

Foundations of Emergency Medicine

Foundations III: Guided Small Group Experience

Session 17: The Critically Ill Ventilated Patient

Unit: Critical Care

❖ Agenda and Learning Objectives

- Case Part I – **Peri-intubation Management** (15 min)
 - Develop an approach to pre-intubation optimization of the patient.
 - Develop an approach to initial ventilator settings
 - Develop an approach to post-intubation sedation
- Case Part II – **An Approach to a Slowly Worsening Ventilated Patient** (10 min)
 - Review the D.O.P.E.S. mnemonic for diagnosing the cause of ventilator dysfunction
 - Review how to differentiate between compliance and resistance problems using peak pressure and plateau pressure
- Case Part III – **An Approach to the Crashing Ventilated Patient** (15 min)
 - Review the D.O.P.E.S. mnemonic for diagnosing the cause for a crashing patient.
 - Review the D.O.T.T.S. mnemonic for treating the crashing patient.
- Case Concludes and Teaching Points (10 min)
 - Review Session Teaching Points

❖ Note to Facilitators

These cases are meant to give learners a systematic approach to caring for critically ill ventilated patients and the management of their ventilators. In the first part of the case, the learners are taken through the peri-intubation management of a critically ill patient with respiratory failure and significant hypovolemia vs sepsis (similar to Session 14: Physiologically Unstable Intubations). The case then continues to address the management of slowly worsening ventilated patient and introduces the DOPES mnemonic for addressing ventilator dysfunction. Finally, the last case takes learners through a crashing ventilated patient and introduces the DOTTS mnemonic for treating a crashing ventilated patient. The session is a large group, question guided discussion and requires no other additional preparation or material to facilitate.

❖ Case Part I – Peri-intubation Management (15 min)

- *EMS arrives with a 68-year-old female who was found in respiratory distress by her husband. She arrives altered with a GCS of 8. EMS reports diffuse wheezing and poor air movement. She received a continuous albuterol neb and 125 mg solumedrol in route. She has the following vital signs:*

Temp unavailable, HR 120, RR 28, BP 65/40, O2 80% on non-rebreather, glucose 119

She is using accessory muscles for respirations, appears fatigued, and has diffuse wheeze and rhonchi on exam. Lung POCUS is notable for lung sliding as well as absence of b-lines, pleural, and pericardial effusion. Cardiac POCUS demonstrates a hyperdynamic heart without McConnell's sign, septal wall flattening, or regional wall abnormalities as well as IVC respiratory variation > 50%.

❖ Discussion Questions with Teaching Points

- **What are your next steps in the stabilization of this patient before attempting intubation?**
 - This patient needs optimization of her blood pressure and oxygenation before attempting intubation
 - Hypotension and hypoxia are both independent risk factors associated with peri-intubation cardiac arrest → these patients often have a reduced intravascular volume, sympathetic output will be maxed, and they will have end organ dysfunction
 - The following are interventions and issues to prepare for as you proceed toward intubation:
 - 2 large bore IV's, O2, cardiac monitor
 - IVF bolus (NS or LR)
 - Exam is consistent with volume depletion, likely due to insensible losses from a COPD exacerbation vs sepsis
 - BiPAP
 - **What settings?**
 - IPAP of 10, EPAP of 5, FiO2 100%
 - **Anything else?**
 - NC under BiPAP mask at 15 L/min
 - **What may happen to the blood pressure with BiPAP initiation?**
 - Increased intrathoracic pressure from BiPAP can work to decrease cardiac venous return, right ventricular preload, and cardiac output → in a hypovolemic patient this can further decrease blood pressure.
 - Push-dose pressors (discussed below)
 - These should be on stand by for blood pressure augmentation after the patient's fluid bolus and BiPAP initiation
- **What would be a good pressor choice for this patient?**
 - Epinephrine 5 - 20mcg every 2-5 min PRN
 - To mix yourself, take 1 mL of the cardiac arrest epi vial (100 mcg/mL) and mix with 9 mL of saline flush → this creates a 10 mL syringe with a concentration of 10 mcg/mL
 - Give 0.5 – 2 mL every 2-5 min (5 - 20 mcg)
 - Onset is < 1 min and lasts 5-10 min
 - Alpha 1, Beta 1/2 effects would improve hypotension and promote bronchodilation

- **Are there any specific considerations regarding RSI medications?**
 - Most can reduce sympathetic tone and blood pressure → be prepared and share your concerns with the room so your team knows what to expect
 - Could consider ketamine 1-2mg/kg in a hypotensive patient
 - NMDA antagonist
 - Stimulates catecholamine release and so good for bronchospasm and hypotension
 - Have push dose pressors (or a pressor bag hanging) available in anticipation of peri-intubation hypotension

❖ Case Part I Continues

- *Your patient is placed on BiPAP and receives a 2 L bolus of lactated ringers. Her repeat exam is notable for a blood pressure of 110/70, HR 110, RR 24, O2 sat 100%. Her mental status has not improved. You elect to intubate using ketamine and rocuronium. The patient's blood pressure drops to 80/40 on your first recycled pressure. You use a one-time dose of push-dose epinephrine 20 mcg with good effect.*

❖ Discussion Questions with Teaching Points

- **What are your initial post-intubation actions?**
 - You need to address the following in order to give your patient the best care, and avoid the potential for downstream complications:
 - Order proper vent settings
 - Order proper analgesia and sedation
 - Continue medical therapy for the patient's underlying disease
 - Vent settings
 - This patient has obstructive lung pathology, so we'll address 2 specific (often competing) considerations.
 - Breath stacking/Auto-PEEP
 - Respiratory acidosis
 - Set tidal volume to ideal body weight, and properly measure the patient's height in order to get this. Consider having a tape measure in your doctor kit or in your resuscitation room for proper measurement.
 - Here are proposed initial vent settings
 - Volume assist control
 - 4-8 mL/kg IBW, titrating to prevent breath stacking (allow full expiration) but also excessive respiratory acidosis
 - Flow rate 60 – 80 L/min
 - Respiratory rate of 10, titrating to prevent breath stacking but also excessive respiratory acidosis
 - PEEP of 0-5 → optimal PEEP in obstructive lung disease is controversial but this is likely a safe range

- FiO₂ of 40%
- First priority: Assess for breath stacking and titrate rate (then TV if needed)
- Measuring auto-PEEP (end expiratory pause)
- Monitoring flow time graph (see below)
- Second priority: Assess for excessive respiratory acidosis and titrate rate (then TV if needed)
- Allow for pH > 7.15 if needed to prevent breath stacking
- Obtain ABG and correlate with EtCO₂
- Sedation
 - Optimize analgesia first with an agent like fentanyl
 - Then add on an agent for sedation like propofol
 - Titrate to RASS -3 to 0
- Continue medical management
 - Continue COPD exacerbation therapy with albuterol, steroids, etc.
- CXR
 - Confirm ETT placement
 - Assess for PTX (be careful not to mistake blebs for PTX)

❖ **Case Part II – The Slowly Worsening Ventilated Patient (10 min)**

- *Your patient continues to be treated for their COPD exacerbation. You have ordered your initial ventilator settings and analgesia/sedation protocol appropriately.*

Thirty minutes later, the nurse comes to you and says, “Doctor, the vent alarms are going off frequently and our patient’s O₂ saturation is now in the mid-80’s. Can you come take a look?”

Vital Signs: HR 90 BP 130/93. O₂ sat 86%

Ventilator Settings: Volume Assist Control, TV 6 mL/kg, RR 10, PEEP 0, FiO₂ 40%

Peak pressure alarm has gone off several times

❖ **Discussion Questions with Teaching Points**

- **What is your approach to the hemodynamically stable patient with ventilator dysfunction?**
 - Use the mnemonic DOPES to trouble shoot the vent → reassess the patient’s sedation and review your ventilator settings
 - DOPES
 - D – Displacement of the endotracheal tube or cuff
 - Check tube insertion level
 - Check pilot cuff for proper pressure
 - Order CXR and/or perform direct laryngoscopy as necessary

- O – Obstructed endotracheal tube
 - See if the patient is biting down
 - Is the patient properly sedated?
 - Is there a kink in the tube?
 - Does the patient need suctioning?
 - Is there excessive condensation in the ventilator tubing that needs evacuation?
- P – Pneumothorax
 - Perform repeat CXR, bedside US
- E – Equipment check
 - Verify all equipment is properly connected from patient to the ventilator
- S – Stacked breaths
 - Review flow time graph or measure auto-PEEP (end expiratory pause) to verify achievement of full expiration
- Ventilator Settings
 - Review alarms on the ventilator
 - Check the peak pressure and the plateau pressure → many respiratory therapists can help you with this
 - Peak Pressure
 - Peak pressure during inspiratory flow from all causes
 - Generally should be below 40 mm H₂O chronically though this can be difficult to achieve at first
 - Plateau Pressure
 - Pressure in absence of flow
 - Measures the pressure from alveoli as a marker of lung compliance
 - Achieved by reviewing the pressure after an end inspiratory hold (this is a button on the ventilator, hold it for 0.5 sec)
 - Goal is a pressure ≤ 30 mm H₂O
 - Use your pressure measurements to narrow your differential diagnosis
 - High peak pressure and normal plateau pressure
 - Resistance Issue
 - Differential Diagnosis
 - Kink in the tube
 - Bronchoconstriction
 - Mucus plug
 - High peak pressure and high plateau pressure
 - Compliance issue (lung issue)
 - Differential Diagnosis
 - Pneumothorax
 - Pulmonary edema
 - ARDS

- Restrictive lung disease
- **Let's talk through this particular case using the DOPES mnemonic introduced above.**
[Facilitator Instructions: Walk your learners through each step, in order, to reassess your patient]
 - In this patient, there was a delay in continuing bronchodilators, causing worsening bronchoconstriction.
 - DOPES checked out all clear.
 - D – ETT is at proper depth, placement confirmed, pilot balloon normal
 - O – Tube was suctioned and clear
 - P – Bedside US with positive lung sliding, CXR unchanged
 - E – All equipment properly connected
 - S – Flow time graph unremarkable
 - Peak pressures were 50 mm H₂O with a plateau pressure of 28 mm H₂O
 - Proper management is continuation of bronchodilators

❖ Case Part III – The Crashing Ventilated Patient (15 min)

- *Your patient stabilizes after initiating bronchodilators. You bump your FiO₂ to 60% pending a therapeutic response. The patient is still boarding for the ICU in your emergency department.*

Twenty minutes later, your nurse comes to you again. She tells you that the ventilator is alarming again, but this time, your patient is hypotensive.

Vital Signs: HR 115, BP 84/44, O₂ 85%

Ventilator Settings: Volume Assist Control, TV 6 mL/kg, RR 10, PEEP 0, FiO₂ 60%

Peak pressure alarm has gone off several times

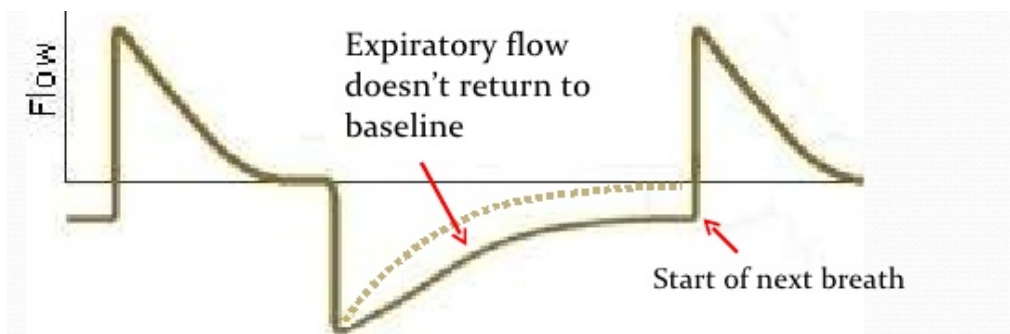
❖ Discussion Questions with Teaching Points

- **What is your approach to this patient with hemodynamic collapse on the ventilator?**
 - Use the mnemonic **DOPES** again for diagnosis but hemodynamic collapse needs immediate action → remember the mnemonic **DOTTS** for the actions you should take
 - **DOTTS**
 - D – Disconnect the patient from the ventilator and decompress chest wall
 - This helps to alleviate breath stacking → allow for complete decompression of the lungs (can also push on the chest)
 - O – O₂ at 100% by bag valve mask
 - While bagging, assess for the following:
 - Chest rise and fall

- Compliance of the lungs with administered breaths
 - Listen for air leaks
 - T – Tube position and function
 - Suction the ETT
 - Verify proper ETT depth
 - Confirm placement by direct laryngoscopy
 - Palpate the pilot balloon of the ETT to assess for cuff rupture
 - T – Tweak the ventilator
 - Review the flow time graph to verify complete expirations
 - Take a pause while bagging to allow decompression of the chest if necessary
 - S – Sonography
 - Assess for pneumothorax
- **Let's apply the DOTTS and DOPES mnemonic to this case.**

[Facilitator Instruction: Have the learners talk you through their actions using the DOTTS mnemonic but then talk your learners through diagnosing the problem using the DOPES mnemonic]

 - This patient has begun to suffer from significant breath stacking and has tension physiology → the patient will recover by allowing the lungs to decompress
 - **DOTTS**
 - **D** – Patient was disconnected from the ventilator.
 - This results in a prolonged expiration and decompression of the lungs
 - **O** – Patient is bagged by BVM at 100% O₂
 - No air leaks noted
 - Equal chest rise with prolonged expiration
 - **T** – Tube position confirmed
 - **T** – Ventilator adjusted with a reduction in RR to 8 after reviewing the flow-time graph
 - **S** – Sonography shows normal lung sliding
 - **DOPES**
 - **D** – ETT is at proper depth, placement confirmed by direct laryngoscopy, pilot balloon normal
 - **O** – Tube was suctioned and clear, no biting on the tube, patient properly sedated
 - **P** – Bedside US with positive lung sliding
 - **E** – All equipment properly connected
 - **S** – Flow time graph showed the following:



Flow/Time Scalar. Sinai EM. <https://sinaiem.org/post-intubation-care-for-the-critically-ill-asthmatic/>

❖ Case Part III Conclusion

- *Your patient's blood pressure improves after identifying that breath stacking was occurring and taking proper action. She is reconnected to the ventilator with a reduced respiratory rate of 8. You take care to reassess acid base status after your vent settings are changed. You want to verify the patient does not get too acidotic during permissive hypercapnia.*

❖ Teaching Points

- It is important to properly treat your patient during the peri-intubation period in order to reduce the chances of post-intubation complications (see Session 14: Physiologically Unstable Intubations). This includes:
 - Accurate diagnosis of the presenting problem
 - Pre-intubation resuscitative measures
 - Therapy targeted at the working diagnosis
 - Optimization of oxygenation
 - Optimization of hemodynamics with fluids and/or pressors
 - Proper post-intubation management
 - Continuation of therapy targeted at the working diagnosis
 - Setting of proper ventilator settings
 - Achievement of adequate sedation and analgesia
 - Continued hemodynamic support
- In the hemodynamically stable patient with ventilator dysfunction, remember the following:
 - Confirm adequate sedation
 - Apply the DOPES mnemonic for navigating your differential diagnosis for ventilator dysfunction
 - DOPES
 - D – Displacement of the ETT
 - O – Obstruction of the ETT
 - P – Pneumothorax
 - E – Equipment failure
 - S – Stacking of breaths
 - Review ventilator settings and alarms

- Flow-time graph can help identify breath stacking
- Perform end expiratory and end inspiratory pauses
- Reviewing the peak pressure and measuring a plateau pressure can narrow your differential for ventilator dysfunction
 - High peak pressure, normal plateau pressure = Resistance Issue
 - High peak pressure, high plateau pressure (≥ 30) = Compliance Issue
- In the hemodynamically unstable patient, you must act more quickly. DOTS is the mnemonic for your action plan and then go to DOPES once the patient is stabilized to diagnose the problem more fully.
 - DOTS
 - D – Disconnect the patient from the ventilator
 - O – O₂ at 100% by BVM
 - T – Tube position and function
 - T – Tweak the ventilator
 - S – Sonography for lung pathology

❖ Optional Case IV

- **Let's have an active review one more time, because... your patient is still boarding in the ED.**

The nurse comes to you and says the patient's ventilator is alarming again and that they are now hypotensive again.

Vital Signs: HR 100 BP 80/50. O₂ sat 82%

Ventilator Settings: Volume Assist Control, TV 6 mL/kg, RR 8, PEEP 0, FiO₂ 60%

Peak pressure alarm has gone off several times

- **What do you do now?**

[Facilitator Instruction: Walk your learners through each step, in order, to reassess your patient]

 - DOPES for your differential, DOTS for your action plan
 - This patient has now developed a pneumothorax (poor lady!) → the proper action is to work through the DOTS mnemonic again and then perform a thoracostomy
 - DOTS
 - D – Disconnect the patient from the ventilator and decompress chest wall
 - The patient's lungs are again allowed to decompress.
 - O – O₂ at 100% by BVM
 - You find a decrease in compliance when manually bagging the patient.
 - T – Tube position and function
 - The tube is in proper position
 - The pilot balloon is normal
 - The tube is suctioned without evidence of obstruction

- T – Tweak the ventilator
 - The blood pressure and oxygenation are so far unchanged, so you have not reconnected the patient to the ventilator
- S – Sonography for lung pathology
 - Sonography reveals presence of lung point → the transition between sliding lung and non-sliding lung (ie lung point) is the most specific sign of PTX

❖ Case IV Conclusion

Your ultrasound shows a lung point. You perform an immediate thoracostomy is performed with a rush of air. A chest tube is placed. Your patient's vitals improved. They are soon in transit to the ICU.

❖ Facilitator Background Reading

Session 17: The Critically Ill Vented Patient

As Emergency Physicians, it is important that we have a basic understanding of ventilator management outside of the immediate intubation period especially if our patients become unstable or the ventilator is malfunctioning. Though many hospitals have well trained respiratory therapists who are invaluable resources, some do not and we must train our learners for these situations.

Worsening ventilated patients can generally be divided into the gradually worsening patient or the immediately crashing patient (though if we ignore the gradually worsening ventilated patient they will often become what seems like an immediately crashing ventilated patient). The DOPPES mnemonic (shown below) is a systematic approach to diagnose the gradually worsening ventilated patient:

- D – Displacement of the ETT
- O – Obstruction of the ETT
- P – Pneumothorax
- E – Equipment failure
- S – Stacking of breaths

The mnemonic is easy to use and will diagnose most pathology applicable to the emergency setting. It does require a basic understanding of peak pressures, the maximal pressure the alveoli are exposed to from all causes (general goal should be < 40 mm H₂O) and plateau pressure, the pressure alveoli are exposed to in the absence of flow which is dependent on lung compliance (general goal should be < 30 H₂O). The plateau pressure is measured by performing an inspiratory hold maneuver (where no flow is sent through the ventilator) and measuring the pressure during the hold period. This is generally a button on the ventilator and many respiratory therapists can help you obtain this number (as well as the plateau pressure).

In contrast, the DOTTS mnemonic is an action plan to employ with the immediately hemodynamically unstable ventilated patient.

- D – Disconnect the patient from the ventilator
- O – O₂ at 100% by BVM
- T – Tube position and function
- T – Tweak the ventilator
- S – Sonography for lung pathology

The DOTTS action plan will often diagnose the problem but if not, one can then go back to the DOPPES mnemonic to further troubleshoot. We should remember that early ventilator management and lung protective strategies make a difference in our patient's outcomes and being facile with the

ventilator, and how to troubleshoot it and our patient, will allow us to take better care of these critically ill ventilated patients.

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- **Secondary Author and expert editor:** Dr. George Leach
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