY ARREST

SIGNS OF IMPENDING RESPIRATORY ARREST

- Vitals (sats, RR)
- Speaking in short sentences
- Cyanosis
- Accessory muscle use
- Decreased consciousness

MODES OF VENTILATORY SUPPORT

Delivered FiO2 DECREASES during respiratory distress due to increased room air entrainment

- Inspiratory flow at rest is ~25 – 40 LPM
- Respiratory distress generates even **higher** flow in the patient (60 – 100 LPM)
- Device flow rates are fixed

LEVELS OF NON-INVASIVE SUPPORT

Supports Oxygenation ≤ 15 LPM	Supports Oxygenation & Ventilation > 15LPM

Low Flow

Nasal Cannula
Face Mask
Non-rebreather Mask

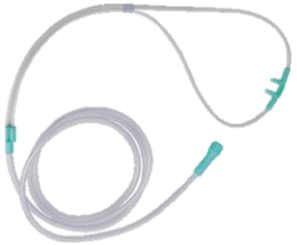
Intermediate Flow

Venturi Mask

High Flow

HFNC
NIPPV

LOW FLOW OXYGEN SUPPORT



Nasal Cannula

Simple Mask

Oxymask

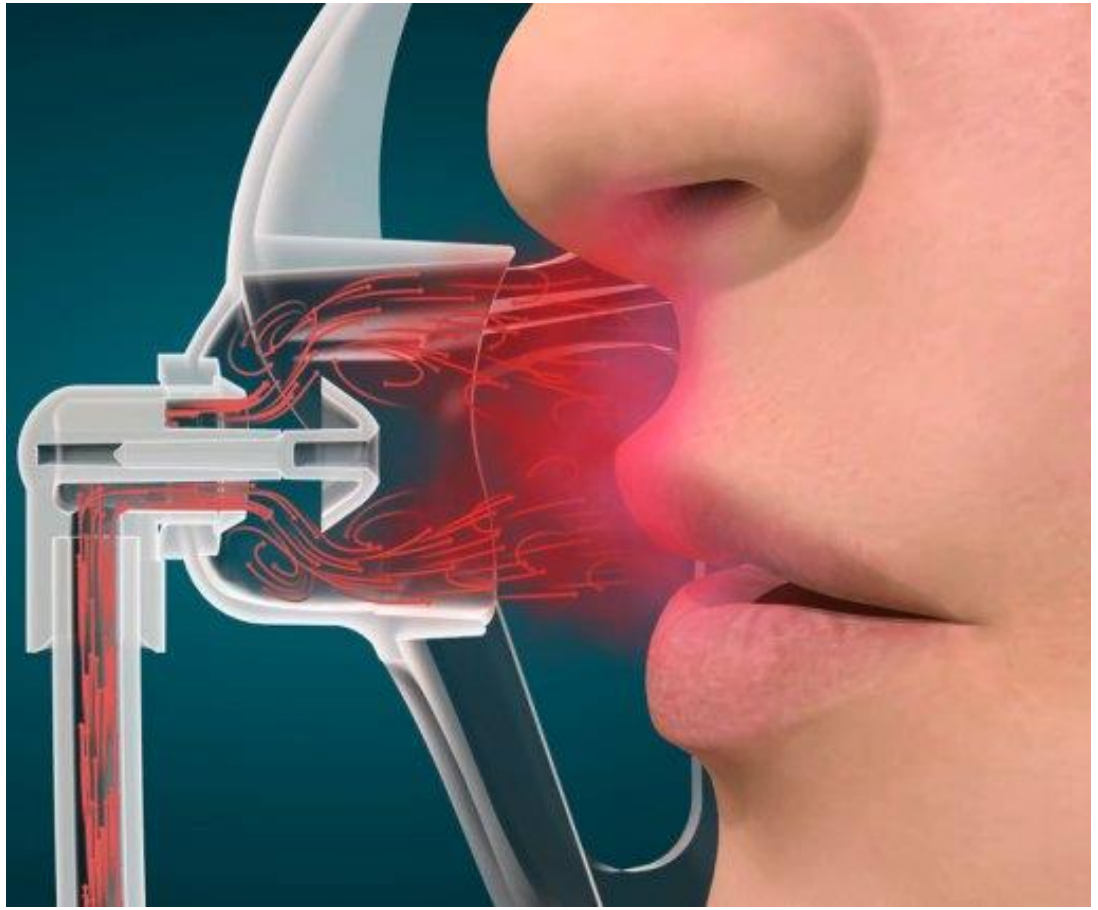
Partial Rebreather Mask

Non-Rebreather Mask

Non-reservoir based devices

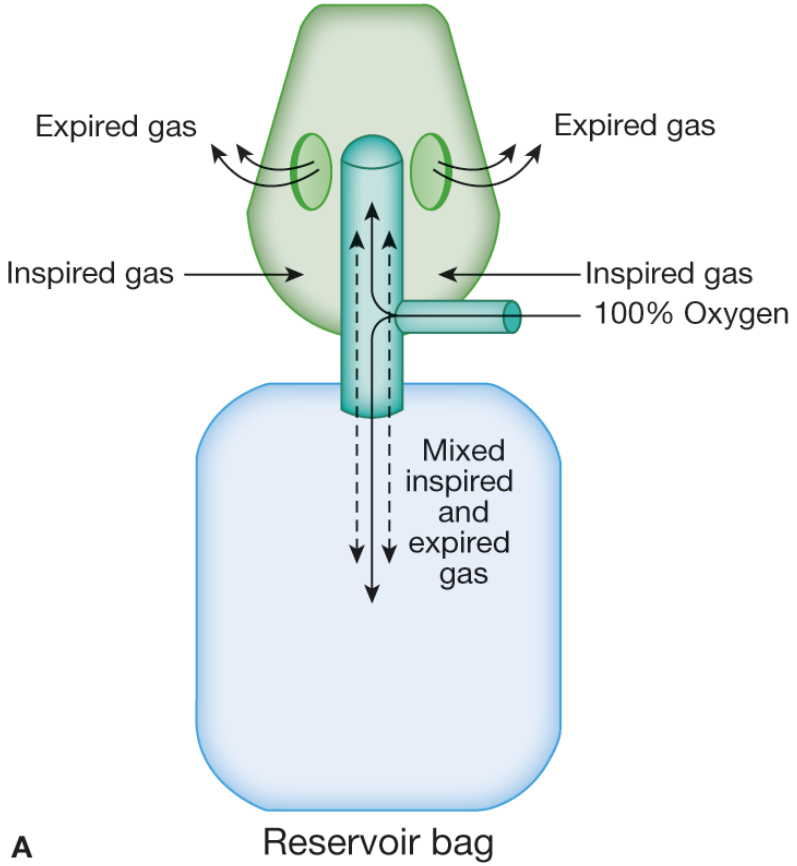
Reservoir based devices

OXYMASK

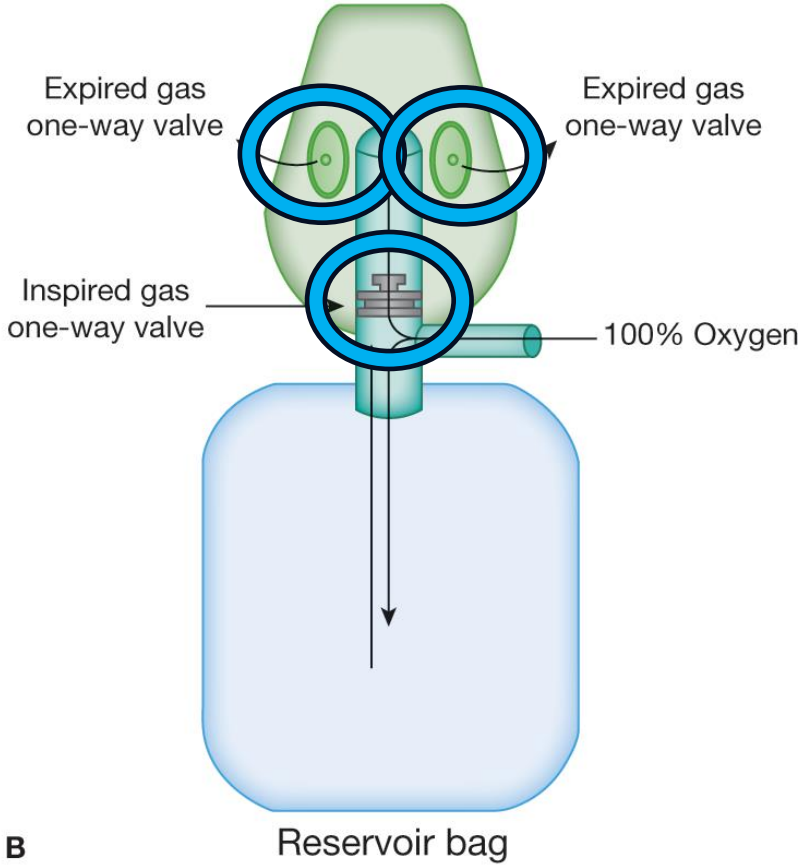


RESERVOIR DEVICES

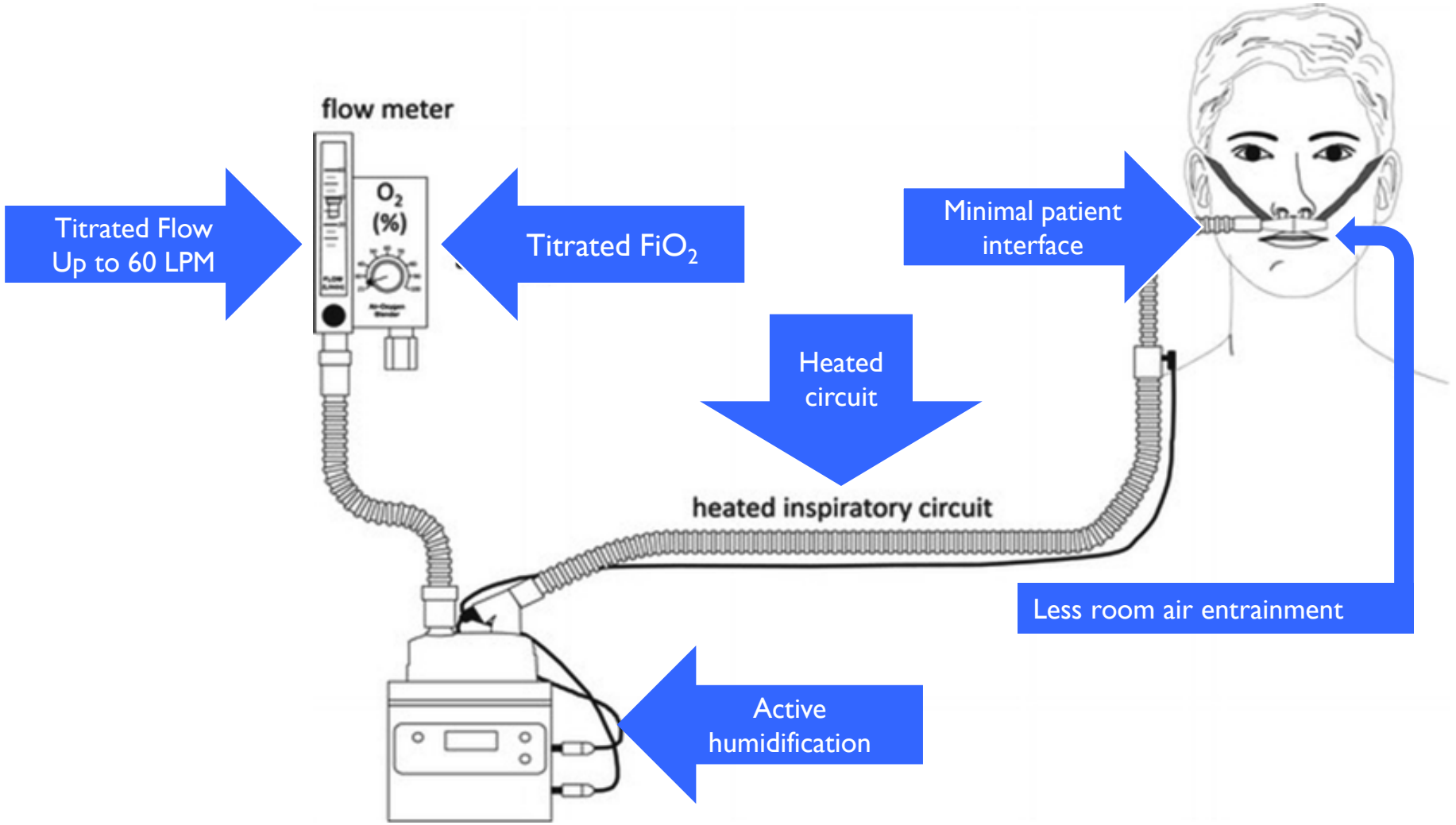
Partial Rebreather



Non-Rebreather

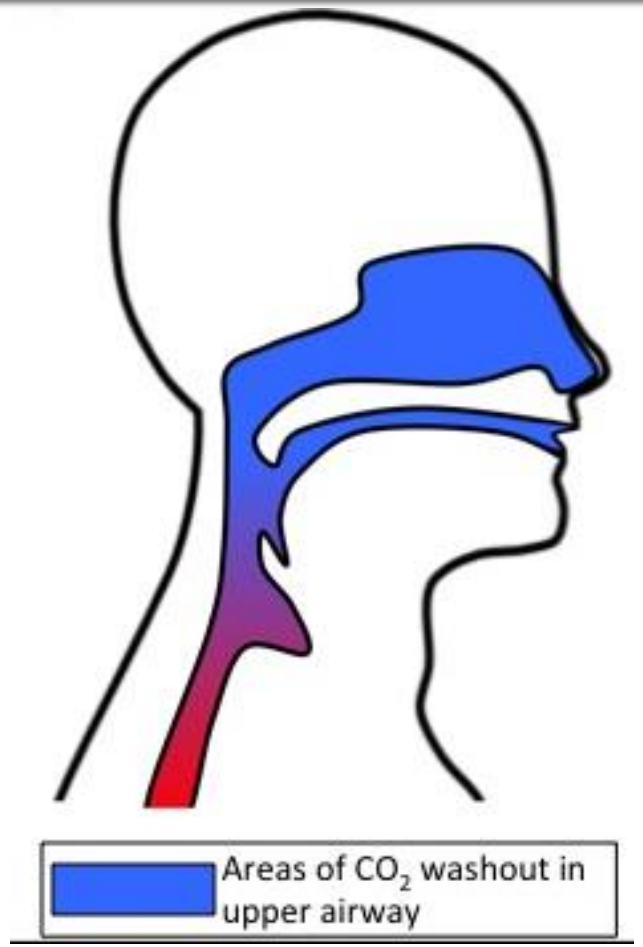


HIGH FLOW NASAL CANNULA



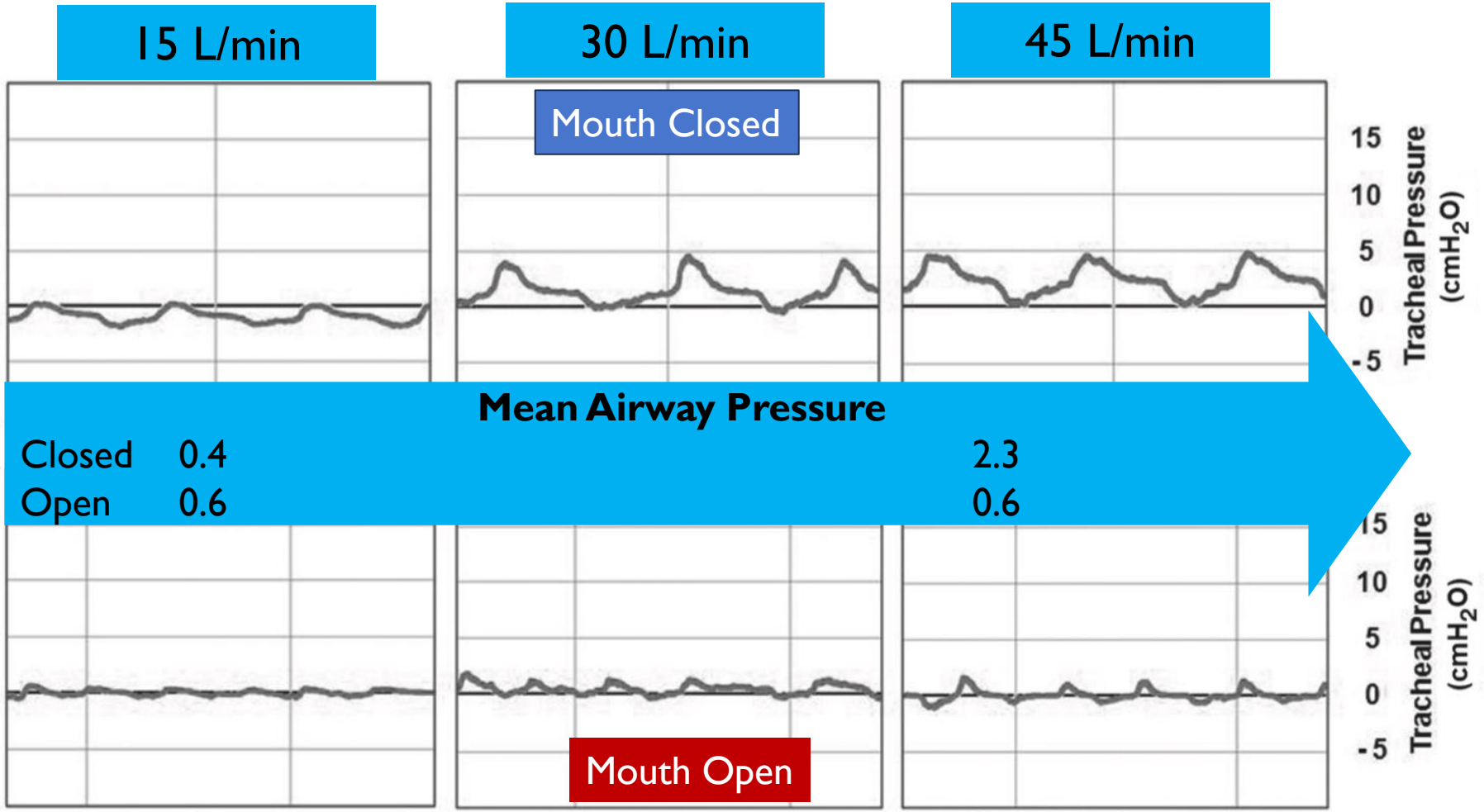
HFNC REDUCES ANATOMIC DEAD SPACE

Flow-Dependent CO2 Clearance



Drake. Annals ATS. 2017.

HFNC & PEEP



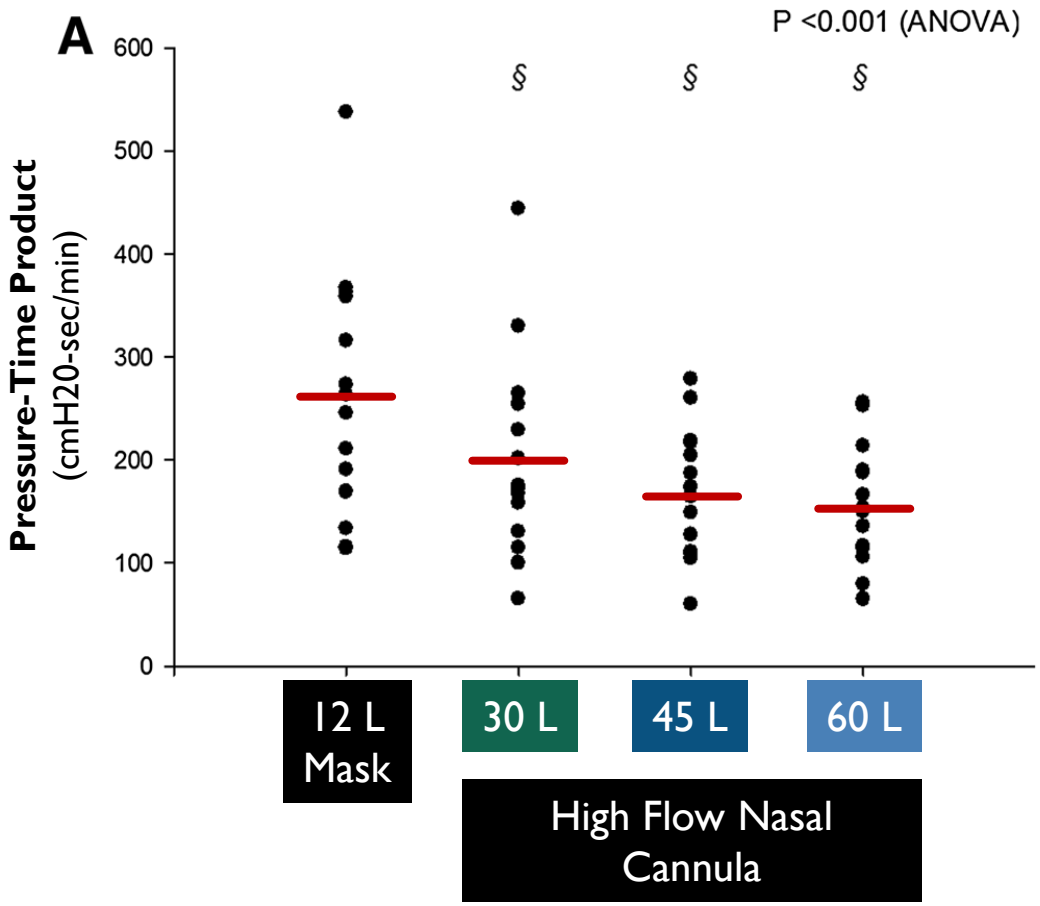
Chanques et al. Comparison of three high flow oxygen therapy delivery devices: a clinical physiological cross-over study. Minerva Anestesiol 2013;

HFNC REDUCES WORK OF BREATHING

Mauri et al. Optimum support by high-flow nasal cannula in acute hypoxemic respiratory failure: effects of increasing flow rate. Int Care Med 2017.

HFNC REDUCES WORK OF BREATHING

Metabolic Demands of Breathing



Mauri et al. Optimum support by high-flow nasal cannula in acute hypoxemic respiratory failure: effects of increasing flow rate. Int Care Med 2017.

HFNC TITRATION

High work of breathing? At risk for intubation?	Low work of breathing?
Support both ventilation and oxygenation	Support oxygenation
Maximize flow (>30 L/min) Titrate FiO_2 to sat goal	Maximize FiO_2 Titrate flow to sat goal

WEANING HFNC

- Has the underlying condition requiring HFNC improved?
- SpO2 ≥88%
- RR ≤ 25
- Low work of breathing
  - Able to speak in full sentences
  - Absence of accessory muscle use

≤ 40 L/min
≤ 60% FiO_2

WEANING HFNC

Increase FiO_2 to 100%
Decrease flow by 10 L/min

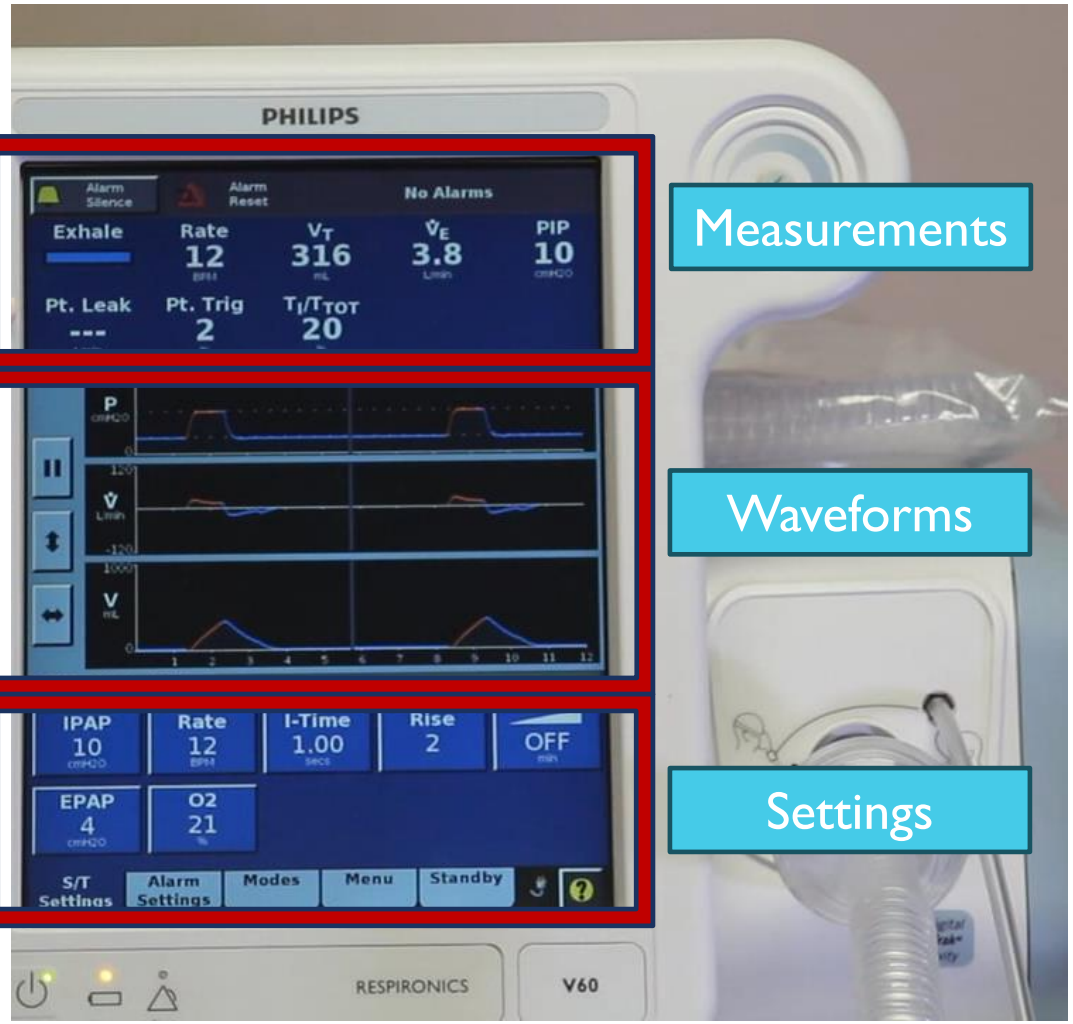
Reassess vital signs and work of breathing in 10-20 minutes

Maintain FiO_2 at 100%
Decrease flow by 10 L/min

Reassess vital signs and work of breathing in 10-20 minutes

Once flow ≤ 20 L/min, trial of low flow cannula or face mask

NON-INVASIVE POSITIVE PRESSURE VENTILATION

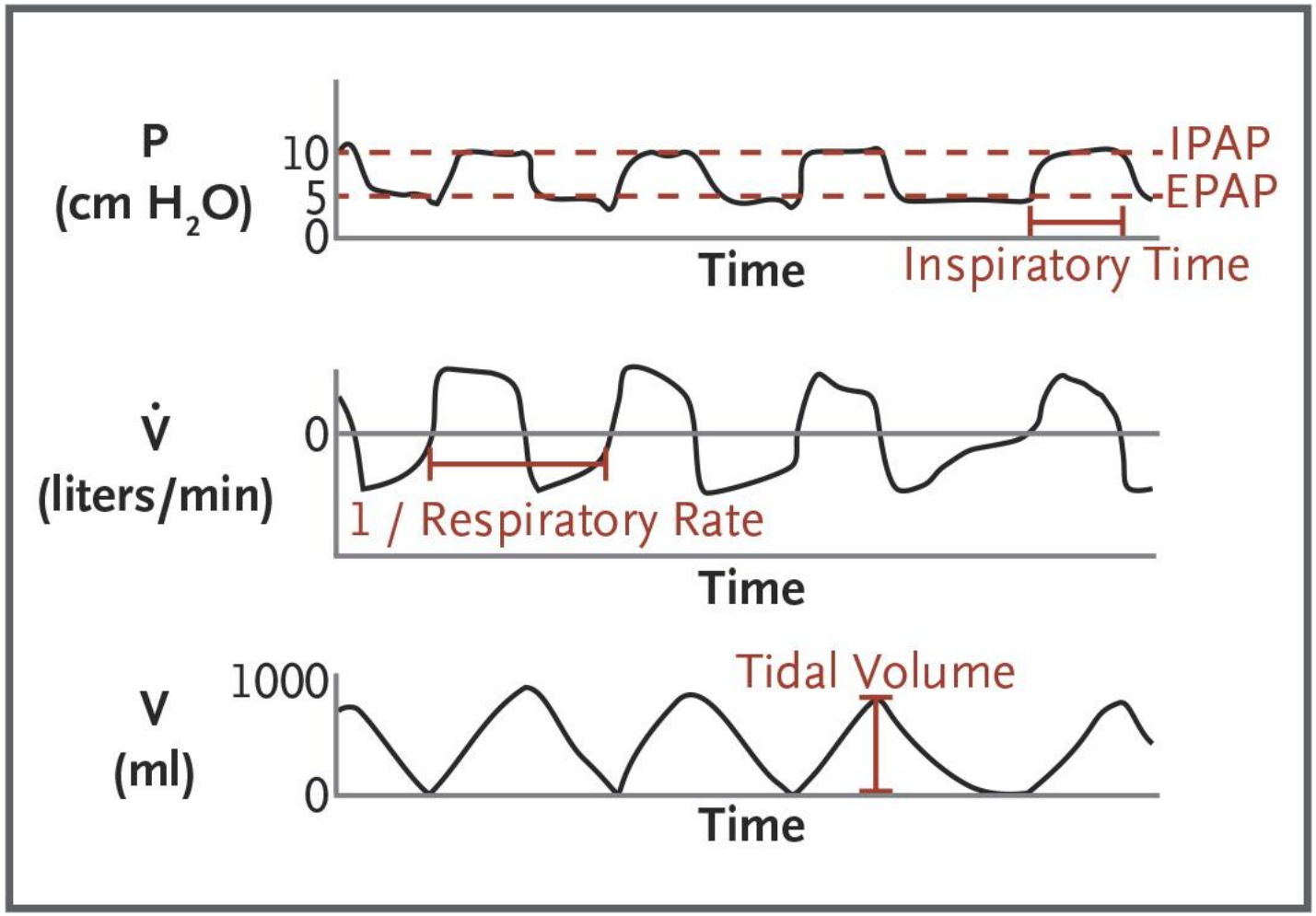


BIPAP WAVEFORMS

Pressure

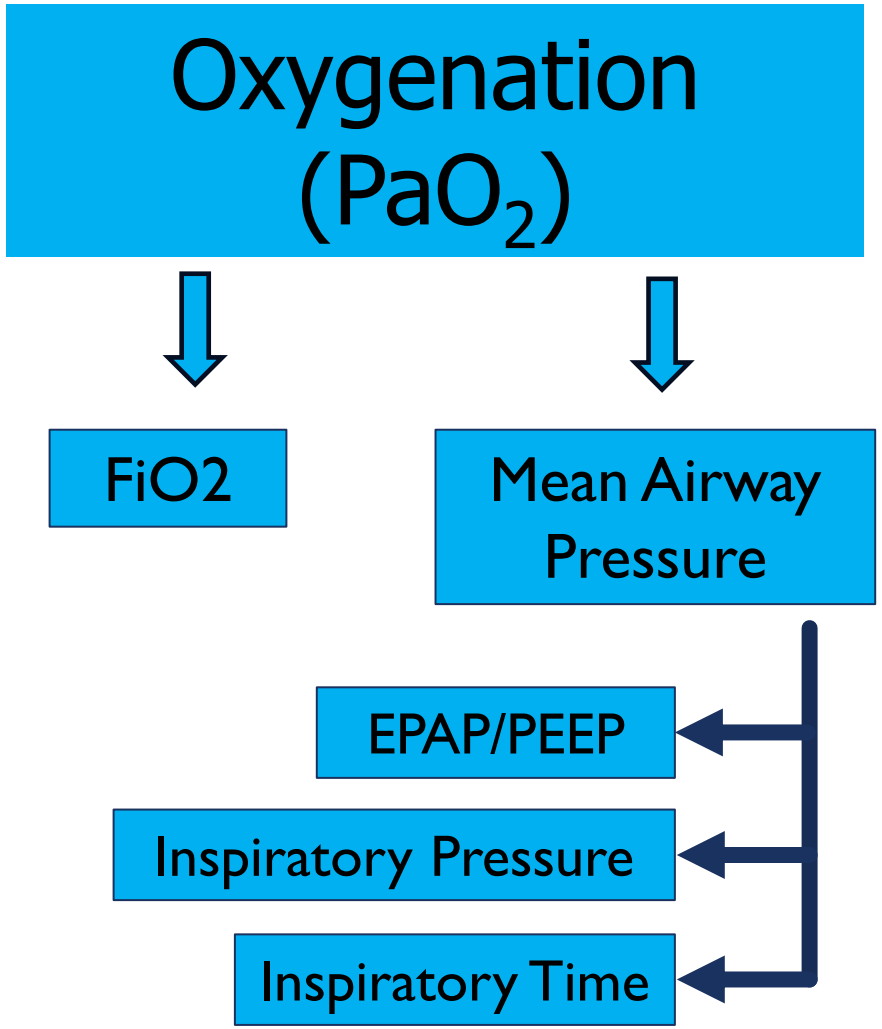
Minute Ventilation

Tidal Volume



BIPAP TITRATION

7.38 / 36 / 58

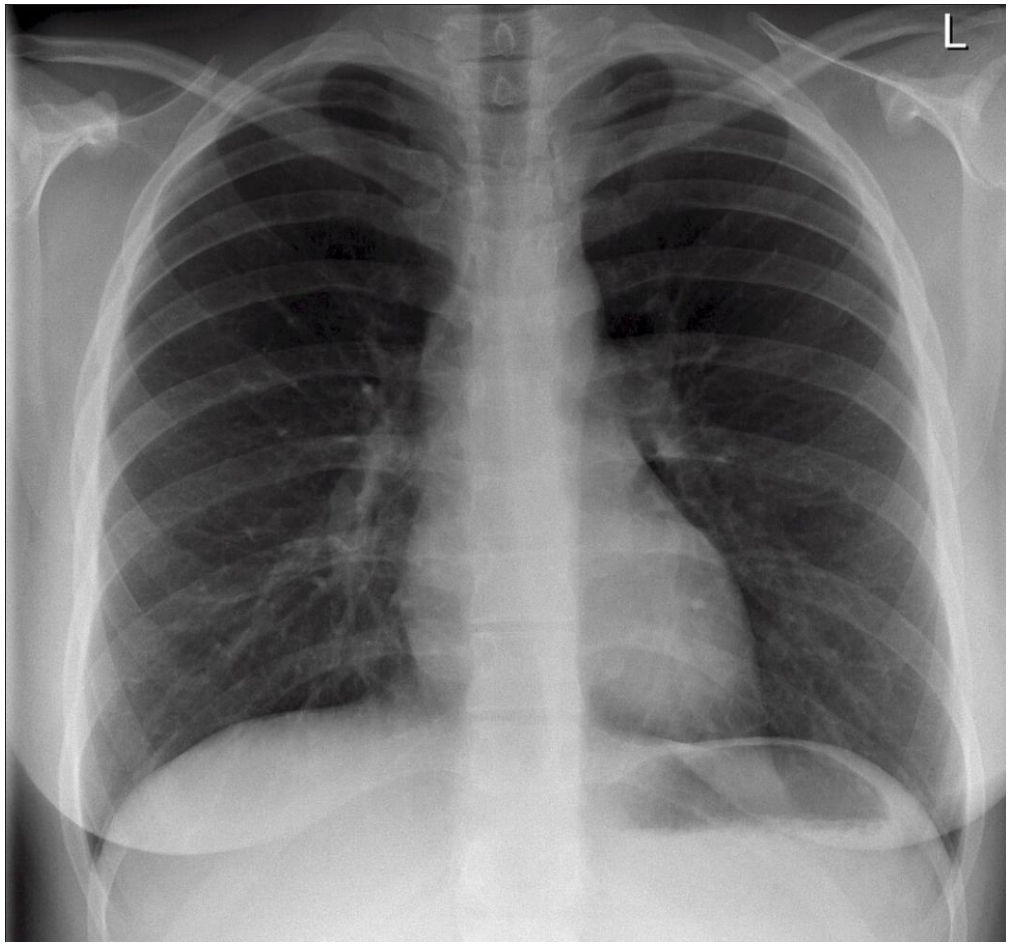


BIPAP TITRATION

7.14 / 85 / 108

Ventilation ($PaCO_2$)

- Tidal Volume
  - IPAP >>> EPAP
- Respiratory Rate



MY ALGORITHM

ASSESS YOUR PATIENT

Overall appearance - toxic, work of breathing, comfortable
Vitals – hemodynamics, sats, resp rate
Obtain ABG or VBG and xrav
Respiratory history?
New medications? Recent blood products?

Determine if the respiratory insufficiency or failure is hypoxic or hypercapnic
Determine if there are any contraindications to NIV ventilation
    If so then consider need for intubation
Review documented goals of care

CONTRAINDICATIONS TO NIV

- Uncooperative patient
- Altered mental status **
  - Unless purely from elevated PaCO2
- Hemodynamically unstable
- Active cardiac ischemia, arrhythmias
- Active upper GI bleed
- Copious secretions
- Vomiting or emesis
- Unable to protect airway
- Facial trauma
- Untreated pneumothorax
- Recent facial/upper airway surgery
- Epistaxis
- Skull base fracture

MY ALGORITHM

Hypercapnic
PaCO2 > 45 with acidemia

BiPAP

Indications:

- Acute COPD exacerbation
- Post-extubation respiratory failure
- OSA
  OHS
- Acute asthma exacerbation
- CHF exacerbation

Initial Settings:

- 100% FiO2 and rapidly titrate to saturation goal
- Start IPAP at 10cmH20 and EPAP 5cmH20

Hypoxic
PaO2 < 60

HFNC

Indications:

- Pneumonia
- Cardiogenic pulmonary edema
- Acute asthma exacerbation
- PE
- Post-extubation respiratory distress
- Post CT surgery

Initial Settings:

- 100% FiO2
- Flow 60L/min

CPAP

Indications:

- Cardiogenic pulmonary edema
- Post-op respiratory failure
- OSA
- Post trauma respiratory failure

Initial Settings:

- 100% FiO2 and rapidly titrate to saturation goal
- Start 5cmH20 and titrate to goal

MY ALGORITHM

Monitoring

- Frequent reassessment is critical!
- Set a goal for your patient (sats or ABG)
- Obtain ABG/VBG and do clinical reassessment at frequent intervals:
  - 30min, 1hr, 2hr, 4hr
- If they aren't making progress to the goal or meeting the goal consider intubation.

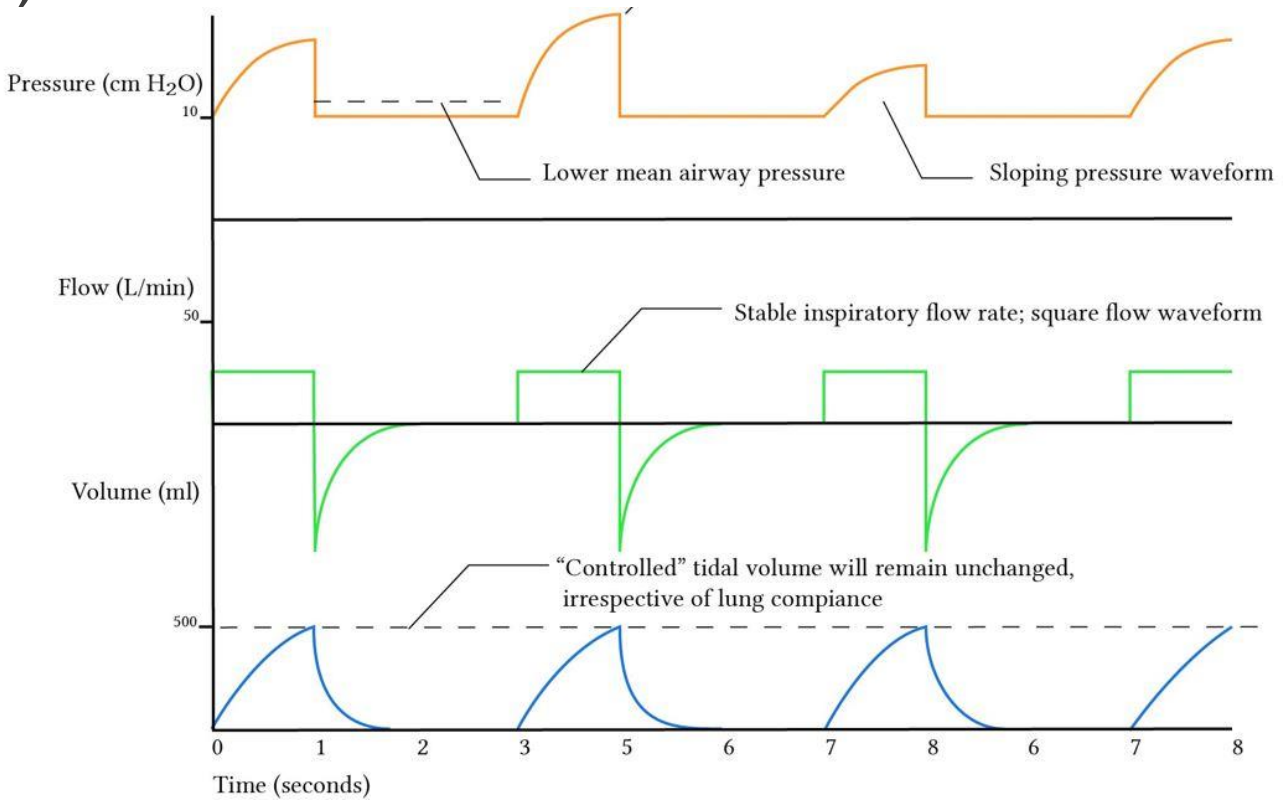
Goals not met by NIV → **Intubation**

INVASIVE VENTILATION

- Common Modes
  - Volume
  - Pressure
- 3 Features of Each
  - Trigger
  - Cycle
  - Limit

VOLUME CONTROL

- Delivers a set tidal volume (TV) with each breath
- We set:
  - **RR, TV, PEEP, FiO2**
- We monitor patient pressures
  - Peak and plateau pressure
  - Driving pressure = plateau - peep



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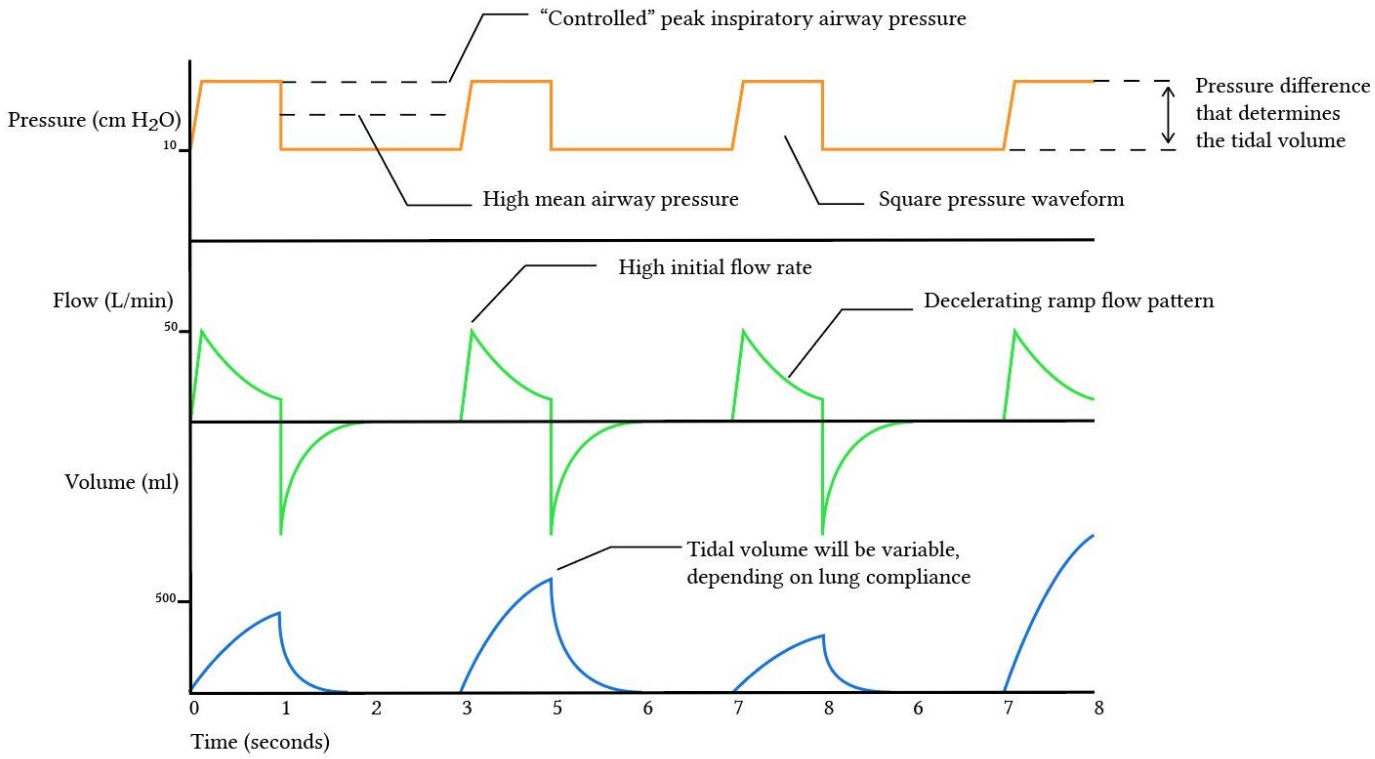
PRESSURE CONTROL

- Delivers a set inspiratory pressure (Pinsp) for a set time (Ti) with each breath

- We set:
  - **RR, Pinsp, PEEP, FiO2**

- We monitor patient:
  - Tidal volume
  - Minute ventilation



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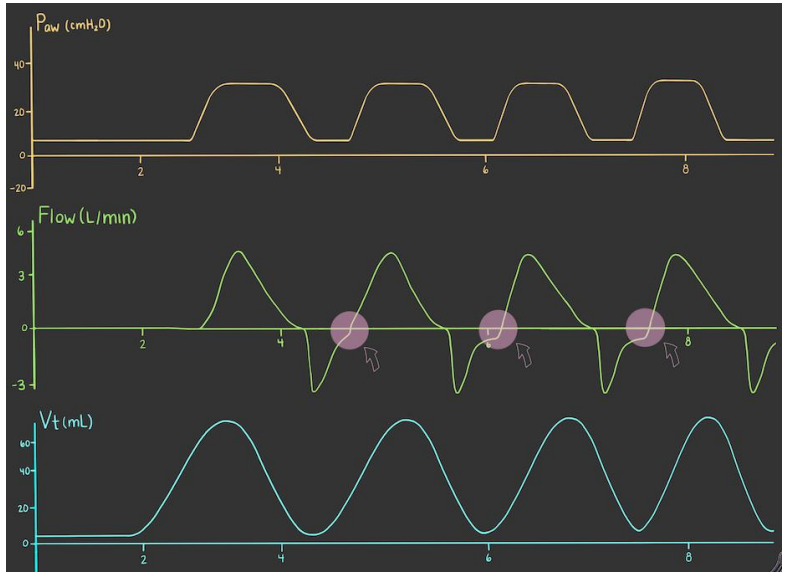
PRESSURE SUPPORT

- **ALL** breaths are patient initiated
- No ventilation guaranteed → determined solely by patient effort
- Used for spontaneous breathing trials
- We set:
  - **PS**, **PEEP**, **FiO2**
- We monitor patient:
  - Tidal volume
  - Minute ventilation
  - RR



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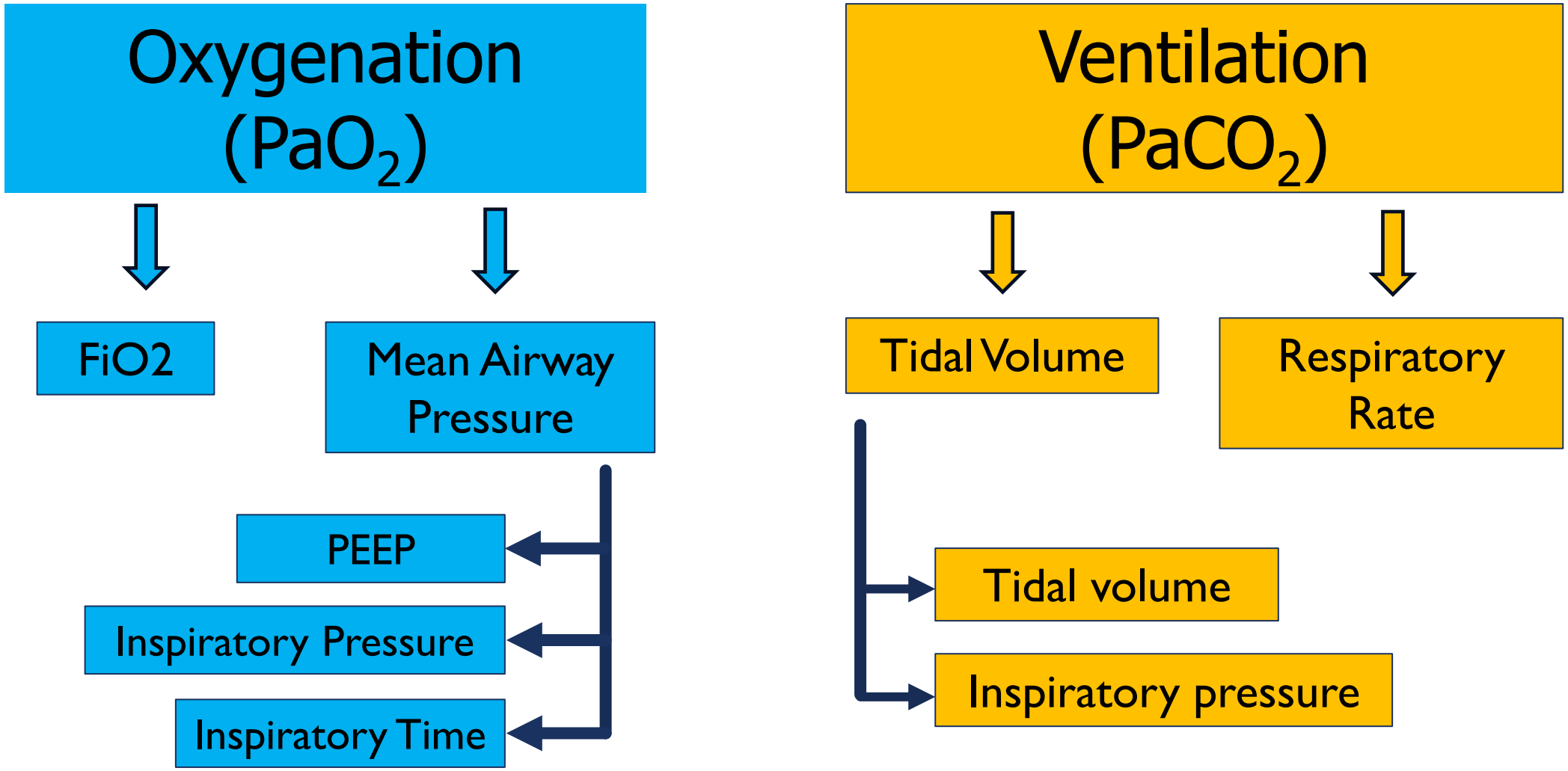
VENTILATOR TITRATION



CLINICAL CASES

65 y/o male with COPD on 3L NC home O2 presents with:

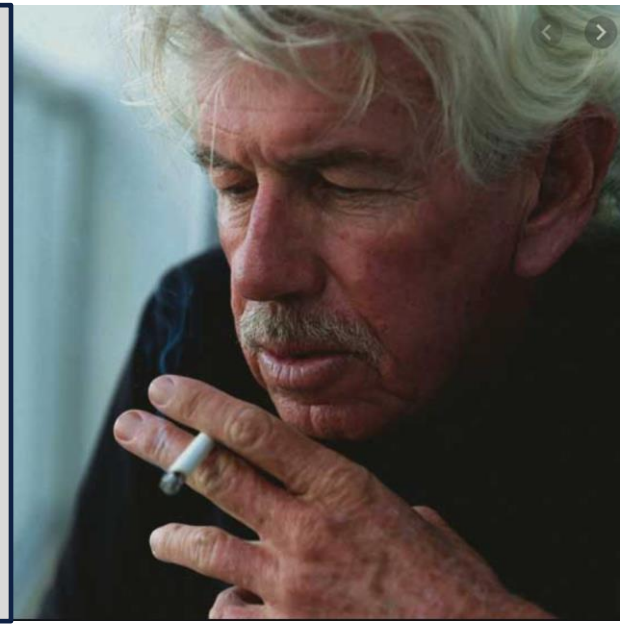
- Productive cough
- Wheezing for 5 days
- History of prior exacerbation requiring intubation

VS: Afebrile
HR 95 and regular
BP 145/84
RR 28 breaths/min
SpO_2 92% on 8 LPM oxymask

Exam: diffuse expiratory wheezing, accessory muscle use

CXR: hyperinflation, airway thickening, no consolidation

ABG: 7.20 / 85 / 59



CASE 1 CONTINUATION

- You initiate bronchodilators, prednisone and antibiotics for a COPD exacerbation
- He continues to have a respiratory rate of 35 and accessory muscle use. He requires 10L oxymask.
- Does this patient require additional respiratory support?

BIPAP OUTCOMES VS LOW FLOW O2 IN COPD

- Lower mortality (7.1% versus 13.9%; RR 0.54, 95% CI 0.38–0.76)
- Fewer intubations (12% versus 30.6%; RR 0.43, 95% CI 0.35–0.53)
- Shorter hospital LOS (2.88 days fewer, 95% CI 1.17–4.59 days fewer)
- Short ICU LOS (4.99 days fewer, 95% CI 0–9.99 days fewer)

CASE 1 CONTINUED

- You initiate BiPAP with:
  - IPAP 10cm H2O
  - EPAP 4cm H2O
  - FiO2 titrated to 88-92%
- What would make you comfortable he is improving?
- How soon would you reassess him?

CASE 1 CONCLUSION

- Next ABG:
  - 7.23 / 80 / 65
- Any changes?
  - IPAP 10cm H2O
  - EPAP 4cm H2O
  - FiO2 titrated to 88-92%
- Increase the IPAP to 14
  - New Settings: IPAP 14 / EPAP 4

Final ABG: 7.30 / 65 / 70

65 y/o female with history of systolic heart failure presents with:

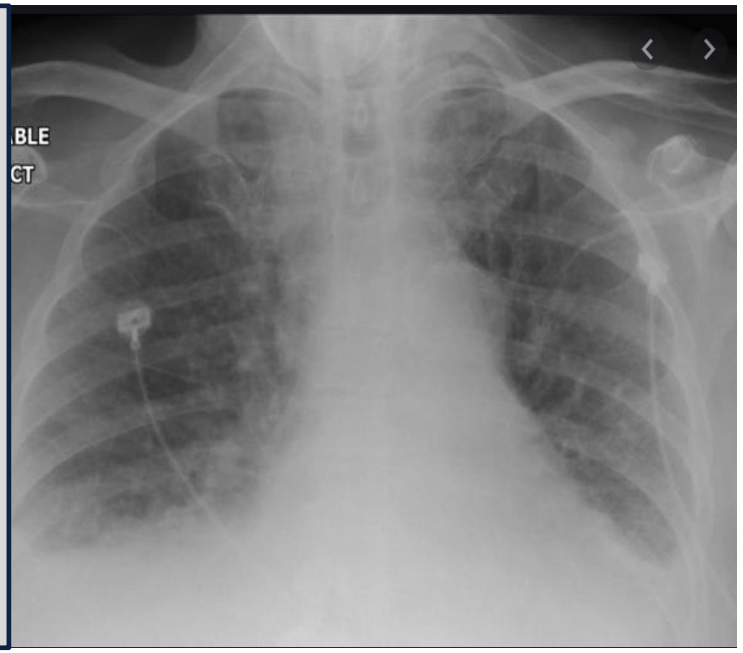
- 2 weeks of increasing dyspnea/orthopnea
- Weight gain
- Lower extremity edema bilaterally

VS: afebrile
HR 105 and irregularly irregular
BP 98/45
RR 34 breaths/min
SpO_2 84% on room air

Exam: inspiratory rales from bases to midlung
accessory muscle use

EKG: afib, no ST-T wave changes

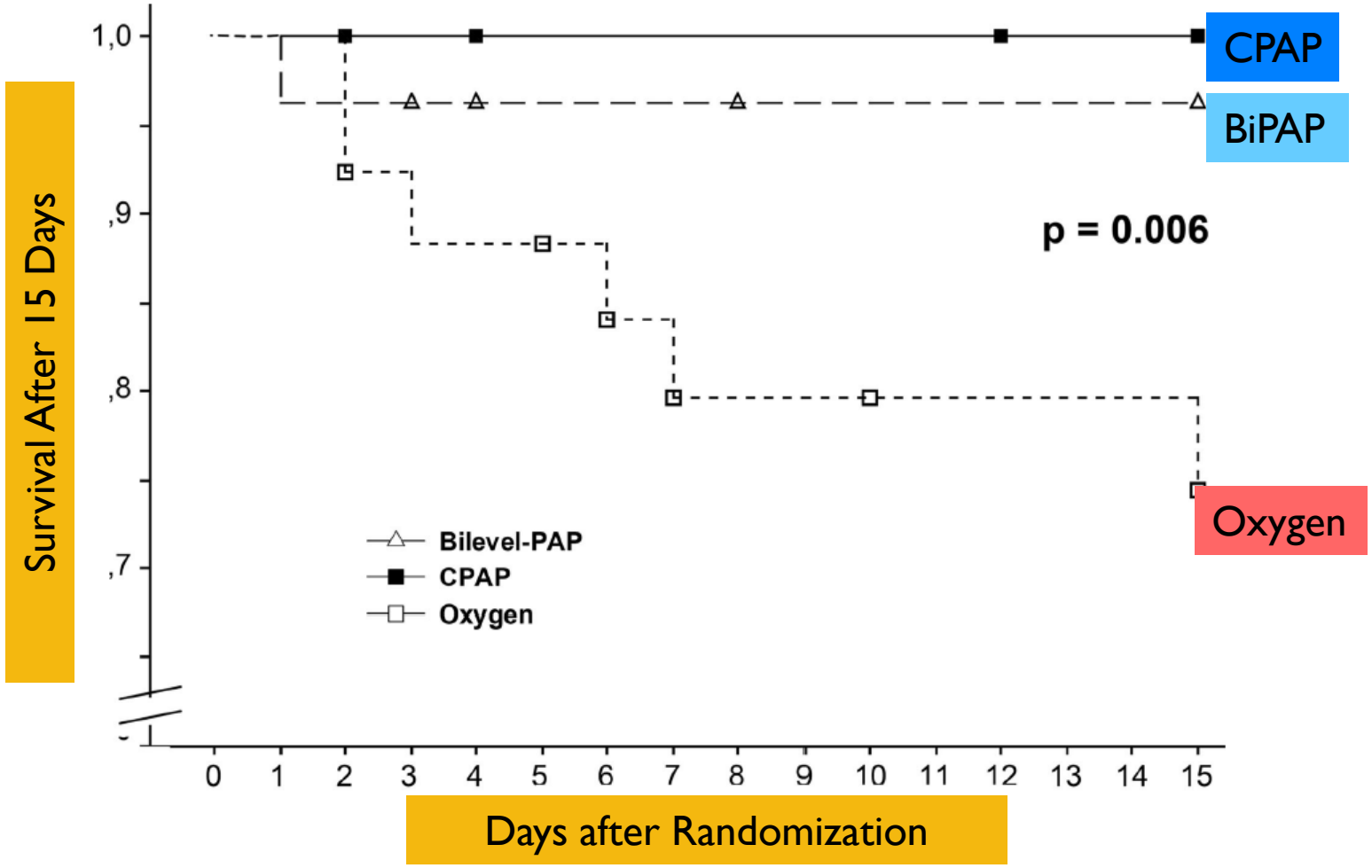
ABG: 7.44 / 30 / 45



CASE 2 CONTINUATION

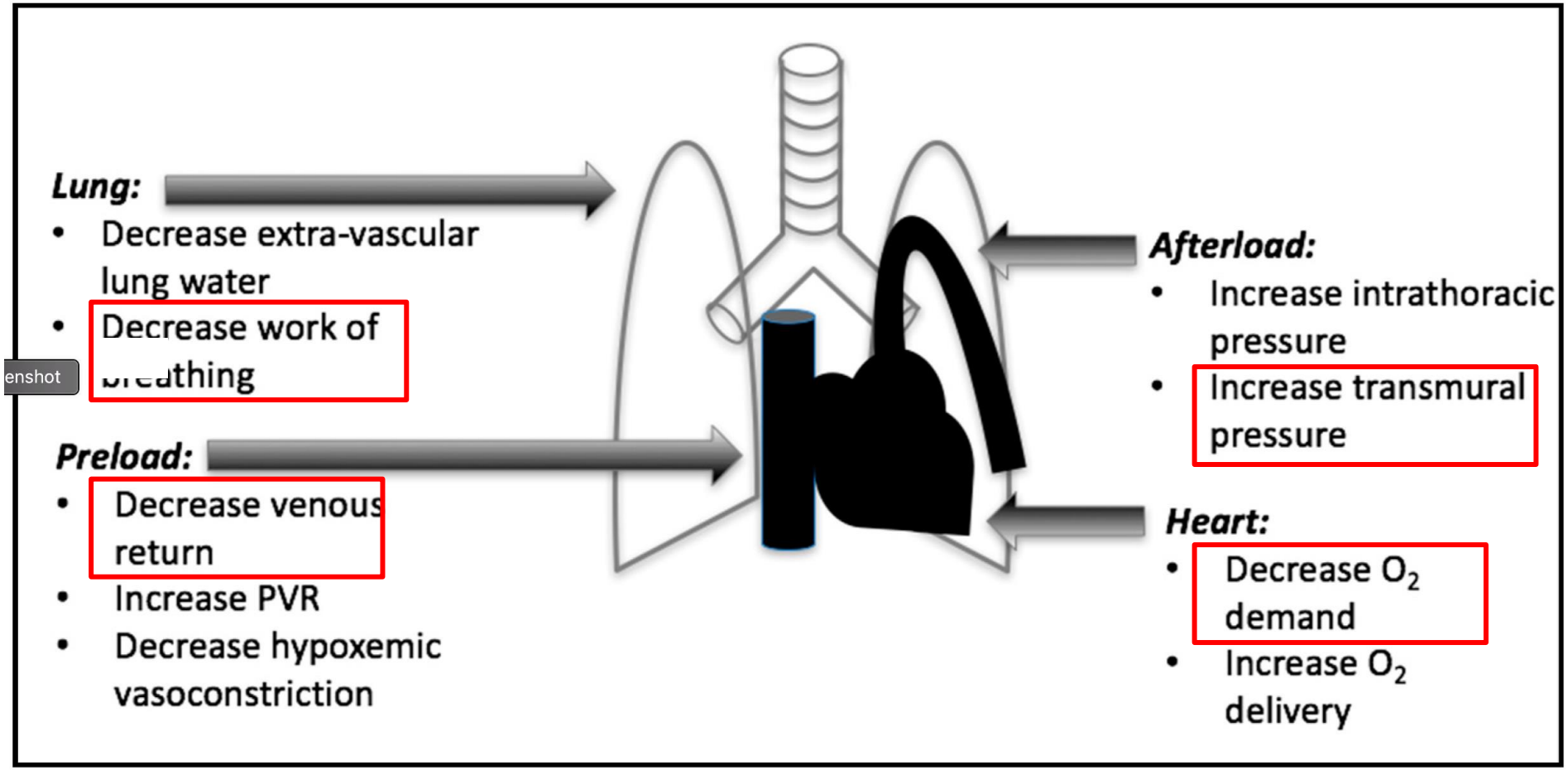
- Patient is AAO x3 but in moderate respiratory distress
- You give 60mg IV Lasix pending UOP response
- What type of respiratory support do you choose in this case?

NIPPV FOR HEART FAILURE EXACERBATIONS



Park et al. CCM 2004

PHYSIOLOGIC EFFECTS OF POSITIVE PRESSURE



J. Cardiovasc. Dev. Dis. **2016**, *3*(4), 33

CASE 2 CONTINUED

- You initiate CPAP with:
  - CPAP 10cm H2O
  - FiO2 titrated to > 92%
- What would make you comfortable she is improving?
- How soon would you reassess her?

CASE 2 CONCLUSION

- Next ABG:
  - 7.42 / 35 / 55
- Any Changes?
- Increase CPAP to 14cm H2O

Final ABG: 7.42 / 35 / 70

28 y/o healthy male presents with:

- 2 days of fevers and chills
- Productive cough with purulent phlegm
- Dyspnea
- LLL Opacity

VS: Temp 39.4° C
HR 138 and regular
BP 95/60
RR 32 breaths/min
SpO_2 82% on room air

Exam: rhonchi and crackles throughout left lung
accessory muscle use

ABG: 7.34 / 32 / 52

CASE 3 CONTINUATION

- You initiate IV fluids, IV antibiotics and apply an oxymask.
- He appears in moderate respiratory distress with high work of breathing despite the improvement in sats to 90% on 15L.
- What respiratory support mode would you move to next?

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 JUNE 4, 2015 VOL. 372 NO. 23

High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure

313 Patients with Acute Resp Failure

- RR>25
- $PaCO_2$ < 45
- P/F < 300
- 10+ liters for 15+ minutes

106 // High Flow N

~48 L/min
~82% FiO_2

96 // Standard Oxygen

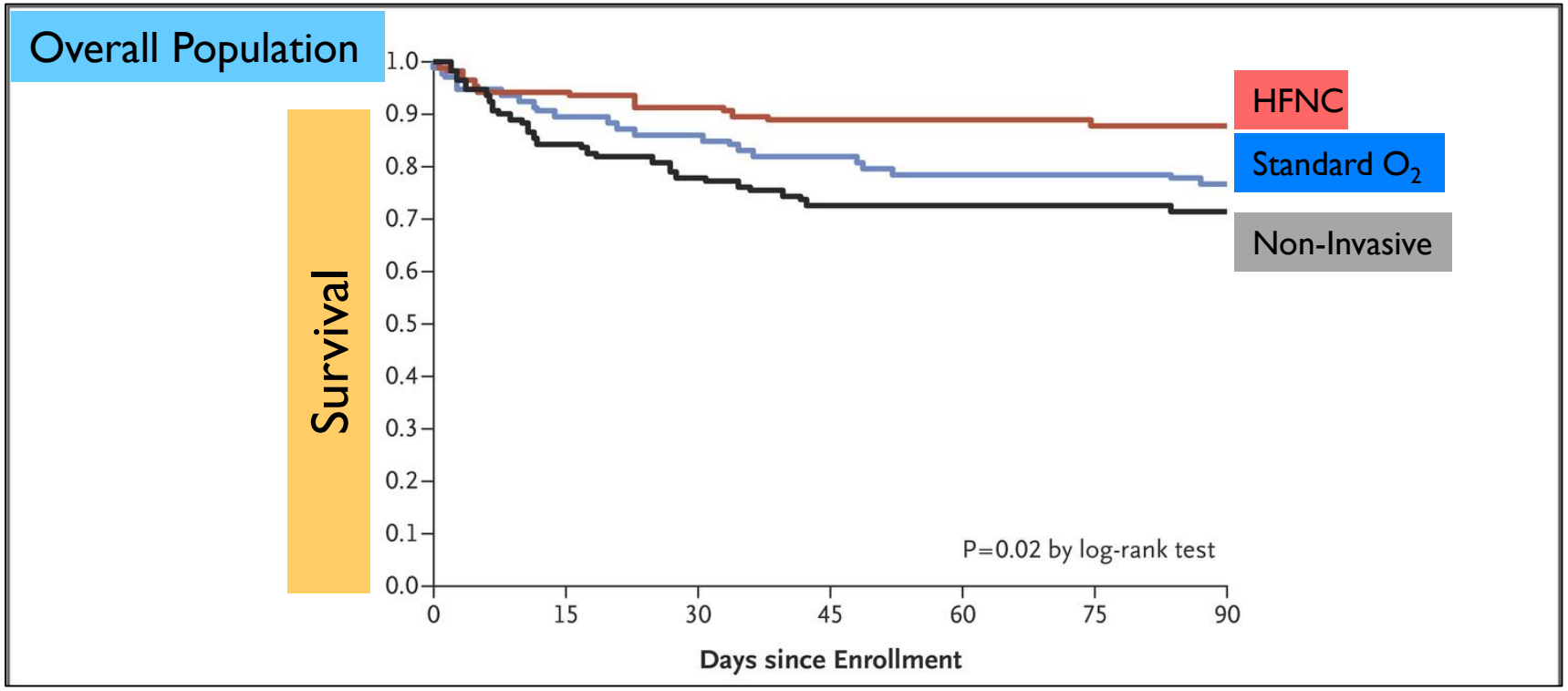
13 L/min

111 // NIV

IPAP 8.3 cm/H_20
Vt ~ 9
EPAP 5 cm/H_20
FiO_2 67%
~8 Hrs per day

FRAT J ET AL. N ENGL J MED 2015;372:2185-2196.

IMPROVED SURVIVAL IN THE HFNC GROUP



FRAT J ET AL. N ENGL J MED 2015;372:2185-2196.

CASE 3 CONCLUSION

- You initiate HFNC with:
  - 40 - 60L flow
  - 100% FiO2
- What would make you comfortable he improving?
- How soon would you reassess him?

WHAT VENTILATOR CHANGES?

- 7.38 / 40 / 45 on 30% FiO2 and PEEP 5

- 7.38 / 40 / 85

- 7.32 / 38 / 50 on 100% FiO2 and PEEP 10

- 7.32 / 38 / 70

- Vent Settings:
  - Volume Control
  - RR 20
  - VT 450ml (6ml/kg)

WHAT VENTILATOR CHANGES?

- Vent Settings:
  - Volume Control
  - RR 14
  - VT 450ml (6ml/kg)

- 7.15 / 85 / 90 on 30% FiO2 and PEEP 5

- 7.28 / 65 / 90

- 7.20 / 85 / 105 on 30% FiO2 and PEEP 5

- 7.14 / 105 / 95

GENERAL WORKFLOW

NIPPV

High Flow
Nasal Cannula

COPD Exacerbation → BiPAP
Heart Failure Exacerbation → CPAP or BiPAP
Hypoxemic Respiratory Failure → High Flow

TAKE HOME POINTS

- Respiratory failure can by hypoxic, hypercapnic or mixed
- Respiratory support chosen is determined by cause and type of respiratory failure
- Reassess your patient's response to the chosen respiratory support early and often initially
- Call for help or transfer if the patient isn't responding as expected to the changes you are making

QUESTIONS?

THANK YOU!