Mechanical Ventilation for Patient Transport

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Objectives

- Respiratory Failure
- Common Vent Parameters
- Control
- Modes
- Support Modes
- Non-Invasive Positive Pressure Ventilation
- Trouble Shooting
- Strategies
- Cases
- Sedation package

Ventilator Parameters

- Ventilation parameters to be familiar with:
  - V_E - Minute Volume (V_T x F) (4-8L/min)
  - V_T - Tidal Volume - 6-10 ml/Kg (IBW)
  - F - Frequency - 8-20 bpm
  - I:E - Inspiratory to Expiratory Ratio - 1:2 - 1:3
  - FiO_2 - Fraction of Inspired Oxygen - 0.21-1.00
  - pPlat - Plateu pressure - < 30 cm H_2O
  - PIP - Peak Inspiratory Pressure ~20-30 cm H_2O

Respiratory Failure

2 Types of Failure:

- Hypercarbic
  - Failure to remove CO_2 from the body
- Hypoxic
  - Failure to Oxygenate Tissue

Ventilatory Failure

Failing to remove adequate CO_2

- Dx: Respiratory Acidosis - specifically pCO_2 > 50mmHg and not improving
- Rx: Increase V_E - Increase T_V and then F

Hypoxic Failure

Failure to Oxygenate the tissue

- Dx: ABGs Respiratory Alkalosis, or Metabolic Acidosis
- Critical Value is a PO_2 < 60mmHg
- Rx: Increasing Mean Airway Pressure
  - PEEP
  - I:E Ratio modification
  - FiO_2 Increase

PEEP

Positive End Expiratory Pressure

- Retains airway pressure in the lungs at the end of expiration.
- Reduces effective TV
- Treat associated HOTN

- Physiologic is 3-5 cmH_2O, therapeutic is as high as 20 cmH_2O

I:E Ratio

Inspiratory to Expiratory Ratio

- Normal I:E is 1:2 - 1:3
- Mean Airway Pressure increases as we equalize the I:E
- 1:1 or inverted
  - Causes CO_2 retention
  - Permissive Hypercapnia
    - Keep pH above 7.2

FiO_2

Fraction of Inspired Oxygen

- Raising the FiO_2 is a short term solution
  - Oxydative stress, free radical damage in the lungs
  - Occurs in the space of hours.
- Target is to Keep FiO2 as low as possible, while maintaining adequate oxygenation.

The Decision to PPV

- Pros:
  - Airway Control
  - Real time assessment of respiratory system
- Cons:
  - Invasive Ventilation is not intrinsic
  - Reduction in Cardiac Output
  - VAP

Ventilator Related Lung Injury

- Lung Injury
  - Volutrauma
  - Barotrauma
  - Reduced Cardiac Output
  - Alveolar Shear injury

PPV - Breath Mechanics

- Normal Inspiration - the diaphragm and intercostals used to power negative pressure
  - Overcome resistance to flow created by airways, and lung compliance
    - PIP = airway resistance + lung compliance
    - pPlat = static measure of compliance, no flow
- Exhalation is passive

pPlat - Measuring…

- Expiratory Hold
  - High PIP and High pPlat = lung compliance problem
  - High PIP and Normal pPlat = Airway flow resistance

PPV - patient workload

- PPV reduces Oxygen demand
  - Patient still needs to perform some work
    - Muscle atrophy in hours - VIDD
    - Avoid prolonged paralysis
  - Acute vs. Longer term care strategies involve the patient doing a percentage of the work load

Syncrony

- The vent and the patient will work together if...
  - Set vent to the patient
  - meet the patient's demand
    - bucking? - adjust for demand.
    - Ensure adequate sedation and analgesia

Ventilator Control Modes

Volume Control

- TV remains constant regardless of pressure

Pressure Control

- Breath to preset pressure despite volume

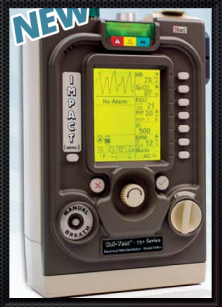
**Time Cycled*

- Approximation of Volume based on Flow x Inspiratory Time

Control Modes

What starts a breath?

- CMV
- A/C
- IMV
  - SIMV



Control Mode Ventilation

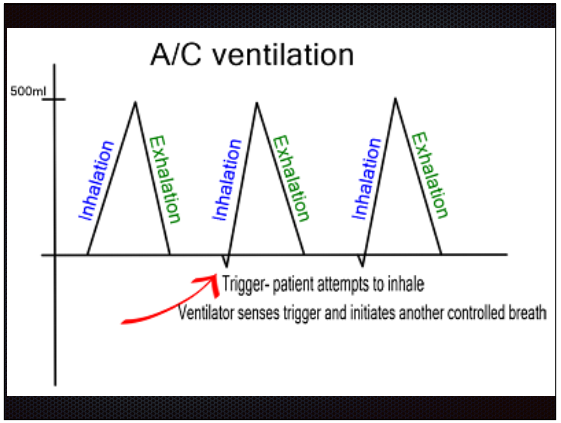
CMV

- Preset V_T/PIP x Preset Frequency
- 100% Ventilator Controlled
- Low tolerance, poor syncrony in awake patients
- Requires large amounts of sedation or paralysis

Assist Control

A/C

- Preset Frequency x Preset T_V/PIP
- Patient takes additional breath as desired
  - Each patient breath is at Preset T_V/PIP



Intermittent Mandatory Ventilation

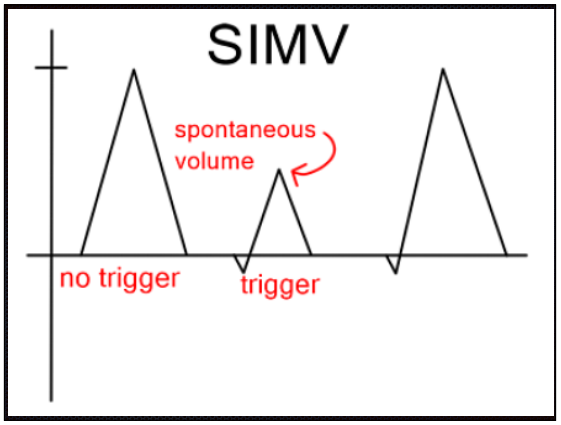
IMV

- Preset Frequency x Preset T_V/PIP
- Patient can take additional breaths
  - Patient breaths are at their own T_V

Syncronized IMV

SIMV

- Preset Frequency x Preset T_V/PIP
- Spontaneous breaths as in IMV
  - Vent senses breaths - achieves syncrony by:
    - Gives full machine breath if patient starts breathing near the next machine breath
    - All other breaths are at the patient's T_V



Support Modes

PEEP

- Positive End Expiratory Pressure
  - Elevates MAP
  - Retains Volume in the airways

Support Modes

Pressure Support

- In SIMV, patient receives additional flow during inspiration on patient initiated breaths
- Eases breathing through the ET tube, dead space, helps achieve higher Tv.
- Range of additional 5-10 cmH_2O

NiPPV

Non Invasive Positive Pressure Techniques

- CPAP
- BPAP, BiPAP (Name Brand) BiLevel, VLPAP, etc.
  - IPAP + EPAP

Trouble Shooting

High Pressure Alarms

- Always an Emergency!
  - Until proven otherwise
- DOPE or SCOPE

SCOPE:

- Suction
- Connections
- Obstruction
- Pnemothorax
- ETT-Displacement

Trouble Shooting

Low Pressure Alarms

- Gas Supply
- Circuit disconnect
- ET-Displacement
- Hypovolemia

Trouble Shooting

Low Oxygenation

- Vent Settings outside parameters
- ET Placement
- Suction
- Pneumothorax
- Pulmonary Embolus

Universal Vent Strategy

1. Blood Pressure
2. Acid Base Status
3. Syncrony
4. Titration

Vent Titration

- Oxygen status is controlled by ***Mean Airway Pressure***
  - PEEP, I:E, FiO2
- Ventilation is controlled by **VE** (Minute Volume)
  - Freq. and TV

Ve vs. Va

- Making smart adjustments to Ventilation
  - Dead space is about 1ml/lb IBW
  - Ve = Va + Vd
  - Does 12 at 500 = 24 at 250?
    - Ve = yes, but Va = no

Using the whole lung

- PIP vs. pPlat
  - PIP - compliance + resistance to flow
    - Measure pPlat in some cases.
  - Keep PIP <30-35 cmH2O
- OK to Increase Tv until pressures begin to rise.

Vent Strategies

- Neuromuscular Injuries / Diseases
  - Total Support
  - Larger TVs
  - higher flow rates
  - no PEEP

Vent Strategies

- ARDS - Lung protective
  - pPlat <30 cmH20
  - Maximize PEEP to achieve SpO2 >88-95%
  - PaO2 target 55-80mmHg
  - FiO2 <0.60
  - Smaller TV (6-8ml/Kg IBW)
  - Recruitment / sigh

Vent Strategies

- COPD
  - Apply PEEP
  - AC / with paralysis / heavy sedation for vent synchrony
  - High flow rates
  - Low VE, watch for auto PEEP and give longer E-Time as needed.

Vent Strategies

- CHF / AMI
  - Proper sedation and analgesia
  - Minimize patient work load (Oxygen Demand)
  - NPPV for CHF

- 70 Kg Male w AMI / Pulmonary Edema
- Intubated, Vent and Labs as noted

Vent	ABG	Chem7
700ml x 16	pH 7.36	Na 137
FiO2 0.40	PaO2 56	K 3.5
PEEP 0	PaCO2 38	Cl 97
I:E 1:1.8	HCO3 22	TCO2 23
PIP 46 pPlat 40	SaO2 81%	BUN 9.3
	BE -3.2	Cr 0.9
	Temp 36.9 C	Gluc 89

- 80 Kg Male w CVA / Pulmonary Edema
- Intubated, Vent and Labs as noted

Vent	ABG	Chem7
650 x 12	pH 7.10	Na 149
FiO2 0.40	PaO2 88	K 4.3
PEEP 0	PaCO2 62	Cl 102
I:E 1.2:1	HCO3 22	TCO2 22
PIP 42 pPlat 32	SaO2 94%	BUN 11.1
	BE -3.2	Cr 1.2
	Temp 36.9 C	Gluc 102

- 75 Kg female w altered LOC / acute respiratory distress
- Intubated, Vent and Labs as noted

Vent	ABG	Chem7
650 x 12(+ 12-14)	pH 7.13	Na 147
FiO2 0.30	PaO2 126	K 3.2
PEEP 0	PaCO2 26	Cl 107
I:E 1:1.7	HCO3 12	TCO2 11
PIP 26 pPlat 22	SaO2 98%	BUN 20.1
	Temp 36.8 C	Cr 1.9
		Gluc 397

- 60 kg female ejected from MVA in a rollover
- Intubated, Vent and Labs as noted

Vent	ABG	Chem7
650 x 18	pH 7.51	Na 139
FiO2 1.00	PaO2 368	K 4.2
PEEP 5	PaCO2 28	Cl 98
I:E 1:1.5	HCO3 21	TCO2 26
PIP 49 pPlat 42	SaO2 100%	BUN 10
	Temp 36.2 C	Cr 0.8
		Gluc 90

Sedation Package

- RASS score and gauging sedation quality
- Sedatives
- Analgesics
- A1 Sedation Strategy

Richmond Agitation Sedation Scale (RASS) *

Score	Term	Description	
+4	Combative	Overtly combative, violent, immediate danger to staff	
+3	Very agitated	Pulls or removes tube(s) or catheter(s); aggressive	
+2	Agitated	Frequent non-purposeful movement, fights ventilator	
+1	Restless	Anxious but movements not aggressive vigorous	
0	Alert and calm		
-1	Drowsy	Not fully alert, but has sustained awakening (eye-opening/eye contact) to *voice* **(≥10 seconds)**	Verbal Stimulation
-2	Light sedation	Briefly awakens with eye contact to *voice* **(<10 seconds)**	Verbal Stimulation
-3	Moderate sedation	Movement or eye opening to *voice* **(but no eye contact)**	Verbal Stimulation
-4	Deep sedation	No response to voice, but movement or eye opening to *physical* stimulation	Physical Stimulation
-5	Unarousable	No response to *voice or physical* stimulation	Physical Stimulation

Hitting the Sweet Spot

- Mistakes of the past lead to delirium
  - Profound sedation
- Current Thinking
  - RASS -2 to -4
  - Maybe deeper for techniques that are less natural (i.e. inverse I:E, High PEEP, etc.)
- Sedation Vacation
  - Avoiding Delirium
    - 2.5-3.2x the mortality rate
    - Other persistent cognitive impairments

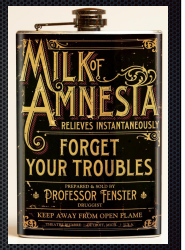
All Sedatives can provoke HOTN in the setting of shock.

Use Caution and reduced dosing as needed

Opiates and Benzos

- Fentanyl with Versed is common
  - Bolus dose vs. Infusion
- Dosing should be regimented to keep dosing as low as possible.
  - Caution with large bolus doses of Benzos if the patient is at risk for HOTN

Propofol / Diprivan



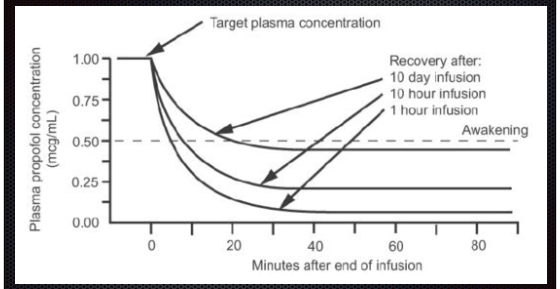
- Lecithin based sedative hypnotic
  - Avoid with Soy or egg allergies
  - Use strict aseptic technique.
  - Only use for 4 hours in the original container, or 2 hours as drawn up

Propofol

- Propofol produces a dose dependent sedative / hypnotic effect.
  - Also is cardio suppressive and produces a dose dependent hypotension in susceptible patients
  - Dosing is 2-100 mcg/Kg/Min

Propofol Trivia

- Propofol Infusion Syndrome
  - Huge doses (>5mg/Kg/Hr) for periods longer than 48 hours
  - Results in a syndrome characterized by characterized by severe metabolic acidosis, hyperkalemia, lipemia, rhabdomyolysis, hepatomegaly, cardiac and renal failure.



Dexmedetomidine

- A2 agonist
  - Causes Sedation with arousability
  - Should be combined with some analgesia
- Dosing is 0.2-0.7 mcg/Kg/Hr
- Can Cause AV and SA nodal blocks, bradycardia, HOTN
  - Side effects are most common with initial dosing

Sedation strategies

- A1 Sedation Analgesia
  - Avoiding delirium
- Analgesia is given in doses high enough to make being intubated (almost) comfortable / tolerable
- Sedation is then added to a level that allows the patient to achieve the preferred RASS score
  - This minimizes the amount of sedative and lowers the risk of delirium.

Questions or Comments ?