ETCO2 Monitoring: Riding the Wave!

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Wesley Medical Center

Disclosure

- I have no financial conflicts to disclose.
- I have participated in focus groups for Draeger Medical and Aerogen.
- No interest in companies providing capnography products or equipment.
**Objectives**

- Overview of ETCO2 monitoring
- Physiology
- CO2 waveform
- New recommendations for ETCO2 Monitoring
  - Cardiopulmonary resuscitation
  - Patient Monitoring in sedation / pain management
    - Wesley’s experience with ETCO2 monitoring

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**What Is Capnography?**

- A non-invasive, continuous measurement of exhaled carbon dioxide concentration
- Exhaled CO$_2$ is sampled
  - Via specialized nasal cannula
  - Via airway adapter for ET/trach
Quantitative ... not to be confused with CO2 detector!

- CO2 detector – color change
- Capnography
  - Value
  - Waveform
Capnography

Physiology of ETCO2 ...

Metabolism + Circulation + Ventilation
What info does capnography provide?

**ETCO2 display**
- Numerical value for ETCO2
- Normal value 35-40 mmHg
- Distinct waveform (tracing) for each respiratory cycle

**Normal Waveform**
- A-B: Baseline = no CO₂ in breath
- B-C: Rapid rise in CO₂
- C-D: Alveolar plateau
- D: End expiration (EtCO₂)
- D-E: Inhalation
**Hypoventilation**

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

**Hyperventilation**

\[ \uparrow \text{RR} = \downarrow \text{CO}_2 \quad \text{Hyperventilation} \]
Value of ETCO2 waveforms

- Accurately measures respiratory rate/ventilation
- Able to monitor non-intubated patients
- Monitors hypoventilation more effectively than pulse oximetry
  - Early indicator of ventilation issues
  - Early warning of apnea
  - Indicator of perfusion and metabolism

Capnography
AHA Recommendation:

The 2010-2015 AHA Guidelines for ACLS recommend using quantitative waveform capnography in intubated patients during CPR. Waveform capnography allows providers to monitor CPR quality, optimize chest compressions, and detect ROSC (return of spontaneous circulation) during chest compressions.

ETCO2 Monitoring in CPR

- Quantitative Waveform Capnography
- The 2010-2015 AHA Guidelines for ACLS now recommend using quantitative waveform capnography in intubated patients during CPR.
- Waveform capnography allows providers to
  - Confirm and on-going monitoring of endotracheal tube placement
  - Monitor CPR quality and optimize chest compressions,
  - Detect ROSC (return of spontaneous circulation) during chest compressions
Normal ETCO2 in the adult patient should be 35-45 mmHg.

Evaluating the effectiveness of chest compressions
- 10-20 mmHg: High quality chest compressions
- Less than 10 mmHg during CPR: Indicates quality of chest compressions needs improvement.

Return of Spontaneous Circulation (ROSC)
- Significant increase in ETCO2
- Greater than 30 mmHg
- Represents drastic improvement in blood flow (more CO2 being transported to the lungs)
…a little background

- 2001 The Joint Commission (TJC) released new Pain Management Standard
- Accurate pain assessment
- Applying appropriate pain management techniques
- Increased emphasis on pain management
“Opioid anagesics rank among the drugs most frequently associated with adverse drug events”

“…the most serious effect being respiratory depression… generally preceded by sedation”

Incidence of Opioid-Related Respiratory Depression: Patient-Controlled Analgesia (PCA)

- 13 million patients receive PCA annually
- Respiratory depression averages about 0.5% = 65,000 patients:
  - low 0.16% = 20,800 patients
  - high 5.2% = 676,000 patients
- Estimated 5,200 potentially preventable episodes of respiratory failure
- As many as 50% of of PCA adverse events could be prevented with effective monitoring

Dr. Robert Stoelting
President
Anesthesia Patient Safety Foundation
(slides presented at Patient Safety, Science & Technology Summit (Jan 2013))
Leah, age 11  
Mariah, age 17  
Amanda, age 18  
Matt, age 43, Code Blue survivor  
Louise  

Justin, age 11  

“Dead in Bed” Syndrome
Incidence of Opioid-Related Respiratory Depression: Patient-Controlled Analgesia (PCA)

Dr Richard Dutton
(Executive Director, Anesthesia Quality Institute):
“PCA errors certainly occur, both in programming and in delivery, but any published estimate is likely to be only the tip of the iceberg.”

Why not Pulse Oximetry?

- Until recently, only practical method to assess respiratory function
- The pulse oximeter is a LATE detector of respiratory depression*
- Supplemental oxygen further delays detection*
  - O₂ no longer linearly correlates with SpO₂
- Historically, associated with frequent nuisance alarms
- Vital signs frequently stimulate patients prior to pulse oximetry assessment

The Respiratory Cycle has two separate physiologic processes:

**Ventilation & Oxygenation**

<table>
<thead>
<tr>
<th>EtCO₂ Monitoring (Measures Ventilation)</th>
<th>SpO₂ Monitoring (Measures Oxygenation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Measures carbon dioxide</td>
<td>• Measures oxygen saturation (O₂ attached to hemoglobin)</td>
</tr>
<tr>
<td>• Reflects breath-to-breath ventilation</td>
<td>• Reflects oxygenation / detects hypoxia</td>
</tr>
<tr>
<td>• Detects hypoventilation / apnea immediately</td>
<td>• Influenced by supplemental oxygen</td>
</tr>
<tr>
<td>• Does not appear normal if patient is not breathing</td>
<td>• May remain “normal” even if patient is not breathing</td>
</tr>
<tr>
<td>• Not effected by supplemental oxygen</td>
<td>• Should be used with capnography</td>
</tr>
</tbody>
</table>

**Oxygenation and Ventilation**

- Oxygen reading
- CO₂ waveform flatline
TJC's Recommendations

Screen patients for respiratory depression risk factors
- Sleep Apnea / sleep disorder
- Morbid obesity
- Snoring
- Older age
- No recent opioid use
- Post surgery (longer length of OR; thoracic / upper abdominal)
- Receiving other sedating drugs
- Preexisting co-morbidities
- Smoker

TJC's Recommendations

Create P&Ps for ongoing clinical monitoring of patients receiving opioids
- Pulse oximetry to monitor oxygenation
- Capnography used to monitor ventilation
- Use continuously rather than intermittently
- Educate staff not to rely on pulse oximetry
Wesley Medical Center
Wichita, KS

Licensed for 760 Beds
HCA Facility

700 physicians
3,000 employees

28,000 Inpatient Admissions
18,000 Surgeries
150-225 pts/mo PCA therapy

Wesley’s Experience:
Previous Strategies Implemented

2002-2007

- Increased emphasis on pain management
- Increase in Opioid related ADRs

Strategies

- Preprinted PCA Order sets;
- Eliminated basal rates; Established dosing ranges; Eliminated Meperidine

Strategies

- PCA by Proxy education
- eMAR documentation for bolus and shift totals
### Wesley’s Results

#### Opioid ADRs by Severity

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
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<tbody>
<tr>
<td>%Mild</td>
<td>47.80%</td>
<td>36.40%</td>
</tr>
<tr>
<td>%Mod</td>
<td>32.60%</td>
<td>49.00%</td>
</tr>
<tr>
<td>%Severe</td>
<td>19.60%</td>
<td>14.60%</td>
</tr>
<tr>
<td>%Code Mod/Severe (All Opioids)</td>
<td>37.50%</td>
<td>31.40%</td>
</tr>
<tr>
<td>% Code Mod/Severe (PCA Only)</td>
<td>16.70%</td>
<td>11.40%</td>
</tr>
</tbody>
</table>

### Wesley’s Experience:

**Implementation of Smart Pump Technology**

- **2009**
  - Expanded Multidisciplinary Implementation Team
  - Identification of High Risk Patients
    - All patients screened on admission
    - Modified STOP BANG score

- **May 2009**
  - Conversion to “Smart” Pump system
    - Included Capnography
  - Policy/Procedures to monitor all PCA pts and all High Risk patients receiving IV opioids for first 48 hours

**Goal**

- Effective pain management
- Reduce Severe Adverse Drug Events
- Improve Patient Safety
Wesley’s Experience: PCA volumes and Risk Scoring

<table>
<thead>
<tr>
<th>PCA Stats</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total PCA Orders</td>
<td>4122</td>
<td>3831</td>
<td>2265</td>
</tr>
<tr>
<td>Total PCA Patients</td>
<td>3580</td>
<td>3114</td>
<td>2037</td>
</tr>
<tr>
<td>Orders Using Order Set</td>
<td>4031</td>
<td>3879</td>
<td>2207</td>
</tr>
<tr>
<td>% PCA Ord Using OS</td>
<td>97.94%</td>
<td>98.33%</td>
<td>99.96%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patient Risk Scoring</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total PCA Pat w/ RS</td>
<td>3118</td>
<td>2961</td>
<td>1923</td>
</tr>
<tr>
<td>High Risk</td>
<td>178</td>
<td>156</td>
<td>170</td>
</tr>
<tr>
<td>Low Risk</td>
<td>2645</td>
<td>2428</td>
<td>1551</td>
</tr>
<tr>
<td>Missing</td>
<td>485</td>
<td>265</td>
<td>114</td>
</tr>
<tr>
<td>Diagnosed</td>
<td>274</td>
<td>251</td>
<td>202</td>
</tr>
<tr>
<td>Not Eval</td>
<td>0</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>% Pats w/PCA Ord w/RS</td>
<td>87.09%</td>
<td>95.09%</td>
<td>94.40%</td>
</tr>
</tbody>
</table>

Wesley’s Experience: Results

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>%Mild</td>
<td>47.80%</td>
<td>36.4%</td>
<td>35.1%</td>
<td>27.6%</td>
<td>54.3%</td>
<td>45.9%</td>
<td>60.2%</td>
</tr>
<tr>
<td>%Mod</td>
<td>32.60%</td>
<td>49%</td>
<td>51.4%</td>
<td>41.4%</td>
<td>39.0%</td>
<td>50.5%</td>
<td>35.6%</td>
</tr>
<tr>
<td>%Severe</td>
<td>19.60%</td>
<td>14.60%</td>
<td>13.50%</td>
<td>31.0%</td>
<td>6.80%</td>
<td>3.6%</td>
<td>1.4%</td>
</tr>
<tr>
<td>%Code Mod/Severe (All Opioids)</td>
<td>37.50%</td>
<td>31.40%</td>
<td>20.80%</td>
<td>42.8%</td>
<td>11.1%</td>
<td>10.0%</td>
<td>10.3%</td>
</tr>
<tr>
<td>% Code Mod/Severe (PCA Only)</td>
<td>16.70%</td>
<td>11.4%</td>
<td>12.5%</td>
<td>14.3%</td>
<td>3.70%</td>
<td>1.7%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>
Wesley’s Experience:
ADRs by Severity

Wesley’s Experience:
Code Prevalence
Wesley’s Experience: Transfer to ICU

% PCA ADRs Transfer to ICU

Pre-2010 | Post 2010 | 2011 | 2012
--- | --- | --- | ---
0% | 10% | 20% | 30%

Wesley’s Experience: On-going Performance Improvement

Reduce Severity in Non-PCA ADRs

Dec. '12: Monitor all Post-op pts receiving IV opioids for 1st 24 hrs
Methodology to identify other risk factors for respiratory depression
Medical patients receiving IV opioids?
Wesley’s Experience: Lessons Learned

Staff Education: ETCO2 Pulse Oximetry

Patient Education

Management of Alarms

Team Collaboration

ETCO2 an effective tool for early detection of Respiratory Depression

In recognition for our efforts to improve patient-controlled analgesia (PCA) outcomes, Wesley Medical Center was honored by the Institute of Safe Medication Practice with the Cheers Award in 2012.
END TIDAL CO2 MONITORING: Role of the Respiratory Therapist

- Integral role – RTs have expertise in ventilation
- Development of policies/procedures,
- Establishing alarm limits
- Identification of high risk patients
- Staff Education
  - Nurses, ARNPs, PAs, physicians
  - Initial and on-going education
  - Pulse oximetry vs. ETCO2 monitoring
- Bedside support for problem solving and patient assessment
Wesley Protocol for Responding to Alarm Situations

- RN notifies RT of Alarm situation
- Bedside collaboration w/ pt assessment
  - Sedation Scale
  - Respiratory Rate / tidal volume
- Confirm correct placement of sampling cannula
- Collaborate to review pain medication orders
  - Contact physician
  - Naloxone reversal if indicated
- RT may initiate non-invasive ventilation (NIV)
  - BiPAP (IPAP 15, EPAP 5, Rate 12)
  - Continue ETCO2 monitoring with NIV
- Follow-up call to physician after 1 hr if ventilator assistance is still needed. Consider transfer to ICU.

Summary

- Capnography continues to be the gold standard for continuous monitoring of ventilation.
- Capnography useful in CPR to monitor the airway, effectiveness of compressions and return of spontaneous circulation.
- Pain management increases the risk of opioid-induced respiratory depression.
- Capnography is superior to oximetry for monitoring patients receiving opioid pain medication.
- Early detection + Early Intervention = Patient Safety
- Respiratory Therapists play an integral role in a comprehensive pain management program.
Cruisin’ to the Bahamas!

Enjoy the Rest of your Cruise!

-- Bon Voyage --