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Impact of a respiratory ICU rotation on resident knowledge and confidence in managing mechanical ventilation

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Chart S1. Test used to assess the participants at the two moments of the study.

QUESTIONS - RESPIRATORY ICU

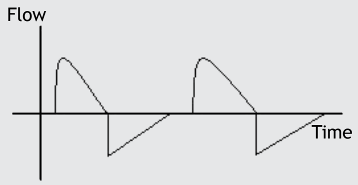
1. A patient with COPD is transferred to the ICU due to exacerbation. Respiratory rate = 27 cycles/min. Ideal body weight = 70 kg. Arterial blood gas on room air: pH: 7.32; pO_2: 50; pCO_2: 53; bicarbonate: 28; BE: +2.5; and SaO_2: 86%. The following can be stated:

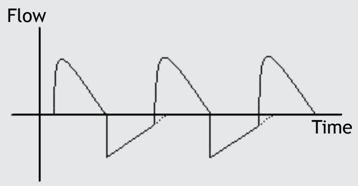
a. It is type II respiratory failure, because there is hypercapnia.
b. It is type II respiratory failure, because the alveolar-arterial oxygen gradient is increased.
c. It is acute type I respiratory failure.
d. The patient has chronic, rather than acute, respiratory failure, because there is already bicarbonate retention.

2. The patient in the question above was intubated and presented with worsened hypercapnia and respiratory acidosis. He is on assisted pressure-controlled ventilation, with a respiratory rate of 15 cycles/min; PEEP: 8 cmH_2O; pressure support: 10 cmH_2O; FiO_2: 40%, and V_T: 350 mL. You want to manage ventilation in order to reduce CO_2. What parameters can be changed?

a. Increase the RR.
b. Increase pressure support to increase V_T.
c. Reduce the dead space by removing extra filters and circuits between the patient and the Y of the circuit.
d. All of the above.

3. You have modified the ventilation parameters, and the flow curve of the ventilator, which was initially as depicted on the first figure, became one like that depicted on the second figure. What could be happening?





a. The ventilation seems to be appropriate now.
b. Auto-PEEP is probably occurring, and I will confirm this by performing an inspiratory pause.
c. Auto-PEEP is probably occurring, and I will confirm this by performing an expiratory pause.
d. The flow curve does not provide relevant information on mechanical ventilation in this case, and it is not possible to give an opinion about it.

4. The two patients below required orotracheal intubation:

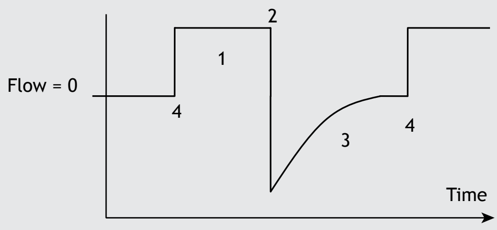
Patient 1: Exacerbated COPD

Patient 2: Septic shock and ARDS

What can you expect from the evaluation of the respiratory mechanics of each of them, respectively?

a. 1: Decreased compliance, decreased resistance. 2: Increased compliance, increased resistance.
b. 1: Normal compliance, increased resistance. 2: Normal compliance, normal resistance.
c. 1: Markedly decreased compliance, increased resistance. 2: Increased compliance, decreased resistance.
d. 1: Normal compliance, increased resistance. 2: Decreased compliance, normal resistance.

To set the context for questions 5 and 6, answer the questions about the respiratory cycle depicted in the flow curve below.



5. What is the ventilation mode?

a. Volume-controlled
b. Pressure-controlled
c. Pressure support
d. CPAP

6. What phases of the respiratory cycle do numbers 1 to 4 correspond to?

a. 1: expiration; 2: triggering; 3: inspiration; 4: cycling.
b. 1: expiration; 2: cycling; 3: inspiration; 4: triggering.
c. 1: inspiration; 2: cycling; 3: expiration; 4: triggering.
d. 1: inspiration; 2: triggering; 3: expiration; 4: cycling.

7. Regarding the assessment of a difficult airway and the criteria used in order to diagnose this condition, mark the incorrect statement.

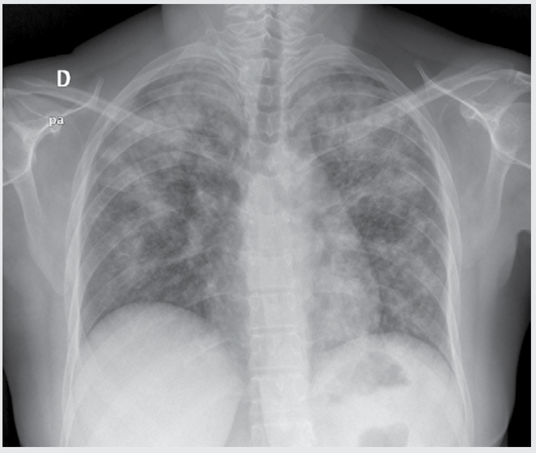
a. Patients weighing > 100 kg are more likely to have a difficult airway.
b. Mallampati III-IV is a predictor of difficult airway.
c. A thyromental distance > 6.5 cm increases the risk of difficulty in performing the procedure.
d. Mouth opening > 6 cm is a predictor of fewer complications during the procedure.

(Statement for the next 5 questions). A patient was diagnosed with septic shock due to pulmonary involvement. Initial measures adopted in the ER: general laboratory tests and blood cultures; arterial blood gas analysis with lactate; fluid expansion with 2,500 mL of buffered crystalloid solution; antibiotics in the first hour; invasive monitoring with the insertion of a central venous catheter and indwelling urinary catheter; and ICU transfer request.

You receive the patient in the ICU:

Anamnesis: regular overall health status, pallid +/+4, hydrated, acyanotic, T = 37.8°C; ideal weight = 60 kg, and measured weight = 70 kg; Neurological assessment: RASS = +2 and agitated; Cardiovascular assessment: MAP = 70, HR = 130 bpm, arterial lactate = 10 (at arrival = 18), and regular heart rate without heart murmurs; Respiratory assessment: RR = 27, pulmonary auscultation without adventitious sounds, SpO_2 = 90%, CPAP = 5 cmH_2O, and FiO_2 = 100%.

Chest X-ray:



8. What is the diagnosis?

a. Alveolar hemorrhage
b. Acute lung edema
c. Acute lung injury
d. Severe ARDS

9. What is the main mechanism of hypoxemia in this patient?

a. This is a true shunt effect.
b. It is a V/Q mismatch with a predominance of shunt.
c. It is a V/Q mismatch with a predominance of dead space.
d. There is a problem of alveolar-capillary membrane diffusion.

10. What is the best practice at this time?

a. Orotracheal intubation, ventilate the patient spontaneously with higher PEEP and V_T depending on the patient's effort.

b. Orotracheal intubation, ventilate the patient spontaneously with lower PEEP and V_T at approximately 490 mL.
c. Orotracheal intubation, ventilate the patient in controlled mode with higher PEEP and V_T at approximately 490 mL.
d. Orotracheal intubation, ventilate the patient in controlled mode with higher PEEP and V_T at approximately 300 mL.

11. During the intubation process, after sedation with propofol and morphine, you start ventilating the patient with the use of a bag-valve-mask and an appropriately sized Guedel airway. Prior to orotracheal intubation ventilation, the SpO_2 is 85% and the chest is immobile. Concerned about the situation, you perform laryngoscopy, but you cannot visualize the vocal chords. What is the best practice?

a. Administer an intravenous neuromuscular blocker and intubate using a laryngoscope with an articulated arm.
b. Perform an emergency cricothyroidotomy to ventilate the patient.
c. Use a laryngeal mask to ventilate the patient and call for help.
d. Increase sedation to facilitate ventilation of the patient and request bronchoscopy for orotracheal intubation.

12. The patient, despite the measures adopted to reverse respiratory failure after the beginning of invasive ventilation, continues to require an FiO_2 of 100% to maintain an SpO_2 of 90%. The patient is hemodynamically stable; on chest X-ray, there is bilateral alveolar infiltrate and pneumomediastinum. What should be done at this time?

a. Increase the minute volume to improve gas exchange.
b. Place the patient in a prone position to improve the V/Q ratio.
c. Perform alveolar recruitment maneuvers and titrate the optimal PEEP to improve gas exchange.
d. Start inhaled NO to improve alveolar ventilation.

13. A 32-year-old patient has presented with a 24-h history of ascending weakness of the extremities. He arrives at the ER in a wheelchair because he cannot walk.

Initial PE: ascending symmetrical weakness with bilateral hyporeflexia on Achilles reflex test.

MAP = 80, HR = 125, capillary refill time = 3 s, SpO_2 = 94% on room air, and RR = 30 breaths/min

Regular heart rhythm without murmurs

Pulmonary auscultation with some scattered rhonchi, MIP = −20 cmH_2O

Normal abdomen

No edema of the lower limbs

Concerned about the possibility of respiratory muscle weakness due to neuromuscular disease, you collect a sample for arterial blood gas analysis under these conditions. Thirty minutes later, you find out that the sample is still sitting by the sink in the emergency room.

What is the best approach?

a. Send that sample to be analyzed anyway, wait for the results, and decide on the best practice after receiving the results.
b. Collect another sample, send it properly, and wait for the results to decide on the best practice.
c. Use BiPAP to rest the respiratory muscles and to improve ventilation.
d. Proceed to orotracheal intubation due to imminent respiratory failure and to prevent aspiration.

14. Which of the conditions below indicates a risk of extubation failure?

a. Hemodynamically stable patient with norepinephrine 0.2 µg/kg/min.
b. FiO_2 = 50% and PEEP = 6
c. Rapid shallow breathing index (Tobin index) < 105.
d. Frequent aspirations to clear bronchial secretions.

15. A female patient with primary pulmonary hypertension is in the ICU due to a decompensation of the underlying disease. She has a nasal catheter for oxygen supplementation, an RR of 26 breaths/min, and an SpO_2 of 93%. Routine blood gas results: pH: 7.46; pO_2: 61; pCO_2: 27; bicarbonate: 22; BE: +1.0; SaO_2: 90%. Your shift is about to end, and, during the rounds, you are asked what you think about the blood gas results and if or what you would change. You answer:

a. The blood gases look good, and I would not change anything.
b. The blood gas results show respiratory alkalosis, which is bad, because it shifts the hemoglobin dissociation curve to the left, decreasing oxygen supply to the tissues. I suggest administration of anxiolytics.
c. The blood gas results show respiratory alkalosis, which is good, because it shifts the hemoglobin dissociation curve to the right, increasing the supply of oxygen to the tissues. Therefore, I would not change anything.
d. The blood gas results show respiratory alkalosis and hypoxemia, which is bad, because alkalosis moves the hemoglobin dissociation curve to the left, decreasing the supply of oxygen to the tissues. The cause for alkalosis must be hypoxemia. Therefore, I suggest increasing oxygen supplementation and excluding other causes of respiratory alkalosis, such as pain and anxiety.

16. During the rounds in the ICU, you are relating the case of a patient who was intubated in the emergency room due to respiratory failure.
Results of the blood gas analysis on room air obtained at admission (prior to orotracheal intubation) were as follows:

pH = 7.33; pO_2 = 50; pCO_2 = 62; bicarbonate = 26; BE = +2.0; SaO_2 = 90%

Which parameter would help elucidate the cause of respiratory failure?

a. Hb/Ht
b. Respiratory rate
c. Pulse oximetry
d. $EtCO_2$

17. Noninvasive ventilation is recommended, except in patients with:

a. Exacerbated COPD
b. Acute lung edema
c. Mild ARDS
d. Respiratory failure after 4 h of extubation

18. An obese patient with diabetes mellitus and SAH arrives at the ER with a 3-day history of dyspnea, as well as lower limb edema and worsening of overall health status. After the initial evaluation, your diagnostic suspicion is acute lung edema. RR = 27; SpO_2 = 88% with the use of an O_2 catheter, blood pressure = 160/100; HR = 104.

Blood gas results: pH = 7.50, pO_2 = 55, pCO_2 = 27, bicarbonate = 21, BE = −1, SaO_2 = 88%.

In addition to the prescribed medications and diagnostic methods requested to elucidate the condition, you choose to use noninvasive ventilation.

Indicate the correct practice:

a. In this case, I choose BiPAP to improve ventilation and alveolar recruitment.
b. In this case, I choose CPAP to improve hypoxemia and hemodynamics.
c. In this case, I choose BiPAP to rest the respiratory muscles and to improve ventilation.
d. In this case, I choose CPAP to rest the respiratory muscles and improve ventilation.

19. A patient submitted to orotracheal intubation due to a refractory asthma attack receives bronchodilators. If the treatment is effective, what do you expect to see in the pressure/time, flow/time, and volume/time curves?

a. A reduction in expiratory time.
b. An increase in Pplateau-PEEP.
c. A reduction in Ppeak-Pplateau.
d. A reduction in expiratory V_T.

Table S1. Relationship between the competencies assessed by the test and previously published competencies in mechanical ventilation. (Continue...)

Competency assessed	Corresponding competency[a]	Question
Recognize patterns of resistance and compliance of the respiratory system and their relationships with prevalent diseases	Define compliance and describe how to calculate static compliance for a ventilated patient. Define the term resistance with regard to the respiratory system	4
Apply the basic modes of mechanical ventilation in patients with acute respiratory failure	Describe commonly used modes of mechanical ventilation (pressure support, volume control, pressure control) in terms of the trigger, limit, and cycle variables	5
Interpret ventilator waveforms	Describe auto-PEEP and demonstrate how to measure it on the ventilator	3
	Describe commonly used modes of mechanical ventilation (pressure support, volume control, pressure control) in terms of the trigger, limit, and cycle variables	6
List risk factors for a difficult airway	Describe the patient's airway assessment regarding the prediction of: a) difficult bag-mask ventilation; and b) difficult intubation	7
Recognize acute respiratory failure due to ARDS and pathophysiological mechanisms of hypoxemia	Describe the etiology, pathophysiology, clinical manifestations, treatment, and prognosis of acute mechanical ventilator-induced lung injury	8
	Describe a physiological approach to hypoxemia	9
Select ventilator settings consistent with protective ventilation in patients with ARDS	Define lung-protective ventilation and describe the proposed mechanism(s) of lung protection; list indications for lung-protective ventilation	10
List strategies for securing the airway in a patient who is difficult to intubate	Describe the patient's airway assessment regarding the prediction of: a) difficult bag-mask ventilation; and b) difficult intubation	11
Describe the advantages and risks of rescue measures for refractory hypoxemia and their indications	Provide an approach to the patient with refractory hypoxemia: list causes and select adjuvant therapies	12
Adequately indicate the need for ventilatory support in patients with acute respiratory failure due to neuromuscular disease	List the criteria that indicate that a patient needs mechanical ventilation	13

auto-PEEP: auto-positive end-expiratory pressure; ARDS: acute respiratory distress syndrome; CPAP: continuous positive airway pressure; and BiPAP: bilevel positive airway pressure. [a]In accordance with Goligher et al.[1]

Table S1. Continued...

Competency assessed	Corresponding competency[a]	Question
Recognize risk factors for extubation failure	List the criteria that indicate that a patient is failing a spontaneous breathing trial	14
Adjust ventilator settings according to the clinical status and laboratory test results of the patient	Demonstrate ability to interpret arterial blood gases correctly	15
	Demonstrate ability to interpret arterial blood gases correctly	16
Identify particularities in the ventilatory management of patients with certain lung diseases	Describe and, in the appropriate clinical situation, demonstrate an approach to intubation and mechanical ventilation in the patient with respiratory failure due to obstructive airway disease	1
	Describe ventilatory management approaches to the patient with hypercapnia	2
	Demonstrate ability to recognize patient-ventilator asynchrony and describe methods for minimizing it	19
List indications for noninvasive mechanical ventilation	List indications and contraindications for noninvasive ventilation	17
	Describe the difference between CPAP and BiPAP in noninvasive ventilation	18

auto-PEEP: auto-positive end-expiratory pressure; ARDS: acute respiratory distress syndrome; CPAP: continuous positive airway pressure; and BiPAP: bilevel positive airway pressure. [a]In accordance with Goligher et al.[1]

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