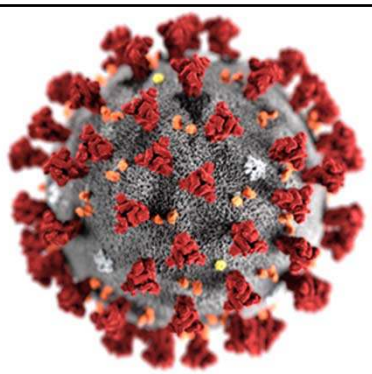
COVID-19 Healthcare Professionals' RT Cross-training



Airway Management & Mechanical Ventilation

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Disclaimer

- This lesson is designed to provide training in basic respiratory care and ventilator management, in the event that there is a disaster that causes a surge in the number of patients that require mechanical ventilation. Our goal is not to train you to become a respiratory therapist, but to teach you the most basic skills needed to meet the respiratory needs of patients requiring ventilation.

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Video References

Ventilator Basics Videos:

Part 1 (approx. 13 minutes)
https://www.youtube.com/watch?v=05zhBlwNENU

- Part 2 (approx. 10 minutes)

https://www.youtube.com/watch?v=naFzl5V1Wg4

Cross-training- Very detailed (approx. 1 hour, 10 minutes)

- https://youtu.be/vFuGERzxKxU

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Terms & Definitions

- **Respiratory Failure** includes conditions involving:
  - Heart
  - Lungs
  - Brain
  - Spinal cord
  - Muscles involving ventilation (mainly the diaphragm)
- **Oxygenation** occurs via alveoli (air sacs) when oxygen diffuses into our blood stream to be delivered to our muscles and other tissues and organs in the body.
- **Ventilation** occurs when carbon dioxide (CO_2) is diffused back into the alveoli to be exhaled out of the lungs before the next breath
- **Mechanical ventilation** uses positive pressure to force air and O_2 into a patient's lungs using an artificial airway:
  - Endotracheal tube (can be used orally or nasally)
  - Tracheostomy tube

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Terms & Definitions

- **Modes of ventilation**: refers to the manner in which the ventilator delivers breaths, either providing:
  - Complete ventilatory support (CMV/AC, APRV)
  - Partial ventilatory support (SIMV, PS/CPAP)
- The **care provider determines the appropriate mode of ventilation** by determining:
  - The patient's underlying condition
  - The patient's ability to breathe spontaneously
- Careful monitoring should always occur if modes are changed.

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Terms & Definitions

- **Respiratory Rate (RR or f)** is the frequency of breaths per minute
  - Normal rate is 12-20 breaths/min
  - Example, a RR of 12 will provide a breath every 5 seconds; whereas a RR of 20 will provide a breath every 3 seconds
- **Tidal volume (Vt)** is the amount of air delivered with each breath
  - Determined by patient's height and degree of lung disease
  - Current practice utilizes tidal volumes of 6-8 mL/kg
  - ARDS protocol utilizes 4-6 mL/kg
  - Vt is expressed in milliliters (i.e. 400 mL) or liters (i.e. 0.400 L) (depending on the ventilator)
  - Lung size is determined by a patient's height, NOT weight.

Example, if your patient's ideal body weight (IBW) is 55kg, the appropriate initial tidal volume will be 330 mL or 0.330 L.

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Terms & Definitions

- Ideal Body Weight Chart…quick reference

MALE		FEMALE	
Height	Ideal Weight	Height	Ideal Weight
4' 6"	28 - 35 Kg	4' 6"	28 - 35 Kg
4' 7"	30 - 39 Kg.	4' 7"	30 - 37 Kg.
4' 8"	33 - 40 Kg.	4' 8"	32 - 40 Kg.
4' 9"	35 - 44 Kg.	4' 9"	35 - 42 Kg.
4' 10"	38 - 46 Kg.	4' 10"	36 - 45 Kg.
4' 11"	40 - 50 Kg.	4' 11"	39 - 47 Kg.
5' 0"	43 - 53 Kg.	5' 0"	40 - 50 Kg
5' 1"	45 - 55 Kg.	5' 1"	43 - 52 Kg.
5' 2"	48 - 59 Kg.	5' 2"	45 - 55 Kg.
5' 3"	50 - 61 Kg.	5' 3"	47 - 57 Kg.
5' 4"	53 - 65 Kg.	5' 4"	49 - 60 Kg.
5' 5"	55 - 68 Kg.	5' 5"	51 - 62 Kg.
5' 6"	58 - 70 Kg.	5' 6"	53 - 65 Kg.
5' 7"	60 - 74 Kg.	5' 7"	55 - 67 Kg.
5' 8"	63 - 76 Kg.	5' 8"	57 - 70 Kg.
5' 9"	65 - 80 Kg.	5' 9"	59 - 72 Kg.
5' 10"	67 - 83 Kg.	5' 10"	61 - 75 Kg.
5' 11"	70 - 85 Kg.	5' 11"	63 - 77 Kg.
6' 0"	72 - 89 Kg.	6' 0"	65 - 80 Kg.

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Terms & Definitions

- **Inspiratory time (T_I)** is the time in seconds required to achieve one full inspiratory tidal breath (the time it takes to inhale).
  - T_I is determined by the healthcare provider to achieve
  - Normal inspiratory time for an adult is **0.8 – 1.25 seconds**
  - The higher the respiratory rate, the shorter your T_I will be in order to allow for adequate expiratory time
- Setting appropriate inspiratory time is vital to setting an efficient inspiratory to expiratory time **I:E ratio**
  - An appropriate I:E ratio is 1:2, 1:3 or 1:4
- I:E ratios of 1:1.5 or 2:1 or greater should only be used in specialized cases, such as ARDS or problems associated with severe hypoxia.
  - An I:E ratio such as **2:1 or 3:1** is called an **inverse ratio**

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Terms & Definitions

- **PEEP** stands for positive end expiratory pressure
- It is the pressure left in the lungs after exhalation to improve alveolar recruitment and oxygenation
- PEEP is typically set between 5-20 cmH2O.
  - 5 cmH2O is considered a therapeutic level of PEEP
  - PEEP levels higher than 10 are typically considered a part of the ARDS protocol

- **FiO2** is the fraction of inspired oxygen delivered by the ventilator
  - Room air is 21% oxygen
  - Higher FiO2's should be administered as need and if patient condition is in question
  - Procedures such as suctioning may require higher FiO2 to pre- or hyperoxygenate patient

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Terms & Definitions

- **Sensitivity** is a value set that allows patients to take a breath (in any mode)
  - The typical setting is 2 to 3 L/min OR -2 to-3 cmH2O
  - Sensitivity is also know as:
    - Trigger
    - Breathing effort
    - Or simply, sensitivity setting

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Terms & Definitions

- **Airway pressure** is a result of positive pressure being delivered to the lungs artificially via a ventilator or manual resuscitation bag
  - AKA:
  - Peak airway pressure
  - Peak inspiratory pressure (**PIP**)
  - The degree of positive pressure with each breath is highly influenced by the patient's lung compliance and airway resistance.
    - As lungs compliance decreases (i.e. with ARDS), lungs become stiffer; thus causing PIP's to increase
    - As airway resistance increases (i.e. secretions in airway), PIP's will increase
  - **PIP**'s above 35 cmH2O are considered unsafe and should be avoided
  - Spontaneously breathing patients have very low PIP's

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Terms & Definitions

- **High pressure alarm** !!!!!
- The high pressure alarm limit designates the highest possible pressure that will be delivered by the ventilator.
- If the PIP reaches this set value, an alarm will sound and the breath will be expelled in order to prevent lung injury due to high pressures
  - PIP's above 35 cmH2O should be avoided
  - High pressures should only be permitted for short periods of time, as with a patient coughing.
- The high pressure alarm setting should be set 10-15 cmH2O above the average PIP readings.

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Terms & Definitions

- **Low pressure alarm!!**
- This alarm activates when inspiratory pressure is less than the set value
- Although not available on all ventilators, it is generally set 5-10 cmH2O above end expiratory pressure (or PEEP)

- This alarm is **typically caused by a disconnection from the ventilator**

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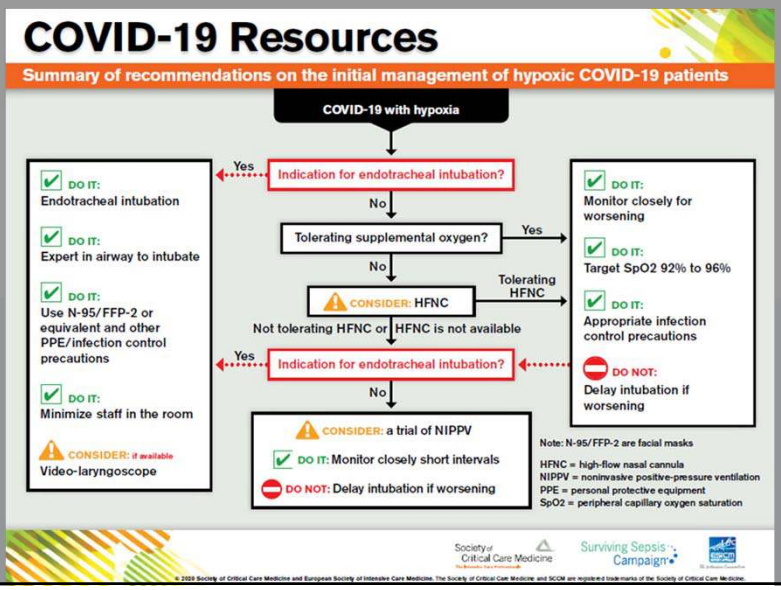
Recommendations For C-19 Patient Management



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Appropriate PPE

- PPE Needed:
  - N95 respirator
  - Face shield/goggles
  - Gown
  - Gloves

- Aerosol-generating Procedures:
  - endotracheal intubation,
  - extubation,
  - bronchoscopy,
  - open suctioning,
  - administration of nebulized treatment,
  - manual ventilation intubation,
  - disconnection of the patient from the ventilator,
  - non-invasive positive pressure ventilation,
  - tracheostomy,
  - high-flow nasal cannula (CFNC) >25 lpm
  - and cardiopulmonary resuscitation

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Airway Management

- **Types of artificial airways**:
  - Endotracheal tubes (ETT); can be placed orally or nasally
  - Tracheostomy tubes; surgically placed
  - Laryngeal Mask Airway (LMA); orally placed without laryngoscope (FOR TEMPORARY USE)
- **ALL artificial airways must be adequately secured** before leaving the patient
  - ET tube holder
  - Trach tie
  - Twill tape (looks like white shoe string)
- For endotracheal tubes, **always check tube marking(s)** to ensure the tube has not migrated.
  - The initial placement is determined by the intubating personnel; then verified by chest x-ray
  - Document the size of the ET tube and the place marking at the lip or teeth (use same anatomical landmark each time)
  - Tube placement should be assessed with each patient–ventilator assessment and as needed
    - For example, after turning a patient or after a coughing spell

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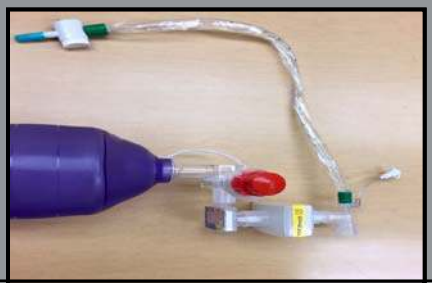
Manual Ventilation With An Artificial Airway

- Connect the resuscitation bag to the ET tube or trach without pulling or tugging to prevent dislodgement. Also, be careful not to kink or bend the ET tube.
- When bagging a patient, provide just enough volume to see chest rise. Avoid hyperinflation.
- Always manually ventilate your patient with 100% O2 with flowmeter set to flush
- For Covid-19 patients, bag with a HEPA filter attached to bag



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Invasive Ventilation…Types of Breaths

- **Spontaneous breaths** are initiated by the patient (patient-triggered), patient-timed.
- With **mandatory breaths**, the ventilator determines the start time according to the time or volume (or both) set by the operator.
- **Assisted breaths** are patient-triggered but the volume or pressure is determined by the preset values (Vt or PI).

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Basic Ventilator Modes: CMV/AC

- Continuous Mandatory Ventilation/Assist Control
- Can deliver tidal volume (Vt) or pressure (P_I)
- Set rate and tidal volume (Vt)
- Pt can initiate as many breaths as they want but each breath will be given at the set Vt
- Used to allow patient to rest
- Ventilator does all the work

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Basic Ventilator Modes: CMV/AC

- A specific tidal volume **or** inspiratory pressure is set for each breath. When the patient triggers (starts) a breath, it is considered **assist/control**.
- Example Vent Settings:
- Volume Control- CMV (or VC-AC)

Vt	F	PEEP	FiO2	Sensitivity
420 mL	15 breaths	+5 cmH2O	60%	2 L/min

- Pressure Control- CMV (or PC-AC)

P_I	F	PEEP	FiO2	Sensitivity
25 cmH2O	15 breaths	+5 cmH2O	60%	2 L/min

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Basic Ventilator Modes: SIMV

- Synchronized Intermittent Mandatory Ventilation
- Can deliver tidal volume (Vt) or pressure (P_I)
- Set rate and Vt given with each mandatory breath
- In between mandatory breaths, patient can take their own breath with "pressure support"
- Good mode for weaning
- Vent does part of the work and pt does the rest (only if the pt makes effort to breathe over the set rate)

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Basic Ventilator Modes: SIMV

- When in SIMV mode, spontaneous breaths are supported (not controlled) with pressure support [PSV]. PS helps to augment the resistance of ETT and helps with patient's wob.
- This mode was designed to prevent "breath stacking"- (when the ventilator accidentally delivers a mandatory breath when the patient triggers a spontaneous breath).
- Example Vent Settings:

Vt	F	PEEP	PS	FiO2	Sens.
450mL	12	+8cmH2O	+10cmH2O	50%	2 L/min.

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Basic Ventilator Modes: CPAP/PS

- Continuous Positive Airway Pressure with Pressure Support
- Spontaneous mode of ventilation
- CPAP stents alveoli open while PS helps to augment Vt. PS helps surpass resistance of ETT
- No set rate; patient must initiate all breaths
- Appropriate settings of
  5 of PS/5 of CPAP -OR-
  10 of PS/ 5 CPAP
- Can indicate how well the patient will do once extubated. Pt's should have spontaneous volumes of 4-6 mL/kg or about 300 mL on average to be considered for weaning

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Basic Ventilator Modes: APRV

- Airway Pressure Release Ventilation
- Used for patient who are unable to oxygenate with traditional ventilation despite high FiO2 and PEEP
- Uses inverse ration ventilation to keep lungs open longer for maximal oxygenation
- Risk of pneumothorax, barotrauma, decreased cardiac output

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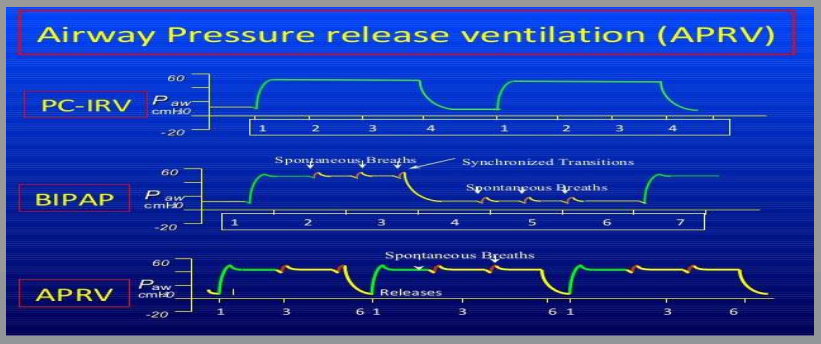
Basic Ventilator Modes: APRV



P_{high} 30 cmH2O	P_{low} 5 cmH2O	T_{high} 2.5 sec	T_{low} 0.5 sec	FiO2 100%

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Ventilator Alarms

High Pressure

- Possible causes
  - Biting ET tube
  - Kink in tube or circuit
  - Occlusion (Suction catheter left in ETT)
  - Plug (i.e. mucous or blood)
  - Tension pneumothorax
  - Pt coughing or bucking the vent

Low Pressure

- Possible cause
  - Pt "popped off" vent; disconnected
  - Cuff not properly inflated or severe leak in circuit
  - Pt is extubated (ET tube cuff is above vocal cords)

Apnea Alarm

- Sounds when patient fails to breath within a preset period of time in a spontaneous vent mode (i.e. PS/CPAP)

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Troubleshooting Airway Problems

- Possible Airway Problems…
  - ETT migrated above vocal cords (accidental extubation)
    - Check tube markings to verify correct placement; will cause a low volume or low pressure alarm
  - ETT advanced to far down the trachea to the carina
    - Check tube markings to verify correct placement; will cause excessive coughing and/or high pressure alarm
  - Right mainstem bronchus
    - Check tube markings to verify correct placement and auscultate breath sounds; will cause high pressure alarm and/or desaturation per POX
  - Kinking or patient biting
    - Straighten tube or add bite block: may result in high pressure alarm and/or low Vt
  - Ruptured cuff
    - Check cuff pressure and refill. If pressure does not hold, pt will require reintubation. Manually ventilate if required. Will cause low pressure or volume alarm
  - Tube obstruction due to mucous plugging (or blood)
    - Attempt to pass suction catheter to verify; will cause high pressure alarm and/or desaturation of POX, and increased wob/distress

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Troubleshooting Low Volume or Low Pressure Alarms

- Possible causes of leaks…
  - Patient disconnect
  - Circuit leaks (areas of the circuit including embedded equipment like HME, spacers)
  - Disconnect of circuit tubing from ventilator
  - Temperature monitor ports
  - Exhalation valve leaks
  - ETT or tracheostomy tube cuff leaks
  - Chest tubes
  - Tracheal deformities (i.e., tracheolmalacia or tracheoesophageal fistula)

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Troubleshooting High Pressure Alarm

- **3 Conditions Can Contribute/Cause High-Pressure Alarms**…
  - Conditions related to the airway
    - Coughing, secretions, mucus in airway(s)
    - Biting of ETT or Kinking of ETT
    - Mainstem bronchus
    - Herniated ETT
  - Conditions related to the lungs
    - Increased airway resistance (bronchospasms, secretions, mucous plugs, mucosal edema)
    - Reduced lung compliance
    - Patient-ventilator asynchrony
  - Changes in the ventilator circuit
    - Excessive condensation in circuit
    - Kinking or pinching of patient circuit
    - Malfunction of inspiratory or expiratory valves

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Troubleshooting High Pressure Alarm

- If you are unable to correct this alarm in a short time, disconnect patient from ventilator and provide bag-to-tube ventilation and call for help!
- If bagging is difficult due to some type of resistance, and your the suction catheter cannot be successfully passed, call for help! Extubation and bag/mask ventilation may be required.

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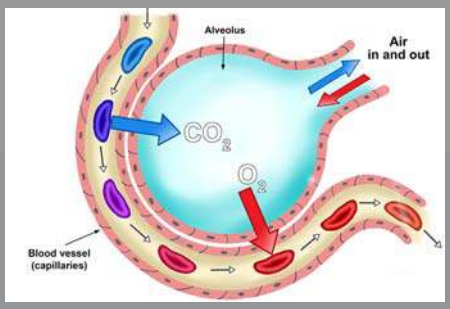
Ventilator Management… According to ABG Results

- What two vent settings control oxygenation?
  - FiO2 and PEEP
- How would you manipulate those settings to improve oxygenation?
- Manipulate FiO2 or PEEP (Remember, oxygen is a drug)

- What two vent settings control ventilation?
  - RR and Vt
- How would you manipulate those settings to improve ventilation?
- Increase RR; if unsuccessful, increase Vt



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Weaning from Mechanical Ventilation

Weaning should begin when initial reason for mech. ventilation is resolved!

- Wean sedation
- Place pt in spontaneous mode of ventilation
- Monitor vital signs, Vt, RR and work of breathing
- Place back on controlled mode if pt becomes tachypneic or tachycardic or in anyway unstable
- If pt passes trial they are probably ready for extubation
- Breathing tests or ABG's can be ordered to further assess pt's readiness for extubation

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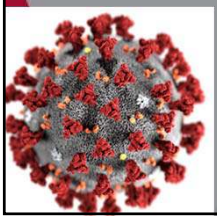
Extubation

- Equipment for Reintubation nearby
- Procedure
  - Upright
  - Suction ETT
  - Remove ETT from holder
  - Place surgical mask
  - Ask patient to take a deep breath and exhale
  - Deflate cuff and remove ETT
  - Suction oral cavity
  - Ask patient to take deep breath and cough
  - Provide Supplemental Oxygen

Ensure all staff are wearing appropriate PPE for this aerosolizing procedure!



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If ever in doubt, call Respiratory Therapy!

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