SOCIEDAD ARGENTINA DE PEDIATRÍA
Dirección de Congresos y Eventos
COMITÉ NACIONAL DE NEUMONOLOGÍA PEDIÁTRICA

Por un niño sano
en un mundo mejor

6º Congreso Argentino de Neumonología Pediátrica

Jornada de Kinesiología Respiratoria

GRUPO DE TRABAJO DE KINESIOLOGÍA DE LA SAP

Jueves 22 de Noviembre 14-14.45

Conferencia: Uso racional de métodos de tecnología. Oximetria y Capnografia

Presentadora: Lic. Maria Alejandra Timoni

Disertante: Lic. Gustavo Olguin

OXIMETRIA

- Método no invasivo continuo que mide la saturación de oxígeno de la hemoglobina, basado en la absorción de la luz a diferentes longitudes de onda por la hemoglobina reducida y oxigenada.

Los monitores de saturación de oxígeno, u oxímetros de pulso (SpO_2) se introdujeron en la práctica en la década de 1980 no sólo sin efectuar previamente estudios de distribución aleatoria, sino también –lo que es probablemente más importante– sin una educación apropiada de los proveedores de asistencia neonatal en todo el mundo (el personal de enfermería, los terapeutas respiratorios y también los médicos). La educación acerca de algunos conocidos principios fisiológicos, como la relación cambiante entre el oxígeno y la hemoglobina, la presión parcial arterial de oxígeno (PaO_2) y la saturación de oxígeno ($SatO_2$), no cursó paralelamente a la puesta en práctica sistemática de los monitores de SpO_2.

A. Sola, L. Chow y M. Rogido An Pediatr (Barc) 2005;62(3):266 81

Monitoring of standard hemodynamic parameters: Heart rate, systemic blood pressure, atrial pressure, pulse oximetry and end-tidal CO_2

V. Ben Sivarajan, MD, FRCPC; Desmond Bohn, MB, FRCPC

Background: Continuous monitoring of various clinical parameters of hemodynamic and respiratory status in pediatric critical care medicine has become routine. The evidence supporting these practices is examined in this review.

Methodology: A search of MEDLINE, EMBASE, PubMed, and the Cochrane Database was conducted to find controlled trials of heart rate, electrocardiography, noninvasive and invasive blood pressure, atrial pressure, end-tidal carbon dioxide, and pulse oximetry monitoring. Adult and pediatric data were considered. Guidelines published by the Society for Critical Care Medicine, the American Heart Association, the American Academy of Pediatrics, and the International Liaison Committee on Resuscitation were reviewed, including further review of references cited.

Results and Conclusions: Use of heart rate, electrocardiography, noninvasive and arterial blood pressure, atrial pressure, pulse oximetry, and end-tidal carbon dioxide monitoring in the pediatric critical care unit is commonplace; this practice, however, is not supported by well-controlled clinical trials. Despite the majority of literature being case series, expert opinion would suggest that use of routine pulse oximetry and end-tidal carbon dioxide is the current standard of care. In addition, literature would suggest that invasive arterial monitoring is the current standard for monitoring in the setting of shock. The use of heart rate, electrocardiography, and atrial pressure monitoring is advantageous in specific clinical scenarios (postoperative cardiac surgery); however, the evidence for this is based on numerous case series only. (Pediatr Crit Care Med 2011; 12[Suppl.]:S2–S11)

Key Words: hemodynamic monitoring; heart rate; systemic blood pressure; atrial pressure; pulse oximetry; end-tidal CO_2

Clinical assessment and frequent reassessment is essential in critically ill children because "normal" parameters are less guided by published population curves (Table 1) and more by trends established during monitoring of the individual patient.

The goal of such monitoring is to allow anticipatory management of infants and children. Relationships between specific hemodynamic variables are complex enough in states of health. In disease states, the specific responses of heart rate, central venous pressure, and blood pressure to treatments are essential to rapid diagnosis and curative therapy.

Appropriate monitoring allows one to comprehend etiologic and compensatory factors contributing to shock pathophysiology. This allows the clinician to calculate secondary parameters (Table 2) that are paramount in executing specific therapeutic strategies (1). However, the primacy of monitoring lies in documentation of improved outcomes based on hemodynamic monitor-driven treatments in controlled clinical studies. The question of whether there is sufficient scientific evidence supporting or discouraging standard monitoring practices in pediatric critical care is the basis for this review.

Process

MEDLINE, EMBASE, PubMed, and Cochrane Database searches were conducted to find controlled trials regarding the use of heart rate, noninvasive and invasive pressure, end-tidal carbon dioxide, and pulse oximetry monitoring. Adult and pediatric data were considered. Guidelines published by the Society for Critical Care Medicine, the American Heart Association, the American Academy of Pediatrics, and the International Liaison Committee on Resuscitation were reviewed, including further review of references cited.

Background

As the discipline of critical care medicine evolved out of the battlefields of Normandy and the MASH (Mobile Army Surgical Hospital) units of Korea, the importance of objective vital sign monitoring became singularly apparent. In 1952, a study by Ibsen (2, 3) had demonstrated that operating room techniques such as tracheotomy and curare could be used in an intensive care unit setting. In 1953, he converted the surgical recovery ward in Copenhagen's Kommunehospital into the first intensive care unit (ICU) (2, 4). The ICU established by Dr. Peter Safar at Baltimore City Hospital emphasized bedside resuscitative interventions and the primary importance of maintenance of airway and breathing (5). At the University of Southern California, Drs. Max Weil and Herbert Shubin became interested in why patients died suddenly after a myocardial

From the Divisions of Cardiac Critical Care and Cardiology (VBS), Departments of Critical Care Medicine and Paediatrics, The Labatt Family Heart Centre, The Hospital for Sick Children, Toronto, Ontario, Canada, and the Department of Critical Care Medicine and Paediatrics, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada; and the Department of Critical Care Medicine (DB), Hospital for Sick Children, Professor of Anaesthesia and Paediatrics, University of Toronto, Department of Critical Care Medicine, Hospital for Sick Children, Toronto, Ontario, Canada.

The authors have not disclosed any potential conflicts of interest.

For information regarding this article, E-mail: ben.sivarajan@sickkids.ca

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Evidencia científica para el uso de Oximetría

- This recommendation is based on case series and observational studies
  - **level of evidence: IV; grade of recommendation C**

Pediatr Crit Care Med 2011 Vol. 12, No. 4 (Suppl.)

1. ¿Cómo funcionan los monitores de SpO_2?
2. ¿Cómo maneja el ruido y las señales alteradas el monitor de SpO_2?
3. ¿La alarma es "verdadera"?
4. ¿El monitor tiene "períodos de latencia" o mantiene valores registrados previamente?
5. ¿El monitor funciona bien y con exactitud cuando más se le necesita?
6. Cuando la lectura de la $SatO_2$ es superior al 96%, ¿cuál es la PaO_2 en el niño prematuro?
7. Cuando el monitor de SpO_2 lee un determinado nivel de $SatO_2$, ¿cuál es la verdadera SaO_2 en el niño prematuro?
8. Cuando el monitor de SpO_2 lee un determinado nivel de $SatO_2$, ¿cuál es su variabilidad ("error")?
9. Cuando un monitor lee un determinado nivel de $SatO_2$, ¿cuál es la lectura en otro monitor?
10. Finalmente, ¿qué grado de conocimientos tienen los clínicos acerca de las diferencias entre los monitores de SpO_2, descritas tecnológicamente en muchos estudios clínicos?

Algunos datos…

- La mayoría de los Profesionales creen que han recibido un adiestramiento suficiente sobre este tema.

A. Sola, L. Chow y M. Rogido. Oximetría de pulso en la asistencia neonatal .An Pediatr (Barc) 2005;62(3):266 81

IMPORTANTE

- La distancia existente entre los conocimientos y la práctica se acompaña de morbilidad, que a veces puede ser letal.

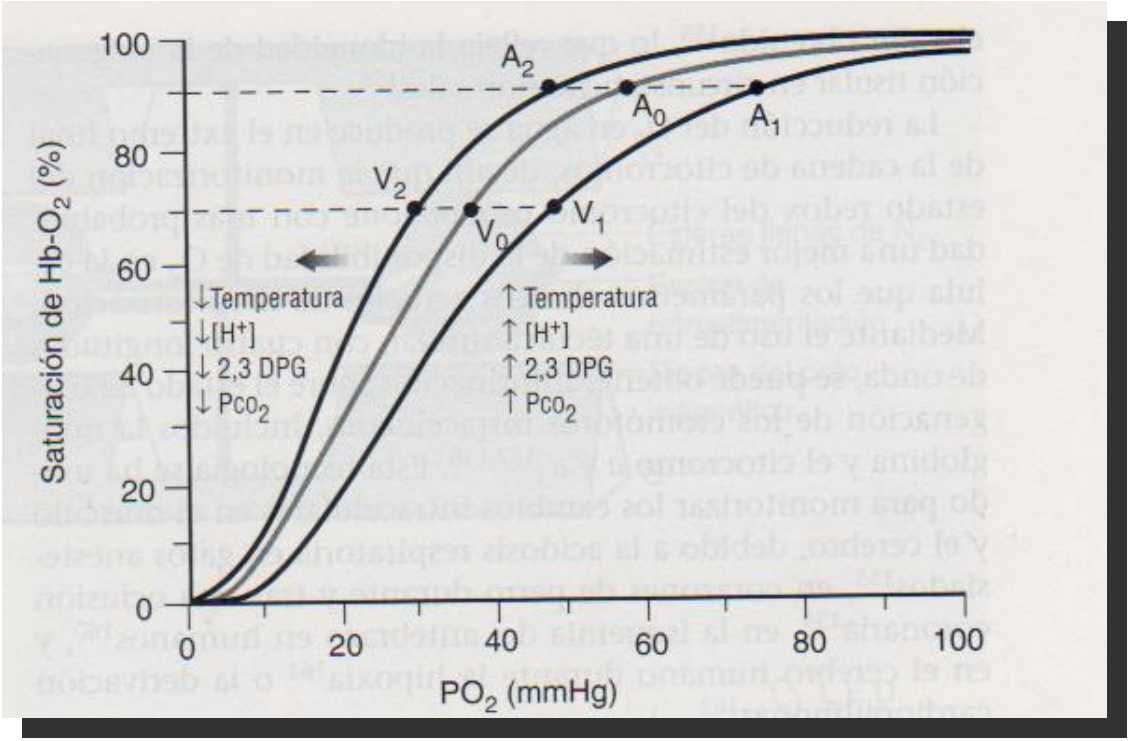
- Lo que conlleva riesgos que pueden evitarse mediante la educación y el incremento de los conocimientos de los profesionales de la salud.

A. Sola, L. Chow y M. Rogido An Pediatr (Barc) 2005;62(3):266 81

Si estas dentro del 20% de los que no saben que mide un oxímetro…y / o dentro del 80% que no recuerdan la curva de disociación de la hemoglobina…

LO QUE SIGUE TE PUEDE INTERESAR!!

CURVA DE DISOCIACIÓN DE LA HB



$pSaO_2$ [%]	PaO_2 [mm Hg]
99 o 100	95-650
95	≈ 80
90	≈ 60
70	≈ 40
50	≈ 25

Los valores dependen de:
- Temperatura
- Valor de pH
- [2,3-DPG]
- $PaCO_2$

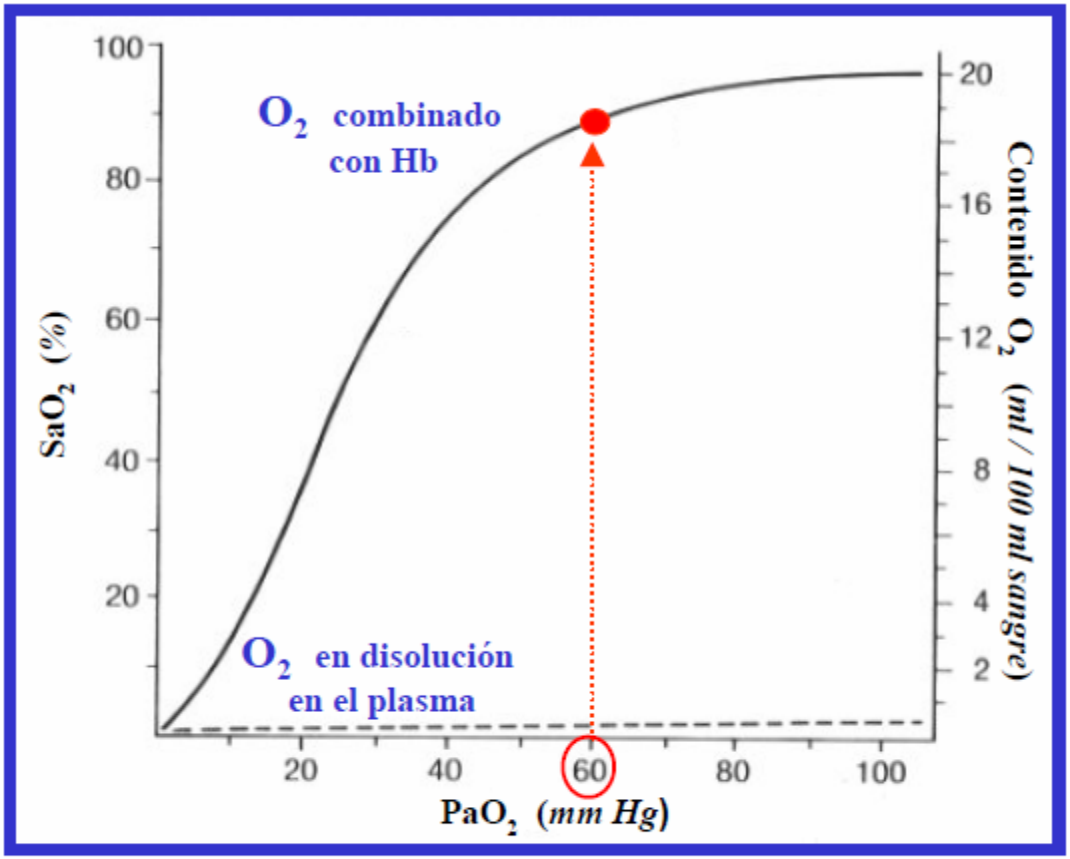
La pulsioximetría tiene una exactitud de aprox 2% en un rango de medición del 80-100% de $Sa0_2$ y se reduce a medida que disminuye por debajo de estas cifras.

Pequeños descensos de la $p0_2$ por debajo de 60 causan desaturaciones importantes.

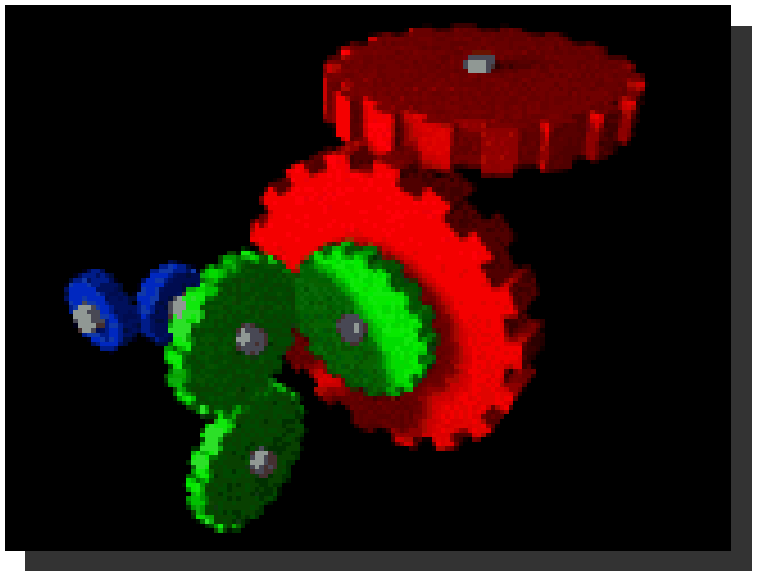
Oxihemoglobina

Insuficiencia Respiratoria

PaO_2 < 60 mm Hg



P_{50}: PaO_2 a la que el 50 % de la Hb está saturada



50% out…

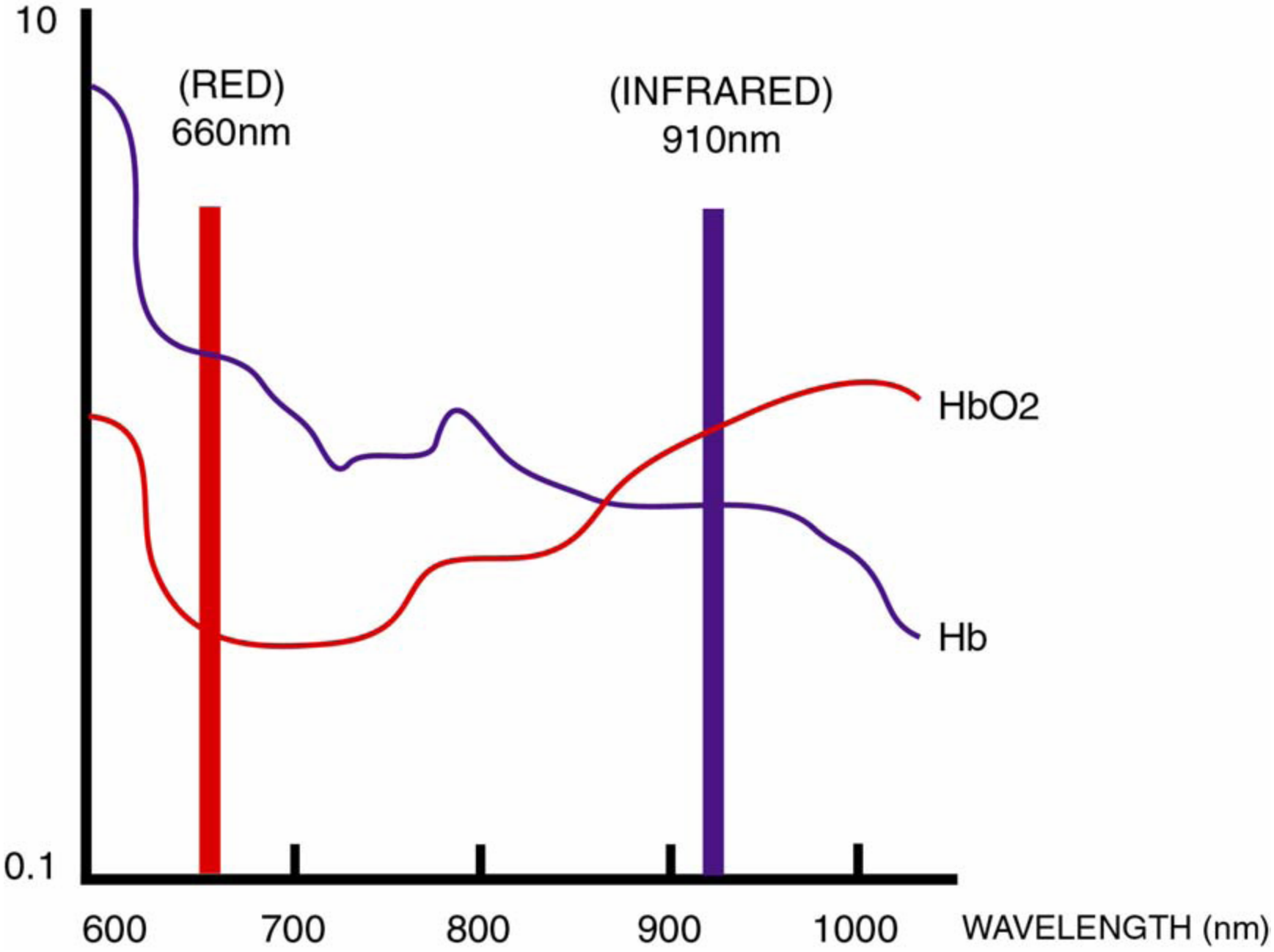
ASI TRABAJA…

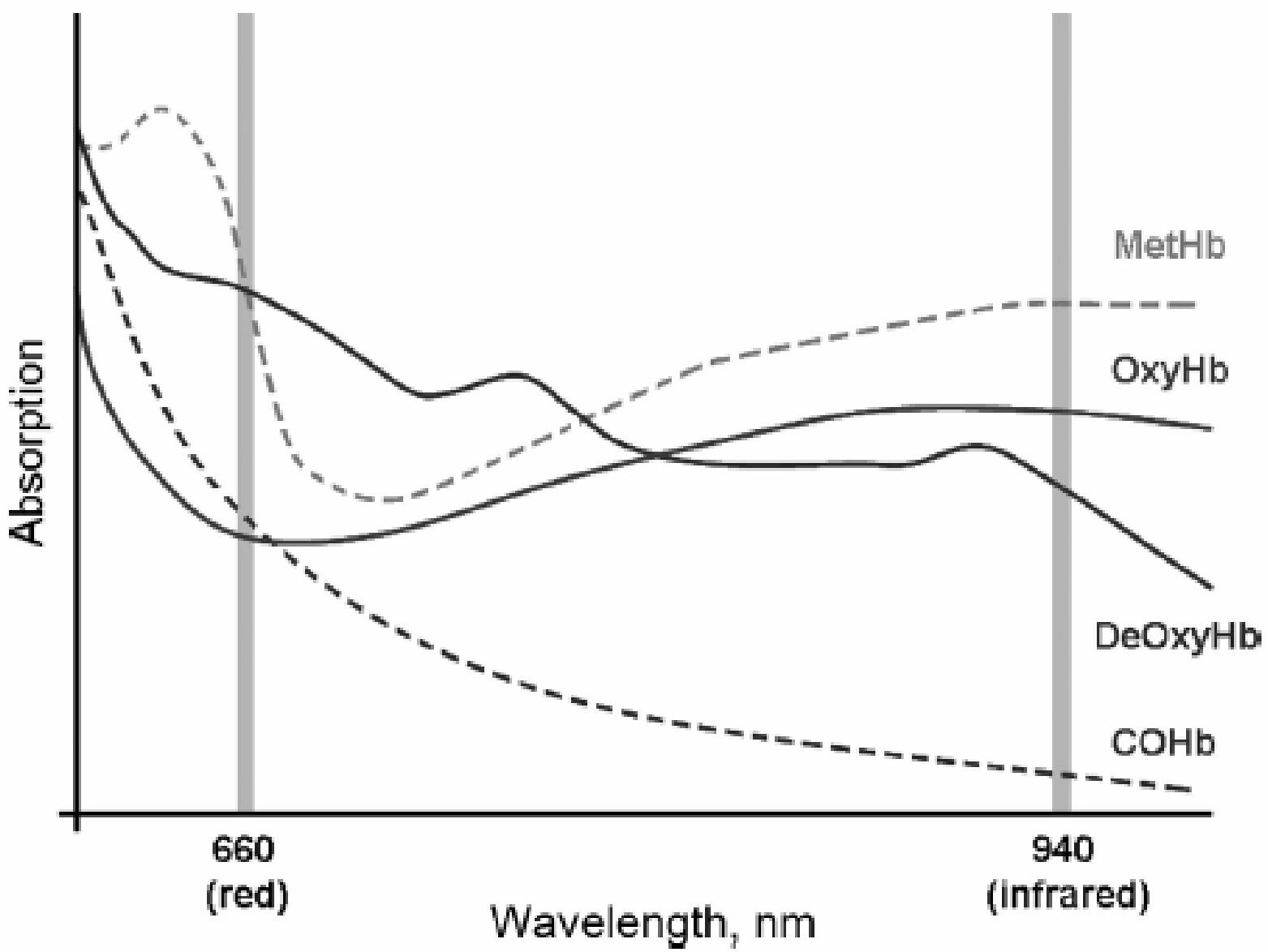
El principio de medición se basa en la, LEY DE LAMBERT-BEER

La concentración de un soluto disuelto en un solvente puede determinarse por absorción de luz (Hb en plasma)

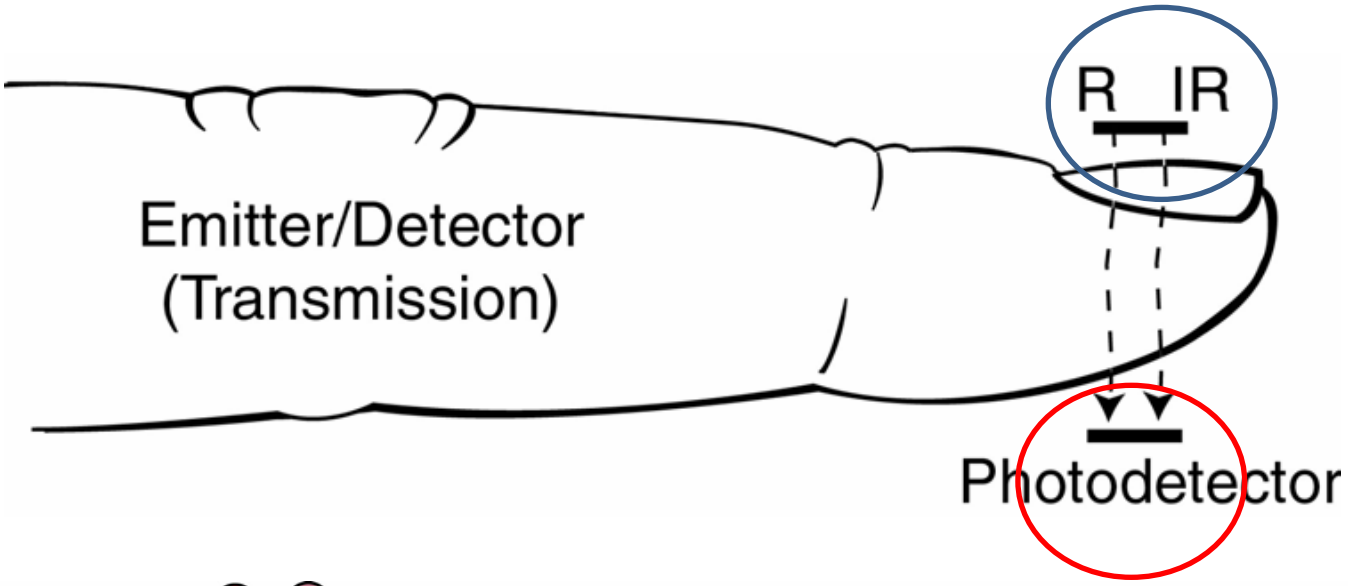
Cada soluto específico posee una constante de extinción (E) conocida.

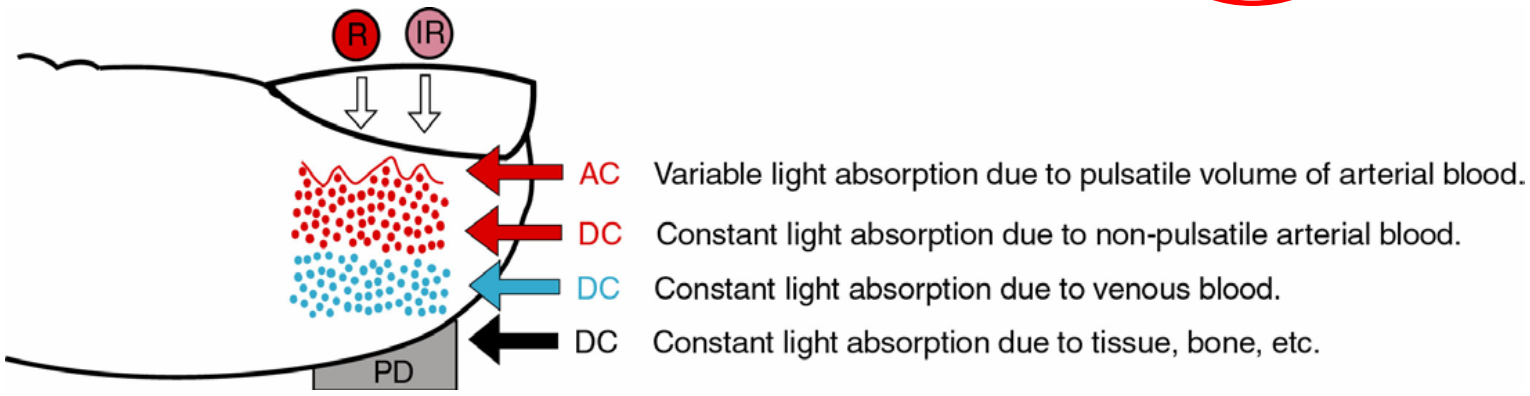
Para la hemoglobina, 'E' se halla en el rango de longitud de onda del rojo y el infrarojo


10
(RED)
660nm
(INFRARED)
910nm
HbO2
Hb
0.1
600
700
800
900
1000
WAVELENGTH (nm)


MetHb
OxyHb
DeOxyHb
COHb
Absorption
660
(red)
940
(infrared)
Wavelength, nm

Dispositivo con dos diodos luminosos, que emiten luz a una lg de onda de 910 nm (infrarrojos, absorción máxima por la oxiHb) y de 660 nm (roja, absorción máx por la Hb reducida), siendo recibida por un fotodiodo colocado en el lado opuesto.





Oximetria

- Es necesaria la presencia de pulso arterial para que el aparato reconozca alguna señal.

- Mediante la comparación de la luz que absorbe durante la onda pulsátil con respecto a la absorción basal, se calcula el porcentaje de oxihemoglobina.

$$\frac{\text{(CA luz roja/CE luz roja)}}{\text{(CA luz infrarroja/CE luz infrarroja)}} = \text{SpO}_2 \text{ arterial}$$

- Sólo se mide la absorción neta durante una onda de pulso, lo que minimiza la influencia de tejidos, venas y capilares en el resultado.

La pulsioximetria…

- No sustituye a la gasometría en la valoración completa de los enfermos respiratorios.

- Sin embargo supera a la gasometría en rapidez y en la monitorización de estos enfermos.

Desventajas respecto a la gasometría

- La pulsioximetría no informa sobre el pH ni $PaCO_2$.
- No detecta hiperoxemia.
- No detecta hipoventilación (importante en pacientes respirando aire con concentración elevada de O_2).
- Los enfermos críticos suelen tener mala perfusión periférica.

No mide hiperoxia…

- La noción esencial es que la PaO2 es necesaria para ayudar a saturar la Hb…..

…….pero permitir que la PaO2 sea alta no ofrece absolutamente ninguna ventaja, y sí riesgos.

Tener en cuenta que…

- El aporte y la entrega de oxígeno dependen del contenido de O2 y también del flujo sanguíneo a los tejidos; esto último, a su vez, depende del gasto cardíaco (frecuencia cardíaca y volumen sistólico), la postcarga, el grado de vasoconstricción o vasodilatación regional y otros factores.

Y el oxímetro esto no lo puede discriminar…

concepto fundamental

- Con una SatO2 máxima (100 %) puede haber hipoxia tisular si:
  - la [Hb] es baja
  - el gasto cardíaco disminuye
  - o el flujo local se altera.
- De modo similar, con una SatO2 “más baja” puede haber un aporte y una entrega de O2 suficientes.

Sabia que?

- La saturación hallada en las determinaciones de gases en sangre arterial (GSA) es una cifra *calculada y, por lo* tanto, no debe considerarse en la práctica clínica.

- La SatO2 informada en el análisis de GSA a menudo no tiene relación con la verdadera SatO2 arterial.

Porque es Usada la Oximetria?

- Detección superior de eisodios hipoxémicos
- Es No Invasiva
- Baja Morbilidad y muy buen adherecnia del paciente
- Más barata que la medición de gases extracción de sangre

Respiratory assessment and monitoring
Update 2012 European Society of Intensive Care Medicine.

Respiratory assessment and monitoring

Update 2012 European Society of Intensive Care Medicine.

- Ofrece la ventaja de proveer datos sobre la saturación de la hemoglobina mas que de la PO2.

- Refleja el 98% de contenido de O2 arterial que normalmente es transportado por la Hg, mientras que la PO2 mide directamente solo de la pequeña cantidad de O2 disuelto en plasma.

IMPORTANTE!!

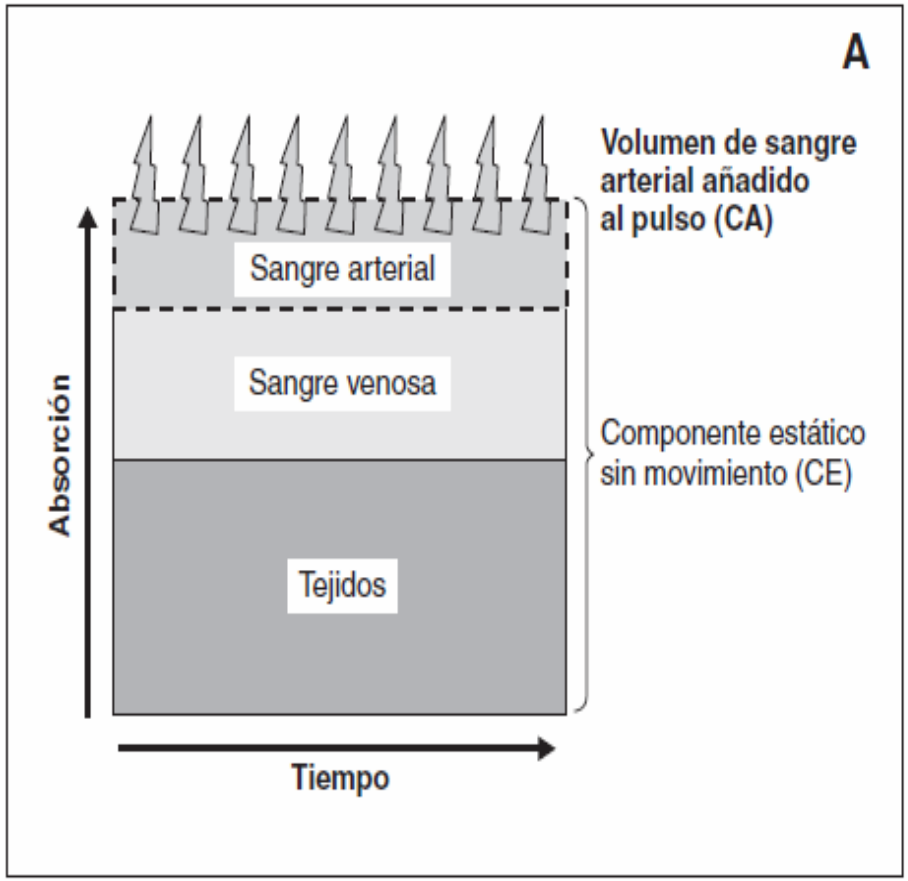
La magnitud del error en la medición de la SpO2 está influida por:

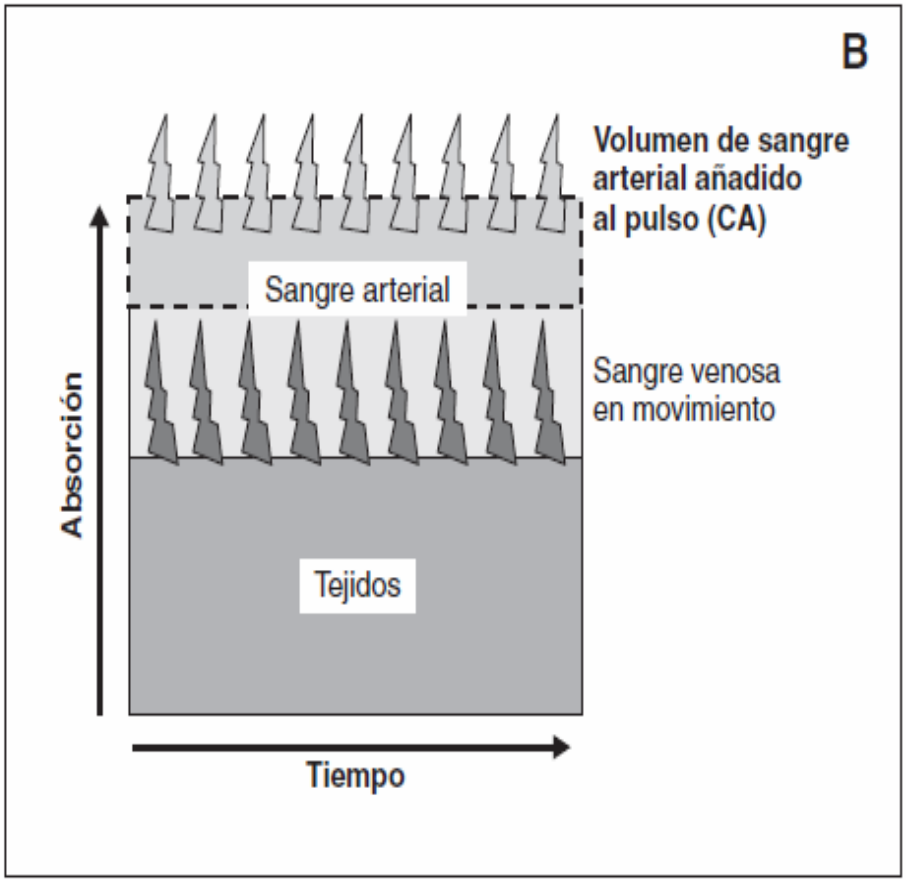
- **Perfusión, Disminución en la pulsación periférica, amplitud de la señal arterial**
- **La SatO2 venosa, que disminuye en las situaciones de bajo flujo.**
- **La magnitud de los movimientos del paciente.**
- **Interferencia con luz de la fototerapia.**
- **Los algoritmos técnicos de cada monitor de SpO2.**

Goldman L. Monitorización Ventilatoria. Hospital Infantil la Paz. Mayo de 2005.

Movimientos

- Saben por qué, cuando un paciente se mueve el registro que se ve en pantalla disminuye?
- un ajuste excesivo e innecesario del oxígeno inspirado. FALSA ALARMA.


A
Volumen de sangre arterial añadido al pulso (CA)
Sangre arterial
Sangre venosa
Componente estático sin movimiento (CE)
Tejidos
Absorción
Tiempo


B
Volumen de sangre arterial añadido al pulso (CA)
Sangre arterial
Sangre venosa en movimiento
Tejidos
Absorción
Tiempo

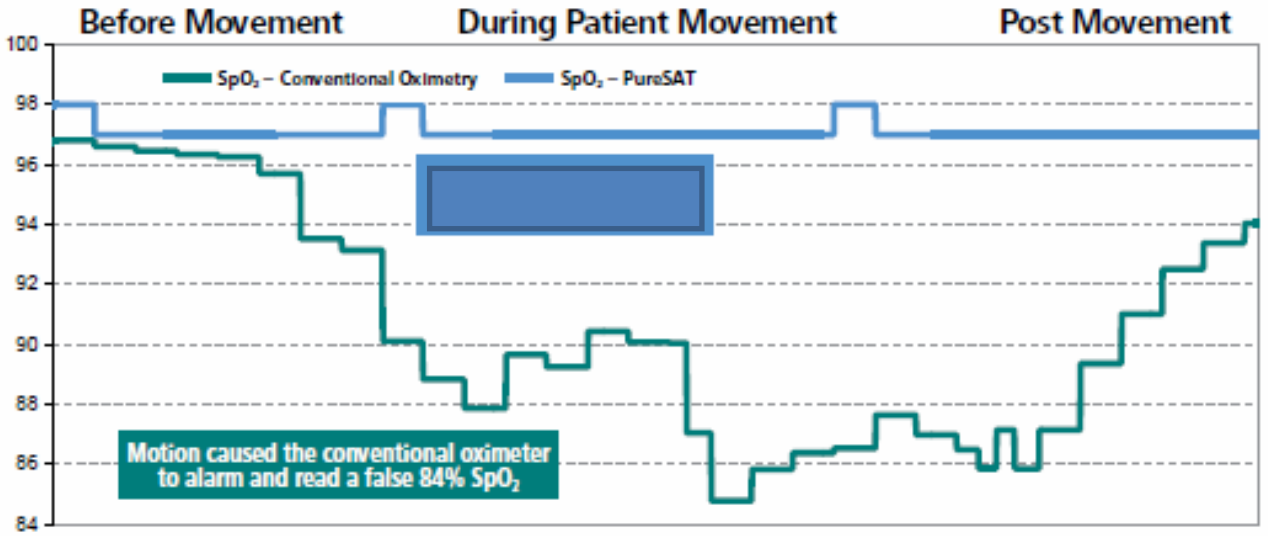
No todos los oxímetros son iguales

Detección verdadera de pulso

- Reducción de falsas alarmas, sobre todo en movimiento y en baja perfusión
- Menos tiempo para obtener lectura
  - 1 a 1.5 segundos
- Lee íntegramente la onda pletismográfica

MOTION

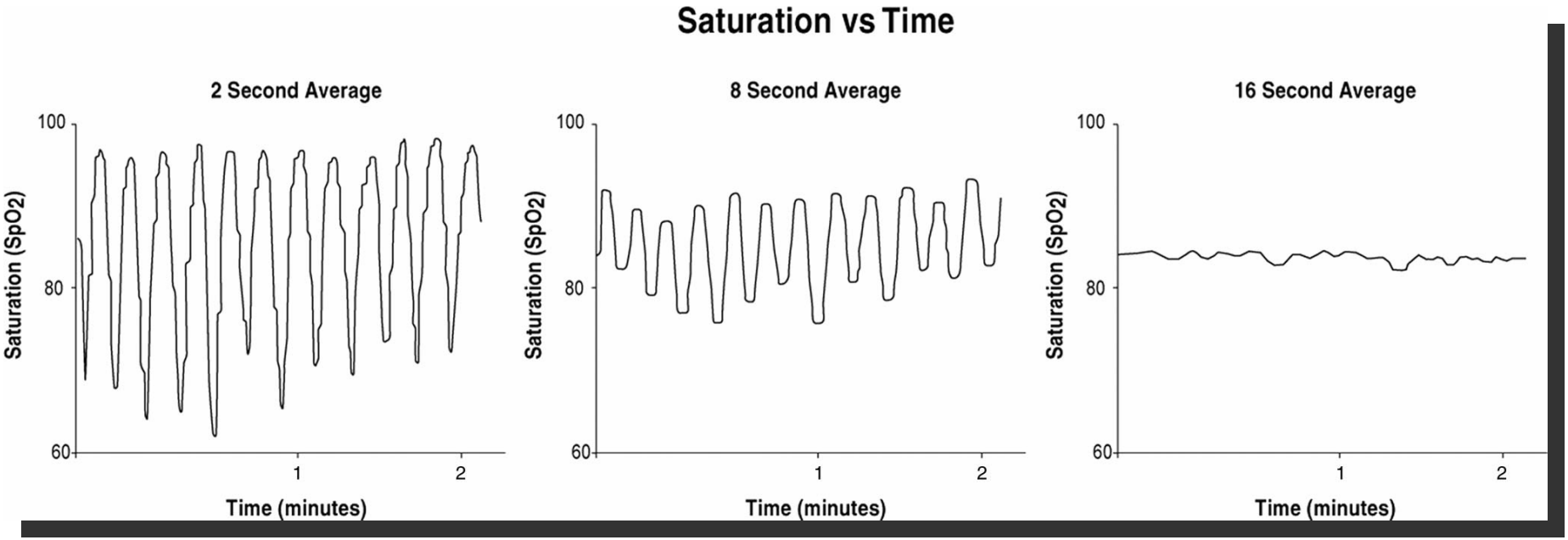
Elimination of False Alarms Due to Patient Movement[4]



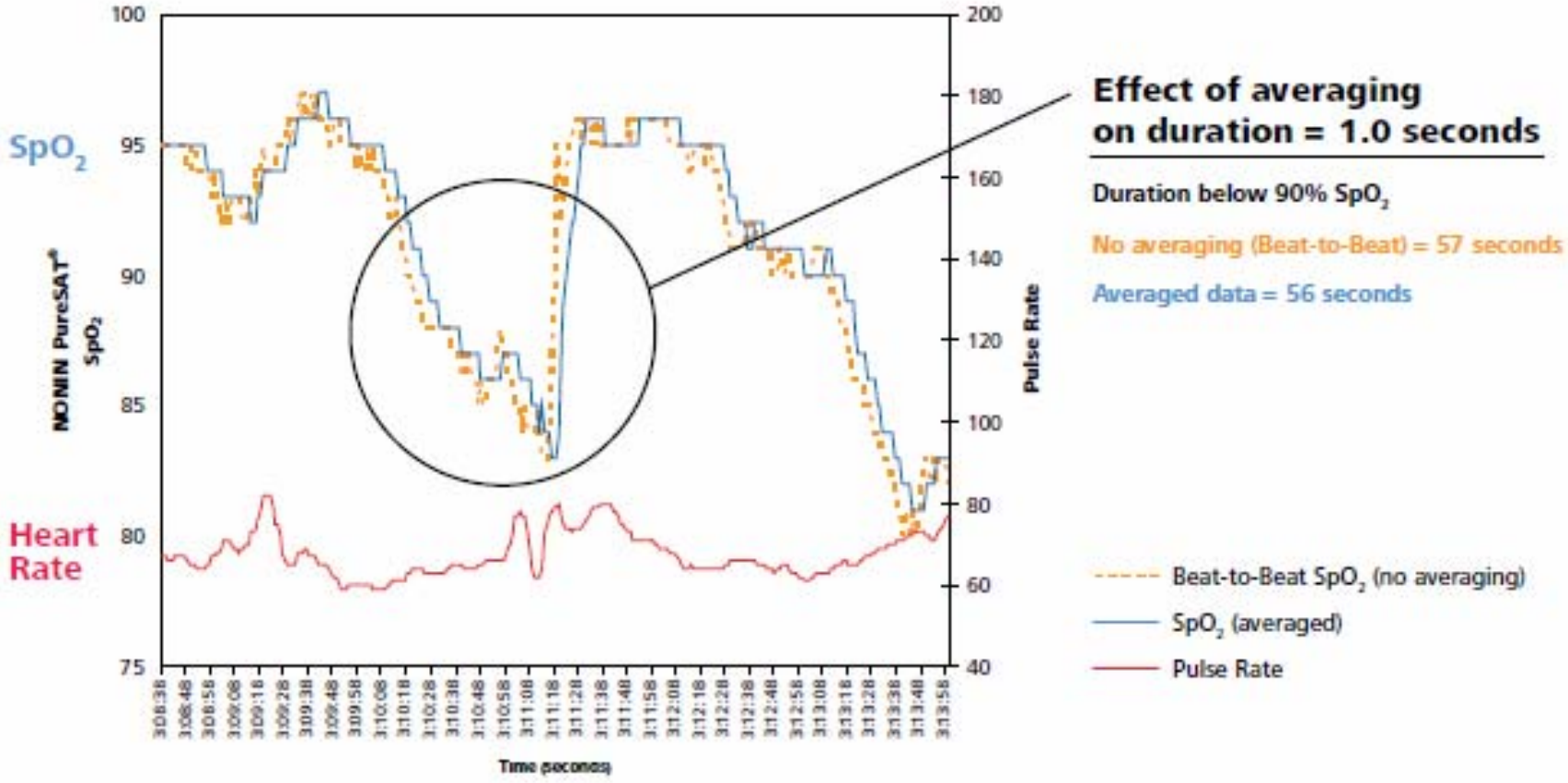
Promedio eficaz o inteligente

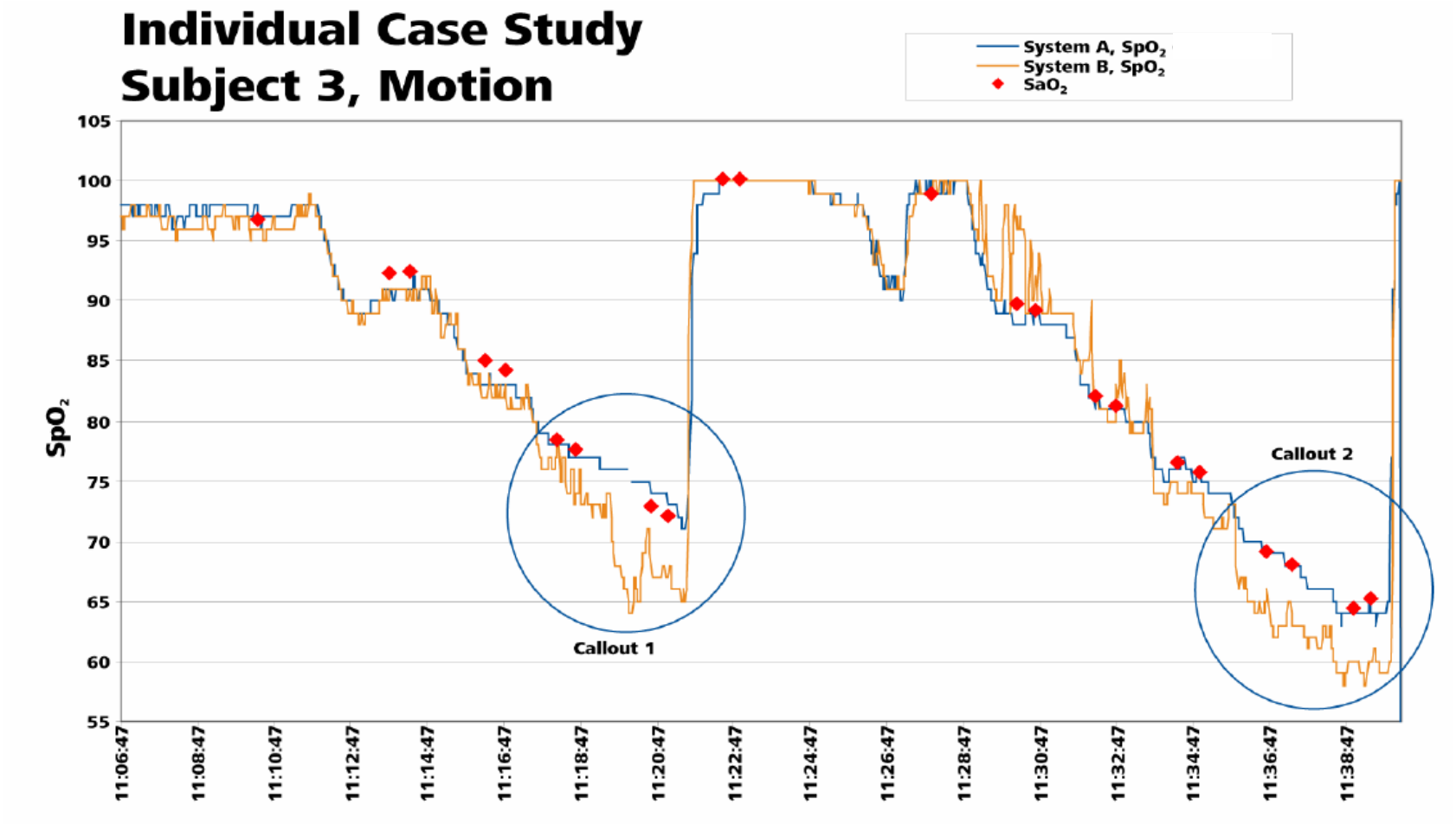
- Debe tardar 3 segundos o menos en recalcular y hacer un promedio usando pulso a pulso
- Automático
- Se Ajusta a los cambios, a mas FC mas rápida lectura

Promedio eficaz o inteligente



SpO_2 Event During Sleep




Individual Case Study
Subject 3, Motion
System A, SpO2
System B, SpO2
SaO2
SpO2
105
100
95
90
85
80
75
70
65
60
55
11:06:47
11:08:47
11:10:47
11:12:47
11:14:47
11:16:47
11:18:47
11:20:47
11:22:47
11:24:47
11:26:47
11:28:47
11:30:47
11:32:47
11:34:47
11:36:47
11:38:47
Callout 1
Callout 2

Seguridad y Perfomance

- Se comparo la seguridad de procesamiento de la señal de los sensores de dos marcas de oximetros, con el Gold Standard

- Se utilizo el **standard desaturation protocol** de la UCSF Hypoxia Research Laboratory in San Francisco, California, Enero 2005.

- 12 sujetos sanos, 7 varones, 5 mujeres

- Hipoxia inducida, hasta lograr cinco plateaux entre 60 – 100% sat.

Hypoxia Research Laboratory of the University of California

RMS

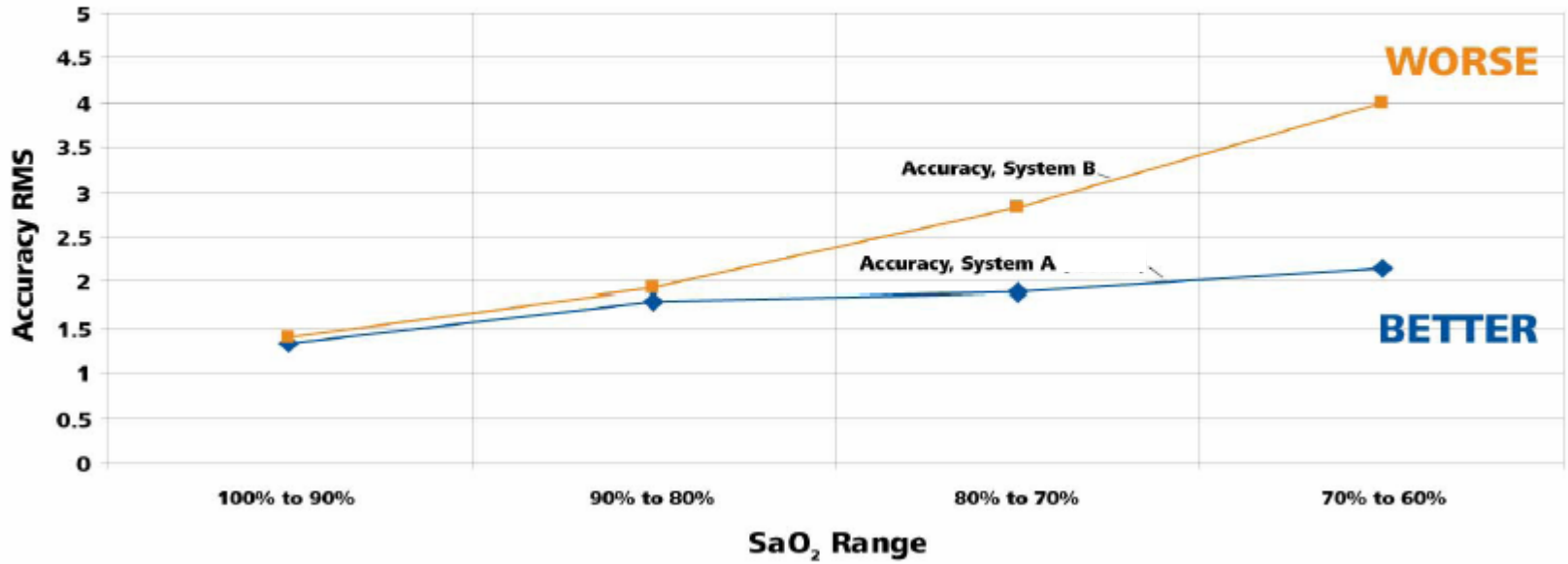
- La Medida de seguridad esta representada como Arms value, y fue calculada bajo las normas ISO 9919, Standard Specification for Pulse Oximeters.

- **Arms (RMS)**
  - (√ (BIAS2 + SD2)).

- Este es el método habitual que requiere la FDA para la representacion de la seguridad de los datos en oximetria de pulso.

Movimiento, golpeando y frotando

Table 3: Accuracy by SaO_2 Decade
(Motion – Tapping & Rubbing)



	RMS	samples	RMS	samples
	Accuracy, System A	n1	Accuracy, System B	n2
100% to 90%	1.34	93	1.40	93
90% to 80%	1.80	83	1.94	83
80% to 70%	1.90	76	2.83	77
70% to 60%	2.16	11	4.00	11

The Effects of Dark Skin Pigmentation and Low Saturation in Oximetry

METHODS

Thirty-six normal subjects underwent a standard breath-down protocol to achieve arterial oxygen saturation between 70% and 100%. The pulse oximeters tested included: NONIN Avant® 9700, Masimo Radical®, and Nellcor OxiMax® N-595. Seventeen subjects were categorized as "dark skinned" and are included in this report.

The mean and precision (SD) of the bias compared to arterial oxygen saturation, were computed. Accuracy is reported as A_{rms}, a computed value based on mean and SD of bias per FDA standards for pulse oximetry accuracy ($A_{rms} = \sqrt{Bias^2 + SD^2}$).

RESULTS

At 70% to 80% oxygen saturation, the mean bias (± S.D.) in dark skin pigmentation was minimal for NONIN's oximeter with the clip sensors at -0.6% ± 1.4, compared to the mean bias for Masimo (2.6% ± 3.0) and Nellcor (2.6% ± 2.6) oximeters with clip sensors. (Table 1)

Accuracy – a combined measure of error and variability – was excellent with the NONIN oximeter and clip sensor in dark skin subjects throughout the most challenging environments. NONIN's oximeter with the clip sensor maintained acceptable variability (per FDA Standards: A_{rms} <3.0) in the most challenging environment of dark skin pigmentation and SaO_2 less than 80%. (Figure 1)

Hypoxia Research Laboratory of the University of California

Nonin

	Bias (Mean)	Precision (SD)	Accuracy (A_{rms})
>90%	-0.5	1.0	1.1
80% – 90%	-1.1	0.8	1.4
70% – 80%	-0.6	1.4	1.6
60% – 70%	0.5	1.8	1.8
ALL Saturation Levels	-0.6	1.2	1.3

Nellcor

	Bias (Mean)	Precision (SD)	Accuracy (A_{rms})
>90%	1.3	1.4	1.9
80% – 90%	2.4	1.7	3.7
70% – 80%	2.6	2.6	3.7
60% – 70%	1.5	2.8	3.2
ALL Saturation Levels	2.0	2.1	2.9

Masimo

	Bias (Mean)	Precision (SD)	Accuracy (A_{rms})
>90%	1.4	1.7	2.2
80% – 90%	2.5	2.6	3.6
70% – 80%	2.6	3.0	3.9
60% – 70%	2.6	3.5	4.4
ALL Saturation Levels	2.1	2.9	3.6

Bias (Mean) = Mean Differences Between Oximeter Readings and Co-Oximeter

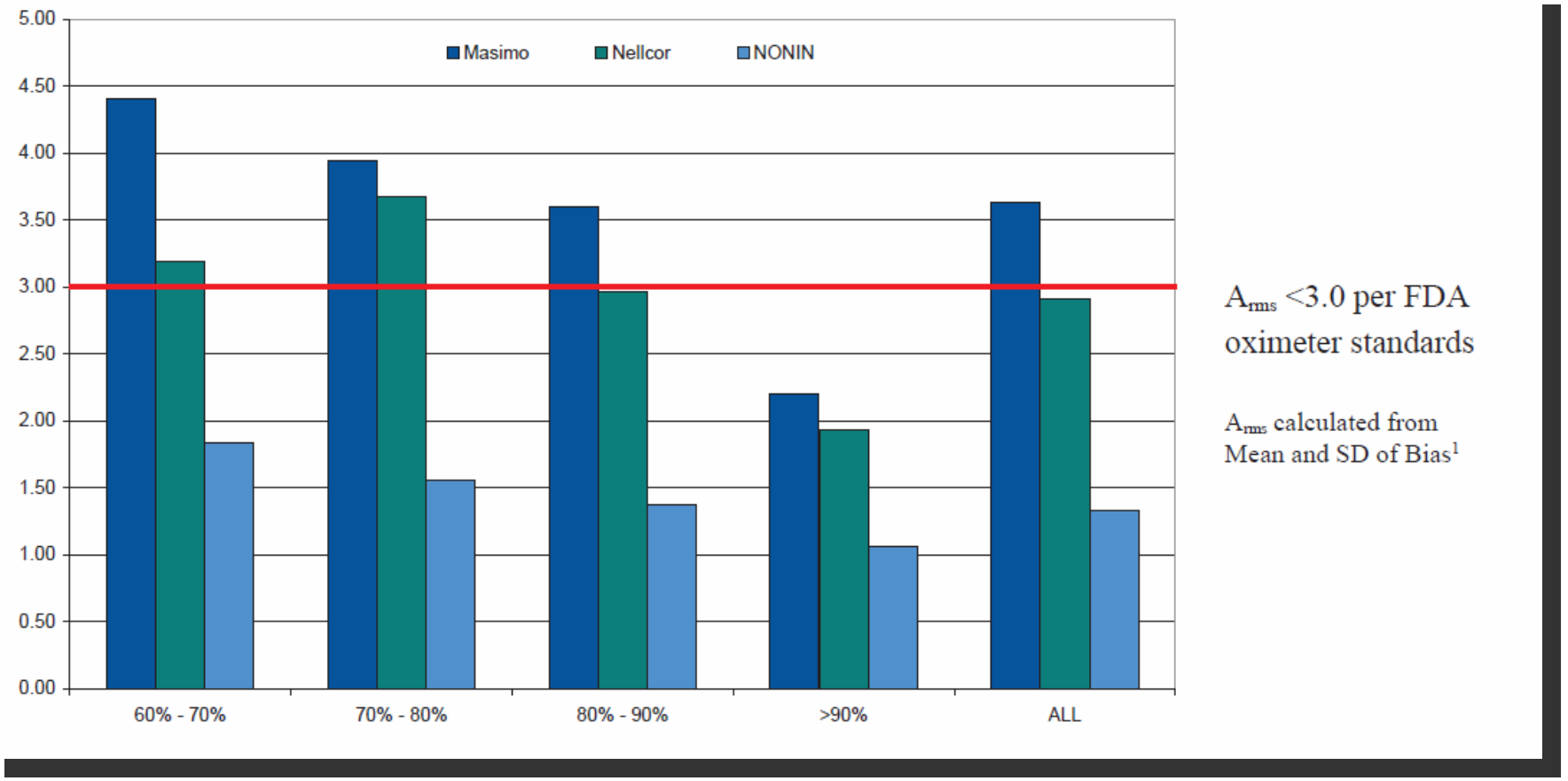
Bias is the mean of the differences between oximeter readings and the functional SpO_2 values as measured by a co-oximeter from an arterial sample. Positive bias means the test oximeter overestimates saturation. Negative bias means the oximeter underestimates the saturation. Units are in % saturation.

Precision (SD) = Standard Deviation of Differences from Co-Oximeter Measurements

Precision is the standard deviation of the difference between oximeter readings and the functional SpO_2 pt values as measured by a co-oximeter from an arterial sample. Units are percent saturation.

Accuracy (A_{rms}) = Combination of Both the Bias and the Precision

The A_{rms} accuracy is a standard method for reporting pulse oximeter accuracy which combines both the Bias and the Precision into a simple term for reporting the accuracy of the pulse oximeter. Accuracy in terms of A_{rms} is equivalent to the Square Root of the ($Bias^2 + Precision^2$).



"Dark skin decreases the accuracy of pulse oximeters at low oxygen saturations: effects of oximeter probe type and gender", John Feiner, et al. *Anesthesia & Analgesia*, December, 2007.

Ejemplos de mediciones estándares o Guías 88% - 92%

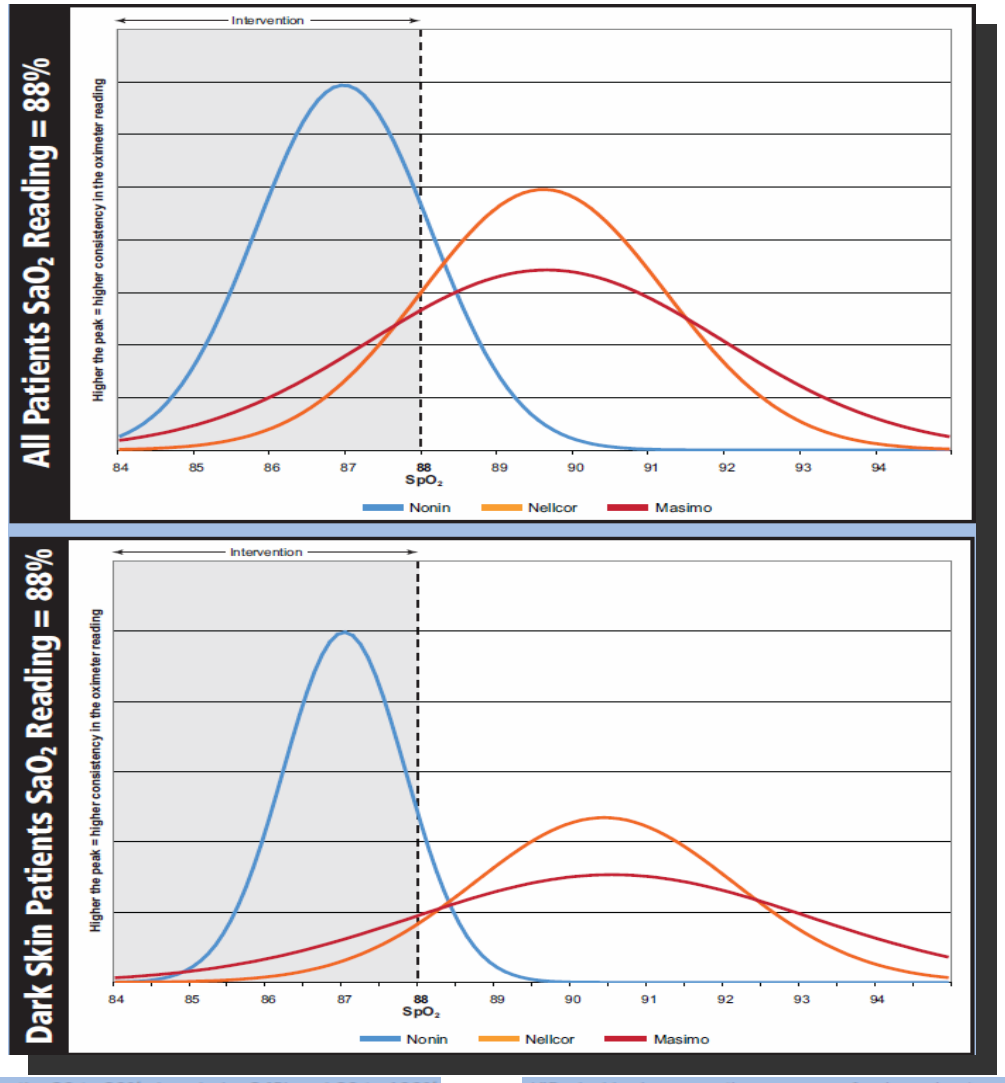
a) 88% saturation level is referenced by Medicare to authorize reimbursement for supplemental oxygen at home.

b) 88% is referenced by AARC clinical guidelines – oxygen therapy in acute settings preterms/neonates

c) Oxygen Therapy: Guidelines for Monitoring (Dec2005) reference both 88% and 92% saturation levels.

d) American Thoracic Society – Standards for the Diagnosis and Management of Patients with COPD – references 88% as the saturation level for oxygen intervention.

Actual CO-Oximetry SaO_2 Reading = 88%

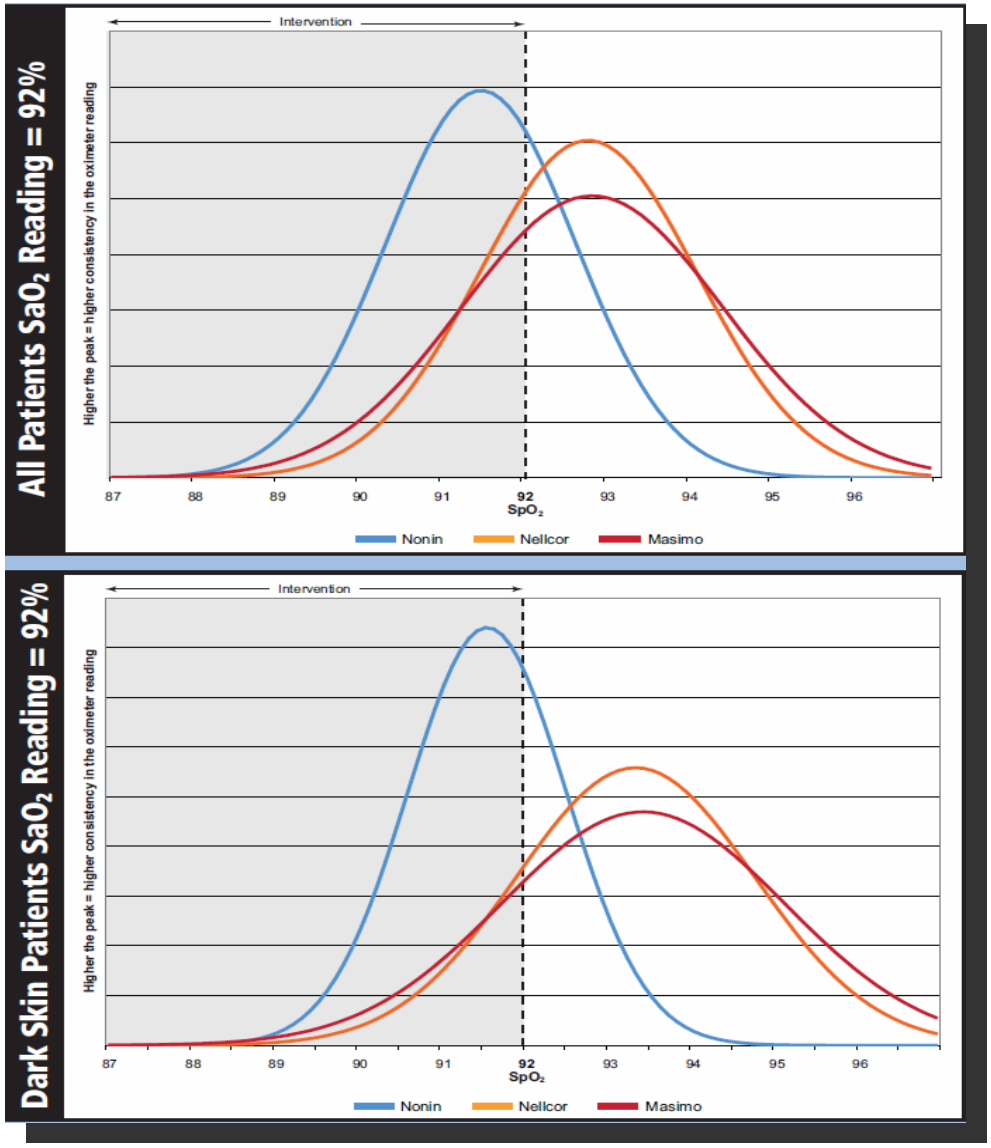


*Using the mean and standard deviation from the 80 to 90% decade (n=243) and 90 to 100% decade (n=281), the normal distribution curves were created to explain accuracy.

**"Dark skin decreases the accuracy of pulse oximeters at low oxygen saturations: effects of oximeter probe type and gender", John Feiner, et al. *Anesthesia & Analgesia*, December, 2007

Hypoxia Research Laboratory of the University of California

Actual CO-Oximetry SaO_2 Reading = 92%



COMENTARIOS FINALES….

DE OXIMETRIA!

- El uso de pulsioximetría para la evaluación y monitorización de pacientes está bien establecida en los entornos de cuidados críticos, anestesiología y servicios de urgencias. [2]

- En años recientes, la disponibilidad de pulsioxímetros pequeños, fáciles de usar, portátiles y económicos, ha abierto el potencial para el uso de esta técnica en una amplia gama de situaciones clínicas, entre ellas la de atención Primaria. [1]

2. National Health Service (UK) Center for Evidence based Purchasing. 2009. Project initiation document: Pulse oximeters.
1. Schermer T, et al. 2009. Pulse oximetry in family practice: indications and clinical observations in patients with COPD. *Fam Pract 26(6):524-31.*

- Si bien la pulsioximetría resulta como un auxiliar útil para la toma de decisiones clínicas, no sustituye a la evaluación clínica ni es suficiente para un diagnóstico por sí sola.[1]

- Las mediciones de gas en sangre arterial, obtenidas por punción arterial, siguen siendo el criterio de referencia de la saturación de oxígeno.[2]

2. National Health Service (UK) Center for Evidence based Purchasing. 2009. Project initiation document: Pulse oximeters.
1. Schermer T, et al. 2009. Pulse oximetry in family practice: indications and clinical observations in patients with COPD. *Fam Pract 26(6):524-31.*

Alabama Department of Public Health

HOSPITAL GUIDELINES FOR IMPLEMENTING PULSE OXIMETRY SCREENING FOR CRITICAL CONGENITAL HEART DISEASE

ADPH
ALABAMA DEPARTMENT OF PUBLIC HEALTH

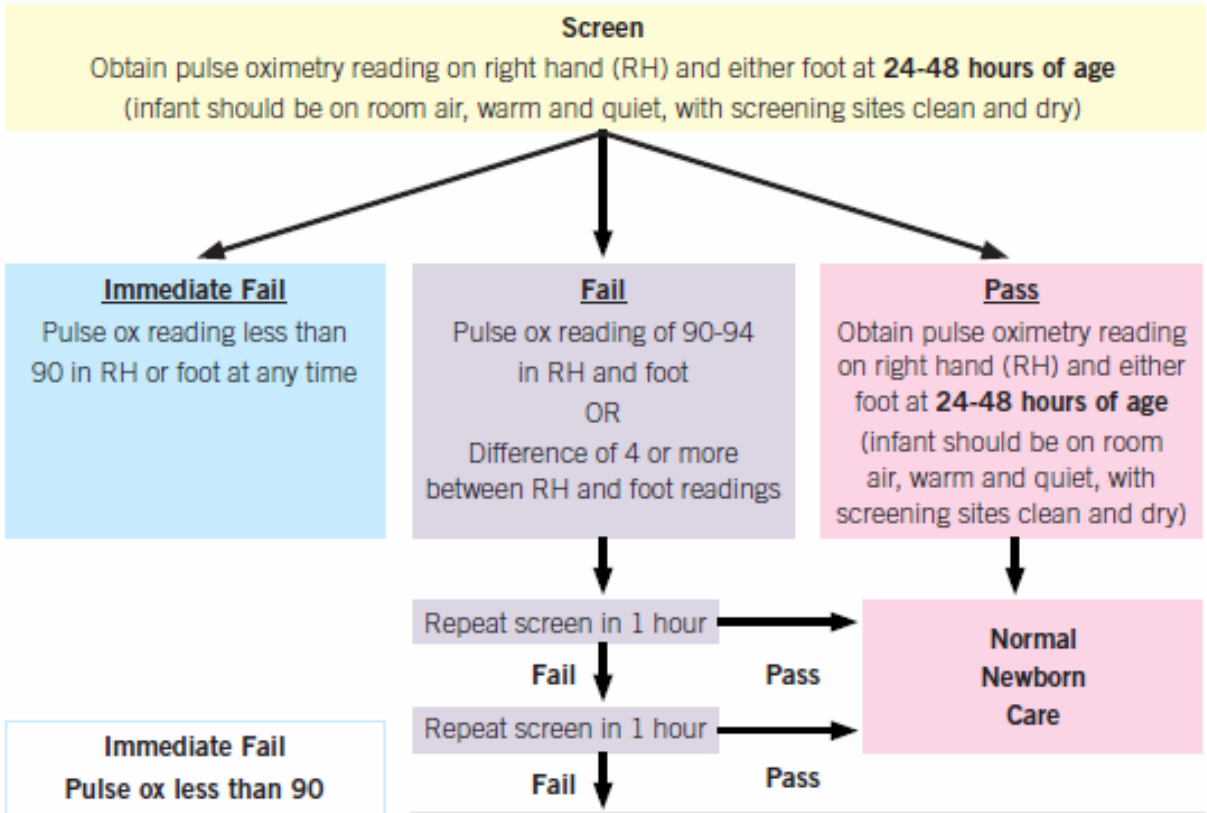
Alabama Newborn Screening Program

Children's National Medical Center

Newborn Screening 201 Monroe Street, Suite 1350 Montgomery, AL 36130-3017 Phone 1-866-928-6755 Fax 334-206-3791

March 2012

PULSE OX SCREENING ALGORITHM



Immediate Fail

Pulse ox less than 90

- Perform immediate evaluation for causes of hypoxemia including infectious and pulmonary pathology.
- If no other etiology is found, immediate echocardiogram interpreted by a pediatric cardiologist is indicated. This may require transfer to an NICU with pediatric cardiology services.

Failed Screen

Pulse Ox 90-94 or RH/foot difference of 4 or more x 3

- Perform comprehensive evaluation for causes of hypoxemia including infectious and pulmonary pathology.
- If no other etiology is found, consultation with pediatric cardiology or neonatology is indicated to arrange for a diagnostic echocardiogram to be interpreted by a pediatric cardiologist. This may require telemedicine, transfer to an NICU with pediatric cardiology services, discussion with cardiology services, or discussion with cardiology to schedule a timely outpatient echocardiogram.

Condiciones de los equipos

SECTION 1 – EQUIPMENT

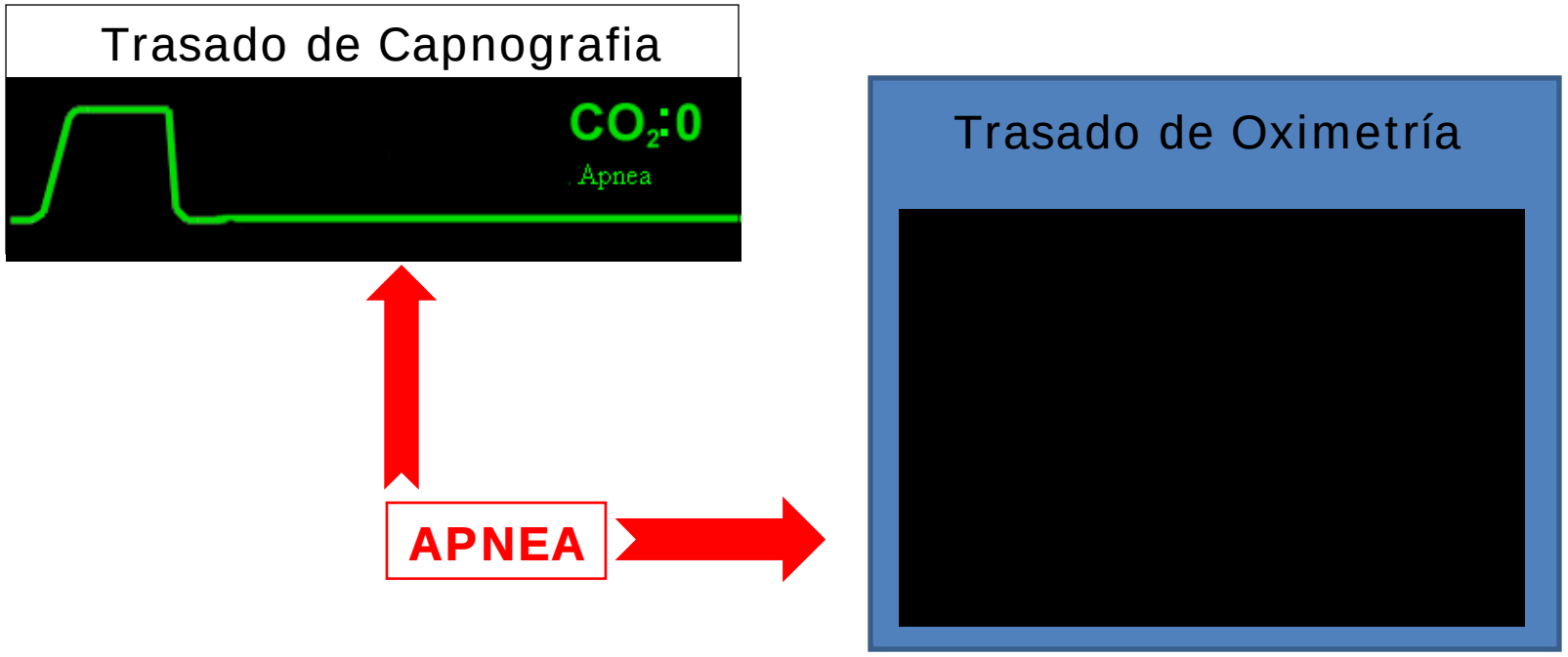
Each birthing facility will be responsible for selecting and securing pulse oximeter equipment for screening newborns for CCHD, if appropriate equipment is not already available. Such equipment must be compliant with national standards and adhere to the following:

- Must be motion-tolerant and report functional oxygen saturation.
- Must be validated in low-perfusion conditions.
- Must have been cleared by the FDA for use in newborns.
- Must have 2% root, mean-square accuracy.
- Must be calibrated regularly based on manufacturer guidelines.

Y MUY IMPORTANTE!!!

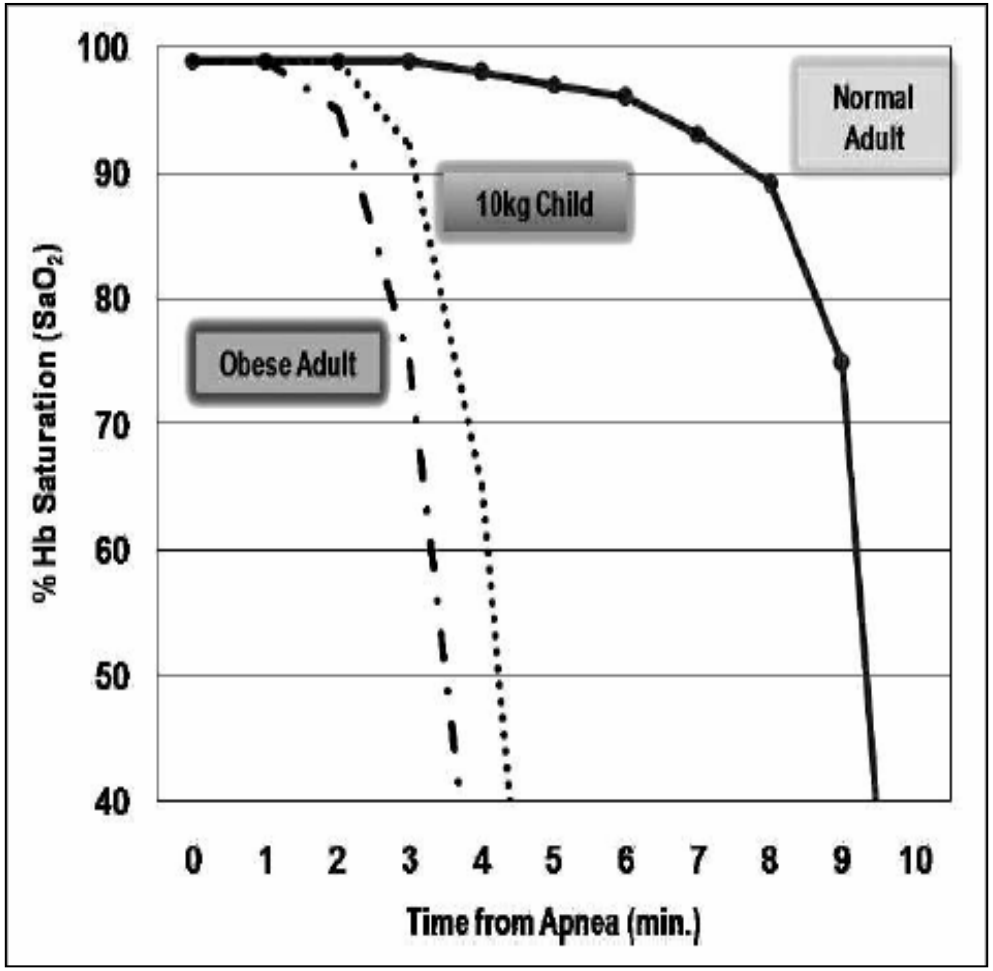
Y pasamos a otro tema…

- Numerosos artículos, demuestran que la capnogarfía capta lo que la Oximetría puede esconder…



Capnography website. Harvard Medical School, 2006

Caída de la SaO2 post Apnea



Anesth Prog 56:14 -22 2009 Respiratory Monitoring: Physiological and Technical Considerations Daniel E. Becker, DDS* and Andrew B. Casabianca, DMD, MD

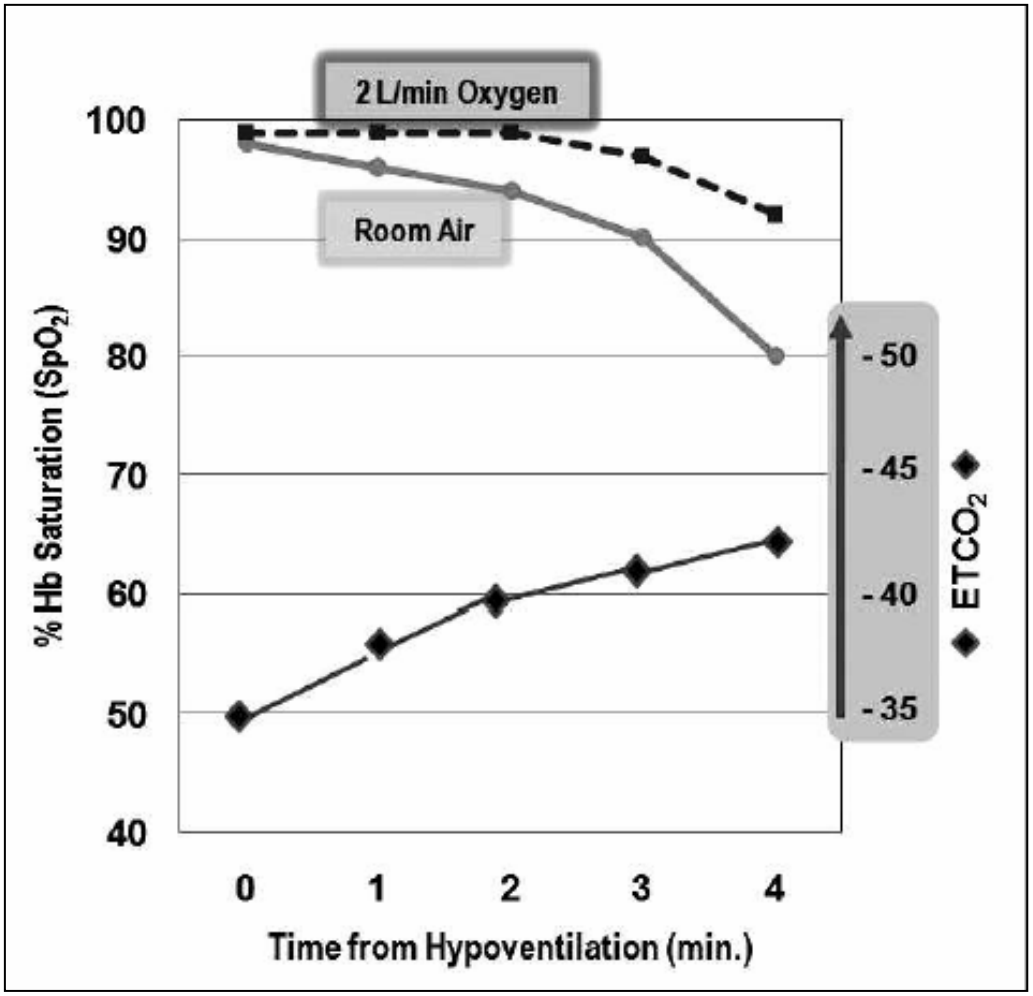
A tener en cuenta

- Un campo de importante de aplicación es la evaluación de las terapias en pacientes que deben recibir durante la noche, oxigeno suplementario y en pacientes que reciben soporte ventilatorio.

- Supplemental oxygen increases oxygen concentration in the functional residual capacity and will delay the onset of hypoxemia should the patient experience airway obstruction, hypoventilation, or apnea.

Anesth Prog 56:14 -22 2009 Respiratory Monitoring: Physiological and Technical Considerations Daniel E. Becker, DDS* and Andrew B. Casabianca, DMD, MD

O2 suplementario y tiempo de Hipoventilación

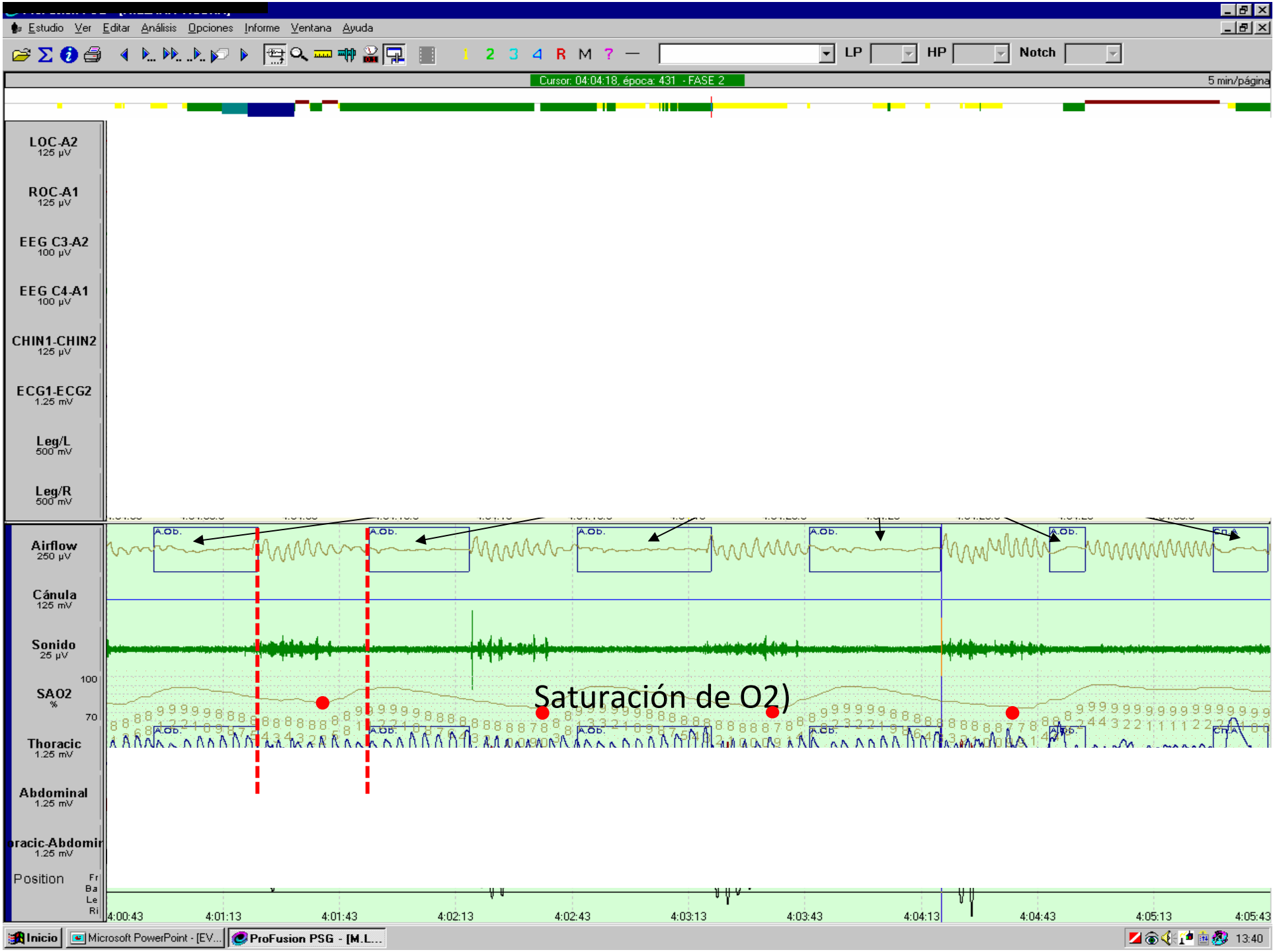


Anesth Prog 56:14 -22 2009 Respiratory Monitoring: Physiological and Technical Considerations Daniel E. Becker, DDS* and Andrew B. Casabianca, DMD, MD

Capnografía y Oximetría de Pulso, es la combinación de monitoreo “ideal” para el cuidado standard en muchas situaciones clínicas

Oximetría de pulso → **Indirecta** → Oxigenación

Capnografía → **Directa** → Ventilación


Estudio Ver Editar Análisis Opciones Informe Ventana Ayuda
LP HP Notch
Cursor: 04:04:18, época: 431 - FASE 2
5 min/página
LOC-A2 125 µV
ROC-A1 125 µV
EEG C3-A2 100 µV
EEG C4-A1 100 µV
CHIN1-CHIN2 125 µV
ECG1-ECG2 1.25 mV
Leg/L 500 mV
Leg/R 500 mV
Airflow 250 µV
Cánula 125 mV
Sonido 25 µV
SAO2 %
100
70
Thoracic 1.25 mV
Abdominal 1.25 mV
Position
Fr
Ba
Le
Ri
Saturación de O2)
4:00:43
4:01:13
4:01:43
4:02:13
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4:03:13
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4:04:43
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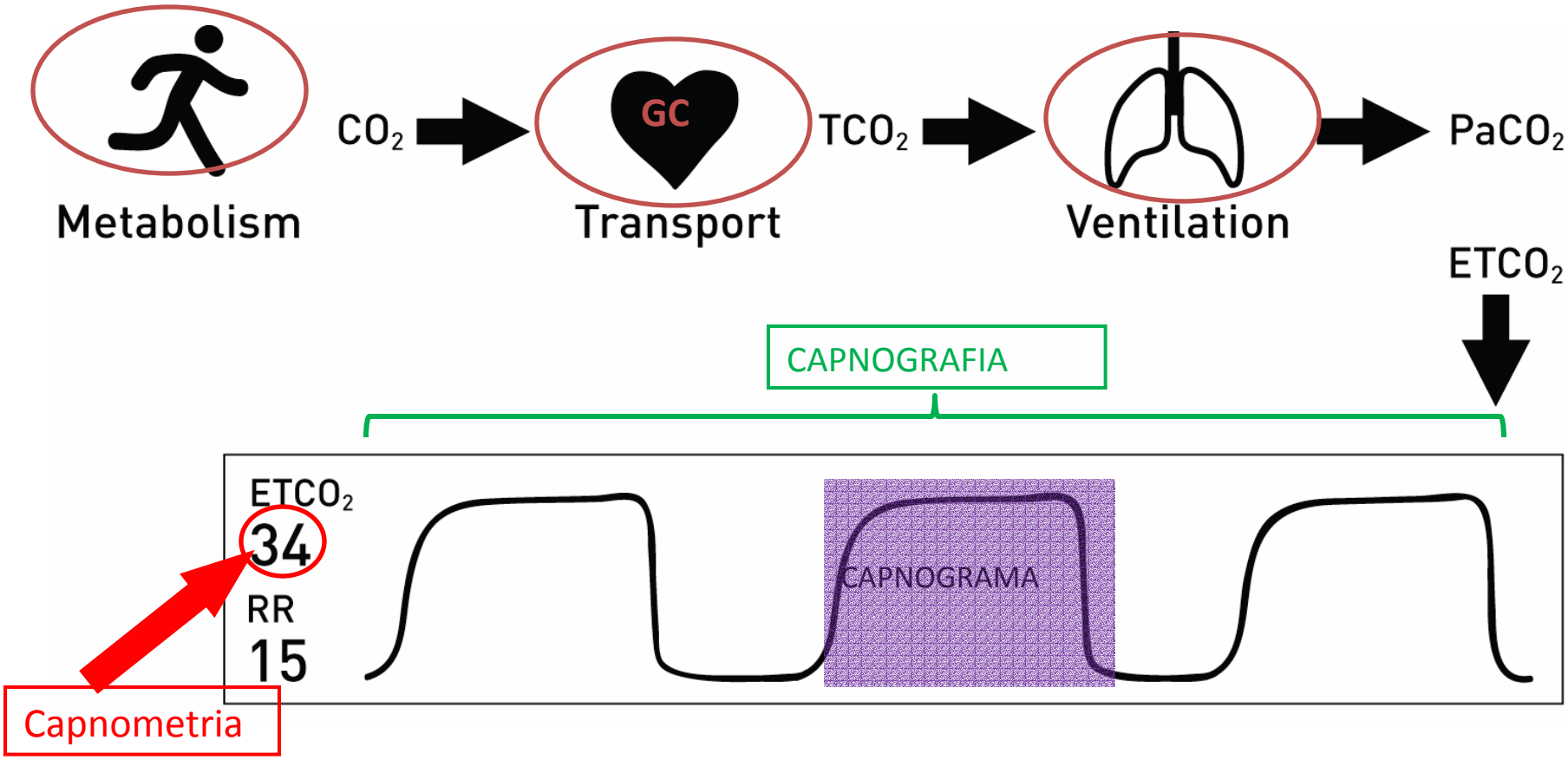
Inicio
Microsoft PowerPoint - [EV...
ProFusion PSG - [M.L...
13:40

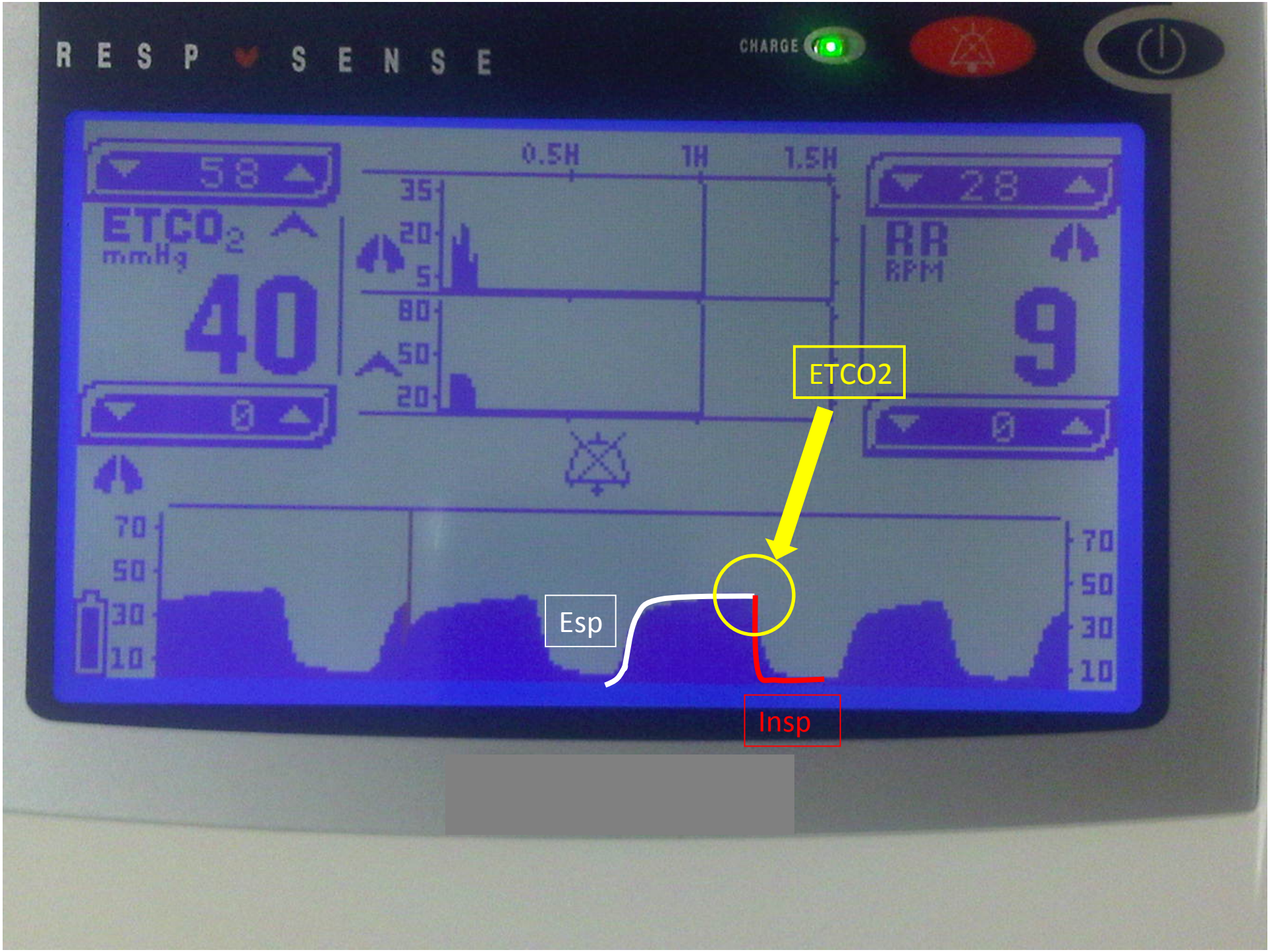
ETCO2

Fisiología del CO2



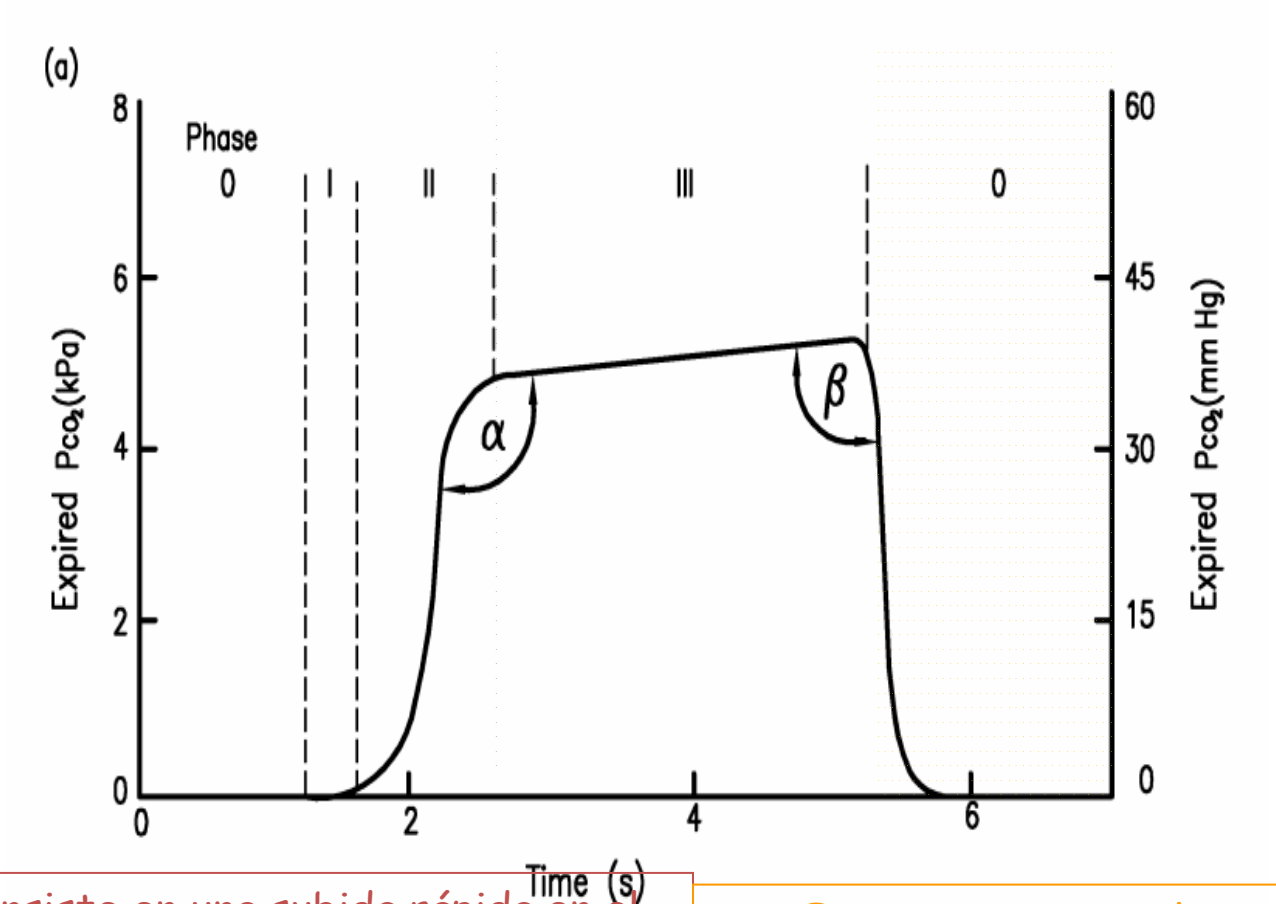
EN TIEMPO REAL!

Describimos la curva?


RESP SENSE
CHARGE
0.5H
1H
1.5H
58
ETCO2
mmHg
40
35
20
5
80
50
20
28
RR
RPM
9
70
50
30
10
ETCO2
Esp
Insp

FASE I : Representa el inicio de la espiración, gas que primero se espira libre de CO_2, procedente del espacio muerto anatómico y del circuito anestésico.

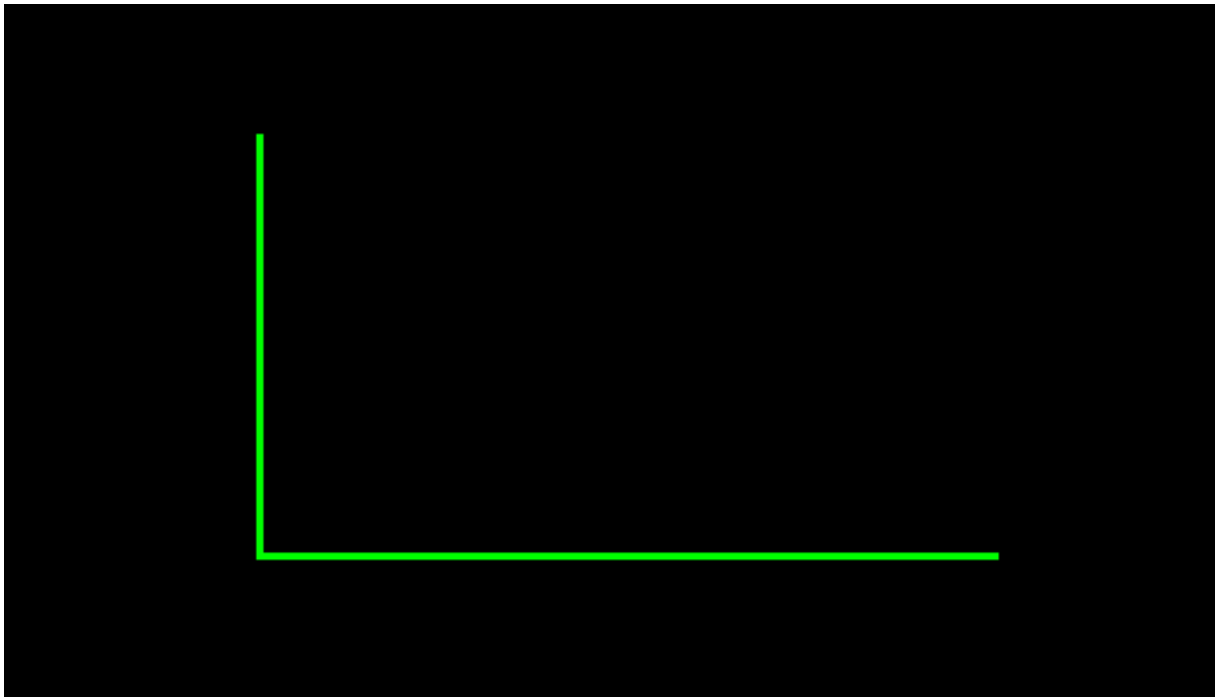
FASE III: Fase de meseta alveolar; gas rico en CO_2 procedente totalmente de los alveolos. Normalmente la concentración de CO_2 alcanza su máximo al final de la espiración (end-tidal CO_2). Pendiente ascendente (alveolos lentos).



FASE II: Consiste en una subida rápida en el trazado debido al aumento de la concentración de CO_2 por la mezcla de gas procedente del espacio muerto anatómico y gas procedente de los alveolos

FASE O : Representa el inicio de la siguiente inspiración cuando el capnograma cae rápidamente hasta su línea basal.

LA $PEtCO_2$ SE CONSIDERA UNA MEDIDA INDIRECTA DE LA PRESIÓN ARTERIAL DE CO_2



- Normal entre 2-5 mm Hg
- Es un índice del espacio muerto alveolar

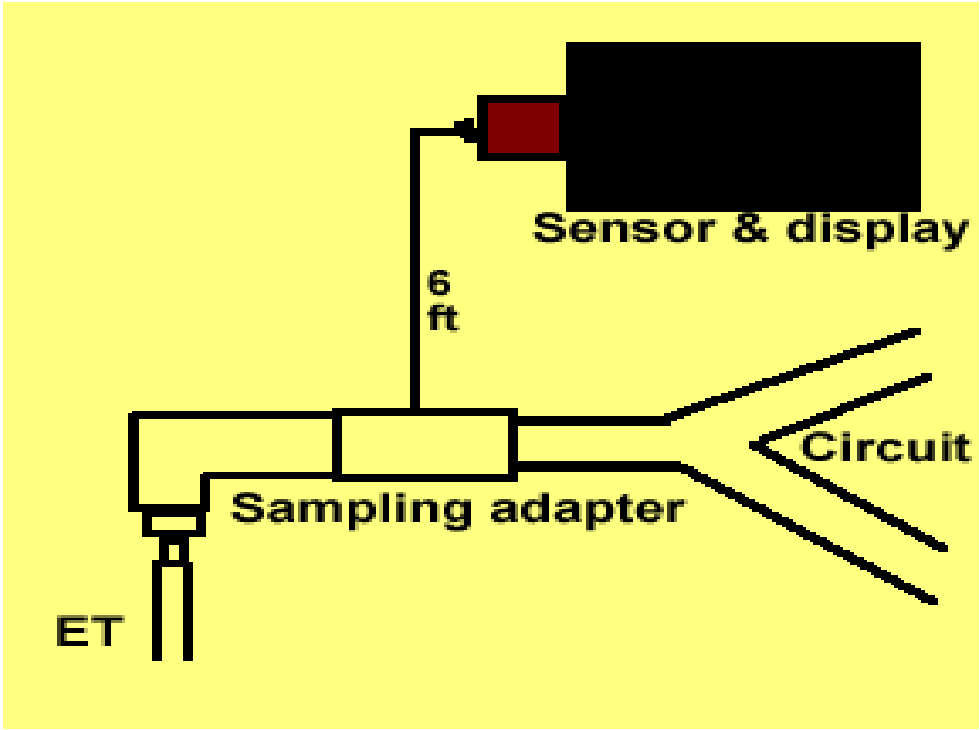
Gradiente $PaCO_2$-$EtCO_2$

Como se mide el CO2 Espirado?

- 2 Métodos
  - Sidestream
  - Mainstream

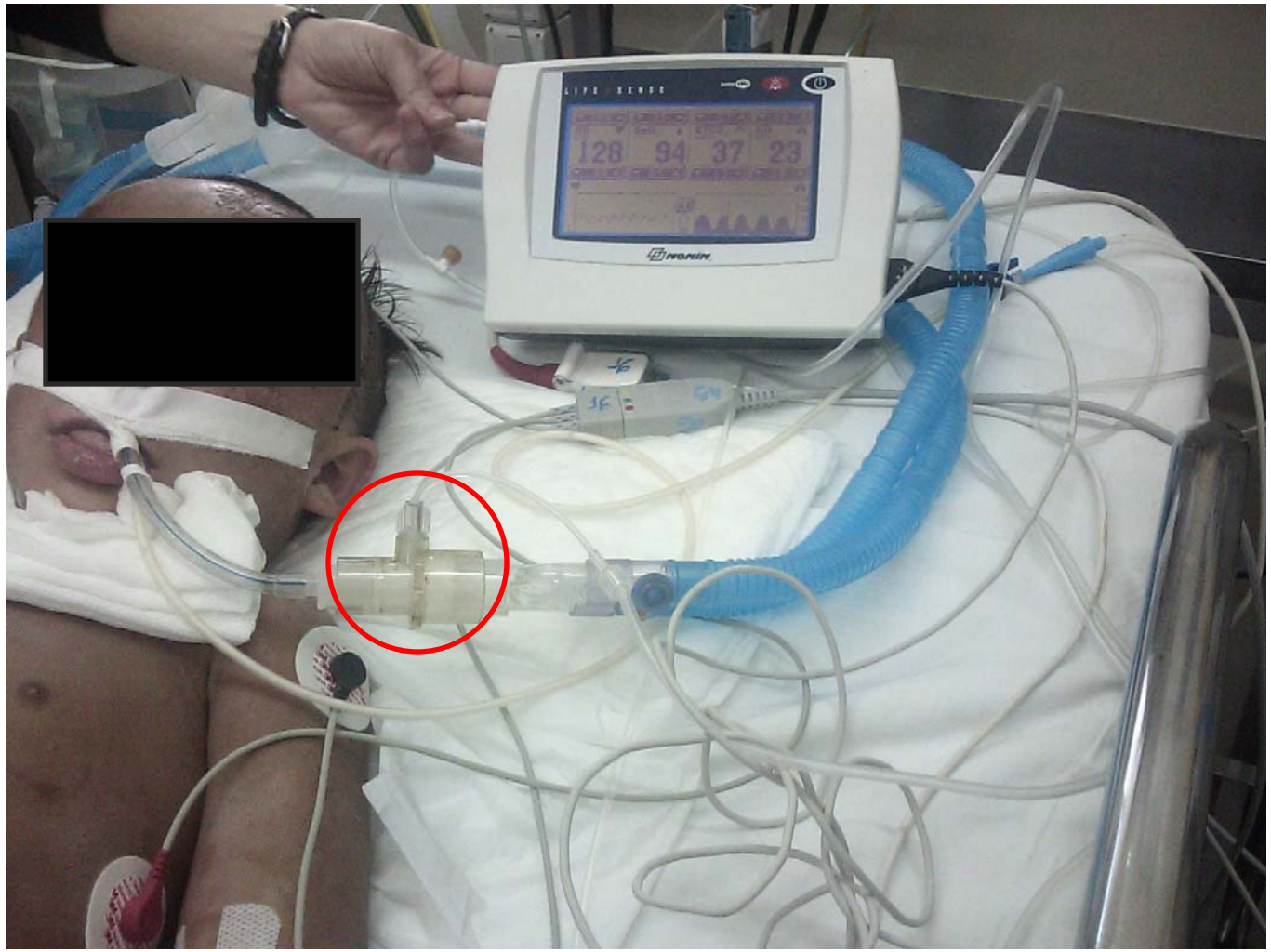
TÉCNICAS DE MUESTREO DEL GAS

- Monitores de flujo lateral "side stream"

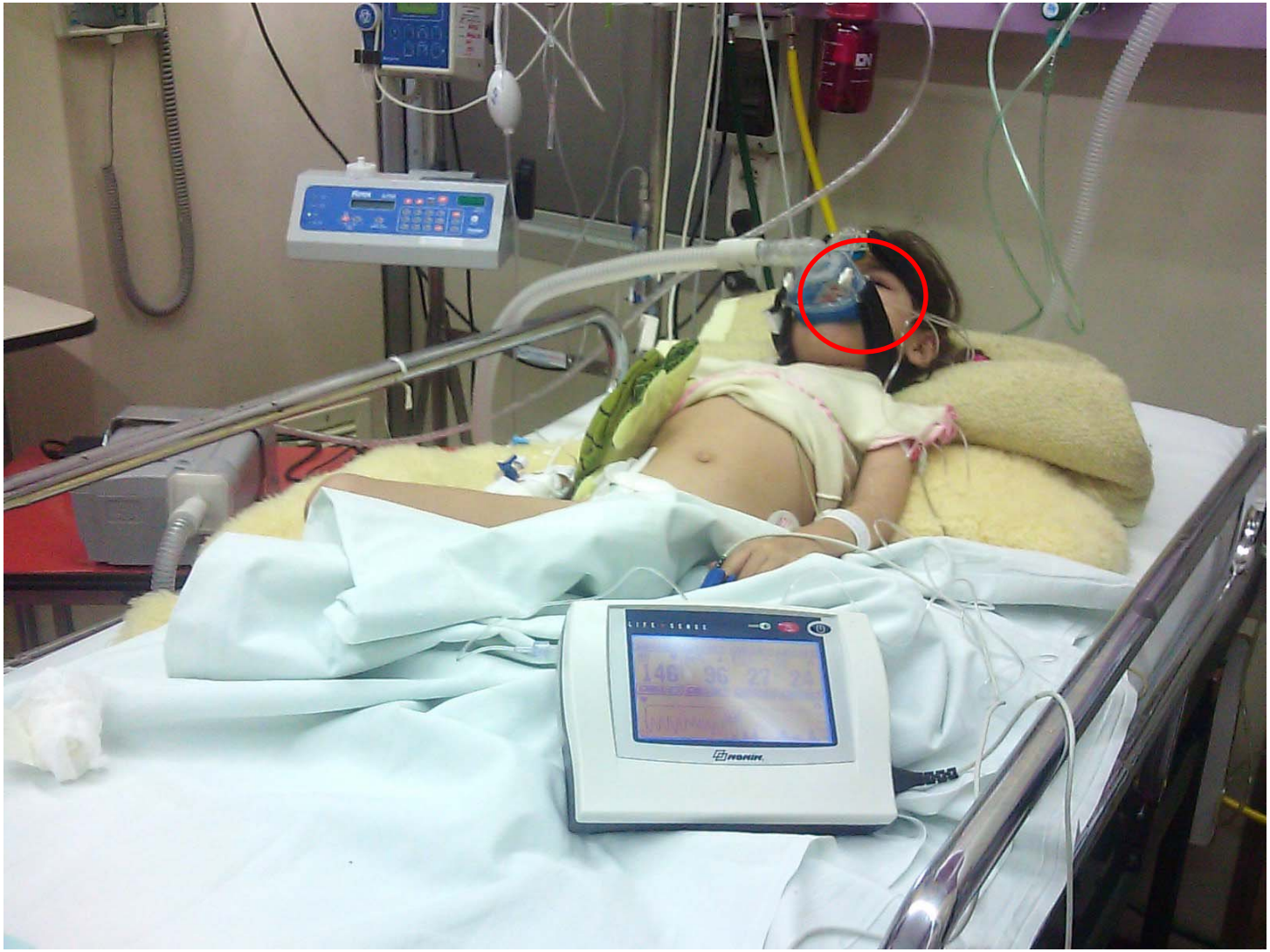


El sensor está situado en la unidad principal y el CO_2 es aspirado por un tubo de muestreo conectado a una pieza en T entre el paciente , (TET) y el circuito respiratorio.

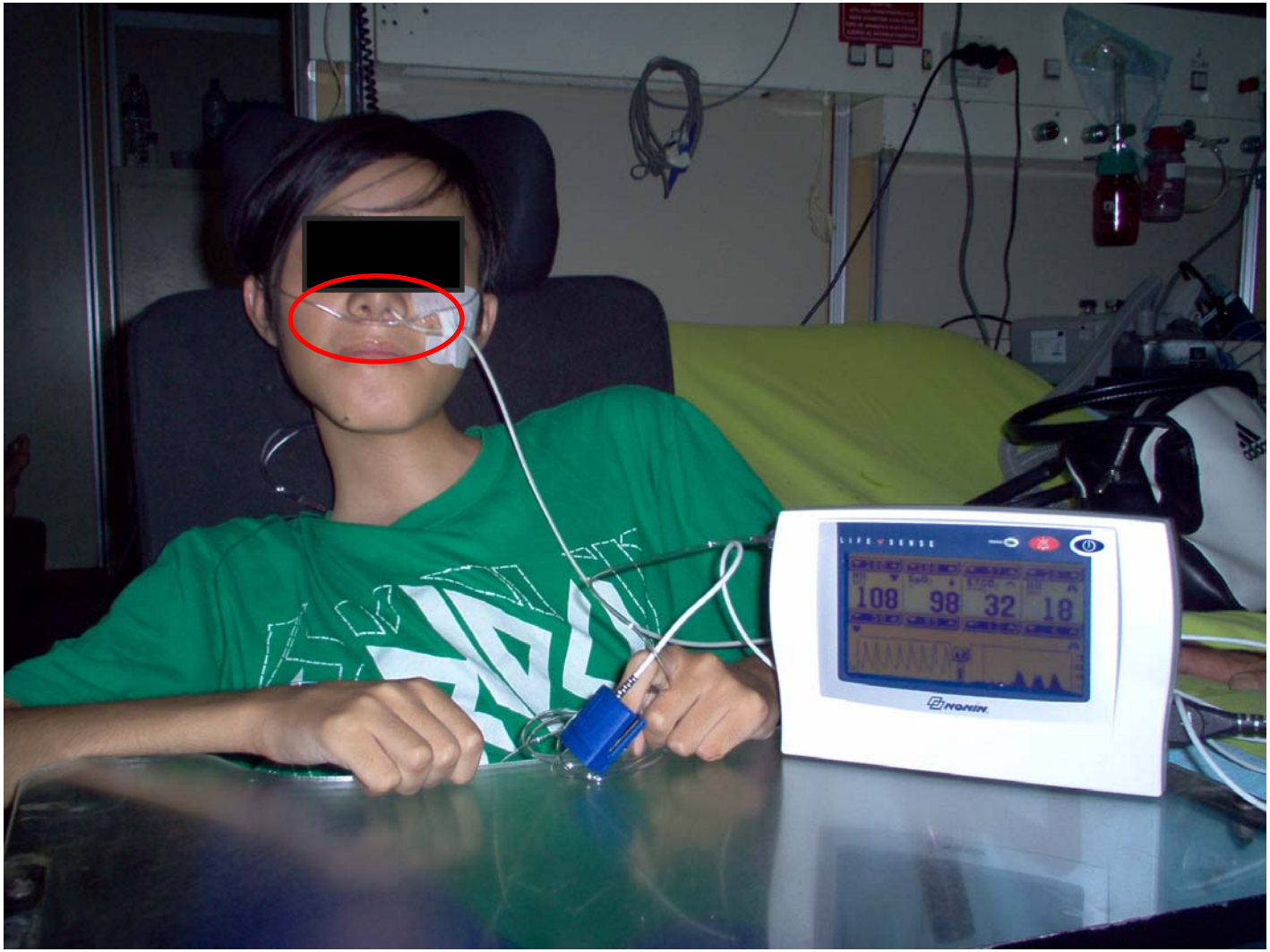
Pacientes intubados



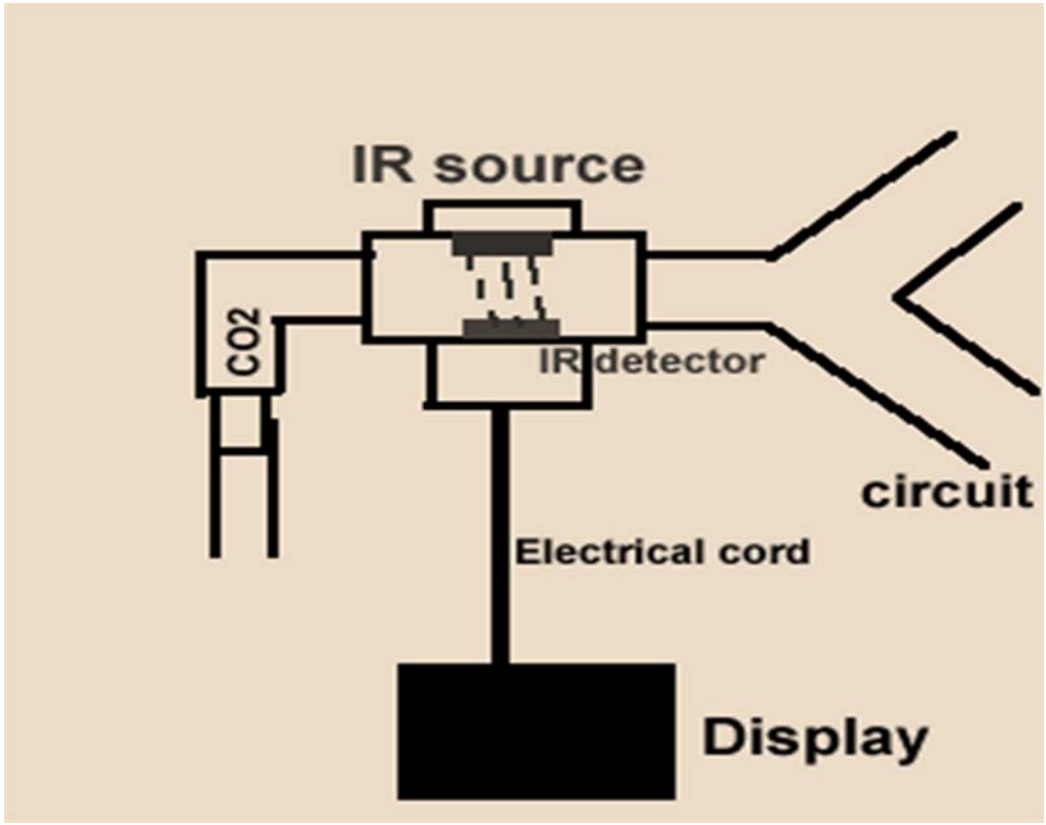
VNI



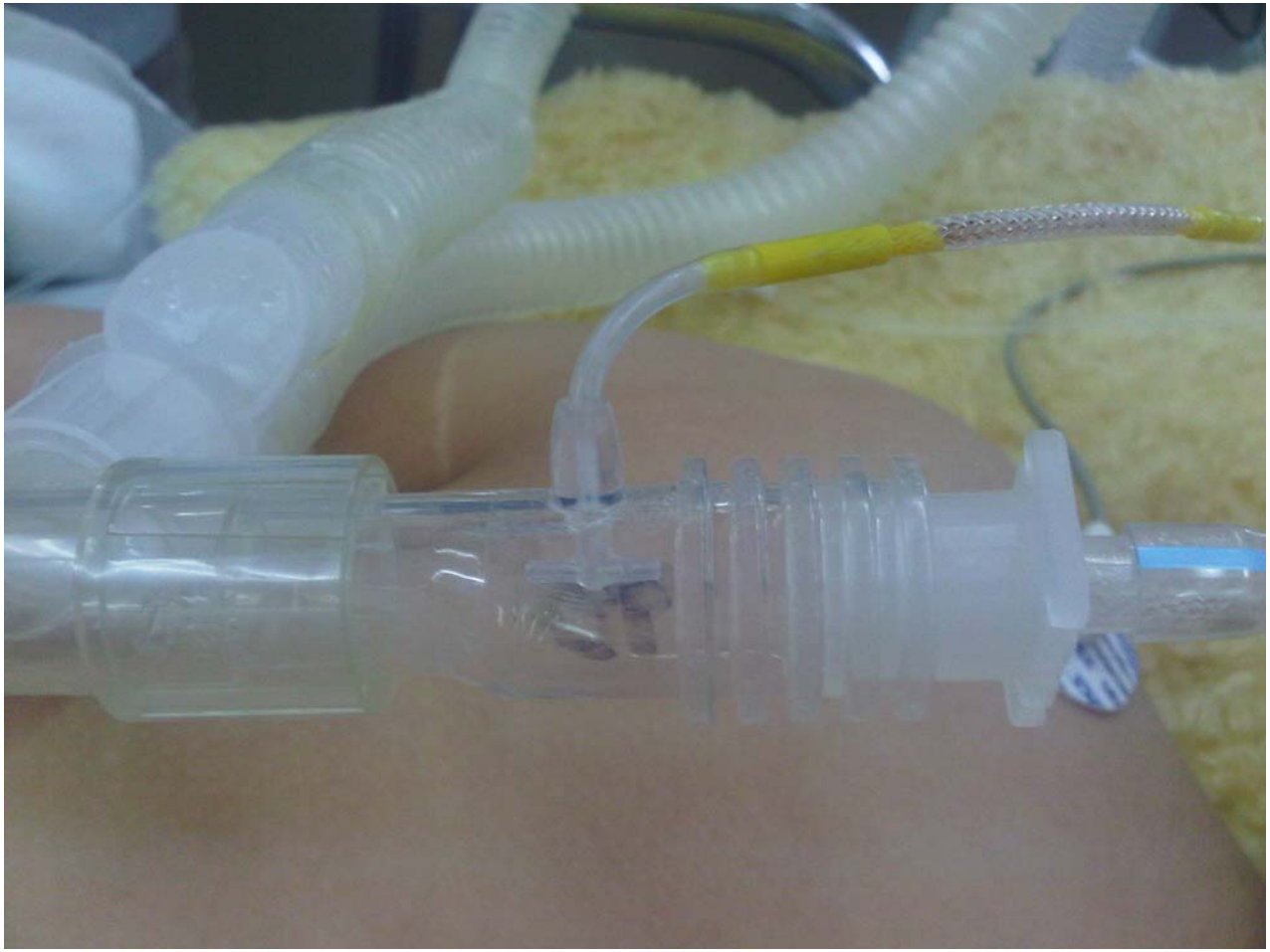
Respiración Espontanea

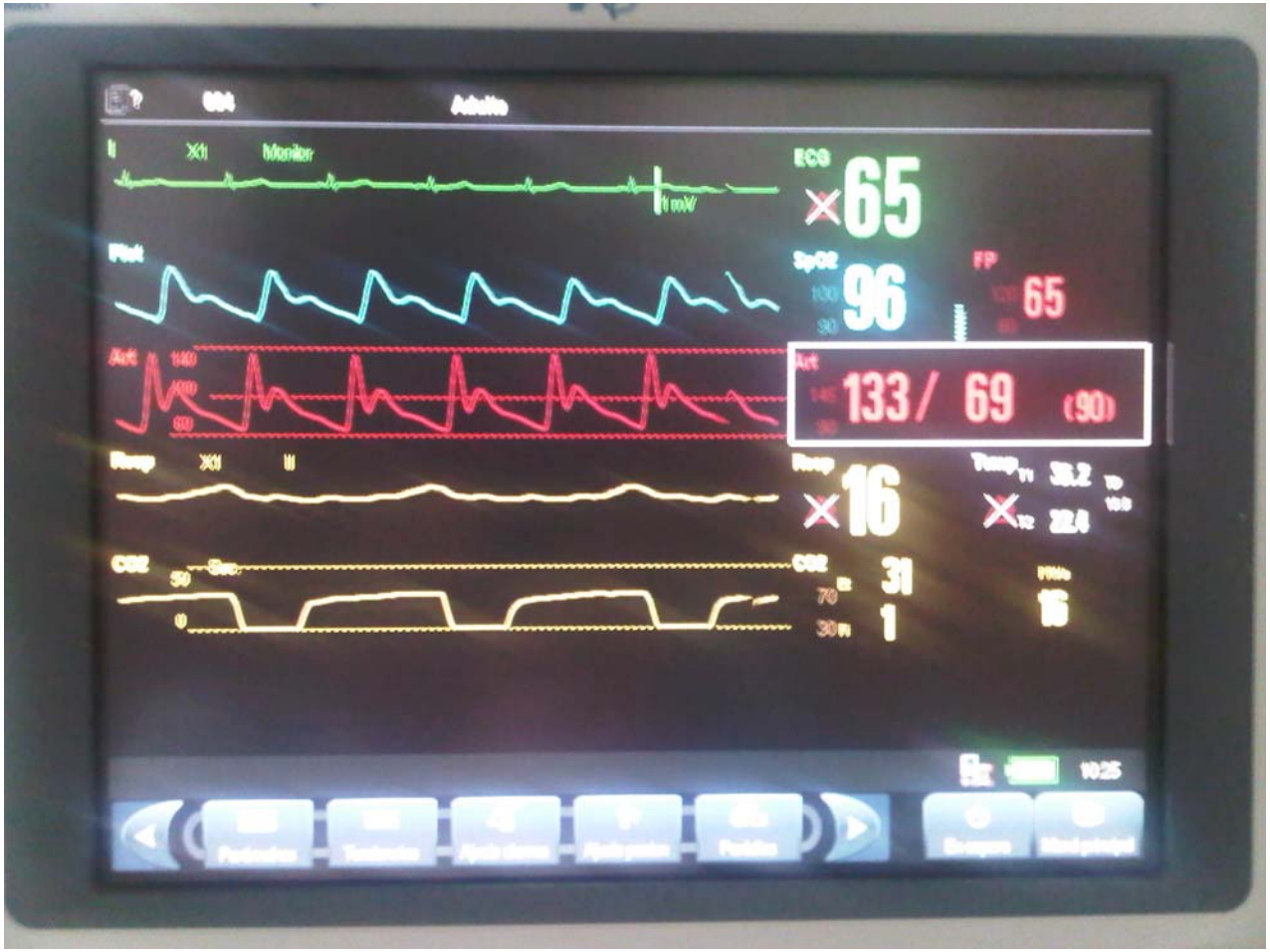


- Monitores de flujo principal "main stream"



El sensor de CO_2 está situado entre el TET y el circuito respiratorio.




Adulto
Monitor
ECG
65
SpO2
96
FP
65
Art
133/ 69 (90)
Resp
16
31
1
10:25

Sidestream

- VENTAJAS
- Fácil de conectar.
- Aplicable en pacientes en VM y en pacientes con ventilación espontánea, c/S $0_{2,}$ supl, sin VM
- Fácil de usar en posiciones inusuales como el decúbito prono.
- Medición de gases anestésicos y respiratorios
- Trabaja con Vt menores
- DESVENTAJAS
- Retraso en el análisis
- Obstrucci tubo de muestreo

Mainstream

- VENTAJAS
- No retraso en el análisis
- No tubo de muestreo
- No polución
- Adecuado para los neonatos y niños
- DESV NTAJAS
- Sensor pesado y voluminoso
- No en Quemaduras faciales
- Cable eléctrico largo
- Solo para pacientes intubados
- Únicamente medición de gases respiratorios

AARC Clinical Practice Guideline

Capnography/Capnometry During Mechanical Ventilation: 2011

Brian K Walsh RRT-NPS FAARC, David N Crotwell RRT-NPS, and
Ruben D Restrepo MD RRT FAARC

We searched the MEDLINE, CINAHL, and Cochrane Library databases for articles published between January 1990 and November 2010. The update of this clinical practice guideline is based on 234 clinical studies and systematic reviews, 19 review articles that investigated capnography/capnometry during mechanical ventilation, and the 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. The following recom-

(4) Continuous capnometry during transport of the mechanically ventilated patients is suggested. (5) Capnography is suggested to identify abnormalities of exhaled air flow. (6) Volumetric capnography is suggested to assess CO_2 elimination and the ratio of dead-space volume to tidal volume (V_D/V_T) to optimize mechanical ventilation. (7) Quantitative waveform capnography is suggested in intubated patients to monitor cardiopulmonary quality, optimize chest compressions, and detect return of spontaneous circulation during chest compressions or when rhythm check reveals an organized rhythm. *Key words: capnography; capnometry; colorimetric CO_2; end-tidal carbon dioxide; volumetric CO_2.* [Respir Care 2011;56(4):503–509. © 2011 Daedalus Enterprises]

CO_2 MV 1.0 DESCRIPTION

For the purposes of this clinical practice guideline, capnography refers to the evaluation of the CO_2 in the respiratory gases of mechanically ventilated patients. A capnographic device incorporates one of 2 types of sampling techniques: mainstream or sidestream.[1] Mainstream technique inserts a sampling window into the ventilator circuit for measurement of CO_2, whereas a sidestream analyzer samples gas from the ventilator circuit, and the analysis occurs away from the ventilator circuit. Analyzers utilize infrared, mass or Raman spectra, or a photoacoustic spectra technology.[1,2] Flow measuring devices are utilized in volumetric capnographs. Colorimetric CO_2 detectors are a form of mainstream sampling, but are simplistic. The colorimetric CO_2 detector has a pH-sensitive chemical indicator that undergoes color change with each inspiration and expiration, thus reflecting the change in CO_2 concentration. These devices start at baseline color when minimal CO_2 is present and undergo gradual color change with increasing CO_2 concentration.[3]

CO_2 MV 2.0 PROCEDURE

Capnography is the continuous analysis and recording of the CO_2 concentration in respiratory gas. Although the

Brian K Walsh RRT-NPS FAARC is affiliated with the Respiratory Care Department, Children's Medical Center, Dallas, Texas. David N Crotwell RRT-NPS is affiliated with the Department of Respiratory Care, Seattle Children's Hospital and Regional Medical Center, Seattle, Washington. Ruben D Restrepo MD RRT FAARC is affiliated with the Department of Respiratory Care, The University of Texas Health Sciences Center at San Antonio, San Antonio, Texas.

Correspondence: Ruben D Restrepo MD RRT FAARC, Department of Respiratory Care, The University of Texas Health Sciences Center at San Antonio, 7703 Floyd Curl Drive, MSC 6248, San Antonio TX 78229. E-mail: restrepor@uthscsa.edu.

DOI: 10.4187/respcare.01175

Capnography is considered a standard of care during general anesthesia. The American Society of Anesthesiologists has suggested that capnography be available for patients with acute ventilatory failure on mechanical ventilatory support.

American Society of Anesthesiologists. Standards for basic anesthetic monitoring. http://www.asahq.org/knowledge-base/ethics-and-medicolegal-issues/asa/~/media/for%2520members/documents/standards%2520guidelines%2520stmts/basic%2520anesthetic%2520monitoring%25202011.ashx. *Accessed February 8, 2011.*

The American College of Emergency Physicians recommends capnography as an adjunctive method to ensure proper endotracheal tube position.

American College of Emergency Physicians, Clinical Policies Committee. Verification of endotracheal tube placement. Ann Emerg Med 2002;40(5):551-552.

The 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care recommend capnography to verify endotracheal tube placement in all age groups.

Goldberg JS, Rawle PR, Zehnder JL, Sladen RN. Colorimetric end-tidal carbon dioxide monitoring for tracheal intubation. Anesth Analg 1990;70(2):191-194.

Grados de Recomendación

Basados en Grading of Recommendations Assessment, Development, and Evaluation (GRADE) scoring system

Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336(7650): 924-926.
Jaeschke R, Guyatt GH, Dellinger P, Schunemann H, Levy MM, Kunz R, et al. Use of GRADE grid to reach decisions on clinical practice guidelines when consensus is elusive (abstract). BMJ 2008; 337(Suppl):A744.

Grados de Recomendación

14.1 Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an endotracheal tube. (1A)

14.2 If waveform capnography is not available, a non-waveform exhaled CO_2 monitor in addition to clinical assessment is suggested as the initial method for confirming correct tube placement in a patient in cardiac arrest. (2B)

14.3 P_{ETCO_2} is suggested as a method to guide ventilator management. (2B)

14.4 Continuous capnometry during transport of a mechanically ventilated patient is suggested. (2B)

14.5 Capnography is suggested to identify abnormalities of exhaled air flow. (2B)

14.6 Volumetric capnography is suggested to assess CO_2 elimination and V_D/V_T to optimize mechanical ventilation. (2B)

14.7 Quantitative waveform capnography is suggested in intubated patients to monitor CPR quality, optimize chest compressions, and detect return of spontaneous circulation during chest compressions or when rhythm check reveals an organized rhythm. (2C)

Indicaciones

- Verificación de Intubación correcta
- Efectividad en las compresiones torácicas en RCP

4.1.5.1 If the P_{ETCO_2} is < 10 mm Hg during CPR, the clinician should attempt to improve the quality of compressions.

4.1.5.2 An abrupt and sustained increase in P_{ETCO_2} is a sensitive indicator of return of spontaneous circulation.

- Transporte
- Desconexiones de ARM inadvertidas

Indicaciones

- Evaluacion de Circulación Pulomonar y Status Respiratorio

4.2.1 Determining changes in pulmonary circulation and respiratory status sooner than pulse oximetry. In patients without lung disease, substantial hypercarbia may present before pulse oximetry notifies the clinician of a change in ventilation.[14,17-20]

4.2.2 Monitoring the adequacy of pulmonary, systemic, and coronary blood flow,[20,21] as well as estimation of the effective (non-shunted) pulmonary capillary blood flow by a partial rebreathing method.[22-24]

4.2.3 Evaluating the partial pressure of exhaled CO_2, especially P_{ETCO_2}.

4.2.4 Screening for pulmonary embolism.[25-28]

Indicaciones

- Optimización de la VM

4.3.1 Continuous monitoring of the integrity of the ventilator circuit, including the artificial airway[29] or bag mask ventilation, in addition to potentially detecting mechanical ventilation malfunctions.[30-32]

4.3.2 Decreasing the duration of ventilatory support.[33]

4.3.3 Adjustment of the trigger sensitivity.[34]

4.3.4 Evaluation of the efficiency of mechanical ventilation, by the difference between P_{aCO_2} and the P_{ETCO_2}.[35]

4.3.5 Monitoring of the severity of pulmonary disease[36,37] and evaluating the response to therapy, especially therapies intended to improve the ratio of dead space to tidal volume (V_D/V_T) and ventilation-perfusion matching ($\dot{V}/\dot{Q}$).[23,27,38-46]

4.3.6 Monitoring of $\dot{V}/\dot{Q}$ during independent lung ventilation.[47,48]

4.3.7 Monitoring of inspired CO_2 when it is being therapeutically administered.[49]

Optimización de VM

4.3.8 Graphic evaluation of the ventilator-patient interface. Evaluation of the capnogram may be useful in detecting rebreathing of CO_2, obstructive pulmonary disease, the presence of inspiratory effort during neuromuscular blockade (curare cleft), cardiogenic oscillations, esophageal intubation, and cardiac arrest.[50]

4.3.9 Measurement of the volume of CO_2 elimination to assess metabolic rate and/or alveolar ventilation.[43,51-53]

4.3.10 Monitoring of V_D/V_T to determine eligibility for extubation in children.[40,54]

4.3.11 There is a relationship between V_D/V_T and survival in patients with the acute respiratory distress syndrome.[55-57]

Contraindicaciones

There are no absolute contraindications to capnography in mechanically ventilated patients, provided that the data obtained are evaluated with consideration given to the patient's clinical condition.

Complicaciones

Mainstream

6.1.1 Dead Space. Adapters inserted into the airway between the airway and the ventilator circuit should have a minimal amount of dead space. This effect is inversely proportional to the size of the patient being monitored.[44,58]

6.1.2 The addition of the weight of a mainstream adapter can increase the risk of accidental extubation in neonates and small children.[58]

adults

Sidestream

6.2.1 The gas sampling rate from some sidestream analyzers may be high enough to cause auto-triggering when flow-triggering of mechanical breaths is used. This effect is also inversely proportional to the size of the patient.[58]

6.2.2 The gas sampling rate can diminish delivered V_T in neonates and small patients while using volume targeted or volume controlled ventilation modes.[58]

Jacobus C. Noninvasive monitoring in neonatal and pediatric care. St. Louis: Elsevier; 2009:137-146.

Limitaciones

few limitations. It is important to note that although the capnograph provides valuable information about the efficiency of ventilation (as well as perfusion), it is not a replacement or substitute for assessing the P_{aCO_2}.[4,41,59-61]

Hess D, Branson RD. Noninvasive respiratory monitoring equipment. Philadelphia: Lippincott; 1994:184-216.

Jellinek H, Hiesmayr M, Simon P, Klepetko W, Haider W. Arterial to end-tidal CO_2 tension difference after bilateral lung transplantation. Crit Care Med 1993;21(7):1035-1040.

Hess D. Capnometry. New York: McGraw-Hill; 1998:377-400.

Isert P. Control of carbon dioxide levels during neuroanaesthesia: current practice and an appraisal of our reliance upon capnography. Anaesth Intensive Care 1994;22(4):435-441.

Laffon M, Gouchet A, Sitbon P, Guicheteau V, Biyick E, Duchalais A, et al. Difference between arterial and end-tidal carbon dioxide pressures during laparoscopy in paediatric patients. Can J Anaesth 1998;45(6):561-563.

Limitaciones

The difference between P_{ETCO_2} and P_{aCO_2} increases as dead-space volume increases.[62] In fact, the difference between the P_{aCO_2} and P_{ETCO_2} varies in the same patient over time.[43,63-65] Alterations in breathing pattern and V_T may introduce error into measurements designed to be made during stable, steady-state conditions.[51,52,66] Interpretation of results must take into account the stability of physiologic variables such as minute ventilation, V_T, cardiac output, $\dot{V}/\dot{Q}$, and CO_2 body stores. Certain situations may affect the reliability of the capnogram.

Limitaciones relacionadas con las características de los equipos

7.1.1 The infrared spectrum of CO_2 has some similarities to the spectra of both oxygen and nitrous oxide.[50] A high concentration of either oxygen or nitrous oxide, or both, may affect the capnogram, so a correction factor should be incorporated into the calibration of any capnograph used in such a setting.[59]

7.1.2 The reporting algorithm of some devices (primarily mass spectrometers) assumes that the only gases present in the sample are those that the device is capable of measuring. When a gas that cannot be detected by the mass spectrometer (such as helium) is present, the reported CO_2 values are incorrectly elevated in proportion to the concentration of the gas present.[4,67]

7.2 The breathing frequency may affect the capnograph. A high breathing frequency may exceed the capnograph's response capabilities. The presence of high airway resistance, respiratory rate, or inspiratory-to-expiratory ratio may decrease the accuracy of the measurement obtained from a sidestream capnograph, compared to a mainstream capnograph.[68,69] In addition, a breathing frequency $>$ 10 breaths/min affects different capnographs differently.[67]

7.3 Contamination of the monitor or sampling system by secretions or condensate, a sample tube of excessive length, too high a sampling rate, or obstruction of the sampling chamber can lead to unreliable results.

7.4 Use of filters between the patient airway and the capnograph's sampling line may lead to artificially low P_{ETCO_2} readings.[31,70]

Limitaciones

Condiciones Clínicas Asociadas a Falsos Negativos

7.6.1 Low cardiac output may cause a false negative result when attempting to verify endotracheal tube position in the trachea.[72]

7.6.2 During CPR a positive test confirms placement of the ETT within the airway, whereas a negative test indicates either esophageal intubation or airway intubation with poor or absent pulmonary blood flow and requires an alternate means of confirmation of tube position.[73-75]

7.6.3 When the endotracheal tube is in the pharynx and when antacids and/or carbonated liquids are present in the stomach, a false negative reading may be present. However, the waveform does not continue during subsequent breaths.[76]

7.6.4 Elimination and detection of CO_2 can be dramatically reduced in patients with severe airway obstruction and pulmonary edema.[77]

Limitaciones

Condiciones Clínicas Asociadas a Falsos Positivos

7.7.2 Detection of CO_2 in expired gas after esophageal intubation as a result of prior bystander mouth-to-mouth ventilation may result in a false positive reading.[79]

7.7.3 A transient rise in P_{ETCO_2} after sodium bicarbonate administration is expected, but should not be misinterpreted as an improvement in quality of CPR or a sign of return of spontaneous circulation.[5]

Medición Insegura

7.8.1 Leaks in the ventilator circuit.
7.8.2 Leaks around the tracheal tube cuff, an uncuffed tube, or the mask, including LMA.
7.8.3 Bronchopleural fistula.
7.8.4 Dialysis or extracorporeal life support.

Table 1. Variations in $EtCO_2$ in mechanically ventilated patients

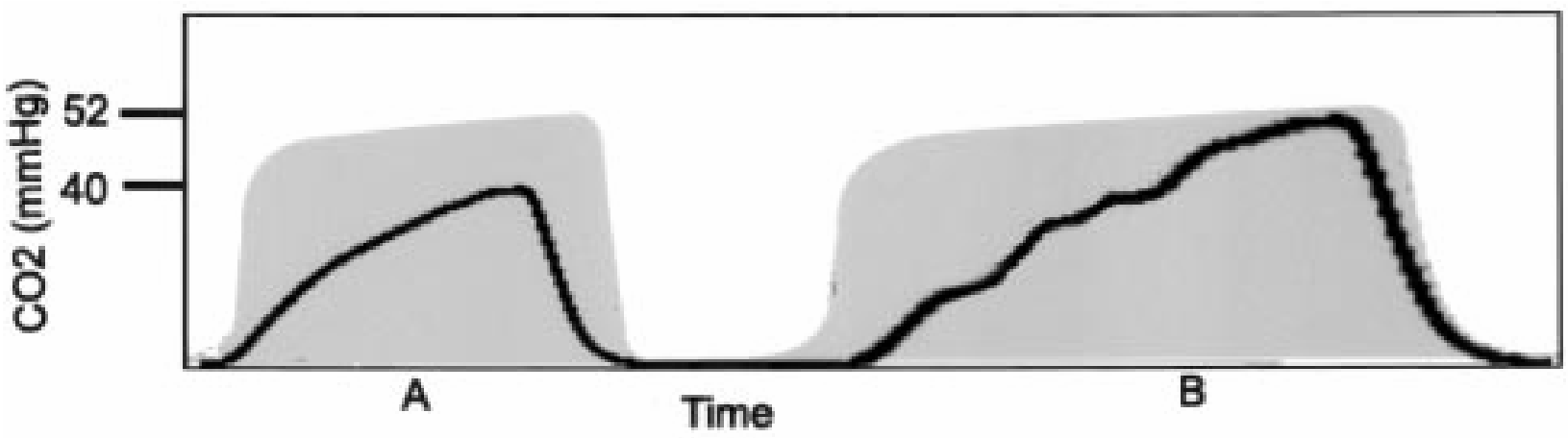
Increased $EtCO_2$	Reduced $EtCO_2$
Alveolar ventilation • Hypoventilation • Bronchial intubation • Partial airway obstruction • Rebreathing	**Alveolar ventilation** • Oesophageal TT placement • Hyperventilation • Apnoea • Total or partial airway obstruction • Accidental tracheal extubation • High levels of *PEEP during **IPPV
Pulmonary perfusion • ↑Cardiac output • ↑ Blood pressure	**Pulmonary perfusion** • ↓ Cardiac output • ↓Blood pressure • Hypovolaemia • Pulmonary embolism • Cardiac arrest
↑ CO_2 Production • Fever/ Sepsis/ Seizures/ Hyperthyroidism • Malignant hyperpyrexia • Sodium bicarbonate • Tourniquet release • Venous CO_2 embolism	**↓ CO_2 Production** • Hypothermia • Sedation • Paralysis
Technical errors • Exhausted CO_2 absorber • Inadequate fresh gas flow • Ventilator valve malfunction • Leaks in breathing system • Faulty ventilatorReduced $EtCO_2$	**Technical errors** • Circuit disconnection • Sampling tube leak or obstruction • High fresh gas flow • Faulty ventilator • Large leak around TT

Use of capnography in intensive care **E blair MB, chb, CD deakin MA, MD, FRCP, Frca, summer 2007 | british journal of intensive care**

- La ETCO2 es una herramienta necesaria para el manejo ventilatorio de los pacientes con TEC prehospitalarios.

Davis et al, The use of quantitative ETCO2 to avoid inadvertent hiperventilation in head injury patients following paramedic rapid sequence intubation. The Journal of Trauma: Injury, Infection, and Critical Care:Volume 56(4)April 2004pp 808-814

TEC



John E Thompson RRT FAARC and Michael B Jaffe PhD. Capnographic Waveforms in the Mechanically Ventilated Patient [Respir Care 2005;50(1):100 –108.© 2005

Asma / EPOC

- En el año 2004 se detectaron 106 casos de efectos adversos en el uso de la ACP, incluyendo 22 muertes. Menos del 30% se atribuyeron a errores de desprogramación.

Food and Drug Administration (FDA) Manufacturer and User Facility Device Experience Database (MAUDE) Database January 2004 – November 2004.

- EL $EtCO_2$ es un indicador más sensitivo que la SpO_2 para detectar depresión respiratoria inducida por opioides. La detección temprana por monitoreo continuo, permite intervenciones para evitar resultados indeseables.

Maddox RR, Williams CK, Fields M: Respiratory monitoring in patient-controlled analgesia. Am J Hosp Pharm. 2004;16:2628,2635. Letter.

Manejo del Dolor

Un nivel de 10 mmHg o menos de ETCO2, medido a los 20 minutos de iniciadas las maniobras de ALS, es predictor de muerte en pacientes con PC asociado con actividad eléctrica pero sin pulso. *New England Journal of Medicine, July 1997: 337: 301-306*

8 estudios de casos mostraron que con un elevado ETCO2 inicial los pacientes tenían más posibilidades de resucitación que aquellos que tuvieron un menor valor. *Wayne MA, Levine RL, Miller CC. Use Of end-tidal carbon dioxide to predict outcome in prehospital cardiac arrest. Ann Emerg Med. 1995;25:762–767. Bhende MS, Thompson AE. Evaluation of an end-tidal CO2 detector during pediatric cardiopulmonary resuscitation. Pediatrics. 1995;95:395–399. Callaham M, Barton C. Prediction of outcome of cardiopulmonary resuscitation from end-tidal carbon dioxide concentration. Crit Care Med. 1990;18:358 –362. Grmec S, Klemen P. Does the end-tidal carbon dioxide (EtCO2) concentration have prognostic value during out-of-hospital cardiac arrest? Eur J Emerg Med. 2001;8:263–269. Grmec S, Kupnik D. Does the Mainz Emergency Evaluation Scoring (MEES) in combination with capnometry (MEESc) help in the prognosis of outcome from cardiopulmonary resuscitation in a prehospital setting? Resuscitation. 2003;58:89 –96.Grmec S, Lah K, Tusek-Bunc K. Difference in end-tidal CO2 between asphyxia cardiac arrest and ventricular fibrillation/pulseless ventricular tachycardia cardiac arrest in the prehospital setting. Crit Care. 2003;7: R139–R144. Mauer D, Schneider T, Elich D, Dick W. Carbon dioxide levels during pre-hospital active compression– decompression versus standard cardiopulmonary resuscitation. Resuscitation. 1998;39:67–74. Sanders AB, Kern KB, Otto CW, Milander MM, Ewy GA. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation: a prognostic indicator for survival. JAMA. 1989;262:1347–1351.* **Improved cardiac arrest outcomes: as time goes by?** Peter T Morley
Intensive Care Unit, Royal Melbourne Hospital, Grattan Street, Parkville, Victoria, Australia 3050, *Critical Care 2007,* ***11:130***

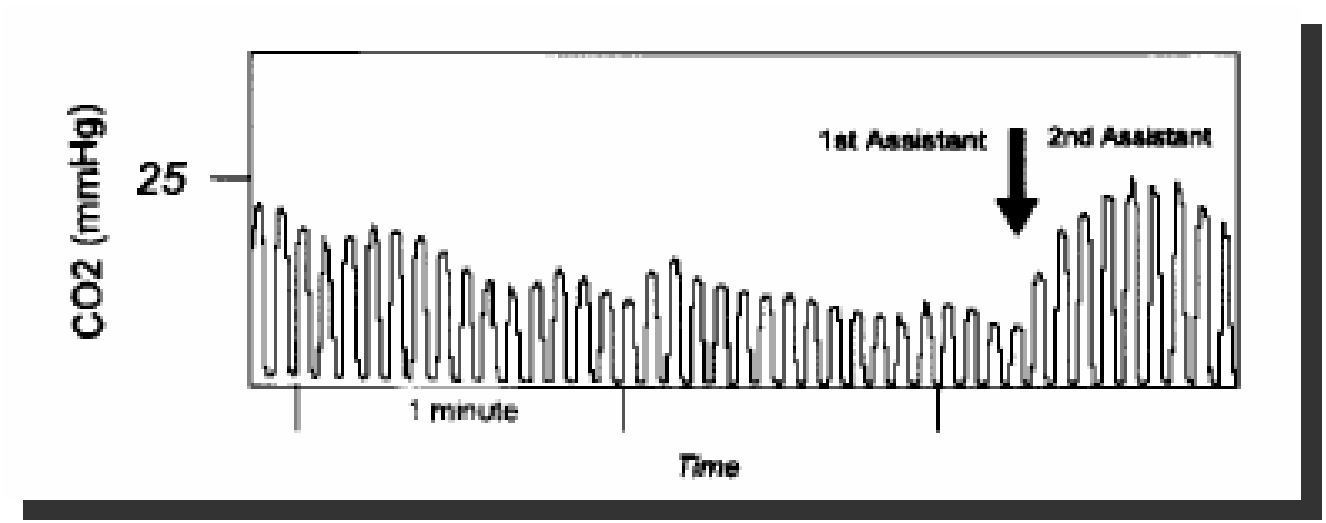
Predictor de sobrevida o muerte

End-tidal CO2 monitoring is a safe and effective noninvasive indicator of cardiac output during CPR and may be an early indicator of ROSC in intubated patients.

Part 7.4: Monitoring and Medications. *Circulation 2005;112;78-83*

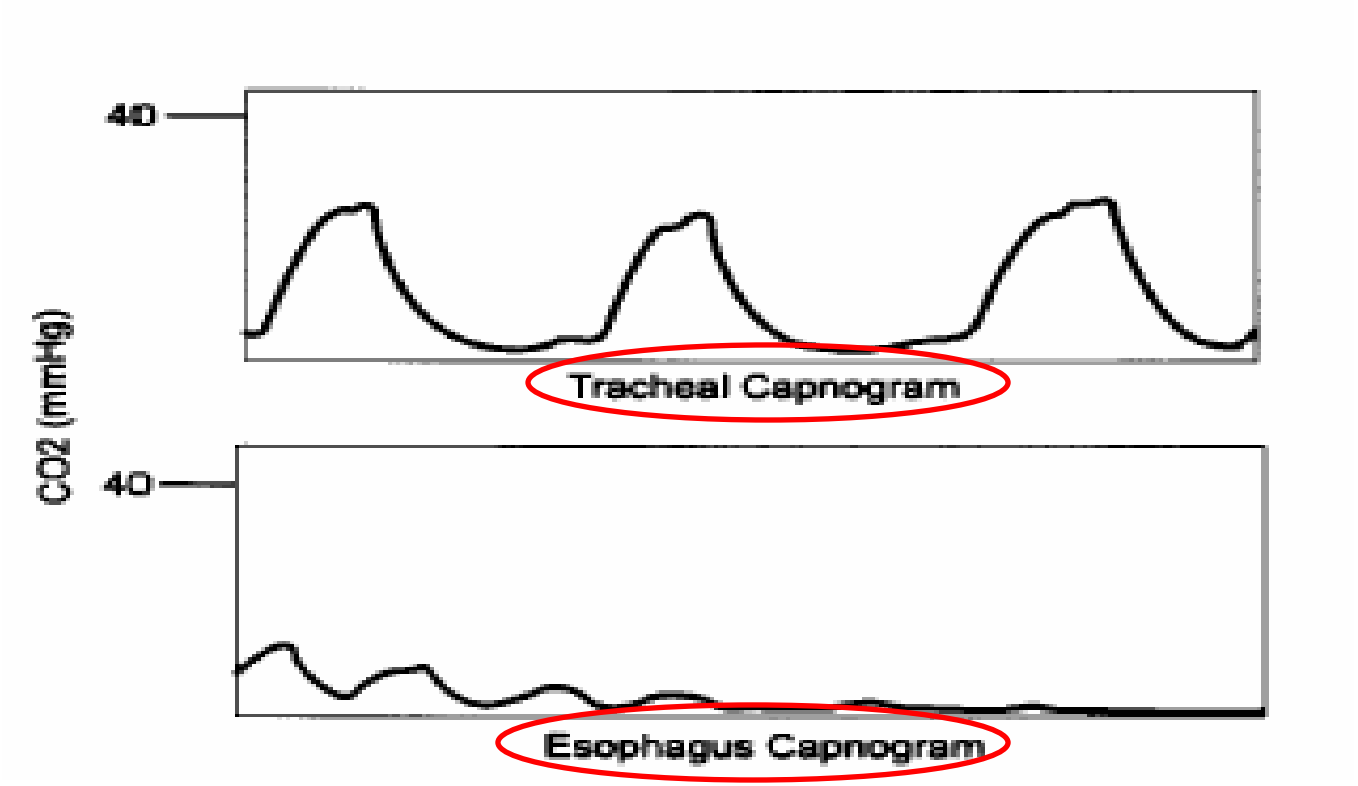
Reanimación Cardio-Pulmonar

RCP



Capnographic Waveforms in the Mechanically Ventilated Patient . John E Thompson RRT FAARC and Michael B Jaffe PhD. RESPIRATORY CARE • JANUARY 2005 VOL 50 NO 1

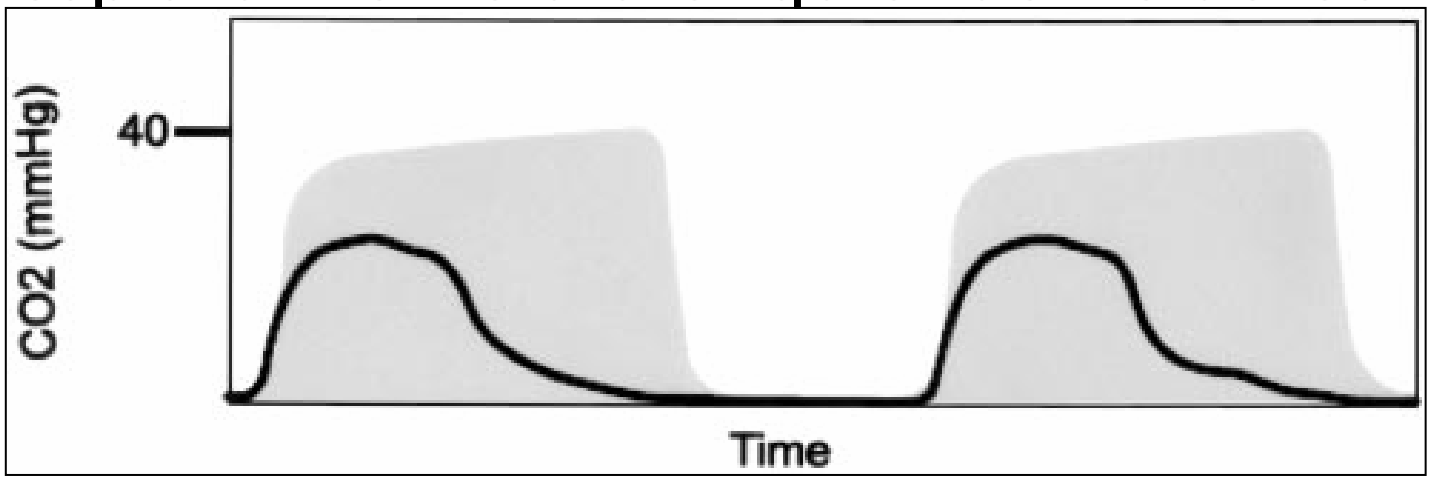
- También el ETCO2 sirve para determinar en donde está colocado el TeT.



John E Thompson RRT FAARC and Michael B Jaffe PhD. Capnographic Waveforms in the Mechanically Ventilated Patient [Respir Care 2005;50(1):100 –108.© 2005

Verificación de Intubación

O…desplazamiento a bronquio fuente derecho…



John E Thompson RRT FAARC and Michael B Jaffe PhD. Capnographic Waveforms in the Mechanically Ventilated Patient [Respir Care 2005;50(1):100 –108.© 2005

Capnography is indispensable as a rapid monitor of respiratory depression that can be pharmaceutically imposed. Many bedside monitors allow caregivers to use capnography in the ICU. During critical care stays, patients may benefit from early indicators of impending respiratory depression; capnography is the fastest method to alert caregivers of respiratory depression.

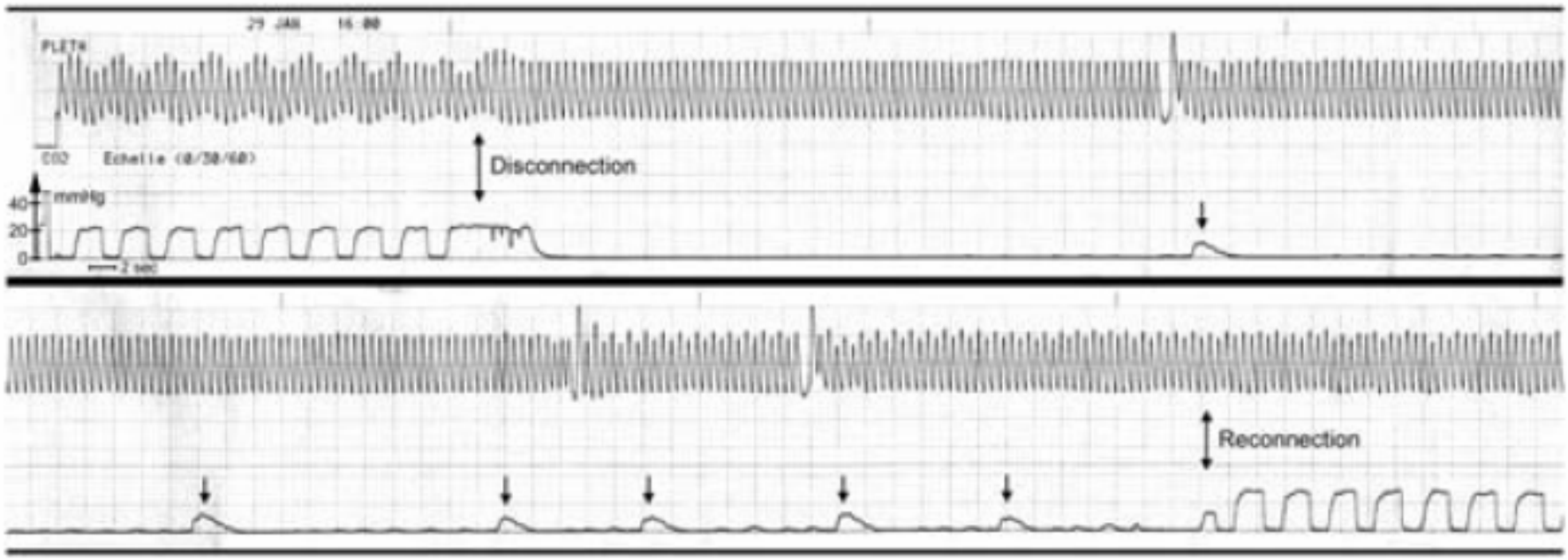
Use of capnography in intensive care **E blair MB, chb, CD deakin MA, MD, FRCP, Frca, summer 2007 | british journal of intensive care**

End-tidal CO_2 should be systematically monitored and recorded, at least for medico-legal considerations, during the apnoea test in brain-dead patients. The high variability in the carbon dioxide partial pressure–end-tidal CO_2 gradient increase precludes any extrapolation of the carbon dioxide partial pressure from the end-tidal CO_2 at the end of the apnoea test.

prospective study

An evaluation of capnography monitoring during the apnoea test in brain-dead patients
B. Vivien*. European Journal of Anaesthesiology 2007; 24: 868–875


17 OCT 1:00
RESP
CO2 Echelle (0/20/40)
mmHg
40
20
0
5 sec
Disconnection
17 OCT 1:15
Reconnection


PLETH
CO2
Echelle (0/30/60)
mmHg
40
20
0
2 sec
Disconnection
Reconnection

Que hay que tener en cuenta al ahora de medir ETCO2

Variables Ventilatorias

- VT
- respiratory rate
- PEEP
- ratio of inspiratory-to-expiratory time
- Peak airway pressure
- concentrations of respiratory gas mixture

Variables Hemodinamicas

- systemic and pulmonary
- blood pressure
- cardiac output
- shunt
- V/Q imbalances

Cuando hay que usar ETCO2

- Capnography is not indicated for every mechanically ventilated patient; however, when it is used, the measurement period should be long enough to allow determination of the PaCO2 -PETCO2 difference, to note changes in the PaCO2 -PETCO2 difference as a result of therapy, and to allow interpretation of observed trends.


El uso de tecnología no reemplaza, ni hace prescindible la observación clínica, sino que la hace aún más efectiva.....
¡¡¡PERO SI HACE 5 MINUTOS SUS SIGNOS VITALES ESTABAN NORMALES !!!!

Esto es Todo!

Muchas gracias!

Lic. Gustavo Olguin Klgo Ftra. TRC
Hospital de Pediatria Prof. Dr. J. P. Garrahan
Buenos Aires