Capnography

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Objectives

- Link patient monitoring to patient safety
- Review routine monitoring
  - Strengths
  - Gaps
- Describe the difference between oxygenation and ventilation
Trip Down Memory Lane
Patient Monitoring During Procedural Sedation

* Before 1980’s - Nurse assessment only

* Late 1980’s - Pulse oximetry introduced
  * Revealed truths
    * e.g. “blue” patient = <80% O₂ saturation

* 1995 - Standard of Care: Pulse oximetry plus a dedicated nurse performing direct visual assessment
Difficult to imagine clinical practice without pulse oximetry
Important to recognize!

- Pulse oximetry:
  - Measures the concentration of $O_2$-bound hemoglobin
  - Reflects oxygenation, NOT ventilation
  - Late indicator of ventilatory problems

- Current standard monitoring may not detect apnea until $O_2$ desaturation has occurred.
What Is Capnography?

- A non-invasive, continuous measurement of exhaled carbon dioxide concentration
- Expired CO$_2$ is sampled via specialized nasal cannulae
- Measures ventilation, NOT oxygenation
Capnography
Capnography
What info does capnography provide?

ETCO2 display

- Numerical value for ETCO2
- Distinct waveform (tracing) for each respiratory cycle
Overall principles of capnography

- Accurately monitors respiratory rate
- Monitors ventilation in non-intubated patients
- Monitors hypoventilation more effectively than pulse oximetry
  - Early indicator of ventilation issues
  - Early warning of apnea
Ventilation and Oxygenation....

What’s the Difference?
Oxygenation and Ventilation

- Respiratory Cycle = two-phase
  - related, *but separate* physiologic processes

- Oxygenation

- Ventilation
Physiology of Oxygenation and Ventilation
Oxygenation vs. Ventilation

**Oxygenation**
- Measured by pulse oximetry
- $O_2$ attached to hemoglobin
- Influenced by supplemental O2
- May remain normal even after patient stops breathing

**Ventilation**
- Measured by capnography
- Expired and inspired levels of ETCO$_2$
- Not affected by O2 delivery
- Does not appear normal if patient is not breathing
Oxygenation and Ventilation
A-B: Baseline = no CO$_2$ in breath

B-C: Rapid rise in CO$_2$

C-D: Alveolar plateau

D: End expiration (EtCO$_2$)

D-E: Inhalation
Hypoventilation

\[ \text{RR} = \uparrow \text{CO}_2 \quad \text{Hypoventilation} \]

Graph showing changes in CO₂ over time.
Hyperventilation

\[ RR = \downarrow \text{CO}_2 \quad \text{Hyperventilation} \]
How do you know when breathing is abnormal???

* Changes from baseline
  * Change in ETCO2 value >10 mmHg
  * Significant waveform change

* Flatlines
Keep it simple…

"Hey, c'mon. This isn't brain surgery."
Indications for Capnography*

- Deep sedation
- Difficult-to-sedate patients
- Difficult-to-monitor patients
- Patients at risk for apnea (i.e. Obese)
- Patients who cannot be adequately assessed via typical means (e.g. visually)
- Patients receiving supplemental oxygen
- Elderly, More complex patients??

* Cohen, 2007
Putting It All Together...

* Capnograms can provide immediate information about:
  * Airway obstruction
  * Hypoventilation
  * Total lack of breathing

* Ventilatory abnormalities on capnography *precede* oxygen desaturation, as noted on oximetry.
Putting It All Together...

Early detection
+ Early intervention
= ! Improved patient safety
Thank You!