Clinical Practice Procedures: Assessment/Waveform capnography

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<td>Purpose</td>
<td>To ensure a consistent procedural approach to waveform capnography.</td>
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<td>Scope</td>
<td>Applies to Queensland Ambulance Service (QAS) clinical staff.</td>
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<td>Health care setting</td>
<td>Pre-hospital assessment and treatment.</td>
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**Waveform capnography** is the continuous quantitative measurement of exhaled carbon dioxide (CO₂). CO₂ concentration is displayed graphically as a capnogram (waveform) representing CO₂ throughout the respiratory cycle. CO₂ provides valuable information on ventilation, haemodynamics and metabolism in both intubated and non-intubated patients [1]. The corpul3 mainstream capnometer measures the CO₂ concentration in the patient's expiratory breath (EtCO₂) in real time, with the peak value displayed numerically in mmHg. A 'normal' EtCO₂ is considered between 35–40 mmHg, however results may be influenced by various physiological factors.

Measurement of EtCO₂ in the cardiac arrest patient is an effective, non-invasive indicator of chest compression quality (aim for > 20 mmHg) and the return of spontaneous circulation.

Waveform EtCO₂ monitoring is mandatory to confirm correct ETT placement and throughout subsequent patient ventilations.

The CO₂ capnogram comprises four key phases:

**Phase I (inspiratory baseline)** – reflects inspired gas (devoid of CO₂)

**Phase II (Expiratory upstroke)** – reflects transition of anatomical dead space and alveolar gas from the alveoli/bronchioles.
- alpha angle – reflects the transition between Phase II to III and can be used to assess ventilation perfusion of the lungs. V/Q mismatches will have an alpha angle greater than 90 degrees.

**Phase III (Alveolar plateau)** – reflect last of the alveolar gas being sampled.
- beta angle – reflects transition between Phases III to 0 and can be used to identify rebreathing. If rebreathing occurs, the beta angle will be greater than 90 degrees.

**Phase 0 (Inspiratory downstroke)** – reflects the beginning of inspiration.

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**Indications**
- CPR
- Sedation and procedural sedation
- Endotracheal intubation (placement confirmation)
- Ongoing monitoring of ventilation

**Contraindications**
- Nil in this setting

**Complications**
- When performing effective CPR during cardiac arrest, EtCO₂ values are not to be used to vary IPPV from the recommended rate [1].

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Procedure for oral BVM/LMA/ETT capnography monitoring

1. Remove the corpuls3 disposable CO₂ oral connector from its package.

2. Attach the in-line connector to the breathing circuit, ensuring that a bacterial/viral filter is connected to the airway adjunct (mask/LMA/ETT).

3. Connect the capONE sensors (x2) to the CO₂ oral connector. Ensure all cables are free to avoid patient entanglement or strangulation.

4. Confirm appropriate CO₂ values are displayed.
Procedure for nasal capnography monitoring

1. Remove the corpuls3 disposable CO₂ oral connector from its package.

2. Connect the capONE sensors (x2) to the CO₂ oral connector.

3. Position the sensor cable behind the ears and gently slide the fastening ring. Ensure all cables are free to avoid patient entanglement or strangulation.

4. Consider attaching the disposable CO₂ nasal connector to the nose with adhesive tape, without occluding the patient’s nose or mouth.

5. Attach the in-line connector to the breathing circuit, ensuring that a bacterial/viral filter is connected to the airway adjunct (mask/LMA/ETT).

6. Confirm appropriate CO₂ values are displayed.
**Procedure – Waveform capnography**

### Additional information

- In cardiac arrest, tracheal placement of the ETT must be confirmed using capnography. If there is a complete absence of EtCO₂ (or if the capnography device becomes unserviceable) the ETT must be removed, and the failed intubation algorithm is to be commenced.\(^{[3,4]}\)

- In non-cardiac arrest situations, tracheal placement of the ETT must be confirmed and monitored continually with capnography. If the capnograph indicates that tracheal placement cannot be confirmed, the ETT must be removed and the failed intubation drill is to be commenced.\(^{[4,6]}\)

- In situations where IPPV is provided without an ETT, (i.e. when using a BVM or LMA), capnography is highly desirable and should be connected as soon as other urgent priorities allow.\(^{[7]}\)

- QAS clinicians must be familiar with the operating instructions, with particular attention to warnings, alarms and troubleshooting.

### Normal capnography

- **A normal capnograph is present when the patient:**
  - is spontaneously breathing or adequately ventilated
  - has normal cardiac output
  - has normal metabolic function

### Endotracheal tube in the oesophagus

- **Oesophageal intubation may be confirmed by:**
  - an absence of waveform and EtCO₂
  - small transient diminishing waveforms
Reduced EtCO₂ levels

Possible causes:
- shock
- pulmonary embolus
- effective CPR being performed during cardiac arrest

Sudden significant increase in EtCO₂

Possible causes:
- return of spontaneous circulation
### Absent EtCO2 levels and waveform

**Possible causes:**
- no metabolic activity
- no CPR in cardiac arrest
- exsanguination / profound shock

### Inadequate seal around endotracheal tube

**Possible causes:**
- a leaky or deflated endotracheal or tracheostomy cuff
- an artificial airway that is too small for the patient
Increased EtCO₂ levels from normal

**Possible causes:**
- respiratory depression/failure
- inadequate respiratory rate and/or tidal volume
- increased CO₂ production through increased metabolic rate or temperature or reperfusion of ischaemic tissue

Decreased EtCO₂ levels from normal

**Possible causes:**
- inadequate respiratory rate and/or tidal volume
- diminished CO₂ production through decreased metabolic rate
- falling cardiac output
Obstruction in breathing circuit or airway

Possible causes:
- obstruction in the expiratory breathing circuit
- presence of a foreign body in the upper airway
- partially kinked or occluded artificial airway
- bronchospasm

Increased EtCO₂ values towards normal

Possible causes:
- restoration of normal respiratory rate and/or tidal volume
- cardiac output improved
- improved integrity of airway seal (BVM/LMA/ETT)
Possible causes:

- inadequate or ‘lightening’ of paralysis

Possible causes:

- restoration of normal metabolism/CO₂ production
- normalised respiratory rate and/or tidal volume