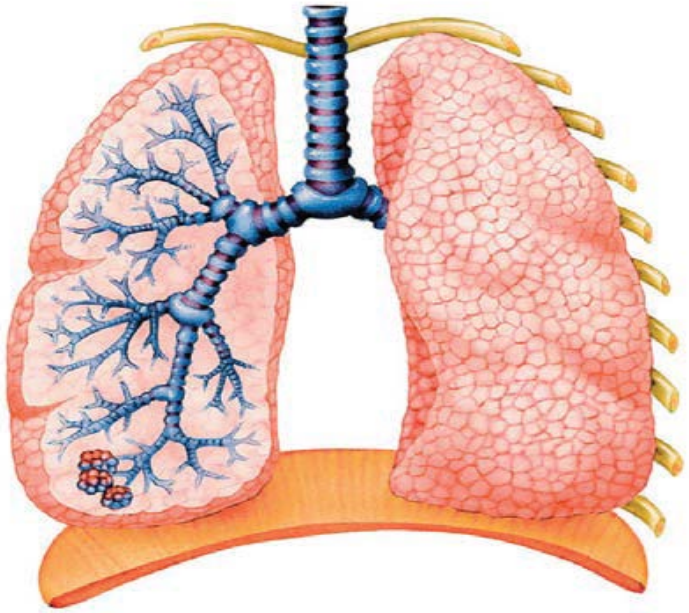
Transcutaneous Monitoring and Case Studies

Objectives

- General concept, applications and principles of operation
- Role of TCM in clinical settings
- Role of TCM in home care settings
- Need for continuous TCM
  - *"There is no original thinker we all are just plagiarizing in different forms" C.S. Lewis*
  - *"There is no such thing as a new idea. It is impossible. We simply take a lot of old ideas and put them into a sort of mental kaleidoscope. We give them a turn and they make new and curious combinations. We keep on turning and making new combinations indefinitely; but they are the same old pieces of colored glass that have been in use through all the ages." Mark Twain*

Respiratory System: A Brief Review

- Lungs as vital organs of gas exchange
- Primary function is to obtain oxygen for use by body's cells & eliminate carbon dioxide that cells produce

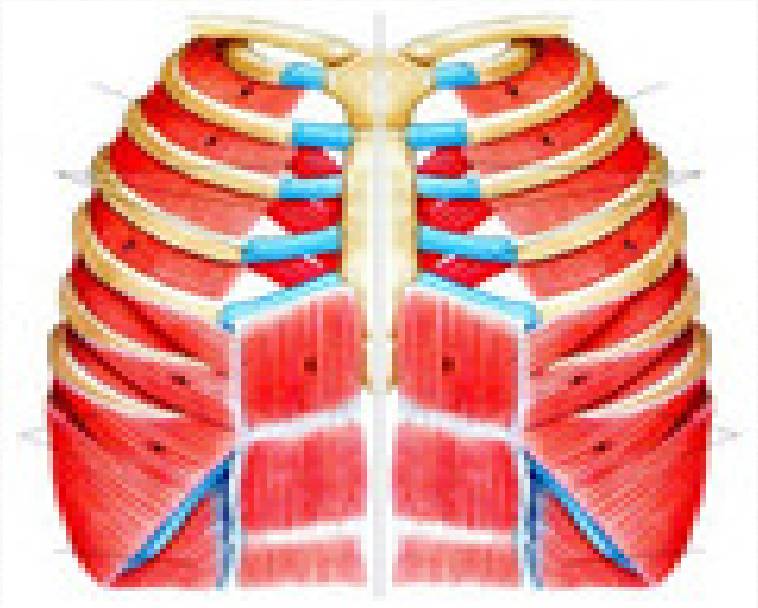


- Trachea
- Bronchial Tube
- Bronchioles
- Alveoli

They Don't Work Alone

Respiratory muscles

- Internal/External Intercostal
- Diaphragm
- Scalene
- Sternomastoids
- Abdominal muscles



Exchanges of Gases

- The exchange of gases (O2 & CO2) between the alveoli & the blood occurs by simple diffusion
- Diffusion requires a concentration gradient
- 300 million alveoli with a total surface area of about 75 square meters or 807.2 square feet
- Occurs by simple diffusion along partial pressure gradients
- Partial pressure gradients

Exchanges of Gases

Oxygen & Carbon Dioxide transported in the blood

Oxygen is carried in blood:

- bound to hemoglobin (98.5% of all oxygen in the blood, this depends on PO2 of the blood)
- dissolved in the plasma (1.5%

Carbon dioxide - transported from the body cells back to the lungs as:

- bicarbonate (HCO_3) - 60%
- carbaminohemoglobin - 30%
- dissolved in the plasma - 10%

Transcutaneous Monitoring TCM

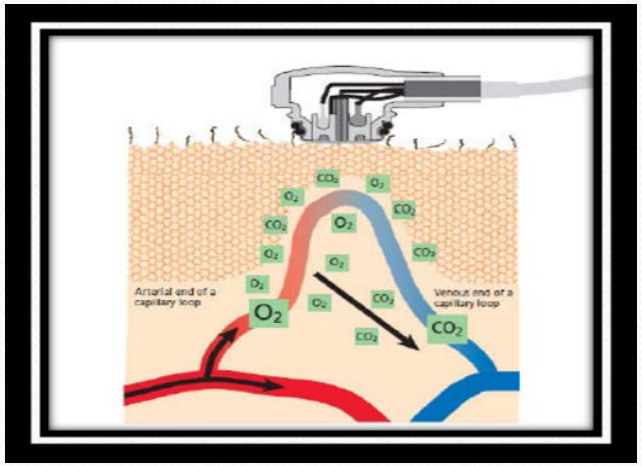
- Principles of operation
  - Heating element
  - PcO2
  - PcCO2
- Application
  - Site selection and application
  - Change site every 12 hours

TCM Sensor
Principles of Operation

- TCM heating element induces hyperperfusion of underlying capillaries

  Typical time 3-10 minutes

- A thin electrolyte layer is confined to the sensor surface with a CO2 permeable membrane contacting the patient's during monitoring
- Sensor measures CO2 by changing pH of the electrolyte solution



TCM Sensor
Principles of Operation

Electrochemical, Stow–Severinghaus electrode

- Sensor temperature 42°C
- Diffusion of CO2 (tissue/skin to sensor)
- Stow–Severinghaus electrode

  $CO_2 + H_2O = H_2CO_2 = HC_3 + H$

- Change in pH value
- Potential difference proportional to PCO_2

Principles of Application TCM
Application Areas

Neonatology *(including neonatal transport)*

Pulmonary/ Respiratory medicine *(NIV, lung function, bronchoscopy…)*

Sleep Medicine

Anesthesia/ Pain Management

- *Operating Room*
- *Procedural Sedation Settings (colonoscopy, bronchoscopy, cardiac lab, plastic surgery,..)*
- *Recovery Room (Post Anesthesia Care Unit)/ General Care Floor (with V-CareNeT™)*

Pediatrics

Critical Care

SpO2 monitoring/Virtually in all clinical settings

Principles of Application TCM

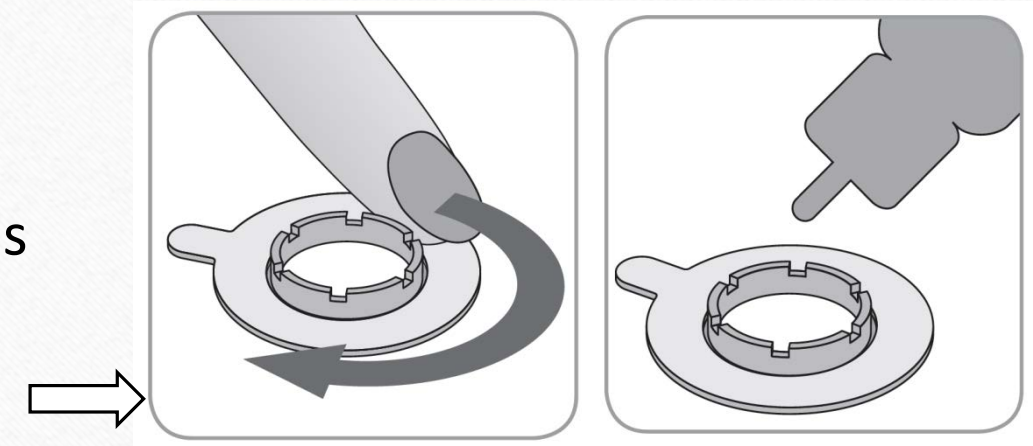
- Sensor calibration
- Selection of appropriate attachment ring
- Application of 1-2 drops of contact gel to the skin inside the attachment reading

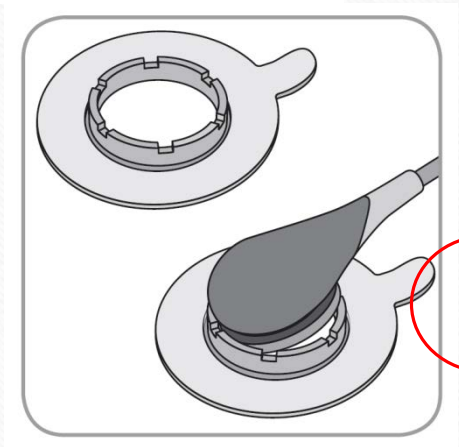
  Improved sensor accuracy and increase the diffusion of gasses more efficiently
- Placement of sensor into the attachment reading.

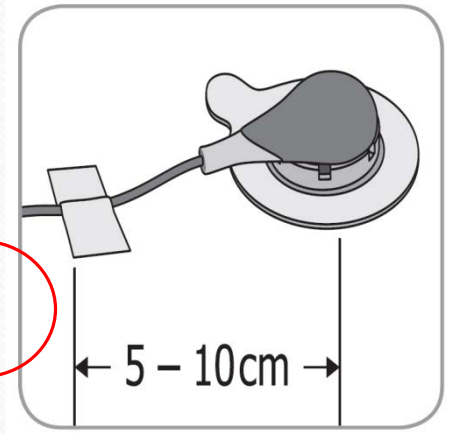
  Must create a good seal to prevent air leaking inside the attachment reading. Air reaching the sensor will alter recorded values

Sensor Application TCM

Various Sites



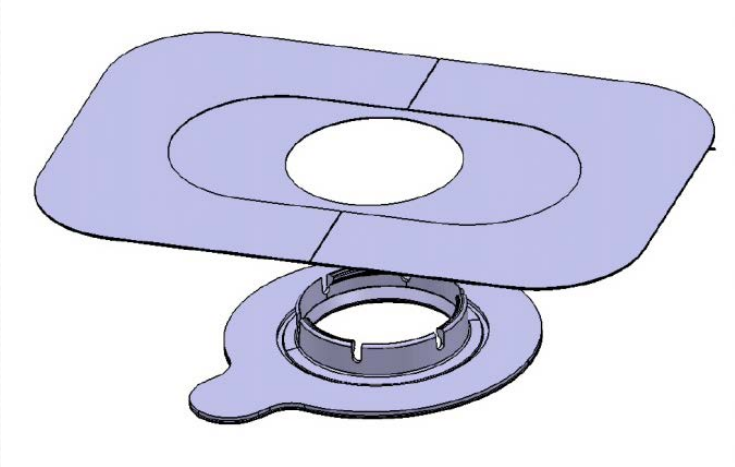


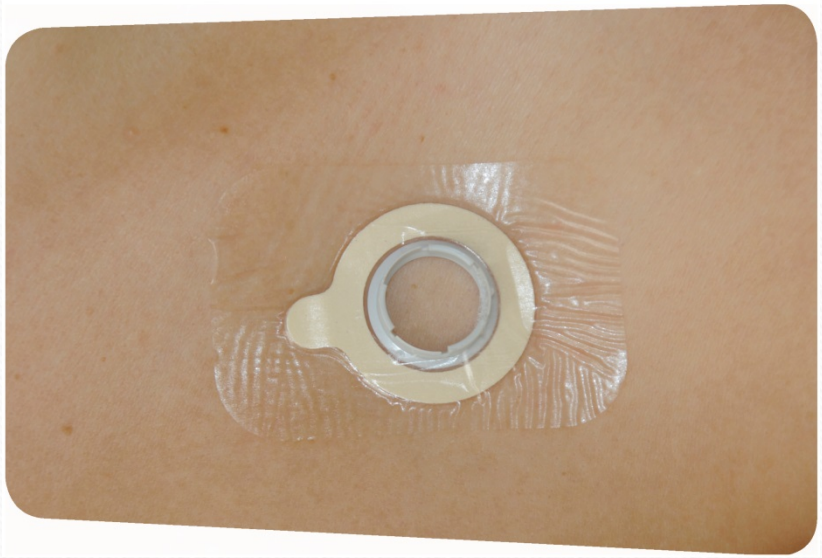


***Warning**: Application of any pressure to the measurement site (e.g. by using a pressure bandage) may cause pressure ischemia at the measurement site and, consequently, inaccurate measurements, necrosis or - in combination with heated sensors - burns.*

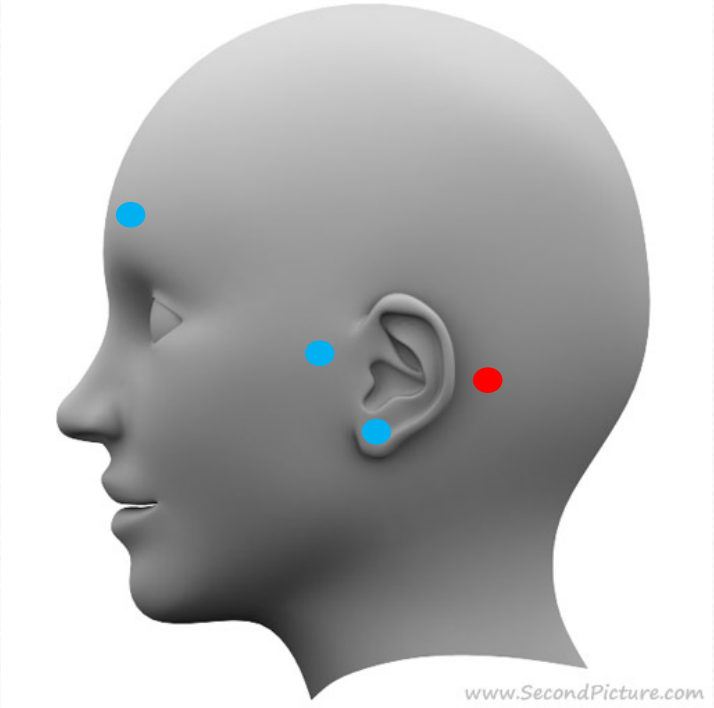
Sensor Application – TCM StaySite™ Adhesive

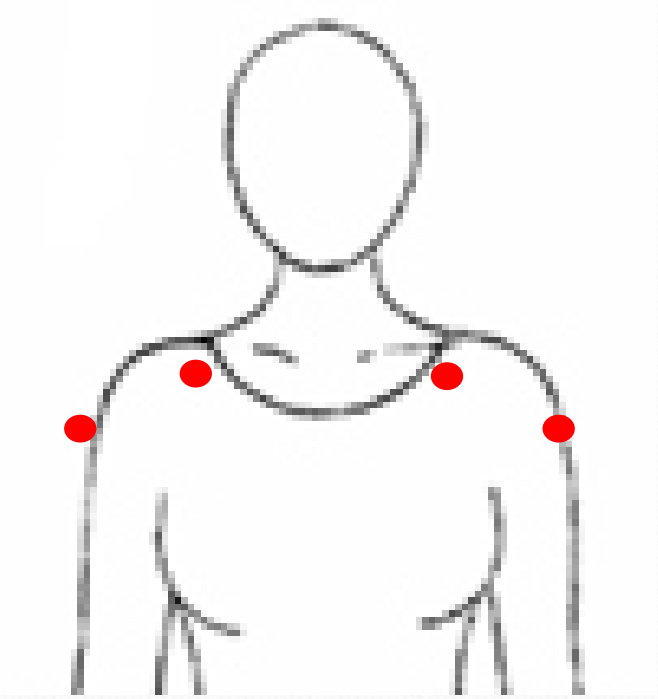
Staysite™ Adhesive is an optional, single-use adhesive which is indicated for use with Multi-Site Attachment Rings if more secure attachment is required *(e.g. in high humidity environments or during or under challenging patient motion conditions)*

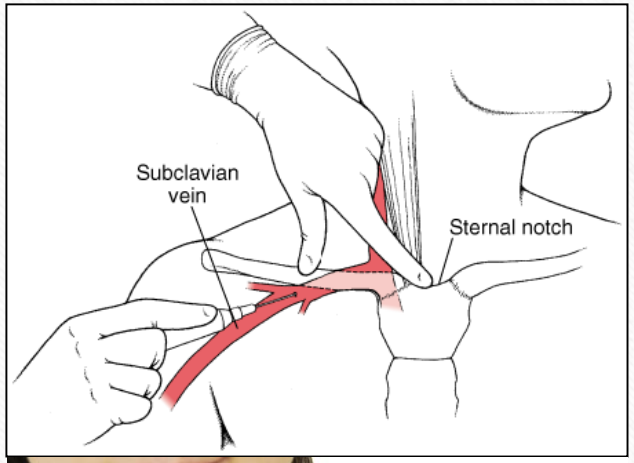


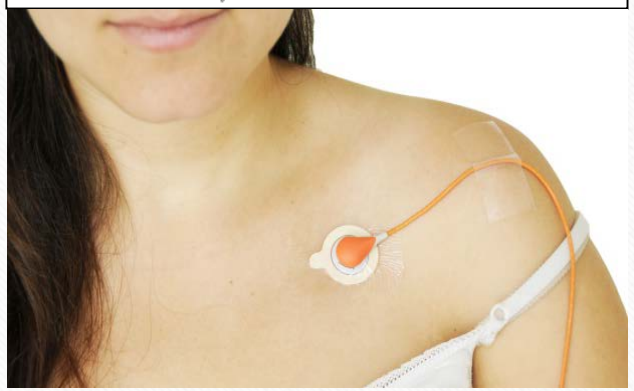


Sensor Application – Adult / Pediatric Patients





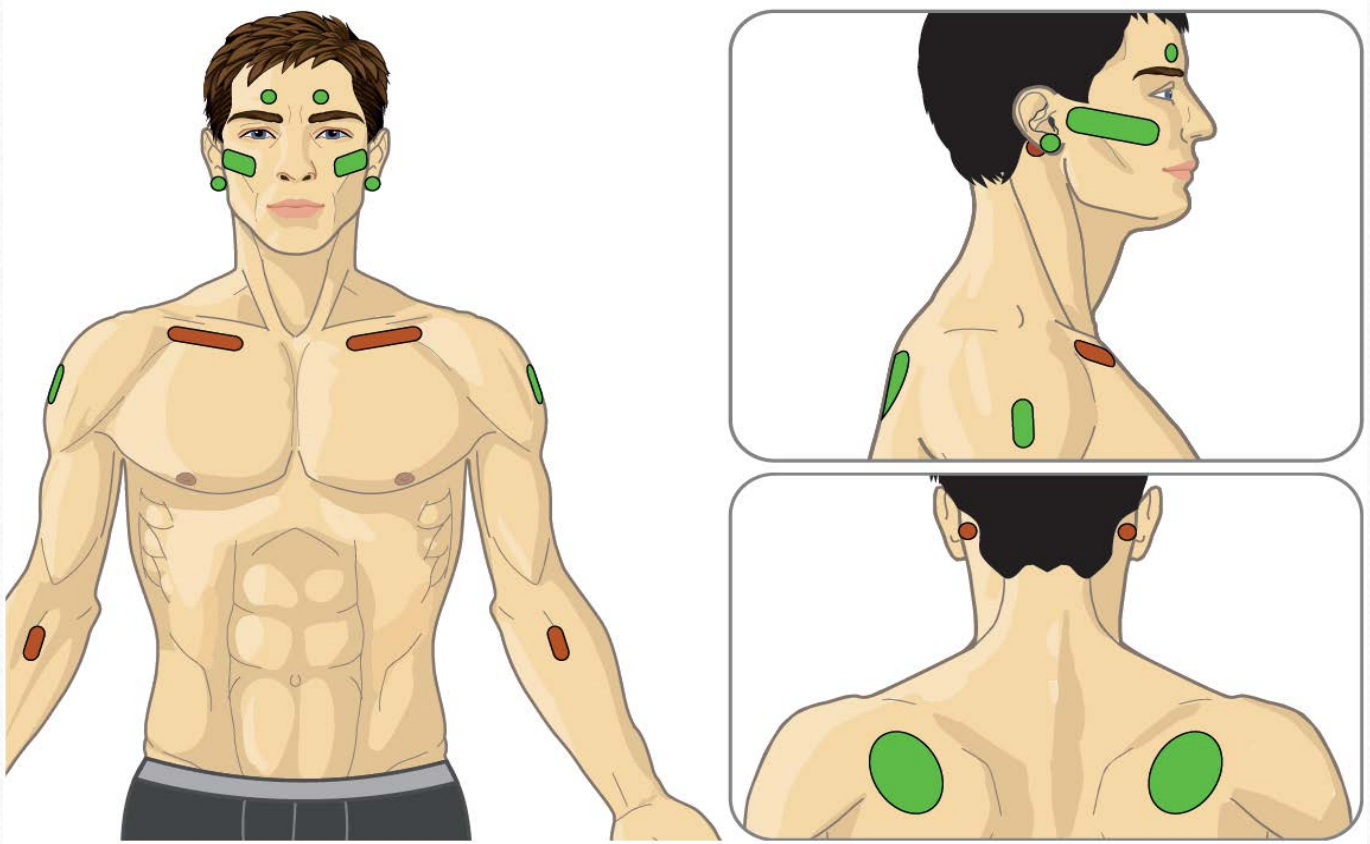




tcPCO2-only sites

***Warning**: Application of any pressure to the measurement site (e.g. by using a pressure bandage) may cause pressure ischemia at the measurement site and, consequently, inaccurate measurements, necrosis or - in combination with heated sensors - burns.*

‘Adult’ if Older than Term Birth + 1 Month

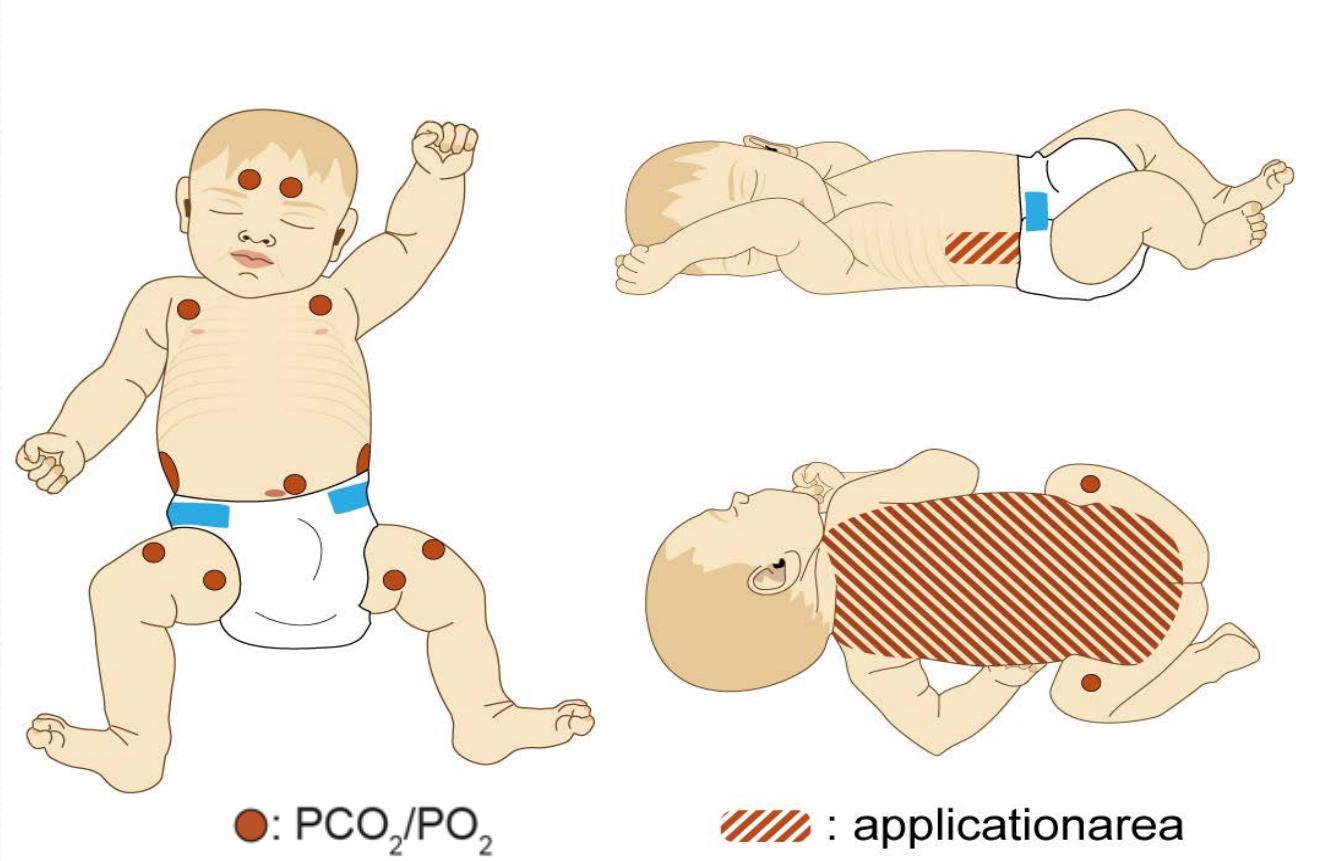


: PCO_2

PCO_2 / SpO_2 / Pulse Rate

***Warning**: SenTec TC Sensors are heated. Please pay special attention to sensor temperature and site time applied in patients with susceptible skin and refer to the separate training unit “temperature management” as well as to all warnings in the instruction manual.*
Do not apply any pressure to measurement site.

‘Neonatal’ if Younger than Term Birth + 1 Month



***Warning**: SenTec TC Sensors are heated. Please pay special attention to sensor temperature and site time applied in patients with susceptible skin and refer to the separate training unit “temperature management” as well as to all warnings in the instruction manual.*
Do not apply any pressure to measurement site.

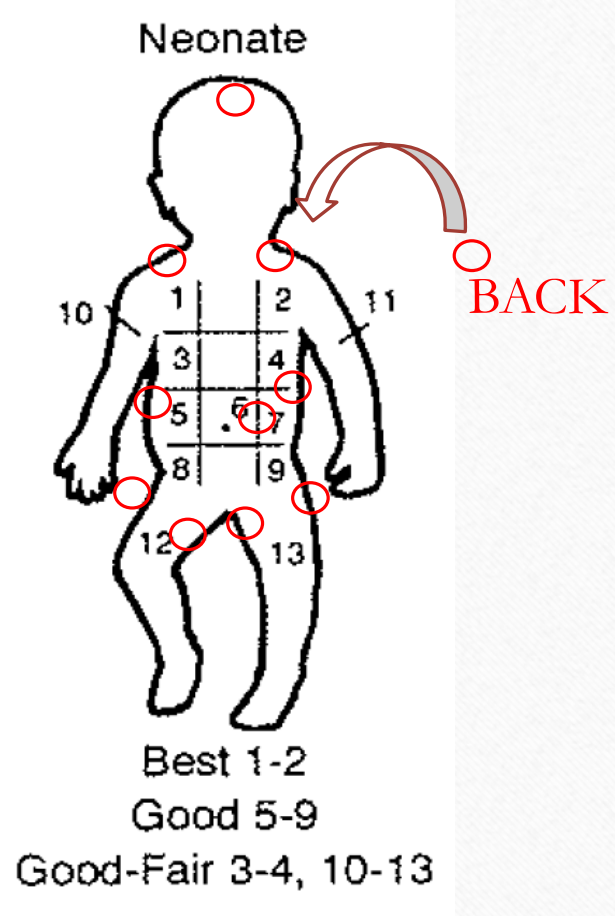
***Note**: SpO2 and Pulse Rate is not available for neonatal patients*

Sensor Application – Neonates

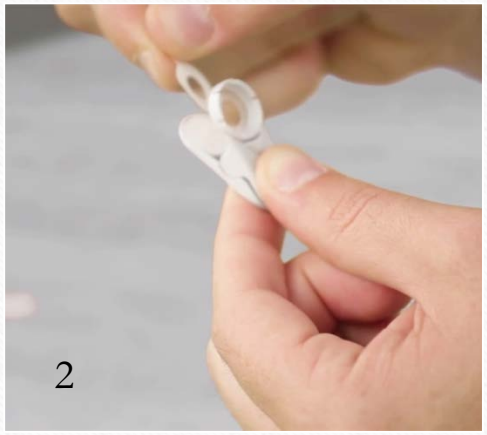
tcPCO2 ONLY Application Sites

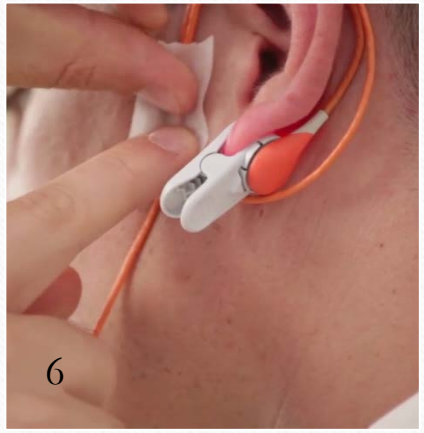
Neonates (up to 1 month of age)			
Parameter	Measurement Site	Skin Condition	Application Accessory
$tcPCO_2$	Thorax under clavicle, abdomen, back, low on forehead, inner or anterior aspect of the thigh	mature, intact	MAR-MI
		sensitive, fragile	MAR-SF

***Warning**: Application of any pressure to the measurement site (e.g. by using a pressure bandage) may cause pressure ischemia at the measurement site and, consequently, inaccurate measurements, necrosis or - in combination with heated sensors - burns.*



Alternative Sensor Application – Ear Clip first to ear





Sensor Application TCM

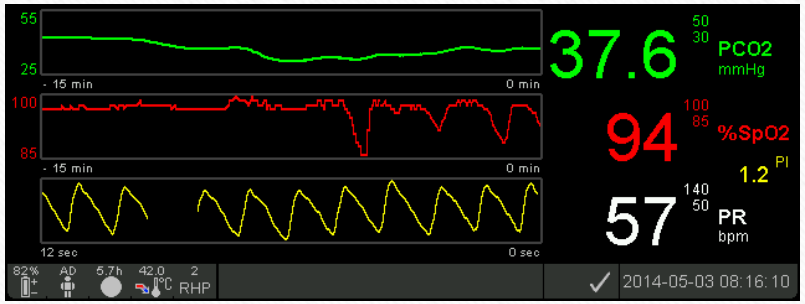
Verify proper operation on your patient

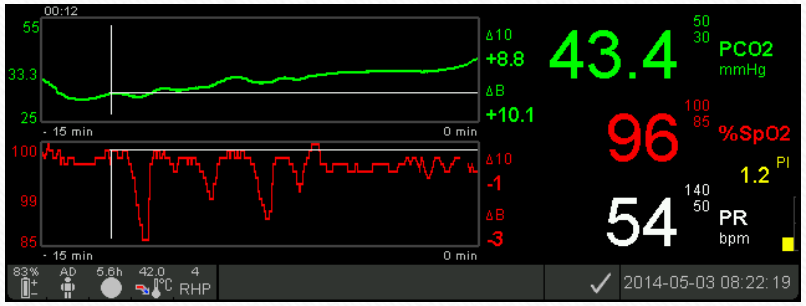
Patient follow-up

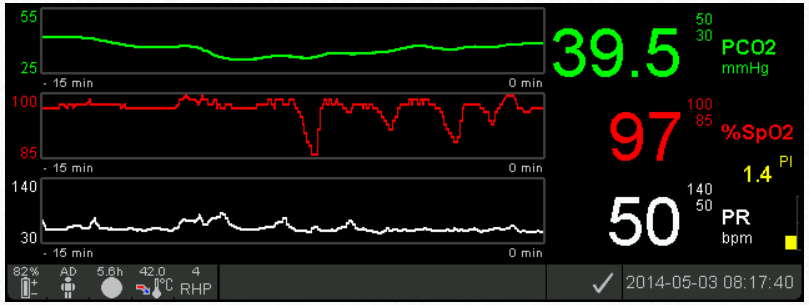
Measurement Screens (PCO2 SpO2 PR)

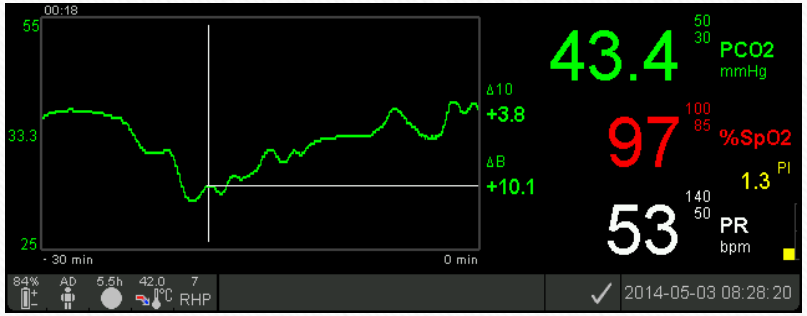
Enabled Parameters = PCO2 SpO2 PR

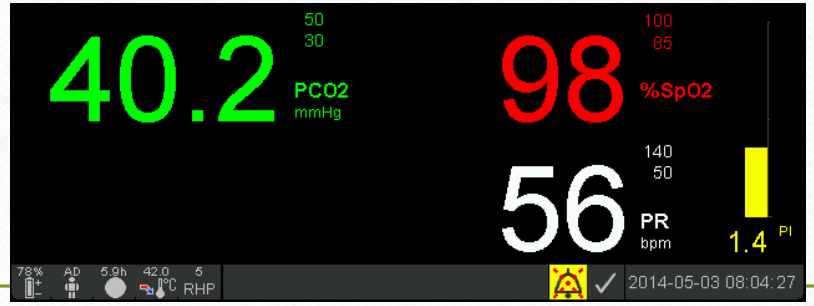
Sensor type = V Sign™ Sensor 2 or OxiVenT™ Sensor / Selected Patient type = Adult



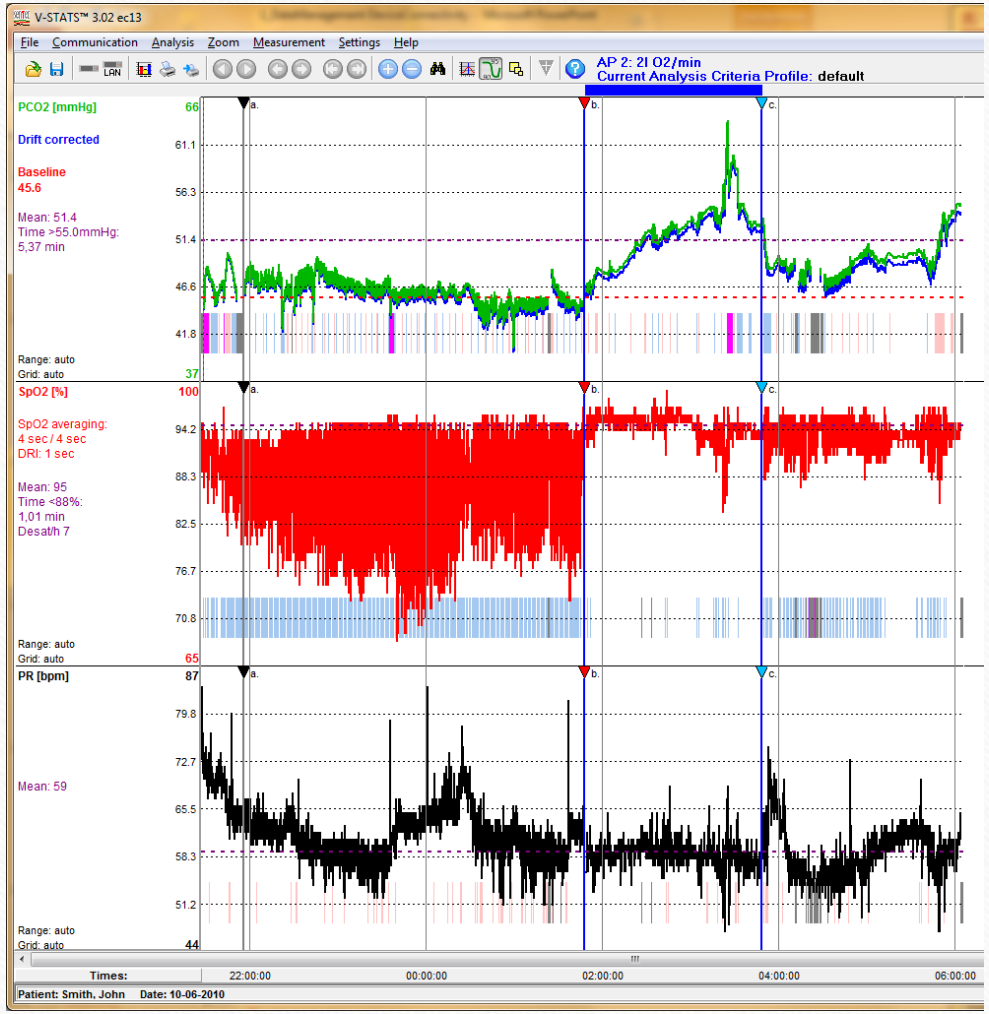








Trend Data Display within V-STATS™



Operator Events previously marked on the SDM during patient monitoring are displayed in V-STATS™' Graphic Window as colored triangles.

Grey vertical lines at the position of an operator event indicate the start of a new Analysis Period. A 'Partial Report' can be generated for each 'Analysis Period' (split night studies).

If retrospective correction of residual PCO2 drift is possible drift corrected PCO2 data are displayed in blue and uncorrected PCO2 data in green.

Main Indications for the TCM

- Continuous monitoring or spot check measurements in hospital or office settings, at home, or during transport
- Whenever etCO2 is unreliable or difficult to use !!
- Mechanically Ventilated Patients

  Invasive Ventilation (titrate ventilation, one-lung ventilation, HFOV, HFJV, SBT, weaning, …)

  Noninvasive Ventilation (Initiate/ titrate NIV (helps to avoid intubation!),..)

- Not-Mechanically Ventilated Patients

  Sleep Medicine (Interfaced with PG/ PSG systems or as screening tool, OHS, ..)

  Pain Management (Procedural Sedation, Recovery Room, General Care Floor)

  Various Settings (Exercise Testing, Dialysis, …)

TCM in Chronic Hypercapneic Respiratory Failure on Home Noninvasive Ventilation TCM

Typical Patient:

A 34-year-old woman with a history of traumatic brain injury at age 4. She also has spastic quadriplegia, and seizure disorder presents with chronic hypercapneic respiratory failure (daytime $PaCO_2$ value 82 mm Hg). She is started on noninvasive bi-level positive airway pressure therapy at night.

TCM in Chronic Hypercapneic Respiratory Failure on Home Noninvasive Ventilation

Description of procedure(s)/service(s):

She undergoes overnight transcutaneous CO2 monitoring on multiple nights while on her bi-level positive airway pressure therapy is titrated in a step-wise manner to improve her minute ventilation. On the best bi-level setting, transcutaneous CO2 values are less than 60 mmHg for two-thirds of the night with oxygen saturations remaining above 90%. Despite excellent compliance on the best bi-level setting, daytime transcutaneous CO2 monitoring reveals persistent hypercapnia with transcutaneous CO2 values of 64-77 mm Hg.

TCM in Chronic Hypercapneic Respiratory Failure on Home Noninvasive Ventilation

SpO2

Minimum (occur.)	75 % (1:43:10)
Maximum (occur.)	99 % (1:54:02)
Mean	94 %
Median	95 %
Time <88%	21,24 min
Time <88% [%]	5
Events < 88%, duration > 5min.	0

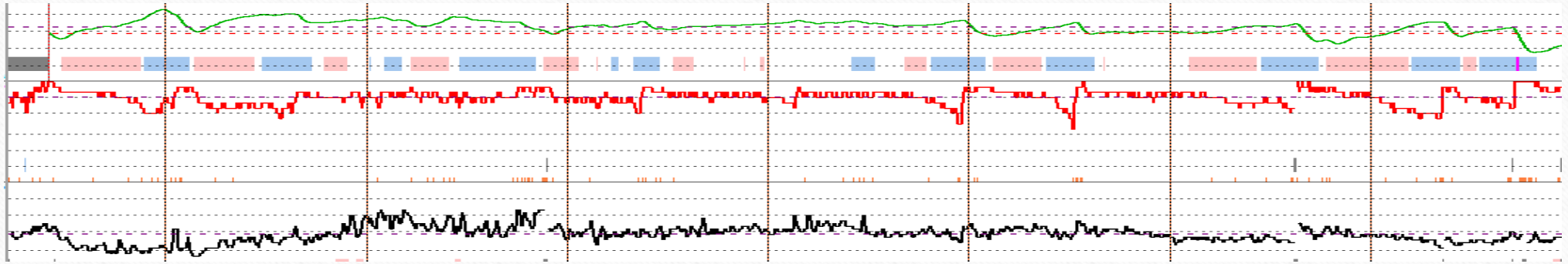
PCO2

Baseline (occur.)	76.3 mmHg (1:16:41)
Minimum (occur.)	50.9 mmHg (7:18:26)
Maximum (occur.)	77.1 mmHg (1:28:38)
Mean	63.8 mmHg
Median	63.0 mmHg
Time >55.0mmHg	7:14,00 hrs
Time > 55.0mmHg [%]	100
Events > 55.0mmHg, duration > 5 min.	0

Full Measurement Curve Report

Therefore, a tracheostomy was performed, with placement of a cuffed #6 Shiley. Patient has done extremely well since discharge, on the nocturnal ventilatory support. She sleeps well and appears entirely comfortable on the ventilator.

Her daytime transcutaneous PaCO2 is checked every 3 months here in the clinic and appears to be normal, 42.3 mmHg. In-home overnight recordings have been completed multiple times with transcutaneous PaCO2 trending 35-43 mmHg and saturation 98 to 100%.



TCM in Obesity Hypoventilation Syndrome in ICU on Noninvasive Ventilation

Typical Patient:

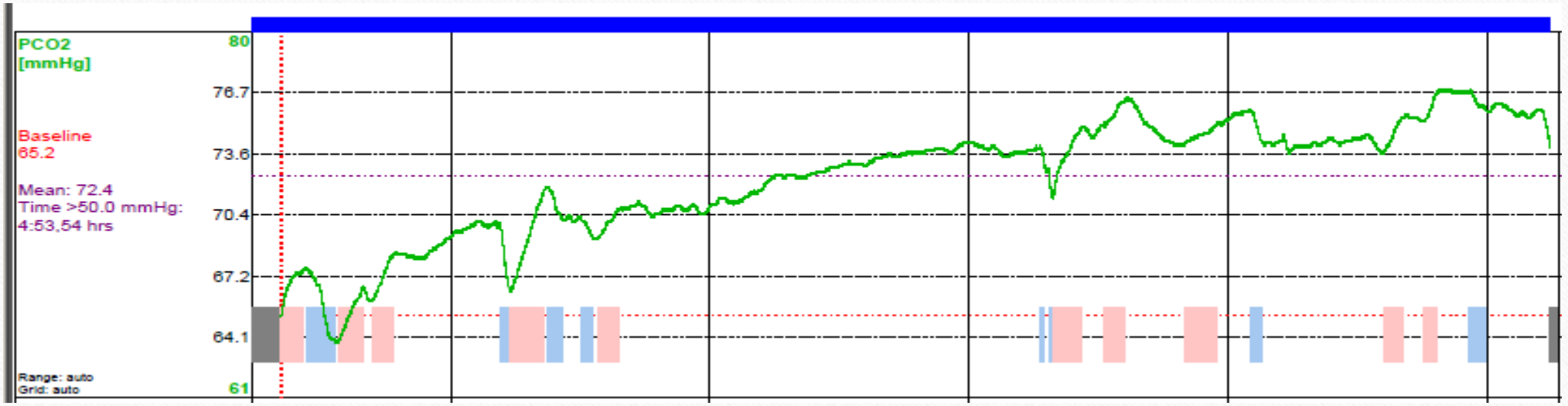
A 38-year-old female with a history of morbid obesity (body mass index 74.3 kg/m^2), obesity hypoventilation syndrome, and obstructive sleep apnea poorly compliant with nocturnal bi-level positive airway pressure therapy and supplemental oxygen at 2 liters/min presented to the emergency department with a two week history of dyspnea, lower extremity edema, and orthopnea. PaCO2 on arterial blood gas measurement was 75 mm Hg.

TCM in Obesity Hypoventilation Syndrome in ICU on Noninvasive Ventilation

Description of procedure(s)/service(s):

During her hospitalization, overnight transcutaneous CO2 monitoring was initiated with the patient using her home bi-level positive airway pressure settings and supplemental oxygen. This revealed periods of apnea during sleep and persistent hypercarbia requiring initiation of non-invasive ventilation with Pressure Control mode with Average Volume-Assured Pressure Support (PC/AVAPS) and a backup rate of 8 breaths/minute.

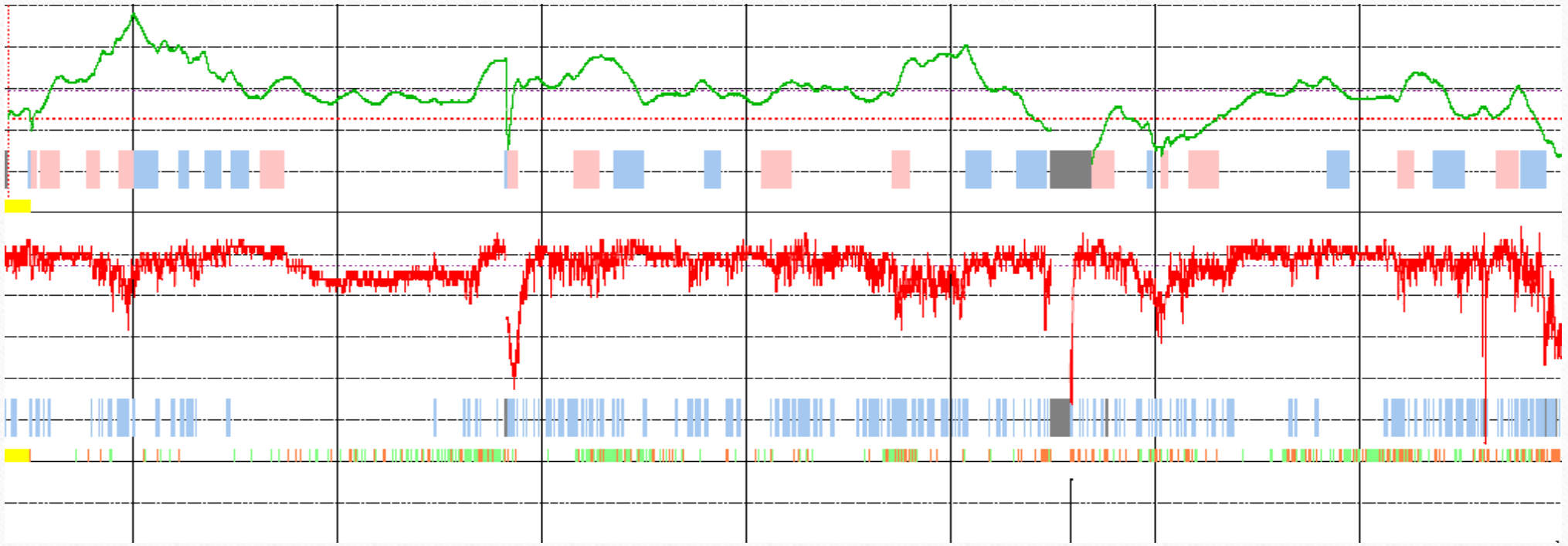
Full Measurement Curve Report



TCM in Obesity Hypoventilation Syndrome in ICU on Noninvasive Ventilation

Overnight transcutaneous CO2 monitoring was again performed with the patient on non-invasive ventilation on PC/AVAPS mode. This revealed persistent hypercapnia requiring an increase in tidal volume (300 to 400 cc) and an increase in respiratory rate (8 to 20 breaths/minute). Subsequent overnight transcutaneous CO2 monitoring on optimal PC/AVAPS settings revealed values of 52-55 mm Hg.

Full Measurement Curve Report



TCM in Neuromuscular Respiratory Failure at Home on Noninvasive Ventilation

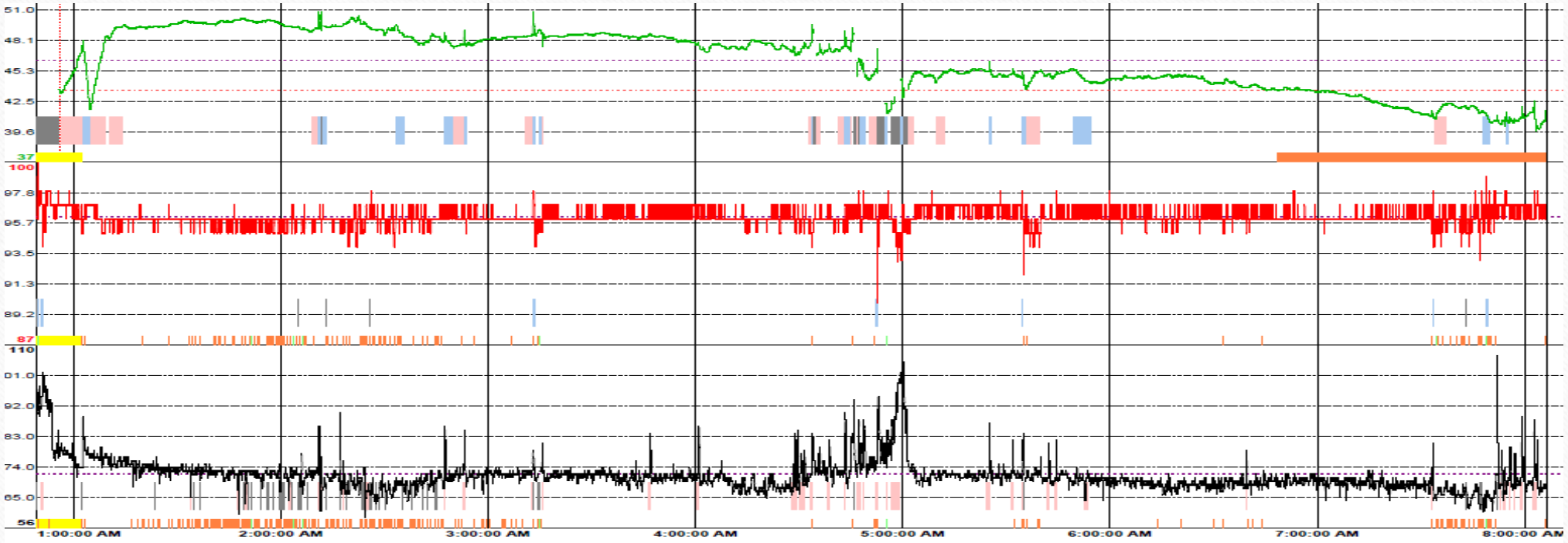
Typical Patient:

A 57 year old male with chronic neuromuscular respiratory failure secondary to Mitochondrial Myopathy and OSA. He is very compliant with his NIV and feels that it helps him when he uses it.

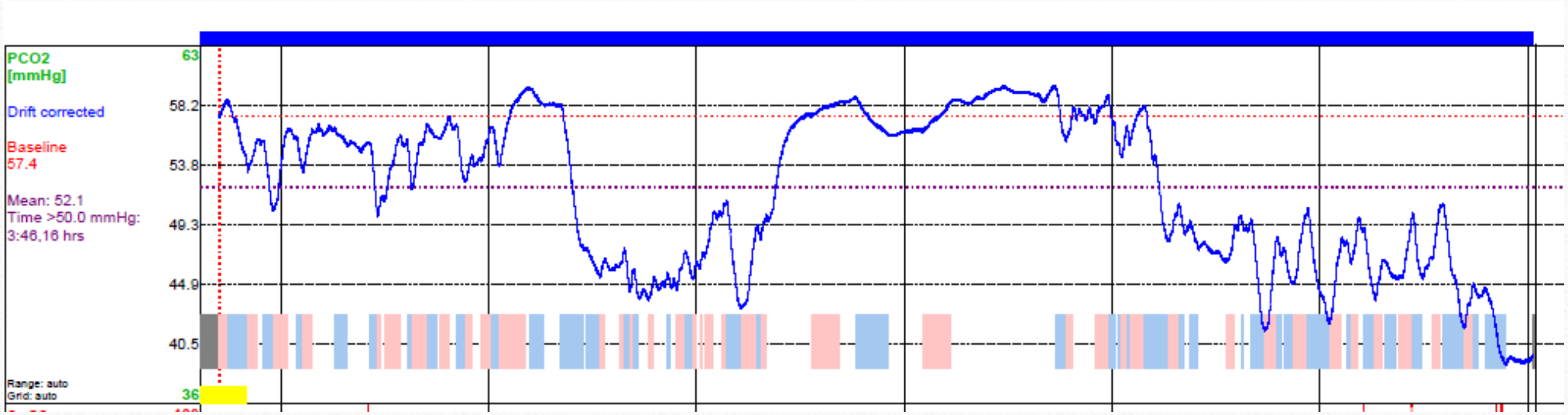
Description of procedure(s)/service(s):

He had a previous TCM study in December with a CO2 of 28 with a higher tidal volume of 450. He did another study on Feb 1 with a tidal volume of 360 and noted a CO2 of 50. He increased the tidal volume to 385 and ended up with a CO in the 40s

Full Measurement Curve Report



Leak to CO2 relationship



Thank You.

Questions?