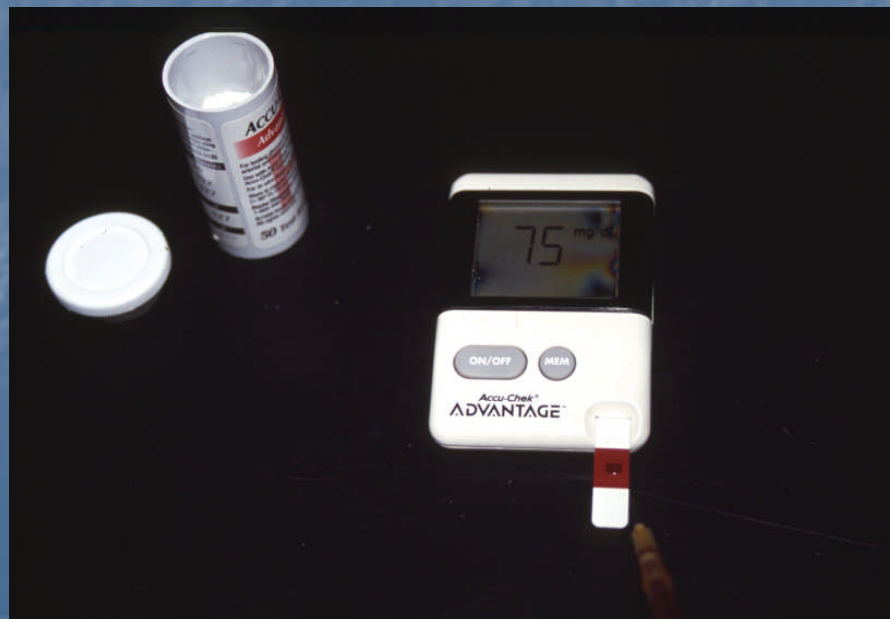
Glucose in Neonatal Foals

Jon Palmer, VMD
New Bolton Center, University of Pennsylvania

Fluid Therapy
Glucose Support

- All compromise neonates
  - Will benefit from exogenous glucose support
- Blood glucose interpretation
  - Not relate directly to adequate glucose stores
  - Hypoglycemia
  - Normoglycemia
  - Hyperglycemia



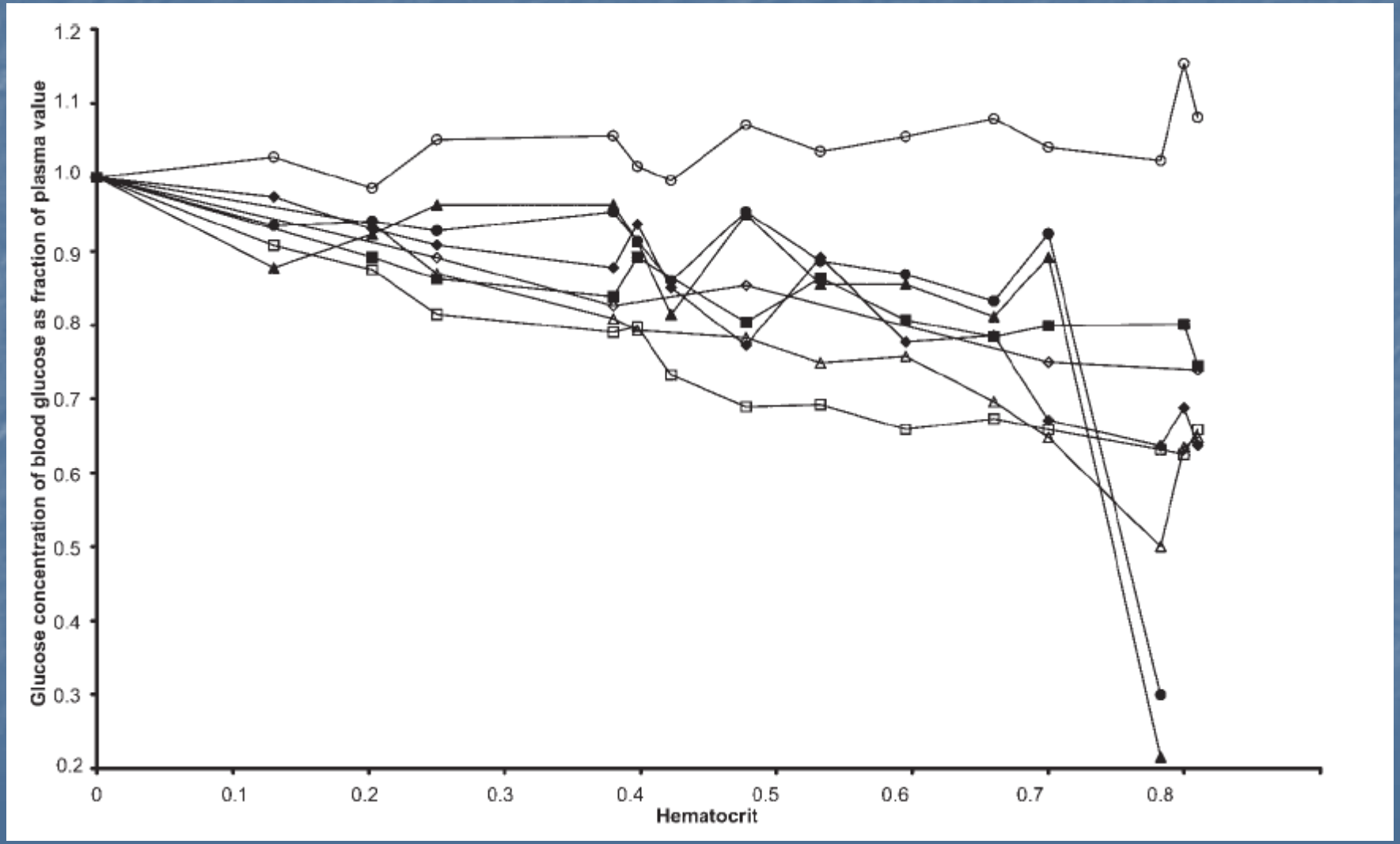
Glucose Measurement

- Bedside monitoring – Glucometers
- Whole blood measurement
  - Electrochemical biosensor
  - Photometric test strips

Glucose Measurement Variation

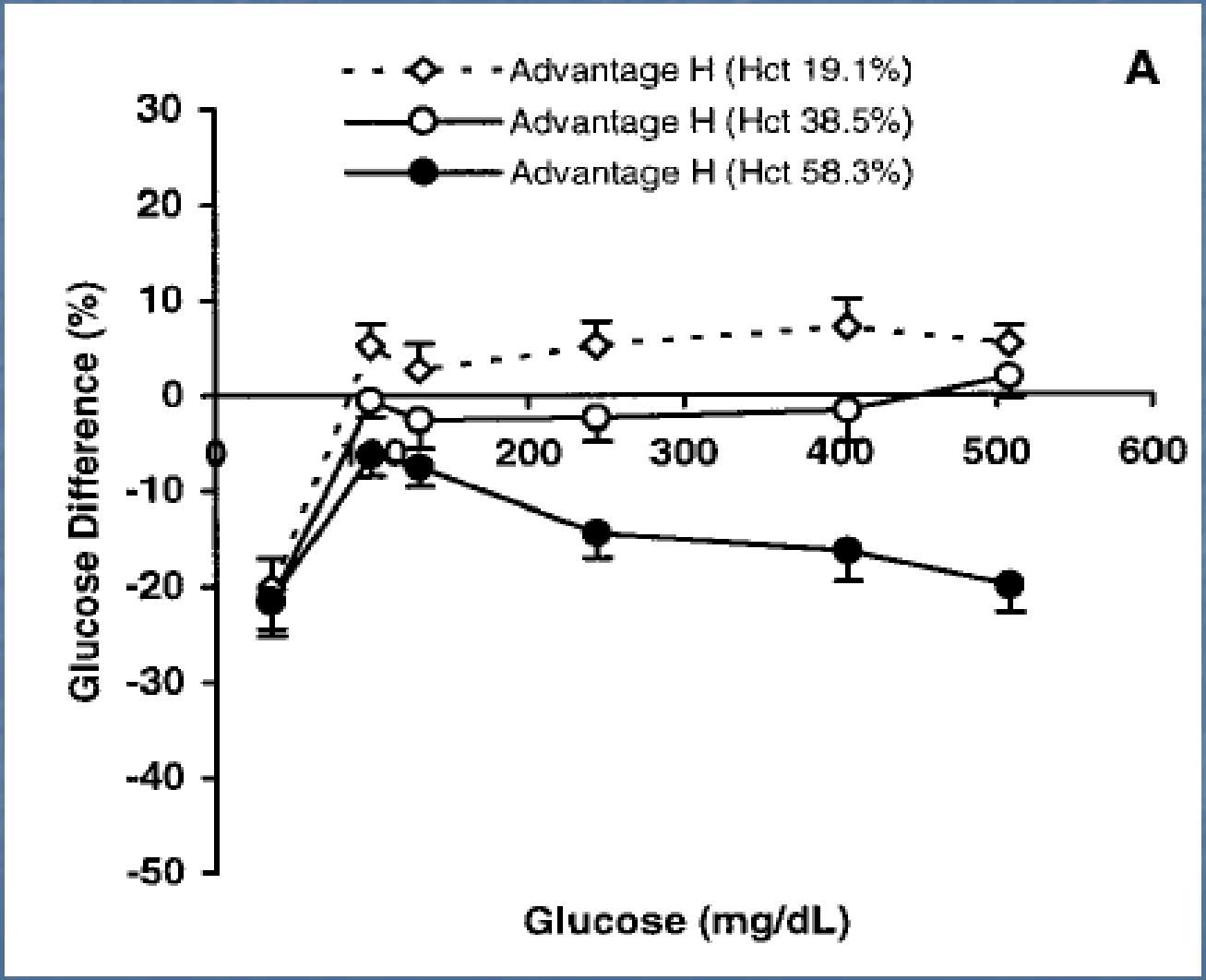
- PCV
- Total protein
- P_{O_2}
- pH
- Model/Instrument
- Reagent strip
  - Handling
  - Age
  - Lot

Glucose Measurement
PCV



Püntmann et al Clin Chem Lab Med 2003; 41(6):809–820

Glucose Measurement
PCV and Glucose Level



Tang et al Arch Pathol Lab Med. 2000;124:1135–1140

Glucose Measurement
PCV

- Whole blood vs plasma
- Reagent strip sieve plasma
  - Increased hematocrit
  - Block the "holes"
  - Rouleau formation

Glucose Measurement
PCV

- Critically ill neonatal foals
  - Microclot formation
  - Sample hemolysis
  - Protein deposition
  - High fibrinogen levels
  - Fibrin aggregation
  - Platelet/other cellular aggregation
  - Other inflammatory phenomena

Glucose Support

- Placental glucose delivery to fetus
  - Glucose transfer rate - 4 to 8 mg/kg/min
    - Fetal foal 6.8 mg/kg/min
    - Fetal calf 5 mg/kg/min
  - Varies between species
  - Varies with energy intake on dam

Glucose Support

- Birth - glucogenesis
  - Normal fetus is born before gluconeogenesis
  - Low birth blood glucose – 50 – 60% of mare's
    - Neonatal foal 1.4 – 2.0 mmol/L
  - Continues to drop for the first few hours of life
  - Low point of blood glucose levels
    - Is usually 2 to 4 hours after birth

Glucose Support

- Established fetal distress
  - Placentitis/lack of nutrient transfer
    - Precocious glucogenesis
- Late term/perinatal fetal distress
  - Failure of metabolic transition
  - Neonate suffering from perinatal disease
  - Normal birth blood glucose level
    - Drops to < detectable within hours

Glucose Support
Response to Exogenous Glucose

- Response patterns of compromised neonates
  - Hyperglycemia
    - Slow insulin response
    - Continued glucogenesis
    - Stress glucogenesis
    - Metabolic anarchy
  - Hypoglycemia
    - SIRS response
    - Hypermetabolism
    - Failure of metabolic transition

Glucose Support

- Give 4 – 8 mg/kg/min
  - 100 – 250 ml/hr 10% glucose
  - Don't bolus glucose
- Most foals tolerate 8 mg/kg/min
- Foals with severe sepsis/septic shock
  - Infusion rate as high as 20 mg/kg/min
- With high exogenous glucose loads
  - Addition of thiamine to the fluids
  - may help ensure proper metabolism

Glucose Support
Glucose Intolerance

- Hyperglycemic neonate
  - Check the infusion rate
  - Is intolerance secondary to sepsis?
  - Be patient, allow time for insulin response

Glucose Support
Glucose Intolerance

- Consequences of hyperglycemia
  - Without an insulin response
    - Selective cellular dehydration
  - Glucose diuresis with subsequent fluid and electrolyte wasting
- Mild hyperglycemic (< 13.5 mmol/L)
  - No glucose diuresis
    - Give the neonate time (hours) to develop insulin response
  - Glucose diuresis, blood dextrose is persistently high without apparent adaptation
    - Initiate insulin therapy
    - Decrease glucose infusion

Glucose Support
Glucose Intolerance

- Consequences of hyperglycemia
  - Sepsis???
  - Strict glucose control
  - NICE SUGAR

Glucose Support
Renal Glucose Threshold

- Glucose threshold higher in neonate
  - Marked variation between species
- Immature kidney
  - Increased glucose reabsorption capacity
  - *Low Affinity High-capacity Transport*
    - Only mechanism in adult kidney some species
    - Usually less efficient in neonate
  - *High Affinity Low-capacity Transport*
    - Compensates for what other transport mechanisms miss
    - Higher affinity in neonates
      - Not present in adults of all species

Glucose Support
Renal Glucose Threshold

- High glucose threshold in neonate/fetus
  - Lower GFR
    - Complete reabsorption more likely
  - ↑ efficiency of high affinity low capacity transport mechanisms
- Threshold varies between individuals
  - Foals – 10 to 11 mmol/L
  - Crias – 11 to 13 mmol/L

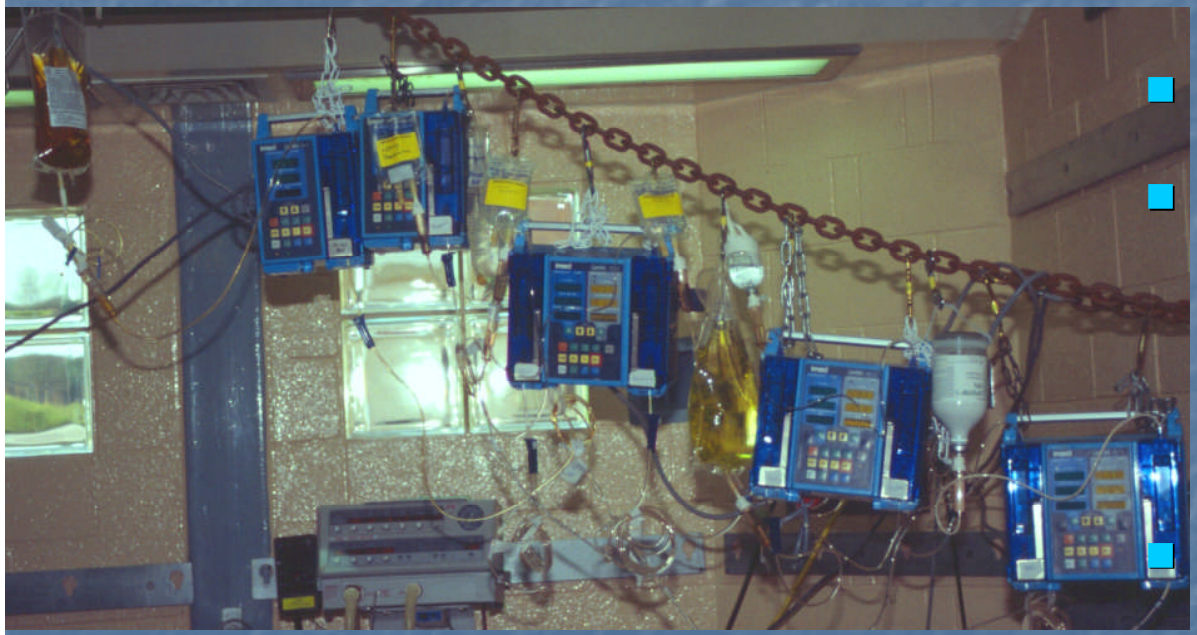
Glucose Support
Regular Insulin therapy

- Should we use tight glucose regulation?
- Continuous infusion of regular insulin
  - Well tolerated by most neonates
  - Allows more control of glucose kinetics
- Most cases insulin deficiency
  - Not resistance
  - Respond to low insulin levels
  - Even in the face of sepsis
  - Reflect slow adaptation to regulation
    - Neonatal Metabolic Maladaptation

Glucose Support
Regular Insulin therapy

- Dose regular insulin – CRI
  - Range – 0.00125-0.2 U/kg/hr
  - Began at 0.0025 U/kg/hr
  - Double rate every 4 to 6 hr
    - until the glucose controlled
    - or the infusion rate is > 0.04 u/kg/hr
- Response to the infusion
  - Not seen immediately
  - Avoid the "glucose rollercoaster"

Glucose Support
Preparing Regular Insulin Infusion



- Use Regular Insulin
- Insulin <3 months old
- Insulin is a suspension
  - To resuspend
    - Gently rock or roll
    - Never shake
- For neonates
  - 0.1 U/ml solution
    - In 100-150 mls of saline

Glucose Support
Preparing Regular Insulin Infusion

- Insulin adheres to glass and plastic
  - Blocked with albumin containing solutions
  - Blocked with careful pretreatment of IV lines
    - Insulin solution in final dilution
    - Running 40-60 ml through line
      - Carefully flush
    - Use lines after plasma transfusion
  - Insulin should be diluted in saline in a glass bottle
    - Infusing into the saline
    - Do not allow undiluted insulin to run down the glass
  - If lines are not pretreated (line change)
    - Insulin kinetics may be erratic
    - Sudden increase in delivery once the sites are occupied