Vet/Ox® G2 Digital™ Monitor

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Vet/Ox® G2 Digital™ Monitor
Monitoring in the Veterinary Practice

• Primary use - protocols requiring anesthesia
  – Surgery
  – Dentistry
  – Therapeutic procedures

• Animals with disorders of oxygenation
  – Heart / lung disease
  – Chest cavity disease
What things are monitored?

- Heart rate and rhythm
- Respiratory (i.e. breathing) rate and lung sounds
- Body temperature
- Oxygenation (i.e. is adequate oxygen reaching tissues?)
- Ventilation (i.e. is there adequate removal of waste gases?)
Oxygenation

• Are heart/lungs/blood vessels functioning properly?
• Are body tissues receiving enough $O_2$? (i.e. are tissues being adequately “perfused”?)
  – Depth of anesthesia
  – Maintenance while under anesthesia
  – Drugs
  – Condition of patient
Assessing O$_2$ Status

• **Invasive** – arterial blood gases
  – Difficult to draw
  – Can’t send out to lab*
  – Requires special equipment to test
  – Only gives oxygenation status at one particular moment in time

• **Non-invasive** – pulse oximetry
  – Gives *constant, ongoing* arterial oxygen saturation measurements *without having to draw blood*
What is its purpose?
Basics of Pulse Oximetry

• Uses red (660 nm wavelength) and infrared (905 nm) light
  – Red light – absorbed by deoxygenated blood
  – Infrared light – absorbed by oxygenated blood
Basics of Pulse Oximetry

• Sensors send red and infrared light through tissue
• Monitor calculates how much of the blood supply is oxygenated vs deoxygenated
Poor oxygenation – very little oxygenated blood – red light absorbed, infrared passes through
Good oxygenation – mostly oxygenated blood – infrared light absorbed; red light passes through
Sensor Designs

- Transmittance sensors – sends light through tissues

"C"

"Lingual"
Sensor Designs

- Reflectance sensor – bounces light off tissue

Underside of tail, just outside rectum

Wrap snugly in place
Sensor Designs

- Transmittance sensors
  - Attach to limbs, toes, lips, tongue
- Reflectance sensor
  - Attach to underside of tail
  - Insert into rectum or esophagus
#1 Problem in Pulse Oximetry is Improper Sensor Application!!!
Sensor Application

• Choose sensor that is appropriate for patient and application site
  – Don’t try to use lingual sensor during dentistry!
• Don’t apply sensor to the following sites:
  – Black tissue
  – Very thin tissues (ears, skin flaps)
  – Very thick tissues
  – Tissues with poor blood supply (tendons)
Sensor Application

- Be aware of drug effects
  - Hypotension
  - Decreased cardiac output
  - Muscle tremors
- Be aware of disease effects
- *Keep patient warm*
Site Preparation

• Choose well-perfused area
• Shave small spot for sensor application
  – Optimal sensor-to-skin contact
• Wet site with water or alcohol
  – Water preferred – alcohol evaporates
• Transmittance sensor: orient so light shines toward floor, or cover with drape
Lingual Sensor

• Best site: tongue
  – Orient so light shines down
  – Start applying at tip then move toward base to find best site
  – Keep tongue wet throughout procedure
  – Very small tongues – fold sides together; apply single layer of damp gauze
C Sensor

- Orient so that light faces down
- Apply to “meaty” tissues
  - Toes, toe webbing, tongue, very small paws, vulva, prepuce
- Remove and reapply periodically – pressure from jaws blanches tissue
Reflectance Sensor

- Best sites:
  - Ventral base of tail
  - Esophagus
- May also be used rectally, but must contact sphincter
Historical Problems in Pulse Oximetry
Patient Movement

• Patient moves – adds a noise component to patient signal
• Outside electronic signals create noise
  – Electrosurgery instruments
  – Ultrasonic dental scalers
  – Fluorescent lights
• Noise overwhelms patient signal – monitor no longer recognizes patient
Wave Combination

• Like notes on a piano – can strike multiple keys but only hear one sound.
  – Individual waves from each key blend together

300 Hertz + 500 Hertz =

500 Hertz
Low Perfusion

- Patient signal very weak
- Indistinguishable from interference waves and/or noise
- *Condition not recognized*
### Low Perfusion

- Low perfusion conditions occur frequently and are dangerous to the patient:

<table>
<thead>
<tr>
<th>Surgery/anesthesia complications:</th>
<th>Certain drugs:</th>
<th>Heart diseases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood loss</td>
<td>Acepromazine</td>
<td>Arrhythmias</td>
</tr>
<tr>
<td>Drop in blood pressure</td>
<td>Propofol</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>Shock</td>
<td>Xylazine / Detomidine</td>
<td>Valve defects</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>Isofluorane / Sevofluorane</td>
<td></td>
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</tbody>
</table>
Approaches to Fix

• Amplify signal
  – *Doesn’t work* – amplifies both patient wave and interference waves in proportion
G2 Solution

• #1 Solution - Produce a clean data stream
  – “Digital at the source” sensor - converts patient signal directly to digital form
    • No analog component
    • Very clean data stream entering the monitor
  – Patented technology
  – Heska has exclusive world-wide license
Basics of Pulse Oximetry

• In all monitors except G2, current travels through connector cable to monitor as analog waves
  – Analog = \[\sim\] = wave of voltages over time

• In all monitors except G2, analog wave is converted into a stream of discrete numbers (i.e. *digitized*) within the monitor
IMPORTANT NOTE!!

• Last slide – “analog wave is DIGITIZED…”
  – **ALL PULSE OXIMETERS ARE “DIGITAL” IN SOME PART OF THEIR OPERATION!!**

• Manufacturers use “digital” as buzzword for new technology – NOT TRUE!
Frequency Domain Analysis

• **G2 solution:**
  – Frequency domain analysis
  • Time domain = total signal over time – can’t separate out interference
  • Frequency domain = signals due to movement and electronic noise are easily filtered out
G2 Solution

• **Frequency domain analysis**

**TIME DOMAIN:**
Patient + Interference in one wave.
Cannot separate!

**FREQ DOMAIN:**
Patient and Interference split out by frequency.
Easy to separate.
Data Management

• Readings taken at *millisecond* intervals
• *Huge* stream of data entering monitor
• Even using frequency domain analysis, most monitors *can’t keep up*
  – Can’t eliminate all interference and noise waves
  – True patient signal still overwhelmed

• *G2 Solution:*
  – *Fast Fourier Transfer* algorithm used for signal processing
  – Advanced processing technology – easily keeps up with incoming information
G2 Monitor

Sensor

- LED
- Photodetector
- A/D Converter
- Digital Signal Processing (Frequency Domain Analysis) (FFT)
- Display
LED Photodetector

Sensor

Signal Amplifier → A/D Converter → Digital Signal Processing → Display
The Best Monitor Will…

- Minimize interference signals coming into the monitor
  - G2 direct-to-digital sensors
- Use frequency domain analysis to isolate patient signal
  - G2 programming
- Use algorithms that can handle the data stream
  - G2 programming
G2 Digital Monitor Excels At:

- Eliminating electronic noise artifact
- Eliminating patient motion artifact
- Extracting the maximum amount of patient information when signal is very weak
- Detecting and reporting asystole
Why Veterinarians Love the G2

- **Significantly improved** ability to locate and extract patient signal in low perfusion situations
- **Significantly improved** ability to eliminate motion artifact
  - Frightened patients (shivering)
  - Trauma patients
  - Patient moved during surgery
  - Patients recovering from anesthesia (shivering)
  - Patients who object to having sensor on body
Why Veterinarians Love the G2

• Excellent monitoring of oxygenation
  – Ventilation/perfusion mismatches
  – Heart disease
  – Lung disease
  – Chest cavity disease
  – Anesthetic equipment failure
  – Inadequate oxygenation during surgery
Basic Operations & Laboratory
**Overview**

- **On/Off key**
  - press once for 2-min mute;
  - press 3 times for indefinite mute

- **Alarm Silence key**
  - press once for 2-min mute;
  - press 3 times for indefinite mute

- **Alarm Volume key**
  - sets volume of alarm

- **Alarm Limits key**
  - press 3 times to set High and Low alarm limits

- **Menu key**
  - press 3 times to access menus

- **Backlight On / Off**
  - Battery: backlight on for 15 sec
  - AC: backlight on until button pressed again

- **Up/Down arrow bar**
  - adjusts settings; adjusts patient pulse beep
Printer and Power

- Power: Battery (rechargeable NiMH; 4 hours) or AC
- Printer: PC or Seiko printer

Plug adapter into power cord, attach to G2, attach to wall
Sensor Connections

Plug in lingual, temperature, and respiration rate sensors

*Turn on G2*

Place lingual sensor on left index finger, temperature sensor in fist, blow into respiration sensor
Display

SpO₂ reading
Signal strength bar
Pulse Rate reading
Alarm Limit icon
AC power indicator
Battery life indicator
Resp Rate reading
Resp indicator
Alarm Silence icon
Temperature reading
Temperature scale setting

Disable alarming if needed – press ⏰ 3 times
Monitoring Equipment

• ECG (Electrocardiogram) – heart rate, rhythm

• Blood Pressure – pressure on vessel walls exerted by blood flow

• Capnography – ability of patient to remove CO₂

• Blood Gas Analyzers – direct measurement of O₂ and CO₂ in blood

• Pulse Oximetry – *indirect* measurement of O₂ in blood
  – *G2 Digital*
Competition

• Nonin
  – Signal starts as analog
  – Time domain analysis only
  – Inefficient DSP algorithms

• Nellcor (most models)
  – Signal starts as analog
  – Time domain analysis only
  – Primitive DSP algorithms

• Palco
  – Signal starts as analog
  – Time domain analysis only
  – Primitive DSP algorithms
• Nellcor N395
  - Signal starts as analog
  - Frequency domain analysis
  - Inefficient DSP algorithms
  - Very expensive

• Masimo
  - Signal starts as analog
  - Frequency domain analysis
  - Fairly efficient FFT-type algorithms
  - Very expensive