Evaluation of Nurse Alarm Notification Systems (NANS) for Postoperative Patients Receiving Opioids via Patient-Controlled Analgesia

American Society of Pain Management Nursing
September 9, 2011
Mary Lynn Parker, M.S., R.N.
Clinical Nurse Specialist, Orthopaedics/Trauma
University of Michigan Health System

Objectives

• Identify nurse assessment strategies to reduce the patient’s risk of opioid-induced sedation and respiratory depression

• Describe the use of technological monitoring to reduce the patient’s risk of over-sedation and respiratory depression
Safety and Monitoring

Nurses continuously:
• Observe the patient and assess pain
  – Patient rounding
• Critically analyze patient assessment data to determine patterns or change
• Make decisions about changing surveillance level
  – ↑ frequency of post-op patients, or after giving opioid
  – Intervene when patient in danger
• Document according to changes in patient condition

Safety Recommendations

• Joint Commission National Patient Safety Goal
  Improve effectiveness of clinical alarm systems
  a) Implement regular preventive maintenance and testing
  b) Activated with appropriate settings and sufficiently audible with respect to distances and competing noise within the unit
• Institute for Safe Medical Practices and Anesthesia Patient Safety Foundation
  – Need improved monitoring with patient controlled analgesia

Safety Concerns

• Nuisance and desensitization created from high false alarm rates
  – Interfere with communication due to excess noise
  – Contribute to inadequate caregiver response
  • Low priority alarms have status of false alarms
  – Distract people leading to ↑ probability of medical error
  – Reduce safety of patients on general care units
Pulse Oximetry

Oxygenated Hgb & reduced Hgb absorb different amounts of red (RD) & infrared (IR) light

Ratio of red/infrared light absorbed by hemoglobin determines SpO₂

SpO₂ is estimate of SaO₂

Arterial Saturation

- **Functional Saturation**: Percent of oxygenated hemoglobin available to transport O₂
  - Measured by conventional pulse oximeters

- **Fractional Saturation**: Amount of oxygenated hemoglobin as fraction of all measured hemoglobin
  - Measured by co-oximeters

- **Calculated Saturation**: O₂ saturation based on relationship between PaO₂ and SaO₂
  - Measured by pulse oximeter or oximeter

Hypoxemia vs. Hypoxia

**Hypoxemia**: Insufficient O₂ in blood
- Arterial O₂ content or arterial O₂ partial pressure (PaO₂)
- SaO₂ or SpO₂ < 90% (adults); < 94% (pediatrics)
- Individual baseline differences for chronic respiratory/cardiac diseases (COPD & CHF)

**Hypoxia**: Insufficient O₂ at cellular level
- Symptoms—irritability, anxiety, confusion, stupor, coma
- Can cause serious neurological or cardiac problems and lead to death
Capnography

- Monitoring concentration or partial pressure of CO₂ in respiratory gases
- Three phases
  1. Basal state
  2. Exhaled breath -- rapid increase in CO₂
  3. End of expiration -- alveolar CO₂
     - Known as end-tidal CO₂ or ETCO₂
- Normal ETCO₂ differs from PaCO₂ by 2-5mm

What Pulse Oximetry Does And Does Not Do

- Measures adequacy of oxygenation NOT adequacy of ventilation
- Measures oxygenation of arterial blood NOT adequacy of CO₂ elimination
- Yields high readings in patients with respiratory depression receiving oxygen
- Detects hypoxemia - failure of oxygenation
  - Does not detect hypercapnia - ventilatory failure

Background

- Safety of post-op patients on general care areas may be jeopardized due to:
  - ↑ complexity
  - Aggressive pain management
  - Inadequate monitoring practices
- UMHS had ↑ patients on PCA therapy experience O₂ desaturation
- To improve safe pain management practices, UMHS implemented a monitoring policy for adults receiving opioids via IV-PCA
Increased Need For Patient Monitoring

- Pulse oximetry made available at each bedside
- Three levels of oximetry monitoring defined
  1. **Continuous**
  2. **Interval**
     - Uninterrupted SpO2 monitoring < 24 hours while patient in bed, chair, or unattended
     - Can have sensor off when ambulating with PT, to BR, etc.
     - (**Allows alert patient to ambulate without pulse O2 cable tether**)
  3. **Spot check**

UMHS Nurse Alarm Notification System (NANS)

- **MONITOR LIMITS**
  - SpO2 < 90
  - HR < 60 > 140

Specific Aims

- Describe oxygen desaturation events, alarm notification, and nursing response time
- Examine clinical relevance and predictive validity of system through desaturation events, alarm notification and interventions
- Examine reliability of system to convey clinically relevant events by quantifying missed notification of desaturation events
Objective

• To evaluate the effectiveness of an institutionally-developed centralized Pulse Oximetry Monitoring (POM) alarm notification system in facilitating nursing response and intervention for oxygen desaturation events in a general care postoperative setting.

Methods

• Prospective study of adults s/p orthopedic surgery
  – Patient controlled analgesia (PCA) for first 24 hours
  – Pulse oximetry monitoring (POM) per policy
  – IRB exempt
• Recorded total opioid dose in PACU and duration of PCA use
• Nursing interventions recorded by bedside nurses on data collection sheets and medical records

Methods

• O₂ saturation data (HR and SpO₂) continuously captured via Masimo Rad-8 oximeters in three second intervals
• True desaturation events prospectively identified from streamlined POM data (ACSI format)
  • SpO₂ <89 for >15 seconds
• Detailed alarm-paging data obtained
• Alarm notifications (nurse pages) extracted from continuous capture paging data
Methods

• Notification (nurse) pages matched by exact time to POM data, and coded as:
  – Clinically relevant alarm events
  – True desaturation event
  – SpO2<89 for > 15 seconds (verified by ASCII data)
  – Irrelevant artifact
  – Inappropriate threshold
  – Failure to delay notification

Sample

<table>
<thead>
<tr>
<th></th>
<th>34.2 ± 17.6 [range 19-86]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE (years)</td>
<td>54 ± 17.6 [range 19-86]</td>
</tr>
<tr>
<td>WEIGHT (KG) / BMI</td>
<td>89.5 ± 22.4 [29.1 ± 7.7]</td>
</tr>
<tr>
<td>FEMALE</td>
<td>54 (57%)</td>
</tr>
<tr>
<td>ASA PHYSICAL STATUS:</td>
<td></td>
</tr>
<tr>
<td>I-II</td>
<td>58 (62%)</td>
</tr>
<tr>
<td>III-IV</td>
<td>36 (36%)</td>
</tr>
<tr>
<td>CO-MORBIDITIES:</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>55 (59%)</td>
</tr>
<tr>
<td>Obesity</td>
<td>38 (40%)</td>
</tr>
<tr>
<td>Sleep disordered</td>
<td>33 (35%)</td>
</tr>
<tr>
<td>breathing</td>
<td>22 (25%)</td>
</tr>
<tr>
<td>Chronic Pain (pre-op)</td>
<td>12 (14%)</td>
</tr>
<tr>
<td>CPAP (prescribed)</td>
<td></td>
</tr>
<tr>
<td>PROCEDURE:</td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>27 (29%)</td>
</tr>
<tr>
<td>Other extremity</td>
<td>33 (33%)</td>
</tr>
<tr>
<td>Knee</td>
<td>20 (21%)</td>
</tr>
<tr>
<td>Spine</td>
<td>16 (19%)</td>
</tr>
<tr>
<td>DURATION OF PCA USE (hrs)</td>
<td>24.5 ± 15.97</td>
</tr>
<tr>
<td>DURATION OF SPO2 MONITORING (hrs)</td>
<td>18.2 ± 5.2</td>
</tr>
</tbody>
</table>

Pulse Oximeter Alarm Tiered Notification System

SpO2 or HR exceeds limits (SpO2 <89 in this setting)

INITIAL

ALARM

Audible bedside alarm (via oximeter)

NURSE ALARM NOTIFICATION SYSTEM ACTIVATED

8 SEC INTERNAL DELAY

FIRST

NOTIFICATION

15 SEC CONTINUOUS DESATURATION

ALARM PAGE SENT TO NURSE

Flashing green light outside room +

Console display/tone change at central nursing station

SECOND

(ESCALATED)

NOTIFICATION

2 MIN 15 SEC CONTINUOUS DESATURATION

URGENT PAGE SENT TO BEDSIDE NURSE & CHARGE NURSE

Flashing green & flashing white light outside room +

Console double rate tone change at central nursing station

Solid green light outside room
Results

- 103 patients monitored for 1616 hours
- 710 pages generated
  - Nearly all patients experienced at least one desaturation
- 345 desaturation events
  - Range: 0-53
  - Duration: 23.6 seconds
  - Nurse response time
    - 52.1 sec (days)
    - 63.8 sec (nights)

Trend in SpO2 over time in one subject

Results

- 36% of desaturation events were clinically relevant
- Missed events (no page triggered) occurred in 26% of true desaturation events
  - Significantly related to paging burden (p=0.04)
  - SpO2 values lower during missed events vs. those triggering page
- 65% patients with events received interventions
  - Primarily supplemental oxygen

Description of Paging Events (n=672) And Nursing Response

<table>
<thead>
<tr>
<th>Pages per patient</th>
<th>Median 3 [range 0-50]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escalation pages</td>
<td>Median 0 [range 0-4]</td>
</tr>
</tbody>
</table>

Type of pages
- SpO2 < 90 for >10s: 288 (33%)
- Artifact or events <15s (false alarms): 149 (22%)
- Low HR: 21 (3%)
- Unknown: 233 (26%)

Oxygen Desaturation Events (SpO2 < 89) in the Sample

<table>
<thead>
<tr>
<th>Experienced at least 1 event</th>
<th>Median 10 [range 0-40]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events per patient (#)</td>
<td>Median 5 [range 0-35]</td>
</tr>
<tr>
<td>Total minutes SpO2 &lt; 89 per patient</td>
<td>Mean 10.1 [1.4-15.4]</td>
</tr>
</tbody>
</table>

Nursing Response and Interventions per patient

<table>
<thead>
<tr>
<th>0.88 ± 1.3 (0.30 – 20.7)</th>
<th>0.30 ± 1.3 (0.30 – 20.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplemental oxygen on admission</td>
<td>64 (68%)</td>
</tr>
<tr>
<td>Escalation oxygen</td>
<td>23 (24%)</td>
</tr>
<tr>
<td>Stimulate patient</td>
<td>8 (9%)</td>
</tr>
<tr>
<td>CPAP</td>
<td>8 (9%)</td>
</tr>
<tr>
<td>ICU admission</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>Other</td>
<td>10 (11%)</td>
</tr>
</tbody>
</table>
Discussion

- Significant number post-op orthopedic patients with PCA experience desaturation triggering paging alert
- UMHS POM system facilitated timely nursing response
  - Found 1 in 3 alarm pages during POM clinically relevant
  - Promoted early interventions in approx. 50%
- Some desaturation events not triggering page
  - Suggests potential gap in reliability
  - Especially during times of high paging volume

Possible solutions to improve safe/effective monitoring:

- System modifications
  - ↑ paging delay may ↓ number of false pages
  - Variable alarm SpO₂ < 86 for 30 seconds in some patients
- Decentralization to ensure safe & effective monitoring
- Ongoing analysis to determine
  - % of desaturation events missed by NANS system
  - Relationship between events and patient risk factors
Getting Information To The Bedside

- Pain assessment is more than just a pain score
- Critical thinking—look at entire picture
- First night postop most risk prone
  - Know opiate effect on respiratory rate & sedation score
  - Assess patients continuously to evaluate response to care
- Institutional policies and standards indicate minimal requirements for documentation

Nursing Education

- Policies and guidelines
  - PCA
  - Pulse O₂ & Opioid Monitoring for acute care/telemetry units
- Annual Nursing Blitz Opioid Modules
  - Sedation Assessment, Respiratory Assessment, Opioid Safety
- Nursing Grand Rounds
- Meetings—nursing leadership, educators, multidisciplinary
- Nursing orientation
- Nursing school

Educational Topics

- Risk Factors for Opioid-Induced Respiratory Depression
- “Know Your Patient”
- “Know Your Meds”
- Sedation Assessment
- Respiratory Assessment
- Opioid Safety
  - Rescue measures and meds
Risk Factors for Opioid-Induced Respiratory Depression

- Opioid naive—especially first 24 hours
- Age extremes >60 years of < 12 months
- Overweight/obese
- Pre-existing conditions
  - Respiratory: Sleep apnea, asthma, COPD, prematurity
  - Hepatic/renal impairment; altered metabolism/excretion
  - Neuromuscular disorders affecting respiratory effort
- Chronic pain history with high opioid requirements

Risk Factors for Opioid-Induced Respiratory Depression (cont.)

- Complicated acute pain management in PACU, including:
  - Airway obstruction
  - Desaturation
  - Patients who have required aggressive opioid administration
  - Patients receiving ≥ 30 milligrams of morphine (or its equivalent)
  - Uncontrolled pain followed by aggressive analgesic administration
  - Concurrent use of sedative meds

Analgesia
  precedes

Sedation
  which precedes

Respiratory Depression
Level of Consciousness (Sedation)

- Level of consciousness (sedation level) is main concern after giving opioids
- Can be awake, but not alert
  - Patient answers some short questions, but drifts off with more complex questions
- Potential for respiratory compromise becomes greater when sedated
- If see changes in level of consciousness (awake → drowsy → difficult to arouse), can anticipate potential respiratory changes (changes in depth, then rate)

The Slippery Slope of Sedation

<table>
<thead>
<tr>
<th>CONSCIOUSNESS</th>
<th>SEDATION SCORE (UM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWAKE</td>
<td>0</td>
</tr>
<tr>
<td>MINIMAL SEDATION</td>
<td>1</td>
</tr>
<tr>
<td>MODERATE SEDATION</td>
<td>2</td>
</tr>
<tr>
<td>DEEP SEDATION</td>
<td>3</td>
</tr>
<tr>
<td>UNAROUSABLE</td>
<td>4</td>
</tr>
</tbody>
</table>

Sedation Assessment

- Awaken and rate patients sedation score using University of Michigan Sedation Scale (UMSS)
- Follow current hospital guidelines to document sedation assessments
- If patient asleep, and observations indicate no changes from previous assessment, chart "sleeping" and describe respiratory rate/quality

See next slide for steps and instruction of UMSS
University of Michigan Sedation Scale (UMSS)

0 = Awake/Alert
1 = Minimally sedated: tired/sleepy, appropriately responds to verbal conversation and/or sounds
2 = Moderately sedated: somnolent/sleeping, easily aroused with light tactile stimulation
3 = Deeply sedated: deep sleep, arousable only with significant physical stimulation
4 = Unarousable

Malviya, S., 2002

Respiratory Effect of Opioids

- Opioids decrease ventilation:
  - Rate of respirations
  - Tidal volume
  - Desensitization response at CO₂ receptors
- Increased CO₂ levels don’t increase RR
- Body relies on the O₂ driven respiratory regulatory system which is less sensitive
- Even smaller opiate doses can ↓ RR, minute volume, and tidal exchange

Quality Respiratory Assessment

- Respiratory rate, depth, regularity
- Respiratory effort
  - Ineffective gas exchange?
- Breath sounds
  - Abnormal sounds?
    - Snoring, stridor, wheeze
- Any obstruction of airway?
- Patient Position
**Respiratory Depression**

- ↓ rate & depth of respirations from baseline
  - Note trends
- ↓ respiratory rate
  - <10/minute
- ↓ depth (quality)
  - i.e., shallow, irregular, snoring, wheeze, accessory muscles
- ↓ Arterial O₂ content (SaO₂) or arterial O₂ partial pressure (PaO₂)
  - SaO₂ or SpO₂ ≤ 90%

**Assessing The Sleeping Patient**

- Know baseline for your patient
- Know conditions that ↑ patient risk for opioid sedation
- Do thorough respiratory assessment
  - Is the ventilation adequate?
    - Rate, depth, regularity
  - Look at patient with enough light to see
    - Poor color/cyanosis are late signs of ↓ oxygenation
- When is peak effect and duration of meds given?
- Awaken patient and assess for sedation level and any abnormal respirations or concerns

**Case Example**

- Patient is asleep and breathing, having difficulty awakening him even with physical stimulation
- Very somnolent; ↓ responsive
- Check respiratory rate/quality, SpO₂
- Administer O₂ and call for assistance
- Notify M.D.; give Naxolone as ordered if patient on opioid
  - Requires close monitoring
  - May need higher level of care, tests, change in meds
Considerations for Over Sedated Patients

- Evaluate underlying causes
- Eliminate nonessential CNS-acting drugs
- If analgesia is satisfactory, reduce dose (by 10-25%)
- Consider giving lower opioid dose more frequently to ↓ peak serum concentration
- May need to add or ↑ nonopioid for additional pain relief
- Tolerance to sedative effect of opioid occurs over time
- If excessive sedation persists, switch to another opioid

Is Your Patient In Trouble? Should You Call For Help?

- Changes from baseline
- ↓ level of consciousness
- Pinpoint pupils
- ↓ respiratory rate or change in quality of respirations
- Be aware of the difference between oxygenation and ventilation
- Hypotension
- Changes in heart rate

Rescue Measures

Call Rapid Response Team (RRT)- paging operator 141

- Stop opioid & sedatives
- Stimulate patient and call for help
- Administer oxygen
- Stay with the patient & maintain airway
- Administer reversal agent if needed
- Monitor patient: SpO₂, RR, sedation
Causes of Agitation

Symptom of distress
- Respiratory: hypoventilation
- Cardiac: low cardiac output
- Metabolic imbalance
- Neurologic status: ↑ ICP, trauma
- Pain/discomfort

Critical Thinking Is Key

- What is normal and what are risk factors?
- Understand treatment rationale; how it impacts care
- Essential to communicate pertinent information
  - Communication root cause >70% of all Joint Commission sentinel events
- Documentation --essential to do it!!
- Look at the whole clinical picture
  If something doesn't seem/feel right, check it out!

Questions?
References


