Respiratory Therapy of the Neonate

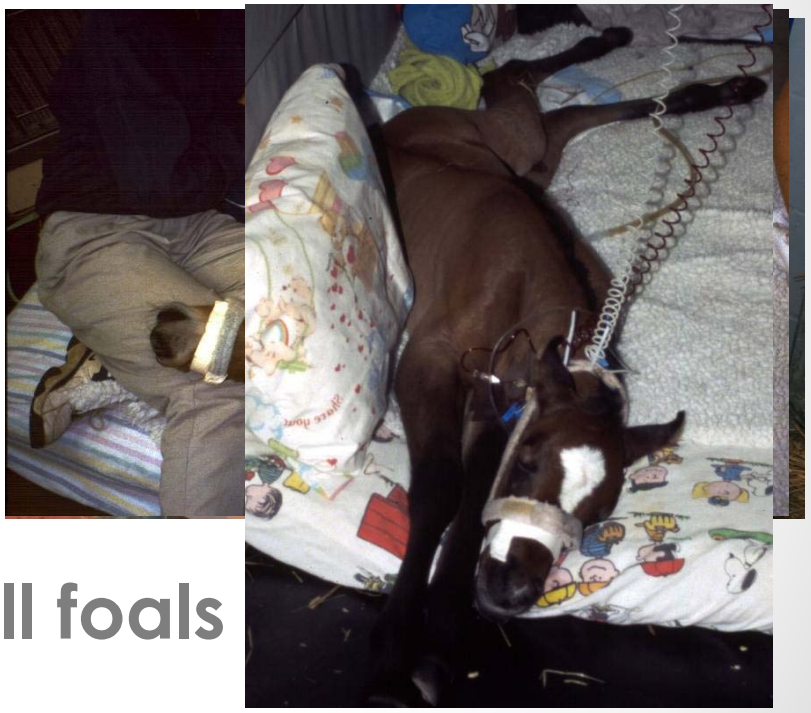
Jon Palmer, VMD, DACVIM
Chief, Neonatal Intensive Care Service
New Bolton Center, University of Pennsylvania, USA

Supportive Respiratory Therapy

- Positional therapy
- Intranasal oxygen insufflation
- Increasing cardiac output
- Stenting the airway
- Bronchodilation
- Respiratory stimulants
- Positive pressure ventilation

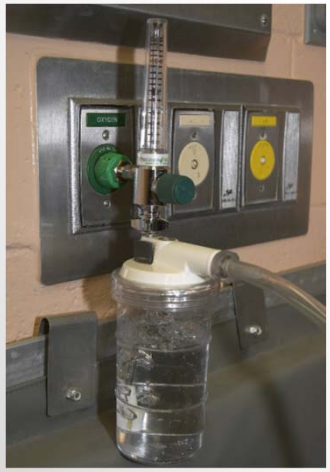
Hypoxemia Positional Therapy

- Help with V/Q matching
  - Aid oxygen loading
- Helpful if
  - Weak
  - Poor inspiratory excursions
  - Marginal perfusion
- Difference is not seen in all foals
  - Fighting the position
  - Arterial blood gas samples “worst case scenario”



Hypoxemia
Intranasal Oxygen Insufflation

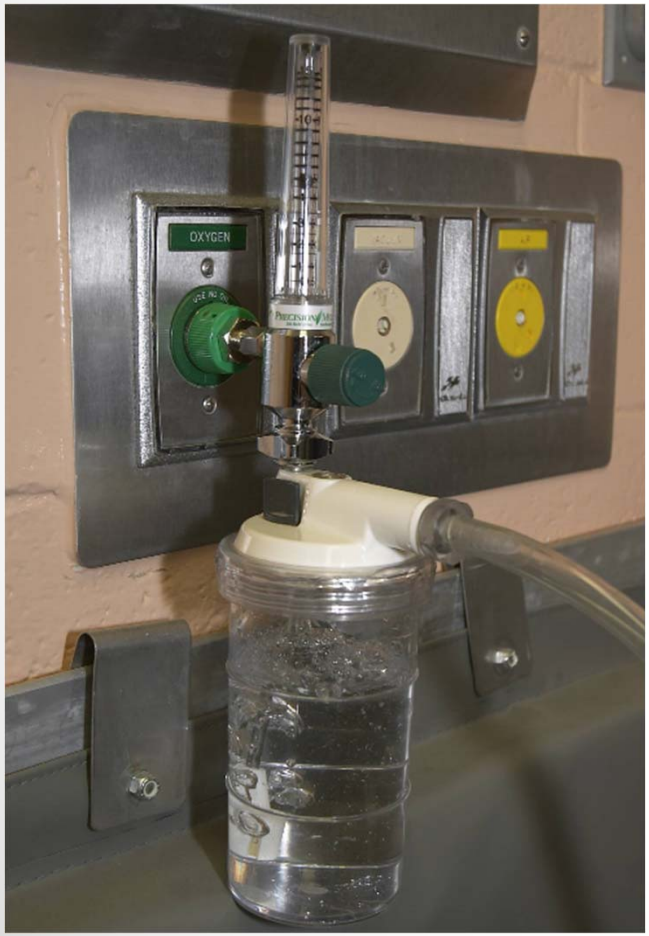
- Oxygen is
  - Most useful/ Most dangerous drug
- INO_2 will correct mismatching
- Should not be used universally
  - Based on careful monitoring
  - Stall side blood gas analyzers
  - But without these most people choose to use O_2
- Complications
  - Oxygen toxicity
  - Nasal irritation
  - Rhinitis
  - Airway drying
    - Tracheal and nasal discharge
    - Increased upper airway resistance

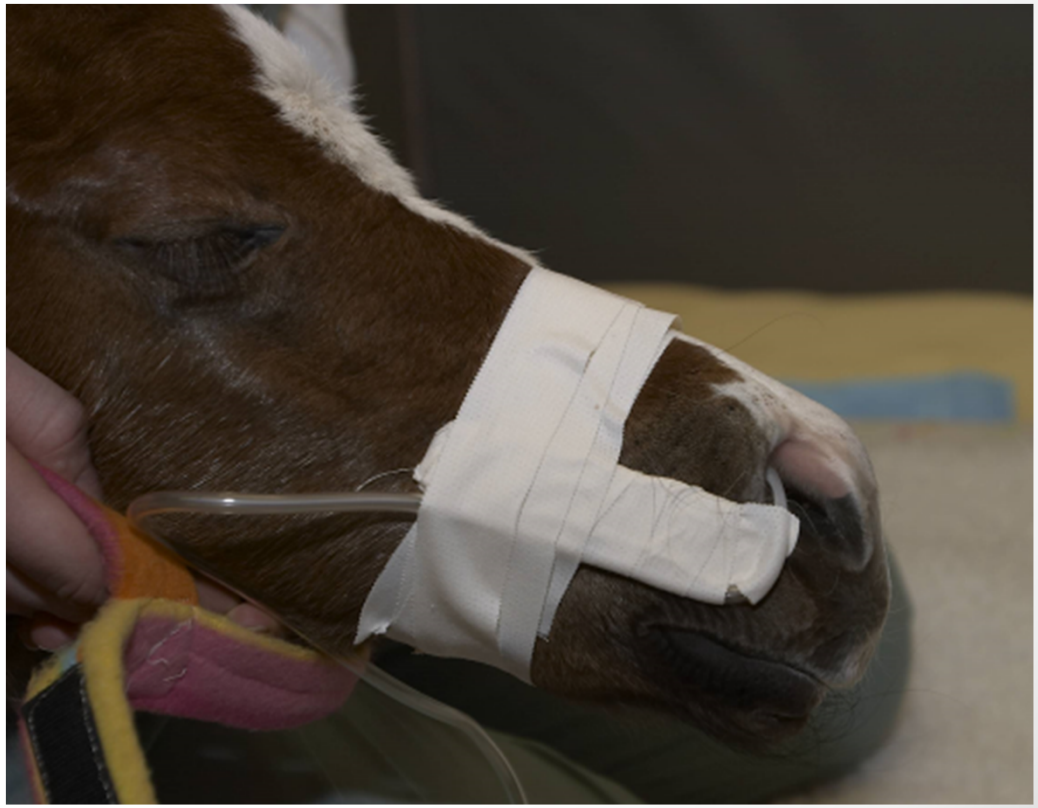


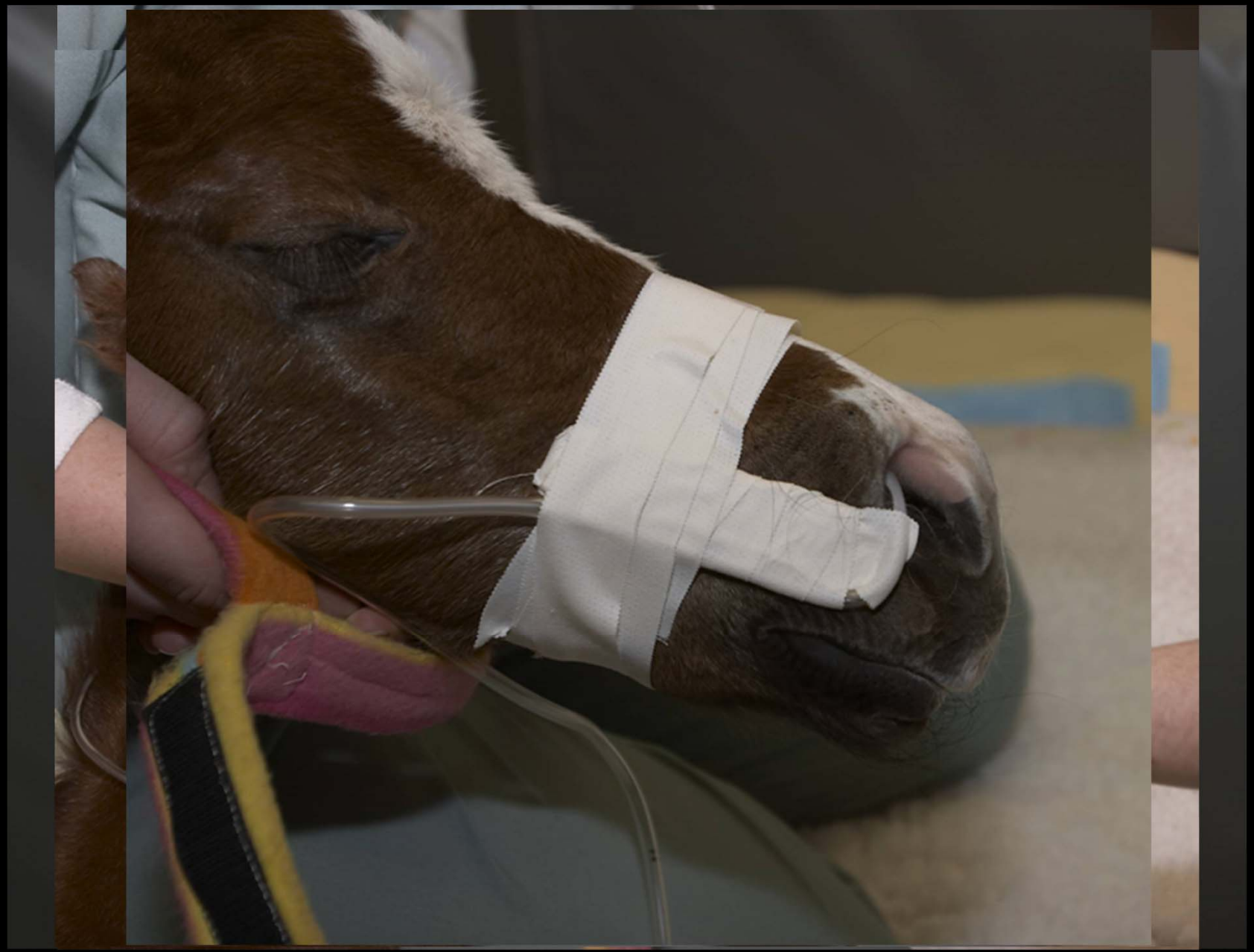
Intranasal Oxygen Insufflation

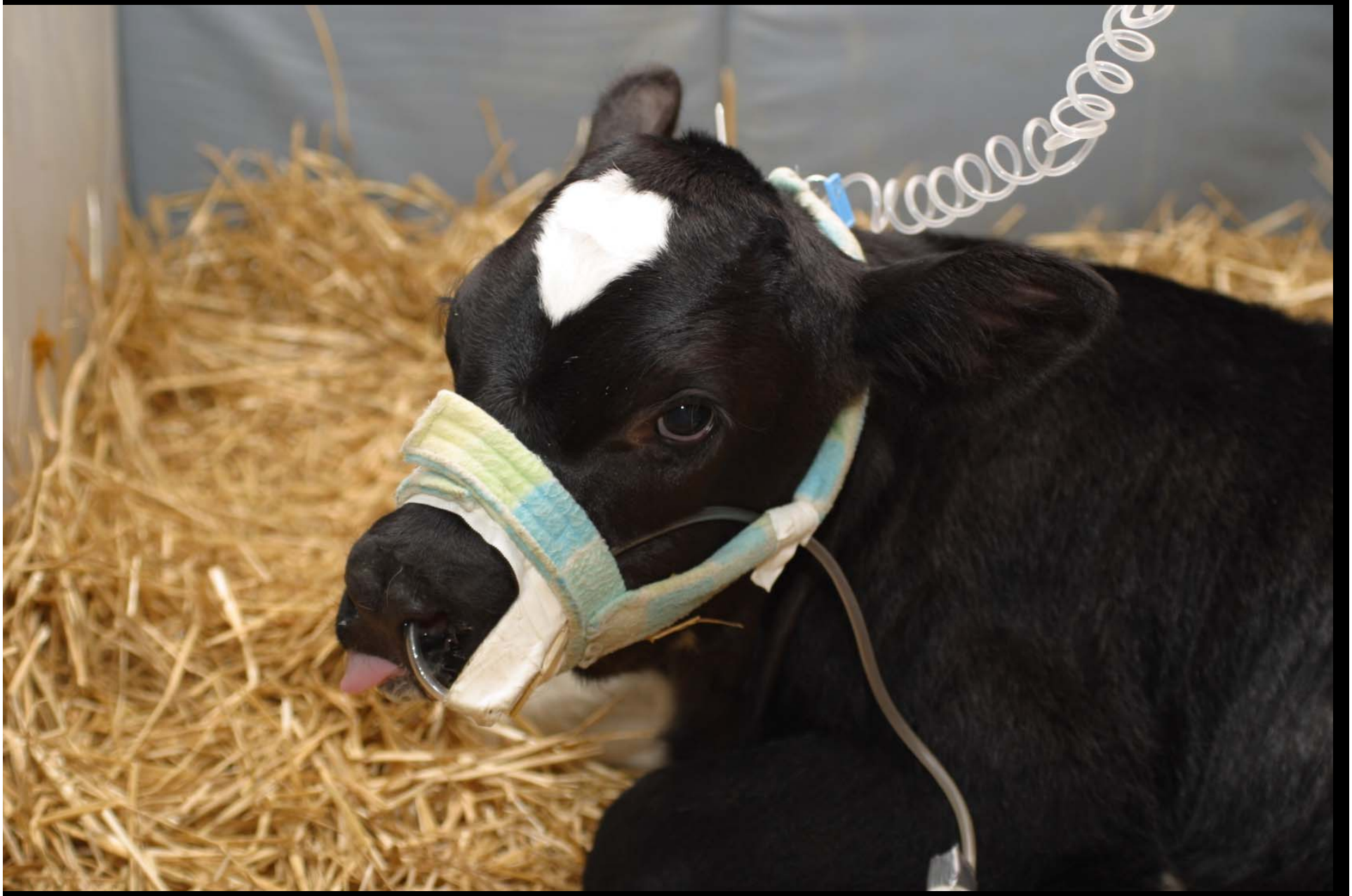
- **Monitoring effect**
  - Oxygen therapy is a "double edged sword"
    - How do you tell if you should use it??
  - Arterial blood gas
    - Is the gold standard for monitoring
      - Ideal Pao_2 > 60 mmHg & < 80 mmHg
    - Can't always do a blood gas
    - Watch for clinical examination signs of positive effect
  - Monitor effect on
    - Respiratory rate and heart rate (work of breathng)
    - Respiratory effort
    - Nostril flair
    - Chest excursion
  - Watch changes as turn on and off INO_2
    - 10 min between changes more than enough time

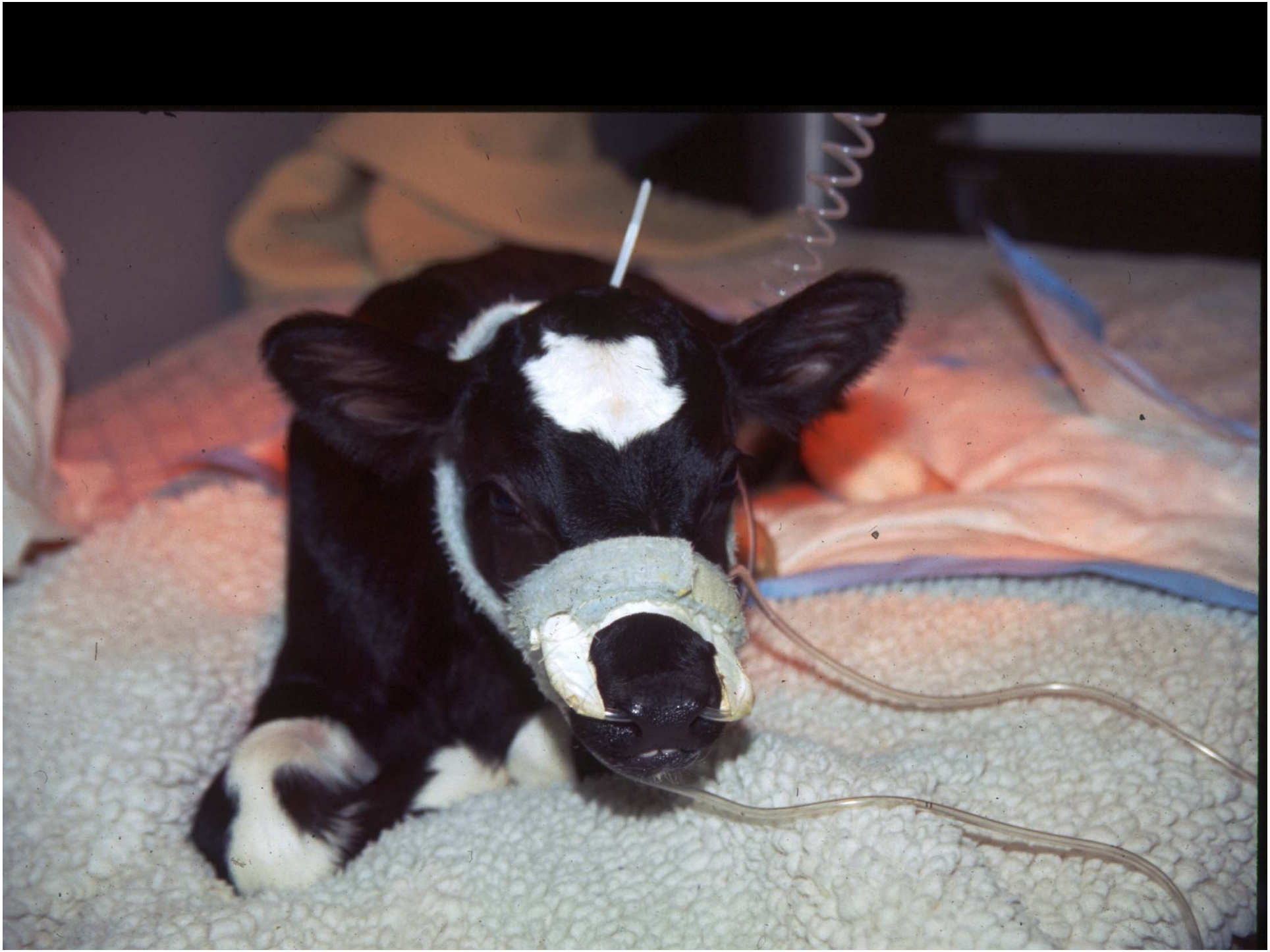
Respiratory Support
Intranasal Oxygen Insufflation











Hypoxemia
Increasing Cardiac Output

- Remain hypoxemic despite INO_2
- Poor lung perfusion
- Shunt fraction
  - Pulmonary hypertension
  - Increasing CO - decrease shunt fraction?
- Fluid therapy if hypovolemic
- Dobutamine
  - Euovolemic hypoxemic
  - Dramatic improvement in oxygenation
  - Referral center therapy
    - Need continuous rate infusion
    - Need a fluid pump – avoid infusion mistakes

Treatment of Pulmonary Hypertension

- **Time if within 24 hr of birth**
  - May reverse right to left shunt on own
- **Deliver high oxygen flows**
  - Ideally 100% O_2
    - Intubate
  - If not then high flow of INO_2
  - Will stimulate pulmonary vasodilation
    - Decrease pulmonary hypertension
  - Short exposure to these high levels – oxygen toxicity
- **NO inhalation therapy**
  - Treatment with NO
    - Foal on mechanical ventilation
    - Metered dose delivery system
    - Toxic side effects require careful dosing
- **Sildenophil**

Pulmonary Hypertension Sidenafil Citrate

- Oral form
  - Can be used orally or rectally
- Dose - 0.5-2.5 mg/kg Q4H or PRN
- Cause pulmonary arteriole vasodilation
  - Caution: also possible vasodilation of other tissues
- Phosphodiesterase 5 inhibitor
  - Help maintain cGMP levels in vasculature
    - NO stimulates cGMP production and thus vasodilation
    - Sidenafil maintains cGMP levels and thus vasodilation
  - Maintain pulmonary vasodilation
  - In theory great! In practice???

Hypoventilation

- **Achieve a normal blood pH**
  - **Not "normal $Paco_2$"**
  - **Appropriate hypoventilation**
- **Permissive hypercapnia**
- **Therapeutic hypercapnia**

Alveolar Hypoventilation ($\uparrow Pco_2$)

- Central Respiratory Center depression
  - Neonatal Encephalopathy
  - Sepsis
  - Drugs – phenobarbital
- Neuromuscular disease
  - Botulism
  - Spinal cord disease
  - Peripheral neuritis
- Respiratory fatigue
  - Primary lung disease
  - Depression
  - Decrease compliance

Alveolar Hypoventilation ($\uparrow Pco_2$)

- **Fractured ribs**
  - **Pneumothorax**
  - **Hemothorax**
  - **Pain?**
- **Diaphragmatic hernia**
- **Primary pulmonary disease**
  - **Atelectasis**
  - **Pneumonia**
    - **Aspiration**
    - **Hematogenous bacterial or viral**
    - **Interstitial pneumonia**

Functional Residual Capacity (FRC)

- **Normal individuals**
  - Most alveoli open and ventilated
- **Opposing forces**
  - Rib spring – opens lungs
  - Lung's elastic properties - lungs collapse
- **Newborn foals**
  - Compliant chest wall
  - Stiff lungs
  - Lungs collapse unless held open by intercostal muscles

Progressive Atelectasis

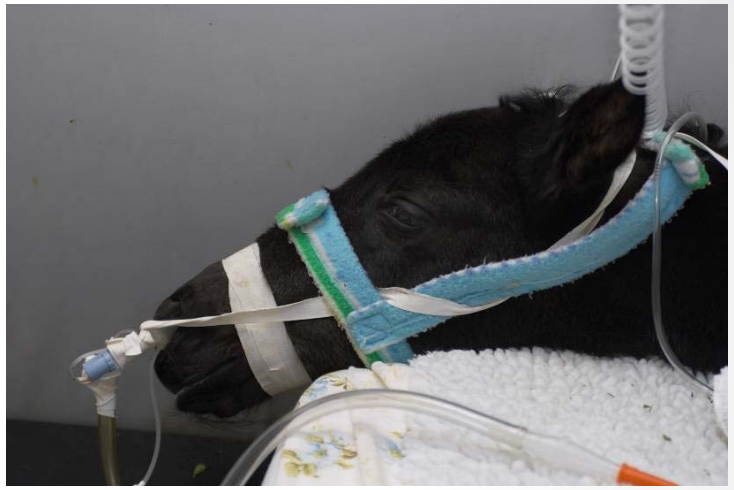
- If foal is weak then
  - Lungs pulled close and can't maintain FRC
  - Some alveoli collapse on expiration
    - Must be reopened with each breath
    - Repeatedly close expelling surfactant
    - Without surfactant alveoli difficult to open
  - Don't reopen on next breath – atelectasis
    - Decreases compliance locally
    - Pull adjacent alveoli close
    - Results increasing area of atelectasis
    - Results in decreased compliance – so lungs even stiffer
    - Foal becomes fatigued
      - Process continues and situation worsens

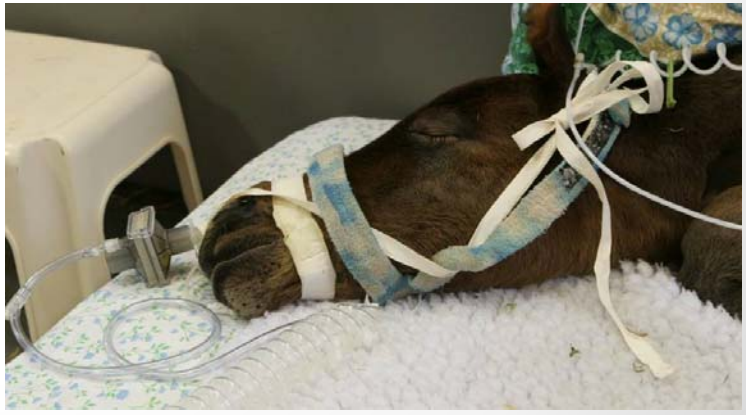
Progressive Atelectasis

- Leads to respiratory failure
  - Initially increased work of breathing
  - But with fatigue hypoventilation
  - Hypercapnea
- Wave chest – paradoxical respiration
  - Intercostal muscles fatigue
  - As the diaphragm contracts
    - Negative pressure in the thorax
    - Chest wall pulled towards the lungs
      - Because of the fatigued intercostal muscles
    - Very inefficient ventilation
    - Movement of chest/abdomen – produce a wave
- Best therapy – mechanical ventilation
  - PEEP/CPAP
    - Full recruitment ~ 20 minutes

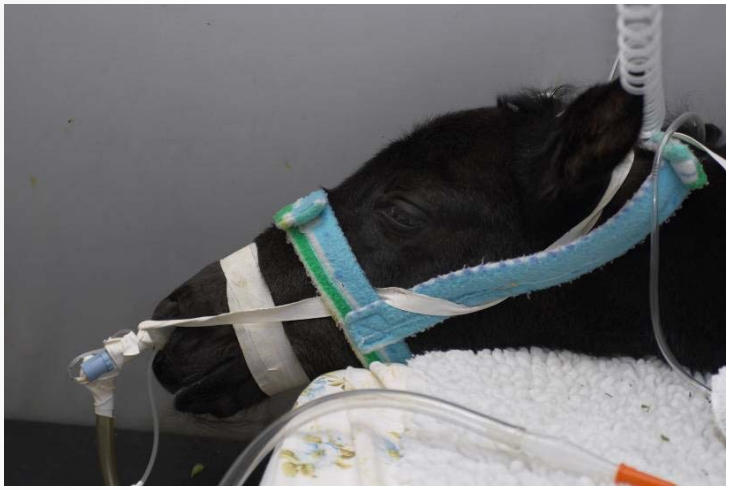
Respiratory Acidosis

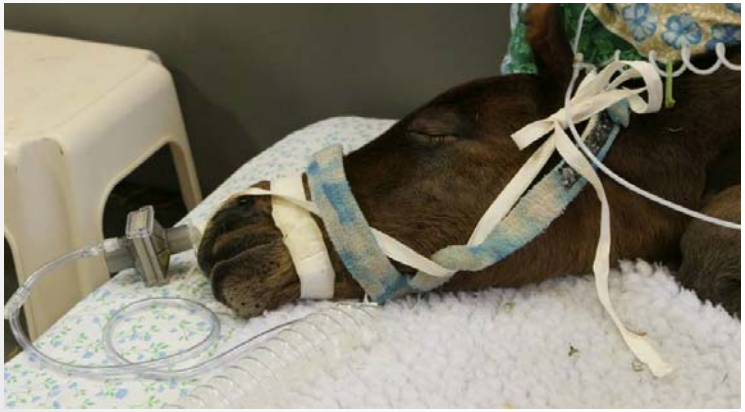
- **Upper airway collapse**
  - Endotracheal tube stent
- **Neonatal Encephalopathy**
  - Blunted central sensitivity
  - Chemical stimulants
    - Caffeine
    - Doxapram

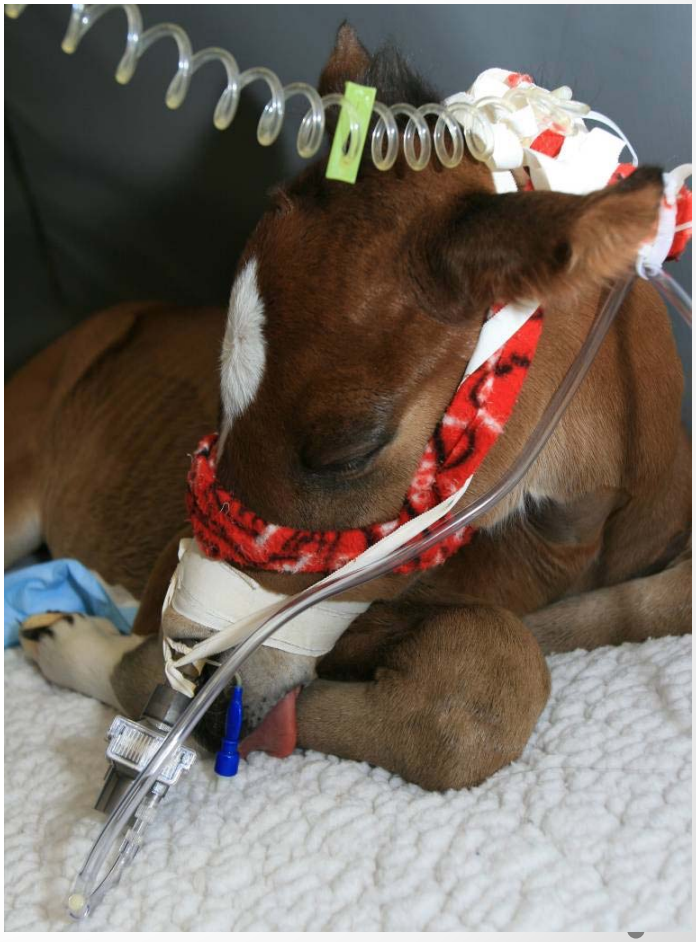




Pharyngeal Collapse







Treatment of Central Hypoventilation

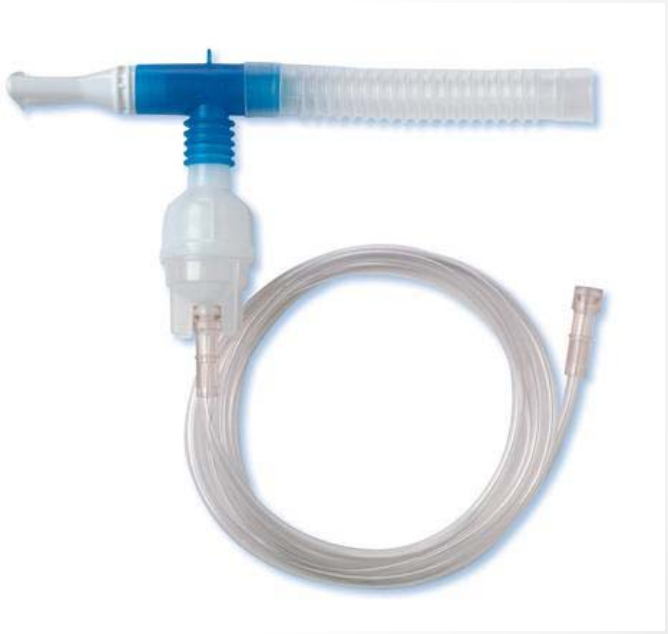
- **Doxapram**
  - Stimulates respiration
  - IV drip
  - Problems
    - $Paco_2$ decreases but so does pH
    - Oxygen demand of myocardium increases
      - So if they don't start breathing – more problems
      - Oxygen demand of brain increases

Treatment of Central Hypoventilation

- **Methylxanthines (caffeine)**
  - **Stimulates respiration**
    - **Decrease $Paco_2$ if acidotic**
  - **Dose – SID/BID/PRN guided by ABG**
    - **Oral**
    - **Rectal**
    - **10 mg/kg (loading dose)**
    - **10 mg/kg (maintenance dose)**
  - **Very safe**
    - **Steady state levels 5-20 µg/l**
    - **Toxic levels >50-75 µg/l**
    - **But is a stimulant**

Treatment of Airway Disease

- Airway disease not common/under-recognized
- Nebulization
  - Effective?? – foals seem to like it
  - 15 ml 5% $NaHCO_3$ + 15 ml NaCl + bronchodilator
  - Use 10 ml/treatment
  - Bronchodilator:
    - Terbutaline (0.001-0.007 mg/kg Q4-6H)
    - Albuterol (0.001-0.01 mg/kg Q6-8H)
    - Epinephrine
- Also can add:
  - Acetylcysteine (3-4 ml 0f 10% solution Q6-8H)
  - Furosemide
- Nebulized furosemide
  - Increases compliance
  - 1 mg/kg by nebulization
  - Does not increase compliance if given systemically
- Other therapy
  - Coupage
    - Percussion of the thorax to aid in the removal of secretions
    - Does it work?
    - Foals seem to like it



Positive Pressure Ventilation

- Manipulation of pulmonary gas exchange
- Increase lung volume returning normal FRC
- Decrease the work of breathing
  - Relieve fatigue
  - Decrease respiratory oxygen and energy utilization
  - Redirect perfusion away from respiratory muscles
- Modern ventilators
  - Normal lungs – easily ventilated
  - Severe pulmonary damage – possible to be successful
    - Septic pneumonia
    - ARDS

Ventilation