Initial Assessment (Treatment) of the Critical Neonate

Jon Palmer, VMD, DACVIM
Chief, Neonatal Intensive Care Service
Director of Neonatal/Perinatal Programs
New Bolton Center, University of Pennsylvania

Graham French Neonatal Section
Connelly Intensive Care Unit


ELSON HORSE WATERER


Compromised Foal

Critical 48 hours

- < 48 Hr old
  - 70-80% of admissions
- 84% survive
  - 70% fatal cases < 48 hr old

Neonatal Problems

- Fetal Distress/Maladaptation
- Sepsis
- Trauma/Anemia
- Congenital Malformations

Neonatal Problems

- Rarely one problem
  - Combination of problems
  - Varying severities
- Wide array of possibilities
  - But predictable course

Goals

- Identify underlying problem
- Identify disrupted vital organ functions
- Therapeutic interventions
  - Support normal organ functions
  - Control infection

Initial Assessment

- Is there evidence of sepsis?
- Is cardiovascular support necessary?
- Is respiratory support required?
- What level of metabolic support is necessary?
  - Will enteral nutrition/fluid maintenance be possible?
  - Is intravenous fluid therapy necessary?
  - Is continuous rate dextrose infusion necessary?
  - Is parenteral nutrition necessary?
- Control behavioral abnormalities
- Will assisted thermoregulation be necessary?
- Will renal support be necessary?
- Requirements for other specific supportive care

Physical Examination

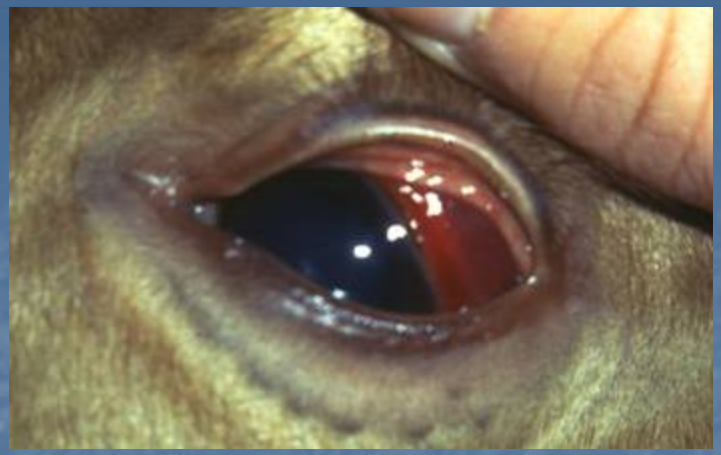
- Cardiovascular examination
  - Mucous membrane
- Thoracic assessment
- Nervous system evaluation
- Abdominal assessment
- Body condition
- Musculoskeletal problems

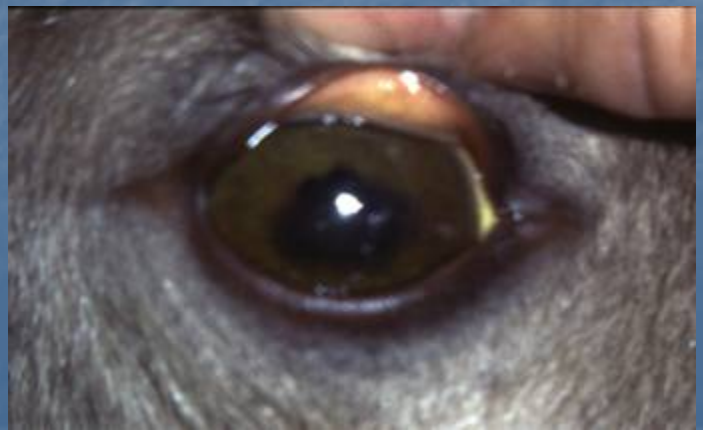
Cardiovascular Examination

- Evaluating perfusion
- Evaluating volemia
  - Volemia vs hydration
  - Dehydration rare
  - Hypovolemia common

Cardiovascular Examination

- Assess effectiveness of perfusion
  - Cold extremities as blood is shunted centrally
    - Do not treat with active warming
  - Depressed mental status
  - Decreased borborygmi
  - Decreased urine production
- Pulse assessment
  - Pulse quality
  - Arterial tone
  - Arterial fill
- Blood Pressure
- Unreliable signs
  - Dry oral membranes
  - Capillary refill time
  - Skin turgor





Thoracic assessment

- Auscultation
  - Lungs
  - Cardiac murmurs
- Tachypnea
  - Pneumonia
  - Benign Neonatal Tachypnea
  - Central tachypnea
  - Pain
- Pharyngeal collapse
- Fractured ribs
- Paradoxical respiration (wave chest)
  - Progressive atelectasis
  - General fatigue

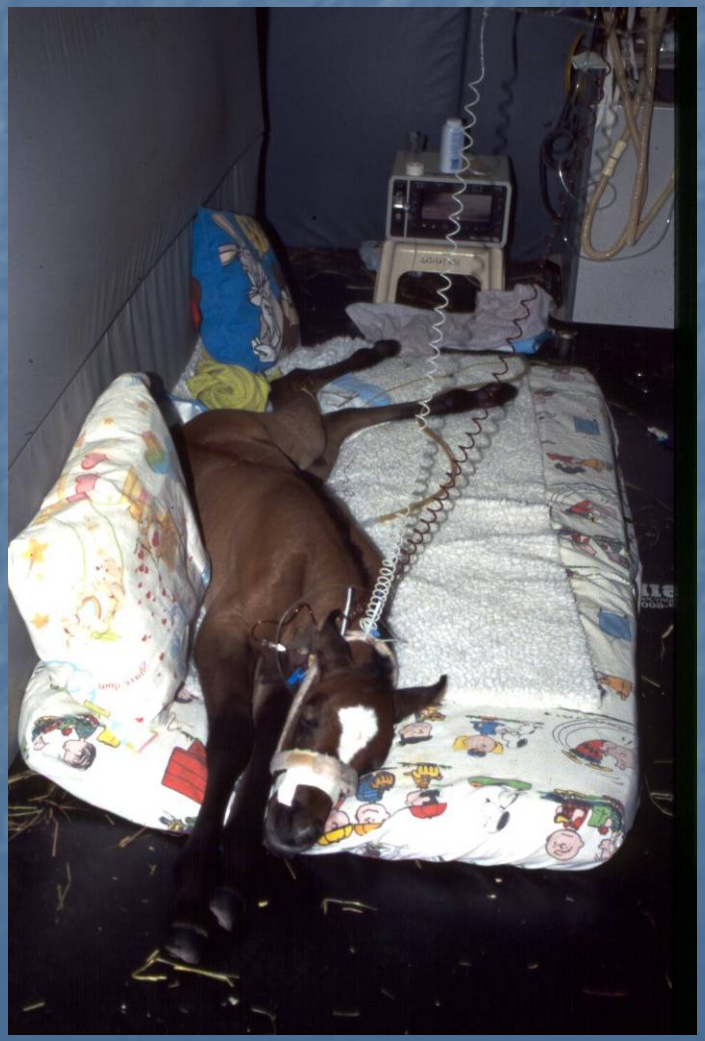
Central Nervous System

- Important parameters
  - Strength
  - Muscle tone
    - Hypertonus or hypotonus
  - Responsiveness
    - Hyperresponsive or hyporesponsive
  - Level of arousal
    - Somnolence
    - Hyperactive or hyperkinetic
  - Behavior
  - Respiratory patterns
    - Apneustic breathing
    - Periodic breathing
    - Ataxic breathing
    - Central patterns
  - Seizures
  - Abnormal vocalization

Changes in responsiveness

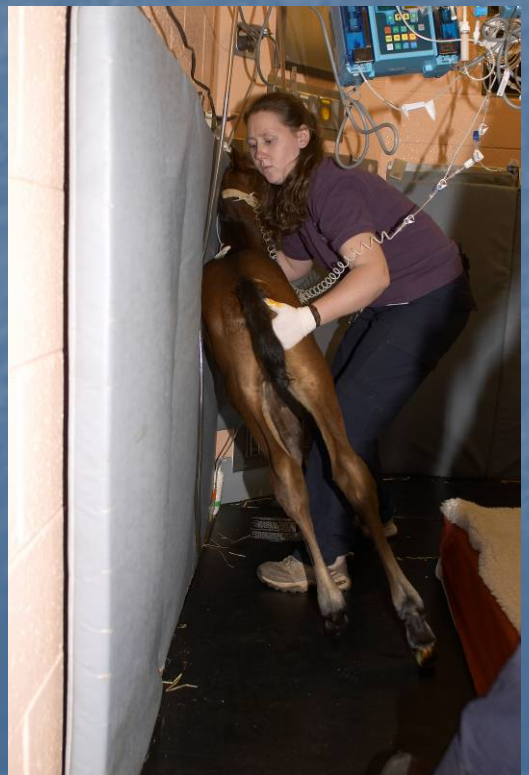
Changes in muscle tone

Changes in muscle tone



Changes in behavior

Brain stem damage



Seizure-like behavior

Abdominal Assessment

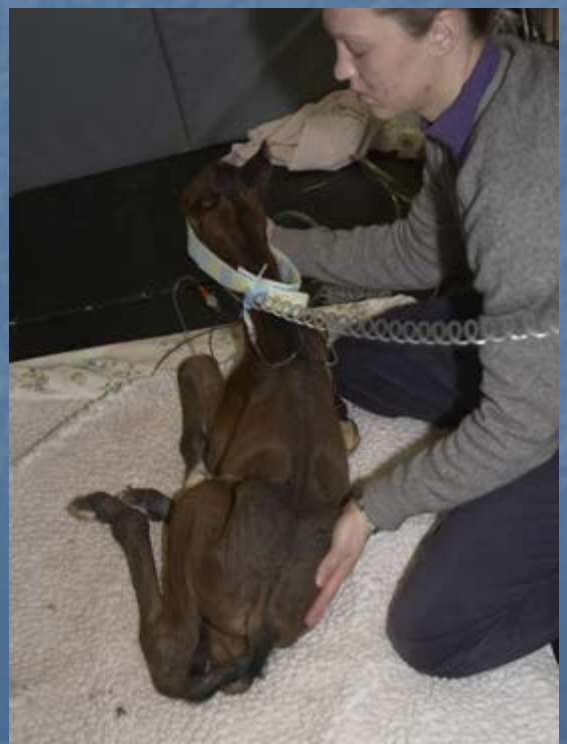
- Abdominal size
  - Appropriate?
- Feces?
  - Digital rectal
  - Meconium staining
  - Nose
- Auscultation?
- Palpation
- Ultrasound

Abdominal Palpation

- Internal umbilical remnants
  - Umbilical triad (2 arteries and urachus)
  - Hemorrhage
  - Omphalitis
- Urinary bladder
  - Luminal and bladder wall hematomas
  - Bladder size
- Intestines
  - Retained meconium
  - Thickened intestinal wall
  - Pneumatosis intestinalis
  - Intussusceptions
- Kidneys
- Liver - Hepatomegaly
- Body wall defects
  - Inguinal or umbilical hernias
  - Other body wall defects

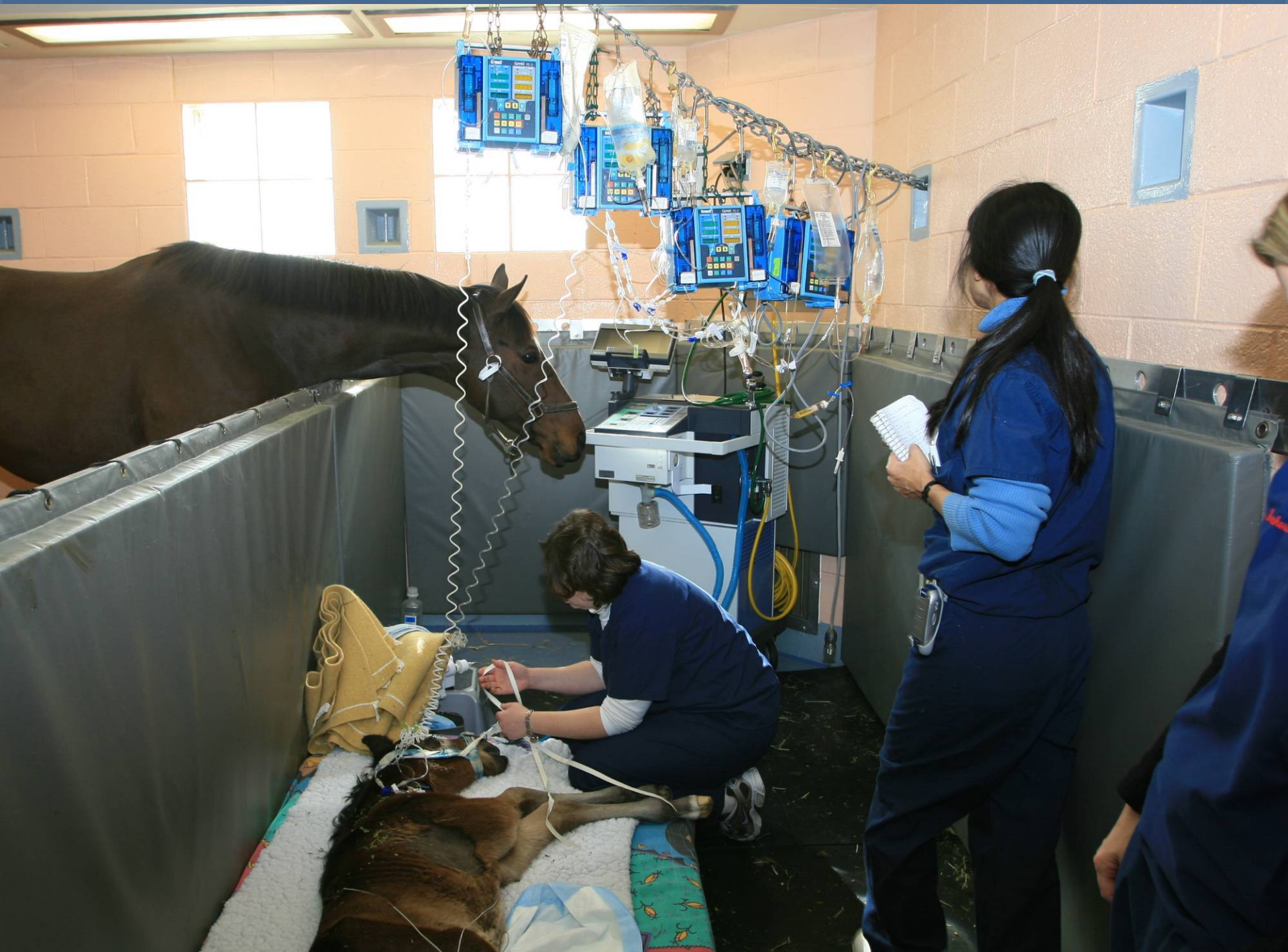
Body Condition

- Thin to emaciated
  - IUGR
  - Fetal SIRS (FIRS)
  - Prematurity
  - Post maturity



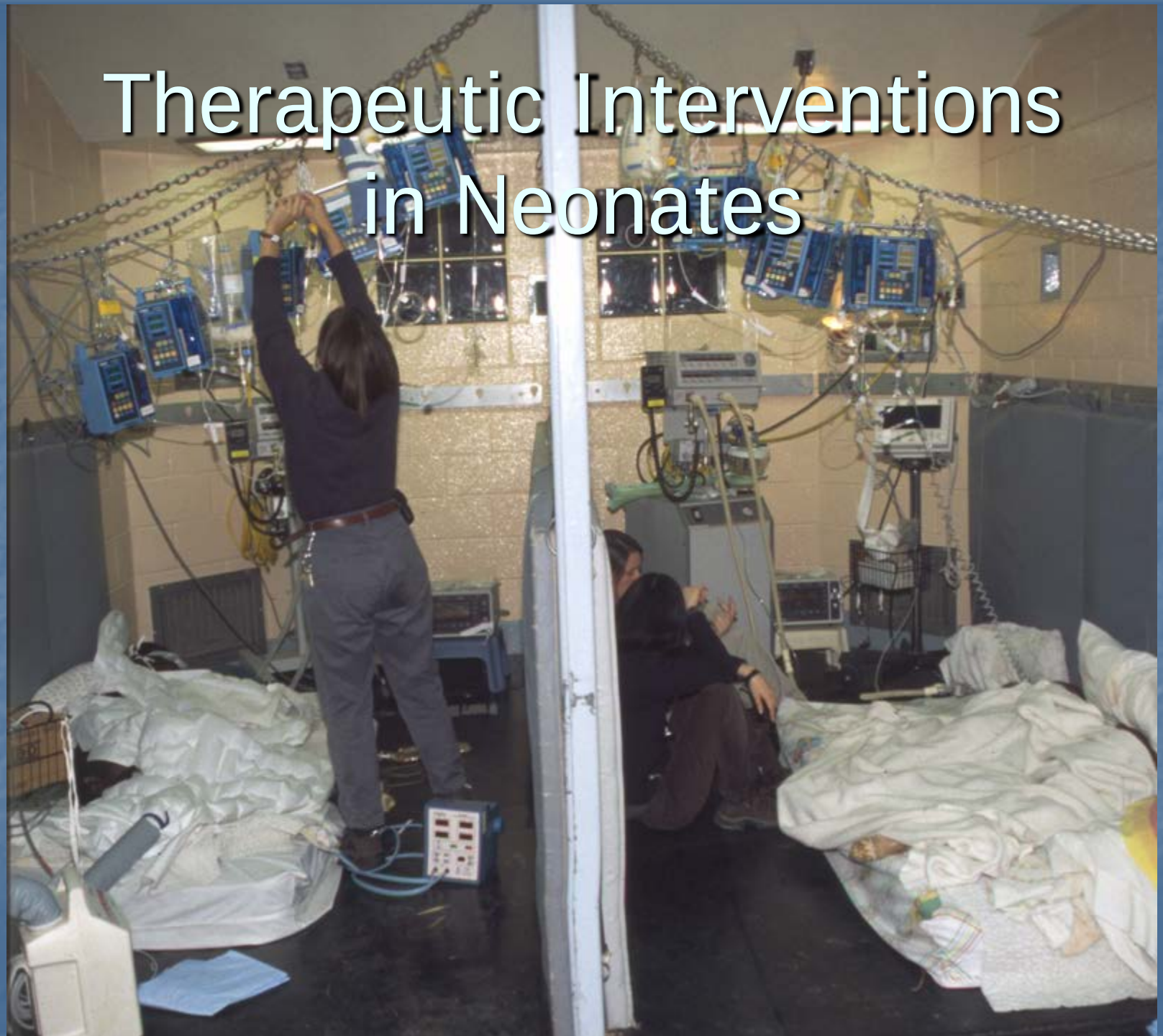
Musculoskeletal problems

- Fractured ribs
- Other musculoskeletal abnormalities
  - Fractures
  - Gastrocnemius disruption
  - Contracture
  - Laxity



- Careful physical
  - Detect major dysfunction
  - Seriousness
- Dynamic monitoring
  - Serial physical evaluation
  - Laboratory analysis
    - Stall side
      - Serial blood glucose levels
      - Serial lactate levels
      - Arterial blood gas
      - Blood electrolyte

Therapeutic Interventions in Neonates

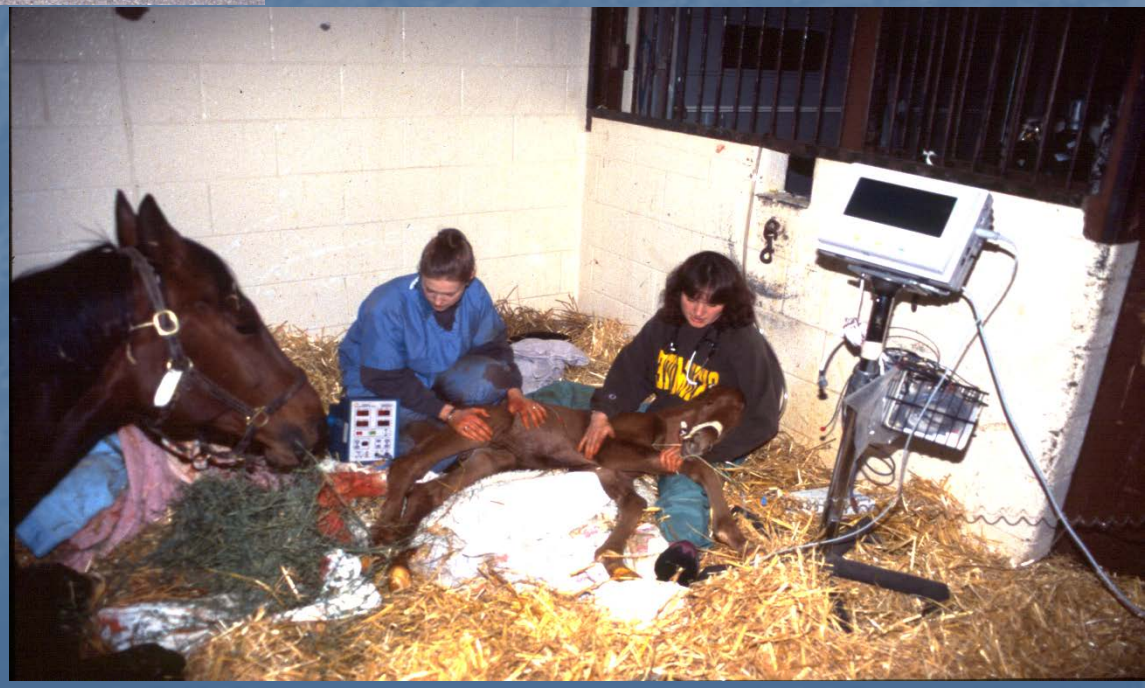


Resuscitation of the Seriously Compromised Foal

- Rapid intervention
- Intensive intervention
- On Farm
- At referral center
  - Rapid transport
    - In a car
  - Short travel time
    - < 2 hours – don't treat - send
    - > 2 hours – begin treatment

"Scoop and Run"

"Stay and Play"



Resuscitation on the Farm

- Delay in transportation
- Delay in decision making
- Lack of referral center availability
- Economic constraints
- Level of care on farm depends on
  - Environment/Facilities available
  - Experience/Energy of the help
  - Time constraints on the clinician
  - Availability of equipment

Resuscitation of the Seriously Compromised Foal

- Insure tissue perfusion
  - Fluid therapy
- Stabilize blood glucose
- Treat sepsis
- Respiratory support
- Deliver cerebral support
  - Control seizures
- Aid thermogenesis
- Spare renal work
- Deliver nutrition
  - Oral/Parenteral
- Give general supportive care

Therapy?

Evidence Based

Traditions

Beliefs

Experience Based

Fluid Therapy

- Hypoperfusion
  - Hypovolemia due to poor vascular tone
  - Almost never dehydrated
    - Hyperhydrated but hypovolemic
- Correct the hypovolemia
  - Balanced crystalloid
  - 10 to 20 ml/kg blouses over 10 to 20 minutes

Fluid Therapy

- Reassessment of the patient
  - Improvement in peripheral perfusion
    - Extremity temperature, peripheral pulses
  - Urine production , mental status
- Guard against fluid overload
  - As bad as hypovolemia?
  - Slow to maintenance fluid rate
  - Include plasma as fluid
  - Goal limit fluids but
    - Maintain perfusion
    - Meet energy needs
    - Give plasma

Continued Hypoperfusion

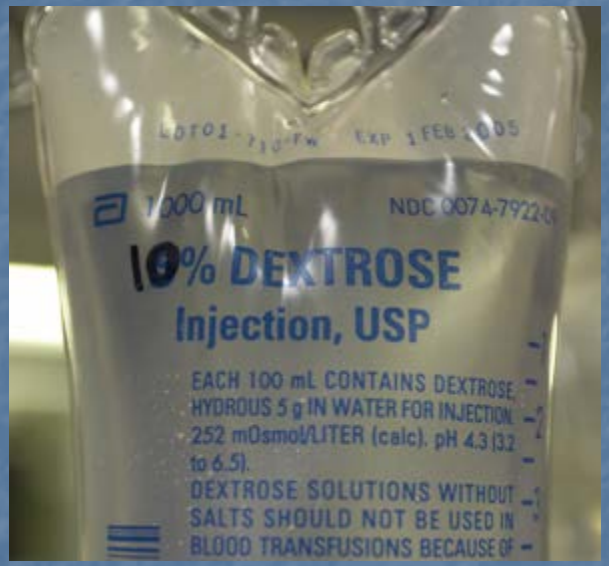
- Inotrope/pressor therapy
  - Restricted to referral centers
    - Intravenous infusion pumps
  - Dobutamine
  - Norepinephrine
  - Vasopressin

Fluid Therapy

- Maintenance fluids
  - 100 ml/kg/day for the 1st 10 kg weight
  - 50 ml/kg/day for the 2nd 10 kg weight
  - 25 mg/kg/day for each kg above 20 kg
- Consider
  - Increased insensible losses
    - Fever
    - Respiratory
    - Environmental temperature
  - Oral intake (feeding, nursing)
  - Avoid sodium overload
  - Avoid fluid overload

Glucose Therapy

- All compromised neonates - NPO
  - Will benefit from glucose therapy
- Placental glucose transport
  - Equine delivers 6.8 mg/kg/min
  - Range between 4 – 8 mg/kg/min
- Neonatal liver
  - Produces similar amounts
- Glucose therapy
  - Begin 4 mg/kg/min
  - Goal of 8 mg/kg/min
- Hyperglycemia - insulin therapy
- Hypoglycemia – hypermetabolism
- Glucose boluses
  - Metabolic anarchy
  - Often more harmful than continued hypoglycemia



Treat Sepsis

- Plasma transfusion therapy
- Antimicrobial
  - Based on likely sensitivity
  - Community isolates vs. nosocomial isolates
  - Avoid
    - Commonly used antimicrobials
    - Toxic effects

Community Acquired Isolates

- 22% *E coli*
- 19% *Enterococcus*
- 19% *Pantoea agglomerans*
- 5% *Klebsiella*
- 5% *Streptococcus*
- Others
  - *Acinetobacter* , *Aeromonas,* Alpha *Strep*
  - *Burkholderia, Listeria, Mannheimia*
  - *Comamonas, Salmonella, Staphylococcus*
- 60% Gram-negative and 40% Gram-positive

Nosocomial Bacterial Isolates

- 23% *Enterococcus*
- 18% *E coli*
- 11% *Enterobacter cloacae*
- 9% *Acinetobacter baumannii* , *Salmonella*
- 7% *Pantoea agglomerans, Pseudomonas*
- 5% Coag neg *Staphylococcus*
- 4% *Klebsiella pneumonia, Streptococcus*
- Others
- 68% Gram-negative and 32% Gram-positive

Antimicrobial Choices

- Community acquired infection
  - Ambulatory patient, controlled sepsis
    - Cefuroxime
    - TMS, doxycycline, minocycline
  - Critically ill neonate, uncontrolled sepsis
    - Ceftiofur Na - IV
      - 10 mg/kg IV QID
    - Ticarcillin with clavulancic acid - IV
    - Gentamicin and beta-lactam
- Nosocomial infection
  - Penicillin and Amikacin (30-35 mg/kg)
  - Imipenem
  - Chloramphenicol

Ceftiofur Sodium

- Intravenous Administration
- Native form not protein bound
- Converted to protein bound active form
  - Blood enzymes
- Injected intravenously too quickly
  - Dose lost in the urine
- Infused slowly over 20 minutes or longer
  - Syringe infusion pumps

Ceftiofur Sodium

- Cleared rapidly from foals with SIRS
- Serious infections - higher dose
  - Increase spectrum
  - Increase effectiveness
- 10 mg/kg IV repeated QID
- No antibiotic induced enteritis

Amikacin

- Once daily dose
  - Neonates (< 2 weeks) – 30-35 mg/kg
  - Foals 1-3 m – 20-25 mg/kg
- Dose tailored to individual
  - Target 30-minute peak of 60 – 75 µg/ml
    - 4 - 8 X target organism's MIC
  - Target 23 hr. trough < 2 µg/ml

Aminoglycoside High Peak Levels

- Results in killing a large % of bacteria
- More effective killing
  - Before adaptive resistance develops
- Improve tissue penetration
- Overwhelm bacterial protective enzymes
- Results in longer post-antibiotic effect

Aminoglycoside SID Dose and Toxicity

- Fear that high dose will be toxic
- Single large dose
  - Less toxic than multiple smaller doses
  - Uptake into the kidney becomes saturated
    - Single high dose - same renal uptake
    - Moderate and high dose same toxicity/dose

Aminoglycoside Toxicity

- “High troughs hurt kidneys”
- Preexisting renal impairment
- Combined with other nephrotoxic drugs
  - Furosemide, Amphotericin-B
- Total dose
  - Length of treatment (> 7-9 days)
  - Repeat courses, multiple doses per day
- Sustained high peaks
  - Intra-articular injection

Aminoglycoside Toxicity

- Monitor creatinine
  - Before initiating therapy
  - Every 2 - 3 days during therapy
  - Neonate normal 88 ± 18 mmol/l (1.0 ± 0.2 mg/dl)
  - Increase > 18 mmol/l significant (0.2 mg/dl)
- Special care after hypoxic ischemic insults
- Renal failure rare
  - Most resolve within 30 days
  - Can be fatal

Antimediator Therapy

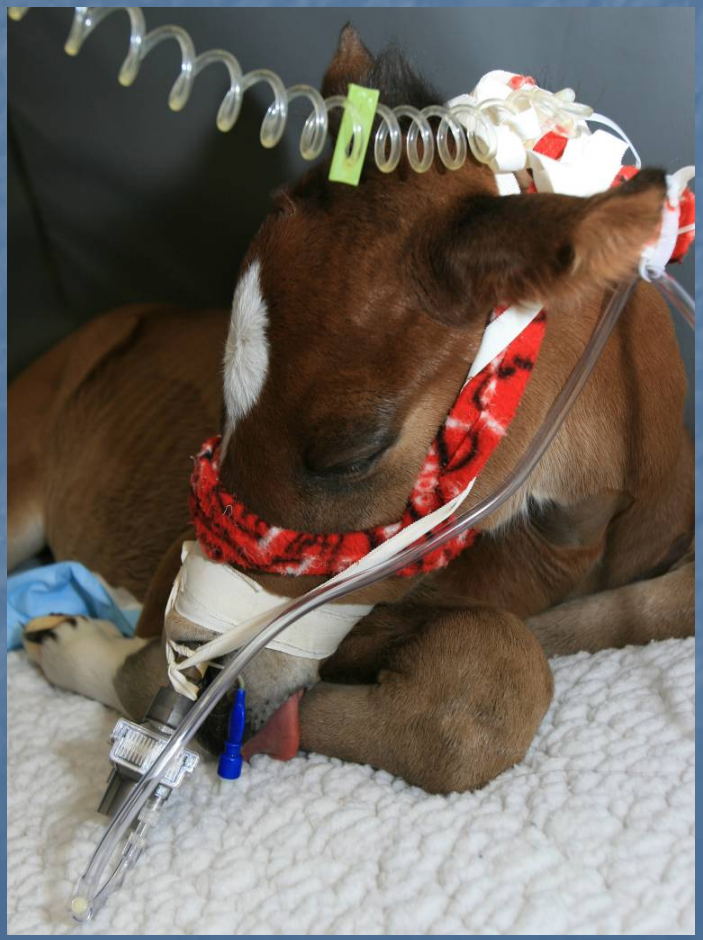
- Specific mediator blocking therapy
  - Block initiators of the cascade
- 12 specific antimediator strategies developed
  - Highly successful experimentally
  - Uniformly unsuccessful in large clinical trials
  - Most promising resulted in increased fatality rates
- Complexity of the cascade
  - Need to balance SIRS and CARS
  - No silver bullet
- Hyperimmune antiendotoxin plasma

Respiratory Support

- Frequently hypoxemic
  - Ventilation perfusion mismatching
- Intranasal oxygen insufflation
  - Pa_{O2} < 60 torr
  - SaO_2 < 90%
  - Goal
    - Pa_{O2} 80 - 110 torr
    - SaO_2 > 92%
  - Nasal cannula
    - Flow rate of 6-10 lpm (2 to 15 lpm)
    - Preconditioned - water filled humidifier
- Central respiratory depression
  - Caffeine (10 mg/kg PO or PR)
  - Positive pressure ventilation

Intranasal Oxygen Insufflation

Pharyngeal Collapse

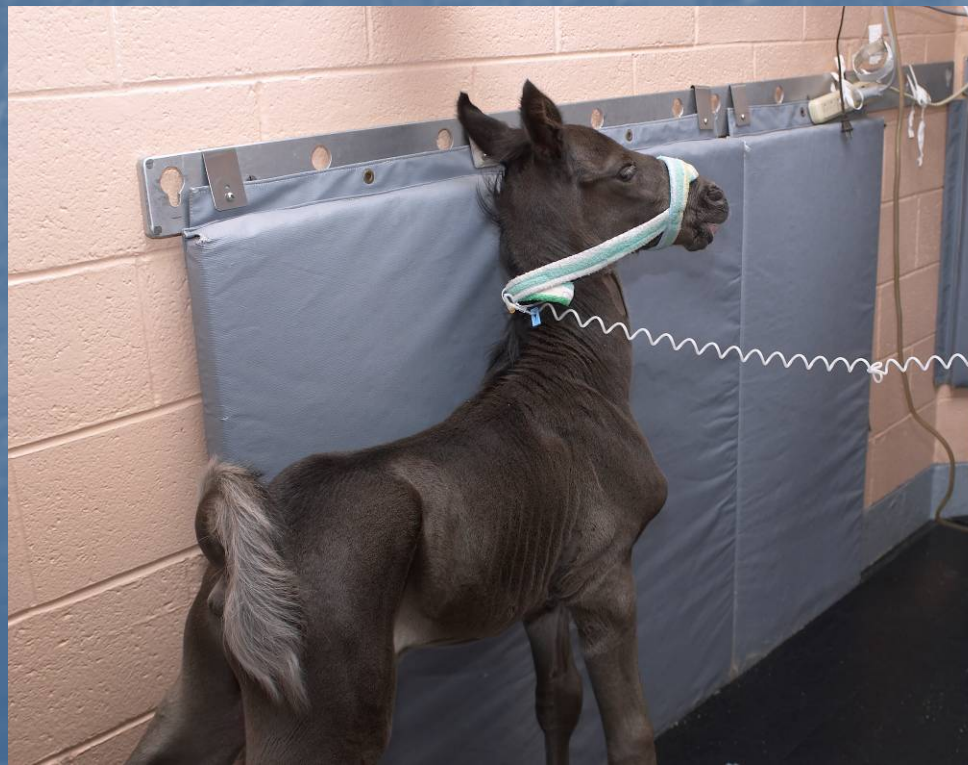


Cerebral Support

- Support cerebral perfusion
  - Insure volemia
    - Careful fluid replacement
  - Defend perfusion
    - Inopressor therapy
- Insure oxygen delivery
  - Achieve pulmonary O_2 loading
  - Avoid anemia
- Nutritional support
  - Permissive underfeeding

Therapy

- DMSO
- Mannitol
- Thiamine
- $MgSO_4$
- Others



Seizure Control

Seizure Control

- Phenobarbital
  - Hypothermia
  - Hypercapnia
  - Hypotension
  - Infused over 15-20 min
  - Half-life of >200 hrs
- Phenytoin
- Others
  - Diazepam
  - Midazolam

Thermogenesis

- Thermogenesis
  - Successful resuscitation
- Active warming
  - Contraindicated early
  - Hot air blanket

Renal Function

- Neonatal distress targets
- Normal neonatal kidney
  - Fluid handling
  - Sodium regulation
- Goal - minimize renal work
  - Regulating fluid balance
  - Regulating sodium balance
- Fluid and Na overload
  - Inappropriate weight gains
  - Development of edema
- Drugs to avoid
  - Flunixin meglumine
  - Aminoglycoside antimicrobials
    - Unless blood levels are measured

Oral Nutrition

- Colostrum
  - Avoid large volumes
- Critical neonate
  - Hypoxemia, hypoperfusion
  - Hypoglycemia, hypothermia
  - Can't support enterocytes
- Criteria for feeding
  - Pao_2
  - Blood glucose
  - Perfusion
  - Core temperature is > 37.8C
  - Borborygmi present
  - Meconium is being passed

Oral Nutrition

Oral Nutrition
What should be fed?

Summary

- Treat sepsis
- Maintain tissue perfusion
- Maintain blood glucose homeostasis
- Maintain fluid balance
- Give respiratory support
- Control seizures and support cerebral perfusion
- Maintain renal function
- Conservatively approach oral nutrition
- Deliver general supportive nursing care

Avoid

- Excessive fluids
- Excessive sodium
- Aggressive warming
- Large volumes oral feeding
- NSAIDs (flunixin meglumine)

Happy Endings

Keys to success

Observant owner/manager

Proactive farm veterinarian

Early referral

primum non nocere