Advanced Assessment Techniques in Critical Care

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http://www.geocities.com/jonesapjr/index.html

Objectives:

- Explain the implications for pulmonary mechanics in ventilated patients.
- Describe procedures for determining optimal PEEP.
- Interpret common ventilator wave form abnormalities.
- Explain the significance of of end-tidal CO2 measurements and wave forms.

Pulmonary Mechanics

Purposes For Monitoring Mechanics

- Determine appropriate ventilator settings
  - tidal volume
  - PEEP
  - inspiratory flow rate/time
  - pressure support

Purposes For Monitoring Mechanics

- Assess condition of lungs
  - consolidation
  - surfactant deficiency
  - bronchospasm

Purposes For Monitoring Mechanics

- Evaluate therapeutic effects
  - bronchodilators
  - recruitment maneuvers
  - surfactant
  - weaning modes
- Determine when to wean or discontinue support

Parameters Monitored

- Dynamic/static compliance
- Inspiratory/expiratory resistance to flow
- Total PEEP
- Work of breathing

Monitoring Methods

- Simple calculation
  - PEEPtotal = (PEEP + PEEPintrinsic)
  - dynamic compliance = tidal volume/(PIP - PEEP)
  - static compliance = tidal volume/(Ppt - PEEP)
  - resistance = (PIP- Ppt)/flow

Measuring Compliance

- Stabilize patient- active expiration will confound results by increasing intrinsic PEEP
- Measure:
  - exhaled TV
  - PIP
  - PEEP (total)
  - Ppt (plateau pressure)

Calculate Compliance

- Cdyn = TVE/PIP-PEEP
  - Example: PIP = 30; PEEP =5; TVE = 0.8L
    - ƒ Cdyn = 0.8L/(30-5) = .032 L/cm H2O
- Cst = TVE/Ppt-PEEP
  - Example: Ppt = 25; PEEP =5; TVE = 0.8L
    - ƒ Cst = 0.8L/(25-5) = .04L/cm H2O

Abnormal Cst

- Decreased Cst
  - ARDS, ALI
  - Extrathoracic restriction
    - ƒ obesity
    - ƒ ascites, distension
  - Thoracic restriction
  - Volume-occupying lesions; e.g., pleural effusion

Implications- Decreased Cst

- Increased work of breathing (WOB)
- Ventilation/perfusion inequality (intrapulmonary shunt)
- Increased ventilation pressure requirement s==>
  - Excessive shear forces on lung tissue, causing inflammation
  - Hyperinflation of compliant lung units, causing volutrauma

PEEP Therapy

Benefits of PEEP in ARDS

- Prevents alveolar collapse (AKA de-recruitment)
- Re-recruits collapsed alveoli
- Reduces shear forces required to ventilate collapsed alveoli

Links to benefits of PEEP
http://jama.ama-assn.org/cgi/content/abstract/299/6/646
http://content.nejm.org/cgi/content/abstract/311/5/281
http://www.chestjournal.org/cgi/reprint/128/5_suppl_2/592S

Adverse Effects of PEEP

- increased PVR
- increased VD_A
- decreased venous return
- increased WOB
- hyperinflation- volutrauma
- right-to-left shunt with patent foramen ovale (PFO)

Links to PEEP and adverse effects
http://www.annals.org/cgi/content/full/119/9/887
http://ccforum.com/content/8/5/R306
http://ccforum.com/content/cc3877

Optimal PEEP

- Defined- level of PEEP that imposes favorable volume-pressure relationship on the majority of lung units ==>
  - increased Cst
  - improved gas exchange
  - reduced shear forces

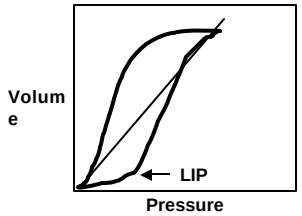
Optimal PEEP

- Methods for determination
  - lower inflection point of PV curve
  - stepwise incremental Cst measurement
  - stepwise decremental Cst measurement

Links to articles on optimal PEEP
http://ajrccm.atsjournals.org/cgi/reprint/165/8/1182
http://ajrccm.atsjournals.org/cgi/content/abstract/164/5/795

Optimal PEEP

- Methods for determination
  - locate lower inflection point (LIP) of PV curve
  - Optimal PEEP = LIP + 2-3 cm H2O



Stepwise Decremental Technique

- Adjust TV to desired level (<8 ml/kg IBW)
- Adjust FIO2 to 1.0
- Increase PEEP by 5, up to 20 cm H2O
  - monitor vital signs
  - monitor SpO2
- Adjust FIO2 for SpO2 90-95%

Stepwise Decremental Technique

- Decrease PEEP by 2 cm H2O
  - Q3 min, or until stabilized
  - monitor SpO2, SvO2, vital signs
  - measure Cst
- Optimal PEEP = level with greatest Cst
- Monitored/adjusted each shift

Ventilator Wave Form Analysis

Applications For Graphics

- Assess lung mechanics
  - resistance
  - compliance
  - WOB

Applications For Graphics

- Assess lung mechanics
  - resistance
  - compliance
  - WOB
- Detect ventilation problems
  - auto-peep
  - lung overdistension
  - patient/ventilator asynchrony

Applications For Graphics

- Evaluate interventions
  - bronchodilator therapy

Applications For Graphics

- Evaluate interventions
  - ventilator settings
    - primary mode
    - tidal volume, drive pressure
    - PEEP
    - ventilation times
    - trigger level
    - rise time
    - expiratory flow limit (PSV)

Graphic Types

- waves
  - pressure-time
  - flow-time
  - volume-time

Graphic Types

- waves
  - pressure-time

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Graphic Types

- waves
  - flow-time

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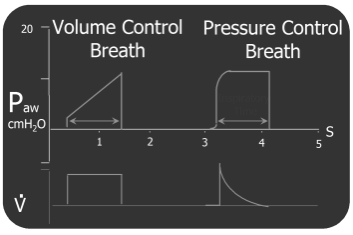
Graphic Types

- waves- comparing volume, vs. pressure control



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Graphic Types

- waves
  - volume-time

A = inspiratory volume
B = expiratory volume

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Graphic Types

- loops
  - pressure-volume

mandatory breath

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Graphic Types

- loops
  - pressure-volume

spontaneous breath

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Graphic Types

- loops
  - flow-volume

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Graphic Types

- loops
  - flow-volume

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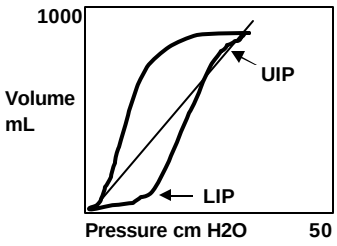
Clinical Applications For Graphics

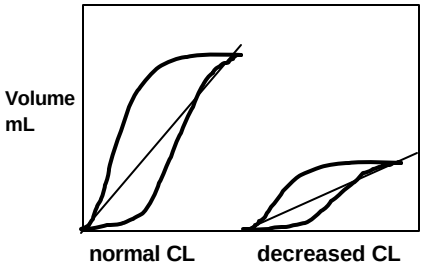
Clinical Applications For Graphics

- Compliance- pressure volume curve



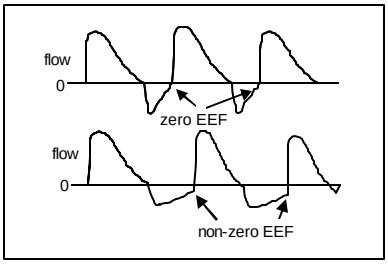
Clinical Applications For Graphics

- Assessment of compliance



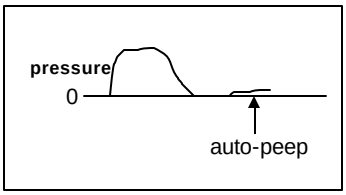
Clinical Applications For Graphics

- Detecting auto-peep
  - zero end-expiratory flow (EEF) ==> zero auto-peep



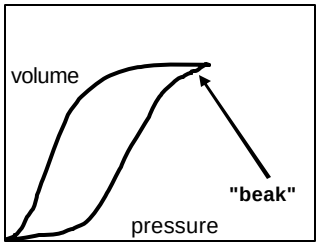
Clinical Applications For Graphics

- Detecting auto-peep during expiratory hold
  - accurately measured during absence of patient effort
  - active exhalation produces auto-peep



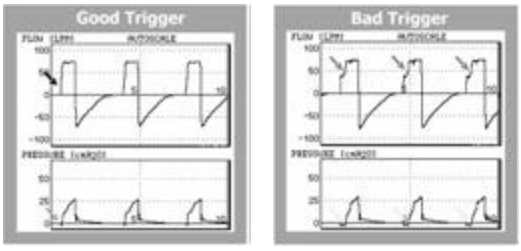
Clinical Applications For Graphics

- Detecting lung overdistension- excess TV



Clinical Applications For Graphics

- Detecting patient/ventilator asynchrony



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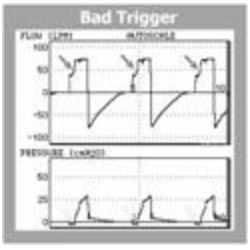
Clinical Applications For Graphics

- Detecting patient/ventilator asynchrony

Scooping on the upswing of the flow waveform

Significant pressure drop at the onset of patient effort



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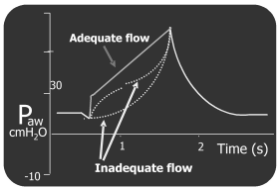
Clinical Applications For Graphics

- Evaluating inspiratory flow/rise- pressure wave

Linear or bowed upward rise in pressure after trigger on the pressure wave

Slow rise in pressure, concave shape of the pressure wave



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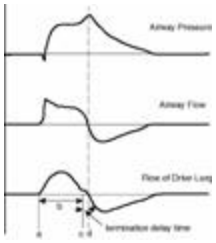
Clinical Applications For Graphics

- Evaluating expiratory flow-cycling (PSV)

Patient expiratory effort

Late termination

Inability to trigger



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Clinical Applications For Graphics

- Evaluating bronchodilator effectiveness

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End-Tidal CO2 Monitoring

Applications

- Estimate PaCO2- reliability not established
- Monitor changes in PaCO2- reliability not established
- Estimate dead space- reliable for finding Vd/Vt

Applications

- Confirm ETT placement- reliable
- Evaluate chest compressions- reliable
- Detect pulmonary embolism- promising
- Detect leak in ventilation circuit
- Compare condition of lungs during independent lung ventilation
- Predict weaning failure

Interpretation- PetCO2

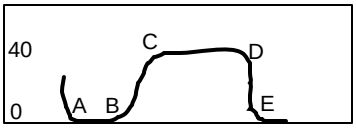
- Normal difference between PaCO2-PetCO2 = 2-5 torr
- Increased P(a-A)CO2 ==> dead space; e.g.:
  - pulmonary embolus
  - excessive PEEP

Interpretation- PetCO2

- Decreased PetCO2- ominous sign during resuscitation
  - low perfusion
  - embolization
  - ventilation air leak
- Increased PetCO2
  - hypoventilation
  - administration of NaHCO3

Link to ETCO2 article
http://www.aacn.org/pdfLibra.NSF/Files/Frakes/$file/Frakes.pages.pdf

Interpretation- Normal Capnogram



A-B: dead space.
B-C: mixed dead space and alveolar
C-D: alveolar gas
D: End-tidal value— Peak CO2
D-E: Inhalation

Link to capnography case studies
http://www.oridion.com/global/english/clinical_solutions/educatonal_resources/case_studies.html#CARE

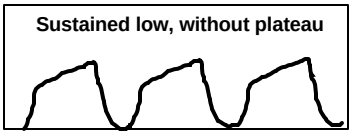
Interpretation- Abnormal Capnogram

- Airway disconnection
- Dislodged ET tube/esophageal intubation
- Totally obstructed/kinked ET tube
- Complete ventilator malfunction

Interpretation- Abnormal Capnogram

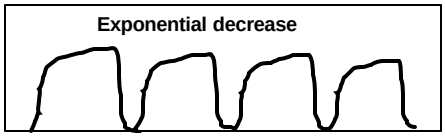
- Hyperventilation
- Hypothermia
- Sedation, anesthesia
- Dead space ventilation

Interpretation- Abnormal Capnogram



- Incomplete exhalation
- Partially kinked ET tube
- Bronchospasm
- Mucous plugging
- Poor sampling techniques

Interpretation - Abnormal Capnogram



- Cardiopulmonary arrest
- Pulmonary embolism
- Sudden hypotension; massive blood loss
- Cardiopulmonary bypass

Summary and Review

- Pulmonary mechanics
  - purposes for measurement
  - implications
  - measurement
- Optimal PEEP
  - implications
  - measurement

Summary and Review

- Ventilator waveforms
  - types
  - normal waveforms
  - abnormal waveforms
- ETCO2 monitoring
  - applications
  - interpretation of P(a-et)CO2
  - etCO2 waveforms

END