



## Chapter 5 – Monitoring the Emergency Patient

**NOTE: CONTENT CONTAINED IN THIS DOCUMENT IS TAKEN FROM ROSEN'S EMERGENCY MEDICINE 9th Ed.**

*Italicized text is quoted directly from Rosen's.*

### Key Concepts:

- 1. Monitoring modalities, when used appropriately, help identify the effectiveness of interventions, predict deterioration, track the patient's clinical course, and inform clinical decision making.*
- 2. Non-invasive blood pressure monitors remain the standard for ongoing measurement of dynamic change. A single episode of hypotension is predictive of subsequent hemodynamic compromise. Despite generally high accuracy and dependability of blood pressure monitoring devices, manual blood pressure may be required at times to verify sudden changes in blood pressure measurements or when readings fluctuate rapidly, suggesting inaccuracy of the automated device.*
- 3. Due to the non-linear relationship of the oxyhemoglobin dissociation curve, pulse oximeters are helpful for screening and monitoring patients but are not an accurate measure of PaO<sub>2</sub> in hypoxic patients and thus should be used with caution*
- 4. In the setting of MetHb or COHb exposure, the pulse oximeter may read falsely elevated, so a CO oximeter is necessary to distinguish oxygenated and deoxygenated blood from other dyshemoglobinemias.*
- 5. Capnography is also useful in spontaneously breathing patients. It can be a good indicator of perfusion, ventilatory response to therapy in the patient with respiratory distress, adequacy of ventilation during procedural sedation, and rapid assessment and response to therapy in patients with metabolic derangements.*

### Core Questions:

1. List modalities for measurement of BP and note which modalities are likely to over and underestimate blood pressure.
2. What is pulse pressure and how does it relate to stroke volume?
3. List 4 indications for an arterial line.
4. What is the Beer-Lambert Law and how does it allow us to measure pulse oximetry?
5. How do dyshemoglobinemias affect your measured SpO<sub>2</sub>?
6. What are the 4 phases of the ETCO<sub>2</sub> waveform?
7. List 5 uses for ETCO<sub>2</sub>.



## Wisecracks:

1. List the pitfalls of pulse oximetry.
2. Describe colorimetric ETCO<sub>2</sub> monitoring and cite the ranges at which you would expect to see the following colours:
  - a. Purple
  - b. Yellow
  - c. Tan
3. How are ETCO<sub>2</sub> values related to PaCO<sub>2</sub>?
4. What are causes of elevated ETCO<sub>2</sub>?
5. What does MOVIE stand for (aka - how to rock your oral exam resuscitation questions)?

## Rosen's in Perspective

Monitoring is something we do often, but think about rarely. This basically provides us real-time information about various physiologic parameters we can use to guide patient care. While this is not a long chapter, there's a few key points to know about the modalities that we use - BP measurement, pulse oximetry, ventilation monitoring, and use of ETCO<sub>2</sub>.

Understanding this content will be invaluable to you. Having a good grasp of these metrics will allow you to better assess patients, judge the efficacy of your treatment modalities, and allow you to make decisions about the acutely deteriorating patient. Basics are foundational for a reason, so sit back, strap in, and listen.

## Core Questions:

**[1] List four modalities for measurement of BP and note which modalities are likely to over and underestimate blood pressure.**

Modalities include:

1. Doppler
2. Palpation (only allows for SBP determination)
3. Auscultation
  - Generally underestimates the systolic blood pressure and overestimates the diastolic pressure.
4. Oscillometric (automatic)
  - What we use every day in the ED.
  - Measures oscillations in the pressure during deflation of the cuff; the maximal point of oscillation represents the mean arterial pressure.
  - Generally overestimates compared with auscultative measurements.



## [2] What is pulse pressure and how does it relate to stroke volume?

- PP closely resembles SV when accounting for arterial compliance and resistance.
- At a given arterial compliance (C), stroke volume (SV) is associated with corresponding changes in pulse pressure:  $C = SV/PP$

## [3] List 4 indications for an arterial line.

1. Persistent or recurrent hemodynamic instability
2. Monitoring of conditions or treatments that result in large fluid or blood pressure shifts
3. Frequent arterial blood sampling
4. Expected inaccuracies in noninvasive blood pressure management (e.g. because of obesity or dysrhythmias)

## [4] What is the Beer-Lambert Law and how does it allow us to measure pulse oximetry?

- Rosen's trivia at its finest. The concentration of an absorbing substance can be determined if the characteristic wavelength of that substance, intensity of the light transmitted through the substance, and distance of transmission are known (**Beer-Lambert Law**).
- Pulse oximetry devices use two LEDs that give off light at wavelengths characteristic of oxyhemoglobin and deoxyhemoglobin (660 and 940 nm).
- These wavelengths are absorbed at different rates, which the pulse oximeter measures.
- So what does the pulse ox actually measure? **Arterial hemoglobin that is in the oxyhemoglobin state.**

## [5] How do dyshemoglobinemias affect your measured SpO<sub>2</sub>?

- Pulse oximetry only measures 2 wavelengths (unless you have a special multi-wavelength machine)
- They cannot distinguish oxyhemoglobin and deoxyhemoglobin from other dyshemoglobinemias (**methemoglobin and carboxyhemoglobin**) In setting of significant MetHb
- Thus, SpO<sub>2</sub> will be falsely elevated in the setting of dyshemoglobinemias.

## [6] What are the 4 phases of the ETCO<sub>2</sub> waveform?

See Figure 5.1 in Rosen's Emergency Medicine, 9th Edition

- **Phase 1-2:** CO<sub>2</sub>-free section of the ETCO<sub>2</sub> respiratory cycle. In the physiologically normal patient, this denotes inspiration, but can also represent apnea or disconnection



of the measuring device. If you are seeing elevated ETCO<sub>2</sub> in the part of the respiratory cycle, the patient is rebreathing CO<sub>2</sub>, either indicating increased dead space in the circuit or sensor contamination.

- **Phase 2-3:** Rapid increase in the amount of expired CO<sub>2</sub>. Denotes beginning of expiration with mixing of gas from the alveoli and dead space. If this phase is prolonged, suspect that there is obstruction to gas outflow in expiration (e.g. bronchospasm, COPD, etc.) or that there are leaks in the breathing system.
- **Phase 3-4:** Plateau phase where CO<sub>2</sub>-rich gas from the alveoli is being expired. Usually, you see a gentle upstroke because of unequal emptying of the alveoli. ETCO<sub>2</sub> is found at the peak of the plateau. If you see an increased sloping of the plateau phase, consider obstructive lung pathology or pregnancy. If you see a dip in the plateau, consider spontaneous respiratory effort in the patient who is mechanically ventilated, potentially indicating the presence of hypoxia, hypercarbia, or insufficient anesthesia.
- **Phase 4-5:** Diminishing CO<sub>2</sub> due to inspiration. If there is an ETT cuff leak, you can see this area blending in with the expiratory phase (Phase 1-2).

## [7] List 5 uses for ETCO<sub>2</sub>.

- Uses for ETCO<sub>2</sub> monitoring include, but are not limited to:
  - **Rapid assessment of critically-ill patients**
    - Just like you learned in medical school, every critically ill patient needs to have their ABC's evaluated. A normal ETCO<sub>2</sub> reading and capnogram denotes:
      - Patent airway
      - Spontaneous breathing
      - Sufficient ventilation
      - Sufficient perfusion
    - Can also be used reliably in seizing patients, giving you information regarding respiratory status, breathing effort, and ventilatory insufficiency
    - Can also detect CNS, airway, and respiratory system complications secondary to chemical terrorism (e.g., laryngospasm, bronchospasm, respiratory failure)
  - **Assessment and measurement of response to treatment in patients with acute respiratory distress**
    - ETCO<sub>2</sub> monitoring can allow you to continually assess your COPD, asthma, CHF, CF, and ARDS patients for dynamic changes.
    - ETCO<sub>2</sub> measurements and capnography can provide you with information regarding resolution of obstructive pathologies after therapies are initiated and correlate well with spirometric measurements like FEV<sub>1</sub>.
    - Capnography be used to distinguish between restrictive and obstructive lung pathologies.
      - Check out Figure 5.2
  - **Monitoring during procedural sedation and analgesia**



- We spoke to the benefits of ETCO<sub>2</sub> monitoring in our last podcast, but in short, you can:
  - Detect apnea in a more timely manner, diminishing incidents of hypoxia and allowing you to launch airway interventions sooner
- **Rapid assessment of patients with severe illness**
  - In patients with metabolic derangements (e.g. sepsis, DKA), can be used to assess changes in pH and HCO<sub>3</sub>
  - There is a linear relationship that exists between ETCO<sub>2</sub> and HCO<sub>3</sub> levels (specifically in cases of DKA and gastroenteritis)
    - In the patient with metabolic acidosis, the patient will be attempting to compensate by increasing minute ventilation
      - Thus, in the patient with metabolic acidosis, the measured ETCO<sub>2</sub> will be lower
      - The lower the ETCO<sub>2</sub>, the worse the metabolic acidosis is, and vice versa
- **Rapid assessment of obtunded or unconscious patients**
  - Long-and-short, ETCO<sub>2</sub> monitoring will allow you to determine which obtunded or unconscious patients have sufficient respiratory effort and effective ventilation and those that do not
    - May allow you to intervene sooner in the patient requiring urgent airway intervention for persistent respiratory depression or failure.

## Wisecracks:

### [1] List the limitations of pulse oximetry.

- Pulse oximetry is limited by:
  - Artifact (movement)
  - Low perfusion states
  - Increased ambient light
  - Deep skin pigmentation
  - Nail polish
  - Methylene blue

### [2] Describe colorimetric ETCO<sub>2</sub> monitoring and cite the ranges at which you would expect to see the following colours:

- a. Purple
- b. Yellow
- c. Tan



Colorimetric carbon dioxide monitors utilize pH-sensitive paper to provide data regarding ETCO<sub>2</sub>. You will likely not be required to describe the exact chemical reaction that takes place within the paper itself, but you should be aware that:

- Purple denotes a CO<sub>2</sub> of <4 mmHg
- Tan denotes a CO<sub>2</sub> from 4-15 mmHg
- Yellow denotes a CO<sub>2</sub> >20 mmHg

If memorizing the exact ranges and corresponding colours is bewildering, just remember: Yellow is mellow, purple is a problem.

### [3] How are ETCO<sub>2</sub> values related to PaCO<sub>2</sub>?

While ETCO<sub>2</sub> values reliably correlate with PaCO<sub>2</sub> levels in the blood, it is important to note that there is typically a 2-5 mmHg difference between the two. ETCO<sub>2</sub> is typically lower than PaCO<sub>2</sub> by the aforementioned margin because the CO<sub>2</sub>-rich gas exiting the lower airways mixes with the relatively hypocarbic gas held within the physiologic dead space.

### [4] What are causes of elevated ETCO<sub>2</sub>?

- Elevated ETCO<sub>2</sub> can be caused by:
  - Hypoventilation
    - Typically from sedative-hypnotic or opioid overdose. The patient retains CO<sub>2</sub> due to poor ventilation, thus increasing the ETCO<sub>2</sub>.
    - Usually only occurs as the sedation lessens
  - Rebreathing
    - Caused by either inadequate gas flow through respiratory circuits or faulty respiratory circuits
  - Increased CO<sub>2</sub> production
    - Causes include, but are not limited to:
      - Fever
      - Sepsis
      - Malignant Hyperthermia
      - Thyroid Storm
  - Increased dead space
    - This is caused by an increased physiologic dead space
    - Seen in obstructive pathologies



## **[5] What does MOVIE stand for (aka - how to rock your oral exam resuscitation questions)?**

- This is your starting line to any oral exam question. You will never go wrong by using this mnemonic to start off your response. **KNOW THIS COLD.**
  - Monitored bed
  - Oxygen
  - Vital signs
  - Intravenous access
  - EKG
- Your spiel will sound like this: “First, I would like to put this patient in a monitored bed and place them on supplemental oxygen, if needed. I would like a new set of vital signs, an urgent EKG, and IV access obtained.
- Boom. You are now a master. Royal College Examination = PASSED!