Nutritional Support of the Neonate

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Nutrition During Fetal Life Constant Supply of Nutrients

- Glucose
- Amino acids
- Lipids
- Calcium, Phosphorus
- Magnesium
- Fluids

Fetal to Neonate Transition

- Neonate must supply and regulate these substances
- Transiently hypoglycemic
  - Low at 2 to 4 hours old
- Hypocalcemia

Nutritional Support

- Early Neonatal Period
- Intravenous fluids – Holliday Segar
  - For each Kg up to 10 kg
    - 100 ml/kg/ 24 hours, 4 ml/kg/hr
  - For each Kg from 11-20 kg
    - 50 ml/kg/ 24 hours, 2 ml/Kg/hr
  - For each Kg > 20 kg
    - 25 ml/kg/ 24 hours, 1 ml/Kg/hr
- Dextrose - 4 - 8 mg/kg/min
- Electrolyte concentrations - lab values
  - K – 3 mEq/kg/day (0.125 mEq/Kg/hr)
    - 6.25 mEq/50 kg foal/hr
- Until enteral or parenteral nutritional support

Holliday Segar Formula

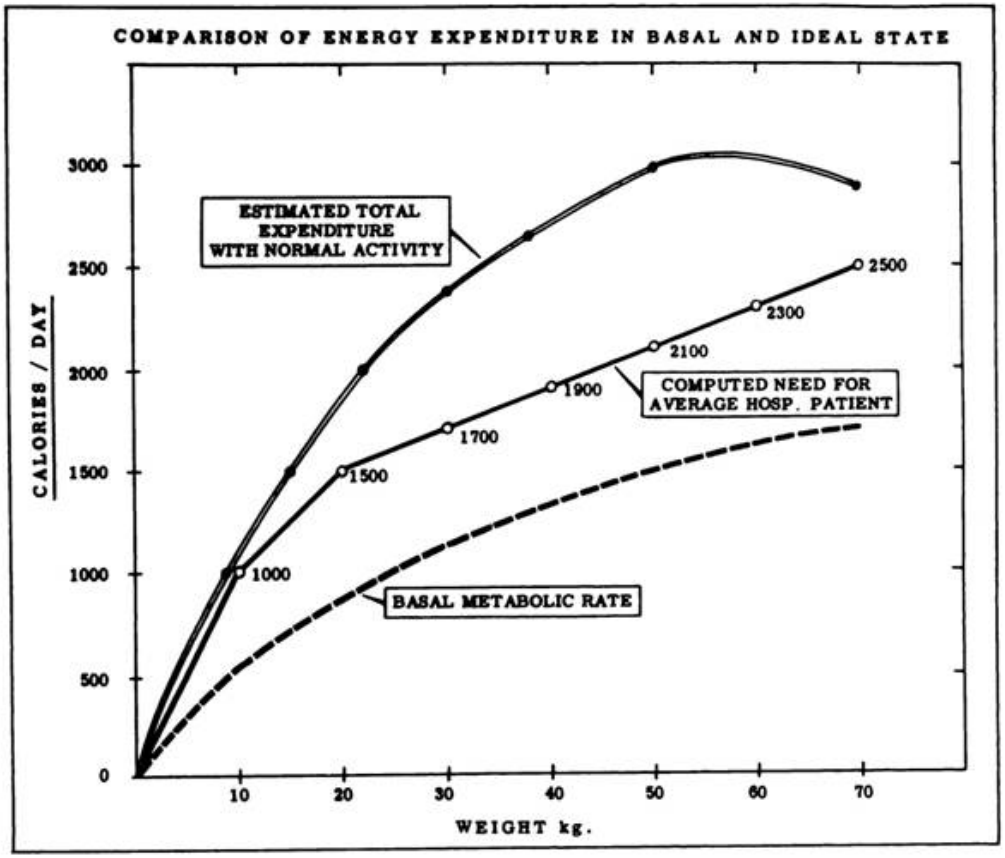
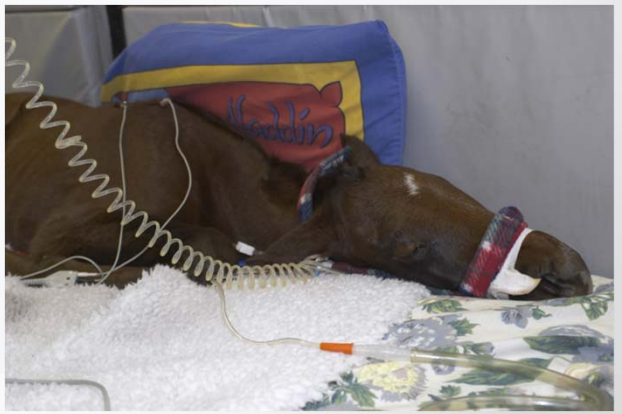


FIG. 1. The upper and lower lines were plotted from data of Talbot.[3] Weights at the 50th percentile level were selected for converting calories at various ages to calories related to weight. The computed line was derived from the following equations:

1. 0-10 kg–100 cal/kg.
2. 10-20 kg–1000 cal + 50 cal/kg for each kg over 10 kg.
3. 20 kg and up–1500 cal + 20 cal/kg for each kg over 20 kg.

Early Neonatal Period
Early Hyperglycemia

- Continued glucose production
- Decreased glucose clearance
- Diminished insulin response – lack of insulin
- Diminished response to insulin
  - Insulin resistance
- Increased cortisol/epinephrine
  - Stress
- Sepsis

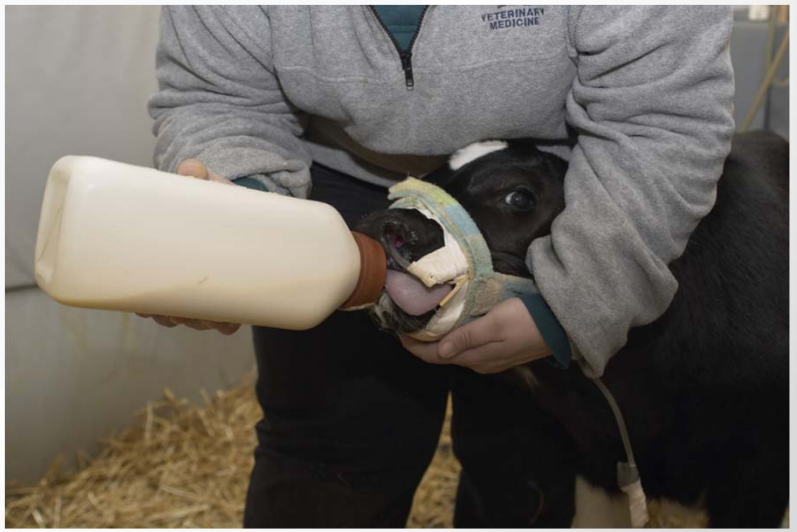


Early Neonatal Period Early Hypoglycemia

- Limited hepatic glycogen stores
- Inadequate endogenous glucose production
  - Failure of transition to glucogensis
- High glucose utilization – hypermetabolism
- High risk for developing hypoglycemia
  - Perinatal asphyxia
  - Placentitis
    - FIRS
  - Intrauterine growth restriction
    - Placental insufficiency
  - Cold stress
  - Sepsis

Enteral Feeding Advantages

- Physiologic stimulation
- Metabolic regulation
- Gastrointestinal mucosa integrity
- Gastrointestinal mucosa development
- Lower cost



Enteral Feeding

Requirements for initiating enteral feeding

- No abdominal distension
- No gastric reflux
- Passage of meconium
- Active GI sounds
- If severe perinatal distress
  - Stable blood pressure
  - Temperatures near 37.5C
  - Normal Pao_2
  - Stable blood glucose


CRITIKON
DINAMAP™
VETERINARY BLOOD PRESSURE MONITOR 8300
MAP
45
SYSTOLIC
73
PULSE
97
DIASTOLIC
35
AUTO MANUAL
START
OPERATION
ALARMS
CYCLE
MINUTES
SET
CUFF
POWER
OFF

Passive Transfer of Immunity

Colostrum

- Source of IgG
- Other biologically active substances
  - Other proteins
  - Immune modulators
  - Pro and anti-inflammatory substances
  - Inflammatory cells
    - Neutrophils, plasma cells
  - Trophic substances
- Role of colostrum
  - Establish an immune barrier GIt
  - Targeting potential pathogens
    - Before invasion
  - Insuring GIt development

Colostral Protective Factors Tailored for the Neonate

- **Defense agents in colostrum**
  - **Enhanced survival in the gastrointestinal tract**
  - **Protect without provoking inflammation**
  - **Inhibit inflammation**
- **Targeting of pathogens**
  - **Without collateral damage**

Colostral Protective Factors Tailored for the Neonate

- **Agents in colostrum**
  - **Alter the physiologic state of the GIt**
  - **Transform from fetal physiology**
    - **To physiology appropriate to extrauterine life**
- **Growth factors in colostrum**
  - **Favor proliferation of commensal enteric bacteria**
  - **Inhibit pathogens**
  - **Trophic factors**
    - **Epithelial growth and development**

Colostral Transfer of Protective Factors

- **GIt is the most likely portal for pathogens**
  - **Preventing luminal establishment of pathogens**
  - **Prevent proliferation of pathogens**
  - **Prevent invasion of pathogens**
  - **Protecting the neonate from sepsis**

Antimicrobial Factors in Colostrum

- **Proteins**
  - **Lactoferrin - bacteriostasis by Fe chelation**
  - **Lactoferricin - causing bacterial killing**
  - **Lysozymes – bacteriolysis**
- **MUCI - inhibits the binding of fimbriated *E coli***
- **Lactadherdrin - binds viruses**
- **Oligosaccharides and glycoconjugates**
  - **Receptor analogues**
  - **Enteric pathogens and toxins**
- **Monoglycerides**
- **Fatty acids**
  - **Disrupt envelope viruses**
  - **Inactivate certain bacteria**
  - **Defend against *Giardia***

Antimicrobial Factors in Colostrum

- **PAF-degrading enzyme**
  - **PAF is an important proinflammatory mediator**
  - **High levels in neonate**
  - **Protects mucosal cells from damage**
- **Erythropoietin**
  - **Protects against epithelium apoptosis**
  - **Trophic substance**
- **Epidermal Growth Factor (EGF)**
  - **Role in mucosal barrier function**
  - **Down-regulates apoptosis**

Passive Transfer

- **Why measure IgG levels?**
  - **Only measurement available**
  - **Surrogate for of the establishment of this immune barrier**
  - **Surrogate for transfer of immune competence**
  - **Quantity vs. quality**

Feeding Sick Foals

- **Problems which prevent feeding 1st week**
  - Reflux
  - Necrotizing Enterocolitis
  - Megaesophagus
  - Esophageal strictures
- **Feeding colostrum may be helpful**
  - Even after classic "closure" period
  - Trophic substances may help mucosal cell growth and development
  - May also strengthen immune barrier
    - IgG still taken up by some enterocytes for up to 3 weeks
    - This antibody stays local – effective?
    - Maternal cells may establish themselves in submucosa
      - If fresh colostrum
  - Favor proliferation of commensal enteric bacteria
  - Inhibit pathogens

Enteral Feeding
Fresh mare's milk

- Preferred source of enteral nutrition
- Unique nutrient composition
- Increased bioavailability of nutrients
- Immunologic properties
- Promotion of maternal-neonate bonding
- Hormones, enzymes, growth factors

Enteral Feeding
Other choices

- **Frozen mare's milk**
- **Goat's milk**
- **High quality powdered milk replacer**

Enteral Feeding

- **Initially feed 5% of body weight / 24 hours**

  Divided into 12 feedings

- **If foal tolerates this volume**
- **Increase to 10% during the first day**
- **Normal foal**
  - **Target of 20-25% of his body weight / day**

    21% provides the ideal 120 kcal/kg/day

Enteral Feeding
Sick Foal

- **If enteral feeding is questionable**
  - **Trophic feelings**
  - **1% body wt divided every 4-6 hr**
  - **Provide calories / protein using parenteral route**
- **Permissive underfeeding**
  - **Much less than amount fed to normal foal**
  - **Over-nutrition associated with sepsis**
  - **Sick foals are confined**
  - **Target – enough to maintain anabolism**
    - **1-2% weight gain per day (0.5-1 kg/day)**
  - **Usually 12-14% body weight**

Enteral Feeding

- **Example 12% - 68 kcal/kg/day**
- **50 kg Foal**

  50 kg X 12% = 6 kg = 6 liters

  6 liters / 12 feedings = 500 ml/feeding

Enteral Feeding Suckling

- **Best route - physiologic stimulation**
- **Abnormal suckling behavior**
  - **Desperately want to suck**
  - **Ineffective**
  - **High risk for aspiration**
    - **Healthy neonate - few consequences**
    - **Critical neonate - pulmonary disease (sepsis)**
  - **May result in behavioral problems**
  - **More difficult to get foal to suckle mare**
- **Feed on demand - at least Q2H**

Enteral Feeding Route

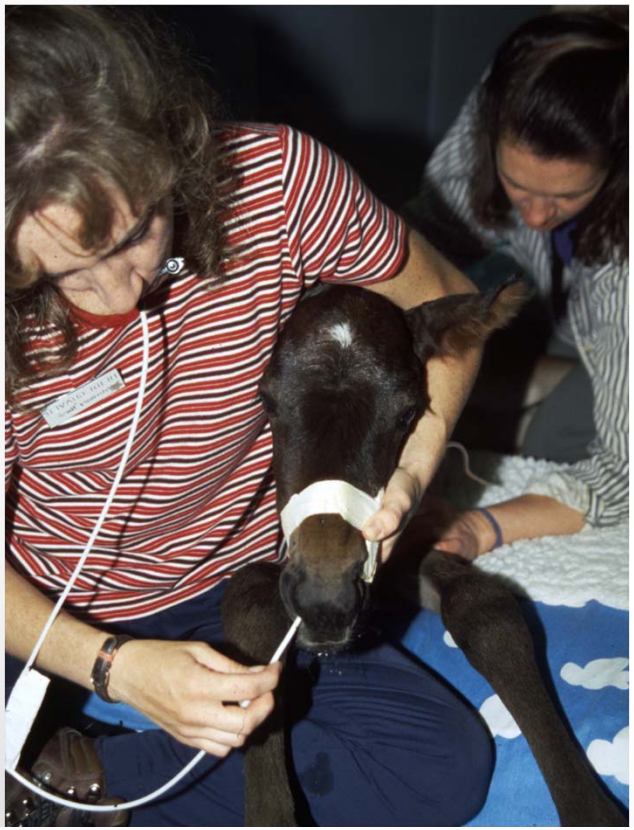
- Suckling
- Tube feeding
- Small Diameter

Indwelling Nasogastric Tube

Enteral Feeding

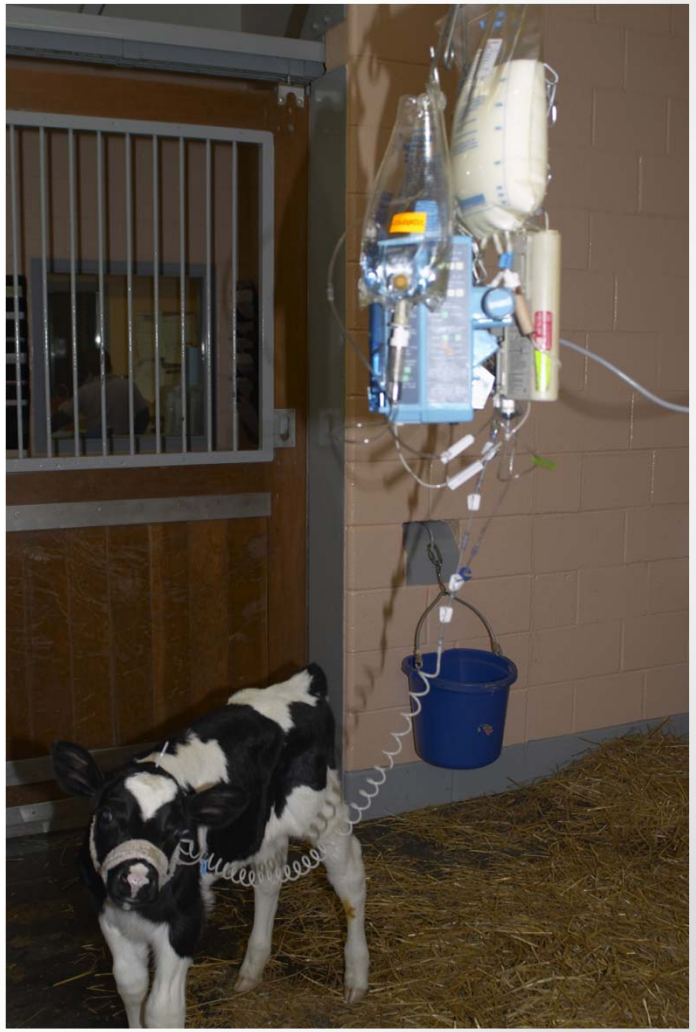
Small Diameter Indwelling Nasogastric Tube

- **Feed every two hours**
- **Bolus feeding**
- **Rhinitis**
- **Pharyngitis**
- **Tube must be closed between feedings**
  - **Air aspiration results in severe colic**



Parenteral Nutrition Intravenous delivery of

- Calories
  - Glucose
  - Lipids
- Protein
  - Amino Acids
- Vitamins
- Trace minerals



Parenteral Nutrition Glucose requirements

- **Primary source of energy developing fetus**
- **Term net umbilical uptake**
  - **4 to 8 mg/kg/min (5.7-11.5 gm/kg/day)**
- **Fetus does not carry out gluconeogenesis**
  - **Unless stress stimulates gluconeogenesis to begin before birth**

Glucose Support

- **All compromise neonates**
  - Will benefit from exogenous glucose support
  - Decrease catabolic state
  - Support their recovery
- **Blood glucose interpretation**
  - Not relate directly to adequate glucose stores
  - Summation of glucose mobilization/utilization
  - Hypoglycemia
  - Normoglycemia
  - Hyperglycemia

Glucose Infusions

- **Manage to prevent hyperglycemia**
  - **Will cause a glucose diuresis**
    - **Lose fluids**
    - **Lose K**
- **Glucose infusion**
  - **Begin at 4 mg/kg/min**
  - **Then if not hyperglycemic in 4 hr increase to 6 mg/kg/min**
  - **And if not hyperglycemic in 4 hr increase to 8 mg/kg/min**
  - **Usually try to keep glucose < 180 mg/dl (<10 mmol/L)**

Glucose Infusions

- **Parenteral Nutrition**
  - If has been normal glycemic on 8 mg/kg/min
    - Begin parenteral nutrition at ½ rate
  - If has been normal glycemic but not receiving exogenous glucose
    - Begin parenteral nutrition at ¼ rate
  - Then after 4 hours infusion if glucose < 180 mg/dl (<10 mmol/L)
    - Increase infusion by ¼ and after 4 more hours check blood glucose
    - If glucose < 180 mg/dl (<10 mmol/L) increase rate by ¼ and repeat
    - Until on full rate
  - My preference is to stop supplemental glucose when begin PN
    - Except glucose in water to make it isotonic
    - Others prefer to keep glucose infusion constant
      - By stepwise turning down glucose infusion as they turn up PN
      - I think this more often lead to hyperglycemia
        - As lipids also a source of glucogenesis

Parenteral Nutrition Glucose requirements

- **At birth glucose**

  Gluconeogenesis (catecholamine secretions)

  Hepatic glycogenolysis

  Umbilical cord rupture - release Glucagon

- **At birth the stimulated fetal liver**

  4 to 8 mg glucose/kg/minute

Parenteral Nutrition Protein Requirements

- **Estimate amino acid utilization late term fetus**
- **Intrauterine nitrogen delivering - lambs**
  - **2.7 to 3.5 gm/kg/day**
  - **When total energy is > 70 kcal/kg/day**
- **Increased requirements**
  - **Stress**
  - **Infection**
  - **SIRS**

Parenteral Nutrition Lipid requirements

- **Lipids are not utilized by fetus as energy**
- **Periods of stress - very important**
- **Neonatal foals utilize lipids as an energy source**

  40 - 50% of total caloric intake can come from fat

Parenteral Nutrition Starting Formula Example - 50 kg foal

- **Dextrose - 10 gm/kg/day - 34 kcal/kg**
- **Amino acids - 2 gm/kg/day - 8 kcal/kg**
- **Lipids - 1 gm/kg/day - 11 kcal/kg**
- **Plus vitamins and trace minerals**
- **Total - 53 kcal/kg**