When did you first realize you were in trouble?

The Seven Deadly “Hs”
- Hypothermia
- Hypoglycemia
- Hypokalemia
- Hypertension
- Hypoxemia
- Hyperkalemia
- Hypovolemia

How to use monitoring equipment during CPR

WHAT DO PEA, EtCO₂, PVI HAVE IN COMMON?
What is PEA?
PEA: Pulseless Electrical Activity

Definition: Any cardiac electrical activity or rhythm that fails to generate a palpable pulse.

Hypotension is defined as a systolic BP less than 80-90 mm Hg or a mean BP less than 55-60 mm Hg

The pulse becomes difficult to palpate when the systolic BP is below 50 mm Hg. Is this PEA? YES!

Which ECG Rhythm produces PEA?

PEA - Pulseless Electrical Activity Includes:
1. Tachyarrhythmias
2. Brady – asystole arrhythmias
3. Ventricular escape rhythms
4. Idioventricular Rhythms
5. Electromechanical dissociation (EMD)
6. Post defibrillation cardiac rhythms
FREQUENTLY LISTED CAUSES OF PEA (Hs & Ts)

- Hypovolemia
- Hypoxia
- Hydrogen ion – acidosis
- Hyperkalemia
- Hypokalemia
- Hypothermia
- (Hypoglycemia)
- Toxins
- Tamponade
- Tension PTX
- Thrombosis – coronary
- Thrombosis – pulmonary
- (Trauma)

PEA

QRS NARROW
MECHANICAL (RV) PROBLEM
- Cardiac tamponade
- Tension PTX
- Mechanical hyperinflation
- Pulmonary embolism

QRS WIDE
METABOLIC (LV) PROBLEM
- Severe hyperkalemia
- Sodium-channel blocker toxicity

Treating PEA

First Steps
- Administer a fluid challenge
- Administer epinephrine
**PEA- Treatment**

- Fluid challenge 3-5 ml/kg/1-3 min
- Atropine 0.02 mg/kg IV
- Glycopyrrolate 0.005 mg/kg IV
- Calcium Gluc 6-12mg/kg IV (1/3 Ca²⁺Cl⁻)
  
- Epinephrine 0.005-0.01 μg/kg IV

**Narrow QRS**

*Venous return (RV) Problem*

- Hypovolemia – **Fluid Rx (How much, how fast?)**
- Tension Pneumothorax - Decompression (chest tube)
- Cardiac tamponade – Pericardiocentesis
- Pulmonary hyperinflation – Breathing/ventilator Rx
- Pulmonary embolism – Theophylline 9-11 mg/kg IV
  
  Sildenafil 0.3-3 mg/kg PO
  
  Streptokinase 90,000 units/30min IV

**Wide QRS**

*Metabolic (LV) Problem*

- Hyperkalemia – NaCl; IV calcium chloride
- Metabolic acidosis – O₂; IV NaHCO₃
- LV failure – dobutamine
Capnography
End tidal carbon dioxide (EtCO₂)

Physiology

- Room air is nearly CO₂-free. During inspiration, the CO₂ in the blood diffuses across the capillary and alveolar walls into the alveolar space.
- Normally, one pass of the blood through the alveolar capillary bed allows the partial pressures of CO₂ in the alveoli and the arterial blood to nearly equalize.

Respiratory Physiology
Capnography

- Definition:
  - Noninvasive measurement of the partial pressure of CO₂ in exhaled air
  - Provides instantaneous information about
    - Ventilation
      - How effectively CO₂ is being eliminated by the pulmonary system
    - Perfusion
      - How effectively CO₂ is being transported through the vascular system
    - Metabolism
      - How effectively CO₂ is being produced by cellular metabolism

Capnograph

Capnogram

End-tidal CO₂ (EtCO₂)

- The peak partial pressure of CO₂ at the end of exhalation is known as the end-tidal CO₂ (EtCO₂).
- EtCO₂ is a reflection of
  - alveolar ventilation
  - pulmonary blood flow (Qp)
  - CO₂ production
**CO₂ Detection**

- Qualitative
- Quantitative
  - Side stream
  - Main stream

**Qualitative EtCO₂ Detectors**

*Colorimetric CO₂*

If a sufficient concentration of CO₂ is detected, the color strip will change from purple to tan to yellow.

The yellow color indicates adequate ventilation and good air exchange.

**Colorimetric CO₂**

- Uses litmus paper that changes color when it comes in contact with CO₂
- Will not change color if no CO₂ is flowing across paper
- Color strip will change from purple to tan to yellow
- Color can change from breath to breath
- The yellow color indicates adequate ventilation and good air exchange
Facts about Colorimetric Devices

- **A Range (Purple):** <4 mmHg EtCO₂
  - 0.03% to < 0.5% EtCO₂
- **B Range (Tan):** 4 to <15 mmHg EtCO₂
  - 0.5% to < 2% EtCO₂
- **C Range (Yellow):** 15 to 38 mmHg EtCO₂
  - 2% to 5% EtCO₂
- Evaluate color of device after 6 full breaths.
  - This allows any CO₂ in the stomach (produced by the ingestion of certain beverages and medications, or by expired air bagged into the stomach prior to intubation) to be blown off.
  - Inaccurate if contaminated with secretions, blood, emesis, acidic meds, etc.

Quantitative Side Stream EtCO₂

- Issues
  - Draw rate (ml/min)
  - Time delay
  - Scavenging

Quantitative Main Stream EtCO₂

Quantitative ETCO₂ is updated every breath
Respiratory Rate displayed after two breaths and updated every breath
Quantitative EtCO2

Capnography

Normal capnogram A & baseline during inspiration, B & C: respiratory upstroke, C–D: expiratory or alveolar plateau, D: Petco₂; D–E: respiratory down-stroke.

Capnography

Hypovolemia, leak in the airway, hypotension, hypothermia, decreased cardiac output, hypoxemia, pulmonary embolism.

Rebreathing of CO₂ (dead space ventilation), defective exhalation valve.
Capnography

What is this???

EtCO$_2$ AND Hemodynamics

Tissue CO$_2$ (P$_t$CO$_2$)

\[ P_t = \text{tissue PCO}_2 \]
\[ P_b = \text{buccal PCO}_2 \]

P$_b$ CO$_2$ surrogate
For P$_t$CO$_2$
**EtCO₂ and CPR**

- Return of Spontaneous Circulation (ROSC)
  - EtCO₂ > 10-15 mm Hg
- Effectiveness of compressions
- Termination of Resuscitation
- Reassessment
CVP or PPV
What is Pulse Pressure Variation

Venous Function and Central Venous Pressure
A Physiologic Story, Simon Gelman, M.D., Ph.D.*
Anesthesiology 2008; 108:735–748

Central Venous Lines & CVP

What Influences CVP

- Central venous blood volume
- Venous return/cardiac output
- Total blood volume
- Regional vascular tone
- Compliance of central compartment
- Vascular tone
- Right ventricular compliance
- Myocardial disease
- Pericardial disease
- Tension

- Tricuspid valve disease
- Sinus
- Supraventricular
- A-V association

- Cardiac rhythm
- Abnormal rhythms
- V-A

- Reference level of transducer
- Intrathoracic pressure
- Positioning of patient
- Respiration
- Intermittent positive pressure ventilation (IPPV)
- Positive end-expiratory pressure (PEEP)
- Tension pneumothorax
CVP: Clinical Relevance

Very poor relationship between CVP and blood volume

Inability of CVP/ΔCVP to predict the hemodynamic response to a fluid challenge.

CVP should not be used to make clinical decisions regarding fluid management.

1. There is no association between CVP and circulating blood volume.
2. CVP does not predict fluid responsiveness across a wide spectrum of clinical conditions

Does Central Venous Pressure Predict Fluid Responsiveness?:
A Systematic Review of the Literature and the Tale of Seven Mares, Paul E. Marik, Michael Baram and Bobbak Vahid
Chest 2008; 134:172-178

CVP: Clinical Relevance

CVP (and Pulm wedge pressure) is a poor indicator of intravascular volume in anesthetized animals primarily due to anesthetic related drug effects and the non-linear changes they produce in vascular compliance.

Kumar A, Anel R, Bunnell E et. al. Pulmonary artery occlusion pressure and central venous pressure fail to predict ventricular filling volume, cardiac performance or the response to volume infusion in normal subjects.

Who is this?

HINT
Alfred Kussmaul
1822-1902

Stroke volume variation: SVV

\[
SVV = SV_{\text{max}} - SV_{\text{min}} / SV_{\text{mean}}
\]

Pulse Pressure Variation

\[
\Delta PP = 100 \times \frac{PP_{\text{max}} - PP_{\text{min}}}{PP_{\text{mean}}} + PP_{\text{mean}}/2
\]
What Works?

Fluid responsiveness is related to cardiac responsiveness

Plethysmograph Variability Index: PVI Calculation

- Automated measurement
  - Changes in plethysmographic waveform amplitude over the respiratory cycle
- PVI is a percentage from 1 to 100%:
  - 1 - no pleth variability
  - 100 - maximum pleth variability
Plethysmograph Variability Index: PVI

PPV and SVV?

- Spontaneously breathing patients
- Cardiac Arrhythmias
- Significant tachycardia
- Very low tidal volumes

Summary

- There are many parameters to use
- Static measurements (ex. CVP) are not accurate or dependable
- PVI is a more reliable (sensitive and specific) indicators of vascular volume status
Lucy: 11 yr; FS
Vomiting for 3 days
Depressed; mildly dehydrated.
Mild leukocytosis
BGs: pH = 7.43
pCO2 = 67.8
pO2 = 32.6
HCO3 = 43.3
BE = 13.7
Lac 1.44

References
Fluid responsiveness is related to cardiac responsiveness

Stroke volume

Fluid responsiveness

Normal heart

Fluid unresponsiveness

Failing heart

Preload

SVV-PVV

Antecution of SV and PVV

Annotation of SV and PVV

Assessment of SV, MV, and RV
dynamics

Respiratory variations