Limitations of Point-of-Care Testing

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Objectives: Monitoring

- Understand the purpose and limitations of point-of-care testing
- Understand which monitors are useful for quick information gathering and what the information means
- Understand the limitations of the monitoring equipment

Point-of-Care Testing

- Purpose: To obtain immediate (within 5-10 minutes), cage-side patient information that will compliment findings from the initial triage examination
- When: Initial presentation and dynamic patients
- Focus: Life-threatening problems
- Limitations: Know your machines!

Recognizing Life-Threatening Problems: Triage and Point-of-Care Testing

- Shock
  - Hypovolemic
  - Distributive
  - Cardiogenic
- Sepsis/SIRS/MODS
- Respiratory distress
- Cardiac disease
- Diabetic Ketoacidosis
- Addison's Disease
- Hypoglycemia
- Hypo/hypertension
- Acute abdomen
- Seizuring
- Head trauma
- Blood disorders
- Electrolyte abnormalities
- Renal failure
- Post-renal obstruction
- Toxins
- Acid-base disorders
- Saddle Thrombus

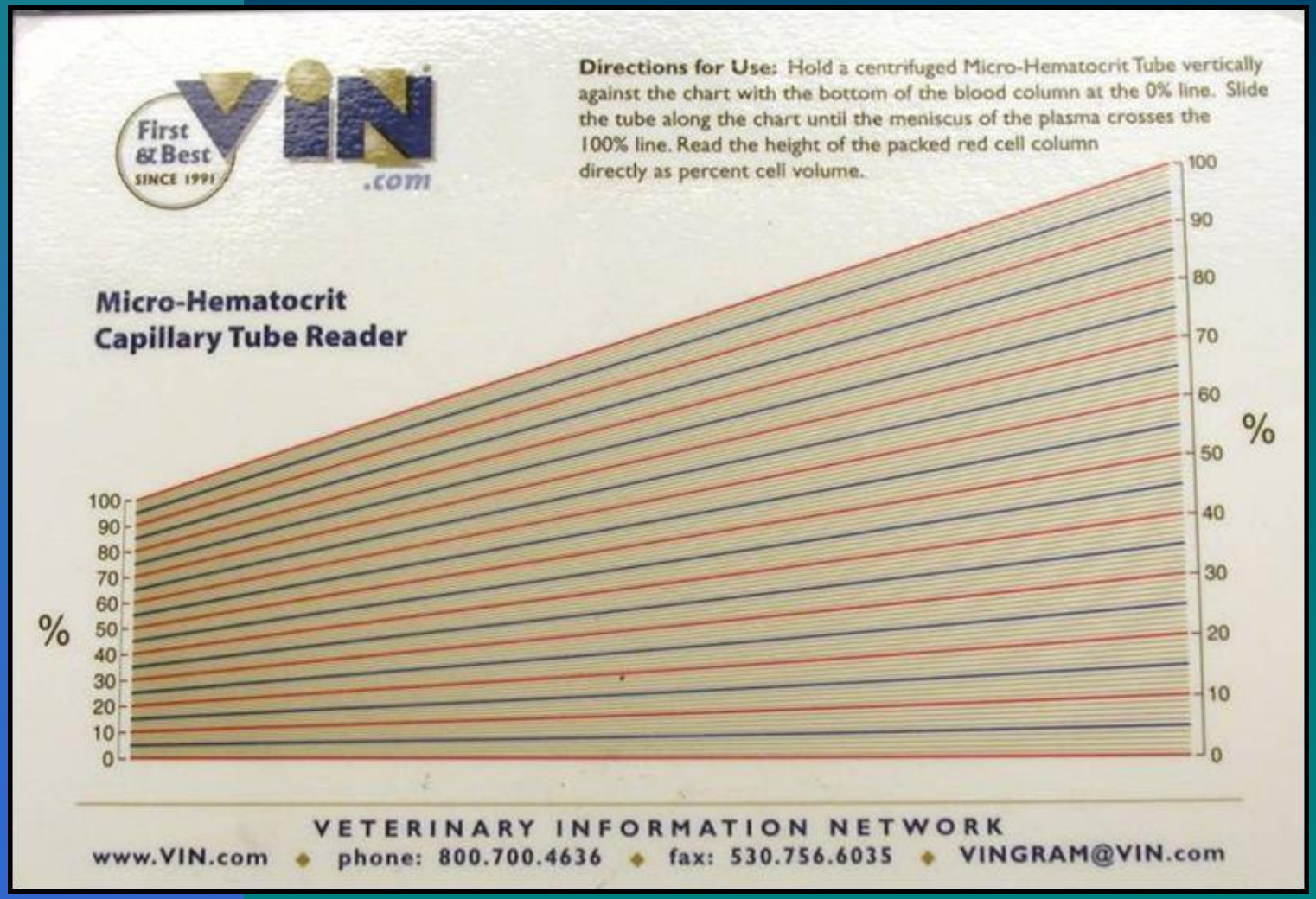
The Extended Data Base

- PCV/TP
- Glucose
- BUN or Creatinine
- Electrolytes
- Lactate
- VBG or ABG
- Urine s.g. & dipstick
- Blood smear
- Coagulation status
- ECG
- Blood pressure
- Pulse oximeter

Packed Cell Volume

- Percentage of whole blood that contains RBC's compared to plasma
- Centrifuged in hematocrit tubes
- Measured on chart

Packed Cell Volume



Packed Cell Volume - Anemia

- Loss, destruction, decreased production, sequestration
- During hemorrhage, TP will drop before PCV due to splenic contraction
- Plasma color and TP can help differentiate causes of anemia
- Look at how the patient is handling the anemia

Packed Cell Volume - Polycythemia

- Hemoconcentration
- Chronic hypoxia
- Primary polycythemic disorder

Packed Cell Volume Limitations

- Diluted samples are common, especially if sample was from a catheter
- Centrifuge speed and length of time can alter results
- Minor subjective errors in reading
- May be excessively hemodilute if recently received lots of fluids
- Blood clots can alter results

Total Protein

- Measured on refractometer
- Can be artificially elevated with lipemia

Total Protein

- Hypoproteinemia
  - Loss (GI, hemorrhage, or renal)
  - Decreased production (liver)
- Hyperproteinemia
  - Dehydration
  - Hyperglobulinemic

Total Protein Limitations

- Can't differentiate between panhypoproteinemia vs. hypoalbuminemia
- Can't differentiate panhyperproteinemia and hyperglobulinemia
- Lipemia, icterus, and hemolysis can artificially raise TP

PCV/TP Case Examples

- PCV = 45%; TP = 7.5 g/dL
  - Normal
- PCV = 55%; TP = 8.5 g/dL
  - Dehydration
- PCV = 40%; TP = 4.0 g/dL
  - Early hemorrhage
  - Hypoproteinemia
- PCV = 25%; TP = 4.0 g/dL
  - Late hemorrhage

PCV/TP Case Examples

- PCV = 68%; TP = 5.2 g/dL
  - Hemorrhagic gastroenteritis
- PCV = 20%; TP = 7.5 g/dL
  - RBC destruction or lack of production
  - Look at plasma color!
- PCV = 70%; TP = 7.0 g/dL
  - Polycythemia
- PCV = 45%; TP = 11 g/dL
  - Hyperglobulinemia
  - Lipemia

Glucose

- Measured on glucometer or blood gas machine
- Glucometers are designed for human diabetics
  - Read approximately 20 mg/dL low during hypoglycemia

Glucose

- Look at your patient!
  - Clinical signs?
  - Pediatric vs. adult?
  - Patient size/species?
- Seizuring doesn't typically occur unless below 40 mg/dL
- Detrimental effects of glucose supplementation?

Glucose

- Hypoglycemia
  - Lab error
  - Sepsis/SIRS
  - Insulinoma
  - Starvation
  - Pediatric
- Hyperglycemia
  - Stress (cats)
  - Diabetes mellitus
  - Massive epinephrine release
  - Head trauma

Renal Values

- BUN
  - May be elevated with GI hemorrhage
- Creatinine
  - More renal specific than BUN
- Pre-renal vs. renal vs. post-renal

Measuring BUN - Azostix

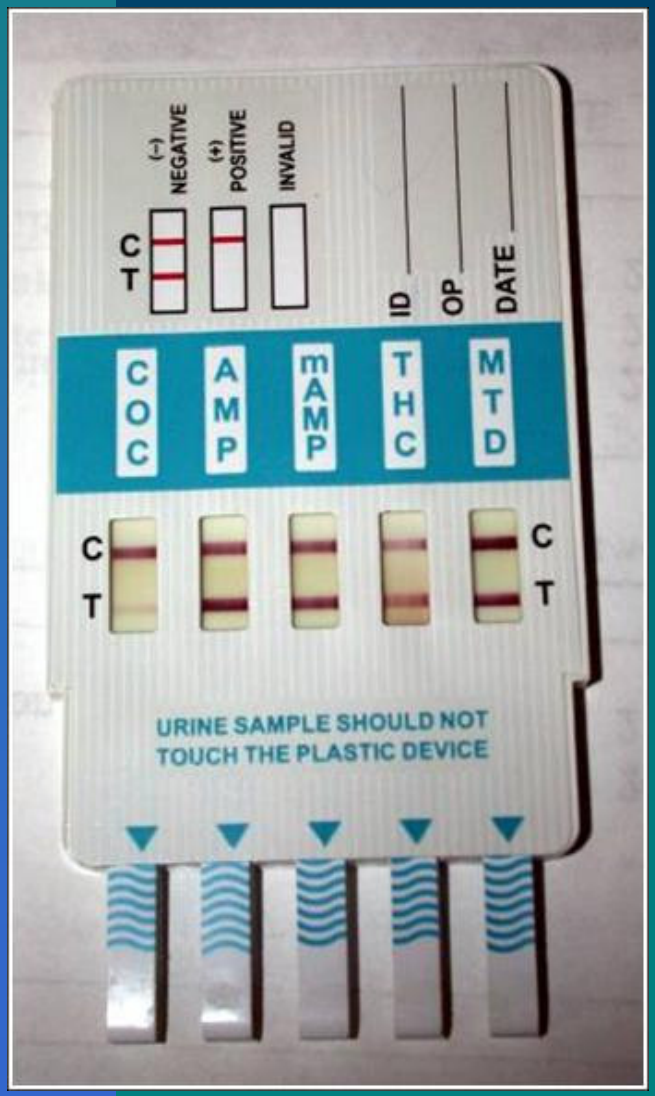
Urine Specific Gravity and Dipstick

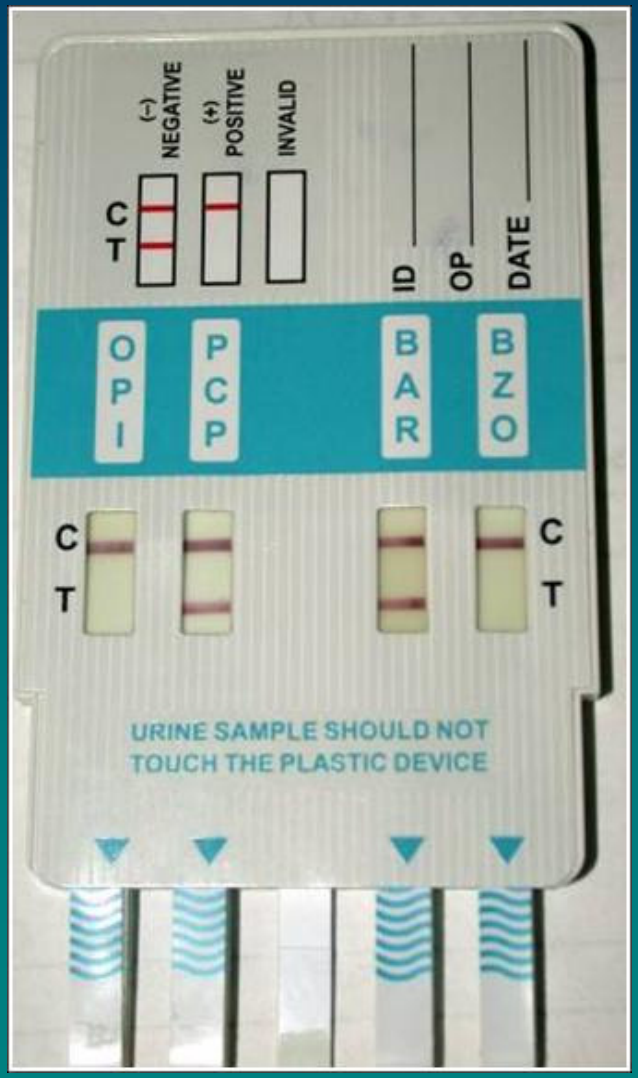
- Pre-fluids s.g. is most useful
- Be comfortable with no coag abnormalities prior to cystocentesis
- Don't withhold fluids just to get s.g.
- Plasma can be used in lieu of urine to look for ketones
- Leukocyte/nitrite not accurate on dipstick in animals

BUN/Specific Gravity Examples

- BUN = 100 mg/dL, Creatinine = 4.0 mg/dL, Urine sg = 1.040
  - Prerenal azotemia
- BUN = 100 mg/dL, Creatinine = 4.0 mg/dL, Urine sg = 1.010
  - Renal azotemia
  - Prerenal azotemia?
- BUN = 100 mg/dL, Creatinine = 1.5 mg/dL, Urine sg = 1.025
  - GI hemorrhage

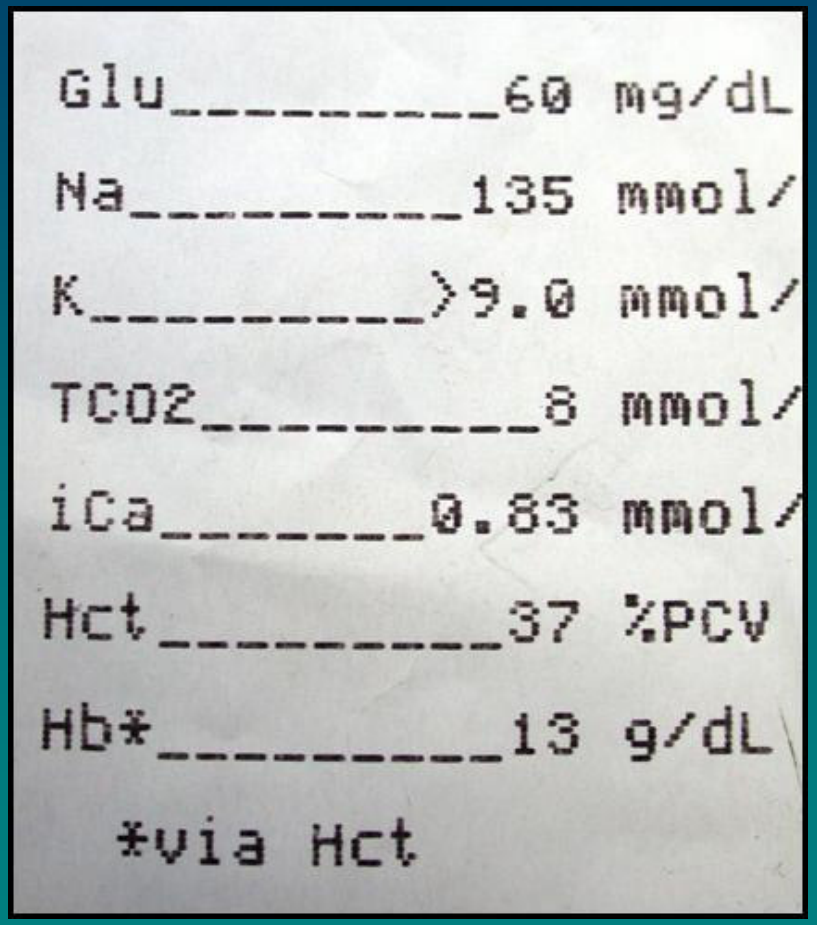
Urine Drug Testing





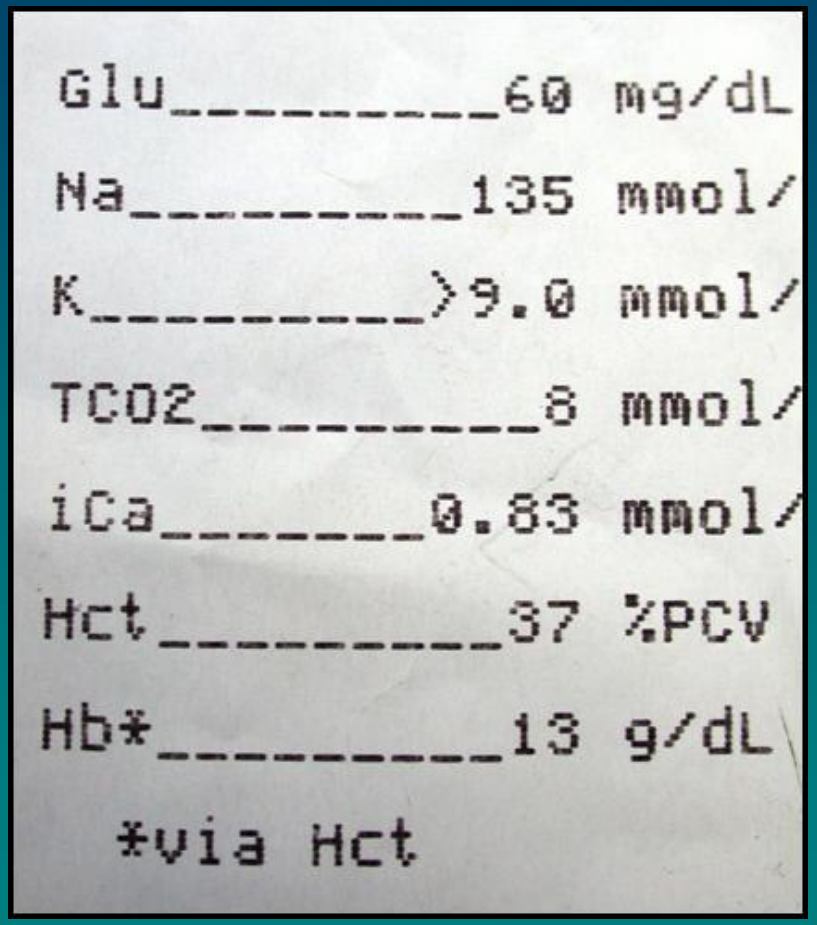
Electrolytes

- Sodium
- Potassium
- Chloride
- Ionized calcium
  - Reads artificially low if sample over-heparinized
  - Acidosis increases ionized calcium



Electrolytes

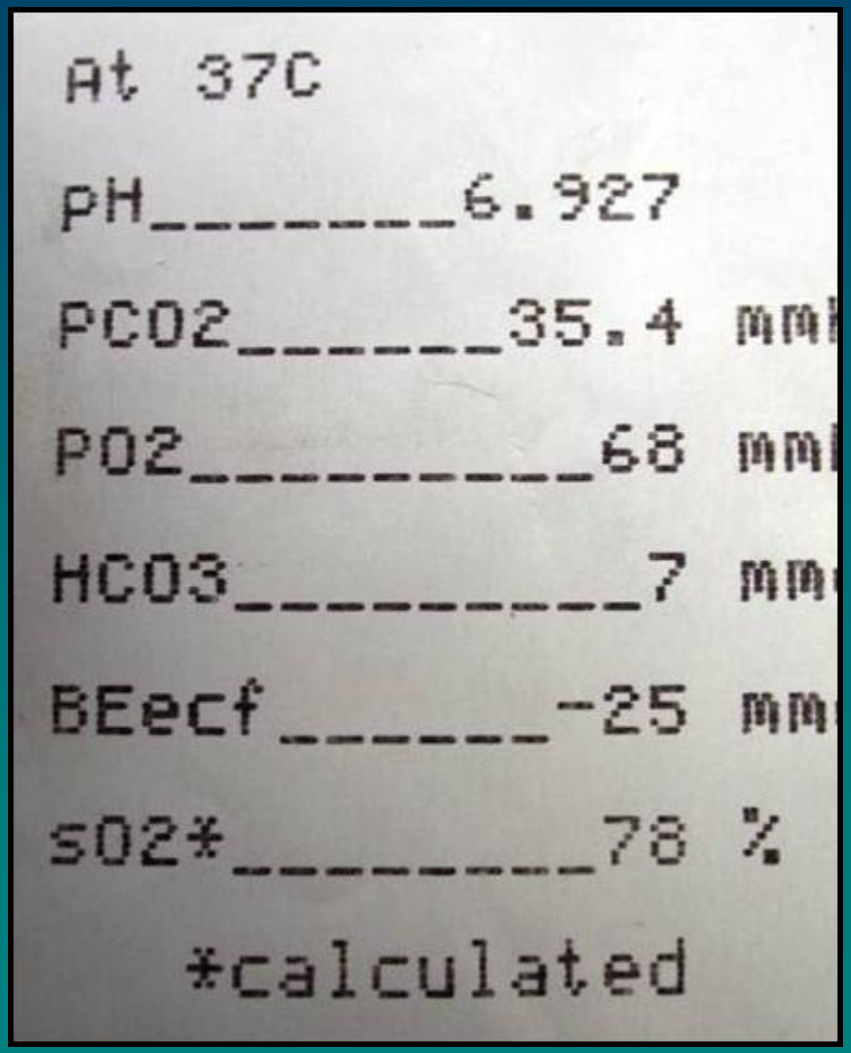
- Make sure samples from catheters are not contaminated with fluids or additives
- Hct/Hb on blood gas machines usually not accurate



Lactate

- A measure of perfusion
- Predictor of gastric necrosis in GDV if > 6 mmol/L
- How quickly lactate drops may be more important than absolute numbers
- Great tool to assess response to resuscitation

Venous or Arterial Blood Gas



Venous vs. Arterial Blood Gases

- Venous blood gases are reliable for acid-base status and ventilatory status
- VBG gives a more accurate picture of global acid-base status during CPR
- pH < 7.2 leads to cellular dysfunction
- Only arterial blood gases can tell you how well a patient is oxygenating
- Venous oxygen tensions are only useful for calculating oxygen extraction
- Venous oxygen < 20 mmHg has been associated with poor prognosis in people

Blood Smear

- WBC estimate
  - Normal estimate 5-15 WBC/10x
- RBC morphology
- Platelet estimate
  - Normal estimate 8-12 plts/100x
- Poor feathered edge and not looking for platelet clumps can alter results

Coagulation: Primary hemostasis

- Platelet count
- Platelet function
  - Von Willebrands disease
  - Buccal mucosal bleeding time, as long as platelet count is normal
- Typically causes mucosal bleeding, epistaxis, and petechiae, not cavity bleeding

Coagulation: Secondary Hemostasis

- Activated clotting time – intrinsic pathway (n < 120s)
- Can affected by low platelets and can be user dependent

Coagulation: Secondary Hemostasis

- Prothrombin time (PT) – extrinsic
- Activated partial thromboplastin time (APTT) - intrinsic

Coagulation Case Examples

- Bilateral epistaxis, melena, hyphema, and petechia on mucous membranes

Coagulation Case Examples

- PT/aPTT WNL
- Thrombocytopenia on blood smear (only 3-5 platelets/hpf)
  - Destruction (ITP)
  - Use (hemorrhage, DIC)
  - Non-production (bone marrow disease)

Coagulation Case Examples

- Dyspnea, dull lung sound ventrally, pale mucous membranes, hemothorax on thoracocentesis, PCV = 20%, TP = 3.9 g/dL
  - Elevated PT only
    - Rodenticide toxicity

Coagulation Case Examples

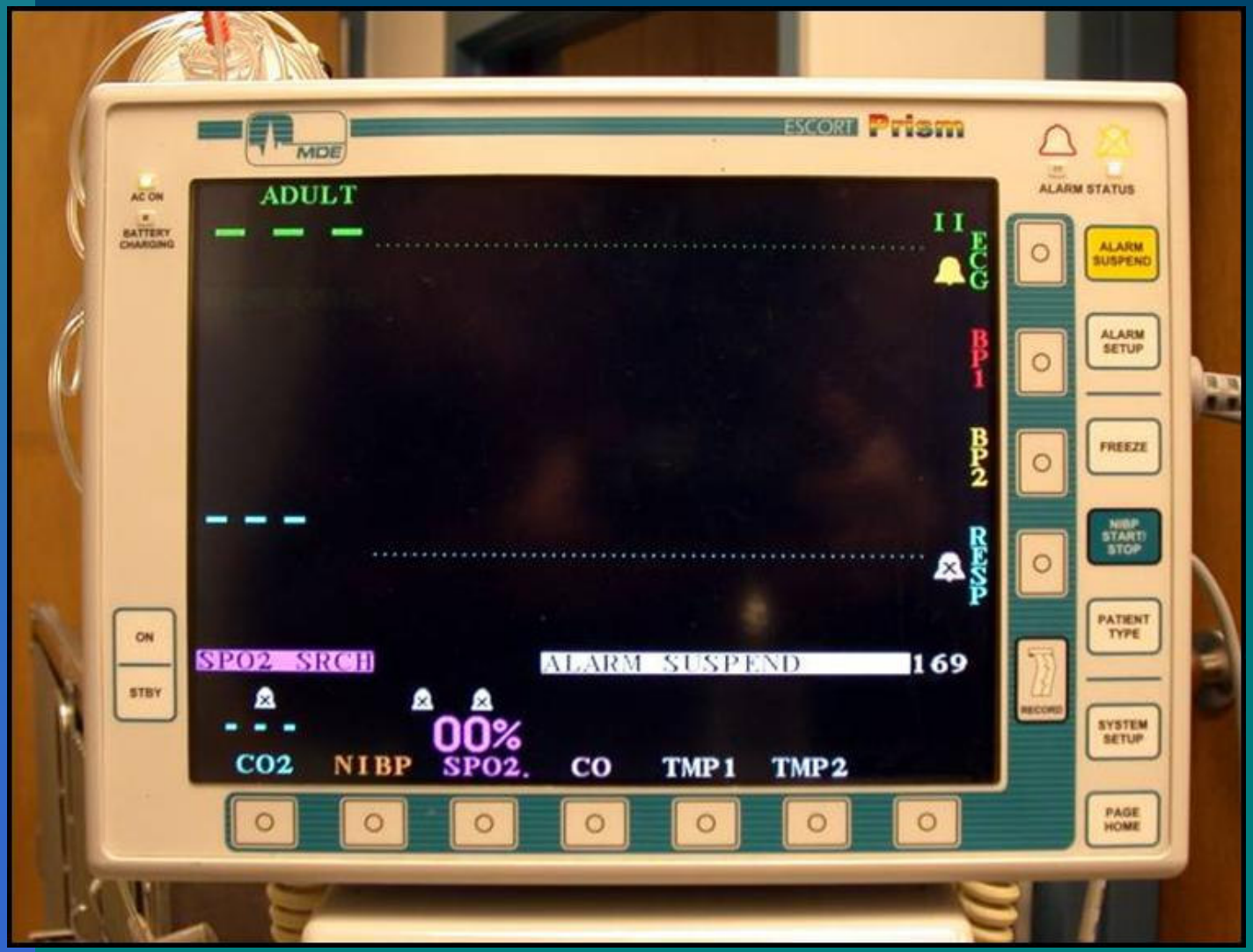
- Vomiting, icterus, bruising ventrally

Pictures courtesy of Dr. Robin VanMetre

Coagulation Case Examples

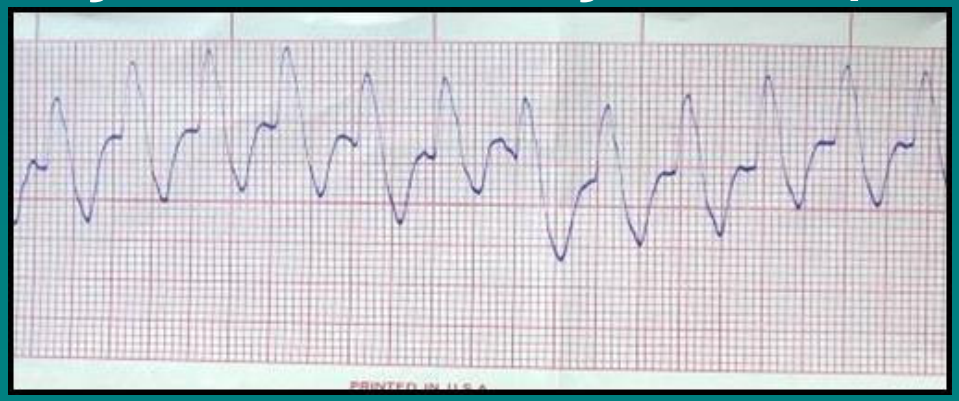
- Elevated PT/aPTT
  - DIC
    - Increased PT/aPTT
    - Low platelets
    - Increased FDPs/D-dimers
  - Liver failure

Electrocardiogram



Electrocardiogram

- Tachycardia
  - Shock
  - Pain
  - Primary cardiac arrhythmia
- Bradycardia
  - Electrolyte abnormalities ($K^{+)}$
  - Primary cardiac arrhythmia (AV block)



Electrocardiogram

- Arrhythmias (VPC's, A-fib)
  - Primary vs. secondary
- Electrical alternans
  - Pericardial effusion

Electrocardiogram Limitations

- Poor contact, shivering, and patient movement can lead to background noise, making ECG difficult to interpret
- Electrical activity can continue long after the heart has stopped (PEA/EMD)!
- ECG is NO substitute for an audible pulse or heartbeat
- Alcohol as contact agent can cause fire if patient needs to be defibrillated

Indirect Blood Pressure

- BP = CO x SVR
- One of the best objective measurement of perfusion we have
- May be difficult to measure during hypotension/poor perfusion
- Target MAP > 80 mmHg in awake patients
- Indirect methods
  - Doppler
  - Oscillometric

Blood Pressure: Doppler

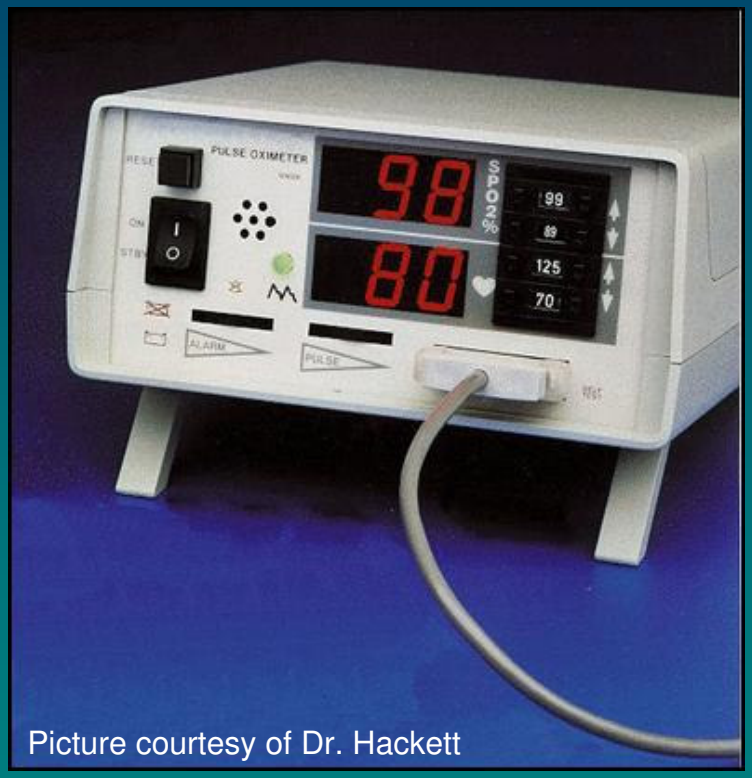
- Only gives systolic blood pressure
- May give mean pressure in cats under anesthesia
- Allows for audible pulse throughout procedure
- May not work well during severe vasoconstriction

Blood Pressure: Oscillometric

- Gives systolic, diastolic, and mean
- Must match heart rate to be considered accurate
- Cuff size important
- Cardell® only oscillo. BP accurate in cats
- Won't read well with poor perfusion and hypotension

Pulse Oximetry

- Indirect method of measuring hemoglobin saturation
- Two wavelengths of light emitted to determine oxyhemoglobin and deoxyhemoglobin levels
- Accounts for tissue absorption by assuming only arterial blood pulsates

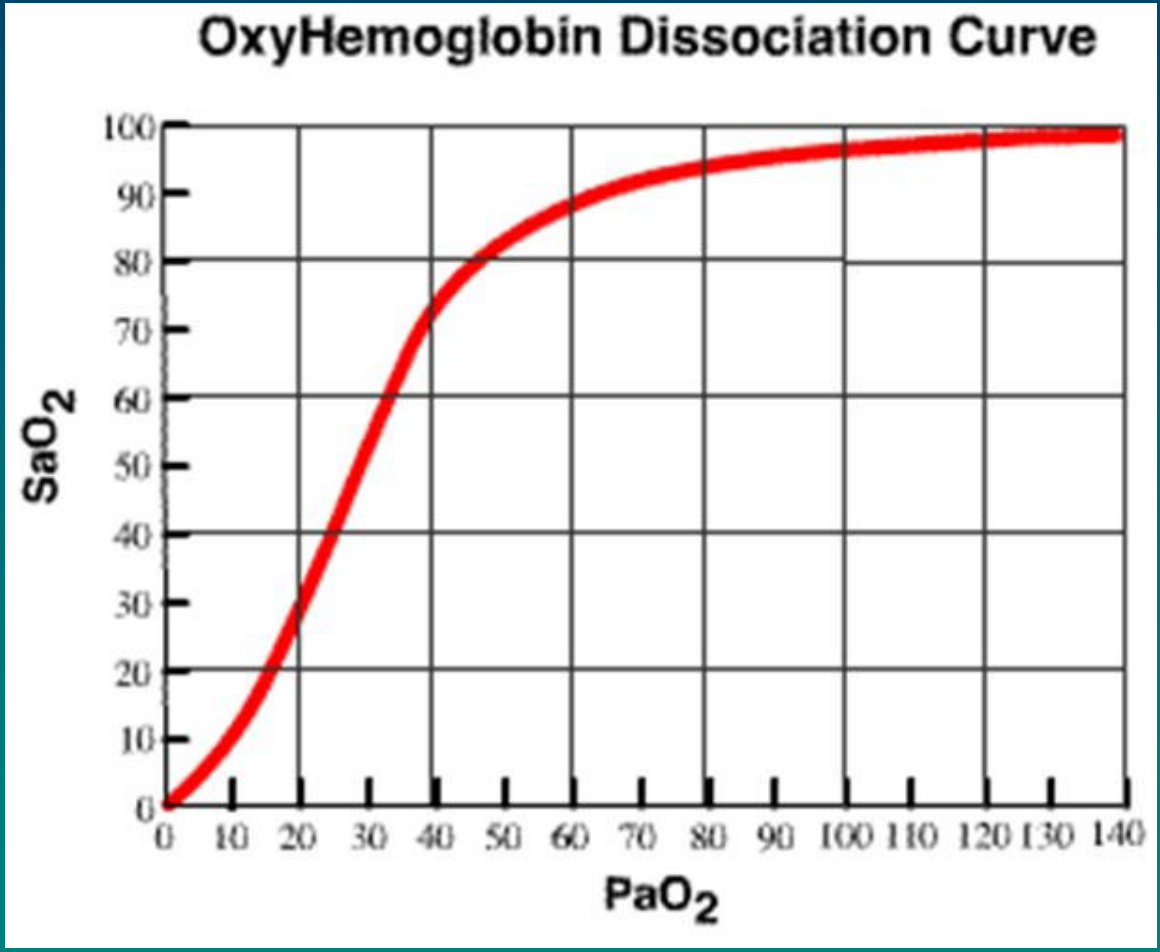


Picture courtesy of Dr. Hackett

Pulse Oximetry - Artifacts

- Ambient light
- Low perfusion
- Motion
- Look for matching heart rate and good plethysmograph waveform
- Reading frequently defaults to 85% when artifacts are present
- Carboxyhemoglobin/methemoglobin

Oxyhemoglobin Dissociation Curve



Graph

Beyond the EDB: Additional Monitoring

- Respiratory
  - Capnography
  - Respirometry
  - Apnea monitors
  - Tidal flow-volume loops
  - Transcutaneous oxygen monitoring

Capnography

- In the normal healthy dog or cat, the $ETCO_2$ is a good representation of the $PaCO_2$
- The $ETCO_2$ is usually 4-6 mmHg lower than the $PaCO_2$

Capnography

- The $ETCO_2$-$PaCO_2$ gradient is due to mixing of gas from alveoli that are being perfused with alveoli that are not being perfused
  - Dead space ventilation

Cardiac Arrest

- During cardiac arrest the $ETCO_2$ frequently is less than 10 mmHg due to little to no pulmonary capillary perfusion
- The $ETCO_2$ is therefore a great tool for determining:
  - Cardiac arrest
  - Adequacy of chest compressions during CPR
  - Return to spontaneous circulation

Beyond the EDB: Additional Monitoring

- Cardiovascular
  - Direct arterial blood pressure
  - Central venous pressure

Direct Arterial Blood Pressure

- Arterial blood gas sampling
- Continuous real-time monitoring
- Intentional pharmacological or mechanical cardiovascular manipulation
- Failure of indirect BP monitoring
- Supplementary diagnostic clues

Central Venous Pressure Monitoring

- Need central line in right atrium
- Normal < 5 cmH_2O, but look for trends
- Determines preload to the heart
  - High CVP = Volume overload or low cardiac output
  - Low CVP = Hypovolemia
- Uses
  - Evaluate response to and capacity for fluid loading
  - Aids in determining success of pericardiocentesis for cardiac tamponade

CVP Monitoring

- Can be artificially high if patient in dorsal recumbency or receiving PPV
- Water manometers read in cmH_2O and pressure transducers read in mmHg (1 mmHg = 1.36 cmH_2O)
- Animal should be in lateral recumbency and transducer at level of the heart
- Kinked catheters can lead to artificially high CVP's

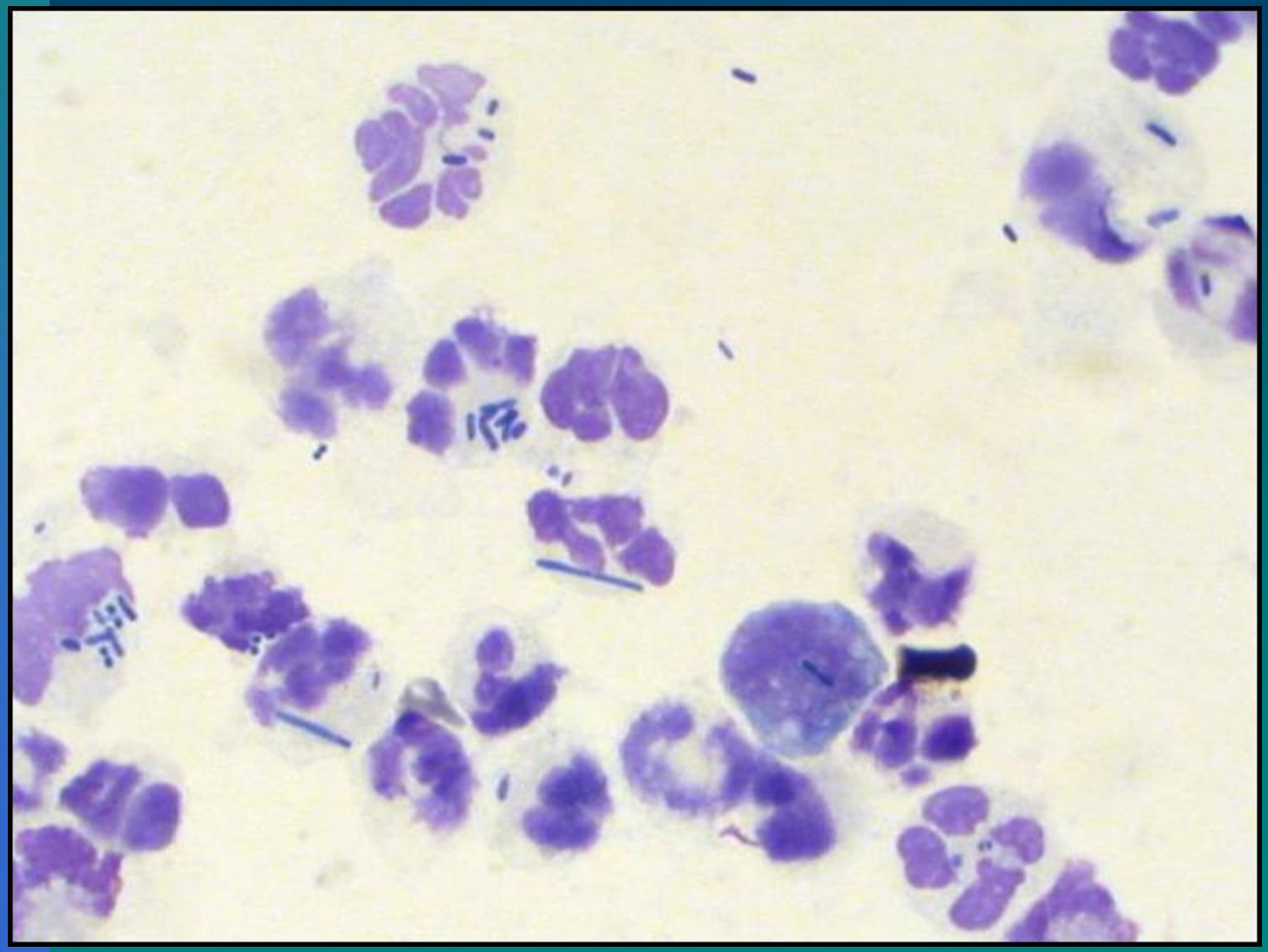
Beyond the EDB: Additional Monitoring

- Abdominal monitoring
- Cytology
- Colloid osmotic pressure

Abdominal Monitoring

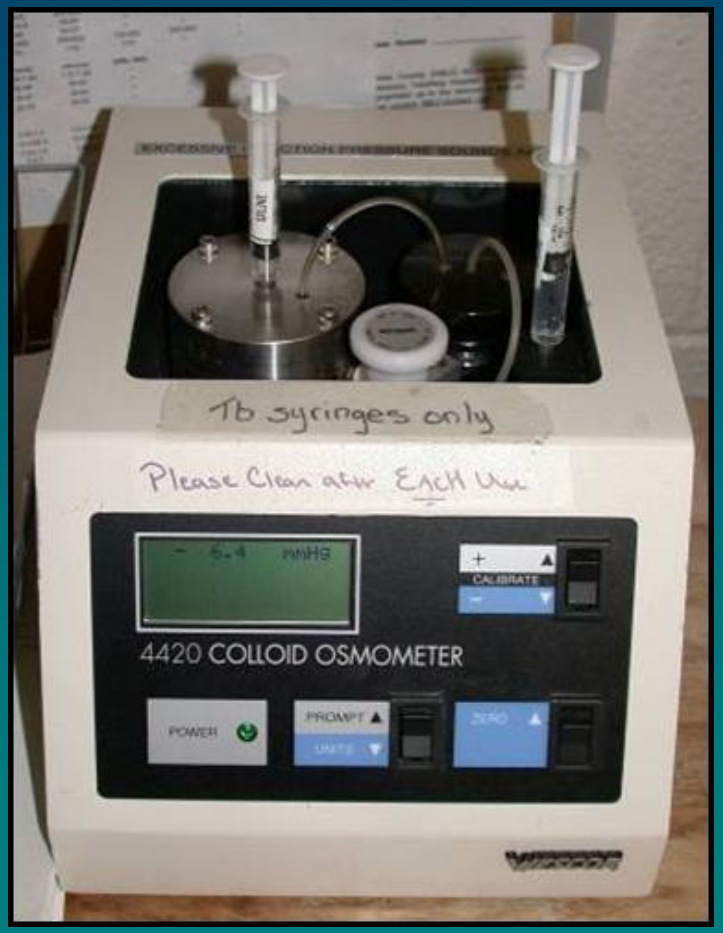
- Intra-abdominal pressure
- Abdominal girth measurements
- Abdominocentesis
  - Generally need 20-30 ml/kg of fluid in the abdomen to have a positive blind abdominal tap
  - Paired lactate and glucose levels
- Diagnostic peritoneal lavage

Cytology



Colloid osmotic pressure

- Measures the colloid osmotic pressure in whole blood
- Normal COP = 18-22 mmHg
- Useful to monitor response to artificial colloid use



Conclusions

- Point-of-care testing is essential to aid in quick diagnosis of life-threatening diseases
- The limitations of point of care testing should be recognized and questionable results should be verified

Conclusions

- Continued monitoring and assessment of dynamic patients (repeating blood tests, urine output, continuous ECG, BP, CVP) is necessary in order to remain proactive in treatment of critical patients