Current And Future Objective Monitors Outside The ICU

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RESPIRATORY CARE

Disclosures

- Philips Respironics
- Pari
- Merck
- Bayer
- McGraw-Hill
- Jones and Bartlett
- UpToDate
- Pulmonary Disease Board, ABIM

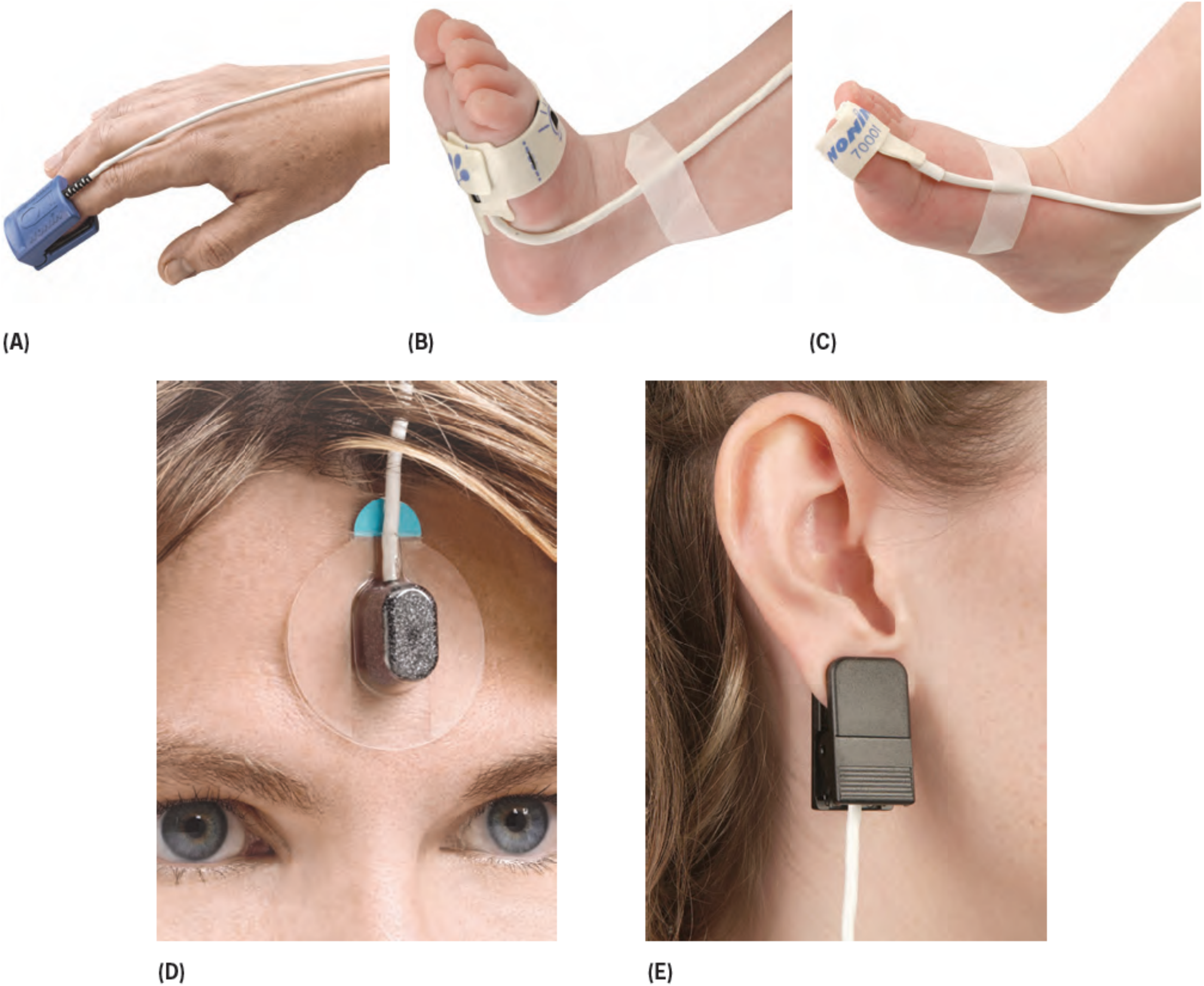
Monitoring

- 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
- When and who to monitor?

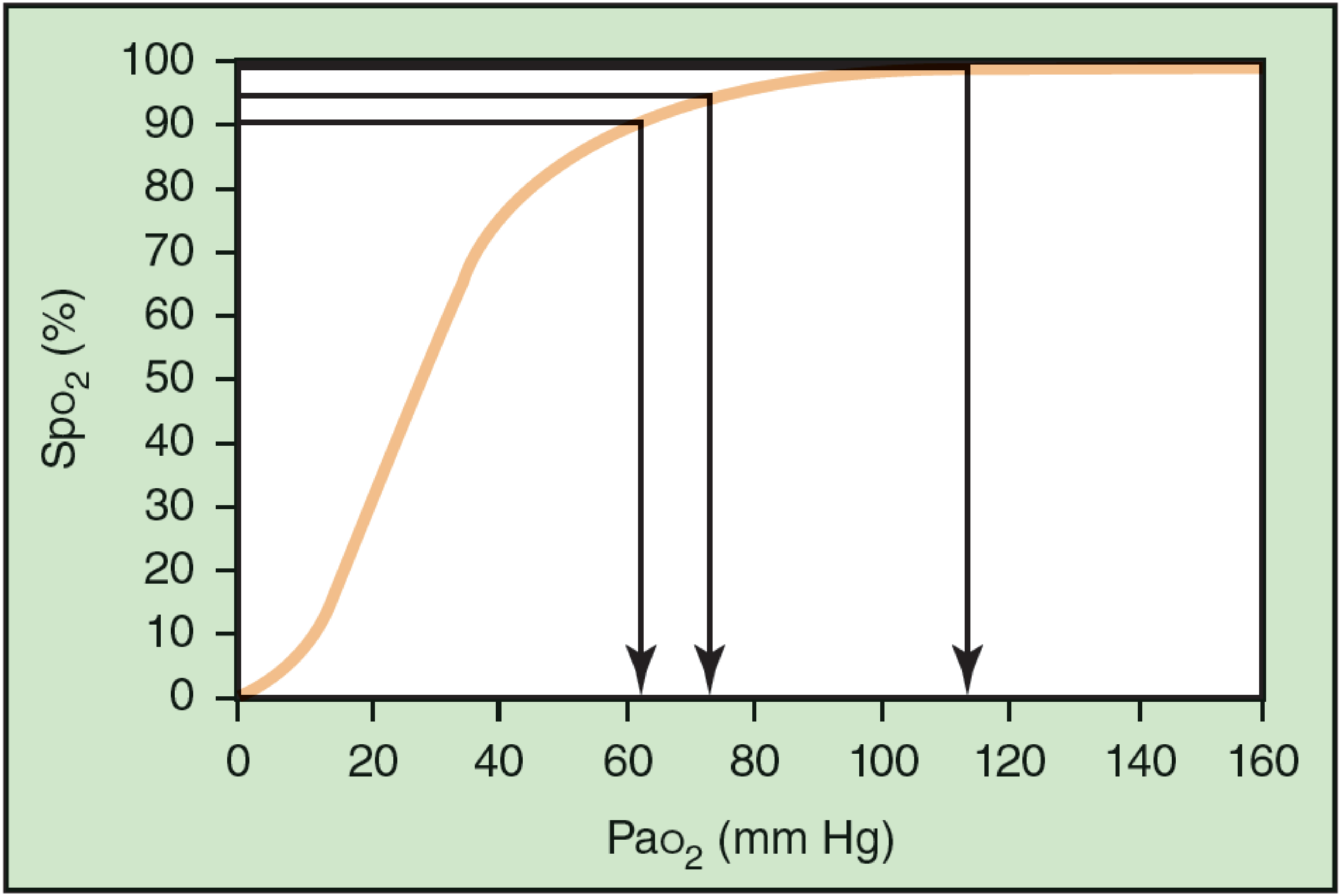


Hess, Respiratory Care: Principles and Practice

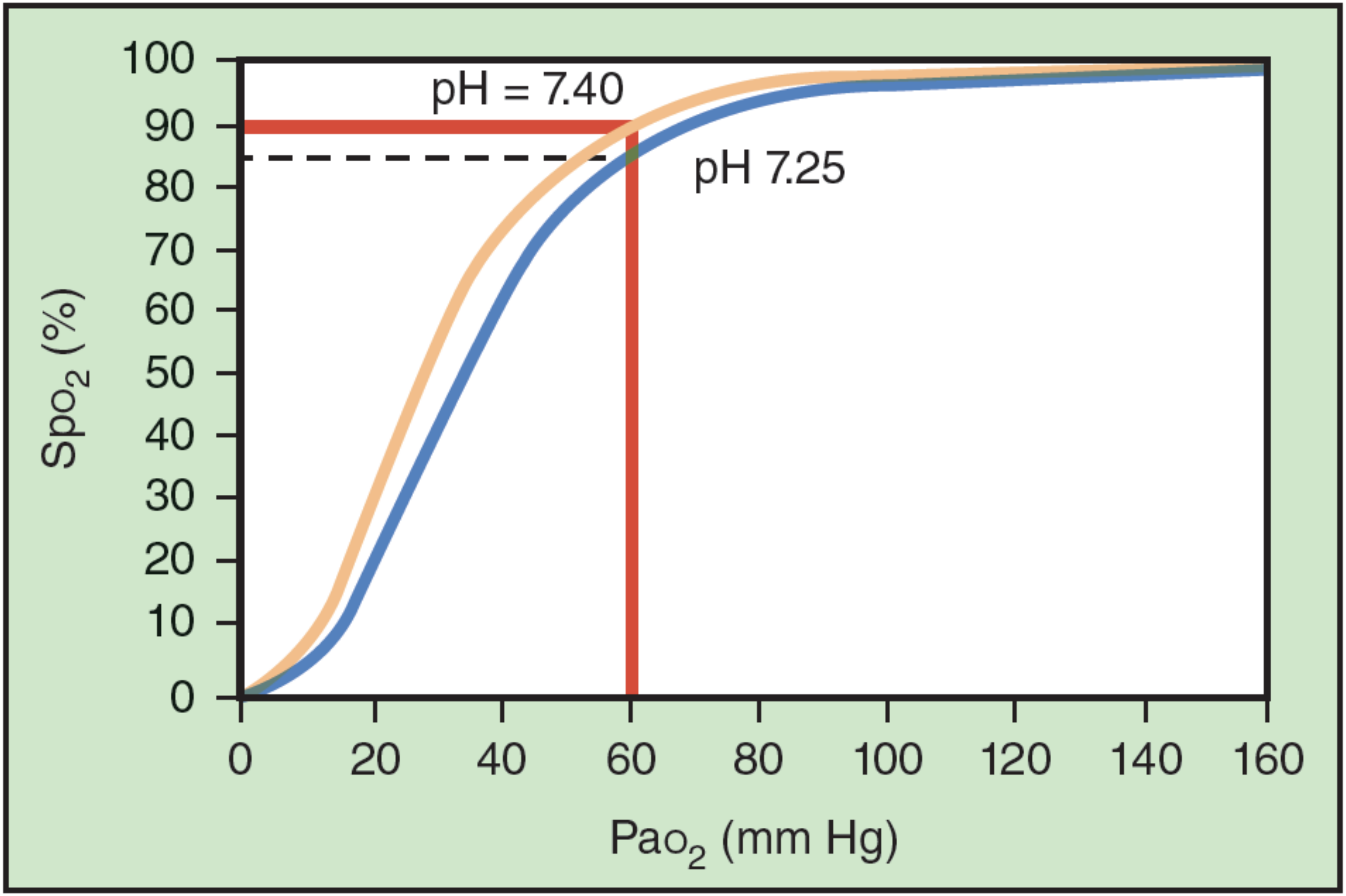
Pulse Oximetry

- **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

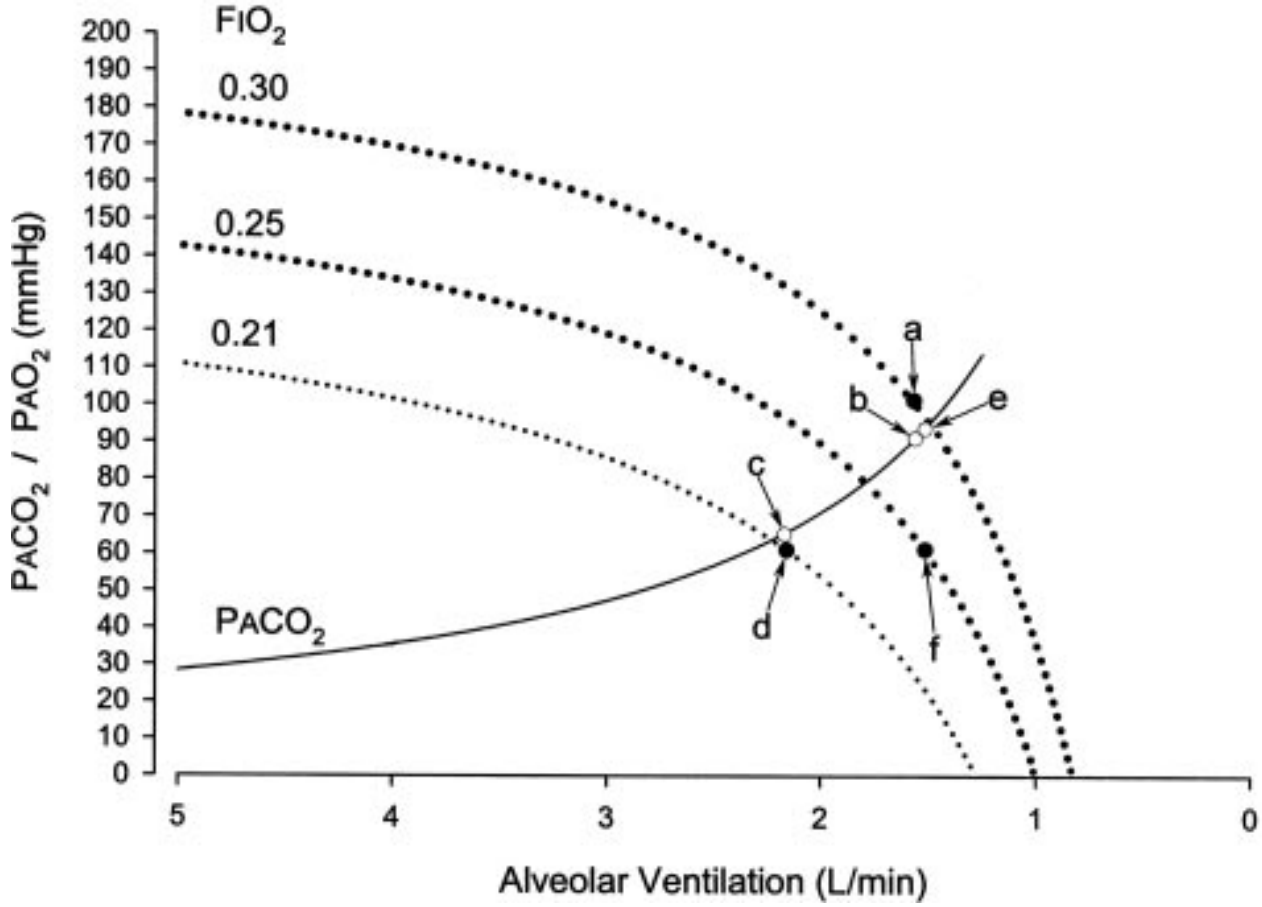
Importance of staff education



Hess, Respiratory Care: Principles and Practice



Hess, Respiratory Care: Principles and Practice



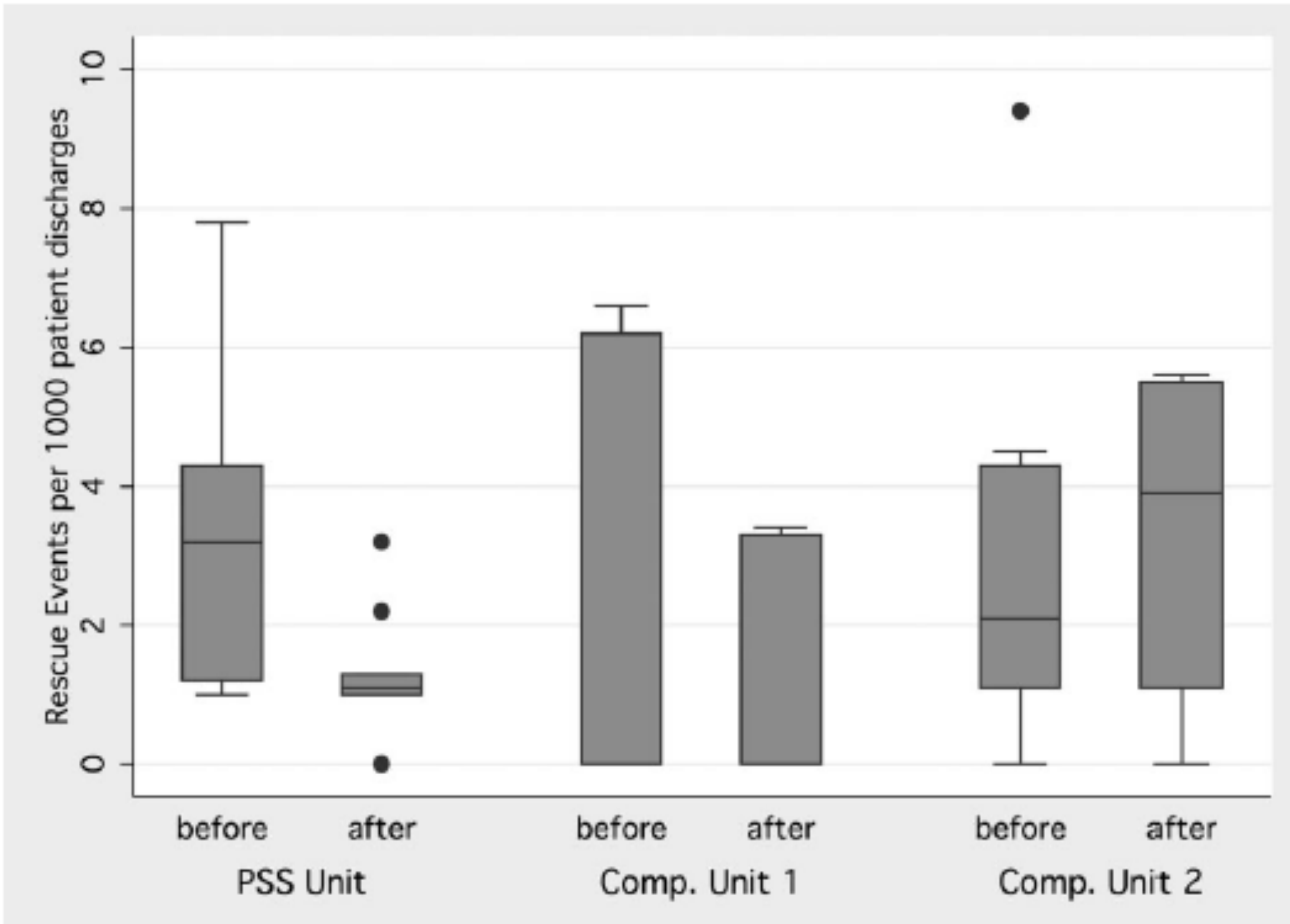
Fu, Chest 2004;126:1552

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

A Before-and-After Concurrence Study

Anesthesiology 2010;112:282

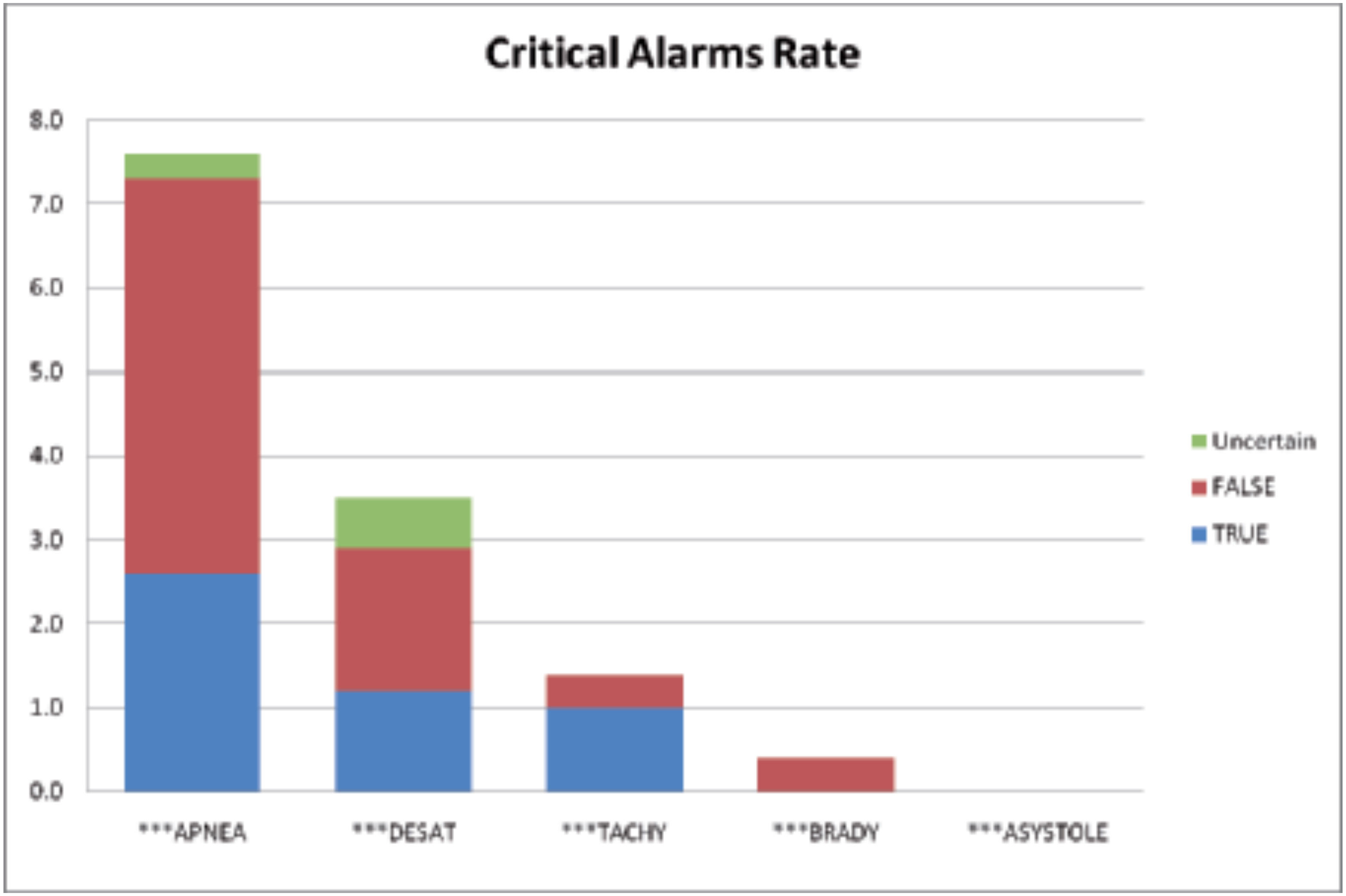
Andreas H. Taenzer, M.D., F.A.A.P.,* Joshua B. Pyke, B.E.,† Susan P. McGrath, Ph.D.,‡
George T. Blike, M.D.§



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

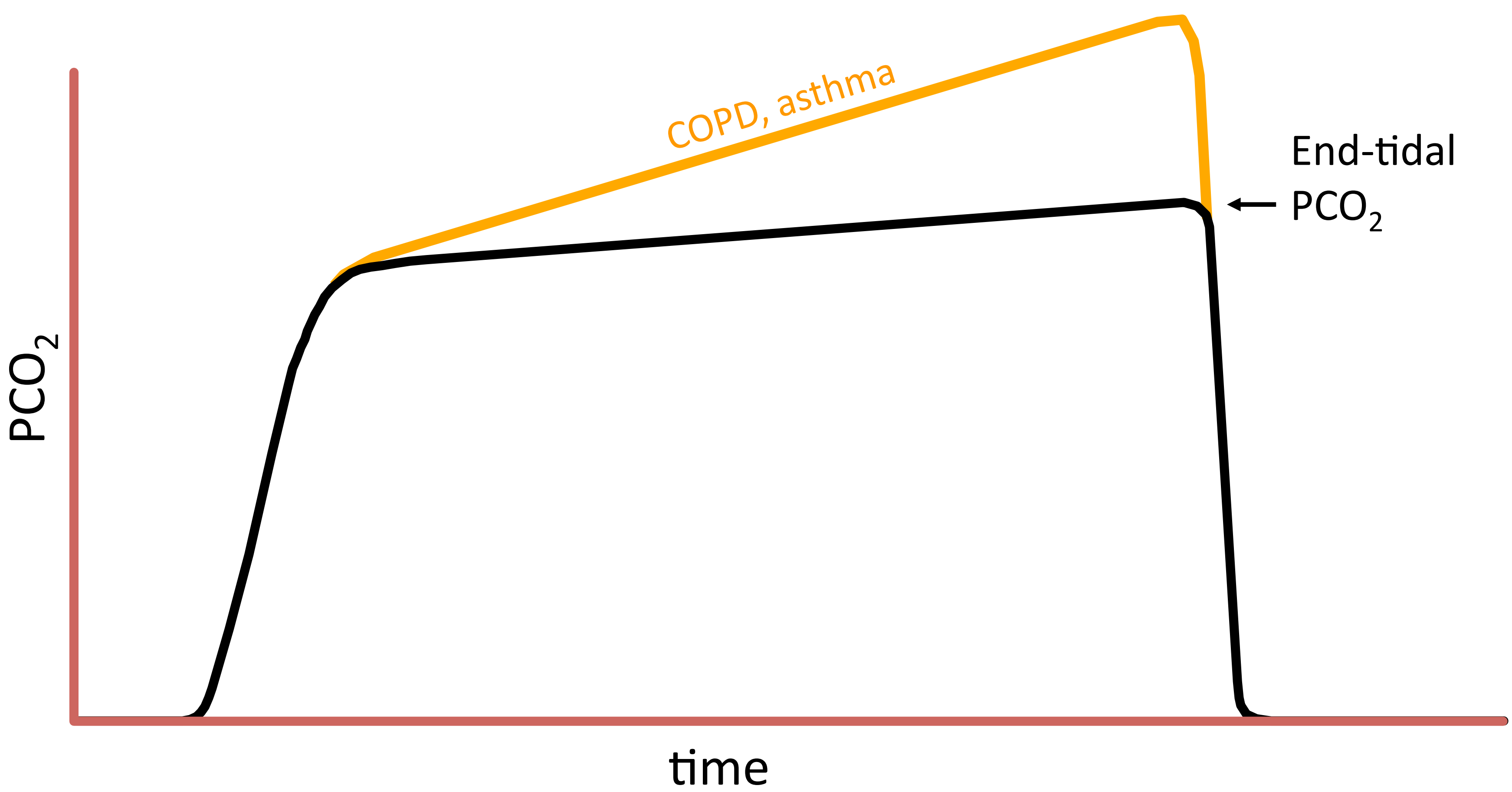


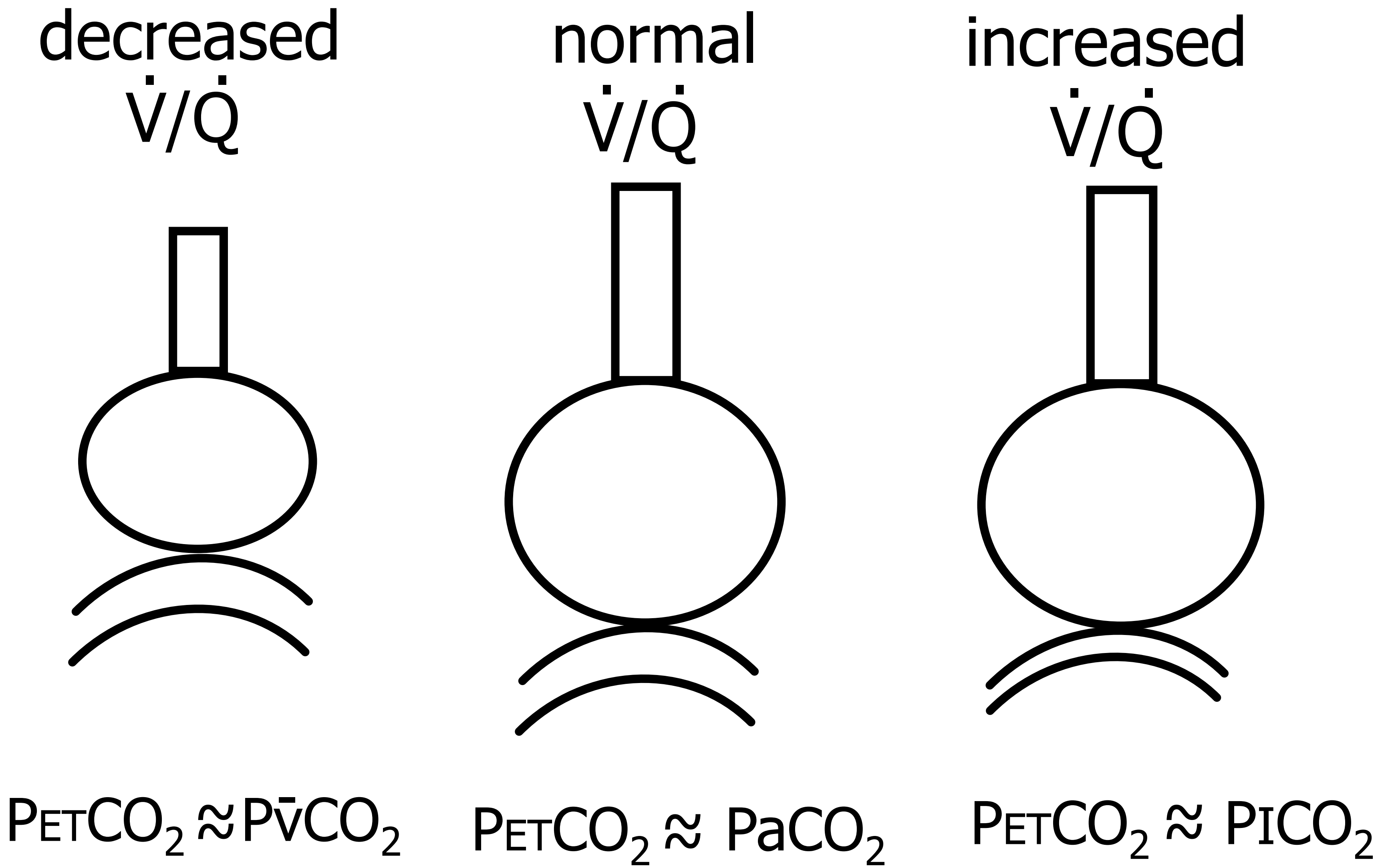
Of monitoring-triggered interruptions to care, only 20% were true and clinically meaningful.

Gross, Biomedical Instrumentation and Technology Supplement 29–36.

Capnography

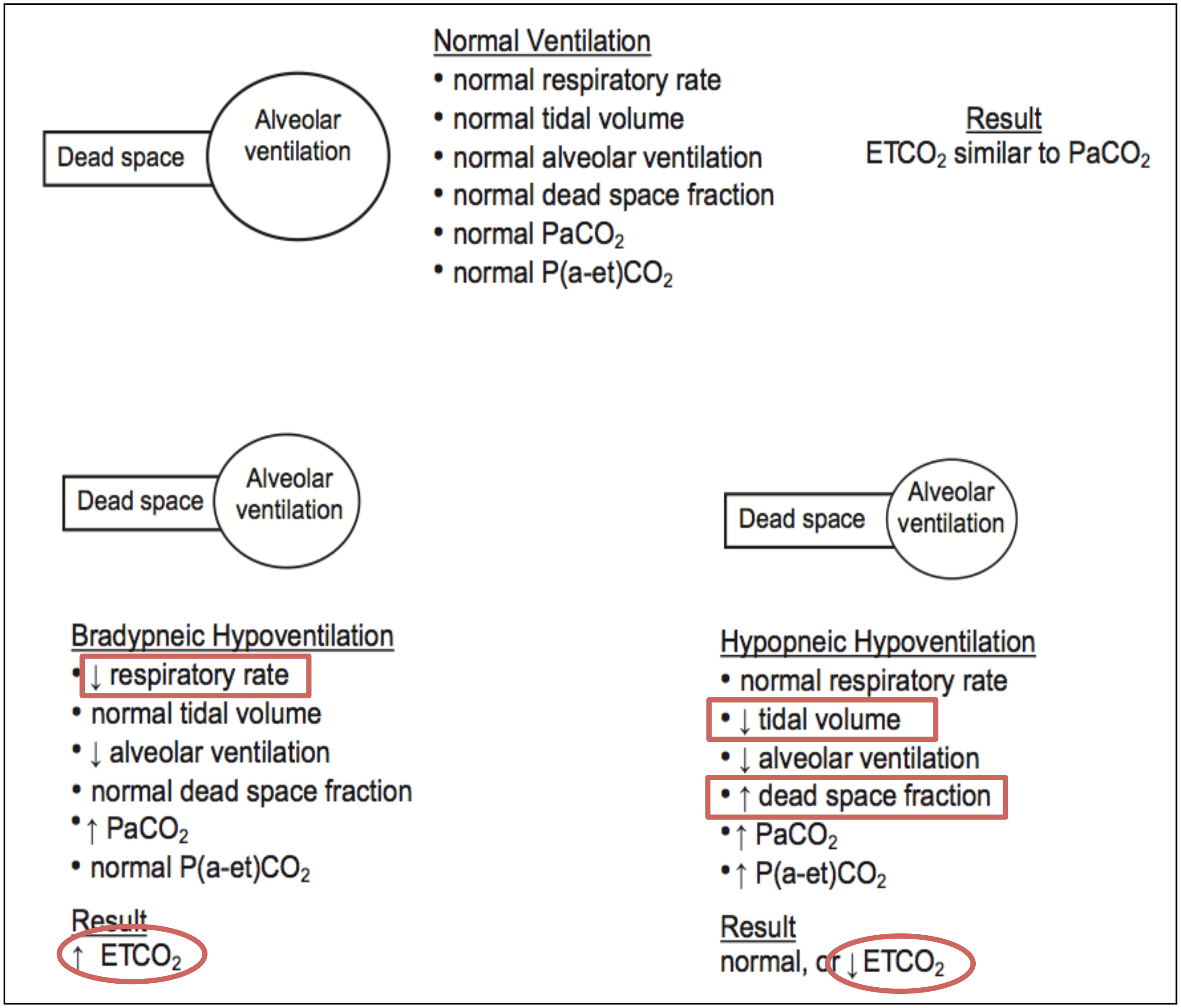
Normal Capnogram





End-tidal PCO_2 may be different from $PaCO_2$

Capnography for Sedation Monitoring



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

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☆,☆☆,★

Melissa L. Langhan, MD, MHS [a,*], Veronika Shabanova, MPH [b], Fang-Yong Li, MPH, MS [b], Steven L. Bernstein, MD [c], Eugene D. Shapiro, MD [a,d]

- 154 children receiving procedural sedation were randomized to whether staff could view the capnograph monitor or were blinded to it (controls).
- 45% had at least 1 episode of hypoventilation.
- There were significantly fewer interventions (stimulation, BVM, jaw thrust, etc) in the study group (OR 0.25).
- 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.

Am J Emerg Med 2015;33:25

PCA With Oximetry and Capnography

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

ROUTINE MEASUREMENT OF RESPIRATORY RATE
AN EXPENSIVE TRIBUTE TO TRADITION

Ross C. Kory, M.D.

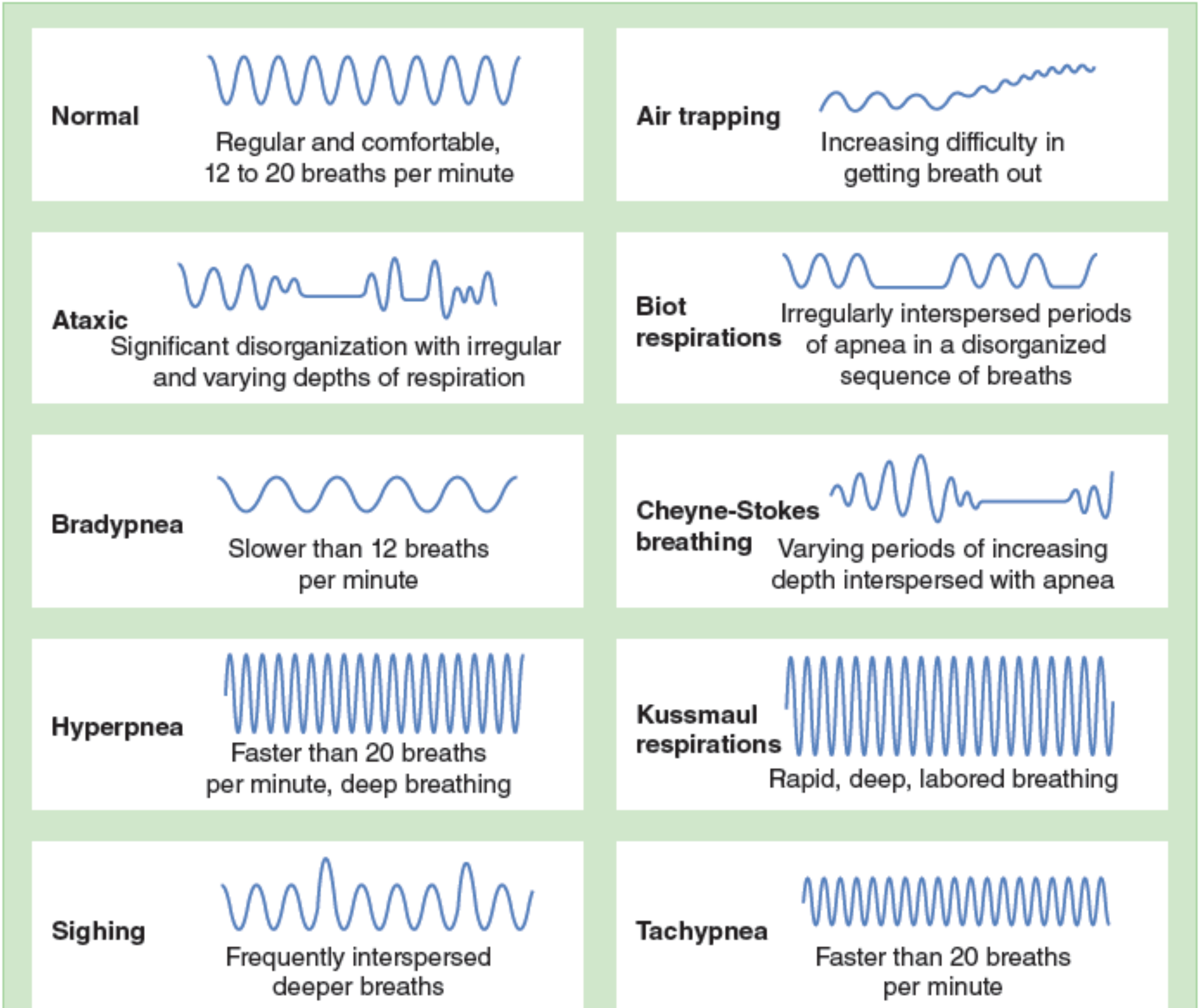
JAMA. 1957;165(5):448-450. doi:10.1001/jama.1957.02980230018005.

ABSTRACT

The routine repeated measurement of the respiratory rate is of clinical value in less than 5% of patients in a hospital, and furthermore physicians themselves rarely show an interest in such measurements. As a result of such indifference, nurses have been increasingly casual in their measurement of respiratory rates, and, in many cases, though a figure is recorded, no actual measurement was made. In one carefully controlled experiment measurements of respiratory rate were carried out in 58 patients within minutes of the routine ward measurements. The ward records showed 57 of these patients as having a rate between 18 and 22 per minute; 40 having a rate of exactly 20. The real range was from 11 to 33 per minute, only five patients showing a rate of 20. If recording the respiratory rate is important, the character of the breathing is of equal importance. Nursing personnel should recognize abnormal breathing patterns and bring these abnormal findings to the attention of the physician. It is suggested that routine recording of respiratory rates be limited to those cases or on those hospital wards where the physician specifically orders such measurements. This not only would improve the accuracy of the measurements and clinical records but also would save millions of hours of personnel time each year.

Respiratory Rate

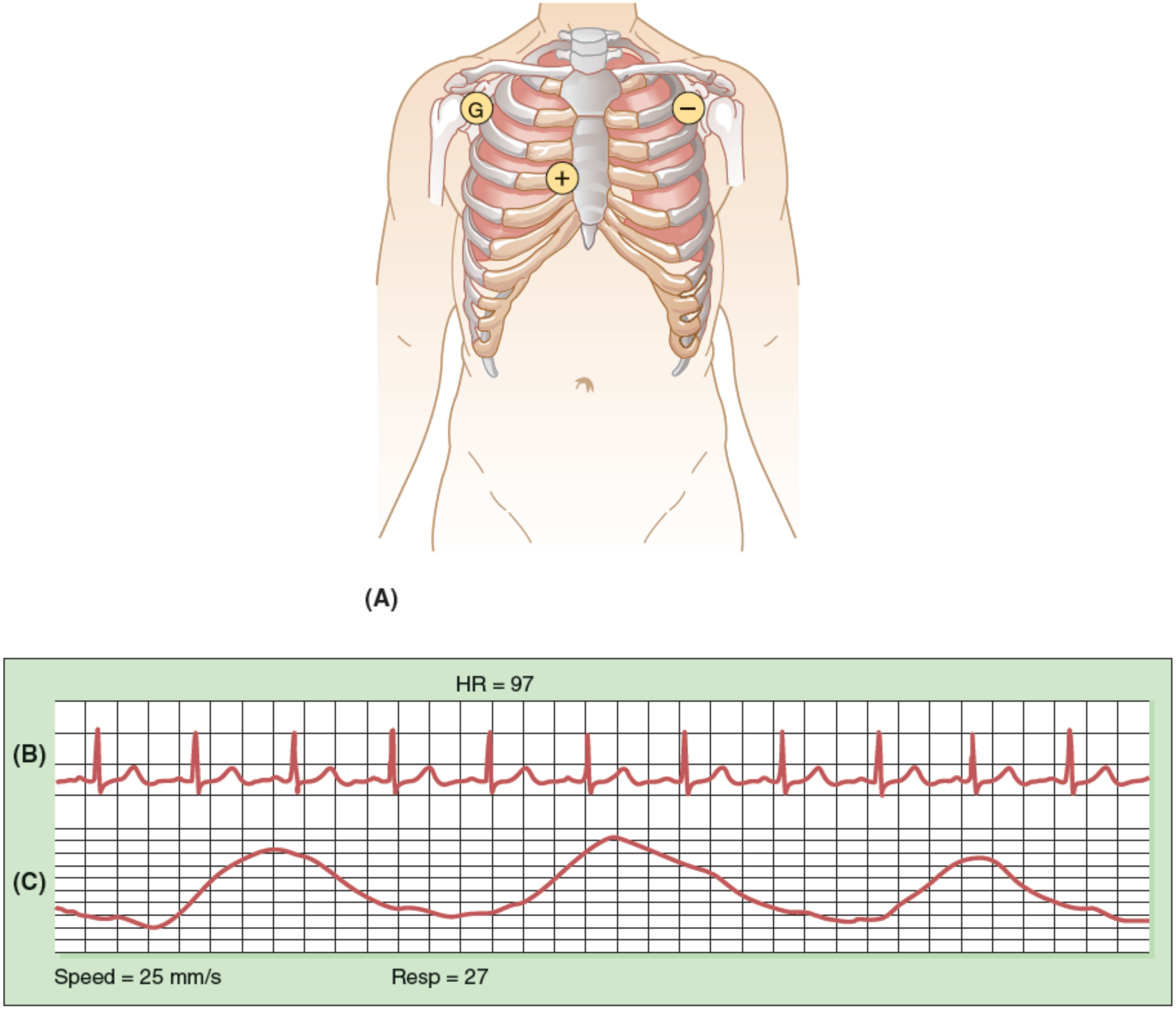
- Tachypnea: respiratory distress, metabolic acidosis, pain, increased metabolic rate (fever)
- Bradypnea: respiratory center depression (opiod)



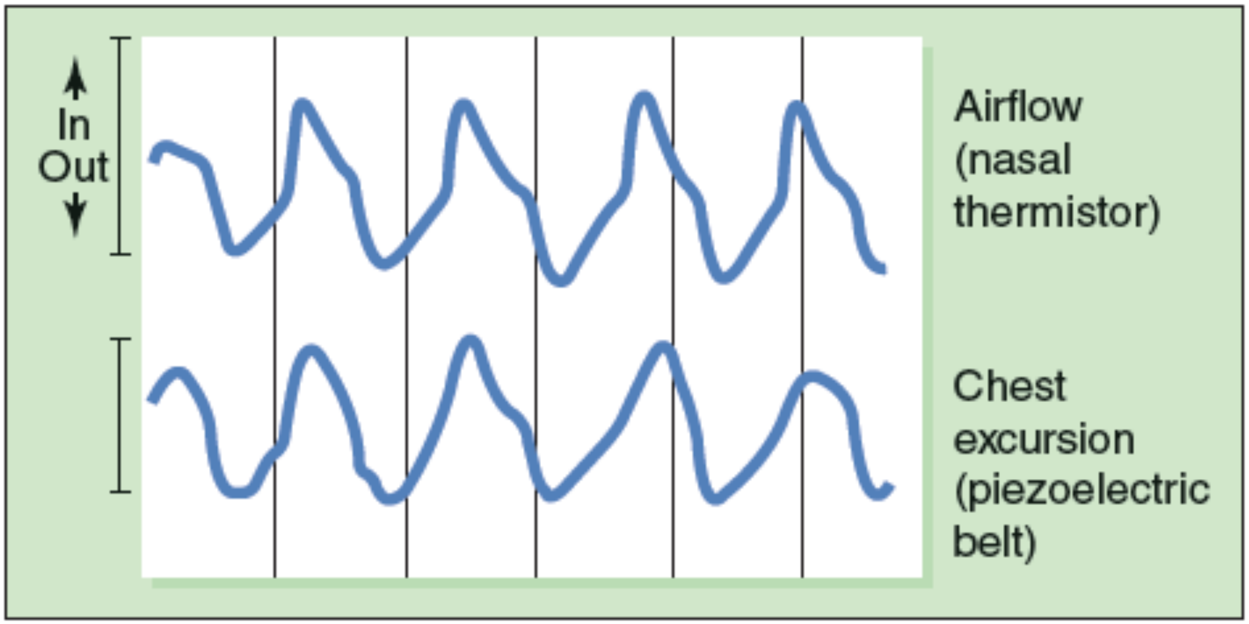
Hess, Respiratory Care: Principles and Practice

Measurement of Respiratory Rate

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



Hess, Respiratory Care: Principles and Practice



Hess, Respiratory Care: Principles and Practice

Optical Methods

- Camera used to detect thoracic movements to determine respiration rate.

Nakajima, Physiol Meas 2001;22:21

Thermal Imaging

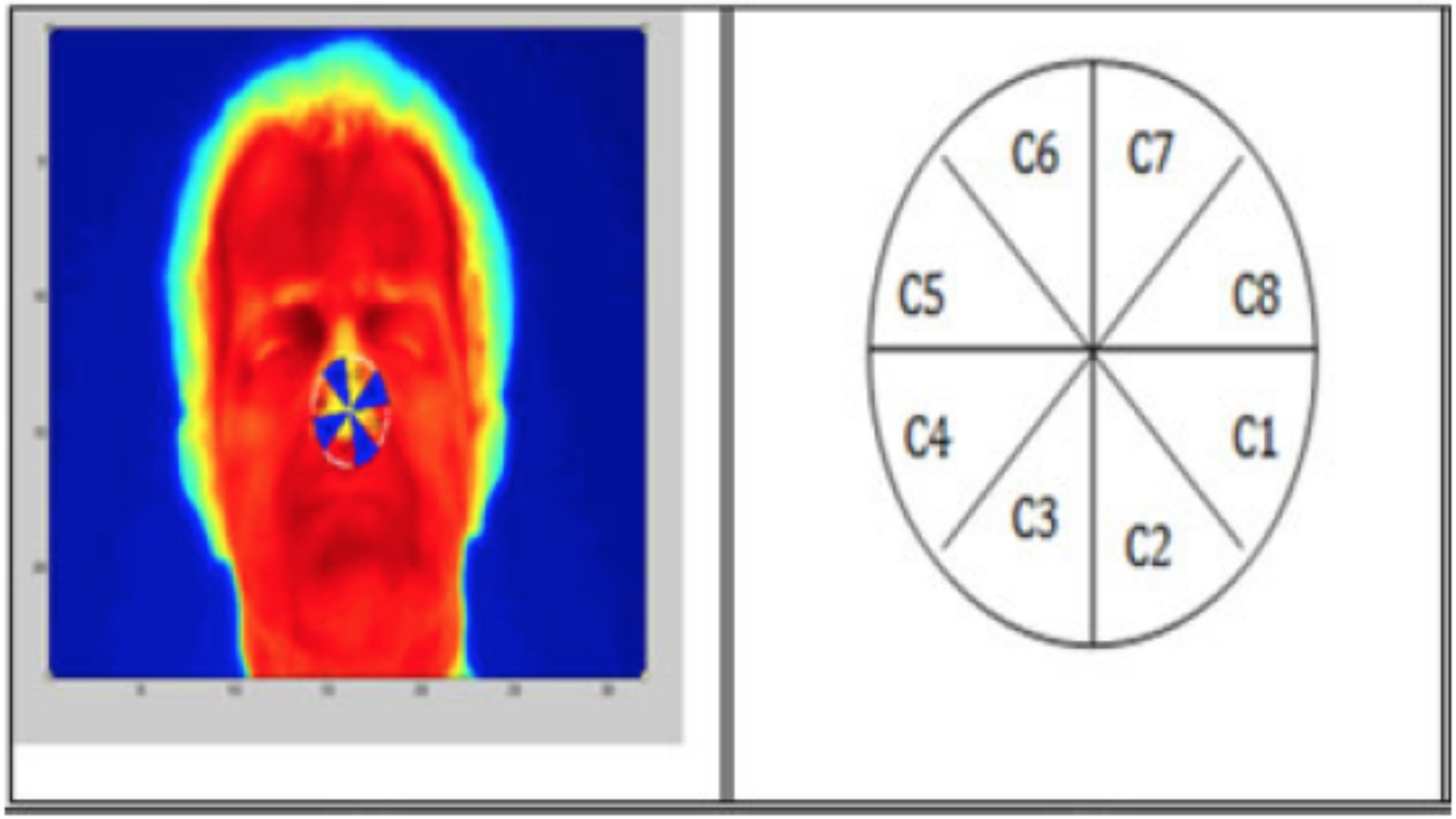
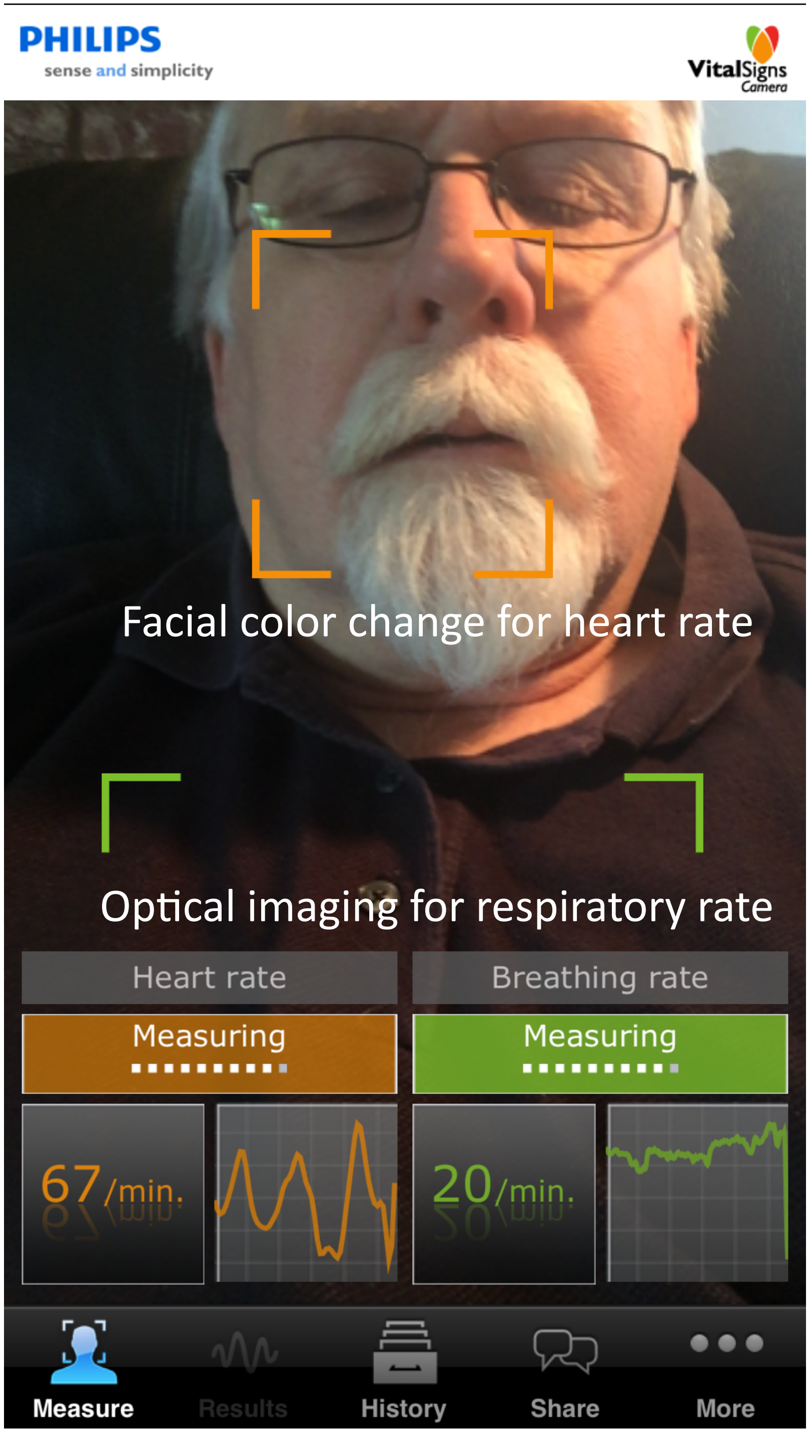
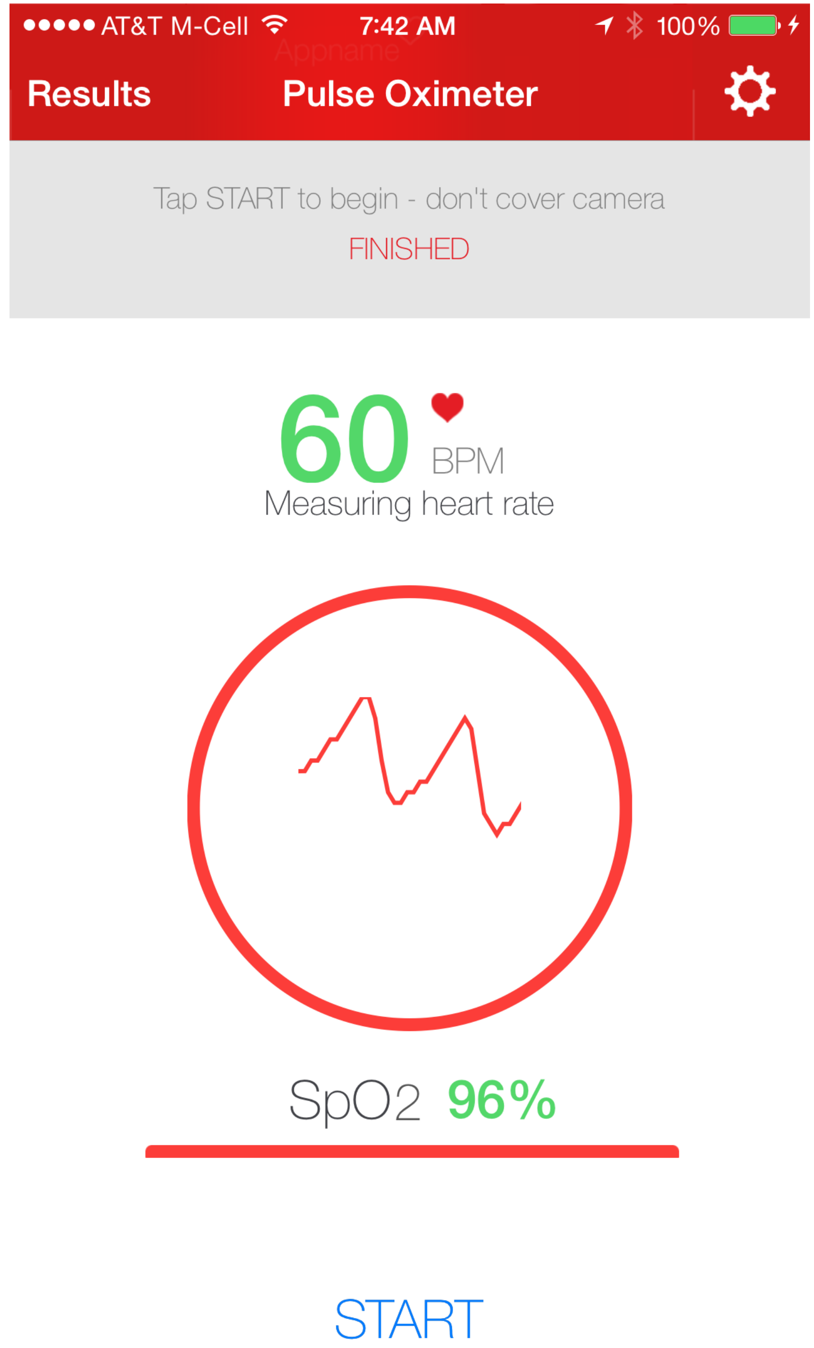


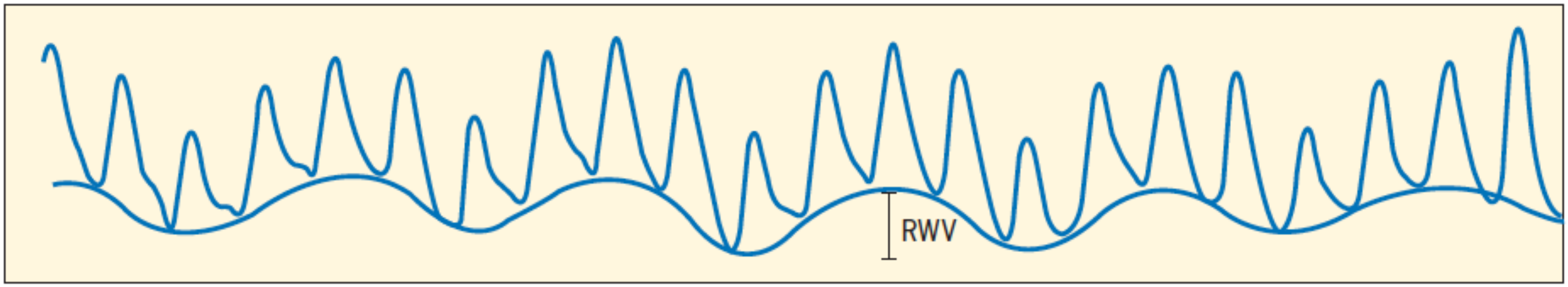
Fig. 3. (a) A thermal image with tip of the nose represented by a circle, (b) the eight segments of the selected respiration region.

AL-Khalidi, Pediatric Pulmonology 2011;46:523

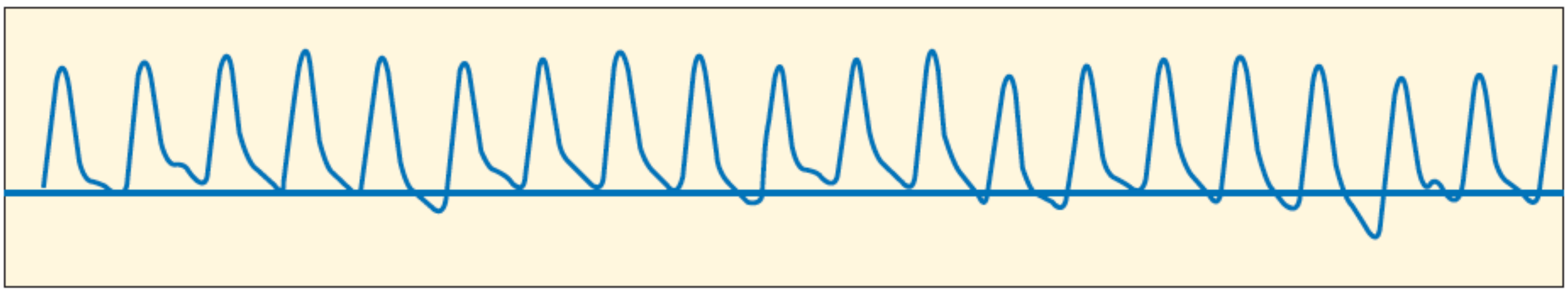

PHILIPS
sense and simplicity
VitalSigns Camera
Facial color change for heart rate
Optical imaging for respiratory rate
Heart rate
Breathing rate
Measuring
Measuring
67/min.
20/min.
Measure
Results
History
Share
More


AT&T M-Cell
7:42 AM
100%
Results
Pulse Oximeter
Tap START to begin - don't cover camera
FINISHED
60
BPM
Measuring heart rate
SpO2 96%
START

Pulse Ox Pleth Waveform: Pulsus



(A)

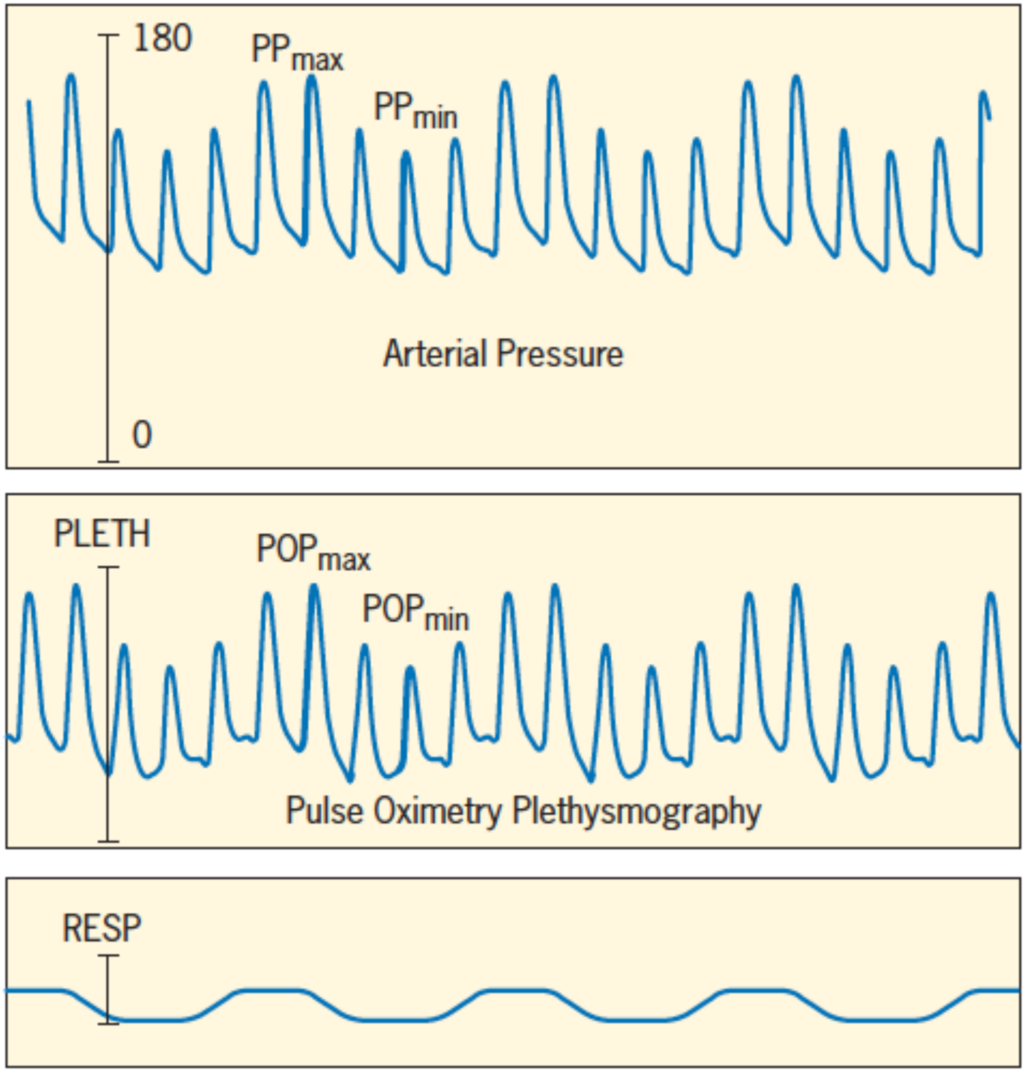


(B)

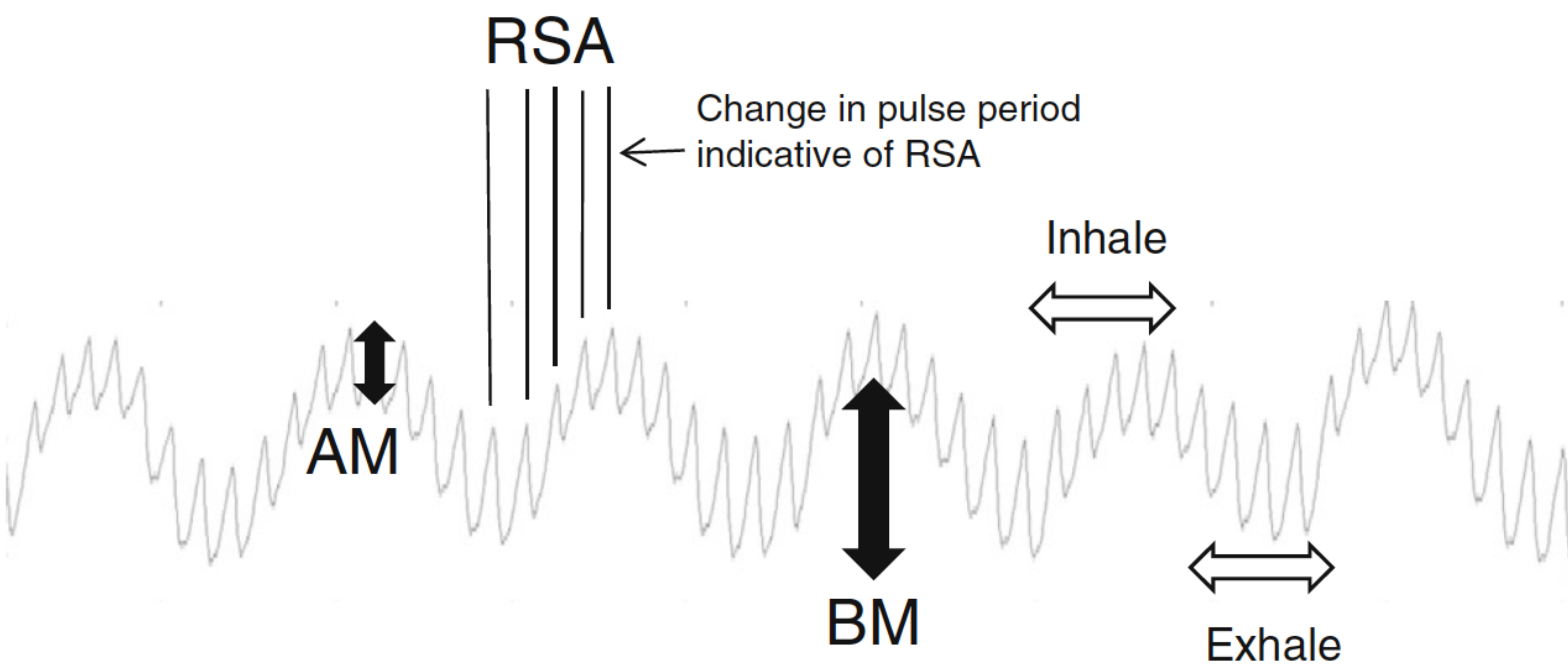
Hartert, Chest 1999;115:475

Pulse Ox Pleth Waveform: Fluid Responsiveness

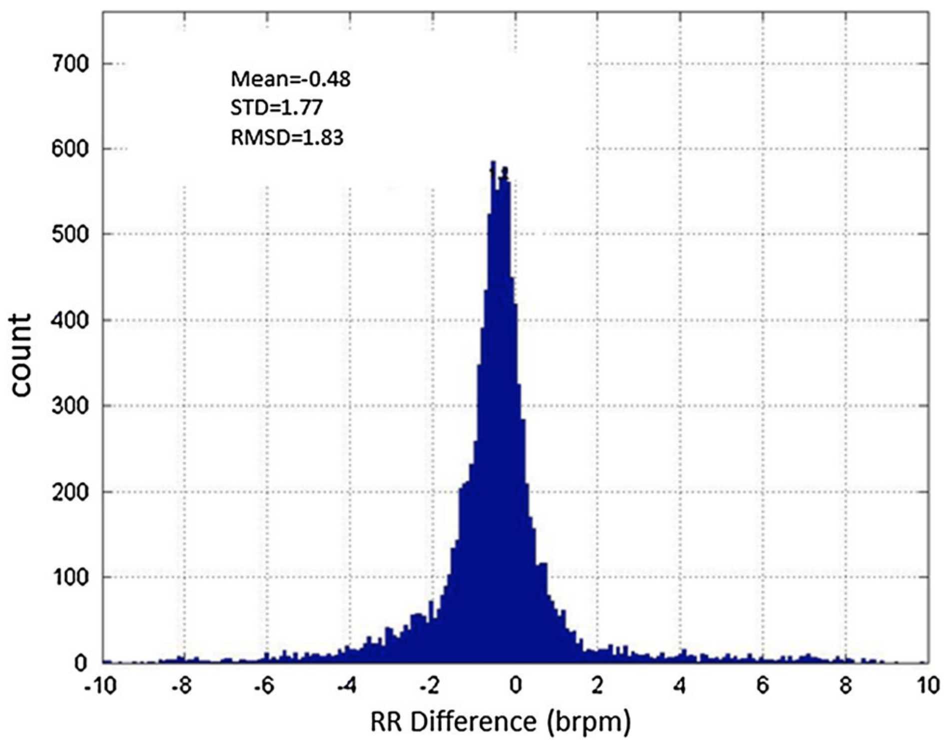
Cannesson, Crit Care 2005;9:R562



Pulse Ox Pleth for Respiratory Rate



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



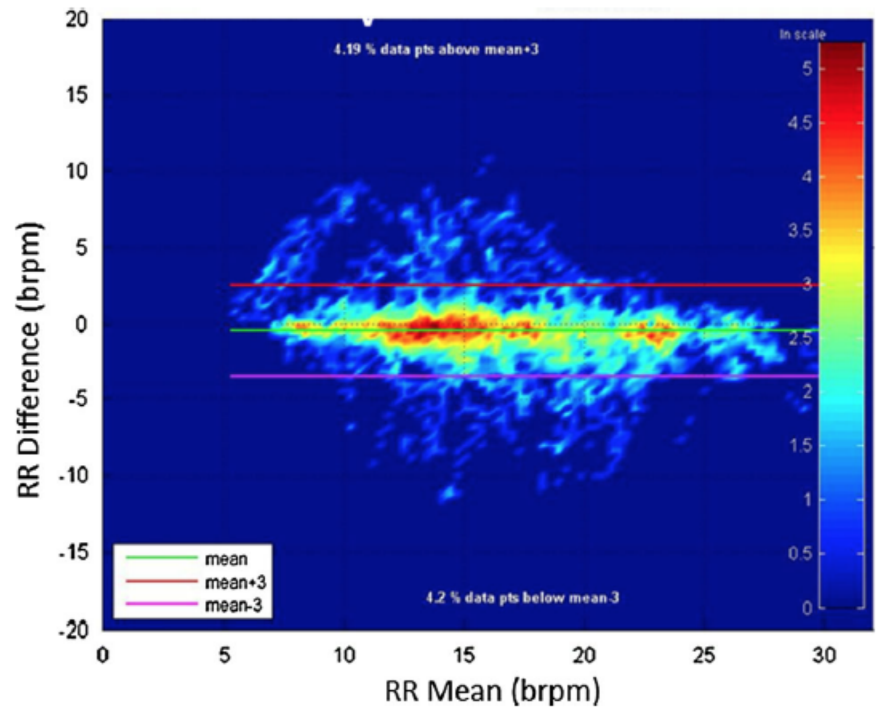
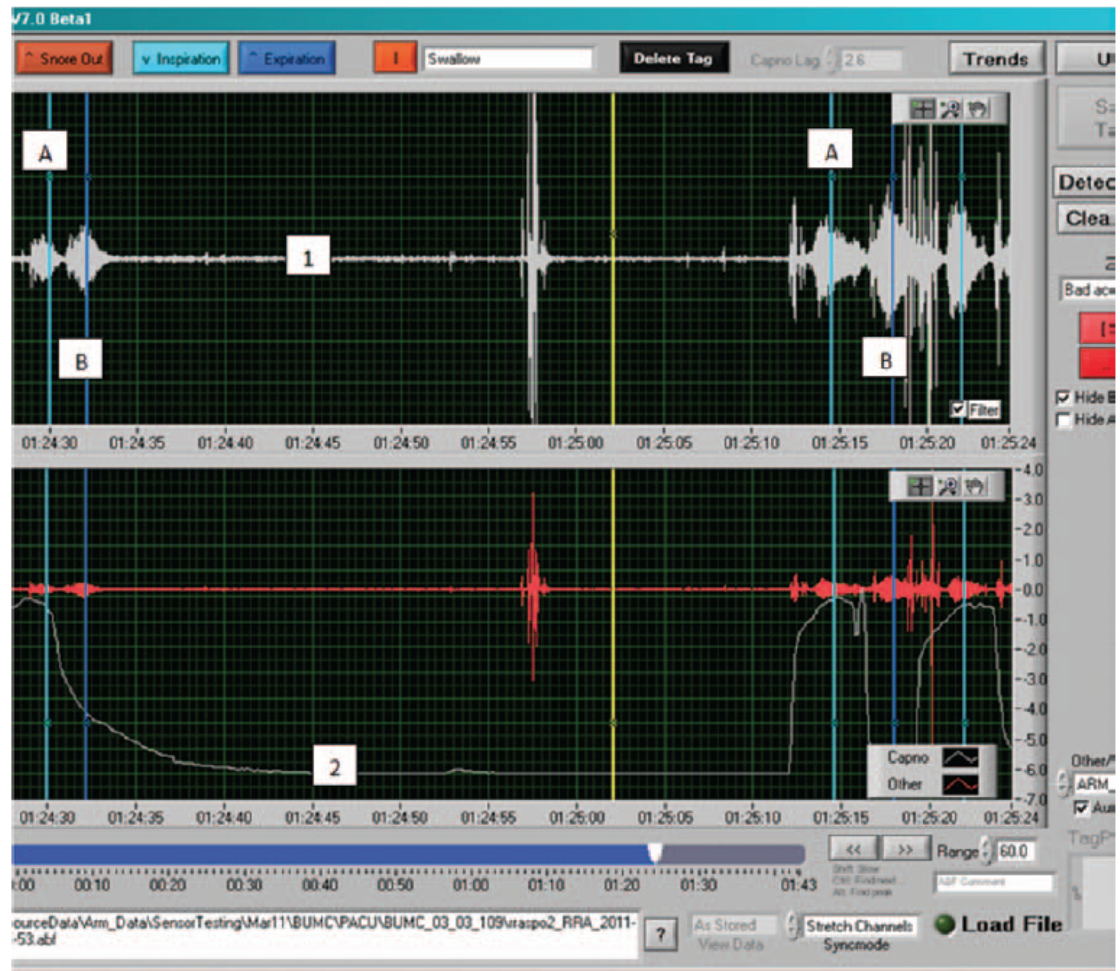


Fig. 4 Bland-Altman density plot of the data (lowest density of points to highest density = *Dark Blue*, *Light Blue*, *Green*, *Yellow*, *Red*)

Addison, J Clin Monit Comput 2015;29:113

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



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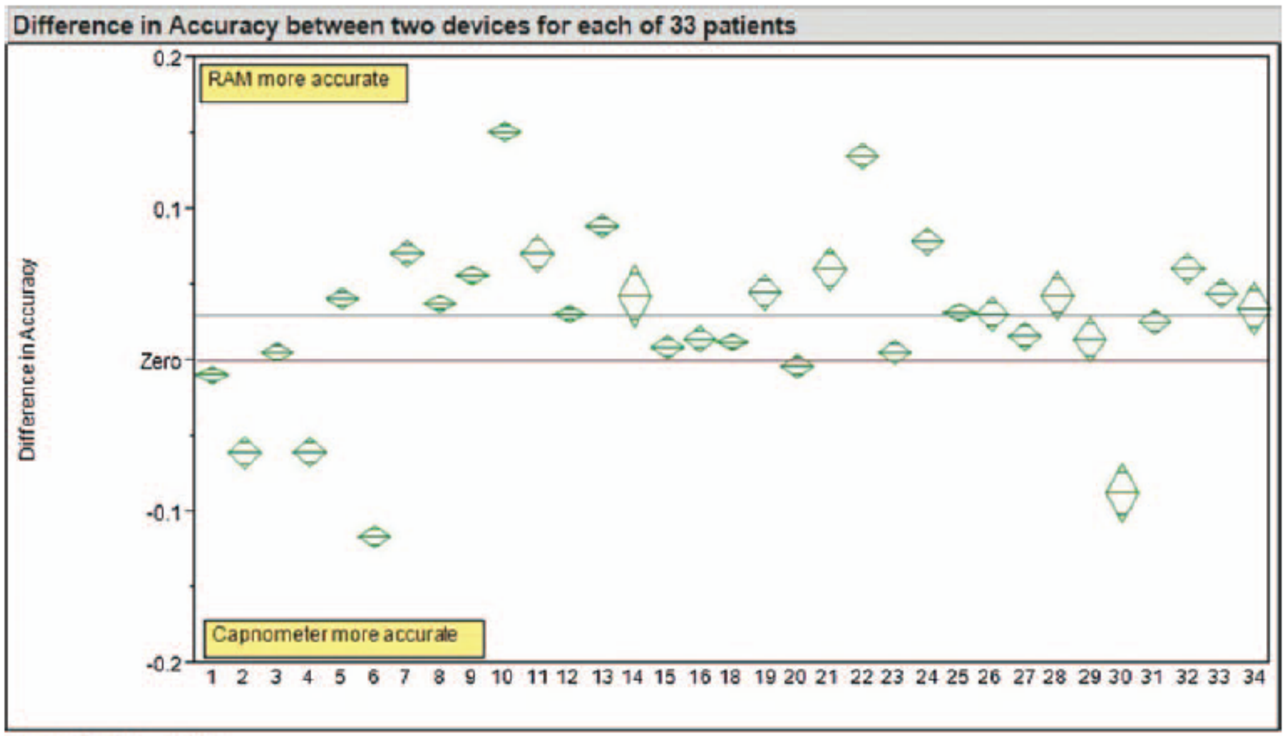


- 33 PACU patients exhibiting a wide range of ventilation rates.
- The reliability of both devices was high.
- The acoustic monitor was about 3% more precise than capnography.
- Did not address whether the better accuracy/precision of RAM was clinically important.

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, Inc., 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.

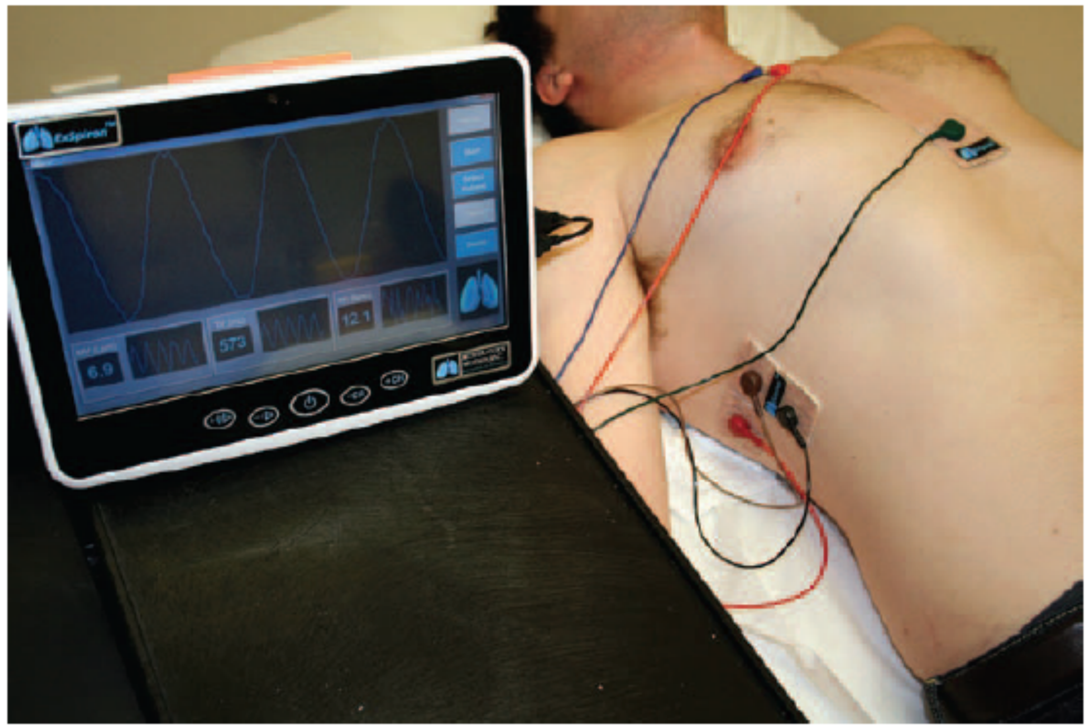


Figure 1. Standard electrode placement. Electrode strip containing 3 electrodes is placed between sternal notch and xiphoid. Separate pad containing an additional 3 electrodes is placed along the right midaxillary line at the level of the xiphoid.

Standardized Hourly Rounding

- 6 month study in 2 32-bed cardiovascular surgery units; 1 received the intervention.
- Significant reductions in call light use and the number of steps taken by the day-shift staff on the intervention unit.
- Differences in the number of patient falls, 30-day readmission rates, and patients' perception of care were not significant.

Krepper, J for Healthcare Quality 2012:62

Additional Monitoring

- NIV: tidal volume, respiratory rate, ventilating pressures, F_IO_2, alarm output to nurse call
- CPAP: 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

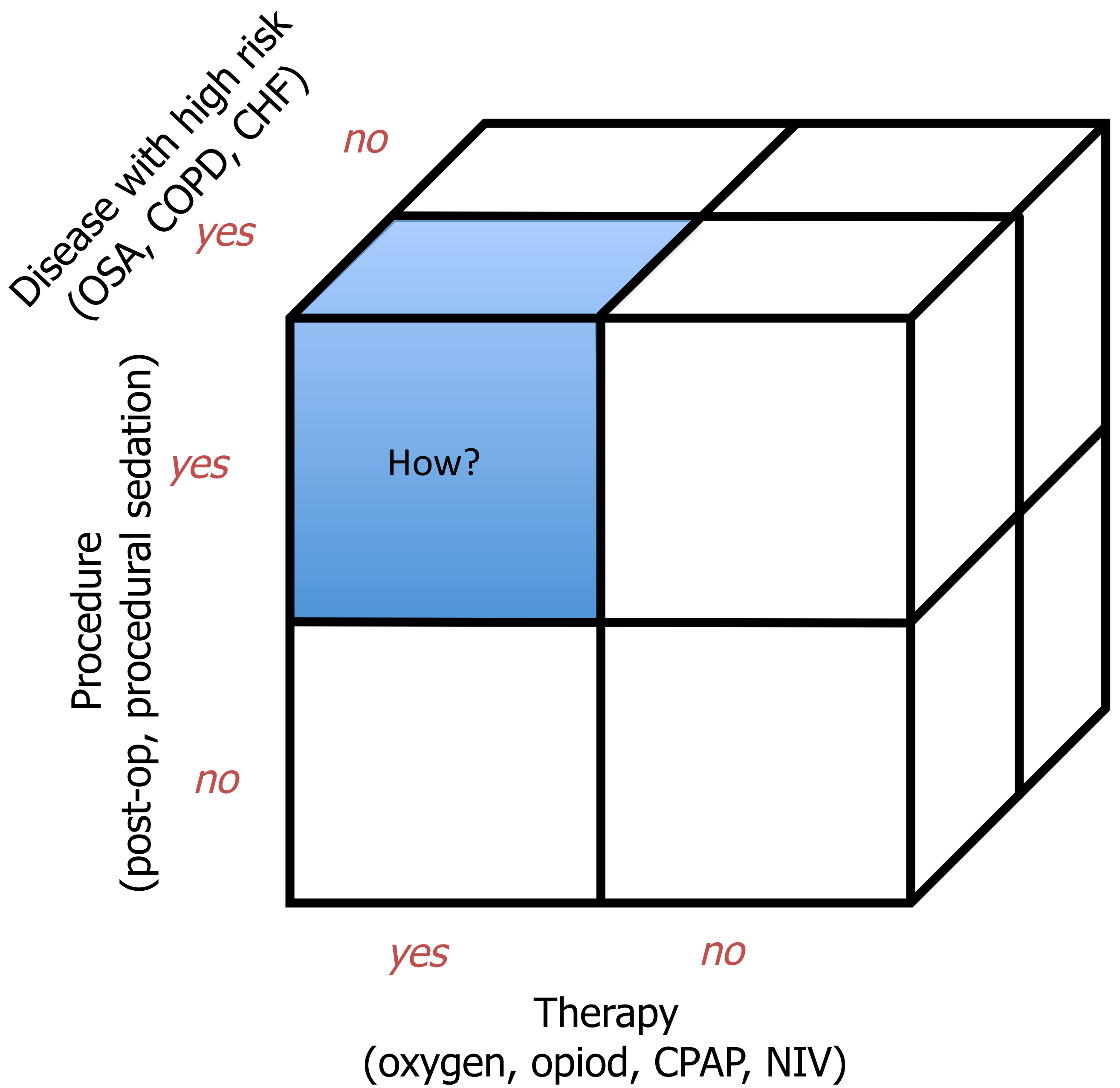
(For more information, refer to Standard EC.02.04.03)

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 (Technology)
When to Start; When to Stop

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

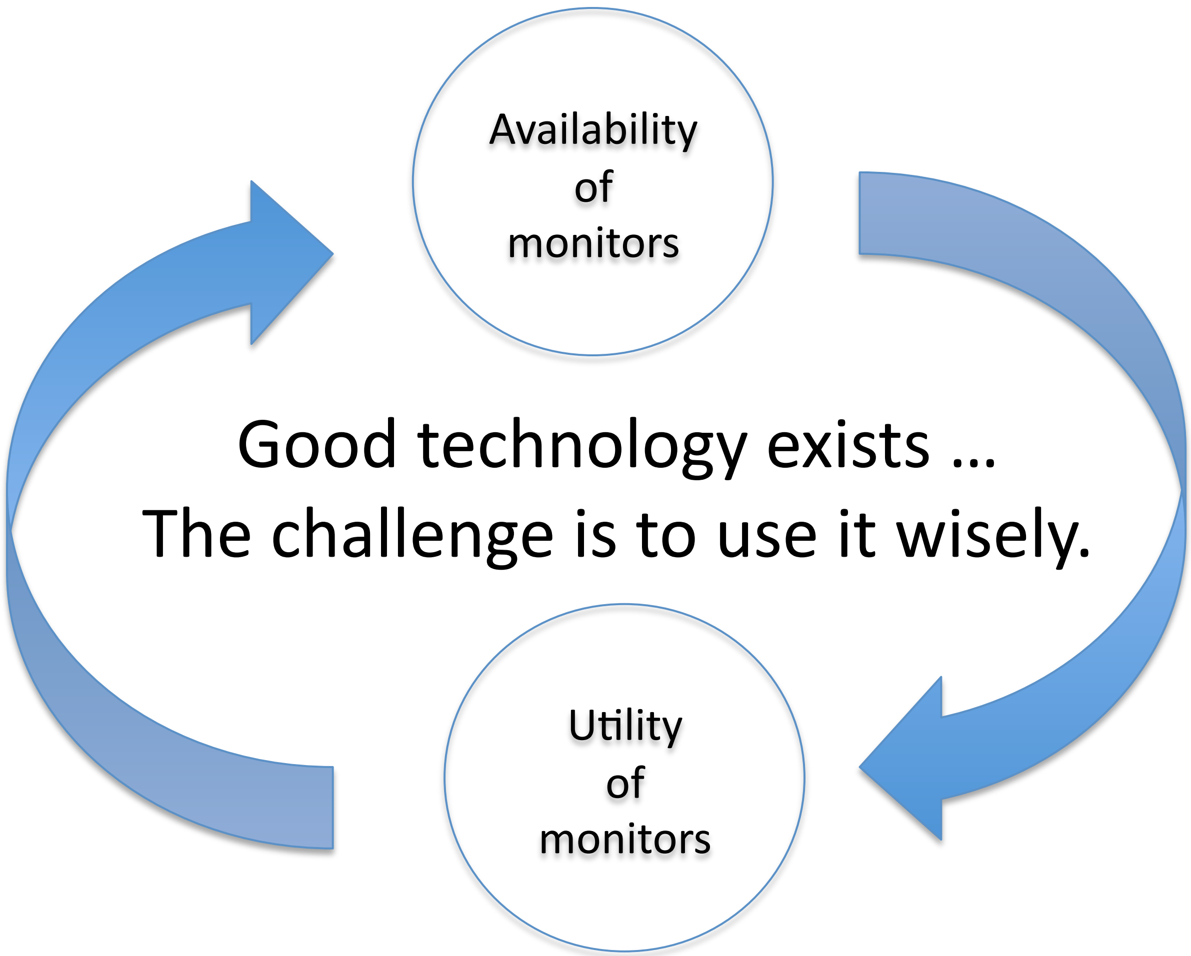
Is there a biomarker?


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

Current And Future Objective Monitors Outside The ICU

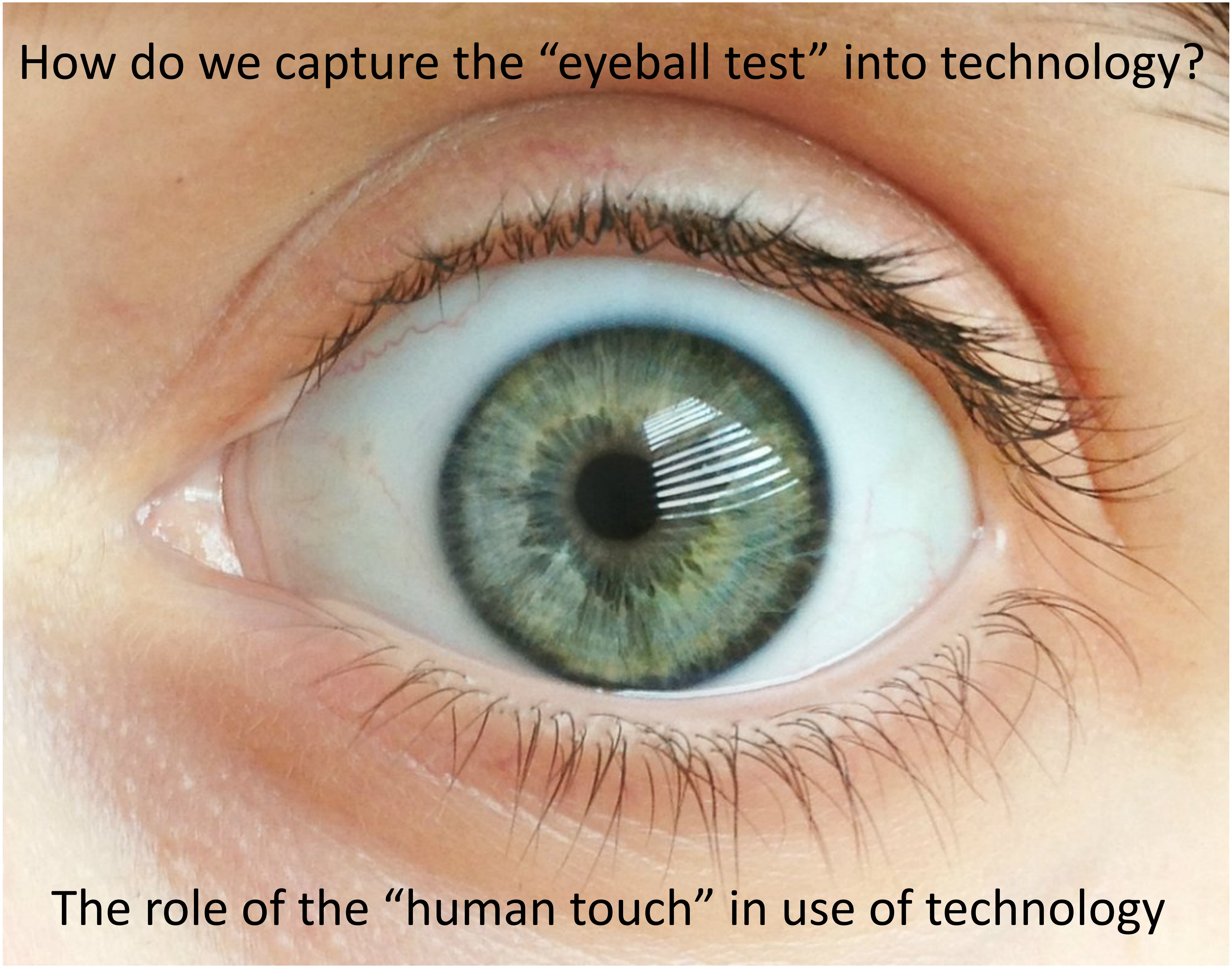
- Monitoring is often implemented based on face validity and what can be monitored.
- The decision to monitor should be based on clinical indications.
- Clinical trials are necessary to determine the appropriate role of monitoring?
- Perhaps we are not using the technology appropriately? Trends versus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

Which Comes First?



When technology becomes master, we get to disaster faster.

Piet Hein


How do we capture the “eyeball test” into technology?
The role of the “human touch” in use of technology