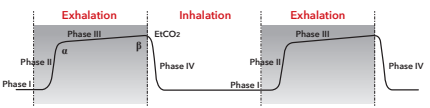
Capnography Waveforms – Quick Reference Guide[1]

Normal Capnogram Waveform



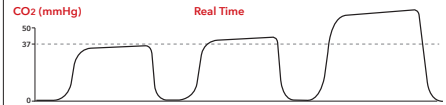
Normal Waveform Characteristics

Phase I: Beginning of exhalation; respiratory baseline containing dead space gas
Phase II: Rapid upstroke representing exhalation; contains mixture of dead space and alveolar gases
α angle: Normally a 108-degree angle
Phase III: Alveolar plateau, containing mostly CO_2-rich alveolar gas.
β angle: End of exhalation and beginning of inhalation; normally a 90-degree angle
$EtCO_2$: End of exhaled breath and point of measurement
Phase IV: Downstroke representing inhalation

Normal Range for $EtCO_2$:
> 35-45 mmHg
> 4.0-5.7 kPa

$EtCO_2$ to $PaCO_2$ Gradient:
> $EtCO_2$ is 1-5 mmHg lower than $PaCO_2$ in patients with normal lung function
> Wider gradient indicates greater ventilation/perfusion deficit

Increasing $EtCO_2$



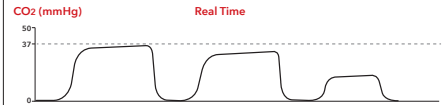
Waveform Characteristics

> Increasing amplitude and width, over variable time period, depending on cause
> Slowing frequency with decreasing respiratory rate is dependent on cause and patient's physiologic response

Nursing Assessment and Considerations

> Assess patient for bradypnea/hypercapnia
> Assess patient for respiratory failure or oversedation
> Consider airway management if needed
> Assess for fever or change in temperature from hypothermia to normothermia
> Assess for hypermetabolic state
> Tourniquet release, sodium bicarbonate, and CO_2 insufflation can cause brief rise in $EtCO_2$

Decreasing $EtCO_2$



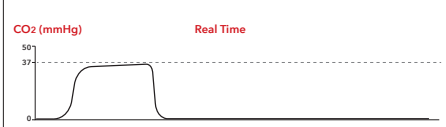
Waveform Characteristics

> Decreased amplitude and width
> Faster frequency, increased respiratory rate

Nursing Assessment and Considerations

> Assess patient for tachypnea/hypocapnia.
> If tachypneic, assess for underlying causes such as pain, anxiety, or respiratory distress
> Assess patient for hypoxemia
> Assess patient for decreasing metabolic rate, hypovolemia, or shock
> Assess patient for temperature change
> Assess patient for pulmonary embolism

Loss of Waveform



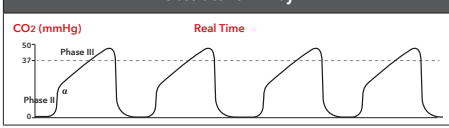
Waveform Characteristics

> Loss of capnographic waveform
> No breath detected by capnograph

Nursing Assessment and Considerations

> Assess patient for apnea, complete airway obstruction, or cardiac arrest
> If intubated check for ET tube extubation, kinks or blockage, or ventilator disconnection
> Confirm cannula or mask is placed on patient correctly and connected to monitor
> Ensure patient's airway is open and patent, and patient is breathing
> If patient is mouth breathing use cannula with oral prong to capture breaths from mouth
> Follow your institution's procedure for airway and breathing support
> Check for equipment failure

Obstructive Airway



Waveform Characteristics

> Phase II slopes upward with a blunted α angle instead of a sharp upstroke with strong α angle
> Phase III (plateau) is more rounded

Nursing Assessment and Considerations

> Assess patient for bronchospasm
> If intubated, assess ET tube for partial kinking
> Assess patient for foreign body in airway
> Assess patient for partial airway obstruction
> The greater the "shark fin" shape, the greater the severity of the obstructive or reactive airway disease

[1] Brast, S., Bland, E., Jones-Hooker, C., Long, M., and Green, K. (2016). Capnography for the Radiology and Imaging Nurse: A Primer. *Journal of Radiology Nursing*, Volume 35, Issue 3, 173 – 190.

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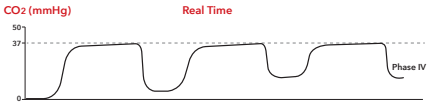
Rebreathing CO_2



Normal Waveform Characteristics

- Waveform shape may be normal but appears to float above baseline
- Phase IV (downstroke representing inhalation) does not go back to baseline or zero

Nursing Assessment and Considerations

- Assess patient for rebreathing of exhaled CO_2
- If patient is mechanically ventilated, assess for air trapping or breath stacking, check vent settings, circuit set up, and equipment
- If patient is spontaneously breathing, ensure drapes are not covering face
- If using oxygen mask, ensure oxygen flow is adequate

Leak

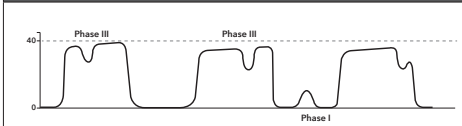
Waveform Characteristics

- First waveform is normal but second and third waveforms (phase III and phase IV) are degraded or distorted

Nursing Assessment and Considerations

- Assess for mask leak or loss of seal in patients on CPAP, BiPAP or NIV
- For intubated patients check ET tube cuff for leak

Curare Cleft and Secondary (Camel) Hump



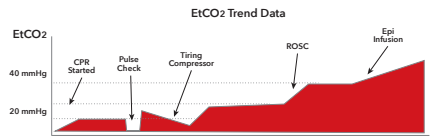
Waveform Characteristics

- Notching or cleft in first two waveforms during Phase III
- Small, secondary waveform during Phase I, between second and third waveform

Nursing Assessment and Considerations

- Sometimes seen in mechanically ventilated patients due to weak, uncoordinated diaphragmatic movement or ventilator asynchrony under sedation and clearing chemical paralysis
- Reassess patient's need for sedation and chemical paralysis
- May also be seen with neuromuscular dysfunction

$EtCO_2$ Trend Data During Cardiac Arrest



- Initially, waveform and $EtCO_2$ value are low during cardiac arrest but increase with effective chest compressions
- The higher the $EtCO_2$ value the greater the chance of ROSC
- $EtCO_2 \geq 20$ mmHg during CPR indicates adequate chest compressions
- $EtCO_2 < 10$ mmHg after 20 minutes of high-quality chest compressions indicates poor prognosis for survival

Five-Step Method for Capnography Interpretation

1. **Is there a waveform? No:** Is patient pulseless, apneic, or accidentally extubated? Is patient mouth breathing with a nasal cannula? Is the airway obstructed? Repositioning head may alleviate airway obstruction. **Yes:** What is the height, width, and frequency (respiratory rate)? Is there a pattern? Is patient hypoventilating or hyperventilating? Is patient in shock or hypovolemic?
2. **What is the shape of the waveform?** Do you see a steep rise in Phase II with a plateau? Is there sloping, notching, or a prolonged Phase III? If the plateau is altered, the expiratory phase and alveolar gas exchange are altered. If sloping is seen, consider bronchospasm, kinked artificial airway, or foreign body.
3. **Does the waveform have a steep return to baseline?** Phase IV represents the inspiratory phase. If patient is rebreathing CO_2, assess for air trapping or excess dead space in ventilator circuit.
4. **What is the $EtCO_2$ trend?** Evaluating the trend provides a graphic representation of patient's ventilatory status over time. Downward trending could indicate shock or hypovolemia. Upward trending could indicate increased metabolic demand, hypoventilation, or hyperthermia.
5. **Does your capnographic assessment correlate to your clinical assessment?** Are there assessment disparities among $EtCO_2$ trend, respiratory rate, waveform, and clinical picture? As a standard of practice, multiple subjective and objective assessment criteria are required to confirm ET tube placement.

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