Obstructive Sleep Apnea and the use of Capnometry

1230-1330
Obstructive Sleep Apnea and Use of End Tidal CO₂ in the PACU

• Objectives:
  • Define Obstructive Sleep Apnea (OSA)
  • Define End Tidal CO₂.
  • Describe the 4 main stages of carbon dioxide (CO₂) physiology.
  • Identify CO₂ waveforms as they relate to the patient’s condition
Obstructive Sleep Apnea (OSA)

• Syndrome characterized by
  – Periodic, partial or complete obstruction of the upper airway during sleep
  – Oxygen desaturation
  – Hypercarbia
  – Cardiac dysfunction

• Associated with reduced muscle tone in the airway leading to frequent airway obstruction during sleep.
Diagnosis

• Polysomnography
• Medical history
• Family interview using focused questions
• Physical examination for preop evaluation

The ASPAN Obstructive Sleep Apnea in the Adult Patient Evidence-Based Practice Recommendation. JOPAN OCT. 2012
Undiagnosed OSA challenges

• ↑ Incidence of perioperative morbidity
• Postop complications
• Difficult intubation
• Longer length of stay
• Higher rate of ICU admission

The ASPAN Obstructive Sleep Apnea in the Adult Patient Evidence-Based Practice Recommendation. JOPAN OCT. 2012
ASPN Practice Recommendation

• Promote perianesthesia safety in pts. (Adults > 18 years of age)
  – Procedural sedation
  – General or regional anesthesia

• Recommend each institution to develop multidisciplinary guideline

The ASPAN Obstructive Sleep Apnea in the Adult Patient Evidence-Based Practice Recommendation. JOPAN OCT. 2012
Assess & screen patients for risk factors/comorbidities

- Body mass index (BMI) > than 30
- Increased abdominal fat
- Cardiovascular disease
- Age
- Endocrine dysfunction
- Male gender
- Associated hypercapnia
- Enlarged upper airway
  - Stroke
  - Ethnicity
  - Lower socioecomonic status
Cardiovascular disease

- Hypertension
- Resistant hypertension
- Ischemic heart disease
- Idiopathic cardiomyopathy and Congestive heart failure
- Atrial fibrillation
Age

- Mean peak prevalence: 50-59 years
- Women peak prevalence: 60-64 years
- Men have higher risk of OSA than women until menopause
Endocrine Dysfunction

- Higher levels of Fasting Blood Glucose, Insulin, & Glycosylated hgb independent of body weight
- Type II diabetes
- Metabolic syndrome
- Altered glucose tolerance
- Thyroid disease
Hypercapnia

• Seen in:
  • Increased BMI
  • Restrictive chest wall mechanics
  • Decreased overnight saturation
Obstructive Sleep Apnea
Clinical Manifestations

• **Nighttime symptoms**
  – Heavy snoring
  – Restlessness
  – Diaphoresis
  – Nocturia
  – Dry mouth
  – Awakening with choking sensation
  – Nocturnal snoring
    » Gasping
    » Cessation of breathing

• **Daytime features**
  • Daytime somnolence
  • Morning headaches related to nocturnal CO2 retention
  • Impaired memory & concentration
  • Decreased dexterity
  • Cognitive difficulties associated with fatigue
  • Personality changes
    – Irritability, anxiety, depression, decreased libido
Incorporate use of standardized screening tools

• Berlin questionnaire established in OSA literature but not applicable to perianesthesia patient
• STOP-BANG
• ASA OSA Checklist

The ASPAN Obstructive Sleep Apnea in the Adult Patient Evidence-Based Practice Recommendation. JOPAN OCT. 2012
STOP-BANG

S: Do you **Snore** loudly?

T: Do you feel **tired** or fatigued during the day?

O: Has anyone **observed** you to stop breathing during sleep?

P: Do you have or have you been treated for **High Blood Pressure**?

B: Body Mass Index > than 35Kg/M²

A: Age > than 50

N: Neck Size > 16 in/40 cm for females or 17in /43cm for men

G: Gender - Male
ASA OSA Checklist

- Snoring
- Tired
- Observed with apnea
- High blood pressure
- BMI > 25 Kg/M²
- Age > 50 years
- Neck circumference > than 40 cm in males
THE ASA OSA GUIDELINE:
THE LOGIC

CAUSES OF OSA

DIAGNOSIS OF OSA

SEVERITY OF OSA

PERIOPERATIVE RISK OF OSA

Invasiveness Of A &/or S or Postop Opioid Requirement

PERIOPERATIVE MANAGEMENT OF OSA

Facility Preop Intraop PACU Postop
Initiate postanesthesia management of pts with OSA

• Routine monitoring including capnography
• Positioning patient in lateral, lateral recumbent or sitting position
• Provide continuous positive airway pressure/bilevel positive airway pressure (CPAP/BPAP) early in postop course
• Individualize pain management plan of care

The ASPAN Obstructive Sleep Apnea in the Adult Patient Evidence-Based Practice Recommendation. JOPAN OCT. 2012
Initiate postanesthesia management of pts with OSA

- Advocate for use of multimodal approach using medications
- Advocate for use of regional anesthesia for pain control
- Initiate of careful titration of opioids
- Note if PCA used, a basal opioid infusion is NOT recommended
  - Consider nonpharmacological comfort measures
  - Patient may require extended monitoring
Plan for patient discharge with diagnosis or suspected OSA

• Patient should not have signs of desaturation when left undisturbed in Phase I PACU

• Anticipate extended PACU stay

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Plan for patient discharge with diagnosed or suspected OSA in Phase II

- Room Air oxygen saturation return to baseline
- No evidence of hypoxia or obstruction when left undisturbed for 30 minutes
- Observe while asleep and unstimulated to establish room air SpO₂
- Anticipate minimum obs time of 2-6 hrs

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Plan for patient discharge with diagnosed or suspected OSA in Phase II

- Outpatients should be observed on average 3 hours longer than non-OSA counterparts before discharge home.
- With each hypoxemic and/or obstruct event monitoring should continue for 7 hours after the last episode.
- If there is no requirement for high-dose oral opioids postop, pts may be discharged home.
Plan for patient discharge with diagnosed or suspected OSA in Phase II

- If no problems in the Phase II PACU, pt may be discharged home
  - Return to baseline LOC
  - Oxygen saturation > than 94% or at baseline for at least 2 hours before discharge.
  - Able to use CPAP on returning home

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Provide discharge education to patients with suspected/diagnosed OSA

- Educate patients about continued risk for respiratory compromise for 1 week postop
- Remind pts with CPAP that it is crucial they use first week
- To prevent oversedation, teach about risks of taking more than the prescribed dose of pain or sedating meds including over-the-counter meds
Provide discharge education to patients with suspected/diagnosed OSA

- Patients Must have a responsible adult caregiver with them overnight after discharge
- Patients should be encouraged to sleep on their side, in prone or sitting position
- Responsible care givers should be taught how to apply CPAP therapy before discharge to home

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Types of Devices

• CPAP
  – Nasal or Nasal/Oral
  – Continuous pressure on inspiration and expiration
• Bi-PAP (Bi-level)
  – Higher pressure on inspiration
  – Lower pressure on expiration to allow easier exhalation
• A-PAP (Auto-titrated)
  – Machine “senses” airway pressure needs and adjusts accordingly
There is no evidence one type of device is superior to another
Diagnosis OSA: Predisposition

- BMI > 35
- Neck circumference
  - 15 cm females
  - 17 cm males
- Craniofacial abnormalities impacting the airway
- Tonsils touching or nearly touching the midline
- Anatomical nasal obstruction
Diagnosis OSA: Sleep Pattern

• Snoring (loud enough to be heard through a closed door)
  – <6% OSA patients will not snore
• Frequent snoring
• Observed pauses in breathing during sleep
• Awakens from sleep with choking sensation*
• Frequent arousals from sleep
• Intermittent vocalization during sleep
• Parental report of restlessness, difficulty breathing, or struggling respiratory effort during sleep
Diagnosis OSA: Somnolence

- Sleepiness or fatigue despite adequate hours of sleep
- Falls asleep easily in a non-stimulating environment (including driving)
- Child that is difficult to awaken in the morning
- Child reported to be easily distracted, sleepy, have difficulty concentrating or acting-out during the day.
www.CritCareMD.com

Download current protocols
End tidal CO₂ Monitoring

• Capnography (ETCO₂) is
  – A snapshot in time
  – A non-invasive method of determining Carbon Dioxide levels in intubated and non-intubated patients
  – A means to measure the exhaled breath to determine levels of CO₂ numerically and via a waveform
  – Directly related to the ventilation status of the patient
Capnography

• Used to
  – Verify endotracheal tube placement
  – Monitor tube position
  – Assess ventilation and treatments
  – Evaluate resuscitative efforts during CPR
Review A & P

- Respiratory system primary purpose is to exchange carbon dioxide with oxygen
- Inspiration – air enters upper airway via nose where it is warmed, filtered and humidified
- Inspired air flows through trachea & bronchial tree to enter pulmonary alveoli
- Oxygen diffuses across the alveolar capillary membrane into the blood
- The heart pumps the oxygenated blood throughout the body to cells where metabolism takes place and carbon dioxide (CO₂) is the by product.
  (Production)
Review A & P

• The CO₂ diffuses out of the cells into the vascular system back to the pulmonary capillary bed. (Transport)

• Transported from the cell in 3 forms
  – 65% as bicarbonate following conversion
  – 25% bound to blood products (Hemoglobin)
  – 10% in plasma solution (Buffering)

• The CO₂ diffuses across the alveolar capillary membrane and is exhaled through the nose or mouth. (Elimination)
Transport of CO₂

• CO₂ is a colorless, odorless gas
• Concentration in the air is 0.03%
• Produced by cell metabolism
• \( \text{PaCO}_2 \) reflects plasma solution
• With normal circulatory conditions with equal ventilation/perfusion relationship, \( \text{PaCO}_2 = \text{ETCO}_2 \)
• Principle determinants of ETCO₂ are
  » Alveolar ventilation
  » Pulmonary perfusion
  » CO₂ production
ETCO₂ Monitoring Technology

• Single (one point in time) measurement
  – Use visual colorimetric method
  – Litmus paper device attached to ETT undergoes a chemical reaction and color changes in presence of CO₂.

• Electronic device (continuous information)
  – Infrared (IR) spectroscopy used to measure CO₂ molecules absorption of IR as the light passes through a gas sample
CO₂ Sensors

• Mainstream: located directly on the ETT with a bulky adapter

• Sidestream: remote from the patient
  – Aspirated via ETT, cannula or mask through a 5-10 foot sampling tube
  – Intended for non-intubated patient

• Microstream: uses modified sidestream sampling method
  – Employs a microbeam IR sensor that isolates CO₂ waveform
  – Can be used on intubated and non-intubated pts
ETCO$_2$ Monitoring

• ETCO$_2$ Monitoring is continuous
  – Changes in ventilation are immediately seen
• SaO$_2$ monitoring is also continuous but relies on trending
  – Oxygen content in blood can maintain for several minutes after apnea.
Normal Values

Arterial CO$_2$ (PaCO$_2$)
Arterial Blood Gas Sample (ABG)

Normal PaCO$_2$ Values
35 - 45 mmHg
4.7 - 6.0 kPa
4.6 - 5.9%

ETCO$_2$
from Capnograph

Normal ETCO$_2$ Values
30 - 43 mmHg
4.0 - 5.7 kPa
4.0 - 5.6%
ETCO₂ Numeric Values

• Normal: 35-45 mm Hg
• <35 mm Hg = Hyperventilation
  – Respiratory alkalosis
• > 45 mm Hg = Hypoventilation
  – Respiratory acidosis
• Dependent on:
  – CO₂ production
  – Delivery of blood to lungs
  – Alveolar ventilation
Physiologic Factors affecting ETCO₂

Increase in ETCO₂
- Increased muscular activity (shivering)
- Malignant hyperthermia
- Increased cardiac output (during resuscitation)
- Bicarbonate infusion
- Tourniquet release
- Effective drug therapy for bronchospasm
- Decreased minute ventilation

Decrease in ETCO₂
- Decreased muscular activity (muscle relaxants)
- Hypothermia
- Decreased cardiac output (cardiac arrest)
- Pulmonary embolism
- Bronchospasm
- Increased minute ventilation
EtCO2 Monitoring

• **EtCO2 in the Intubated Patient**
  • Most often used to identify esophageal intubations & accidental extubations (head/neck motion can cause ETT movement of 5 cm)
  • If ETT in esophagus, little or No CO2
  • Waveforms and numerical values are absent or greatly diminished
  • Do not rely on capnography alone to assure intubation!
Ventilation/Perfusion Ratio (V/Q)

- Effective pulmonary gas exchange depends on a balanced V/Q ratio

- Alveolar dead space (V > Q = ↓CO2 content)

- Shunting (blood bypass alveoli without picking up oxygen)  [V < Q = ↑CO2 content]

- 2 Types of shunting
  - Anatomical: blood moves right -> left without passing through lungs (congenital)
  - Physiological – blood shunts past alveoli without picking up oxygen
Shunt Perfusion: Alveoli perfused but not ventilated (ET tube in mainstream bronchus)

Normal: Alveoli perfused and ventilated

Deadspace Ventilation: Alveoli ventilated but not perfused (Cardiac Arrest)
The Capnogram

- Provides validation of ETCO$_2$ value
- Visual assessment of patient airway integrity
- Verification of proper ET tube placement
- Assessment of ventilator / breathing circuit integrity
Normal Capnogram

![Capnogram Diagram]

- A – B Baseline
- B – C Expiratory Upstroke
- C – D Expiratory Plateau
- D ETCO₂ value
- D – E Inspiration Begins

35-45 mm Hg
Inhalation CO₂ free gas
• A - B describes the respiratory baseline
• It measures the CO2-free gas in the deadspace of the airways
• B-C is also known as the expiratory upstroke, where alveolar air mixes with dead space air
EtCO2 Monitoring

- C-D is the expiratory plateau, exhalation of mostly alveolar gas (should be straight)
- Point D is the EtCO2 level at the end of a normal exhaled breath (35-45mmHg)
EtCO2 Monitoring

- D-E is inspiration, inhalation of CO2-free gas, and rapid return of waveform to baseline
EtCO2 Monitoring
EtCO2 Monitoring

• **Capnography in Terror**
  – Common conditions diagnosed by capnography
    • Apnea
      – No waveform, no chest wall movement, no breath sounds
    • Upper respiratory obstruction
      – No waveform, chest wall moving, no breath sounds, responsive to airway realignment maneuvers (waveform returns)
Capnography in Terror

- Laryngospasm
  - No waveform, chest wall moving, no breath sounds, unresponsive to airway realignment, responds to PPV

- Bronchospasm
  - “shark fin” waveform

- Respiratory failure
  - Values > 70 mmHg in pt w/o COPD
Test Yourself

A.
Hypoventilation (Increase in ETCO$_2$)

Possible Causes:
- Decrease in respiratory rate
- Decrease in tidal volume
- Increase in metabolic rate
- Rapid rise in body temperature (hyperthermia)
B.
Possible Causes:

- Increase in respiratory rate
- Increase in tidal volume
- Decrease in metabolic rate
- Fall in body temperature
Test Yourself

c.

[Graph showing CO₂ levels with real-time and trend sections.]
Possible Causes:

- Missed intubation
- A normal capnogram is the best evidence that the ET tube is correctly positioned
- With ET tube in the esophagus, little or no CO₂ is present
- Appear when muscle relaxants begin to subside
- Depth of cleft is inversely proportional to degree of drug activity
E.
Obstruction in Airway or Breathing Circuit

Possible Causes:
- Partially kinked or occluded artificial airway
- Presence of foreign body in the airway
- Obstruction in expiratory limb of breathing circuit
- Bronchospasm
QUESTIONS??????
ETCO2 Website articles

- [http://www.paramedicine.com/pmc/End_Tidal_CO2.html](http://www.paramedicine.com/pmc/End_Tidal_CO2.html)
- [http://enw.org/ETCO2inCPR.htm](http://enw.org/ETCO2inCPR.htm)
- [http://www.orsupply.com/docuploads/1023317_CapnogRef_Hndbk.pdf](http://www.orsupply.com/docuploads/1023317_CapnogRef_Hndbk.pdf)
- [http://www.powershow.com/view/33fc2-YmEyY/End_Tidal_CO2_EtCO2_Monitoring_flash_ppt_presentation](http://www.powershow.com/view/33fc2-YmEyY/End_Tidal_CO2_EtCO2_Monitoring_flash_ppt_presentation)
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