Capnography (ILS/ALS)

Clinical Indications:

1. Capnography shall be used as soon as possible in conjunction with any airway management adjunct, including endotracheal, Blind Insertion Airway Devices (BIAD) or Bag Valve Mask (BVM).
2. Capnography should also be used on all patients treated with CPAP or epinephrine for respiratory distress.
3. Acute respiratory distress.
4. Assisted ventilations.
5. Sustained altered mental status.

Procedure:

1. Attach capnography sensor to the BIAD, endotracheal tube, or oxygen delivery device.
2. Note CO2 level and waveform changes. These will be documented on each respiratory failure, cardiac arrest, or respiratory distress patient.
3. The capnometer shall remain in place with the airway and be monitored throughout the prehospital care and transport.
4. Any loss of CO2 detection or waveform indicates an airway problem and should be documented.
5. The capnogram should be monitored as procedures are performed to verify or correct the airway problem.
6. Document the procedure and results on/with the Patient Care Report (PCR) and the Airway Evaluation Form.
7. In all patients with a pulse, an ETCO2 >20 is anticipated. In the post-resuscitation patient, no effort should be made to lower ETCO2 by modification of the ventilatory rate. Further, in post- resuscitation patients without evidence of ongoing, severe bronchospasm, ventilatory rate should never be < 6 breaths per minute.
8. In the pulseless patient, and ETCO2 waveform with an ETCO2 value >10 may be utilized to confirm the adequacy of an airway to include BVM and advanced devices when Sp02 will not register.

Critical Comment:

- *When CO2 is **NOT** detected, three factors must be quickly assessed*:

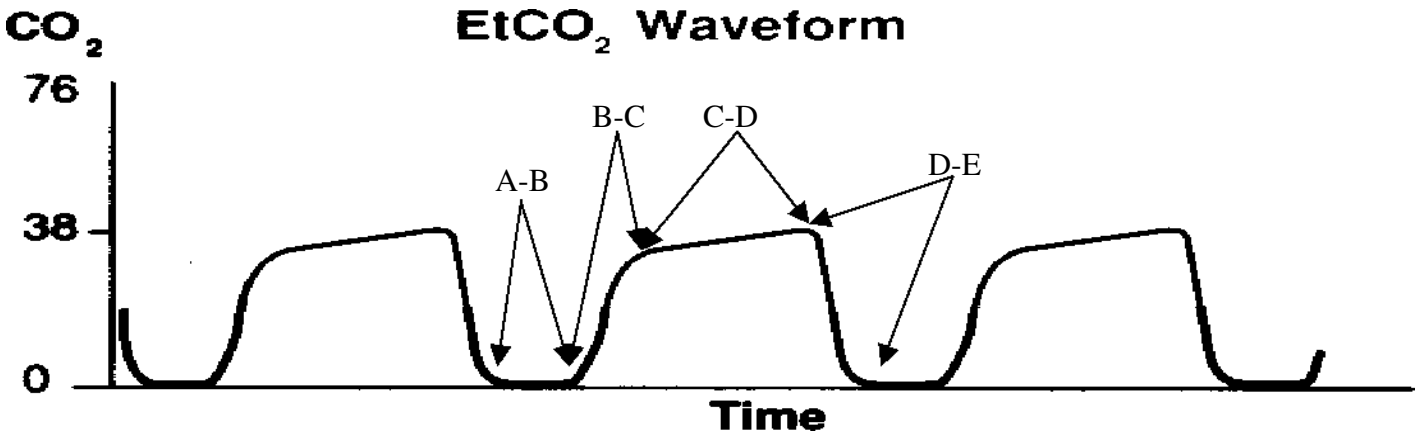
1. Loss of airway - apnea? Esophageal endotracheal tube placement/migration? Obstruction?
2. Circulatory collapse - cardiac arrest? Massive pulmonary embolism? Exsanguination?
3. Equipment failure - disconnected or malfunctioning bag-valve or ventilator?

Interpreting Capnography:

*The figure below shows a normal capnography waveform display. There are 4 phases of the waveform that require analysis. The flat **A – B** baseline segment (Respiratory Baseline) represents the beginning of exhalation of CO_2 – free gas that is contained in dead space from the conduction airways (trachea, bronchi). This value normally is zero. The **B – C** segment (Expiratory Upstroke), a sharp rise, represents exhalation of a mixture of dead space gases and alveolar gases. The **C – D** segment represents the alveolar plateau, characterized by exhalation of mostly alveolar gas. Point **D** is the end-tidal ($EtCO_2$) value that is recorded and displayed by the monitor, (peak concentration of CO_2 occurring at the end of expiration). The **D – E** segment (Inspiratory Downstroke), a sharp fall, reflects the inhalation of gases that are CO_2 – free (room air or supplemental oxygen). Alterations of the normal capno graph or $EtCO_2$ values are the result of changes in metabolism, circulation, ventilation, or equipment function.*

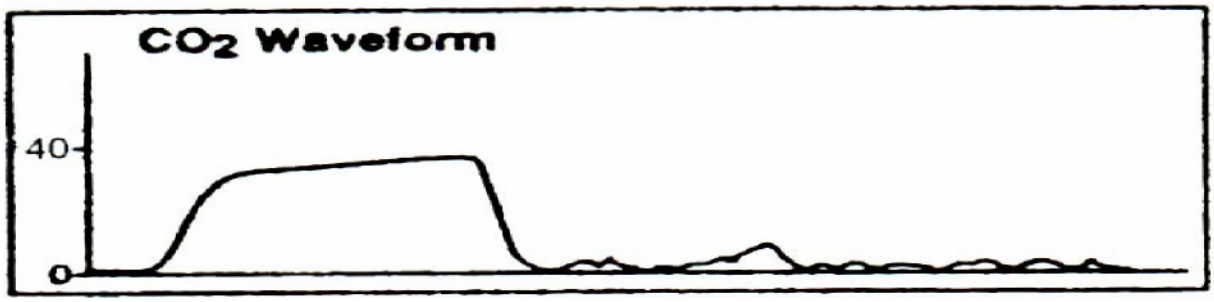
- *A normal range for $EtCO_2$ is **35 – 45 mmHg**, similar to the range of CO_2 in arterial blood.*

Normal Waveform:



Abnormal Waveforms:

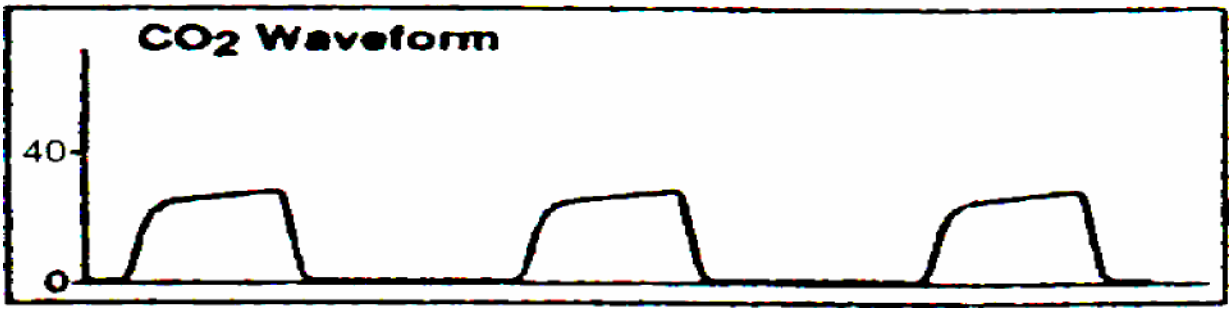
Sudden loss of $ETCO_2$ to zero or near zero:



Possible Causes:

1. ***Endotracheal tube in esophagus***
2. ***Incorrect King Tube tube being utilized for assisted ventilations***
3. ***Apnea***
4. *Endotracheal tube or King Tube not connected to oxygen supply/capnography detector.*
5. *Total obstruction/mucus plugging*
6. *Capnography malfunction - if abnormal waveform persists with change in capnography adaptor, the endotracheal tube or King Tube MUST be withdrawn and intubation or King Tube placement reattempted*

Sustained low $ETCO_2$ with good alveolar plateau:

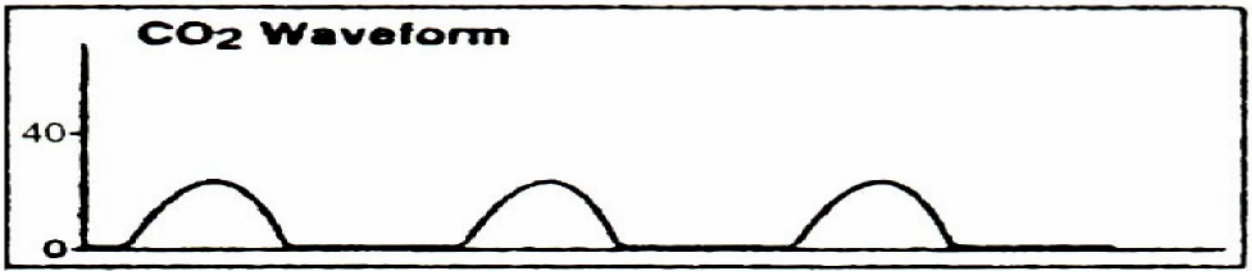


Possible Causes:

1. *Hyperventilation (due to underlying illness/injury or excessive assisted ventilations)*
2. *Hypothermia (Decrease in Metabolism)*

Abnormal Waveforms:

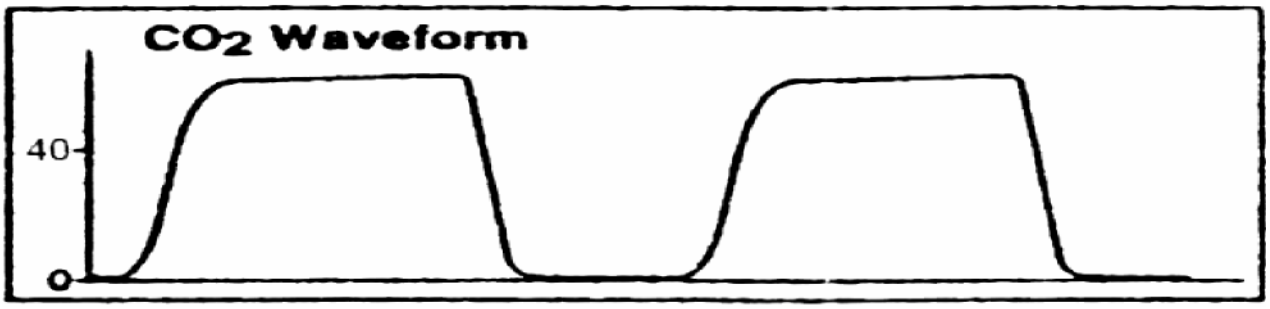
Sustained low $ETCO_2$ without alveolar plateau:



Possible causes:

1. *Bronchospasm of asthma or COPD exacerbation*
2. *Incomplete obstuction/mucus plugging*

Elevated $ETCO_2$ with good alveolar plateau:

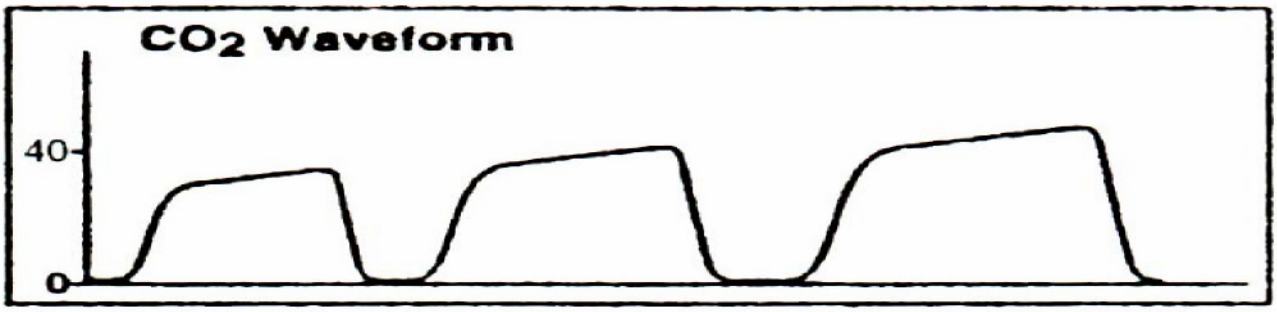


Possible causes:

1. *Hypoventilation (due to underlying illness/injury or inadequate assisted ventilations)*
2. *Hyperthermia, pain, shivering (Increase in Metabolism)*

Abnormal Waveforms:

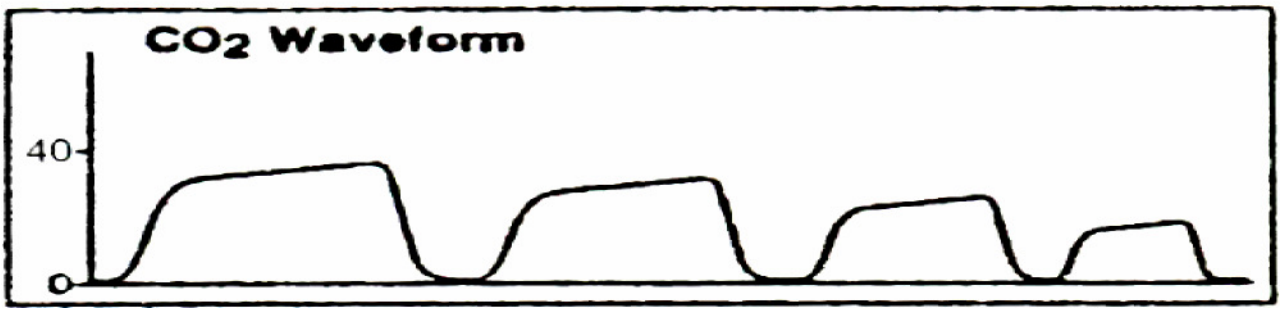
Gradually increasing $ETCO_2$:



Possible causes:

1. *Hypoventilation (due to underlying illness/injury or inadequate assisted ventilations)*
2. *Rising body temperature, increasing pain (Increasing Metabolism)*

Exponential decrease in $ETCO_2$:

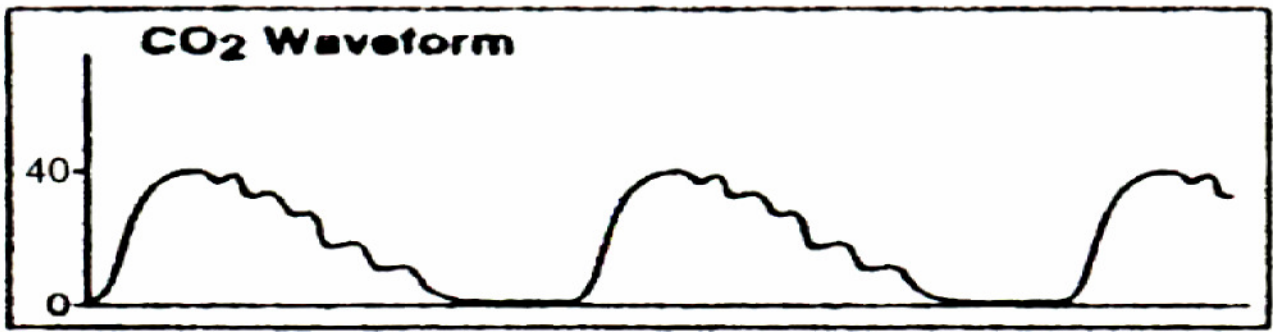


Possible causes:

1. *Cardiopulmonary arrest*
2. *Pulmonary embolism*
3. *Sudden hypotension, massive blood loss*
4. *Cardiopulmonary bypass*

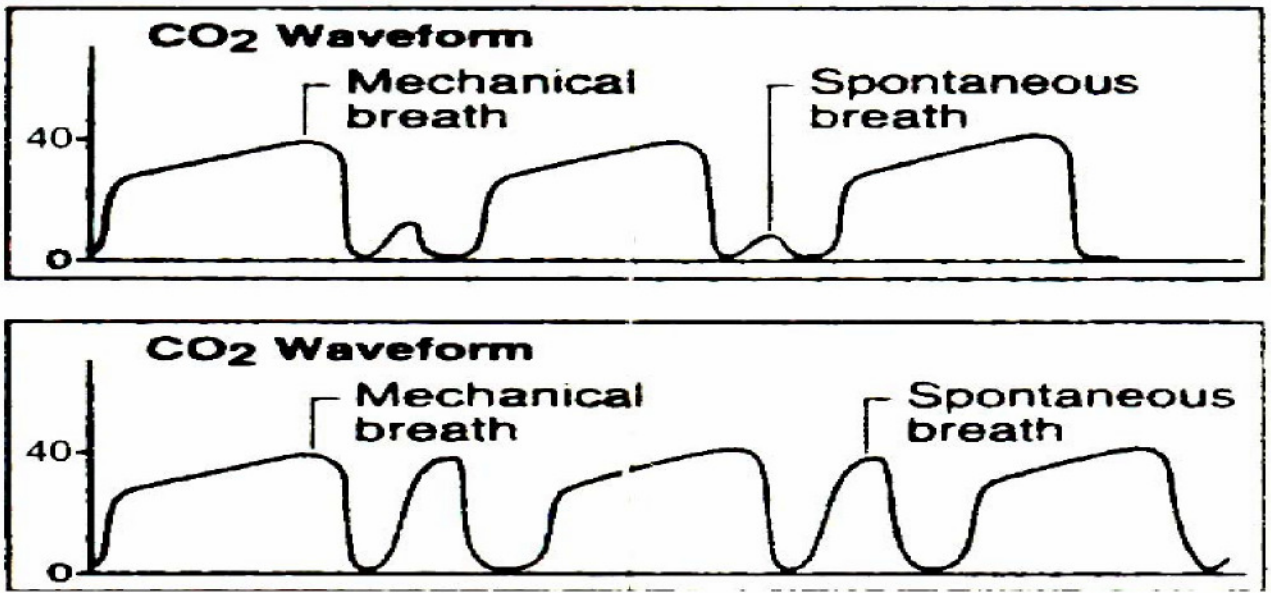
Abnormal Waveforms:

Cardiogenic oscillations:



Cardiogenic oscillations are caused by changes in thoracic volume secondary to expansion and contraction of the myocardium with each heartbeat. They are usually seen in patients with small tidal volumes and slow respiratory rates, and are of little physiologic consequence.

Spontaneous breathing during mechanical ventilation:



Spontaneous breathing efforts may be evident on the CO2 waveform display. The patient on the top demonstrates poorer quality spontaneous breathing effort than the patient on the bottom.

Troubleshooting Tips for EtCO2 monitoring:

Observation	***Possible Cause***	***Corrective Action***
ALARM APNEA *message appears*	*No breath has been detected for 30 seconds since last valid breath*	• *Check the patient, then ventilation equipment for leaks or*
CO2 FILTERLINE OFF *message appears*	*FilterLine, or any other CO2 accessories disconnected or not securely connected to the*	• *Connect FilterLine, or any other CO2 accessories, to input connector or tighten connection*
CO2 FILTERLINE BLOCKAGE *message appears*	*FilterLine is twisted or clogged. The message appears after 30 seconds of unsuccessful purging*	• *Check the FilterLine and if necessary replace it* • *Check the Airway*
CO2 FILTERLINE PURGING *message appears*	*FilterLine tube twisted or clogged with water*	• *Check the FilterLine and if necessary,*
EtCO2 *values erratic*	*A leak in the tubing* *Assisted ventilated patient breaths spontaneously*	• *Check for connection leaks and line leaks to patient and correct if necessary*
EtCO2 *values are consistently higher or lower than*	*Physiological cause Ventilator/Assisted*	• *Check patient* • *Check ventilator &/or assisted ventilation*
XXX *appears in place of EtCO2 value*	*CO2 module not calibrated successfully CO2 module failed*	• *Notify appropriate supervisor/materials of critical*

Certification Requirements:
Maintain knowledge of the indications, contraindications, technique, and possible complications of the procedure. Assessment of this knowledge may be accomplished via quality assurance mechanisms, classroom demonstrations, skills stations, or other mechanisms as deemed appropriate by the PAEMS EMS System. Assessment should include direct observation at least once per certification cycle, or other mechanisms as deemed appropriate by the PAEMS EMS System.