CAPNOGRAPHY
In Emergency Care

Part 3: The Intubated Patient
Part 3: The Intubated Patient
Learning Objectives

• List three intubated applications
• Identify four characteristic patterns seen in:
  – Correct ET tube placement
  – ET tube displacement
  – Effective chest compression
  – ROSC
The Intubated Patient
Capnography Applications on Intubated Patients

- Confirm correct placement of ET tube
- Detect changes in ET tube position immediately
- Resuscitation
  - Assess adequacy of chest compressions
  - Detect ROSC
  - Objective data for decision to cease resuscitation
- Optimize ventilation of patients
- Document, document, document
Confirm ET Tube Placement

- Traditional methods of confirmation
  - Listen for breath sounds
  - Observe chest movement
  - Auscultate stomach
  - Note ET tube clouding

These methods are subjective and unreliable
Confirm ET Tube Placement

“Standard physical examination methods, such as auscultation of lungs and epigastrium, visualization of chest movement, and fogging in the tube, are not sufficiently reliable to exclude esophageal intubation in all situations.”

Source: Verification of Endotracheal Tube Placement - Approved by the ACEP Board of Directors, October 2001 http://www.acep.org/1,4923,0.html (policy statement)
Confirm ET Tube Placement

- “...emergency responders must confirm tracheal tube position by using nonphysical examination techniques.” P I-87

- Secondary confirmation with an EtCO₂ or esophageal detection is Class Ila recommendation P I-150

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Confirm ET Tube Placement

- “...end-tidal CO₂ monitors can confirm successful tracheal tube placement within seconds of an intubation attempt”  P I-101

- “The presence of exhaled CO₂ indicates proper tracheal tube placement.”  P I-101

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Confirm ET Tube Placement

“...devices that use capnographic waveforms are so sensitive that the devices can detect residual CO₂ (during CA) when the tube is in the trachea”. P I-383

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Confirm ET Tube Placement

- 108 patients intubated in the field
  - 52 trauma patients
  - 56 medical patients
- ET tube placement checked on arrival at the ED
- 27 patients (25%) had improperly placed ET tube
  - 18 were in the esophagus
  - 9 in oropharynx with tip above the cords

Confirm ET Tube Placement

“Consensus was reached that EtCO$_2$ evaluation was currently the best method for confirming correct endotracheal tube placement. The group agreed that quantitative capnography was currently the best method for determining endotracheal tube position and strongly recommends its use.”

Turtle Creek Consensus Conference on Prehospital Care

Confirm ET Tube Placement

“All endotracheal intubations must be accompanied by an objective confirmation… The optimal method of measurement is quantitative capnography and its use on all intubated patients.”

Confirm ET Tube Placement

• 108 patients intubated in the field
• Compared to the Falk study
  – 9% had improperly placed ET tube versus 25% in previous study
• No unrecognized misplaced ET tubes in patients with continuous end-tidal CO₂ monitoring

Confirm ET Tube Placement

- Capnography provides
  - Objective confirmation of correct tube placement
  - Documentation of correct placement
Confirm ET Tube Placement
Confirm ET Tube Placement

- ET tube placement in esophagus may briefly detect CO₂
  - Following carbonated beverage ingestion
  - When gastric distention was produced by mouth to mouth ventilation
- Residual CO₂ will be washed out after 6 positive pressure breaths
Detect ET Tube Displacement

- A properly placed ET tube can be displaced out of the trachea without any movement of the proximal tip.

Detect ET Tube Displacement

- “...risk from a misplaced tube is unacceptably high and clinical signs confirming tube placement are not completely reliable” P I-296
- “…animal data shows that detection of a displaced or obstructed tube using pulse oximetry or changes in heart rate or blood pressure may be delayed more than 3 minutes” P I-296

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Detect ET Tube Displacement

- “...use of a device to confirm tracheal tube placement in the field, in the transport vehicle, and on arrival to the hospital is desirable and strongly encouraged.” P I-296
- “Use of a device to confirm tube placement on arrival at the hospital is especially important because displacement of the tube is most likely to occur when the patient is moved into and out of the transport vehicle.” P I-296

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Detect ET Tube Displacement

“Continuous capnography detects acute airway obstruction and hypopharyngeal extubation more rapidly than does pulse oximetry or vital sign monitoring in a hyperoxemic porcine model.”

Detect ET Tube Displacement

“...displacement of the tube is most likely to occur when the patient is moved into and out of the transport vehicle.”

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Detect ET Tube Displacement

- Traditional methods of monitoring tube position
  - Periodic auscultation of breath sounds
  - Gastric distention
  - Worsening of patient’s color
    - Late sign of tube displacement

These methods are subjective and unreliable—and delayed
Detect ET Tube Displacement

“Continuous capnography monitoring devices can identify and signal a fall in exhaled CO$_2$ consistent with tracheal tube dislodgement. This may be very helpful in emergencies when clinicians have other responsibilities.” P 140

Detect ET Tube Displacement

- Capnography
  - Immediately detects ET tube displacement

Detect ET Tube Displacement

- **Only capnography provides**
  - Continuous numerical value of EtCO$_2$ with apnea alarm after 30 seconds
  - Continuous graphic waveform for immediate visual recognition

Confirm ET Tube Placement

- Capnography provides
  - Documentation of correct placement
  - Ongoing documentation over time through the trending printout
  - Documentation of correct position at ED arrival
Capnography in Cardiopulmonary Resuscitation

- Assess chest compressions
- Early detection of ROSC
- Objective data for decision to cease resuscitation
CPR: Assess Chest Compressions

- Properly done chest compressions provide
  - 25-30% of normal blood supply to the brain
  - 5%-10% of normal blood supply to the heart
- Adequate chest compressions promote the elimination of metabolic wastes
CPR: Assess Chest Compressions

- **Airway** - open with ET tube
- **Breathing** - controlled and stable
- **Circulation** - cardiac output directly related to changes in EtCO₂
- **Capnography** provides noninvasive method for monitoring blood flow generated by chest compressions
CPR: Assess Chest Compressions

- 19 minipigs
- Relationship between EtCO$_2$ and cardiac output
- Measured before cardiac arrest and during CPR

CPR: Assess Chest Compressions

- Good correlation between EtCO₂ and cardiac output
- Decrease in EtCO₂ reflects a critical reduction of cardiac output
- Low cardiac output
  - Reduces blood flow to the lungs
  - Fails to clear CO₂ from the bloodstream

CPR: Assess Chest Compressions

- Under conditions of constant ventilation, capnography correlates with the circulatory status produced by chest compressions
- EtCO$_2$ has potential value in monitoring effectiveness of CPR

CPR: Assess Chest Compressions

- Rescuer fatigue
- Ochoa Study
  - Rescuers were not able to maintain adequate chest compressions for more than 1 minute
  - Rescuers did not perceive fatigue even when it was measurably present

CPR: Assess Chest Compressions

• Increase in EtCO$_2$ has been shown to correlate with
  – A fresh rescuer at a faster compression rate
  – A new rescuer during CPR with no change in rate
  – Mechanical compressions

CPR: Assess Chest Compressions

“...measurement of end-tidal carbon dioxide concentration may be a practical, noninvasive method for monitoring blood flow generated by compression during cardiopulmonary resuscitation and an almost immediate indicator of successful resuscitation.”

CPR: Assess Chest Compressions

- Use feedback from EtCO$_2$ to depth/rate/force of chest compressions during CPR
CPR: Detect ROSC

- 90 prehospital patients intubated in the field
- 16 survivors
- In 13 survivors a rapid rise on CO$_2$ production was the earliest indicator of ROSC
  - Before a palpable pulse
  - Prior to blood pressure

CPR: Detect ROSC

- 10 patients on ventilators in ICU
  - EtCO₂ increased within 30 seconds of ROSC in 7
  - Rapid rise on CO₂ production was earliest indicator of ROSC
  - “…an abrupt increase in the EtCO₂ under conditions of reasonably constant ventilation provides the earliest evidence of successful resuscitation.”

CPR: Detect ROSC

- Sudden rise in EtCO$_2$
- Confirm with ECG and capnography
- Questionable pulse
  - Arterial vasoconstriction may make pulse difficult to detect
CPR: Detect ROSC

- Briefly stop CPR and check for organized rhythm on ECG monitor
Decision to Cease Resuscitation

- **Capnography**
  - Has been shown to predict probability of outcome following resuscitation
  - May be used in the decision to cease resuscitation efforts

Decision to Cease Resuscitation

- 120 prehospital patients in nontraumatic cardiac arrest
- EtCO₂ had 90% sensitivity in predicting ROSC
- Maximal level of <10mmHg during the first 20 minutes after intubation was never associated with ROSC

Source: Canitneau J. P. 1996. End-tidal carbon dioxide during cardiopulmonary resuscitation in humans presenting mostly with asystole, Critical Care Medicine 24: 791-796
Decision to Cease Resuscitation

- 27 out-of-hospital patients in cardiac arrest looked at EtCO₂ at 3 points
  - 1 and 2 minutes post intubation
  - Maximum EtCO₂ during CPR

- EtCO₂ in ROSC was higher at each point

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<th></th>
<th>ROSC</th>
<th>No ROSC</th>
<th>P</th>
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<tr>
<td>1 min</td>
<td>23.0±7</td>
<td>13.2±14.7</td>
<td>.0002</td>
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<tr>
<td>2 min</td>
<td>26.8±10.8</td>
<td>15.4±5.7</td>
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<tr>
<td>Maximum</td>
<td>30.8±9.5</td>
<td>22.7±8.8</td>
<td>.0022</td>
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Decision to Cease Resuscitation

- 90 victims of prehospital cardiac arrest with PEA

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<tr>
<th></th>
<th>ROSC</th>
<th>No ROSC</th>
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<tr>
<td>Initial</td>
<td>10.9±4.9</td>
<td>11.7±6.6</td>
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<tr>
<td></td>
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<td><em>P = .672 (NS)</em></td>
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<tr>
<td>20 min</td>
<td>31.0±5.3</td>
<td>3.9+2.8</td>
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<td><em>P &lt;= .001</em></td>
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- 100% mortality if unable to achieve an EtCO$_2$ of 10mmHg after 20 minutes

Decision to Cease Resuscitation

- Capnography provides another objective data point in making a difficult decision.
Optimize Ventilation

- Monitor ventilation efforts and carbon dioxide levels with capnography
- Carbon dioxide has a profound affect on cerebral blood flow (CBF)
  - Influences intracranial pressure (ICP)
Optimize Ventilation

• Use capnography to titrate EtCO₂ levels in patients sensitive to fluctuations

• Patients with suspected increased intracranial pressure (ICP)
  – Head trauma
  – Stroke
  – Brain tumors
  – Brain infections
Optimize Ventilation

- **Intracranial pressure**
  - Tissue and fluid contained within a rigid compartment
  - Affected by changes in any component

- **Treatment goal**
  - Maintain stability
  - Avoid raising intracranial pressures
Optimize Ventilation

- Treatment of patients with head injuries and ↑ICP

Hyperventilate the patient?

Do NOT hyperventilate the patient?
Optimize Ventilation

- Hyperventilation is very effective at lowering ICP
- Prophylactic hyperventilation once mainstay therapy
- New guidelines recommend against prophylactic hyperventilation
- Avoid hypoventilating patients with suspected high ICP

Optimize Ventilation

• Treatment goals
  – Maintain stability of EtCO$_2$ levels
  – Maintain adequate blood flow to the brain
  – Avoid secondary injury as a result of inducing or increasing cerebral edema
Optimize Ventilation

- Treatment goals
- Avoid cerebral hypoxia
  - Monitor blood oxygen levels with pulse oximetry
  - Maintain adequate CBF
Optimize Ventilation

- High CO₂ levels induce cerebral vasodilatation
  - Positive: Increases CBP to counter cerebral hypoxia
  - Negative: Increased CBP, increases ICP and may increase brain edema

- Hypoventilation retains CO₂ which increases levels
Optimize Ventilation

- Low \( \text{CO}_2 \) levels lead to cerebral vasoconstriction
  - Positive: \( \text{EtCO}_2 \) of 25-30mmHG causes a mild cerebral vasoconstriction which may decrease ICP
  - Negative: Decreased ICP but may cause or increase in cerebral hypoxia
- Hyperventilation decreases \( \text{CO}_2 \) levels
Optimize Ventilation

• “In summary, after either cardiac arrest or head trauma, ventilate the comatose patient to achieve normocarbia (Class IIa).” P 168

• “Routine hyperventilation may be detrimental and should be avoided (Class III).” P 168

Source: Guidelines 2000 for Cardiovascular Resuscitation and Emergency Cardiovascular Care, Circulation 102 (suppl I) 8. August 22,2000
Optimize Ventilation

- Monitor ventilations with capnography to maintain appropriate and stable CO₂ levels
- Follow local protocols and medical direction
Part 3: The Intubated Patient

**Summary**

- Capnography can be used in intubated patients for
  - Verification and documentation of ET tube placement
  - Immediate identification of ET tube displacement
  - Confirmation of adequate chest compressions
  - Early indication of ROSC
Part 3: The Intubated Patient

Summary

- Capnography can be used in intubated patients to
  - Detect cardiac output when no pulse palpable
  - Help in the decision to cease resuscitation
  - Maintain CO₂ levels in patients sensitive to changes
Part 3: The Intubated Patient

Now you’re catching on!