Traditional and Novel Ways to Monitor Patients in the Post-Operative Period

Dean Hess

Disclosures

- Philips Respironics
- Ventec Life Systems
- McGraw-Hill
- Jones and Bartlett
- UpToDate
- Daedalus Enterprises
- Pulmonary Disease Board, ABIM

An evaluation of the Nellcor N-10 portable pulse oximeter.

Authors: Hess D; Kochansky M; Hassett L; Frick R; Rexrode WO

Source: Respiratory Care (RESPIR CARE), 1986 Sep; 31(9): 796-802 (41 ref)

Publication Type: journal article - research

The relationship between conjunctival PO2 and arterial PO2 in 16 normal persons.

Authors: Hess D; Evans C; Thomas K; Eitel D; Kochansky M

Source: Respiratory Care (RESPIR CARE), 1986 Mar; 31(3): 191-8 (19 ref)

Publication Type: journal article - research

Crit Care Med. 1988 Jun;16(6):612-4.

Correlation of transconjunctival PO2 with cerebral oxygen delivery during cardiopulmonary resuscitation in dogs.

Guerci AD, Thomas K, Hess D, Halperin HR, Tsitlik JE, Wurmb E, Eitel D.

Peter Belfer Laboratory for Myocardial Research, Johns Hopkins Medical Institution, Baltimore, MD.

Monitoring

- Monitoring is the continuous, or nearly continuous, evaluation of the physiologic function of a patient in real time to guide diagnosis and management decisions - including when to make therapeutic interventions and assessment of those interventions.

Hess, Respir Care 1990;35:482

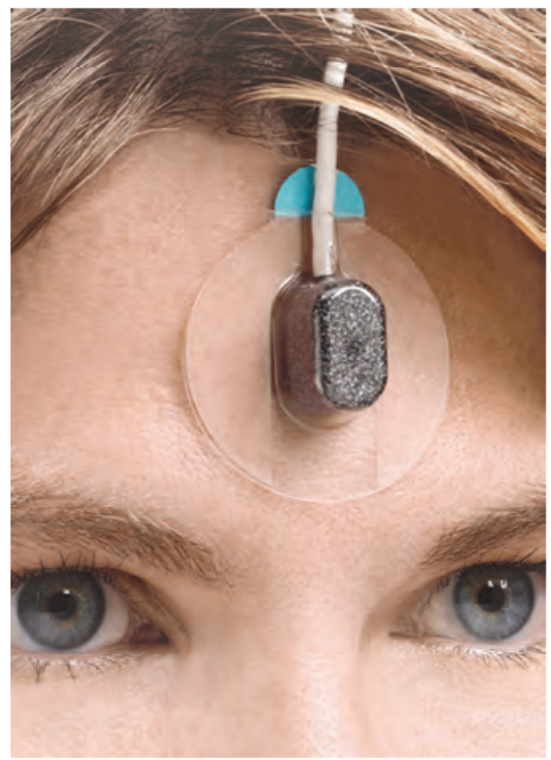
Respiratory Monitoring

- Gas exchange
  - Pulse oximetry
  - Capnography
- Respiratory rate
- Tidal volume
- When and who to monitor?

(A)

(B)

(C)



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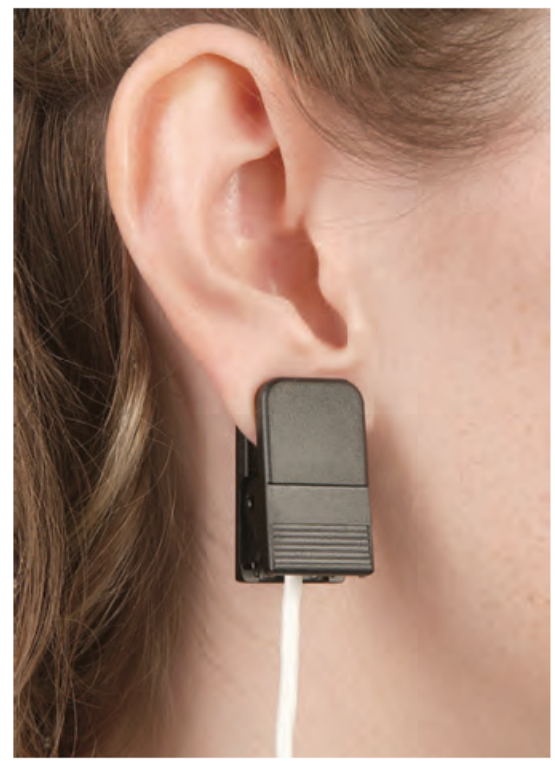


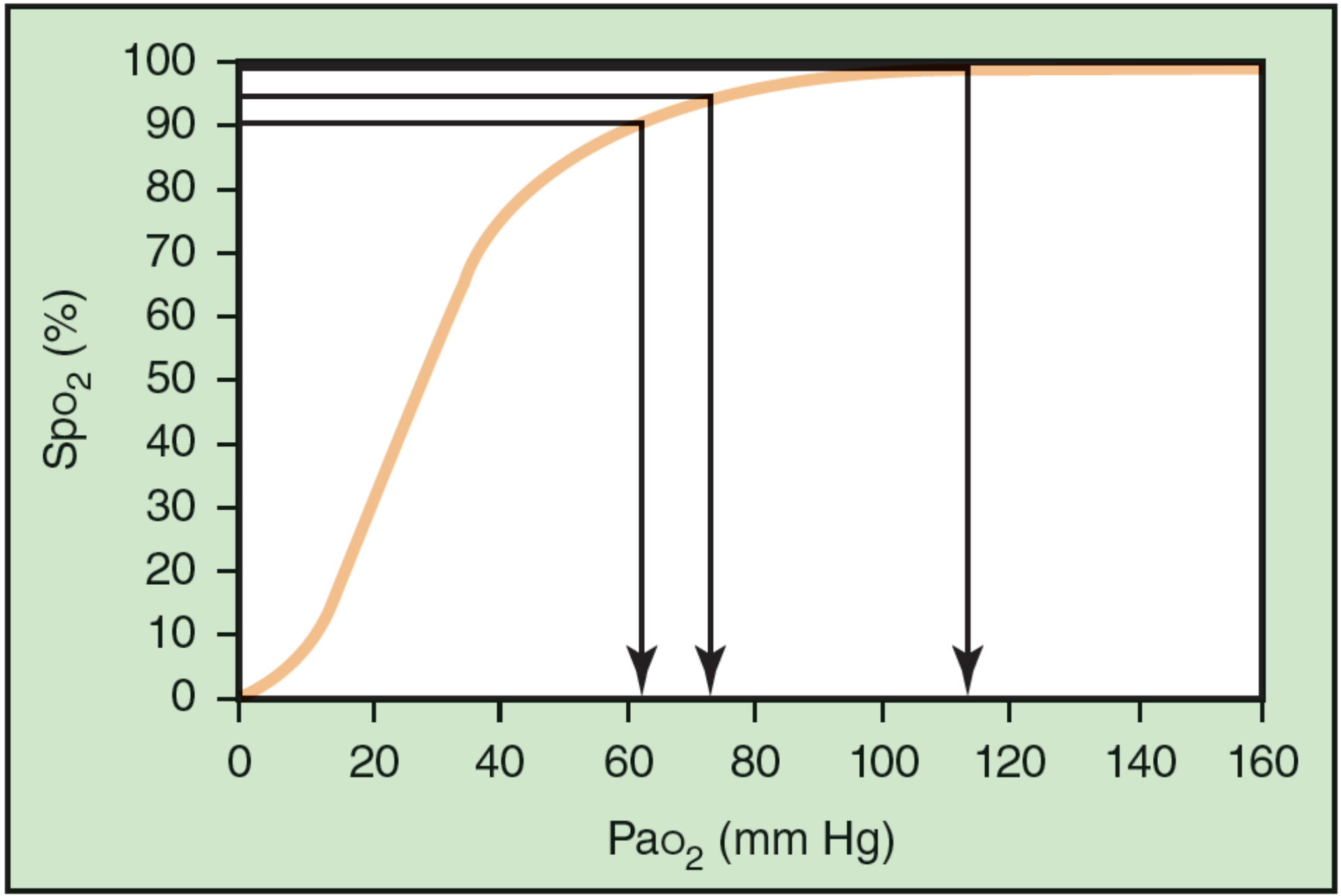
(E)

Hess, Respiratory Care: Principles and Practice

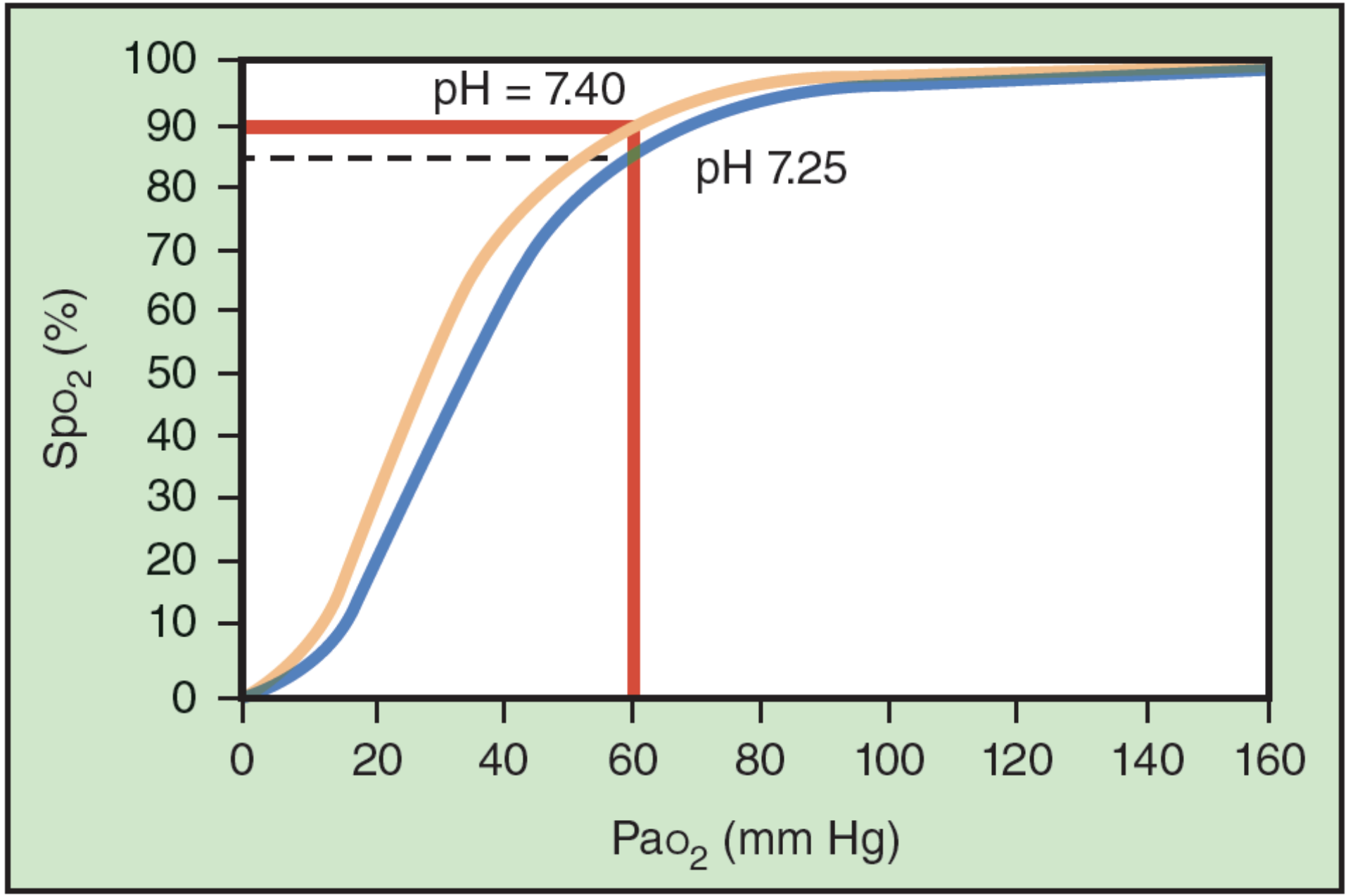
Pulse Oximetry

- **accuracy (± 4%)**
- differences between probes and devices
- penumbra effect
- dyshemoglobinemias
- endogenous and exogenous dyes and pigments
- skin pigmentation
- perfusion
- anemia
- motion
- high intensity ambient light
- abnormal pulses

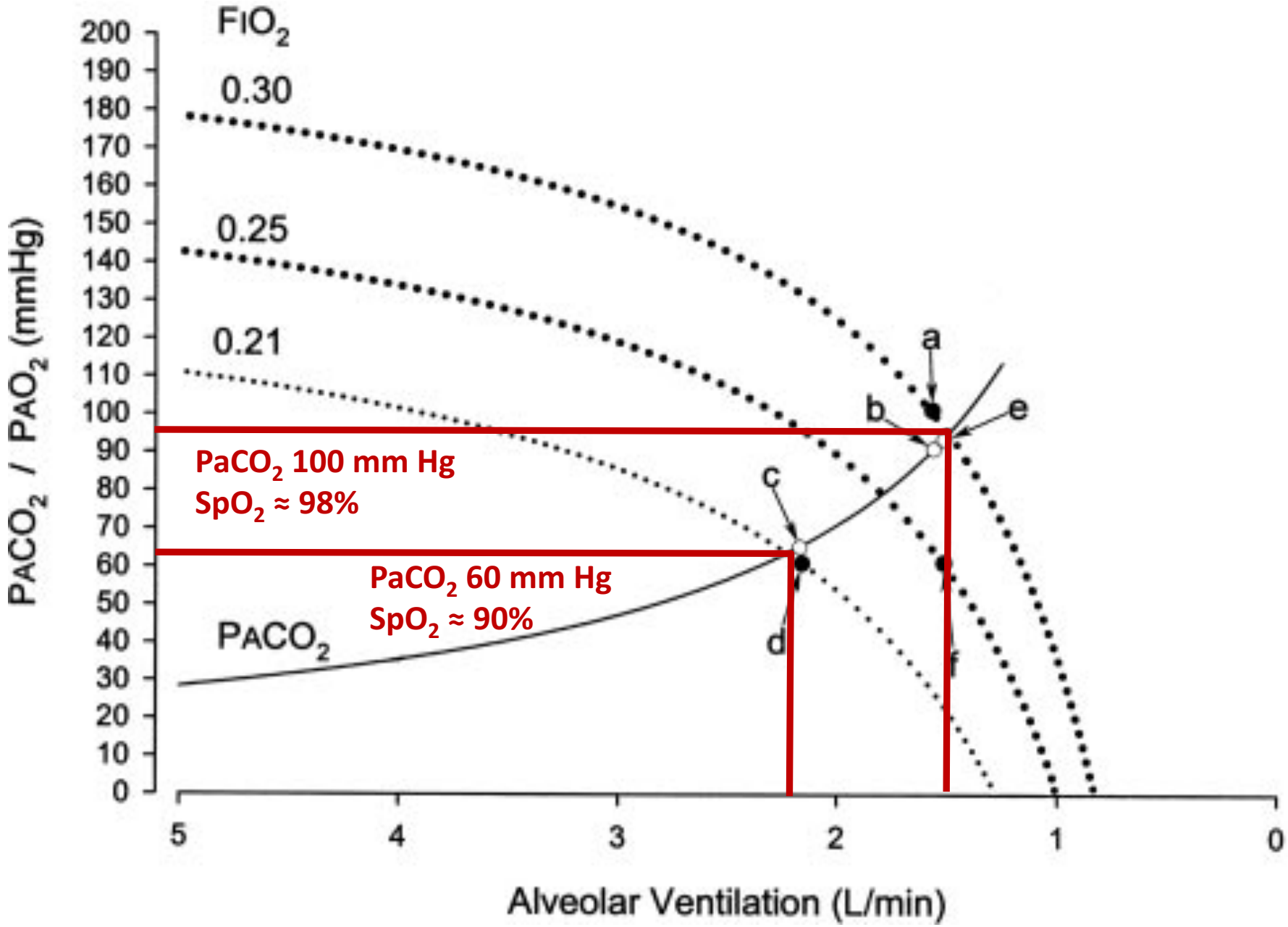
Importance of staff education: Respond to the patient rather than the number.



Hess, Respiratory Care: Principles and Practice



Hess, Respiratory Care: Principles and Practice



Fu, Chest 2004;126:1552

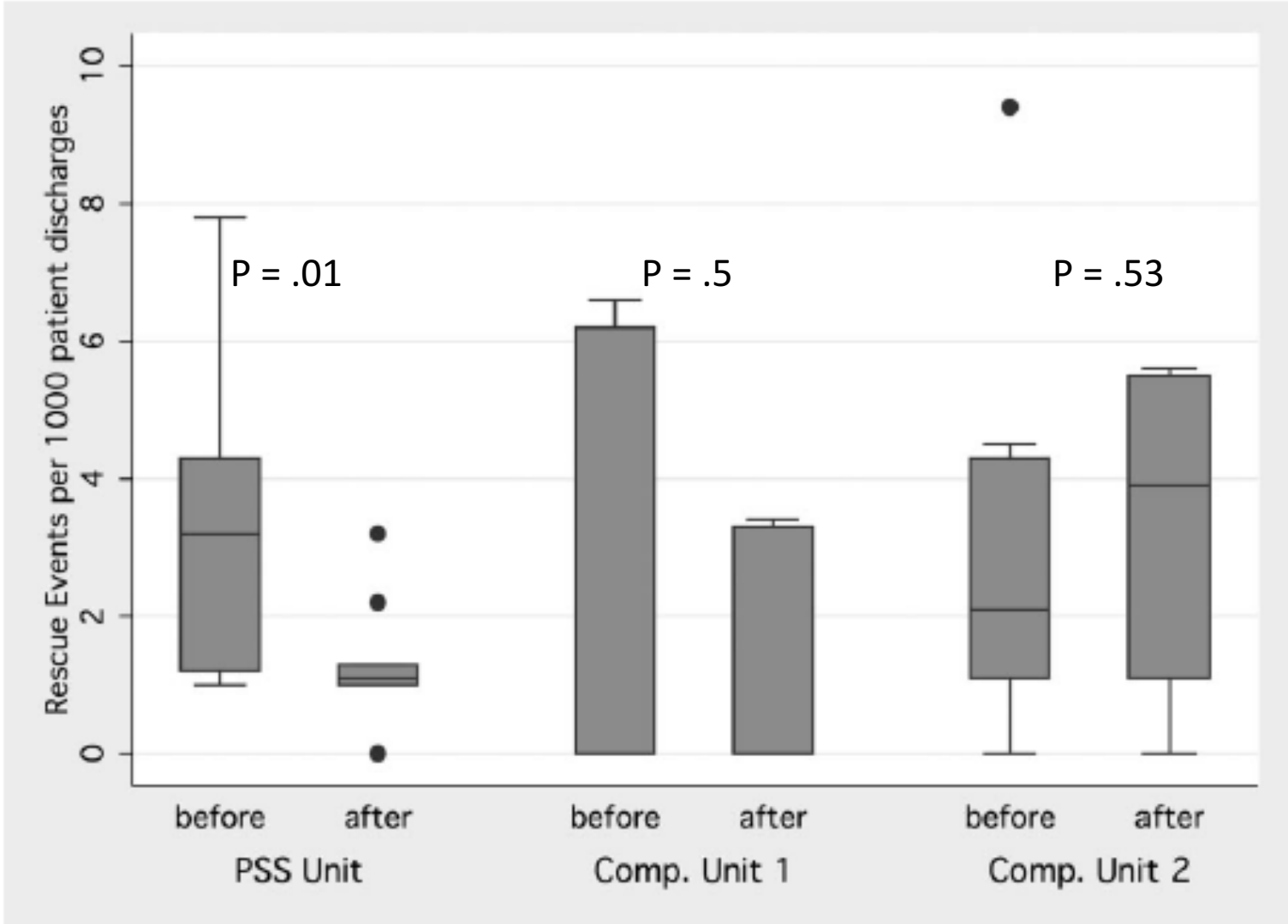
A Comparison of Oxygen Saturation Data in Inpatients with Low Oxygen Saturation Using Automated Continuous Monitoring and Intermittent Manual Data Charting

Andreas H. Taenzer, MS, MD,* Joshua Pyke, BE, PhD,† Michael D. Herrick, MD,‡
Thomas M. Dodds, MD,‡ and Susan P. McGrath, PhD‡

CONCLUSIONS: In a cohort of patients with prolonged desaturations, manual recordings of Spo_2 did not reflect physiologic patient state when compared with continuous automated sampling.

Anesth Analg 2014;118:326

Impact of Pulse Oximetry Surveillance on Rescue Events and Intensive Care Unit Transfers

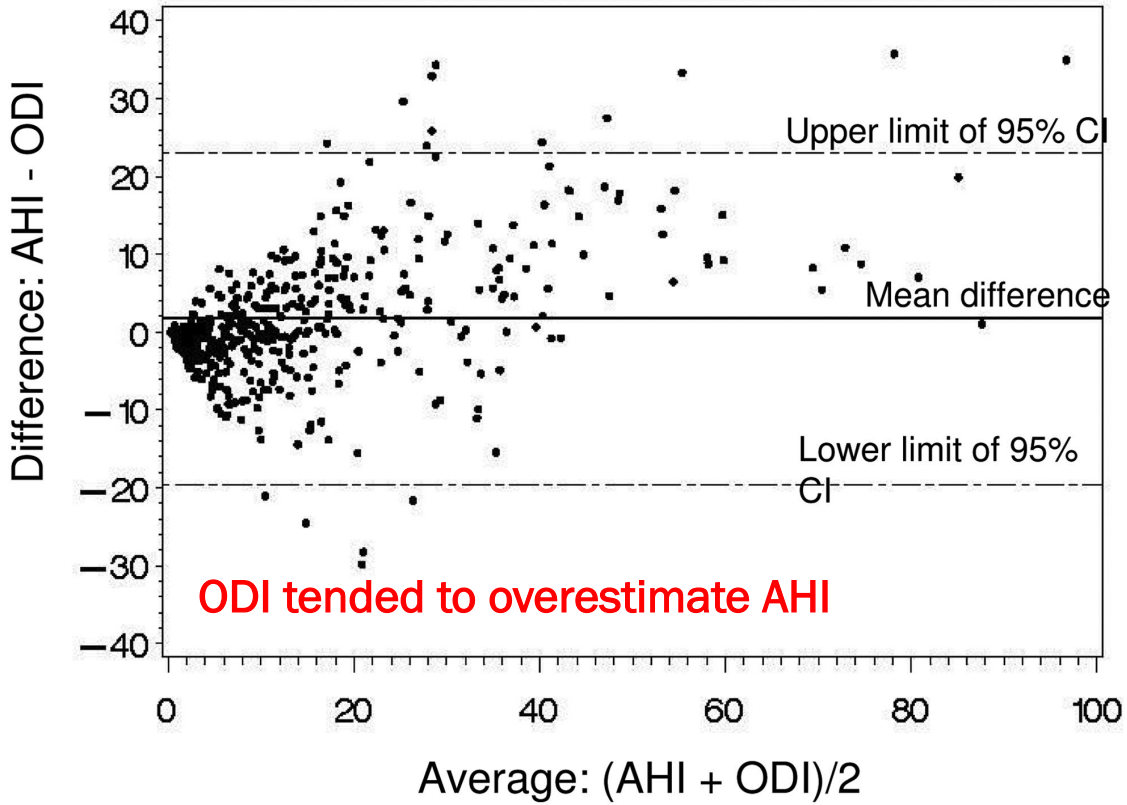


PSS: patient surveillance system based on pulse oximetry with nursing notification of violation of alarm limits *via* wireless pager.

Taenzer, Anesthesiology 2010;112:282

Oxygen Desaturation Index

- ODI = hourly average number of desaturation episodes, defined as at least 4% decrease in saturation from the average saturation in the preceding 120 s, and lasting 10 s.



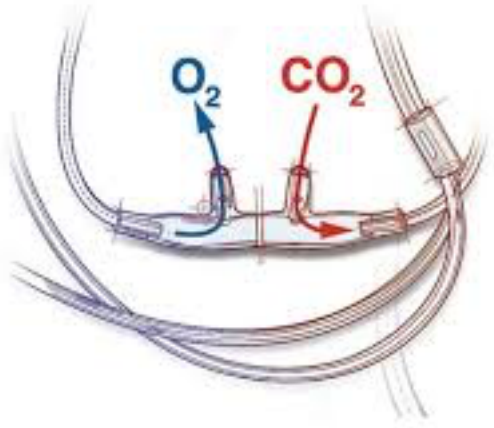
"ODI >10 demonstrated a high sensitivity (93%) and reasonable specificity (75%) to detect moderate and severe SDB." *Chung, Anesth Analg 2012;114:993*

False Alarms

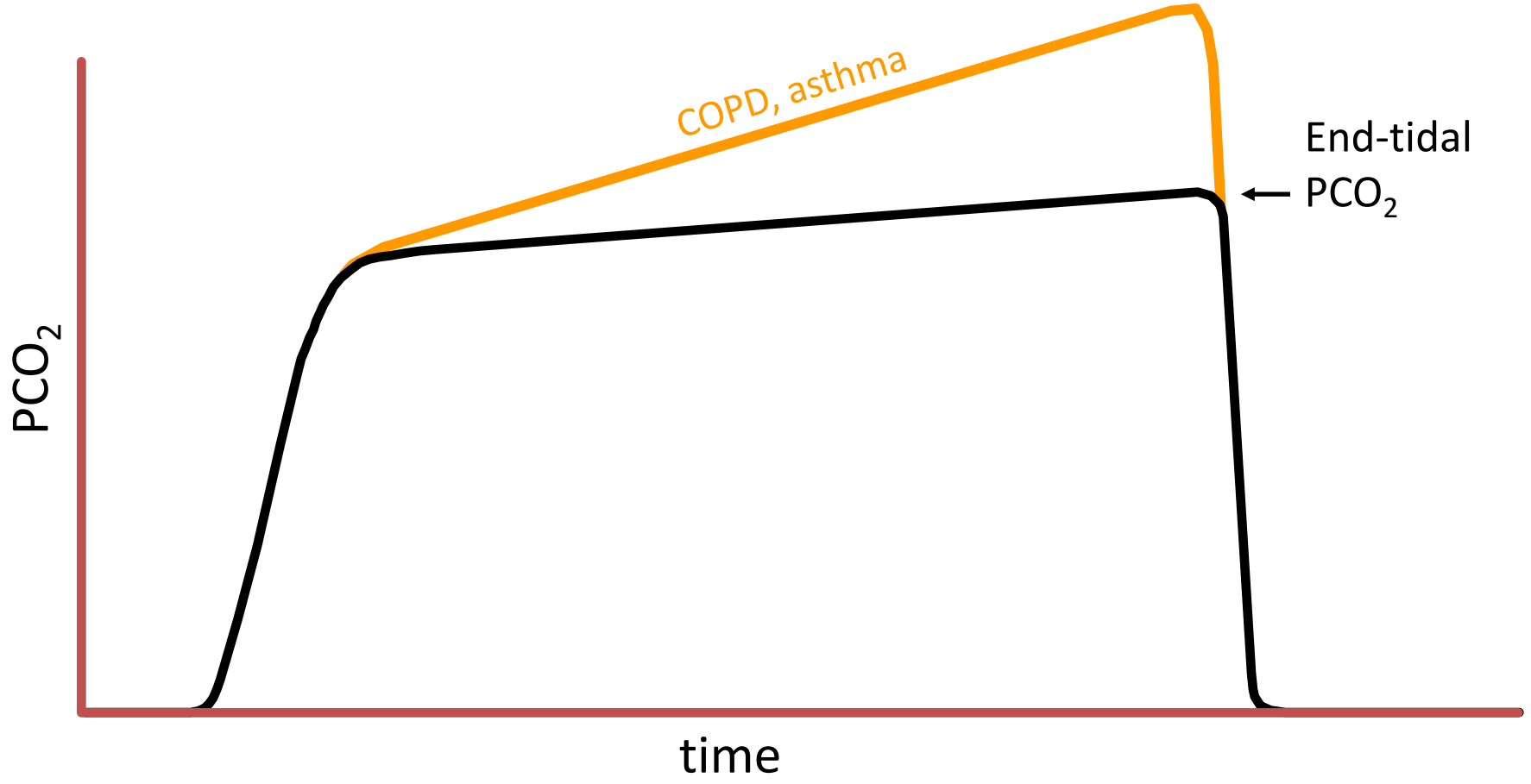
- Prospective, observational study of the alarm and paging data from a convenience sample of adults who were consecutively admitted to a 32 bed general care unit following orthopedic surgery over a 3 month period.
- Only a third of pulse oximetry alarm notifications were for clinically relevant oxygen desaturation, but did facilitate timely nursing response and intervention for most patients.

Voepel-Lewis, International J of Nursing Studies 2013;50:1351

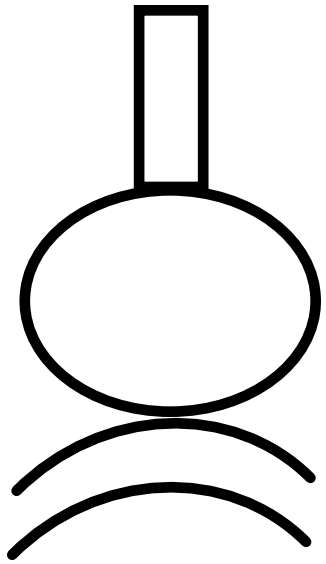
Capnography



Normal Capnogram

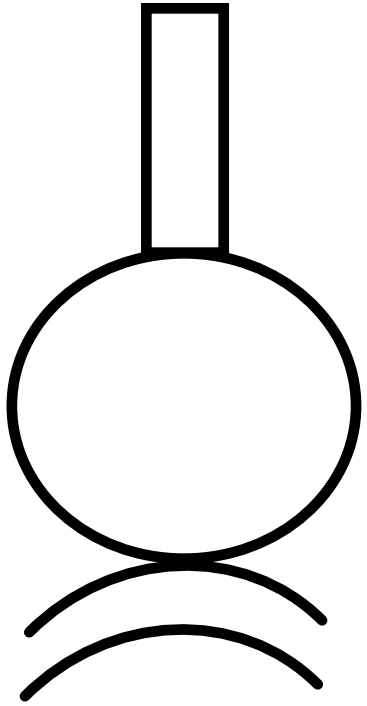


decreased $\dot{V}/\dot{Q}$



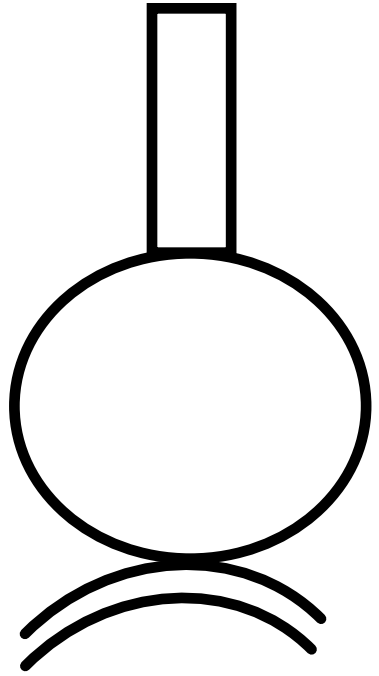
$P_{ET}CO_2 \approx P\bar{v}CO_2$

normal $\dot{V}/\dot{Q}$



$P_{ET}CO_2 \approx PaCO_2$

increased $\dot{V}/\dot{Q}$



$P_{ET}CO_2 \approx PICO_2$

End-tidal PCO_2 may be different from $PaCO_2$

Does End Tidal CO_2 Monitoring During Emergency Department Procedural Sedation and Analgesia With Propofol Decrease the Incidence of Hypoxic Events? A Randomized, Controlled Trial

- Adults who underwent ED propofol sedation randomized to capnography or not.
- Every patient with hypoxia first exhibited capnographic evidence of respiratory depression.
- 63% of patients with capnography-documented respiratory depression had a decrease in end-tidal PCO_2 greater than 10%.

Deitch, Ann Emerg Med 2009;55:258

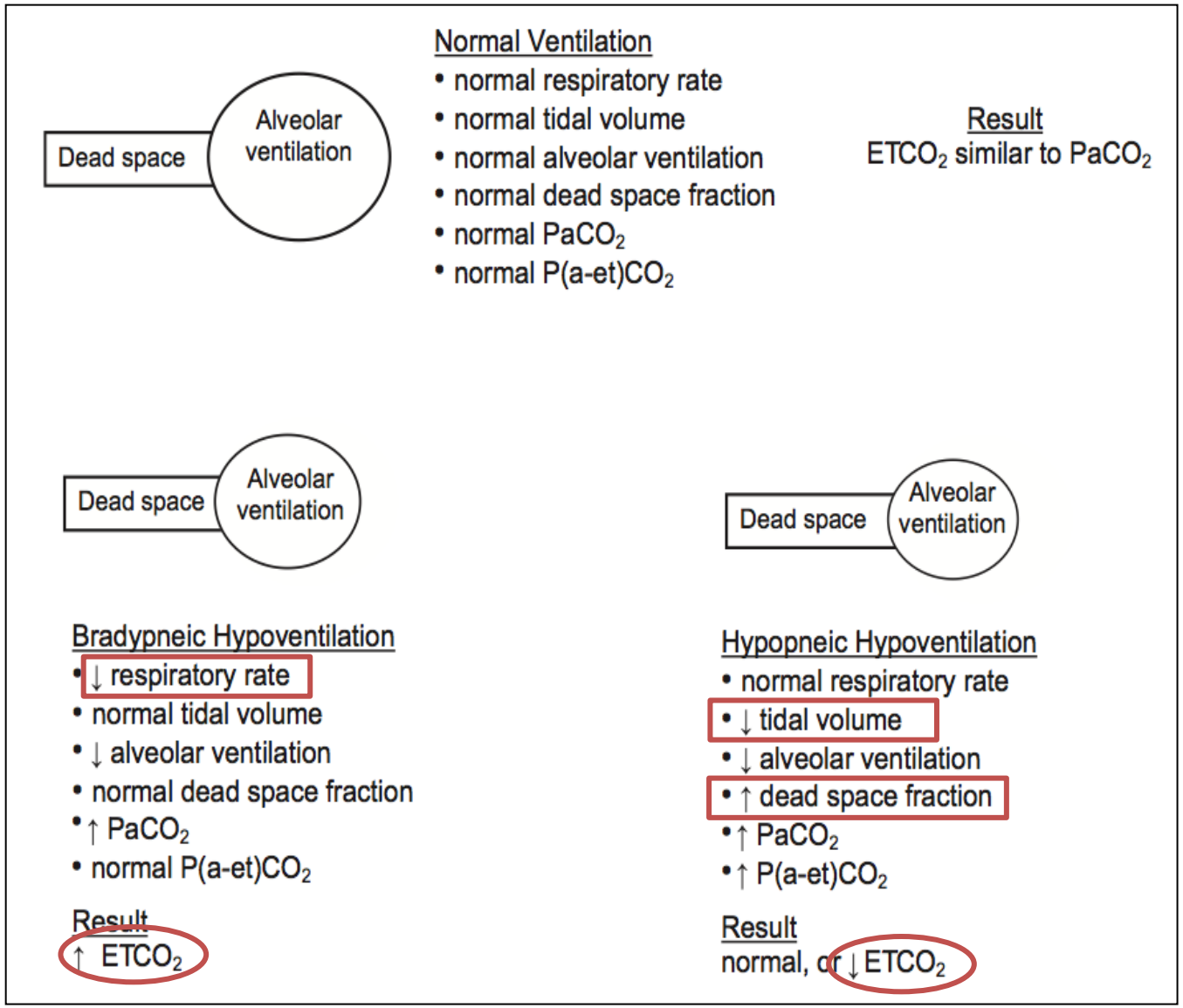
A randomized controlled trial of capnography during sedation in a pediatric emergency setting☆,☆☆,★

Am J Emerg Med 2015;33:25

Melissa L. Langhan, MD, MHS [a,*], Veronika Shabanova, MPH [b], Fang-Yong Li, MPH, MS [b],

- 154 children receiving procedural sedation randomized to whether staff could view the capnograph or were blinded.
- 45% had at least 1 episode of hypoventilation.
- There were significantly fewer interventions in the study group.
- Interventions were more likely to occur contemporaneously with hypoventilation in the intervention group.
- All episodes of hypoventilation were caused by hypopnea, with end-tidal PCO_2 < 30 mm Hg.

Capnography for Sedation Monitoring



Krauss and Hess, Ann Emerg Med 2007;50:172

PCA With Oximetry and Capnography

Continuous Oximetry/Capnometry Monitoring Reveals Frequent Desaturation and Bradypnea During Patient-Controlled Analgesia

- Observational study of 178 patients.
- SpO_2 for pulse oximeter and respiratory rate from capnograph (did not report $P_{ET}CO_2$)
- 12% had episodes of $SpO_2 < 90\%$, 41% had bradypnea with rate < 10/min for ≥ 3 min, 1 required rescue with PPV.
- No control group.

Overdyk, Anesth Analg 2007;105:412

Respiratory rate: the neglected vital sign

Michelle A Cretikos, Rinaldo Bellomo, Ken Hillman, Jack Chen, Simon Finfer and Arthas Flabouris

- Respiratory rate is often not recorded.
- An abnormal respiratory rate is a predictor of potentially serious clinical events.
- Clinicians need to be more aware of the importance of an abnormal respiratory rate.
- Hospital systems that encourage appropriate responses to elevated respiratory rate can be rapidly implemented.

MJA 2008; 188: 657–659

Respiratory Rate As An Indicator Of Serious Illness

- Respiratory rate >27 was an important predictor of cardiac arrest in hospital wards. J Gen Intern Med 1993;8:354
- Respiratory rate is likely better than HR and SBP to discriminate between stable patients and those at risk. Anaesthesia 2003;58:797-802
- 21% of ward patients with a respiratory rate of 25-29 died in the hospital. Anaesthesia 2005;60:547
- Half of patients with a serious adverse event on the general wards had a respiratory rate >24. Resuscitation 2007;73:62

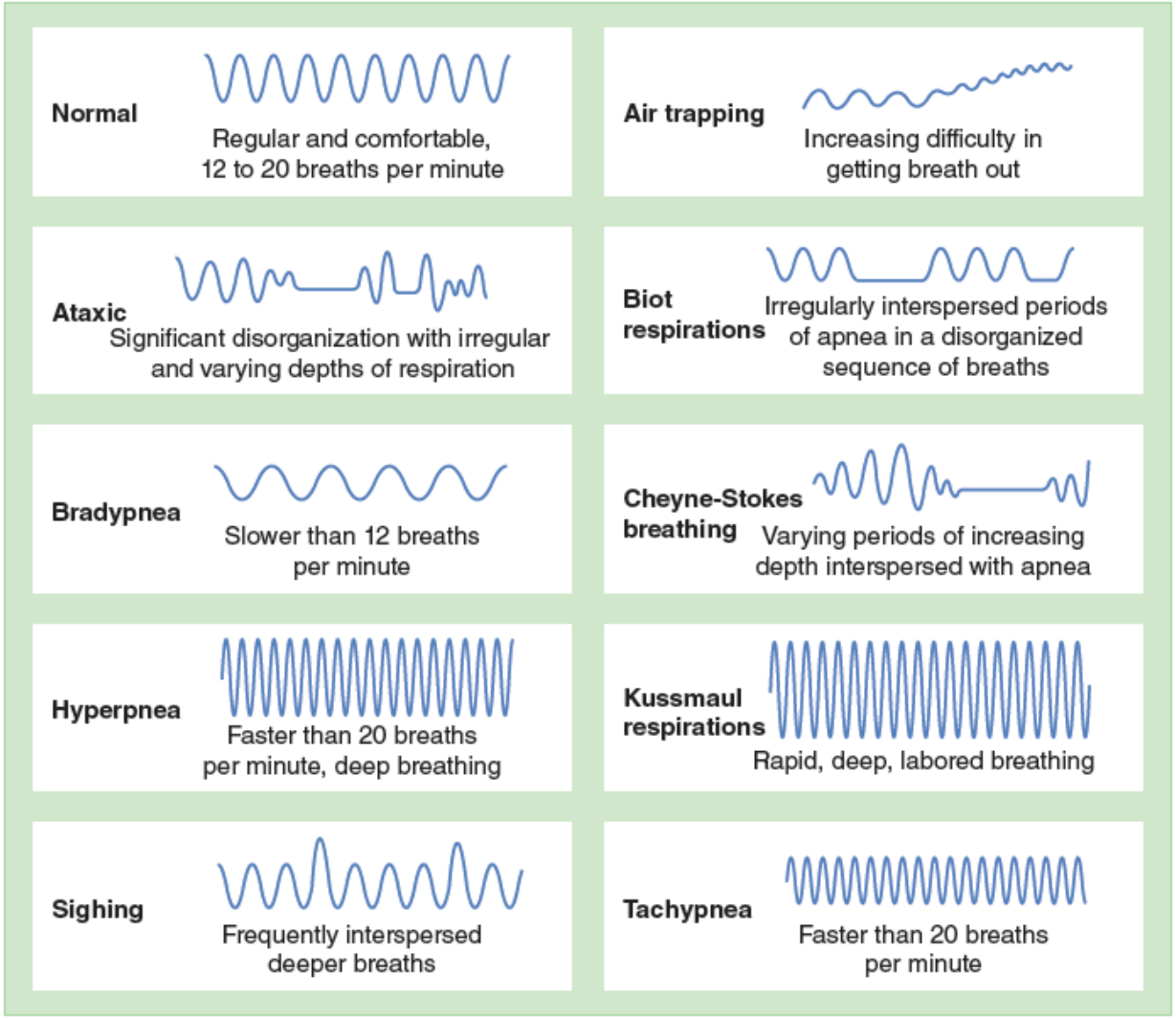
Respiratory Rate

- Tachypnea: respiratory distress, metabolic acidosis, pain, fever
- Bradypnea: respiratory center depression (opioid)

ROUTINE MEASUREMENT OF RESPIRATORY RATE
AN EXPENSIVE TRIBUTE TO TRADITION

Ross C. Kory, M.D.

JAMA. 1957;165(5):448-450. doi:10.1001/jama.1957.02980230018005.

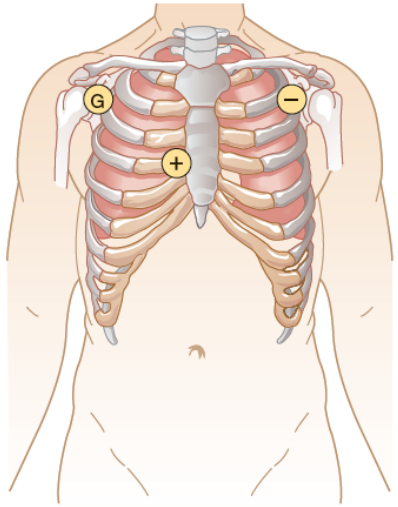


Hess, Respiratory Care: Principles and Practice

Measurement of Respiratory Rate

- Inspection
- Capnography
- Pulse oximetry
- Impedance
- Belts and thermistors
- Optical technology
- Acoustic technology

Respiratory Rare



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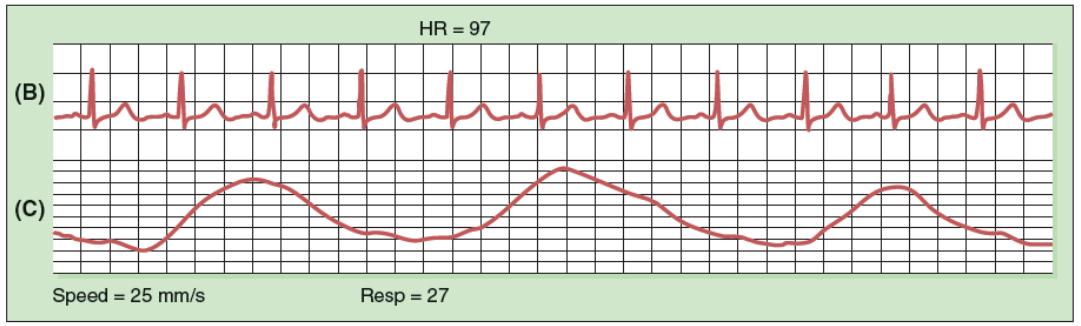
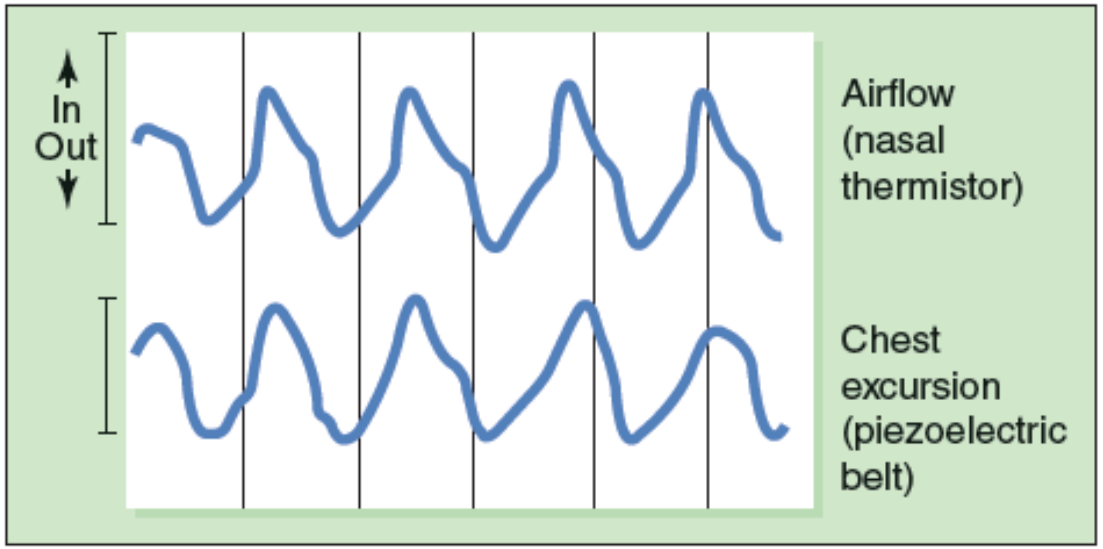


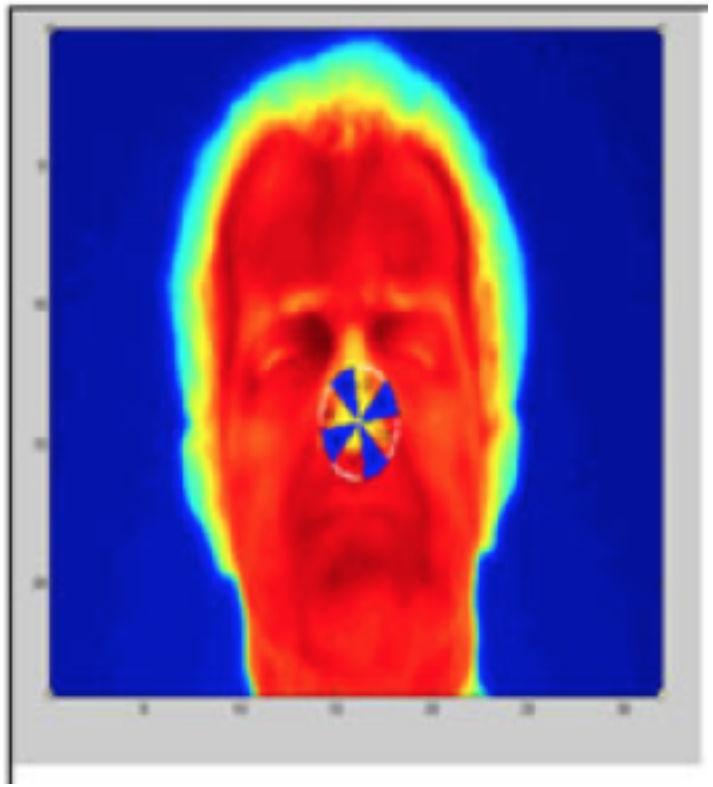


Hess, Respiratory Care: Principles and Practice

Respiratory Rate

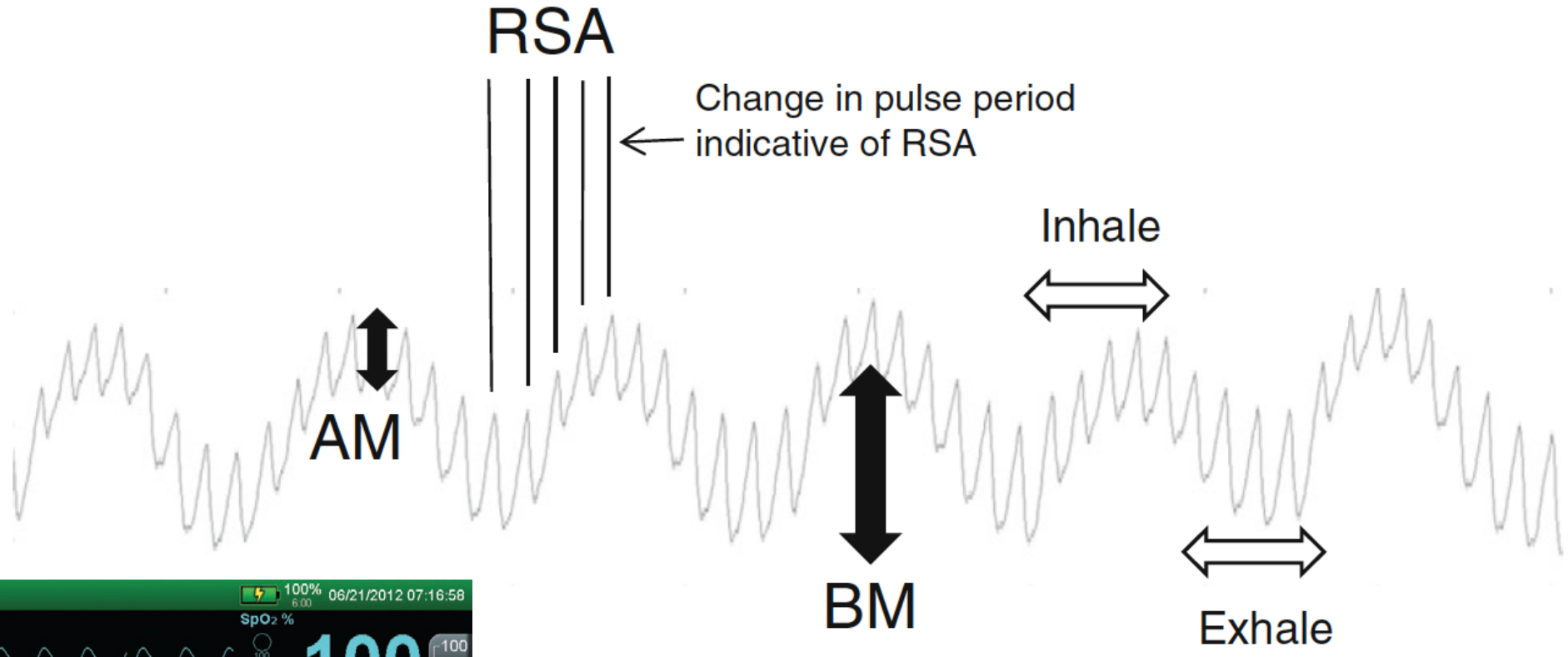
Optical Methods: Camera used to detect thoracic movements to determine respiratory rate. *Nakajima, Physiol Meas 2001;22:21*.

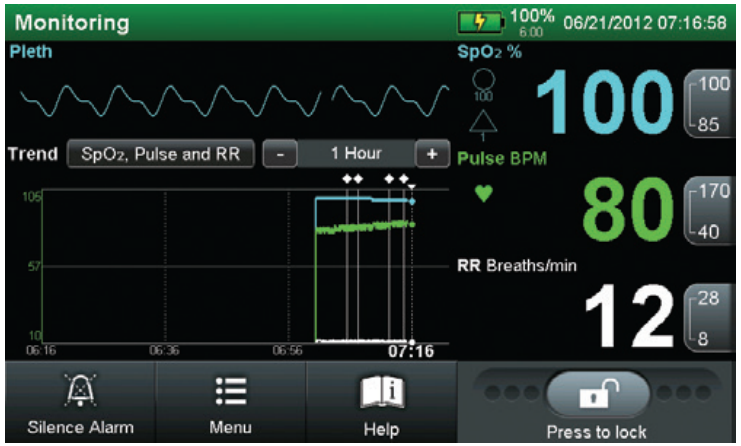
Thermal Imaging



AL-Khalidi, Pediatric Pulmonology 2011;46:523

Pulse Ox Pleth for Respiratory Rate



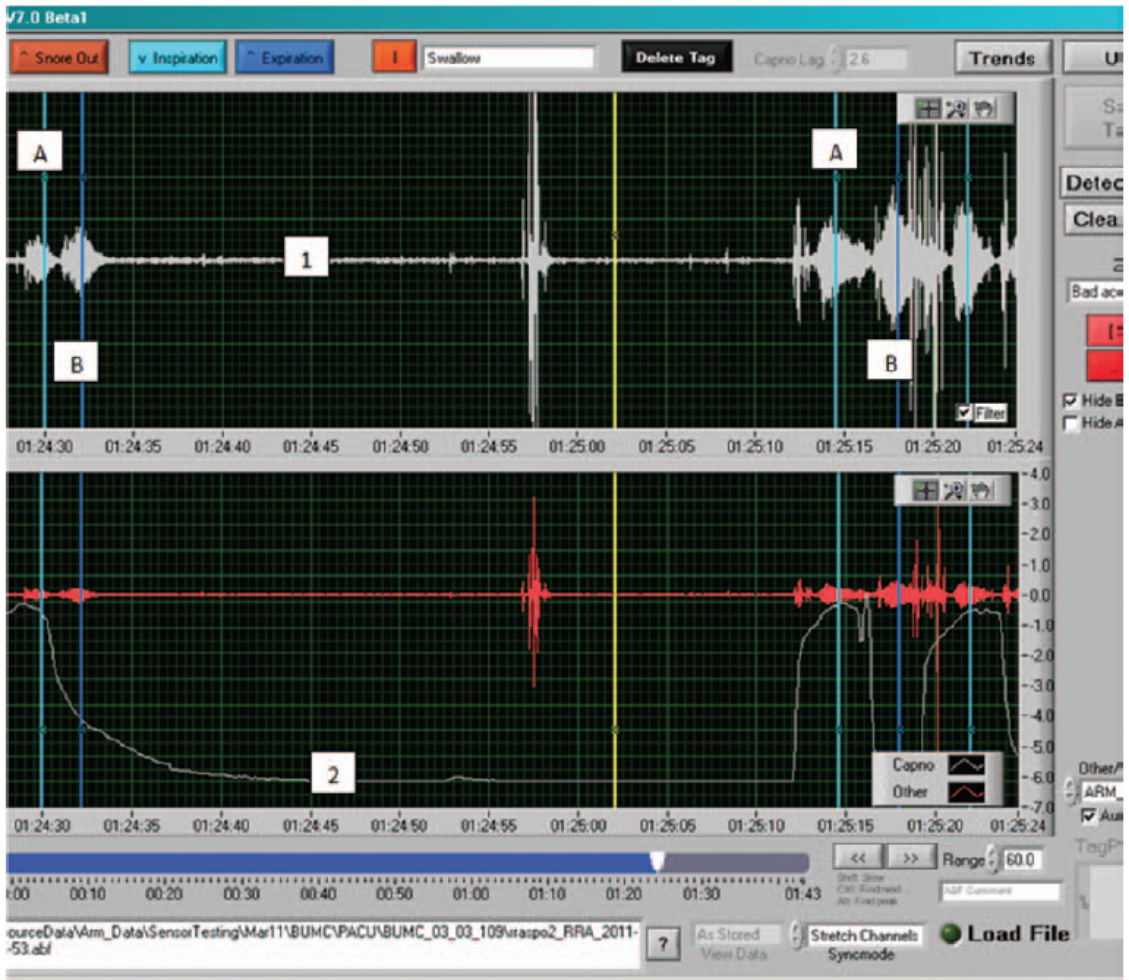


Addison, J Clin Monit Comput 2015;29:113
Nilsson, Anesth Analg 2013;117:859

The Accuracy, Precision and Reliability of Measuring Ventilatory Rate and Detecting Ventilatory Pause by Rainbow Acoustic Monitoring and Capnometry

Michael A. E. Ramsay, MD,* Mohammad Usman, PhD,† Elaine Lagow, RN,‡ Minerva Mendoza, RN,§ Emylene Untalan, RN,§ and Edward De Vol, PhD‖

Anesth Analg 2013;117:69

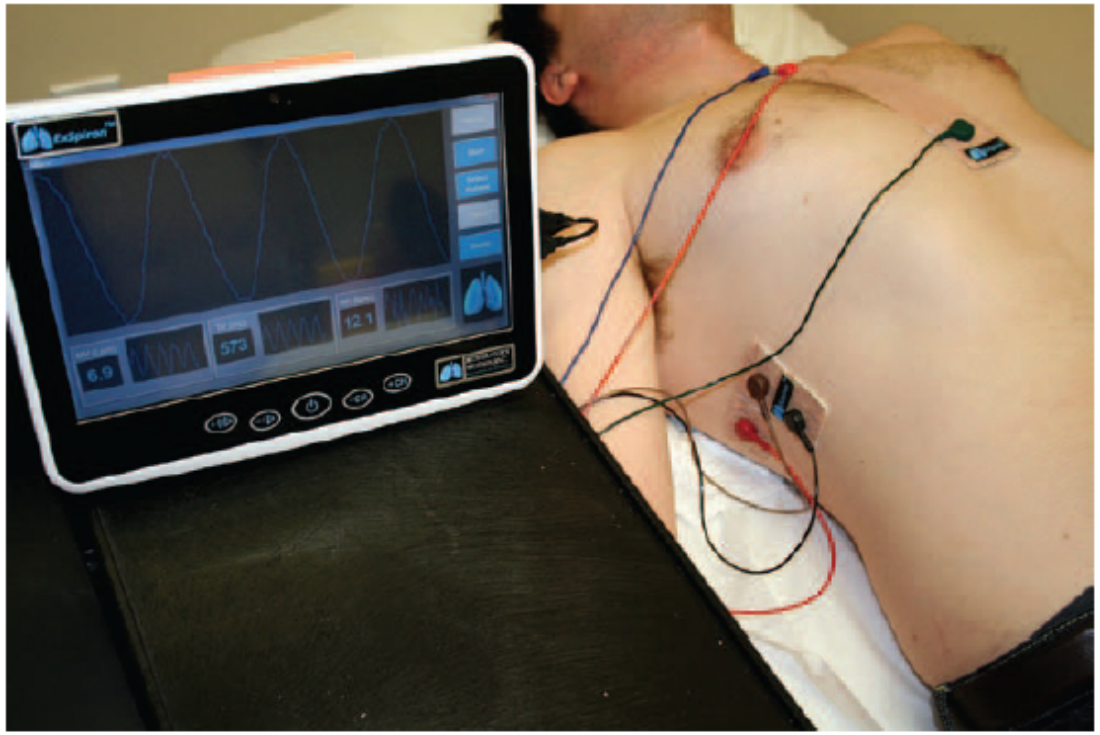


Evaluation of a Novel Noninvasive Respiration Monitor Providing Continuous Measurement of Minute Ventilation in Ambulatory Subjects in a Variety of Clinical Scenarios

Anesth Analg 2013;117:91

Christopher Voscopoulos, MD,* Jordan Brayanov, PhD,† Diane Ladd, DNP,‡ Michael Lalli, BSE,† Alexander Panasyuk, PhD,† and Jenny Freeman, MD†

- RVM (ExSpiron, Respiratory Motion, Waltham, MA).
- 1 electrode pad comprising 3 electrodes is placed along the sternum and the other electrode pad comprising 3 electrodes is placed across the right midaxillary line at the level of the xiphoid.
- Based on impedance measurement.
- RVM displays minute ventilation, tidal volume, respiratory rate, respiratory volume curve, and trends.



Additional Monitoring

- NIV: tidal volume, respiratory rate, ventilating pressures, FIO_2, alarm output to nurse call

- PAP: AHI, hours of use, periodic breathing, pressure

<u>Appropriate monitoring</u>
Identification of clinical deterioration and timely intervention

<u>Too little monitoring</u>
Missed events

<u>Too much monitoring</u>
Cost: equipment and training
Alarm fatigue
Over-diagnosis

False Positive = Alarms

- Assume monitor has a true positive rate of 95% (false positive rate 5%).
- In the presence of 2 monitors, the probability of both monitors giving a true positive is $0.95^2 = 90\%$.
- **In the presence of 20 monitors,** the true positive rate is $0.95^{20} = 0.36 =$ **64% probability of at least one monitor giving a false positive alarm**.

Hess, Respir Care 1990;35:482

Joint Commission Requirement

Official Publication of Joint Commission Requirements

National Patient Safety Goal on Alarm Management

APPLICABLE TO HOSPITALS AND CRITICAL ACCESS HOSPITALS

Effective January 1, 2014

National Patient Safety Goal (NPSG)

If they are not properly managed, alarms can compromise patient safety.

areas have numerous alarm signals and the resulting noise and displayed information tends to desensitize staff and cause them to miss or ignore alarm signals or even disable them. Other issues associated with effective clinical alarm system management include too many devices with alarms, default settings that are not at an actionable level, and alarm limits that are too narrow. These issues vary greatly among hospitals and even within different units in a single hospital.

There is general agreement that this is an important safety issue. Universal solutions have yet to be identified, but it is important for a hospital to understand its own situation and to develop a systematic, coordinated approach to clinical alarm system management. Standardization contributes to safe alarm system management, but it is recognized that solutions may have to be customized for specific clinical units, groups of patients, or individual patients. This NPSG focuses on managing clinical alarm systems that have the most direct relationship to patient safety. As alarm system management solutions are identified, this NPSG will be updated to reflect best practices.*

* Additional information on alarm safety can be found on the AAMI website http://www.aami.org/htsi/alarms/. Also, the ECRI Institute has identified alarm hazards as one of the top technology hazards for 2013; more information on this hazard list can be found at http://www.ecri.org/Forms/Pages/Alarm_Safety_Resource.aspx.

Elements of Performance for NPSG.06.01.01

A 1. As of July 1, 2014, leaders establish alarm system safety as a [critical access] hospital priority. R

A 2. During 2014, identify the most important alarm signals to manage based on the following: R

- Published best practices and guidelines

(For more information on managing medical equipment risks, refer to Standard EC.02.04.01.)

A 3. As of January 1, 2016, establish policies and procedures for managing the alarms identified in EP 2 above that, at a minimum, address the following: R

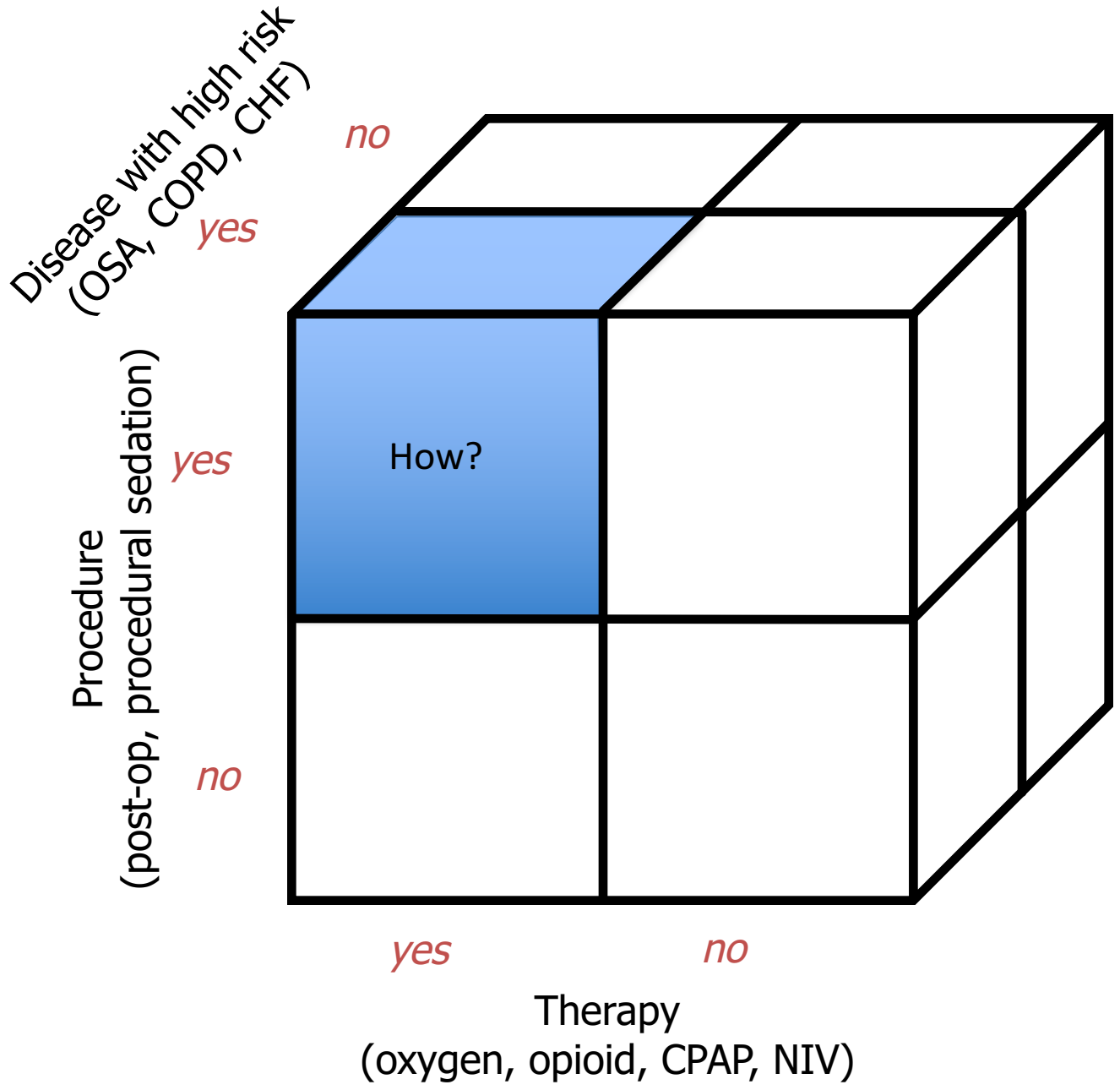
- Clinically appropriate settings for alarm signals
- When alarm signals can be disabled
- When alarm parameters can be changed
- Who in the organization has the authority to set alarm parameters
- Who in the organization has the authority to change alarm parameters
- Who in the organization has the authority to set alarm parameters to "off"
- Monitoring and responding to alarm signals
- Checking individual alarm signals for accurate settings, proper operation, and detectability

(For more information, refer to Standard EC.02.04.03)

C 4. As of January 1, 2016, educate staff and licensed independent practitioners about the purpose and proper operation of alarm systems for which they are responsible. R

When to Monitor: When to Start; When to Stop

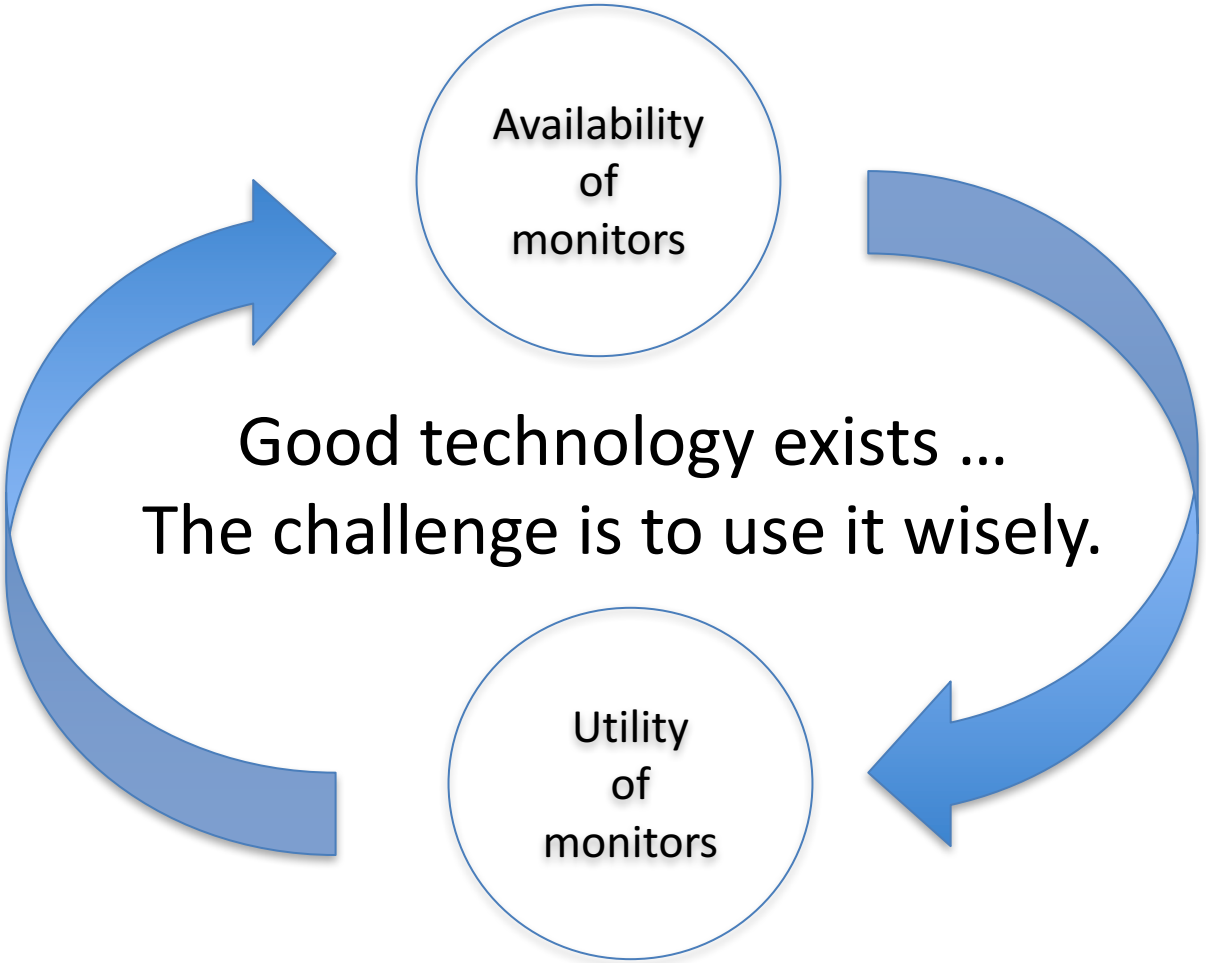
- Disease: COPD, OSA, CHF, etc.
- Procedure: post op, procedural sedation, etc.
- Therapy: O_2, opioid, CPAP, NIV


Disease with high risk
(OSA, COPD, CHF)
no
yes
Procedure
(post-op, procedural sedation)
yes
no
How?
yes
no
Therapy
(oxygen, opioid, CPAP, NIV)

Traditional and Novel Ways to Monitor Patients in the Post-Operative Period

- Monitoring is often implemented based on face validity and what can be monitored.
- Decision to monitor should be based on clinical indications.
- Clinical trials are necessary to determine the appropriate role of monitoring?
- Perhaps we are not using the technology appropriately?
  - Trends versus spot checks.
- What is an appropriate sensitivity/specificity?

Which Comes First?



When technology becomes master, we get to disaster faster.

Piet Hein