Using Capnography to Improve Patient Safety
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Oxygenation vs. Ventilation
• The transport of O2 via the bloodstream to the cells is called Oxygenation
• The movement of air into and out of the lungs and exhaling of CO2 via the respiratory tract is called Ventilation

Pulse Oximetry vs. Capnography
• Pulse Oximetry
  – Oxygen saturation
  – Reflects oxygenation
  – SpO2 changes lag when patient is hypoventilating
  – Reflects change in oxygenation within 5 minutes
  – Should be used with capnography

Pulse Oximetry vs. Capnography
• Capnography
  – Carbon dioxide
  – Reflects ventilation
  – Hypoventilation & apnea detected immediately
  – Reflects change in ventilation within 10 seconds
  – Should be used with pulse oximetry

Why Use Capnography?
• Facilitates patient management by:
  – Providing continuous and non-invasive monitoring of ventilation with three tools
  – Providing early detection of clinically significant or catastrophic events

The Capnogram
• Height shows amount of exhaled carbon dioxide
• Length depicts time
• The shape of a capnogram is identical in all humans with healthy lungs.
• Any deviations in shape must be investigated to determine a cause of the abnormality
Normal Ventilation Waveform
• Normal CO2 waveforms must have all of these components:
  – A zero baseline
  – A rapid, sharp uprise
  – An alveolar plateau
  – A well-defined end-tidal point
  – A rapid, sharp down stroke

Hypoventilation
• Clinical findings:
  – Slow breathing, high EtCO2
• Possible causes:
  – Increased sedation, overmedication
  – Snoring or possible obstruction

Hypoventilation
• Clinical findings:
  – Slow breathing, low EtCO2
  – Followed by deep breath
• Possible causes:
  – Increased sedation
  – Low tidal volume

Partial Obstruction
• Clinical findings:
  – Irregular breathing, possible snoring or audible breathing
  – EtCO2 may be above or below baseline
• Possible causes:
  – Poor head or neck alignment
  – Overmedication or sedation

No Breath
• Clinical findings:
  – Very shallow or no respiratory rate pattern
  – Sudden loss of EtCO2 reading
• Possible causes:
  – No breath or apnea
  – Very shallow breathing
  – Overmedication or sedation
  – Displaced cannula

Hyperventilation
• Clinical findings:
  – Rapid breathing, low EtCO2
• Possible causes:
  – Increase in pain level or splinting
  – Increase in anxiety or fear
  – Respiratory distress or shortness of breath
Why use EtCO2 in the PACU?

- Early warning of hypoventilation, apnea or airway obstruction, malignant hyperthermia
- Use with patient with history of respiratory compromise, such as asthma or COPD to monitor trend and need for breathing treatments and response to treatment
- Verify endotracheal tube placement or monitoring during weaning
- Decrease frequency of arterial blood gases
- Titrate sedation and pain medication

Post-op Applications

- Post operative patients on Patient Controlled Analgesia (PCA) - often starts in PACU
- Bariatric Patients/Obstructive Sleep Apnea (OSA) high risk patients

Patient Safety with PCA

- Patient Controlled Analgesia (PCA) aids patients in balancing effective pain control with sedation
- The risk of patient harm due to medication errors with PCA pumps is 3.5-times the risk of harm to a patient from any other type of medication administration error
- 2004 more deaths with PCA than with all other IV infusions combined
- Due to oversedation and respiratory depression with PCA delivery

Why Use Continuous Monitoring?

- The following patient conditions and alarm states can be observed using continuous EtCO2 and SpO2 monitoring:
  - Opioid-induced apnea: detected by no breath alarm
  - Undiagnosed sleep apnea: detected by no breath alarm
  - Post-op pneumonia/CHF: detected by low oxygen saturation alarm
  - Respiratory depression secondary to opioid overdose detected by all of the following:
    - Low oxygen saturation alarm
    - High EtCO2 alarm
    - Low respiratory rate alarm
    - No breath alarm

Conclusion

- Capnography for sedation, analgesia and postoperative monitoring:
  - Accurately monitors RR
  - Monitors adequate ventilation
  - Monitors hypoventilation due to over-sedation more effectively than pulse oximetry
  - Earliest indicator of apnea and obstruction
  - Adds additional level of safety providing caregiver with objective information to make accurate assessments and timely interventions

References

- Christopher, D.A. Working Smarter with Intelligent Pumps, Pharmacy Solutions, Nov 2008