CAPNOGRAPHY
In Emergency Care

EDUCATIONAL SERIES

Part 4:
Non-intubated
CAPNOGRAPHY
In Emergency Care

Part 4: The Non-intubated Patient
Part 4: The Non-intubated Patient Learning Objectives

- List three non-intubated applications
- Identify four characteristic patterns seen in
  - Bronchospasm
    - Asthma
    - COPD
  - Hypoventilation states
  - Hyperventilation
  - Low-perfusion states
The Non-intubated Patient

CC: “trouble breathing”
The Non-intubated Patient
CC: “trouble breathing”

Asthma?
Emphysema?
Bronchitis?
Cardiac ischemia?
PE?
Pneumonia?
CHF?
The Non-intubated Patient
CC: “trouble breathing”

- Identifying the problem and underlying pathogenesis
- Assessing the patient’s status
- Anticipating sudden changes
The Non-intubated Patient Capnography Applications

- Identify and monitor bronchospasm
  - Asthma
  - COPD

- Assess and monitor
  - Hypoventilation states
  - Hyperventilation
  - Low-perfusion states
The Non-intubated Patient Capnography Applications

- Capnography reflects changes in
  - Ventilation - movement of gases in and out of the lungs
  - Diffusion - exchange of gases between the air-filled alveoli and the pulmonary circulation
  - Perfusion - circulation of blood through the arterial and venous systems
The Non-intubated Patient Capnography Applications

• **Ventilation**
  • Airway obstruction
    – Smooth muscle contraction
    – Bronchospasm
    – Airway narrowing
    – Uneven emptying of alveoli
    – Mucous plugs
The Non-intubated Patient
Capnography Applications

• **Diffusion**
  • Airway inflammation
  • Retained secretions
  • Fibrosis
  • Decreased compliance of alveoli walls
  • Chronic airway modeling (COPD)
  • Reversible airway disease (Asthma)
Capnography in Bronchospastic Conditions

- Air trapped due to irregularities in airways
- Uneven emptying of alveolar gas
  - Dilutes exhaled CO₂
  - Slower rise in CO₂ concentration during exhalation
Capnography in Bronchospastic Diseases

- Uneven emptying of alveolar gas alters emptying on exhalation
- Produces changes in ascending phase (II) with loss of the sharp upslope
- Alters alveolar plateau (III) producing a “shark fin”
Capnography in Bronchospastic Conditions

Prevalence of Asthma

- Asthma is increasing in the US
  - 20.3 million citizens report having asthma
  - Prevalence increased 75% from 1980-1994
  - Two million ED visits each year
  - Most common chronic health problem in children

- Increasing deaths due to asthma
  - 1987 to 1995, death rate doubled to 5600

Sources: Delbridge T., et al. 2003 Prehospital Asthma Management. Prehospital Emergency Care 7(1) 42-47

Capnography in Bronchospastic Conditions

Pathology of Asthma

- Acute onset or progressive over weeks
- Airway
  - Increased responsiveness (hyper-reactivity)
  - Bronchospasm
    - Reversible obstruction
  - Inflammation
Pathology of Asthma

- **Release of inflammatory mediators**
  - Histamine, bradykinin, prostaglandins

- **Bronchial wall reaction**
  - Spasm of bronchial smooth muscle
  - Vasodilatation with swelling of bronchial mucous membranes
  - Increased mucous production
Symptoms of Asthma

- Tachycardia
- Tachypnea
- Wheezing
- Cough
- Chest tightness
- Use of accessory muscles (retractions)
- Anxiety
- Diaphoresis
### Capnography in Bronchospastic Conditions
### Classification of Asthma

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<td>Prefers sitting</td>
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Adapted from the NIH Guidelines for the Diagnosis and Management of Asthma

Capnography in Bronchospastic Conditions

Assessment of Asthma

• Symptoms and observations are primarily subjective
• Severity of symptoms and your patient’s perception may not accurately reflect severity of condition

More objective data needed

Capnography in Bronchospastic Conditions

Capnogram of Asthma

- 28 normal volunteers; 20 asthma patients in ED
- Correlation between PEFR and slope of capnogram waveform
- Conclusion
  - Slope value correlated with PEFR
  - “dCO₂/dt is an effort independent, rapid noninvasive measure that indicates significant bronchospasm”

Capnography in Bronchospastic Conditions

Capnogram of Asthma

- “expiratory airflow obstruction affects the shape of the CO₂ time curve due to uneven emptying of alveolar gas.”
- Waveform examples show increasing change in normal expiratory plateau with increasing obstruction (bronchospasm)

Capnography in Bronchospastic Conditions

Capnogram of Asthma

Changes in $dC{O_2}/dt$ seen with increasing bronchospasm

Capnography in Bronchospastic Conditions

Capnography in Asthma

• Research is underway on the correlation of capnographic changes to patient’s respiratory status
• Anticipating clinical trials on the impact on patient care, outcomes and healthcare costs
Asthma Case Scenario

- 16 year old female
- C/O “having difficulty breathing”
- Visible distress
- History of asthma, physical exertion, “a cold”
- Patient has used her “puffer” 8 times over the last two hours
- Pulse 126, BP 148/86, RR 34
- Wheezing noted on expiration
Capnography in Bronchospastic Conditions

Asthma Case Scenario

Initial

After therapy
Capnography in Bronchospastic Conditions

Prevalence of COPD

• COPD is increasing in the U.S.
  – Fourth leading cause of death in adults
  – 16 million cases in 1996

• Increasing deaths due to COPD
  – 1999 estimated 110,000
  – Number of deaths doubled in the past 25 years

Capnography in Bronchospastic Conditions

Pathology of COPD

• Chronic, progressive disease process
  – Major risk factors: smoking, exposure to dusts and fumes, history of frequent respiratory infections

• Spectrum of diseases
  – Chronic bronchitis
  – Emphysema
  – Asthma
  – Bronchiectasis
Capnography in Bronchospastic Conditions

Pathology of COPD

- Progressive
- Partially reversible
- Airways obstructed
  - Hyperplasia of mucous glands and smooth muscle
  - Excess mucous production
  - Some hyper-responsiveness
Pathology of COPD

- Small airways
  - Main sites of airway obstruction
  - Inflammation
  - Fibrosis and narrowing
  - Chronic damage to alveoli
  - Hyper-expansion due to air trapping
  - Impaired gas exchange
Symptoms of COPD Exacerbation

- Increase in chronic symptoms
  - SOB
  - Cough
  - Wheezing
  - Use of accessory muscles
  - Sputum - increased volume, tenacity and purulence
  - Anxiety
  - Diaphoresis
  - Chest tightness
Symptoms of COPD Exacerbation

- May also have
  - Fever - underlying infection
  - Co-morbidity
    - Congestive heart failure
    - Acute coronary syndrome
    - Diabetes mellitus
    - Hypertension
Capnography in Bronchospastic Conditions

Assessment of COPD

- Symptoms and observations are primarily subjective
- Severity of symptoms and your patient’s perception may not accurately reflect severity of condition

More objective data needed
Capnography in Bronchospastic Conditions

Capnography in COPD

• **Arterial CO$_2$ in COPD**
  - $\mathrm{PaCO}_2$ increases as disease progresses
  - Requires frequent arterial punctures for ABGs

• **Correlating capnograph to patient status**
  - Ascending phase and plateau are altered by uneven emptying of gases
Capnography in Bronchospastic Conditions

COPD Case Scenario

- 72 year old male
- C/O difficulty breathing
- History of CAD, CHF, smoking and COPD
- Productive cough, recent respiratory infection
- Pulse 90, BP 158/82  RR 27
Capnography in Bronchospastic Conditions

COPD Case Scenario

Initial Capnogram A

Initial Capnogram B
Capnography in Bronchospastic Conditions

Capnogram of CHF

• 207 patients in pulmonary function lab
  – 61 with obstructive disease (OD); 34 with restrictive disease (RD)
  – Correlation of slope of exhalation plateau

• C/O severe difficulty breathing (FEV1<50%)
  – 97% of OD had elevations >4°; 5% of RD had elevations >4°
  – P<0.0001

• Conclusion
  – Changes in shape of capnogram in OD confirmed
  – Changes in capnogram in RD did not occur

Capnography in CHF

Case Scenario

• 88 year old male
• C/O: Short of breath
• H/O: MI X 2, on oxygen at 2 L/m
• Pulse 66, BP 114/76/p, RR 36 labored and shallow, skin cool and diaphoretic, 2+ pedal edema
• Initial SpO₂ 69%; EtCO₂ 17mmHg
Capnography in CHF

Case Scenario

- Placed on non-rebreather mask with 100% oxygen at 15 L/min; IV diuretic and SL nitroglycerin as per local protocol
- Ten minutes after treatment:
  
  SpO₂ 69% → 99%
  EtCO₂ 17 mmHg → 35 mmHg

Time condensed to show changes
Capnography in Hypoventilation States

- Altered mental status
  - Sedation
  - Alcohol intoxication
  - Drug Ingestion
  - Stroke
  - CNS infections
  - Head injury

- Abnormal breathing

- CO$_2$ retention
  - EtCO$_2$ >50mmHg
Capnography in Hypoventilation States

Time condensed; actual rate is slower

- EtCO₂ is above 50mmHg
- Box-like waveform shape is unchanged
Capnography in Hypoventilation States

Case Scenario

• Observer called 911
• 76 year old male sleeping and unresponsive on sidewalk, “gash on his head”
• Known history of hypertension, EtOH intoxication
• Pulse 100, BP 188/82, RR 10, SpO₂ 96% on room air
Capnography in Hypoventilation States

Hypoventilation

Time condensed; actual rate is slower
Capnography in Hypoventilation States

Hypoventilation

Hypoventilation in shallow breathing
Capnography in Low Perfusion

- Capnography reflects changes in **Perfusion**
  - Pulmonary blood flow
  - Systemic perfusion
  - Cardiac output
Capnography in Low Perfusion

Case Scenario

- 57 year old male
- Motor vehicle crash with injury to chest
- History of atrial fib, anticoagulant
- Unresponsive
- Pulse 100 irregular, BP 88/p
- Intubated on scene
Capnography in Low Perfusion

Case Scenario

Low EtCO\(_2\) seen in low cardiac output

Ventilation controlled
Capnography Applications on Non-intubated Patients

- New applications now being reported
  - Pulmonary emboli
  - CHF
  - DKA
  - Bioterrorism
  - Others?
Capnography in Pulmonary Embolus
Case Scenario

- 72 year old female
- CC: Sharp chest pain, short of breath
- History: Legs swollen and pain in right calf following flight from Alaska
- Pulse 108 and regular, RR 22, BP 158/88, SpO₂ 95%
Capnography in Pulmonary Embolus

Case Scenario

Strong radial pulse

Low EtCO$_2$ seen in decreased alveolar perfusion
Part 4: The Non-intubated Patient Summary

- Identify and monitor bronchospasm
  - Asthma
  - COPD
- Assess and monitor
  - Hypoventilation states
  - Hyperventilation
  - Low perfusion
  - Many others now being reported
Part 4: The Non-intubated Patient

Ready to take capnography for a run?