

ETCO₂ Monitoring: Riding the Wave!



Debbie Fox, MBA, RRT-NPS, FAARC
Director, Respiratory Care
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

What Is Capnography?

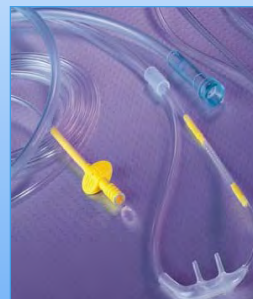
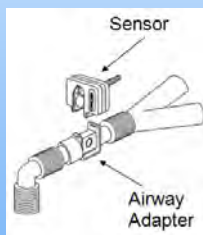
- A non-invasive, continuous measurement of exhaled carbon dioxide concentration
- Exhaled CO₂ is sampled
 - Via specialized nasal cannula
 - Via airway adapter for ET/trach

Quantitative ... not to be confused with CO2 detector!

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

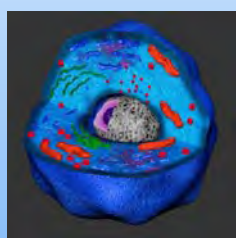


Capnography



Physiology of ETCO₂ ...

Metabolism + Circulation + Ventilation



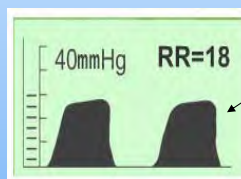
What info does capnography provide?

ETCO₂ display

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

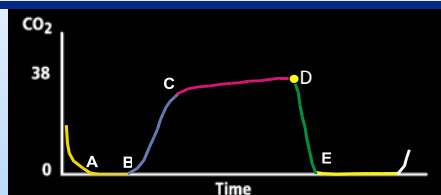


Capnometer



Capnograph

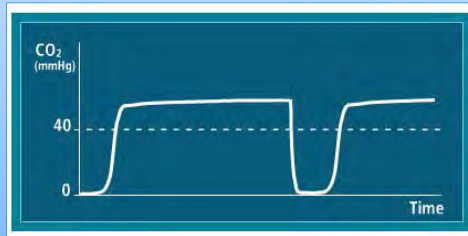
Normal Waveform



- 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

↓ RR = ↑ CO₂ Hypoventilation

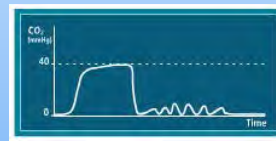
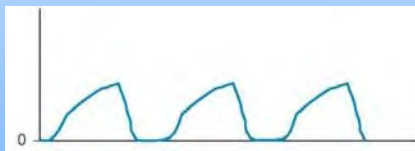
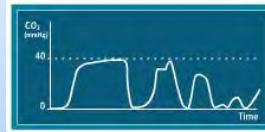


Hyperventilation

↑ RR = ↓ CO₂ Hyperventilation



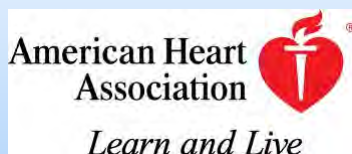
Value of ETCO₂ waveforms



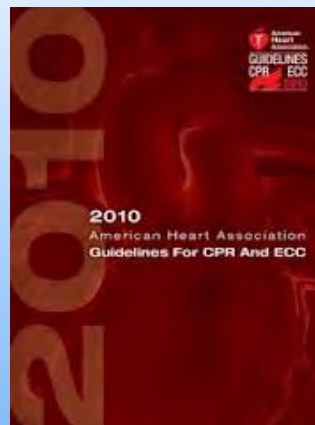
Capnography

- ▣ 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

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



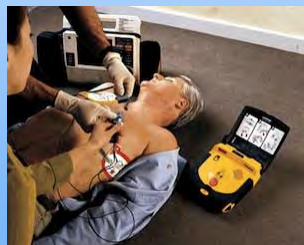
ETCO₂ Monitoring in CPR

- 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.



ETCO₂ Monitoring in CPR

- 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)





Role of ETCO₂ in Pain Management

...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



TJC Sentinel Event Alert

“Safe Use of Opioids in Hospitals”

- “Opioid analgesics rank among the drugs most frequently associated with adverse drug events”
- “...the most serious effect being respiratory depression... generally preceded by sedation”



The Joint Commission
Sentinel Event Alert “Safe use of opioids in hospitals”
(Issue 49, August 8, 2012)

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))

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

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* Hutton & Clutton-Brock, BMJ 1993;307:157-8.

The Respiratory Cycle has two separate physiologic processes:

Ventilation & Oxygenation

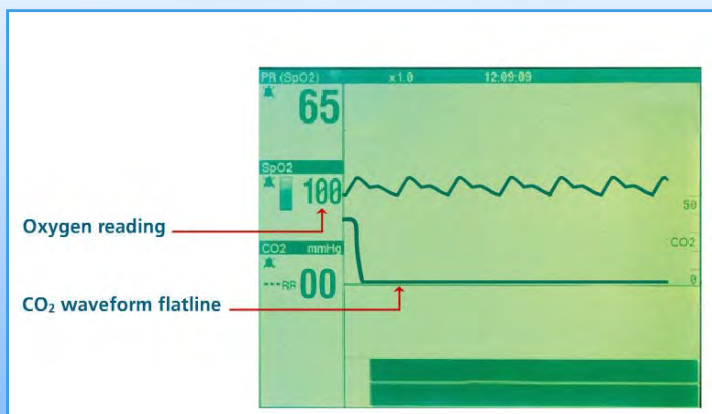
EtCO₂ Monitoring (Measures **Ventilation**)

- Measures carbon dioxide
- Reflects breath-to-breath ventilation
- Detects hypoventilation / apnea immediately
- Does not appear normal if patient is not breathing
- Not effected by supplemental oxygen

SpO₂ Monitoring (Measures **Oxygenation**)

- Measures oxygen saturation (O₂ attached to hemoglobin)
- Reflects oxygenation / detects hypoxia
- Influenced by supplemental oxygen
- May remain "normal" even if patient is not breathing
- Should be used with capnography

Oxygenation and Ventilation



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



Have the Standards
Respiratory Depression Alert

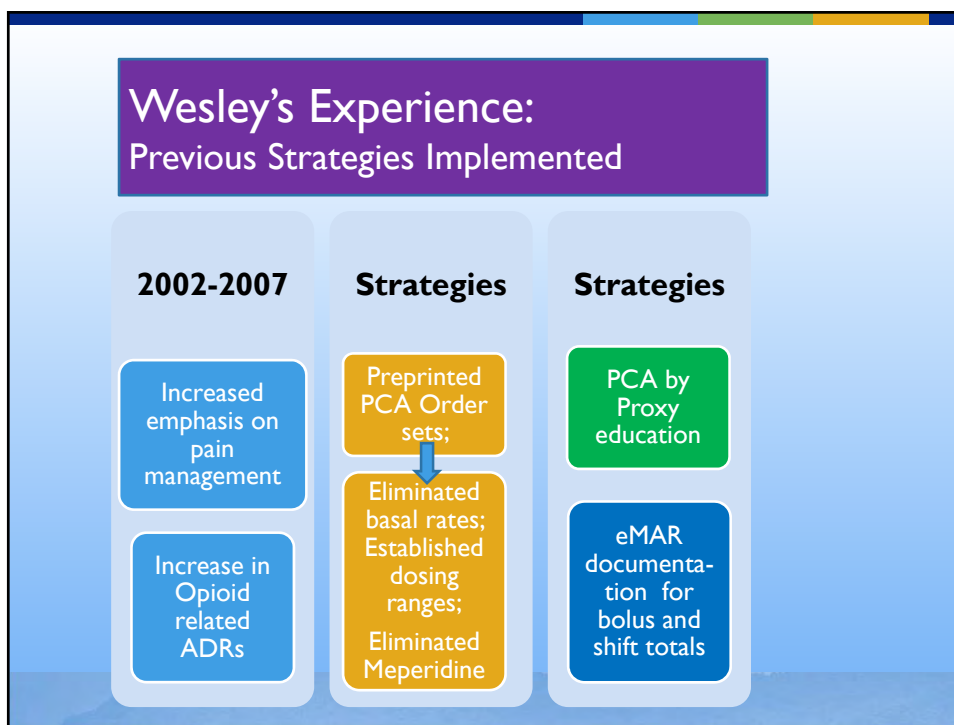
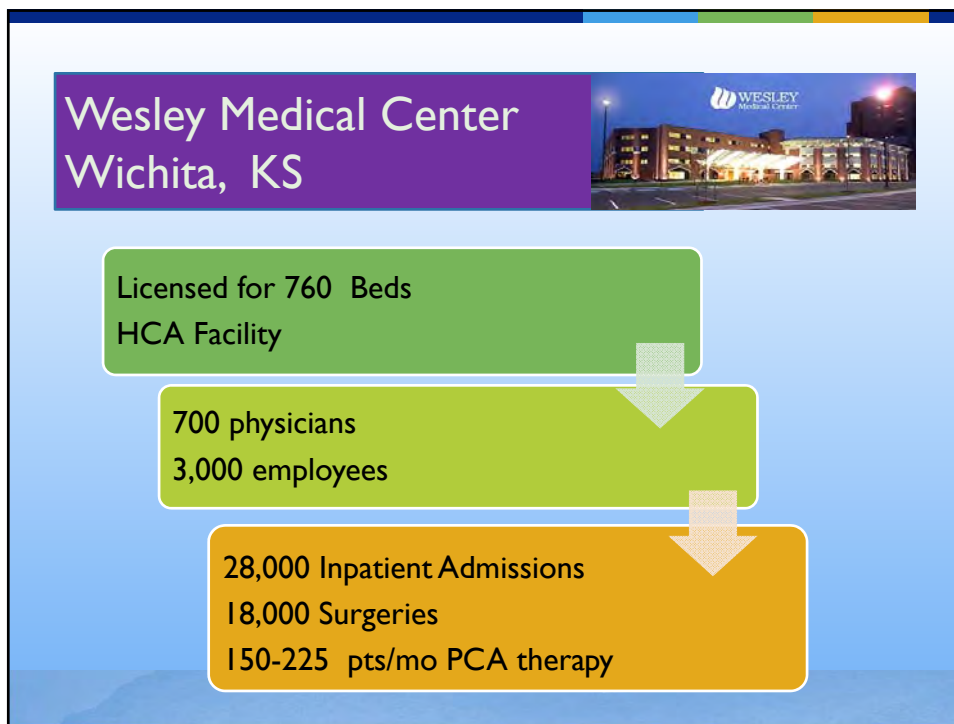
TJC's Recommendations

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



Have the Standards
Respiratory Depression Alert



Wesley's Results

Opioid ADRs by Severity	2007	2008
%Mild	47.80%	36.4%
%Mod	32.60%	49%
%Severe	19.60%	14.60%
%Code Mod/Severe (All Opioids)	37.50%	31.40%
% Code Mod/Severe (PCA Only)	16.70%	11.4%

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

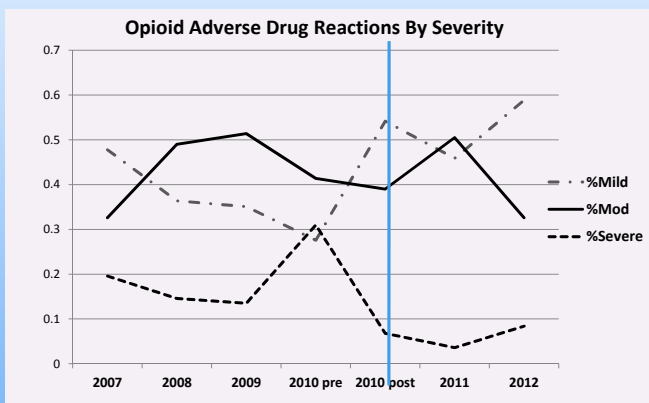
Wesley's Experience: PCA volumes and Risk Scoring

		2010	2011	2012
PCA Stats				
	Total PCA Orders	4122	3531	2268
	Total PCA Patients	3580	3114	2037
	Orders Using Order Set	4037	3472	2267
	% PCA Ord Using OS	97.94%	98.33%	99.96%
Patient Risk Scoring				
	Total PCA Pat w/RS	3118	2961	1923
	High Risk	178	156	170
	Low Risk	2645	2428	1551
	Missing	488	265	114
	Diagnosed	274	251	202
	Not Eval	0	14	0
	% Pats w/PCA Ord w/RS	87.09%	95.09%	94.40%

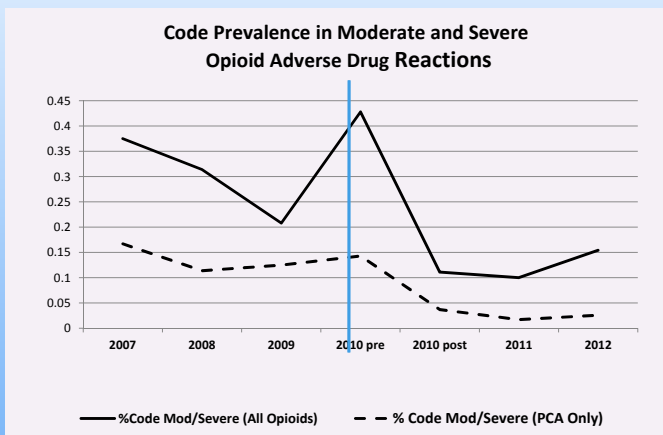
Wesley's Experience: Results

Opioid ADRs by Severity	2007	2008	2009	2010 pre-ETCO2	2010 post-ETCO2	2011	2012
%Mild	47.80%	36.4%	35.1%	27.6%	54.2%	45.9%	60.2%
%Mod	32.60%	49%	51.4%	41.4%	39.0%	50.5%	35.6%
%Severe	19.60%	14.60%	13.50%	31.0%	6.80%	3.6%	1.4%
%Code Mod/Severe (All Opioids)	37.50%	31.40%	20.80%	42.8%	11.1%	10.0%	10.3%
% Code Mod/Severe (PCA Only)	16.70%	11.4%	12.5%	14.3%	3.70%	1.7%	3.4%

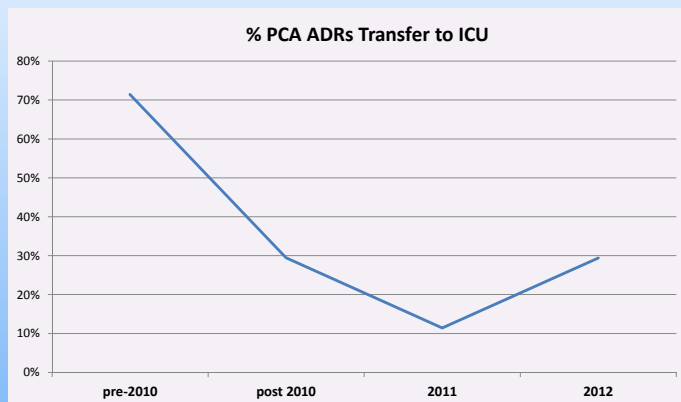
Wesley's Experience: ADRs by Severity



Wesley's Experience: Code Prevalence



Wesley's Experience: Transfer to ICU



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.

AARC Abstract

INTEGRAL ROLE OF RESPIRATORY THERAPISTS IN A COMPREHENSIVE PAIN MANAGEMENT PROGRAM USING END TIDAL CO₂ MONITORING

BACKGROUND: A hospital-wide conversion to a new "smart" infusion pump system including e-prescriptions provided an opportunity to develop a comprehensive program to safely and effectively manage pain. Effective pain management is vital to patient satisfaction. Patient monitoring with end-tidal CO₂ (ETCO₂) is essential in reducing adverse events and preventing respiratory depression from pain medication overdose.

METHOD: A multidisciplinary team of Respiratory Therapist (RT), Nursing, Pharmacists, and Physicians developed policies and procedures for the new system. The components of the program included utilizing the "smart" pump technology to prevent medication administration errors, identifying high risk patients using a modified STOP-BANG scoring, and providing ETCO₂ monitoring for all patients receiving patient controlled analgesia (PCA) therapy and all high risk patients receiving intermittent intravenous opioids. Staff education for Nursing and RTs regarding patient monitoring focused on ETCO₂ technology and patient assessment. Nursing response to alarm situations is to notify RT and work together to follow established protocols for clinical interventions. The importance of collaboration between the bedside nurse and RT is emphasized with shared responsibilities for the initiation of monitoring, frequency of checks, and its use with oxygen and CPAP/BIPAP devices. Educating the patient about the reasons for monitoring is critical in acceptance of the ETCO₂ device. The impact of ETCO₂ monitoring in preventing respiratory depression was measured by the number of adverse drug events related to PCA and opioid pain medications and the use of opioid reversal agent Naloxone.

RESULTS: Comparison of the reported adverse drug events from different time periods are displayed in the table below. The data shows a shift from severe (life-threatening) events to the mild (subconscious reversal) and moderate (multiple subconscious reversals or other interventions required) categories. This shift may be attributed to earlier recognition of respiratory depression and intervening before the patient progresses to a life-threatening event.

	2008 - 1 st Qtr		2010		Oct 2011 - April 2012	
	#	%	#	%	#	%
Mild	4	12%	33	46%	19	7%
Moderate	30	82%	33	46%	19	46%
Severe	1	3%	3	4%	7	4%
TOTAL	35		73		45	

CONCLUSIONS: Respiratory therapists play a central role in the implementation and success of a comprehensive, hospital-wide program of pain management. The use of end-tidal CO₂ monitoring is an effective method for early detection of respiratory depression in patients receiving PCA and intermittent IV opioid pain medication.

American Asso. for Respiratory Care International Congress, Poster presentation, November 2011 in Tampa FL

Abstract published in Respiratory Care Journal, Oct 2011, Vol. 56, number 10

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!

