Respiratory Compromise:

Plant the Seeds of Success

Oregon State Respiratory Care Conference

3-7-18

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Medtronic

Disclosure

Conflict of interest statement:

Lecture Objectives

- Define respiratory compromise and its impact by AOC
  - Prevention
  - Improving patient safety
- Explain the difference between oxygenation and ventilation
- Distinguish between the three types of respiratory failure
- Discuss standards and guidelines for capnography monitoring
- Provide case examples for different AOC
- Review articles showing improved outcomes with capnography
- Myth busters

Medical Errors

Leah Coufal
AGE: 11

DIAGNOSIS: Pectus carinatum (convex projecting sternum) repair

Postoperative General Care Floor

After successful surgery, complained of considerable pain and fentanyl was repeatedly increased- becoming less alert, she was given Ativan for "anxiety".

About 1 AM, her mother Lenore, exhausted, took a nap.

3 AM – Lenore awoke and found her daughter Leah was dead in her bed.

Would real-time monitoring have saved Leah? That is one of the many questions that I have asked myself every day since I found my daughter, Leah, dead in her hospital bed. The answer is yes, it would have."

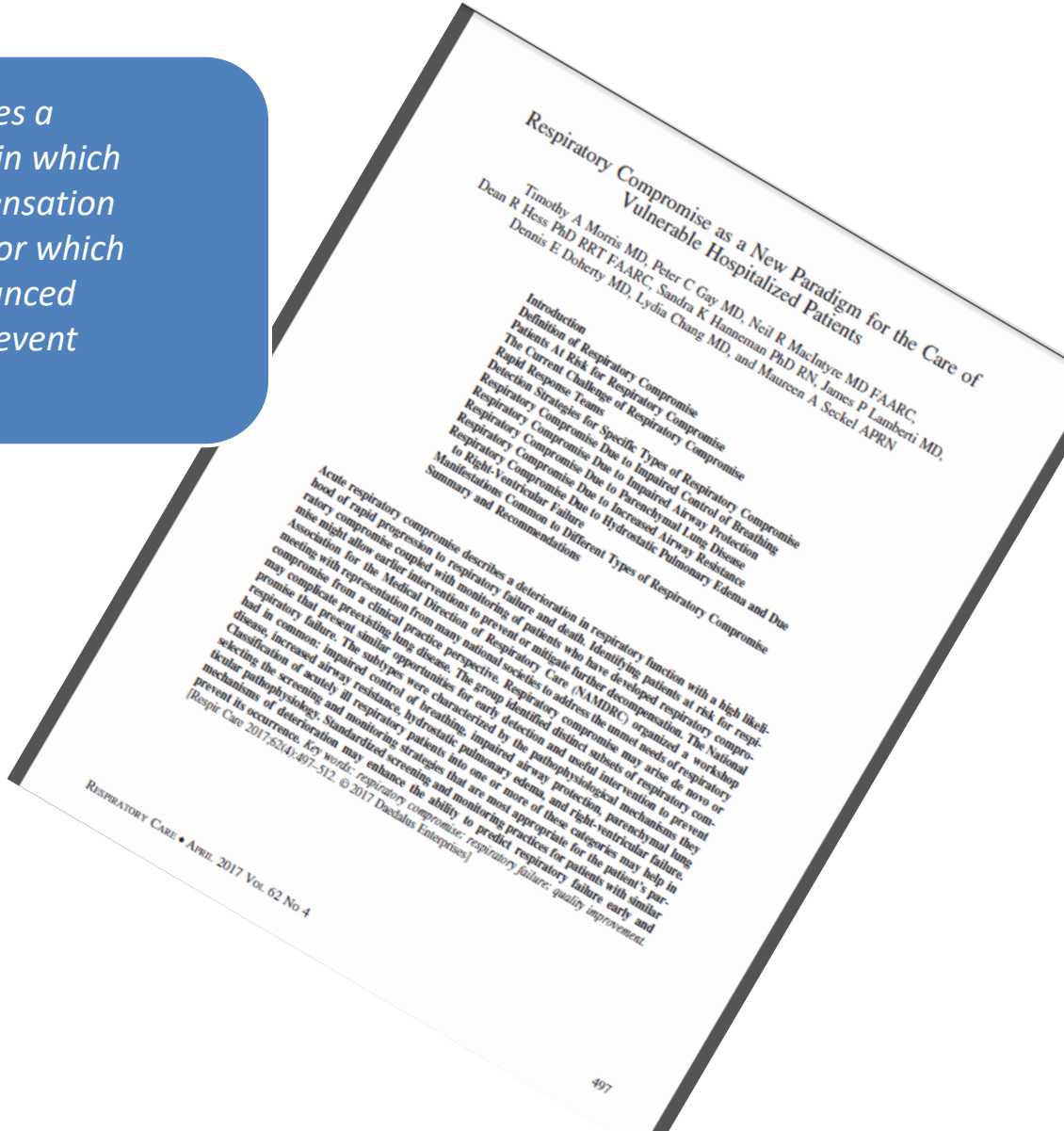
-Lenore Alexander (Mother of Leah)[01]

http://www.medtronic.com/us-en/about/news/news-matt-whitman.html

What is Respiratory Compromise (RC)?

Respiratory compromise describes a deterioration in respiratory function in which there is a high likelihood of decompensation into respiratory failure or death but for which timely specific interventions (enhanced monitoring or therapies) might prevent or mitigate decompensation

www.respiratorycompromise.org



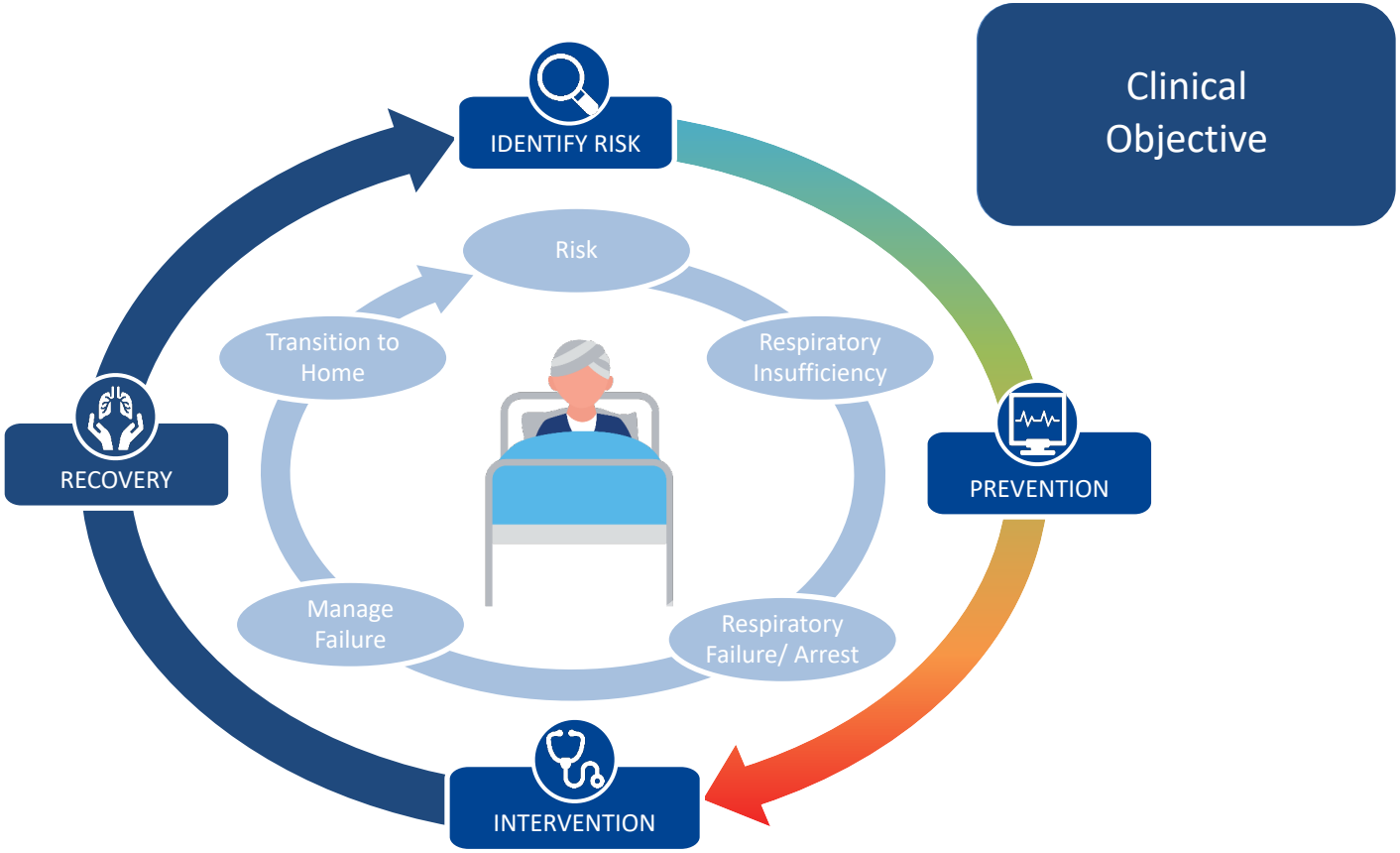
Respiratory Compromise as a New Paradigm for the Care of Vulnerable Hospitalized Patients

Timothy A Morris MD, Peter C Gay MD, Neil R MacIntyre MD FAARC, Dean R Hess PhD RRT FAARC, Sandra K Hanneman PhD RN, James P Lamberti MD, Dennis E Doherty MD, Lydia Chang MD, and Maureen A Seckel APRN

Acute respiratory compromise describes a deterioration in respiratory function with a high likelihood of rapid progression to respiratory failure and death. Identifying patients at risk for respiratory compromise coupled with monitoring of patients who have developed respiratory compromise might allow earlier interventions to prevent or mitigate further decompensation. The National Association for the Medical Direction of Respiratory Care (NAMDRC) organized a workshop meeting with representation from many national societies to address the unmet needs of respiratory compromise from a clinical practice perspective. Respiratory compromise may arise de novo or may complicate preexisting lung disease. The group identified distinct subsets of respiratory compromise that present similar opportunities for early detection and useful intervention to prevent respiratory failure. The subtypes were characterized by the pathophysiological mechanisms they had in common: impaired control of breathing, impaired airway protection, parenchymal lung disease, increased airway resistance, hydrostatic pulmonary edema, and right-ventricular failure. Classification of acutely ill respiratory patients into one or more of these categories may help in selecting the screening and monitoring strategies that are most appropriate for the patient's particular pathophysiology. Standardized screening and monitoring practices for patients with similar mechanisms of deterioration may enhance the ability to predict respiratory failure early and prevent its occurrence. [Respir Care 2017;62(4):497–512. © 2017 Daedalus Enterprises]

Key words: respiratory compromise; respiratory failure; quality improvement.

Respiratory Compromise Cycle



Magnitude of Respiratory Compromise

COMMON

Respiratory Compromise is THE leading cause of:

- ICU admissions
- Rescue (RRT) calls
- 'Code Blue' calls

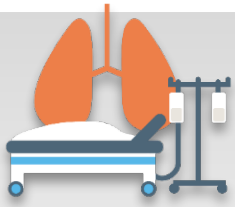
COSTLY

Inpatient Respiratory Compromise costs are expected to surpass

$37B

by **2019**

DEADLY

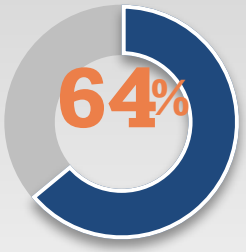


Patients with Respiratory Compromise originating on the general care floor are

29X more likely **to die**

Than those who don't develop Respiratory Compromise

PREVENTABLE



Nearly **two-thirds** of **primary respiratory arrests** were classified **POTENTIALLY AVOIDABLE**

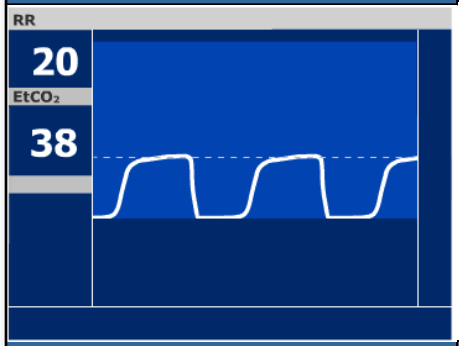
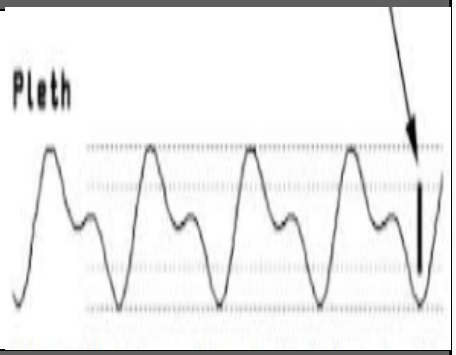
Physiology of Oxygenation

- 98%–99% of O_2 total content is bound to Hb (SaO_2)
- 1%–2% of O_2 is dissolved in plasma (PaO_2)
  - O_2 enters the tissues (PaO_2 gradient)
  - Balance between SaO_2 and PaO2
  - Hb in arterial blood remains 98% saturated (PaO_2 95 mm Hg)
  - Oxygen at tissues decline to 40 mm Hg (70%–75% Hb sat)
- Normal PaO_2 = 80–100 mm Hg
- Assessed by sampling of arterial blood gases (ABG)
- Indirectly by noninvasive pulse oximetry (SpO_2)

Physiology of Ventilation

- Ventilation
  - Carbon dioxide provides direct measurement of ventilation
- 70% transported as bicarbonate ion
- 23% bound to Hb ($HbCO_2$)
- 7% dissolved in blood ($PaCO_2$ 40 mmHg)
- Measure invasively by ABG ($PaCO_2$)
  - $CO_2 + H_20 <> H_2CO_3^- <> H^+ + HC0_3^-$
- While oxygenation may be normal, ventilation can be inadequate

Capnography vs. Pulse Oximetry

Capnography	Pulse Oximetry
	
Carbon Dioxide ($EtCO_2$)	Oxygen (SpO_2)
Ventilation	Oxygenation
Detected immediately	Values lag

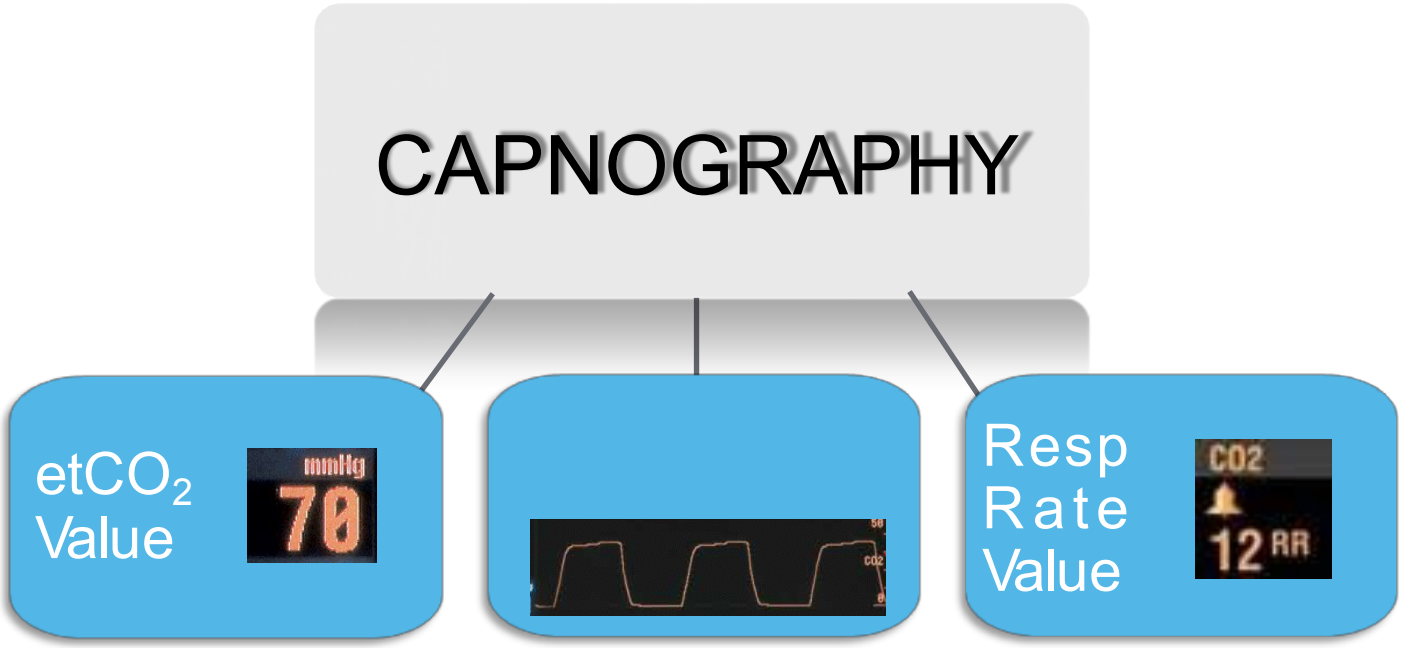
Breath Hold Video.mp4

Clinical Monitoring

- A patient whose vital signs are checked every four hours is unmonitored >96% of the time
- Nurse's presence may stimulate the patient, resulting in overstimulation of the RR, which is often determined by manual respiration counts. What alarm?
- Manual counts of RR have been shown to be inaccurate when compared to Capnography

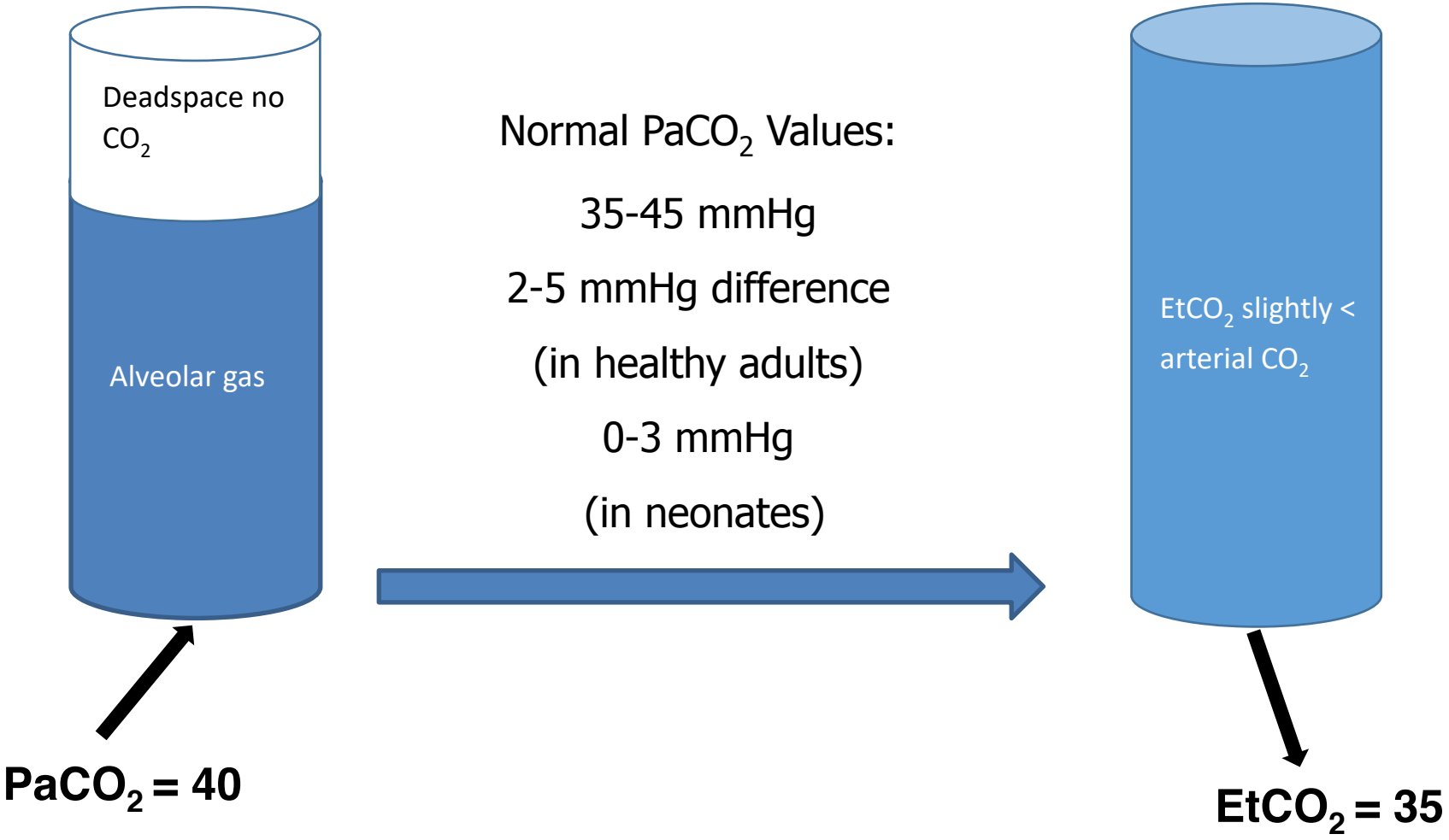
What is Capnography?

Noninvasive, continuous measurement of exhaled carbon dioxide ($etCO_2$) concentration over time



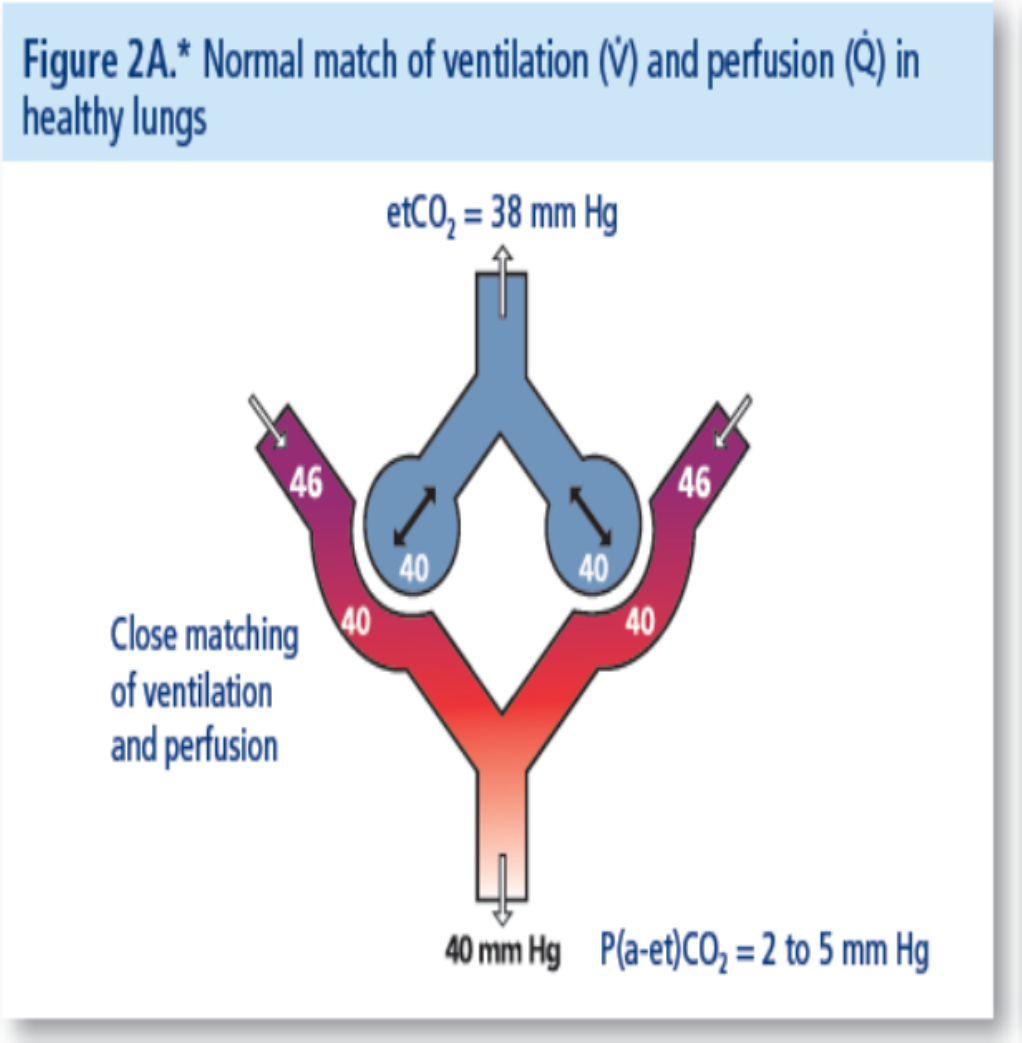
Relationship between $PaCO_2$ & $PetCO_2$

V/Q mismatch



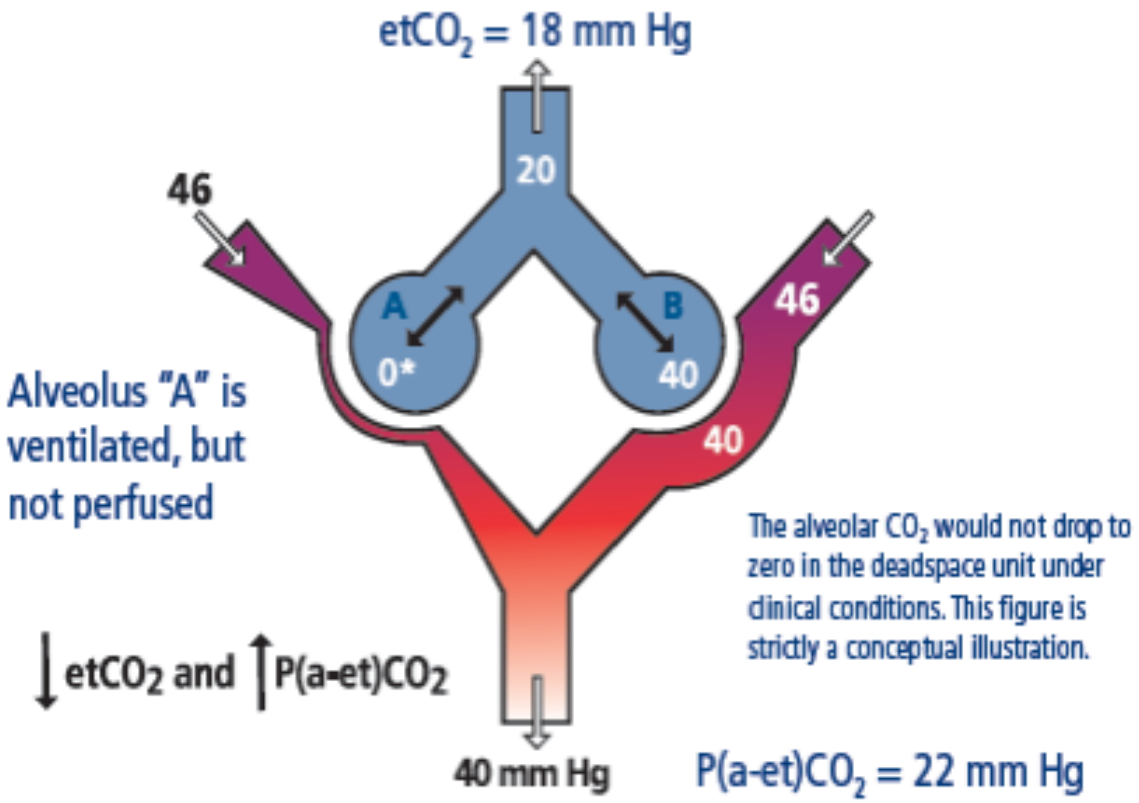
Is using capnography accurate?

- In healthy lungs, there is good V/Q matching
- Alveoli are well ventilated
- Pulmonary capillaries are well perfused
- Pa-etCO2 is normal (2 – 5 mmHg)



Abnormal V/Q matching

Figure 2B.* Acute decrease in alveolar perfusion (deadspace ventilation)



Many Conditions May cause Respiratory Failure…

QUESTIONS/COMPLEXITY ARISE

How do I monitor COPD vs pneumonia vs postop vs HF vs… to provide early identification?

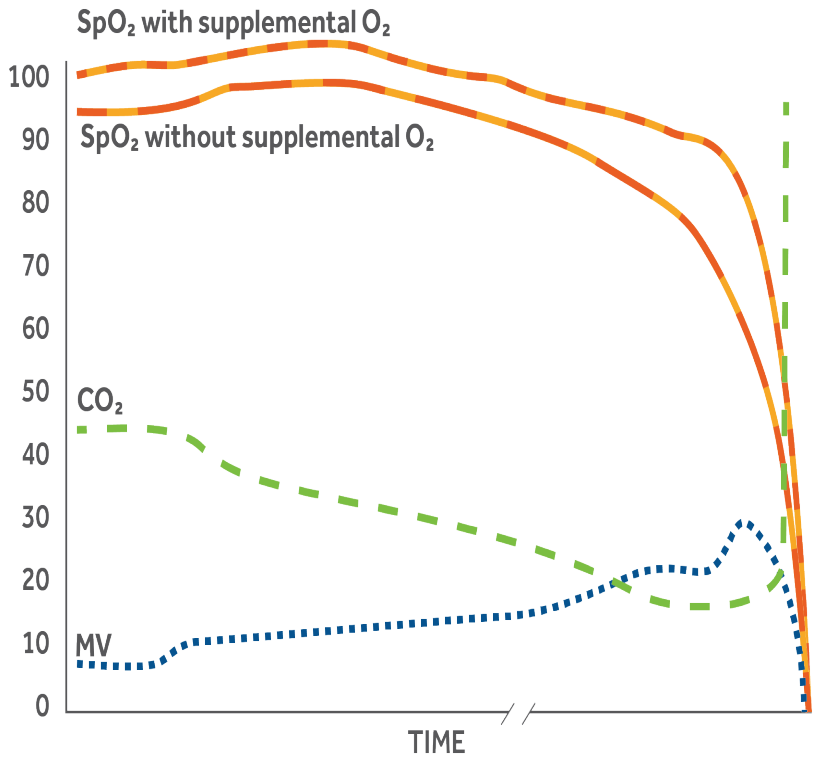
How does monitoring guide earlier intervention?

… there's only 3 physiologic pathways to respiratory failure.

Hypoxemic Respiratory Failure (Type I)

OXYGENATION FAILURE

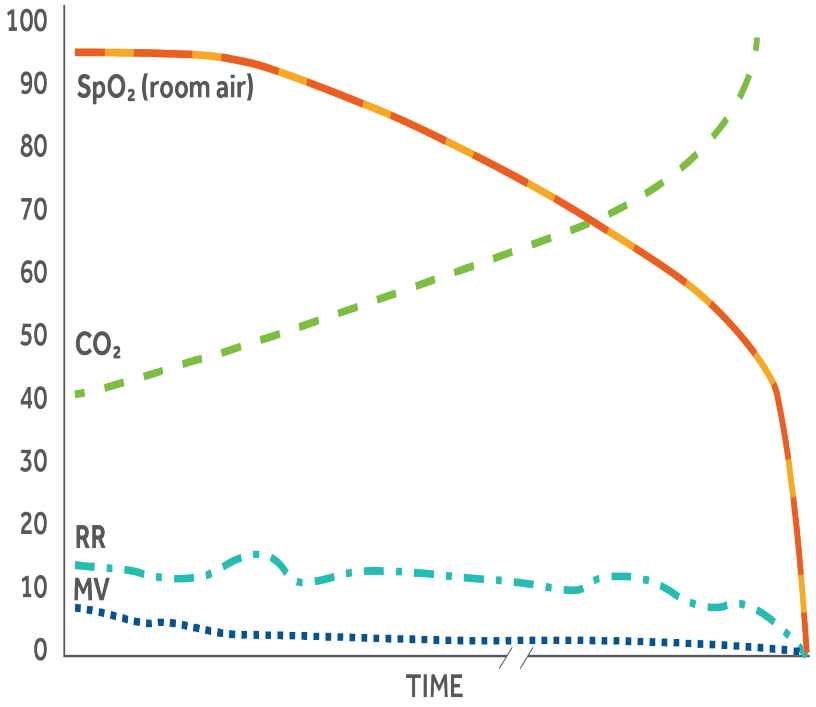
- Primary Issue – Inadequate oxygenation due to congestion in lung
- Examples – pneumonia, ARDS, sepsis, etc.
- Decreasing ability to oxygenate blood
- To compensate patient breathes faster and/or deeper increasing minute volume (MV) and clinicians give O_2
- Monitor Result (graph)



Graphs adapted from: Lynn LA, Curry JP. Patterns of unexpected in-hospital deaths: a root cause analysis. Safety in Surgery 2011, 5:3 (epub) http://www.pssjournal.com/content/5/1/3

VENTILATION FAILURE

- Primary Issue: Inadequate ventilation to CO_2
- Examples – Opioid use, sedation, brain injury
- Decreasing ability to ventilate
  - Decreased RR and/or tidal volume = MV
- SpO_2 maintained above 90% due to plateau of curve through significant rise in CO_2
- Monitor results (graph)



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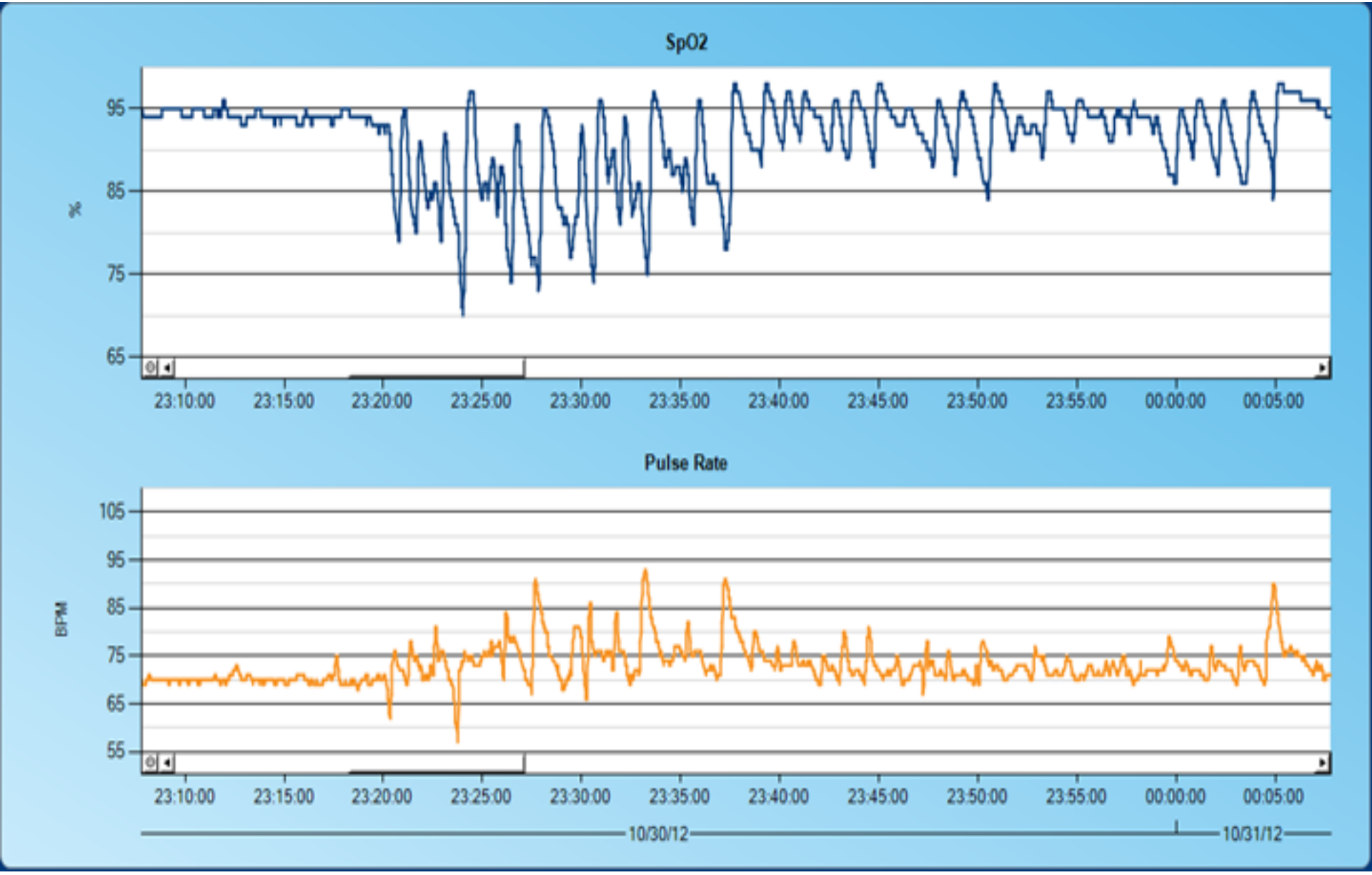
SpO2
%
95
85
75
65
23:10:00
23:15:00
23:20:00
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23:40:00
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Pulse Rate
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23:50:00
23:55:00
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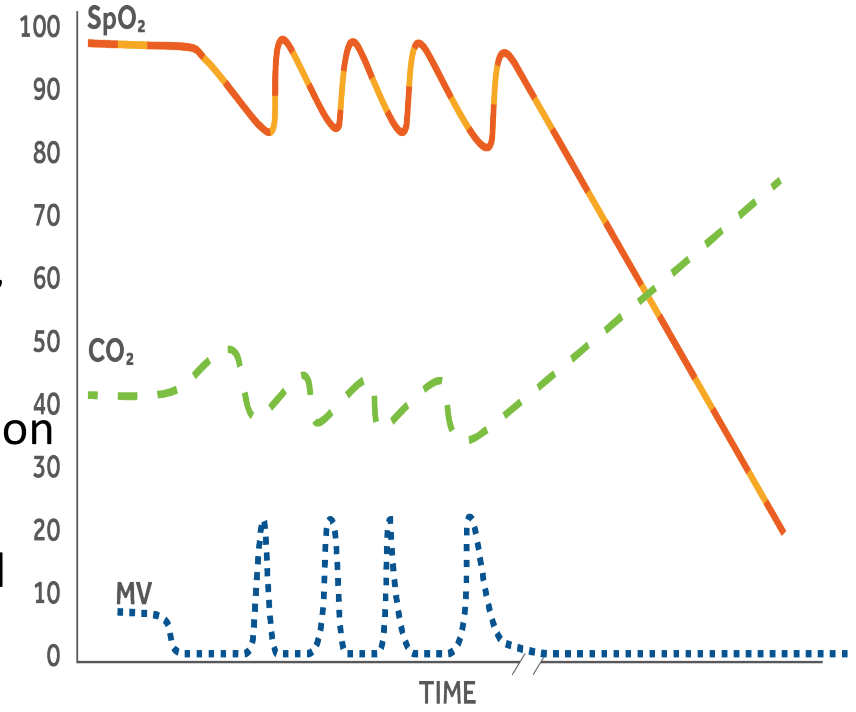
00:05:00
10/30/12
10/31/12

Arousal Failure (Type III)

SLEEP DISORDERED BREATHING

- Primary Issue: Recurring apneas and/or shallow breathing during sleep
- Examples – OSA, central sleep apnea, Cheyne-Stokes Respiration, etc.
- Repetitive pattern of hypoventilation (apnea, hypopnea) followed by hyperventilation to restore normal blood oxygen/CO_2 levels
- Reciprocal sawtooth rises and falls in blood oxygen and CO_2
- Recovery response may be blunted by opioids, sedatives, alcohol, etc.



Graphs adapted from: Lynn LA, Curry JP. Patterns of unexpected in-hospital deaths: a root cause analysis. Safety in Surgery 2011, 5:3 (epub) http://www.pssjournal.com/content/5/1/3

Benefits of Using Capnography

- Resuscitation—in and out of hospital
- Increased patient safety during moderate sedation
- Increased awareness of changes in a patient's respiratory status while receiving opioid therapy (PCA) on med/surg floor
- Prevention of respiratory compromise
- Effective use of rapid response teams

American Heart Association

June 2013 – CPR Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital: A Consensus Statement From the American Heart Association[1]

- How the Patient Is Doing: Monitoring the Patient's Physiological Response to Resuscitative Efforts
  - *Capnography Only: $etCO_2$ >20 mm Hg* - $etCO_2$ concentrations during CPR are primarily dependent on pulmonary blood flow and therefore reflect cardiac output. **Failure to maintain etco2 at >10 mm Hg during adult CPR reflects poor cardiac output and strongly predicts unsuccessful resuscitation**... On the basis of limited animal data and personal experience, the **expert panel recommends titrating CPR performance to a goal $etCO_2$ of >20 mm Hg while not excessively ventilating the patient** (rate <12 breaths per minute, with only minimal chest rise).
  - Avoid Unnecessary Pulse Checks - Manual palpation for a pulse can result in unnecessarily long pauses and is often unreliable.83,85,96–100 These pauses can often be avoided when available monitoring (such as an arterial line or capnography) indicates a level of cardiac output or a rhythm (such as ventricular fibrillation) that is incompatible with organ perfusion.

1. http://circ.ahajournals.org/content/early/2013/06/25/CIR.0b013e31829d8654.full.pdf

96 Minute Man (Howard Snitzer)

- Jan 2011
- Coded in front of grocery store in small-town MN
- 911 called and CPR started
- ED doctor told 1st responders to walk away—he's dead
- $EtCO_2$ suggested blood flow to brain and heart so they did not give up
- Dr. White, anesthesiologist from Mayo Clinic, called
- Shocked him 12x and administered IV drugs to stop fatal heart rhythm
- Airlifted to Mayo
- Walked out 10 days later

Capnography in Procedural Sedation

- Accurately monitors *effective* ventilation,

  giving a true airway respiratory rate

- Earliest indicator of:
  - Apnea
  - Obstruction
  - Hypoventilation
- Get baseline trend before meds
- Watch for: no breath (apnea), shallow

  breathing, ↓ RR & ↑ $etCO_2$ trend

- Titrate dosage according to trends

American Society of Anesthesiologists

July 2011 – Standards for basic anesthetic monitoring: moderate or deep procedural sedation practices..

Be prepared for deeper level of sedation

- ASA Definition of 'Standard':
  - Standards provide rules or minimum requirements for clinical practice. They are regarded as generally accepted principles of patient management. Standards may be modified only under unusual circumstances, e.g., extreme emergencies or unavailability of equipment

"During moderate or deep sedation, the adequacy of ventilation shall be evaluated by continual observation of qualitative clinical signs and monitoring for the presence of exhaled carbon dioxide unless precluded or invalidated by the nature of the patient, procedure or equipment."[1]

DID YOU INTERVENE WITH A HEAD TILT/CHIN LIFT WHILE IN MODERATE SEDATION?

1. ASA Standards for Basic Anesthetic Monitoring, Committee of Origin: Standards and Practice Parameters (Approved by the ASA House of Delegates on October 21, 1986, and last amended on October 20, 2010 with an effective date of July 1, 2011, excerpt from section 3.2.4,

ASA LEVELS OF SEDATION

	Minimal sedation / Anxiolysis	Moderate sedation / analgesia	Deep sedation	General Anaesthesia
Responsive-ness	Normal response to verbal stimulation	Purposeful response to verbal commands or light touch	Purposeful response to repeated or painful tactile stimulation	Unarousable even to repeated or painful stimulation
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous Ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular Function	Unaffected	Usually maintained	Usually maintained	May be impaired

ANESTHESIOLOGY NEWS

Clinical Anesthesiology

MARCH 30, 2016

Modeling Shows Potential Cost Savings With Capnography Monitoring

THIEME OPEN ACCESS

Modeling the costs and benefits of capnography monitoring during procedural sedation for gastrointestinal endoscopy

Authors Rhodri Saunders[1], Mary Erslon[2], John Vargo[3]

Institutions
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[2] Covidien, Boulder, Colorado, United States (current affiliation: Medtronic, Boulder, Colorado, United States)
[3] Cleveland Clinic, Cleveland, Ohio, United States

submitted
30. September 2015
accepted after revision
4. January 2016

Bibliography
DOI http://dx.doi.org/10.1055/s-0042-100719
Endoscopy International Open 2016; 04: E340–E351

E-ISSN 2196-9736

Corresponding author

Background and study aims: The addition of capnography to procedural sedation/analgesia (PSA) guidelines has been controversial due to limited evidence of clinical utility in moderate PSA and cost concerns.

Patients and methods: A comprehensive model of PSA during gastrointestinal endoscopy was developed to capture adverse events (AEs), guideline interventions, outcomes, and costs. Randomized, controlled trials and large-scale studies were used to inform the model. The model compared outcomes using pulse oximetry alone with pulse oximetry plus capnography. Pulse oximetry was assumed at no cost, whereas capnography cost

Results: The addition of capnography resulted in a 27.2% and 18.0% reduction in the proportion of patients experiencing an AE during deep and moderate PSA, respectively. Sensitivity analyses demonstrated significant reductions in apnea and desaturation with capnography. The median (95% credible interval) number needed to treat to avoid any adverse event was 8 (2; 72) for deep and 6 (−59; 92) for moderate. Reduced AEs resulted in cost savings that accounted for the additional upfront purchase cost. Capnography was estimated to reduce the cost per procedure by USD 85 (deep) or USD 35 (moderate).

Conclusions: Capnography is estimated to be

Advance For Nurses (Online Edition)

Six Nursing Lessons – A nurse and mother reflects on the untimely death of her teenage son (July 2015)

Medtronic
Further, Together

Brandon you got some explaining to do……

- https://www.youtube.com/watch?v=VzvHnmqplvY

PACU

The JC Sentinel Event Alert
Issue 49 August 2012

Regarding the safe use of opioids in hospitals

"In addition to monitoring respiration and sedation, pulse oximetry can be used to monitor oxygenation, and capnography can be used to monitor ventilation. Staff should be educated not to rely on pulse oximetry alone because pulse oximetry can suggest adequate oxygen saturation in patients who are actively experiencing respiratory depression, especially when supplemental oxygen is being used – thus the value of using capnography to monitor ventilation. When pulse oximetry or capnography is used, it should be used continuously rather than

Reduce RRT and ICU Transfers

Format: Abstract Send to

J Patient Saf. 2017 Jul 20. doi: 10.1097/PTS.0000000000000408. [Epub ahead of print]

Continuous Capnography Reduces the Incidence of Opioid-Induced Respiratory Rescue by Hospital Rapid Resuscitation Team.

Stites M[1], Surprise J, McNiel J, Northrop D, De Ruyter M.

Author information

Abstract

OBJECTIVE: The aim of this study was to determine the impact of end tidal carbon dioxide or capnography monitoring in patients requiring patient-controlled analgesia (PCA) on the incidence of opioid-induced respiratory depression (OIRD) in the setting of rapid response.

METHODS: A retrospective analysis was conducted in an urban tertiary care facility on the incidence of OIRD in the setting of rapid response as defined by a positive response to naloxone from January 2012 to December 2015. In March 2013, continuous capnography monitoring was implemented for all patients using PCA.

RESULTS: The preintervention incidence of OIRD in the setting of rapid response was 0.04% of patients receiving opioids. After the implementation of capnography, the incidence of OIRD in the setting of rapid response was reduced to 0.02%, which was statistically significant (χ = 46.246; df, 1; P < 0.0001). The rate of transfers to a higher level of care associated with these events was also reduced by 79% (baseline, 7.6 transfers/month; postintervention, 1.6 transfers/month).

CONCLUSIONS: Continuous capnography monitoring in patients receiving PCA significantly reduces the incidence of OIRD in the setting of rapid response and unplanned transfers to a higher level of care.

PMID: 28731933 DOI: 10.1097/PTS.0000000000000408

https://www.youtube.com/watch?v=J0eRFANg7kM

Capnographic Monitoring Can Decrease Respiratory Compromise and Arrest in the Post-Operative Surgical Patient

By Dennis Jensen RRT; Joseph Williamson RRT; Greg Allen, MD; Bryan Wales, MD; Cari Pearson, MN,RN, BC; Edna Zeller, MSN, RN-BC, CDE; Shanna Myers, MSN, RN; Linda Foist, MSN, RN, CNRN, CRRN; Diane Damitio, BSN, RN, MBA; Michelle James, MM, BSN, RN, MBA, CCRN; Respiratory Therapy and Nursing Team Members

Capnographic monitoring of patients at high risk for respiratory compromise substantially reduced "CODE BLUE" events on three post-operative surgical care floors of Providence St. Peter Hospital in Olympia, Washington. These outcomes actually save lives — should capnography become a best practice in this setting?

Health care providers (HCPs), including respiratory therapists and nurses, typically rely on a combination of oxygen saturation, intermittent vital signs, and subjective clinical assessments to evaluate respiratory status on the general care floor[1] and the post-anesthesia care unit.[2] However, these are indirect indicators of ventilatory competence with important limitations.[3] Without a direct, continuous and objective measurement of the adequacy of ventilation, clinical personnel cannot quantify accurately the effects of disordered breathing or drug administration on

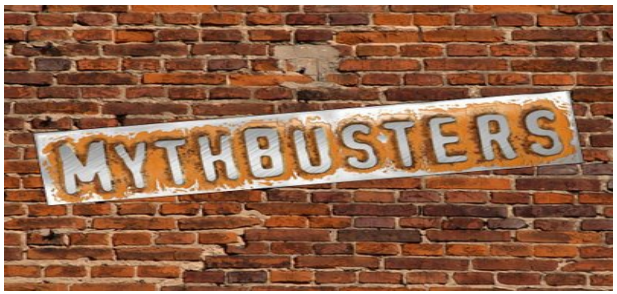
Such patients include but are not limited to those receiving procedural sedation or opioid analgesia.

In 2011, the Anesthesia Patient Safety Foundation (APSF) concluded that intermittent "spot checks" of oxygenation by pulse oximetry and ventilation by nursing assessment are not adequate for reliably recognizing clinically significant evolving drug-induced respiratory depression in the postoperative period.[5] APSF also concluded that capnography or other monitoring modalities that measure the adequacy of ventilation are indicated when supplemental oxygen is needed to maintain acceptable oxygen saturations. Accordingly, Providence St. Peter Hospital in Olympia, Washington, decided to assess surgical patients preoperatively for risk factors of respiratory compromise, and then selectively utilize capnography ($EtCO_2$ monitoring) to try and reduce the risk of adverse outcomes.

Myth Busting #1

My patients complain about wearing $EtCO_2$ cannulas!

TRUE



What hospital patients complain about:

- The NG Tube
- The Foley Catheter
- The drains
- Vital Signs being taken
- The food
- The bed lines
- The cable channels
- Noise
- Roommates
- Nurses, doctors

WHEN WE DISCONTINUE $ETCO_2$, WE ARE NOT DISCONTINUING AN ANNOYANCE, WE ARE DISCONTINUING SAFETY!

Myth Busting

Myth #2

We can reliably predict who will have respiratory depression.

FALSE

Myth Busting

Myth #3

Floor nurses should be able to spot patients at risk.

FALSE

Myth Busting

Myth #4

The Pulse Oximeter should be enough.

FALSE

Myth Buster

Myth #5

I have been doing this for _____years and I have never had a problem with this. There is no need to change my practice.

FALSE

Relying on past history of non-events is a CRITICAL MISTAKE in attempting to prevent harm

"Resting on a safety record measured by the low rate of bad outcomes is akin to regarding a bald tire as safe until it blows out"

James Reason, 1997

Someone involved in a fatal car crash today has never been involved in a fatal car crash before!

How do you collaborate with nurses and physicians?

- “Every great change is preceded with chaos” chopra
- There are similar failures
  - Lack of communication, poor alarm management, lack of education (patient/family, clinician)
  - Change management or lack there of
- Do you have the buy-in…Why before What or How
- Start to plant the seeds for success now!

QUESTIONS AND COMMENTS

http://aemprod.covidien.com/covidien/support/capnography-policy-and-procedure

http://www.covidien.com/pace/clinical-education

http://aemprod.covidien.com/covidien/support/covidien-implementation-connection-uk

http://www.respiratorycompromise.org/

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