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CAPNOGRAPHY CASES VIRGINIA EMS SYMPOSIUM 2013:

Objectives

1) Identify the components of the capnography waveforms and understand the physiology behind the waveform
2) Understand capnography as an adjunct to monitoring critical care patients, as presented through case studies. Capnography is a valuable tool for monitoring airway patency and the effectiveness of ventilation and perfusion.
3) Understand how Capnography promotes patient safety through quantitative data validating the patency of critical interventions, such as advanced airways and sedation.

Presentation

- Brief Review Capnography
  - History
  - Anatomy and Physiology
- Case Presentations
  - Pathophysiology of Respiration and Ventilation
  - Capnography integrated with the critical care patient
  - “Advanced” application of capnography
  - Alternative Applications

Capnography 2013

- Applies to ***any patient requiring ventilation!***
  - Bag-mask
  - ETI and rescue airways
  - Transport vent
  - CPAP?
- Noninvasive applications
  - Monitoring patient respirations

Capnography 2013

- 2010 AHA Guidelines
  - Class I, LOE A
  - 100% Sensitive, 100% Specific
- Quantitative, continuous, waveform capnography
  - Monitor position of airway devices
  - Quality of CPR
- “CAB”
  - Circulation-Airway-Breathing

AHA Recommendations

- The recommendations for airway management have undergone 2 major changes:
  - (1) the use of quantitative waveform capnography for confirmation and monitoring of endotracheal tube placement is now a class I recommendation in adults; and
  - (2) the routine use of cricoid pressure during airway management is no longer recommended.

AHA Levels of Evidence

SIZE OF TREATMENT EFFECT

	CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/administered	CLASS IIa *Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/administer treatment	CLASS IIb *Benefit ≥ Risk* *Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment **MAY BE CONSIDERED**	CLASS III *Risk ≥ Benefit* Procedure/Treatment should **NOT** be performed/administered **SINCE IT IS NOT HELPFUL AND MAY BE HARMFUL**
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is useful/effective ■ Evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Evidence from single randomized trial or nonrandomized studies
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard of care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard of care
Suggested phrases for writing recommendations†	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	is not recommended is not indicated should not is not useful/effective/beneficial may be harmful

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT

First Priority Application

- Confirmation of Intubation
  - Chest X-ray: Single point in time
  - Qualitative Detector: Single point in time
  - Capnography: Continuous verification of placement
- Augmentation of Clinical Assessment
  - Visualization
  - Auscultation
  - Observation

PATIENT SAFETY

ABOVE ALL, DO NO HARM

Priority is OXYGENATION

- Adequate Oxygenation
  - New guidelines titrate to 95-97%
- Adequate Ventilation
  - Quality chest-rise and fall
- Avoid tunnel vision
  - Use your tools, know their limitations
- Quality over Quantity

HYPOXIA KILLS

Intubation RE-Confirmation

- Bag-Valve Movement
- Re-adjustment of ET placement
  - "Pull back 3 cm"
- When you move the patient…
  - How many movements?
  - EMS to Hospital stretcher
  - Transport to CT
  - Admission to ICU
- Patient Self-Extubation
  - Ventilator Alarms

Capnography

- Quantitative, graphical measurement of instantaneous CO2 concentration
- American Society of Anesthesiologists (ASA) standards:
  - *Every patient receiving anesthesia shall have adequacy of ventilation continually evaluated*
  - *Continual monitoring for the presence of expired carbon dioxide shall be performed unless invalidated by the nature of patient, procedure, or equipment*
  - *Continual EtCO2 analysis, in use from the time of ET placement, until extubation/removal or transfer …shall be performed using a quantitative method, such as capnography, capnometry, or mass spectroscopy*

EVERY INTUBATED PATIENT..

Continuous Monitoring…

Quantitative..

History of Capnography

- Developed in 1961 (For practical purposes)
- Expensive and bulky product limited to OR anesthesia
- In mid 1980s, anesthesia related fatalities led to need for improvements in airway management
  - Malpractice costs rise 1975 to 1985

History of Capnography

- 1988: Anesthesia standardized use of pulse oximeters and capnography
  - Malpractice claims from hypoxic related injury almost eliminated -Massachusetts
  - Insurance claims from anesthesia drops from 11% to 3% over 15 years
  - In 2002, anesthesia insurance premium was $18,000, the same as it was in 1985

Integration of Capnography

- In Anesthesia, capnography is an industry standard
- In EMS, it is a standard, but not there are variables
  - Waveform versus colormetric
  - Comfort leads in increased application
- Emergency Departments and ICUs now monitor capnography; interpretation and application varies

A&P for Capnography:

- What is important:
  - Air movement
  - Surface area of lungs
  - Blood flow to lungs and body
- Respiratory Cycle
  - Alveolar level
  - Cellular level

Review of Metabolism

- Aerobic:
  - Oxygen and Glucose metabolize to produce Energy to do work
  - Carbon Dioxide and Water are the byproducts
  - Krebs Cycle
  - Most efficient process
    - Improves with exercise

Review of Metabolism

- Anerobic:
  - Lack of oxygen causes build up of acids
  - Lactic Acid and Pyruvic Acid
- Buffer System
  - Hydrogen Ions of the Acid (pH) combine with Bicarbonate to form Carbonic Acid
  - This breaks down into water and carbon dioxide
  - Increased CO2 stimulate increased ventilation rate to remove it

Carbon Dioxide

- By-product of normal respiration
- Measured as a Partial Pressure
  - 35-45 Mm/Hg
- Measured as a Percentage
  - 5-6%
- Key for: respiratory drive, ph balance
- Considered “acidic”

Drive to Breathe

- CO_2 triggers breathing
- NOT ENOUGH
  - Hypoventilation leads to hypercarbia
  - Hypercarbia leads to respiratory acidosis
- TOO MUCH
  - Hyperventilation leads to hypocarbia
  - Hypocarbia leads to respiratory alkalosis

What do the numbers mean?

- Oxygen and Carbon Dioxide
- Hypoventilation:
  - O_2 < 60mm/Hg
  - CO_2 > 45mm/Hg (Hypercapnea)
- Hyperventilation:
  - O_2 > 100mm/hg (SaO_2 above 98%)
  - CO_2 < 35mm/Hg

CO2 on the BRAIN

- Decreased CO_2 from hyperventilation
  - Cerebral Vasoconstriction
  - Balancing
- Indication: (old school)
  - Traumatic head injury/CVA
  - Maintain perfusion without worsening bleeding
    - End-tidal CO_2 target is 33 to 35mm/Hg

CO2 on the Brain

- Elevated CO_2
  - Permissive Hypercarbia
  - Above 45mm/Hg
  - With adequate ***OXYGENATION!***
- Potential Benefits
  - Cerebral and systemic vasodilation
  - Increase cellular oxygen supply
  - Decrease oxygen demand

Atmospheric Gases

- Convert percentage to pressure
- Normal gas Percentage
  - Oxygen at sea level: 21%
  - CO_2 and other gases: 1%
  - Nitrogen: 78%

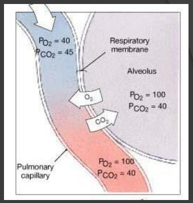
Dalton's Law: Partial Pressure of Gas

Total pressure of a gas is equal to the SUM of the partial pressures of the gas

- Atmospheric pressure is 760mm/Hg at sea level
- Under NORMAL conditions, all of the atmospheric gas pressures add up to 760
  - Oxygen is 159.2 mm/Hg
  - Nitrogen is 592.8 mm/Hg
  - CO2 is 0.23 mm/Hg
  - Other gases, like Argon = 8mm/Hg

Partial Pressure

- Gradient
- The exchange of gases based on pressure gradient
  - Pressure forces Oxygen onto Hemoglobin

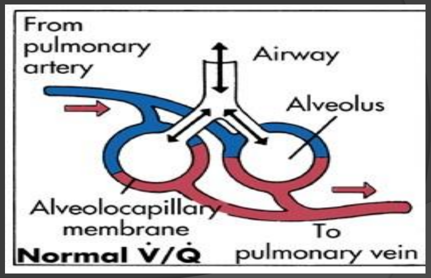


Ventilation and perfusion

Pathology that Impacts CO2

- Ventilation Problems
  - Inability to move air in and out of the alveoli
  - Hyperventilation, hypoventilation
- Perfusion Problems
  - Oxygen transport to cells
  - Lack of blood flow
  - Ability of blood to carry oxygen

Normal Ventilation/Perfusion



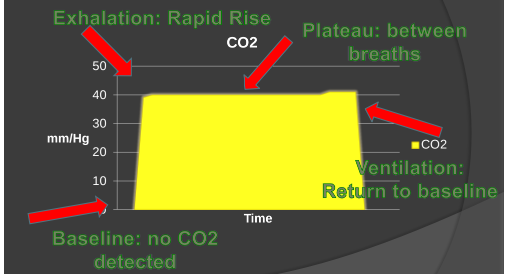
Clinical Conditions: Increased CO2

- Increased CO2 production
  - ***Bicarbonate administration, fever, seizures, sepsis, thyroid storm***
- Decreased alveolar ventilation
  - ***Hypoventilation, muscular paralysis, respiratory depression, COPD (retaining CO2)***
- Equipment Problem
  - ***Rebreathing, ventilator leak***

Clinical Conditions: Decreased CO2

- Decreased CO2 production
  - ***Cardiac arrest, hypotension, hypothermia, pulmonary emboli, pulmonary hypoperfusion***
- Increased alveolar ventilation
  - ***Hyperventilation***
- Equipment Problems
  - ***Airway obstruction, esophageal intubation, ETT leak, incomplete exhalation, poor sampling, ventilator disconnect***

Normal EtCO2 waveform



Sidestream vs. Mainstream

Sidestream

- Easier to use non-invasively
- Key is quality of the patient's respirations
  - Shallow is poor
  - Mouth breathing is challenging
  - Newer devices assist in increasing accuracy
- Sidestream is LESS specific because of its engineering

Side-stream Detector

Sidestream Detector

Cannula with mouth scoop

Oxygen and sensor

Mainstream Detector

- Sensor at end of cable
  - Disposable adapter to ET tube
- “Real time” values-best for critical care
  - As the gas passes the IR sensor
- Concerns:
  - Not easily adapted to non-intubated patient
  - Can be heavy for pediatric of infant ET tubes
  - Cable is expensive

Mai

Troubleshooting

False Positive

- May occur if patient ingested large amounts of carbonated beverage
- Limited IF continuous capnography in place: waveform may occur, then goes away
- Can decieve colormetric detector

False Negative/Low EtCO2

- May indicate poor quality CPR
- Pulmonary Embolism
- Poor blood flow and delivery of CO2 to lungs
  - Poor Perfusion

Troubleshooting

- Sudden loss of waveform
  - IMMEDIATE CLINICAL RECONFIRMATION
  - Lung sounds, SaO2, Anything else
- Place colormetric detector
- Clean/Clear sensor
  - Blockage
  - Vomit can clog
- Recalibrate/zero if able
- Replace adapter

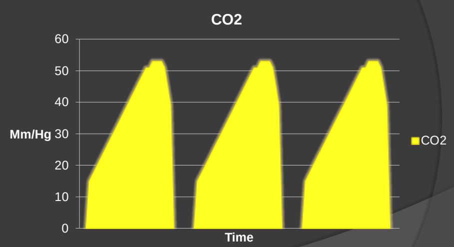
Case Presentations

- What are you seeing?
  - What does your physical assessment tell you?
- What are your transport considerations?
  - Interventions
- Differential Diagnosis?
- Trouble shooting?
  - Is the data valid?

Case 1

- Respiratory Distress
- 54 y/o COPD
- Respiratory Rate: 24
- Pursed lips

Case 1



A wrinkle…Ami…

- EMS uses NRB mask as neb mask
  - "Partial Non-Rebreathing mask"
  - Uses flaps to allow exhalation
  - Only use oxygen
- How do you deliver your neb treatments?
  - Medical Air?
  - Oxygen?
- What are the effects of CO2 retention?

Obstructive Airway Disease

- Shunt problem
- Asthma, COPD, Emphysema
  - Swelling of airways/excess mucus
  - Airflow turbulent
  - Forceful expiration
- Different EtCO2 presentations:
  - Mild=hyperventilation, low EtCO2
  - Moderate=normal EtCO2, waveform change
  - Severe=elevated EtCO2, sharkfin

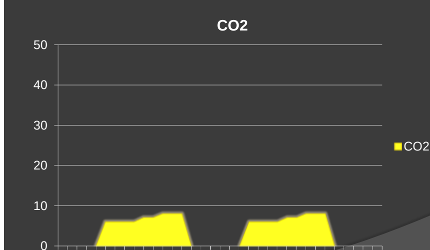
Case 2

- 65 year old obese trauma patient
- Predicted Difficult Intubation
- Multiple Injuries
  - Chest Contusions
  - Abdominal Distention
  - Fractures of right upper leg, left lower leg, and right arm
- Intubation after progressive worsening of Respiratory Distress

Case 2

- Initial Et CO2 6-7mm/Hg
- Intermittent sensor detection of numerical value
- Waveform present
- Low "shark fin" appearance
- What is going on?
- Is the ET good?

Case 2



Shock

- "A rude unhinging of the Machinery of Life"
  - Samuel Gross, 1872
- "A momentary pause in the act of death"
  - John Collins Warren, 1895
- "Pushing back the edge of death"
  - Judy Mikhail, 1999

Shock

- As the body's compensatory mechanisms begin to work, we appreciate changes in vitals signs:
  - Altered mental status
  - Pale, clammy, diaphoretic
  - Increased heart rate and respiration
  - Decreased blood pressure

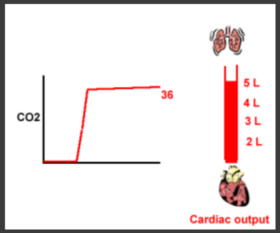
Shock and Capnography

- A Piece of the Puzzle
- Anaerobic compensation for decreased perfusion:
  - Blood CO2 elevated
  - Ventilations increase
  - End tidal CO2 DECREASES
- Cardiac Output drops:
  - Vasodilation vs. hypovolemia:
  - CO2 decreased as detected by EtCO2

Shock

- Capnography:
  - Index of Resuscitation
  - Quality of perfusion
  - Quality of ventilation
- Like ALL monitors, it is a TOOL
  - Understand its limitations
  - It can GUIDE decisions
  - It should not MAKE the decision

Cardiac Output and CO2



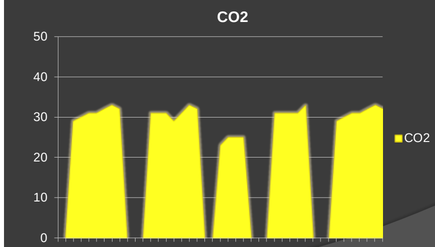
Case 2

- Clinical Considerations:
  - Type of Shock
- Interventions:
  - Ventilation
  - Fluids?
  - Needle Decompression
  - Vasopressors

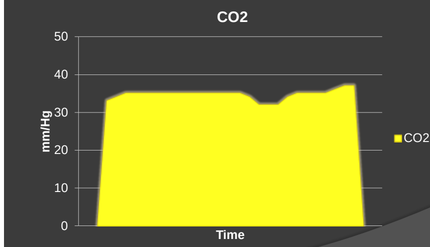
Case 3

- 26 year old MVC at community hospital
- Intubated in ED after becoming combative
- Vitals: BP 164/92, HR 130, Respirations 24, SaO_2 97%; on ventilator
- Ventilator Settings: Assist/Control
  - Rate 12, TV 500, FiO_2 50%, PSV 10, PEEP 5

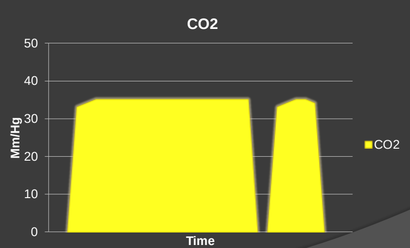
Case 3



Case 3



Case 3



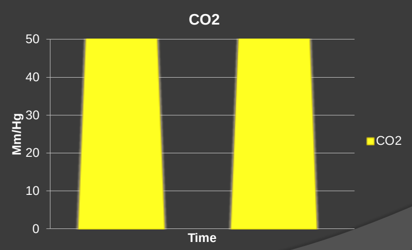
Case 3

- Clinical Considerations:
  - What is going on?
  - Distance to definitive care
  - Mode of Transport
- Interventions:
  - Settings changes
  - Medications

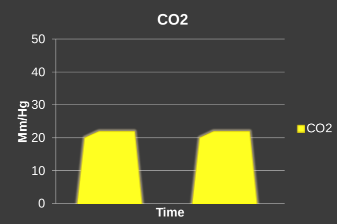
Case 4

- 50 year old cancer patient receiving radiation and chemo
- Presents with respiratory distress to EMS
  - SaO_2: 85%, dramatic work of breathing, becoming tired
  - CPAP Trial; failed and became apneic
- Intubated without RSI
- Vitals: BP 140/88, HR 78, vented at 10 with SaO_2 of 93% with 100% FiO_2
- Initial $EtCO_2$ is 85mmHg
- EMS: “something is not right with end tidal

Case 4: Initial



Case 4: After ventilator placed



Case 4

- Community ED requests transfer to tertiary care for Pulmonary Embolism
- Post Intubation ABG:
  - pH 7.31, PaO2: 140, PaCO2: 49mmHg, Bicarb 27
- CO2 gradient:
  - PaCO2 – PetCO2 (49 minus 20 equals 29mmHg)
  - Normal gradient 3 to 5mmHg
- What is in the blood is not getting out

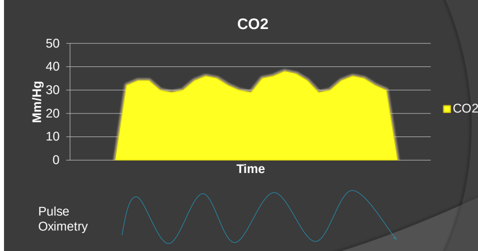
Pulmonary Embolism

- Dead Space Ventilation
  - Decreased EtCO2
- Clot breaks loose in blood vessel
  - Floats to and obstructs pulmonary vasculature
- Causes:
  - Post surgical
  - Sitting for extended time
  - David Bloom, NBC News in 2003

ABGs, pH, and Capnography

- Arterial Blood Gases assess for acid-base balance
  - Acidosis and Alkalosis
  - Mechanisms: Respiratory and Renal (Metabolic)
- pH is a measure of Hydrogen ion concentration (H+)
  - Normal is 7.35 to 7.45
  - Reflects balance between carbon dioxide and bicarbonate
- Capnography only represents the RESPIRATORY

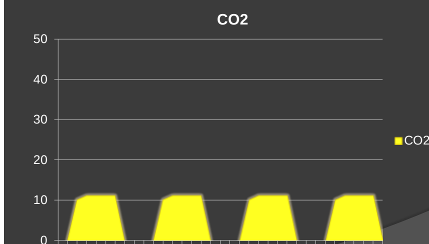
Varient



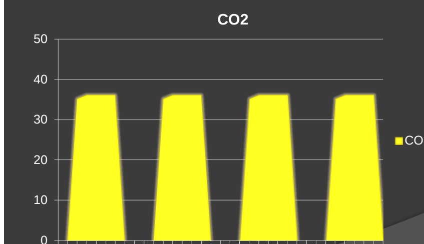
Case 5

- 21 year old female
- Witnesses cardiac arrest on athletic track, defibrillated by AED
- BLS and ALS procedures per protocol
- No pulses or vitals

Case 5 Initial: No pulses



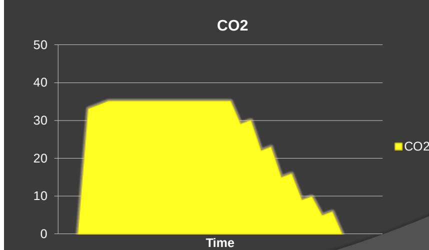
Case 5: No pulses



Cardiac Arrest and CO_2

- In cardiopulmonary arrest
  - CO_2 levels in blood stream increase
  - Exhaled CO_2 levels decrease due to low flow states
    - No ventilation, no circulation of blood
    - No perfusion
  - Cambridge journal Article
- Return of Spontaneous Circulation (ROSC)
  - ***Spike in $EtCO_2$ after trend of low levels***

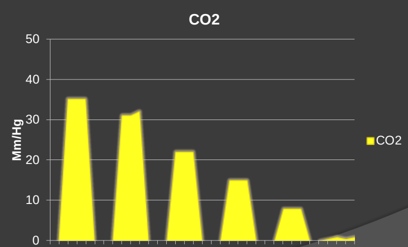
Case 5 Variant



Case 6

- 48 year old COPD
- Cyanotic, lethargic
- Vitals: HR: 131 A-fib, BP: 158/100, RR: 32, SaO_2 on NRB: 90%
- After intubation, $EtCO_2$ 35mmHg
- Patient beginning to wake, and move head

Case 6



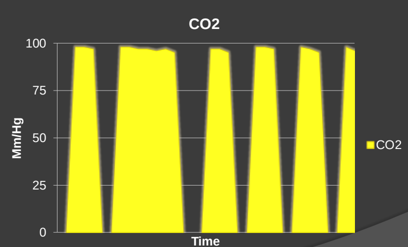
Case 7

- 2 year old female with new onset seizures
- Inter-facility transport for tertiary care
- Intubated / Ventilated by BVM
  - 4.5 ET uncuffed
- Vitals: HR 160, BP 84/40, Ventilated at rate of 36, SaO_2 100%, Temp: 103
- Ventilator: FiO_2 100%, PEEP 5, initial I:E 1:2.7

Case 7

- Capnography
  - Initial level: 98mm/Hg
  - Shape: elevated box shape, irregular respiratory pattern at rate of 36
- What are your actions?
  - Increase rate?
  - Change I:E ratio?
  - ET problem
- How might etiology change treatment?
  - Asthma
  - Trauma

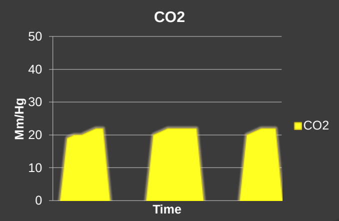
Case 7



Case 8

- Interfacility transport:
  - 56 year old male admitted with “fever”
  - Diagnosed with “sepsis:
- PMH: ESRD, IDDM, CAD, CHF
- Lethargic, GCS 12,
- Vitals: 84/60. HR 130, respirations 10 irregular
- Intubated electively for transport
- Initial $EtCO_2$: 21mmg/Hg

Case 8



Case 8

- Capnography:
  - Reason for Low EtCO2?
- What are your corrective actions?
  - Decrease ventilation rate?
  - Fluids?
  - Pressors?
  - Blood products?

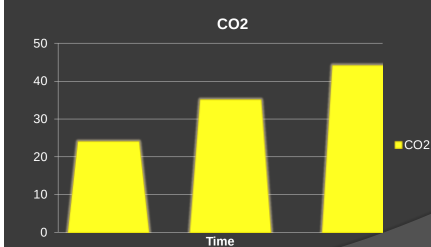
Case 8

- Consider:
  - BP of 140/90, HR 110, RR 28
- EtCO2 of 28mHg
- Respiratory alkalosis as an initial compensation for metabolic acidosis
  - Capnography considered a potential triage tool.

Case 9

- Male patient with dislocation of shoulder, requires conscious sedation
- Awake, oriented, agitated and in severe pain, 10/10
  - BP 150/70, HR 118, R 20, SaO2 100%
- Movement of arm increases agitation and pain
- Initial meds to not achieve adequate sedation and pain control

Case 9

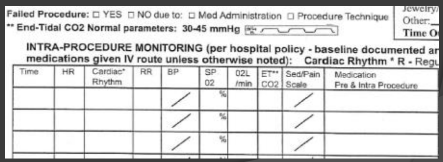


Case 9

- Conscious Sedation Monitoring parameter
  - What is required?
- What do we need to know while monitoring the patient?
  - Apnea?
  - De-saturation
  - Agitation?

Case 9: Sedation

- Quality of ventilation
- Detection of Apnea
- Predictor of Compromise



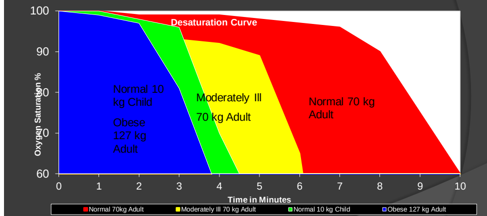
Failed Procedure: ☐ YES ☐ NO due to: ☐ Med Administration ☐ Procedure Technique | Jewelry/ Other:_ Time O

** End-Tidal CO2 Normal parameters: 30-45 mmHg

INTRA-PROCEDURE MONITORING (per hospital policy - baseline documented ar medications given IV route unless otherwise noted): Cardiac Rhythm * R - Regu

Time	HR	Cardiac* Rhythm	RR	BP	SP 02	02L /min	ET** CO2	Sed/Pain Scale	Medication Pre & Intra Procedure
				/	%			/	
				/	%			/	
				/	%			/	

De-saturation curve



From **Manual of Emergency Airway Management**, 2nd Edition, page 25

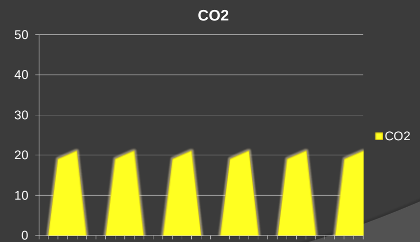
Literature

- ENA Emergency Nursing Resources
  - Level B: Moderate clinical certainty
  - Likely Beneficial
    - Proehl, J., Arruda, T., Crowley, M., Egging, D., Walker-Cillo, g., Papa, A., . . . Walsh, J. (2011, November). Emergency Nursing Resource: The use of Capnography during Procedural Sedation/Analgesia in the Emergency Department. *Journal of Emergency Nursing, 37*(6), 533-536.
    - Lightdale, J. R., Goldman, D. A., Feldman, H. A., Newburg, A. R., DiNardo, J. A., & Fox, V. L. (2006, May 15). Microstream Capnography Improves Patient Monitoring During Moderate Sedation. *Pediatrics, 117*(e1170). Retrieved October 5, 2013

Case 10

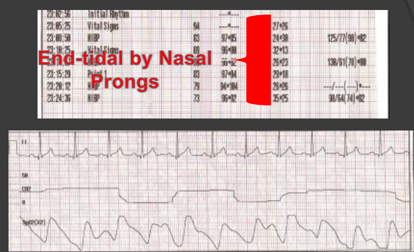
- 21 year old male c/c chest pains
- Sudden onset
- Stabbing, non-radiating, 10/10
- Tingling in his fingers

Case 10



Reality

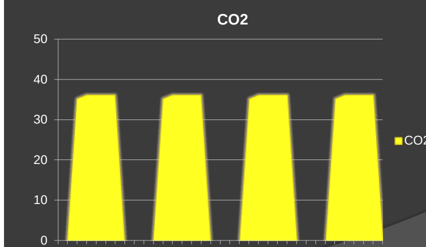
Case 10



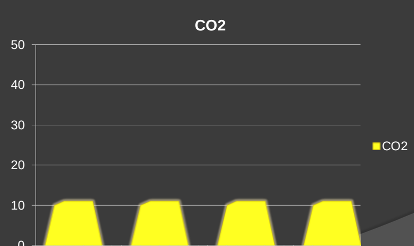
Case 11

- Female trauma patient
  - Unrestrained driver with steering wheel deformity; found under dash after airbag deployed
  - Pattern of injury??
- Intubated successfully
  - Confirmed by waveform sedated and paralyzed
- 25 minute flight to Trauma Center

Case 11: Cruising Along



Case 11: Sudden Change!



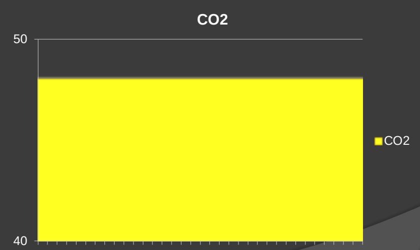
Case 12

- 57 year old obese male with spinal trauma
  - Fell forward, hyper-flexion of neck
  - Confirmed C5, C6 fractures
- CNS Intact-full movement
  - GCS of 9T (14 if not intubated)
- Intubated: and we did not know how
  - Sedation/fiberoptic ETI by anesthesia
- On T-piece, NOT VENTILATED breathing on his own

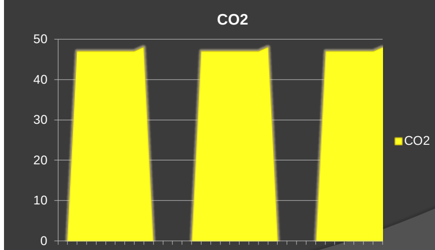
Case 12

- Considerations:
  - Community hospital to Level 1 trauma Center
  - Patient obese: 280 pounds
  - Aircraft: EC135
  - No existing ventilator settings; crew discretion on “optimal”
  - Difficult airway on multiple dimensions
    - Confirmed by CXR prior to movement

Case 12: Volume Ventilation



Case 12: Pressure Ventilation



Case 12

- Pressure versus volume ventilation
  - Pressure Control 24, FiO2 100%, Rate 12, Assist Control with PSV
  - Switch to BVM after desaturation
- Sedation, paralysis, pain control
- How might a different airframe change management? Or ground unit?
  - Bell 407 vs. 412
  - EC130 vs EC 135/145

Case 12

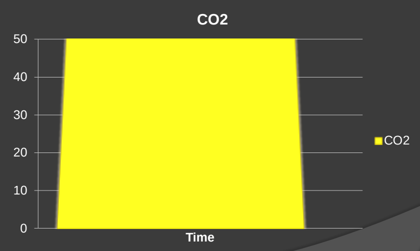
- Physical restriction of breathing
  - Burns
  - COPD
  - Trauma
  - Surgical

Case 13

- 55 year old female
  - History of cancer, undergoing chemotherapy and radiation
- Progressive worsening respiratory distress
- EMS summoned when level of consciousness deteriorated

Case 14

- 24 y/o patient in head on MVC
- Altered LOC, combative, signs of head injury
- RSI clinical course
  - Etomidate 0.3 mg/kg
  - Succinylcholine 1.5 mg/kg
- After paralytic, patient developed trismus and rigidity
- Unable to intubate, but can ventilate with oral airway in place
  - Unable to open mouth to place King LtD



Case 14 Malignant Hyperthermia

- Life Threatening
- Hypermetabolic state in patient's with hereditary skeletal muscle defect
  - Genetic predisposition 1:10000
  - Clinical Incidence 1:30000
- Depolarizing muscle relaxants (Succinylcholine) and anesthetic gases cause raise in myoplastic calcium

Malignant Hyperthermia: Signs and Symptoms

- Hypercarbia: most sensitive indicator in intubated patient
- Tachycardia
- Tachypnea
- Temperature elevation
- Hypertension
- Dysrhythmias
- Acidosis
- Hypoxia
- Hyperkalemia
- Skeletal muscle rigidity
- Myoglobinuria

MH Management

- Get help!
- Hyperventilate patient with 100% oxygen
- Cool patient
- Antidote is Dantrolene
  - Truly the only effective treatment
  - Operating rooms have an MH cart stocked with multiple bottles
- Prehospital considerations
  - Non-depolarizing paralytic
  - Benzodiazepines

Summary:

- Capnography is a TOOL
  - Does not substitute for good clinical skills
- Remember the BASICS
  - ABCs
- DO NOT OVERTHINK Capnography
  - Some cases will be difficult to figure out

Sources:

Ahrens, T. D., & Sona, C. M. (2003). Capnography Application in Acute and Critical Care. *AACN Clinical Issues* , *14* (2), 123-132.

American Society of Anesthesiologists. (2005, October 25). *Publications and Services*. Retrieved September 16, 2007, from American Society of Anesthesiologists: http://www.asahq.org/publicationsAndServices/sgstoc.htm
Brain Trauma Foundation. (2000). *Guidelines for Prehospital Treatment of Traumatic Brain Injury.* New York: Brain Trauma Foundation.

Cooper, J. B. *Medical Technology: Patient Safety is Paramount.*

Garey, B. (2007, August 18). Flight Paramedic, Medflight I. (M. Watkins, Interviewer)

Gravenstein, J. S., Jaffe, M. B., & Paulus, D. A. (2004). *Capnography.* Cambridge, United Kingdom: Cambridge University Press.

Hassett, P., & Laffey, J. G. (2007). Permissive Hypercarbia: Balancing Risks and Benefits in the peripheral microcirculation. *Critical Care Medicine* , 2229-2230.

Huether, S. E., & McCance, K. L. (2004). *Understanding Pathophysiology* (3 ed.). St. Louis, Missouri: Mosby Elsevier.

Hutchison, R., & Rodriguez, L. (2008). Capnography and Respiratory Depression. *American Journal of Nursing* , *108* (2), 35-39.

McGillicuddy, D., Tang, A., Cataldo, L., Gusev, J., & Shapiro, N. I. (2008). Evaluation of end-tidal carbon dioxide role in predicting elevated. *Intern Emergency Medicine* , pre-publish.

Sources:

Amal Mattu, M. (2010, December 30). *The 2012 AHA Guidelines: The 4 C's of Cardiac Arrest Care.* Retrieved January 12, 2012, from Medscape Emergency Medicine: www.medscape.com/viewarticle/734952_print

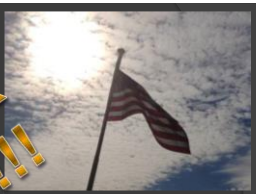
Lightdale, J. R., Goldman, D. A., Feldman, H. A., Newburg, A. R., DiNardo, J. A., & Fox, V. L. (2006, May 15). Microstream Capnography Improves Patient Monitoring During Moderate Sedation. *Pediatrics, 117*(e1170). Retrieved October 5, 2013

Paul, J. T., Mathoulin, S., & Whitehouse, T. (n.d.). *Use of Capnography in the Intensive Care Unit: Are we keeping up?* Department of Anaesthesiolohy and Intensive Care. Birmingham: University Hospitals Birmingham NHS Foundation Trust, Dept of Anaesthesia.

Proehl, J., Arruda, T., Crowley, M., Egging, D., Walker-Cillo, g., Papa, A., . . . Walsh, J. (2011, November). Emergency Nursing Resource: The use of Capnography during Procedural Sedation/Analgesia in the Emergency Department. *Journal of Emergency Nursing, 37*(6), 533-536.

Whitaker, D. K. (2011). Time for Capnograpy Everywhere. *Anaesthesia: Journal of the Association of Anaesthetists of Great Britain and Ireland*, pp. 544-549.

THANK YOU!!!!



ANY QUESTIONS?