Capnography, Pulse Oximetry, and Gas Analysis

YOU SHOULD BE ABLE TO

- ✓ Name the four phases of the capnogram and read the classic abnormal shapes
- ✓ Explain the arterial to end-tidal gradient and say what widens it
- ✓ Pick the right sensor for oxygen, carbon dioxide and the volatile agents, and name the oximeter's blind spots

THE LESSON ON ONE PAGE

Shapes

- Baseline off zero: rebreathing
- Slurred upstroke, sloped plateau: obstruction
- Notch in the plateau: curare cleft
- Ripples at heart rate: cardiogenic
- Same shape, less height: blood flow
- No waveform: airway or circuit

Numbers

- CO2 absorbs infrared at 4.26 microns
- Gradient 2 to 5 mmHg, EtCO2 lower
- Alpha angle 100 to 110 degrees
- Beta angle about 90 degrees
- Sidestream 50 to 250 mL/min
- CPR: keep EtCO2 above 10, aim 20

Oximetry

- 660 nm red, 940 nm infrared
- Pulsatile signal only; calibrated to about 70%
- Ear and forehead read sooner than fingers
- Motion and low perfusion fail most often
- Darker skin: occult hypoxemia risk
- Confirm with co-oximetry when it does not fit

Sensors and standards

- Oxygen: paramagnetic, galvanic, Clark
- Infrared needs two different atoms
- Agent named by multiple wavelengths
- Nitrogen and helium: not on infrared
- ASA: EtCO2 from placement to removal
- ASA: BP and HR every 5 minutes

KEY TABLES

Three patterns

WHAT YOU SEE	WHAT IT MEANS	FIRST MOVE
Baseline above zero	Rebreathing: absorbent, valve, low fresh gas flow	Raise the flow, check valves and absorbent
Slurred upstroke, sloping plateau	Obstruction: bronchospasm, COPD, kinked or plugged tube	Check the tube, then treat the airway
Shape normal, height falls fast	Pulmonary blood flow has fallen	Check pressure and pulse, look for embolism
Whole waveform gone	Airway, circuit or ventilator	Hand ventilate and trace the circuit
Height climbing, shape square	Hypoventilation, absorbed CO2, fever, MH	Check ventilation, then think MH

Oximetry errors

PROBLEM	WHAT IT DOES TO SPO2	WHAT TO DO
Motion, shivering	Erratic, usually reads low	Resite to ear or forehead, warm the patient
Low perfusion, cold, vasopressors	Signal drops out entirely	Warm the hand, move central, consider an arterial line
Venous pulsation (severe TR, dependent limb, head down)	Falsely low	Raise the limb, change site

PROBLEM	WHAT IT DOES TO SPO2	WHAT TO DO
Ambient light, surgical lamps, infrared warmers	Erratic readings	Shield the probe
Nail polish (blue, green, black), artificial nails	Small false decrease	Remove it, or turn the probe sideways on the digit
Methylene blue	Sharp transient fall, sometimes into the 60s	Wait a few minutes, correlate with a gas
Indigo carmine, indocyanine green	Smaller, briefer dip	Note the time of injection
Carboxyhemoglobin	Falsely high (see Lesson 4)	Co-oximetry on a blood sample
Methemoglobin	Drifts toward 85% (see Lesson 4)	Co-oximetry, then methylene blue if indicated

BOARD TRAPS

"A flat capnogram means the tube is in the esophagus."

Not only that. A waveform that disappears also means **disconnection, extubation, apnea, complete airway obstruction, ventilator failure, a blocked sample line**, or a **cardiac arrest** with no pulmonary blood flow. Look at the patient and the circuit before you pull a tube that is in the right place.

"EtCO2 is the same as PaCO2 in a healthy adult."

False. EtCO2 sits **2 to 5 mmHg below** PaCO2 even in normal lungs, because alveolar dead space dilutes the sample. In a sick patient the gap is unpredictable, which is why a craniotomy targeting a set PaCO2 gets a blood gas rather than a capnograph reading.

"The pulse oximeter will warn me if the patient stops breathing."

Late, if at all. A preoxygenated patient can be apneic for **minutes** with an SpO2 of 100%. Saturation reports oxygenation, not ventilation. That gap is exactly why the ASA standards require **end-tidal CO2** for ventilation, and why sedation cases get a sampling cannula.

"Sidestream sampling responds faster than mainstream."

Backwards. Mainstream reads the gas in the airway with no transit delay, so it has the fastest response and the crispest waveform. Sidestream has to pull the sample down feet of tubing first. Sidestream wins on weight, on agent analysis and on nonintubated patients, not on speed.

MEMORY DEVICES

Four steps, in this order

FLAT

- **F** Floor: is the baseline on zero? If not, rebreathing
- **L** Lift: is the upstroke steep? A slurred lift is obstruction
- **A** Alveolar plateau: flat and level? Upslope is obstruction, a notch is a breath, ripples are the heart
- **T** Top: is the height right? Low is dead space or low output, high is hypoventilation or MH, gone is the circuit

Pulse oximetry pitfalls

Dyes dip, CO cheats, Met sits at 85

- **Dyes** Methylene blue (biggest), indocyanine green, indigo carmine: falsely low
- **CO** Carboxyhemoglobin reads as oxyhemoglobin: falsely high
- **Met** Methemoglobin pulls SpO2 toward about 85%
- **Noise** Motion, poor perfusion, dark nail polish, bright light

Drugs that cause methemoglobinemia

Dark Blood Never Pinks

- **D** Dapsone
- **B** Benzocaine (topical spray)
- **N** Nitrates, nitrites, and nitric oxide donors: nitroglycerin, nitroprusside, inhaled nitric oxide
- **P** Prilocaine