

**MONITORING HIGH-RISK PATIENTS POST-OPERATIVELY: IMPLEMENTATION OF A HOSPITAL SCREENING PROCESS AND CAPNOGRAPHY TO IMPROVE OUTCOMES**

ASPMN National Conference  
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*Presented by:*  
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**Objectives**

Identify risk factors that place patients at high risk for respiratory depression post-operatively

List barriers and advantages to the use of capnography for monitoring non-intubated patients post-operatively

Correlate outcome data to the screening process and improved monitoring

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**Background**

Midwestern 526-bed academic medical center  
Safety Improvement Initiative  
IRB approved Retrospective Data Analysis



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## Background

### Root Cause Analysis – Patient Demise

- Morbidly obese patient
- Chronic Renal Disease
- OSA with CPAP therapy
- Morphine PCA for nephrolithiasis
- Anesthesia for pyelogram



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## Case Review

### History of PI:



36 y/o male with ESRD on dialysis for 3 years had a sudden onset of severe left flank pain radiating to LUQ of the abdomen associated with nausea and vomiting.

Received morphine in a local ER with indeterminate CT scan.

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## Past Med-Surg History

**ESRD** with dialysis X 3years

**Hypertension**

**Obstructive sleep apnea**

**Hyperparathyroidism** secondary to subtotal parathyroidectomy

**Diabetes Type 2**  
**Peripheral Neuropathy**

**Epilepsy** w/o seizure for 6 years

**Morbid Obesity**  
Rt. Knee Surgery X2  
AV Fistula  
Tonsillectomy

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## Case Review



### Review of Systems:

- ▣ Unremarkable except flank pain, chronic skin changes and venous stasis

### Allergies:

- ▣ Aspirin and IV Dye

### Family/Social History:

- ▣ Disabled; no illicit drug or alcohol use; quit smoking 10 years ago; single.

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## Case Review

### Diagnostic Test Results:

- Labs

10.6	131	93	64
7.6	5.1	24	12.5
32.0			

- Chest PA and lateral – normal
- CT Scan – atrophic kidneys, left collection duct dilatation, no calculi identified, MRI suggested

### Surgical Procedure:

- Cystoscopy with retrograde bilateral pyelograms
- Results – matrix stone; stent placement

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## Case Review

### Medications

- **Home Meds resumed** Actos, glipizide, calcitrol, depakote, Norvasc, Toprol XL, Tums, phoslo, cholestyramine
- **Hospital:** Ciprofloxacin (acute polyneph), docusate
- **Pain:** Opioid Naïve Morphine order set (suggested settings crossed out) PCA settings – 2mg every 10 minutes, 4-hour lockout 30 mg
- **Peri-op:** fentanyl 150mcq, versed 4 mg, ketamine 75 mg, propofol 220 mg, normal saline bolus for hypotension, Reglan, Zofran

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## Case Review

### Post-op Analgesic Course

#### ▣ Morphine received:

- 1<sup>st</sup> 24 hours – 59.9 mg (dialysis 0900)
- 2<sup>nd</sup> 24 hours – 93.1 mg
- 3<sup>rd</sup> 24 hours – 60.1 mg (surgery 1400-1800)
- 13 hours post-op found unresponsive

#### ▣ Code Team called 0714

- Apneic, pulseless, asystole
- Autopsy requested by family



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## Literature Review - Screening

### ▣ Pre-disposing risk factors

- Morbid obesity (BMI >30-35),
- diagnosis or suspicion of OSA;
- previous history of anesthetic respiratory difficulty; severe renal, cardiac, or hepatic dysfunction;
- moderate to severe pre-existing respiratory disease;
- opioid naïve;
- age > 70 years

*American Society of Anesthesiologists (2006); ISMP (2005).*

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## Literature Review - Screening

### ▣ Contributing risk factors

- Certain anesthetic agents peri-operatively
- Surgeries that restrict respiratory effort
- Opioid therapy for pain
- Concurrent use of sedating medications

### ▣ Individual variability cytochrome metabolism - CYP2D6

*American society of Anesthesiologists (2006); ISMP (2005).*

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## Process Implementation

### ▣ CNS-led multidisciplinary task force

- Risk management
- Anesthesiologist
- PACU RN
- Respiratory therapist
- Pharmacist
- ED & surgical RN
- Educator
- Administrator, nursing leader



### ▣ Monthly Meetings

- ▣ Added Same Day Admission RN, Pre-Op Holding RN, CRNA

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## Development of Screening Tool

### Baseline

12 month case review of **naloxone utilization** and **RRT** for post-op respiratory depression

Review of literature on perioperative care for patients with morbid obesity (BMI) and sleep apnea

- **STOP-Bang** tool for anesthesia screening
- Use of **intra-operative anesthetics**
- **EtCO2 monitoring**
- Choice of **opioid** for pain management

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## Development of Screening Tool

### ▣ Weighted criteria for screening

- based on literature
- baseline data of past year

### ▣ Patients scored prior to surgery

- ▣ Score of  $\geq 5$  indicates high risk

➡ *capnography plus protocol*

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### Screening Tool

Score the patient based on the scale below. A score of 5 or more indicates automatic referral.

High Risk Criteria	Point Value	Points Assigned
<b>Obesity or morbid obesity (BMI &gt;30-35)</b> To calculate BMI: weight (kg)/height <sup>2</sup> (meters)	2	
<b>History of OSA or suspected sleep apnea</b> (If suspected, use STOP-Bang tool)	3	
<b>History of hypertension</b>	1	
<b>Anesthesia history</b> respiratory depression, over-sedation (patient and or immediate family)	1	
<b>History moderate-severe respiratory disease</b> (COPD, asthma, CF, pulm HTN) or current lung pathology	1	
<b>Age &gt; 65 years AND opioid naïve</b>	1	
<b>Major renal</b> (Baseline creatinine >1.4) or <b>hepatic disease</b>	1	
<b>TOTAL POINTS</b>	<b>10</b>	

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### STOP Questionnaire

**STOP Questionnaire**  
 Height \_\_\_ inches/cm    Weight \_\_\_ lb/kg    Age \_\_\_    Male/Female  
 BMI \_\_\_ (weight kg ÷ height<sup>2</sup>)    Collar size of shirt: S, M, L, XL or \_\_\_ inches/cm  
 Neck Circumference\* \_\_\_ cm


**Snoring**  
 Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?  
 \_\_\_ Yes    \_\_\_ No

**Tired**  
 Do you often feel tired, fatigued, or sleepy during daytime?  
 \_\_\_ Yes    \_\_\_ No

**Observed**  
 Has anyone observed you stop breathing during your sleep?  
 \_\_\_ Yes    \_\_\_ No

**Blood Pressure**  
 Do you have or are you being treated for high blood pressure?  
 \_\_\_ Yes    \_\_\_ No

\*Neck circumference is measured by staff




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### STOP-Bang Tool Used

**High risk of OSA:**  
answering yes to three or more items

**Low risk of OSA:**  
answering yes to less than three items

Sensitivity related to the level of OSA.  
 83% at a mild level of AHI  
 93% at a moderate level of AHI  
 100% at a severe level of AHI

\*AHI (apnea-hypopnea index)

**Snoring**  
 Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?  
 \_\_\_ Yes    \_\_\_ No

**Tired**  
 Do you often feel tired, fatigued, or sleepy during daytime?  
 \_\_\_ Yes    \_\_\_ No

**Observed**  
 Has anyone observed you stop breathing during your sleep?  
 \_\_\_ Yes    \_\_\_ No


**Blood Pressure**  
 Do you have or are you being treated for high blood pressure?  
 \_\_\_ Yes    \_\_\_ No

**BMI**  
 BMI more than 35 kg/m<sup>2</sup>?  
 \_\_\_ Yes    \_\_\_ No

**Age**  
 Age over 50 years old?  
 \_\_\_ Yes    \_\_\_ No

**Neck Circumference**  
 Neck Circumference greater than 40 cm?  
 \_\_\_ Yes    \_\_\_ No

**Gender**  
 Male gender?  
 \_\_\_ Yes    \_\_\_ No



Chung, F., et al. (2008). STOP Questionnaire: A tool to screen patients for obstructive sleep apnea. *Anesthesiology*, 108 (5), 812-821

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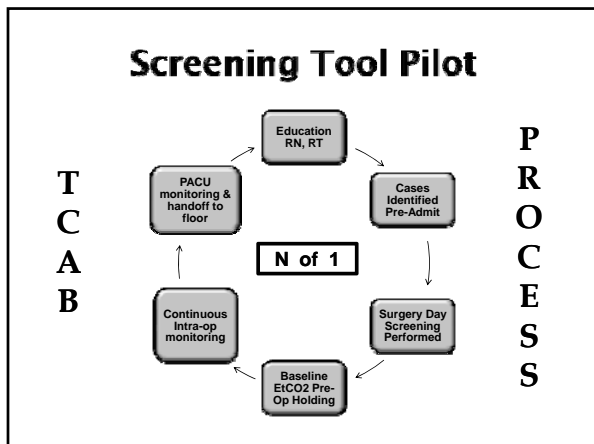
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### RN and RT Staff Education

**Multiple opportunities offered:**

- Unit-based inservices for nursing and RT
- Equipment skills education and validation
- CNS from supplier provided multiple sessions with continuing education credits
- DVD of respiratory physiology and EtCO2 monitoring created for off-shifts
- Separate inservices for non-nursing support techs

**Experience is the best educator!**

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### Screening Implementation

- ☐ **Same Day Surgery**
  - Train staff on screening tool & STOP-Bang
  - Documentation – audit tool and procedure notes
  - Order written for RT referral, capnography
  - Communication/handoff to pre-op holding
- ☐ Inpatients sent for surgery
- ☐ Pre-Op holding documentation of baseline
- ☐ PACU monitoring and report to floor

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### Nursing Protocol - Monitoring

- Initiate capnography for post-op high risk patients for **12-24 hours**
- Place in **lateral or high fowler's position**
-  Determine appropriate **cannula for mouth breathers and oxygen requirements**
-  Set EtCO2 **parameters** at 0-20 (low) 60 (high)
- Document & assess **hourly for first 12 hours**
- Notify RT if **CPAP is needed**

Anesthesiology (2006); 104: 1081-83 and Hutchison & Rodriguez (2008); 108 (2): 35-39

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### Protocol - Interventions

#### Capnography alarms:

1. Check ABC's, (Airway, breathing, circulation)
2. Attempt to arouse and stimulate patient to breathe
3. Ask the patient to use the incentive spirometer if appropriate
4. Ensure open airway
5. Initiate CPAP and respiratory protocol
6. Consider decrease or discontinuation of opioids and other CNS depressants
7. Check cannula positioning, capnography connections, filter

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### Protocol - Interventions

#### Contact anesthesiologist based on criteria:

1. Sedation level 2 or higher; difficult to arouse or keep aroused
2. CO2 levels greater than 60 mmHG **AND**
3. CO2 trends show consistently elevated CO2 levels
4. Oxygen saturation <92% on 2L/NC (this is a LATE sign)

Administer reversal agents as ordered  
Check ABG's as ordered

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## Literature Review

### High Risk Criteria

- ▣ **Obese, Morbidly obese (BMI >30-35)**
  - Obesity-induced changes in hemodynamic status and regional blood flow can affect anesthesia
  - Anesthetic differences – thiopental, propofol, sufentanil
  - Opioid *solubility* differences
    - Fentanyl – lipophilic
    - Morphine - hydrophilic

Casati, A., Putzu, M. (2005).

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## Literature Review

### High Risk Criteria

- ▣ **Obstructive Sleep Apnea (OSA)**
  - 3.5% incidence of perioperative complications
  - Anesthetic agents
    - **Propofol** – increases collapsibility of upper airway
    - **Midazolam** – increases supraglottic airway resistance leading to obstructive episodes
    - **Dexmedetomidine** – reduces post-op opioid need
  - Opioids
    - **Morphine** – directly affects respiration via hypoglossal and phrenic nerve; but decreases hypoxic sensitivity in women
    - **Hydromorphone** – less apnea/hypopnea in lower doses
    - Multi-modal therapy to reduce opioid need

Chung SA et al. (2008)

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## Literature Review

### High Risk Criteria

- ▣ Hypertension
  - Cardiovascular function – reflected in hemodynamic status
  - Independent of OSA
- ▣ History of Anesthesia Problems
- ▣ Moderate to Severe Respiratory Disease or current lung pathology
- ▣ Age >65 and opioid naïve
- ▣ Major renal or hepatic failure

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### Why Capnography?

- ▣ Additional monitoring tool for high risk patients
- ▣ Detects respiratory changes sooner than continuous pulse oximetry
- ▣ Changes from baseline also indicate circulatory and metabolic events post-operatively
- ▣ Alarms can arouse the patient during hypopnea or apneic episodes

**Safe Pain Control = Optimal Outcomes**

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### What is EtCO2

Maximum concentration of carbon dioxide at end-exhalation. . .

This has a direct correlation to PaCO2 and is therefore a reflection of ventilation, metabolism and cardiopulmonary status.

4 main stages of CO2 physiology:

- Production
- Transportation
- Buffering
- Elimination

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### EtCO2 Physiology

- ▣ **Production**  
Rate of CO2 production is directly related to cellular metabolism and is effected by age, physical condition, exertion, and overall health
- ▣ **Transportation**  
Process of CO2 dissolving into the blood stream and being carried for use in acid/base buffering or elimination via the pulmonary system
- ▣ **Buffering**  
Complex process occurring during transport in which the body either carries the CO2 absorbed in the blood, combines it with water to form carbonic acid which aids the body in acid/base balance or eliminates excess CO2 through the lungs
- ▣ **Elimination**  
Diffusion of CO2 out of the blood occurring across alveolar tissue and out through exhalation

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### What EtCO<sub>2</sub> Measures

- ▣ During **normal** circulation, PaCO<sub>2</sub> is closely related to EtCO<sub>2</sub>, therefore we can obtain accurate real time data regarding the body's overall **metabolic and/or respiratory status**
- ▣ Dependent on normal lung function
- ▣ Our job as clinicians is to figure out whether the numbers we are seeing are **respiratory**, in nature or represent a metabolic or circulatory problem.

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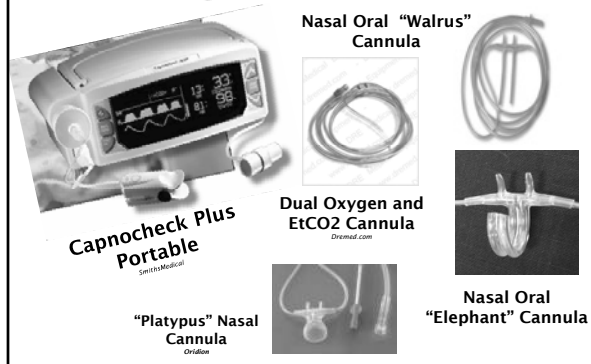
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### Capnography Equipment




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### Capnography Basics

**Normal Ranges:**  
 Arterial PaCO<sub>2</sub> 38–45mmHg  
 Capnography EtCO<sub>2</sub> 35–45mmHg (4–6 Vol. %)

**Uni-Junction™**

O<sub>2</sub> flow

CO<sub>2</sub> sampling

A-B Respiratory baseline  
 B-C Expiratory upstroke  
 C-D Expiratory plateau  
 D End-tidal value—peak CO<sub>2</sub> concentration—normally at the end of exhalation  
 D-E Inspiratory downstroke

**Normal Waveform:**

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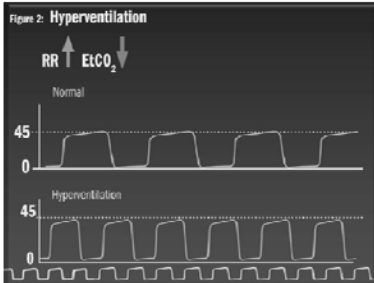
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## Capnography Interpretation

### Causes - Decreased EtCO<sub>2</sub>



**Related to:**

**Metabolic:**  
Hypothermia  
Sedation

**Circulation:**  
Low cardiac output  
Hypotension  
Hypovolemia  
Embolism

**Ventilation:**  
Hyperventilation  
Talking/eating

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## Capnography Interpretation

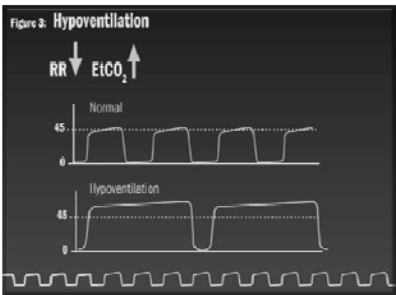
### Causes - Increased EtCO<sub>2</sub>

**Related to:**

**Metabolic:**  
Fever  
Shivering  
Pain

**Circulation:**  
High CO  
Hypertension

**Ventilation:**  
Hypoventilation  
Obstructive lung disease




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## Implementation Speed Bumps

- ▣ **Knowledge gaps**
- ▣ **Monitoring**
  - Documentation and frequency
  - Handoffs across the hospital
  - Monitoring systems throughout hospital differed
  - Use of capnography with CPAP
- ▣ **System-wide changes**
  - Include all clinical and non-clinical departments
  - Admission process
  - Pre-op holding, intra-op, and PACU
  - Billing, coding
  - Supply and monitor cost-center (Central Supply vs. Respiratory Therapy)

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## Implementation Speed Bumps

### Equipment and Cost

- ▣ **Device Selection**
  - Technology compatible with hospital environment
  - Consistent with hospital sleep lab
- ▣ **Grant application for monitors & education**
- ▣ **Purchasing cost analysis for supplies**
  - Monitors and hardware for bedside
  - Nurse call system options
  - Types of nasal cannulas




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## Implementation Support

- ▣ **Administrative and medical staff support**
  - Root cause analysis group
  - Task force
  - Hospital foundation
  - Anesthesiologists, surgeons, CRNAs
- ▣ **TCAB (Transforming care at the bedside)**
  - N of 1
  - Spread to one unit
  - Spread to hospital
- ▣ **Interdisciplinary Effort**
- ▣ **Grant obtained from foundation - \$35K**

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## Screening Tool Outcomes

Screening Criteria	Screening Score ≥ 5	Screening Score < 5
BMI > 30-35	91%	41%
Obstructive Sleep Apnea	86%	7%
Hypertension	74%	57%
Hx Anesthesia Problems	0	0
Mod-Sev Resp Disease	43%	19%
Age > 65; Opioid Naïve	40%	47%
Severe Renal/Liver Dx	6%	2%
	35 patients	81 patients

- Significant difference between groups:**
- **Morbidly Obese**
  - **Obstructive Sleep Apnea or suspected**
  - **Moderate-Severe Respiratory Disease**

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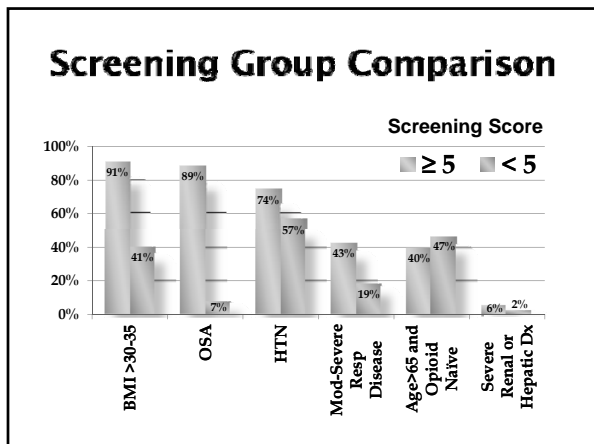
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### Adverse Events - Naloxone

Case Criteria	Patients Low-Mod Risk (1)	High Risk Patients (4)
Screening Score	2	5, 7, 7, 8
High BMI + OSA	No	All
EtCO2 Range	42-50	25-60
Baseline EtCO2	42	32-43
Type of Anesthesia	Spinal, 0.5 Duramorph	3 – spinal, 0.5 Duramorph 1 – spinal, marcaine/fent
CPAP/BiPAP	Yes	1 patient
Contributing factors	1. Cardiovascular Hx 2. BiPAP from PACU 3. Naloxone on arrival	1. Cardiac event 2. Critically low H/H 3. Intraop elevated EtCO2

5/116 (4%) patients received Naloxone  
11% High Risk Patients  
1% of Low-Mod Risk Patients

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- ### Outcome Measures
- ☐ **Effectiveness of Screening tool**
    - False positives in high risk group
    - Consider adding CV history in place of Anesthesia Hx
  - ☐ **Adverse events, naloxone, RRTs**
    - Prevented by increased use of CPAP
    - Type and amount of anesthesia to be addressed
  - ☐ **Successes**
    - Improved nursing and respiratory assessment
    - 4 patients with elevated EtCO2 w/o adverse events
  - ☐ **Opportunities for improvement**

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## Discussion

Your Turn!



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## References

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Brian Gilley, RN, CPAN [gilley.brian@mshil.com](mailto:gilley.brian@mshil.com)

1. American Society of Anesthesiologists. (2006). Practice guidelines for the perioperative management of patients with obstructive sleep apnea. *Anesthesiology*; 104(5):1081-1093.
2. Chung SA, Yuan H, Chung F. (2008). A systemic review of obstructive sleep apnea and its implications for anesthesiologists. *Anesthesia & Analgesia*; 107(5): 1543-1563.
3. Hagle ME, Lehr VT, Brubakken K, Shippee A. (2004). Respiratory depression in adult patients with intravenous patient-controlled analgesia. *Orthopedic Nursing* 23(1): 18-27.
4. Weinger MB. Dangers of postoperative opioids: APSF workshop and white paper address preventions of postoperative respiratory complications. APSF Executive Summary. [http://www.apsf.org/resource\\_center/newsletter/2007/winter/01\\_opioids.htm](http://www.apsf.org/resource_center/newsletter/2007/winter/01_opioids.htm)
5. Paje DTT, Kremer MJ. (2006). The perioperative implications of obstructive sleep apnea. *Orthopedic Nursing* 25(5): 291-294.
6. Pasero C. Fentanyl for acute pain management. (2005). *Journal of PeriAnesthesia Nursing*; 20(4): 279-284.
7. Hutchison R, Rodriguez L. (2008). Capnography and respiratory depression. *AJN*; 108(2): 35-39.
8. Dunwoody CJ, Krenzischek DA, Pasero C, Rathmell JP, Polomano RC. (2008). Assessment, physiological monitoring, and consequences of inadequately treated pain. *Pain Management Nursing*; 9(1): S11-S21.
9. Overdyk FJ, Carter R, Maddox RR, Callura J, Herrin AE, Henriquez C. (2007). Continuous oximetry/capnometry monitoring reveals frequent desaturation and bradypnea during patient-controlled analgesia. *Anesthesia & Analgesia*; 105(2): 412-418.
10. Chung F, Yegneswaran B, Liao P, Chung SA, Vairavanathan S, Islam S, Khajehdehi A, Shapiro CM. (2008). STOP Questionnaire: A tool to screen patients for obstructive sleep apnea. *Anesthesiology*; 108(5): 812-820.
11. Casati A, Putzu M. (2005). Anesthesia in the obese patient: Pharmacokinetic considerations. *Journal of Clinical Anesthesia*; 17: 134-145.
12. Hwang D, Shakir N, Limann B, Sison C, Kalra S, Shulman L, Souza A, Greenberg H. (2008). Association of sleep-disordered breathing with postoperative complications. *Chest*; 133(5): Accessed 6/4/2008. <http://www.mdconsult.com/das/article/body/96408609-4/jorg=journal&sources=&asp=20693...>
13. Somogyi AA, Barratt DT, Collier JK. (2007). Pharmacogenetics of opioids. *Clinical Pharmacology & Therapeutics*; 81(3): 429-444.
14. Bucknall T, Manias E, Botti M. (2007). Nurses' reassessment of postoperative pain after analgesic administration. *Clin J Pain*; 23(1): 1-7.
15. Lee JB, Winstead PS, Cook AM. (2006). Pharmacokinetic alterations obesity. *Orthopedics*; 29(11): 984-988.
16. Golembiewski J, Torrecer S, Katke J. (2005). The use of opioids in the postoperative setting: Focus on morphine, hydromorphone, and fentanyl. *Journal of PeriAnesthesia Nursing*; 20(2): 141-143.
17. Odom-Forren J. (2008). Updated: Postoperative complications: Beyond the postanesthesia care unit (PACU). Mosby's Nursing Consult Clinical Updates. Accessed 1/6/2009. <http://www.nursingconsult.com/das/news/body/2/cup/0/203193/1.html?nid=203193&date=...>
18. Cifaldi L. (2009). Presentation: Capnography pieces of the puzzle. Smiths Medical. [www.smiths-medical.com](http://www.smiths-medical.com)