

# Practical Approach to New-Born Emergencies

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# Graham French Neonatal Section Connelly Intensive Care Unit

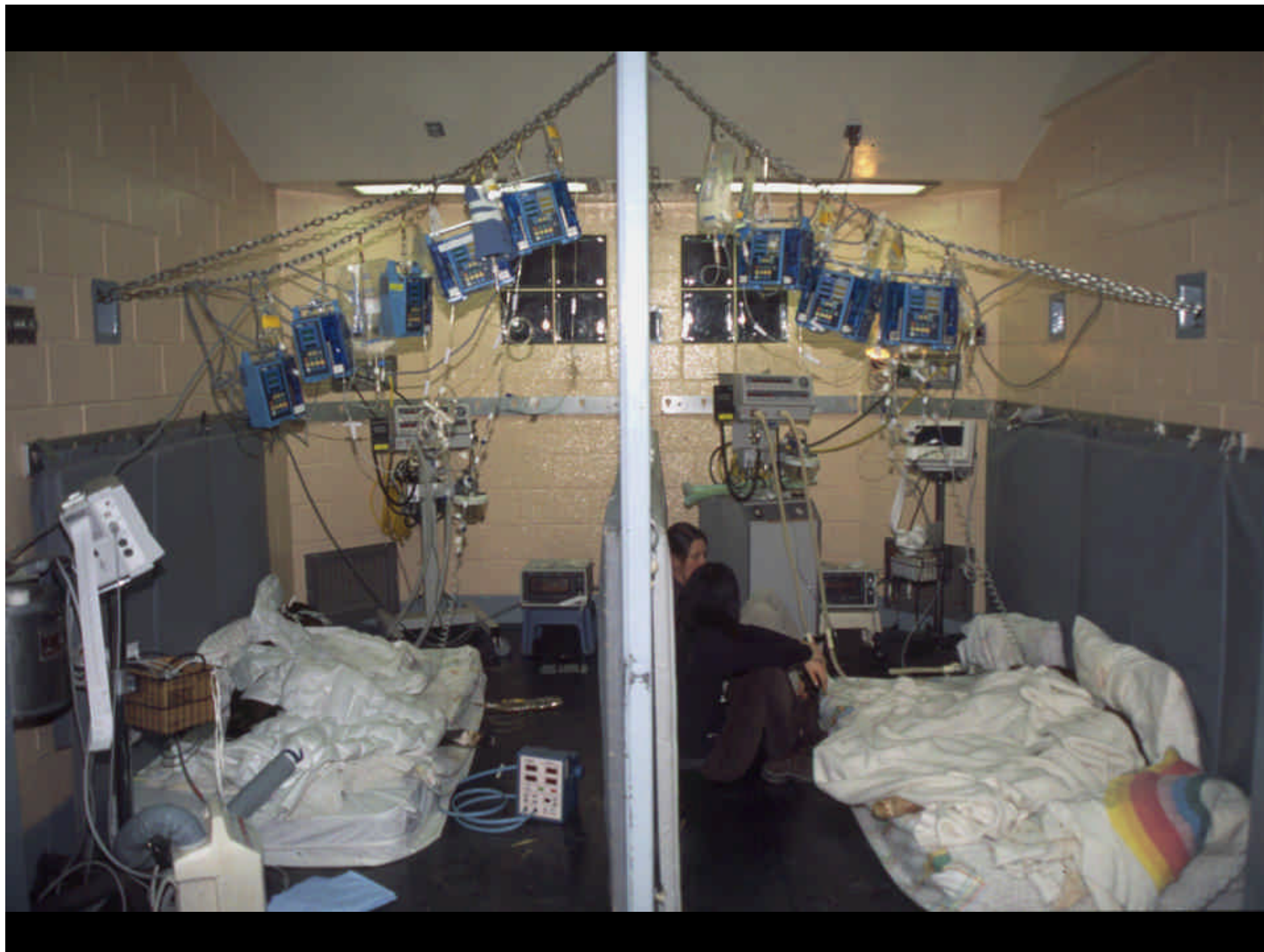


*1990 - 2004*

*1943 Neonates – 84% survivors*









# Compromised Foal





# Critical 48 hours

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



# Weak or Fading Neonate

- Immediate assessment of essential organ function
- Immediate directed, supportive therapy
- Farm care
  - Practitioner's time
  - Sufficient trained
  - Adequately facilities
- Tertiary referral centers
  - Resources needed
  - Facilities
  - Coordinated care delivery team







“Scoop and Run”

“Stay and Play”





# Neonatal Problems

- Fetal distress/maladaptation
- Sepsis/Infection
- Trauma/Hemorrhage



# Neonatal Problems

## Fetal Distress/Maladaptation

- Hypoxic Ischemic Asphyxial disease complex
  - Neonatal encephalopathy (maladjustment syndrome)
  - Neonatal nephropathy
  - Neonatal enteropathy (NEC)
  - Neonatal metabolic/endocrine maladjustment
  - Neonatal cardiovascular failure
- Prematurity
- IUGR
- Other
  - Ruptured bladder
  - Sick Cell Syndrome



# Neonatal Problems

## Sepsis/Infection

- SIRS
  - SIRS/CARS
  - Immune dissonance
- Generalized sepsis
  - Systemic infection
  - Localized
    - Aspiration pneumonia
    - Umbilical infections
    - Infectious enteritis
- Coagulopathies
- MODS
  - ARDS
  - NEC
- Severe sepsis
- Septic shock



# Neonatal Problems

## Trauma/Hemorrhage/Anemia

- Birth trauma
  - Fractured ribs
    - Associated damage
  - Gastrocnemius rupture
- Anemia
  - Umbilical hemorrhage
  - Fractured rib associated hemorrhage
  - Gastrocnemius associated hemorrhage
  - Femoral fractures
  - Neonatal Isoerythrolysis



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

# Physical Examination

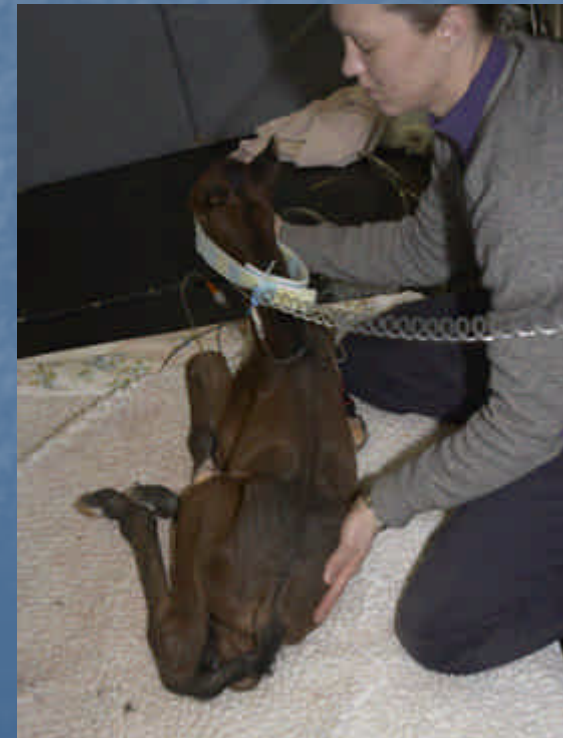
- Body condition
- Musculoskeletal problems
- Mucous membrane
- Cardiovascular examination
- Abdominal palpation
- Nervous system evaluation





# *Body Condition*

- Thin to emaciated
  - IUGR
  - Fetal SIRS
  - Prematurity
  - Post maturity



# Musculoskeletal problems

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





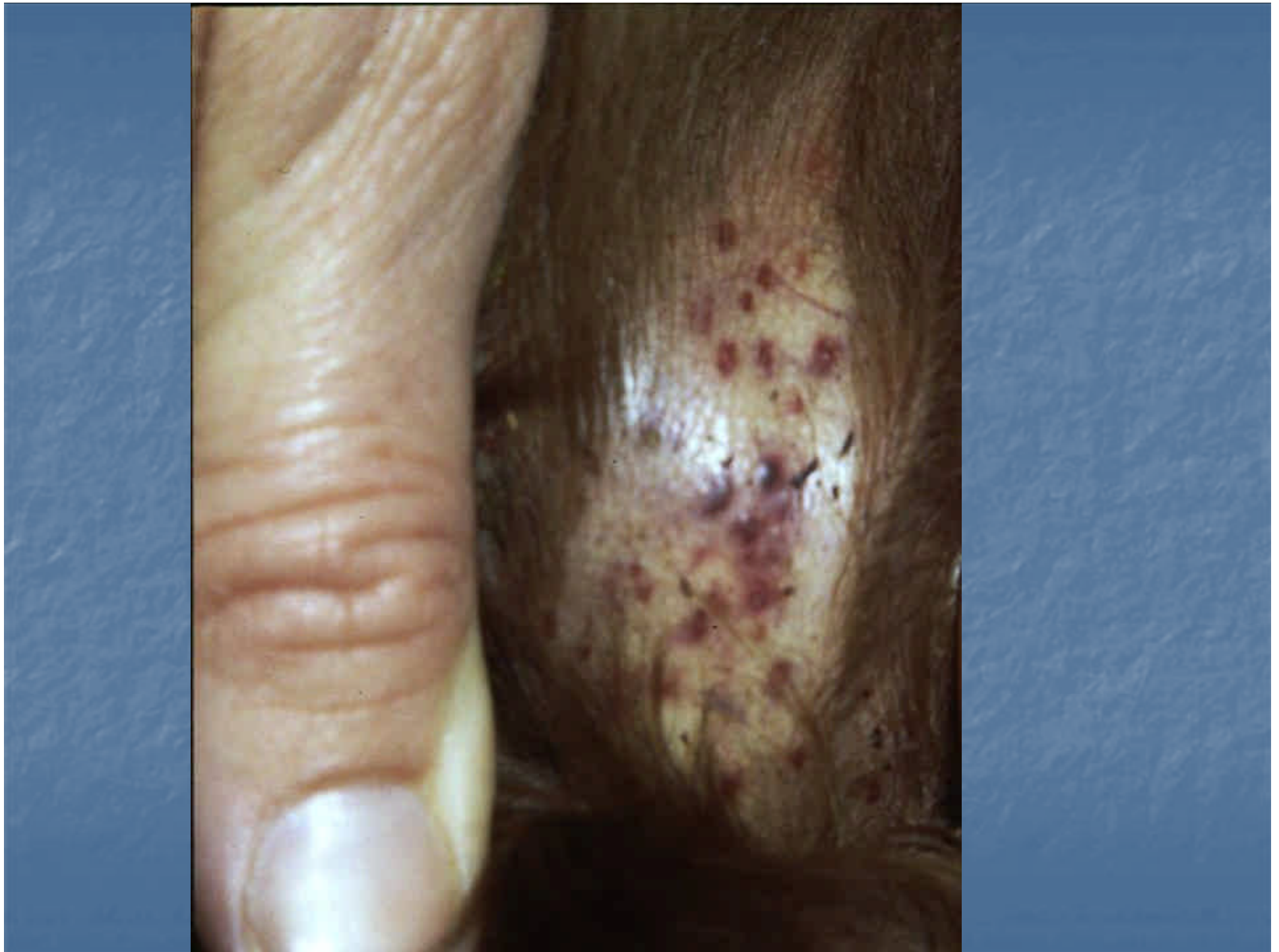




















# *Cardiovascular Examination*

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



# *Cardiovascular Examination*

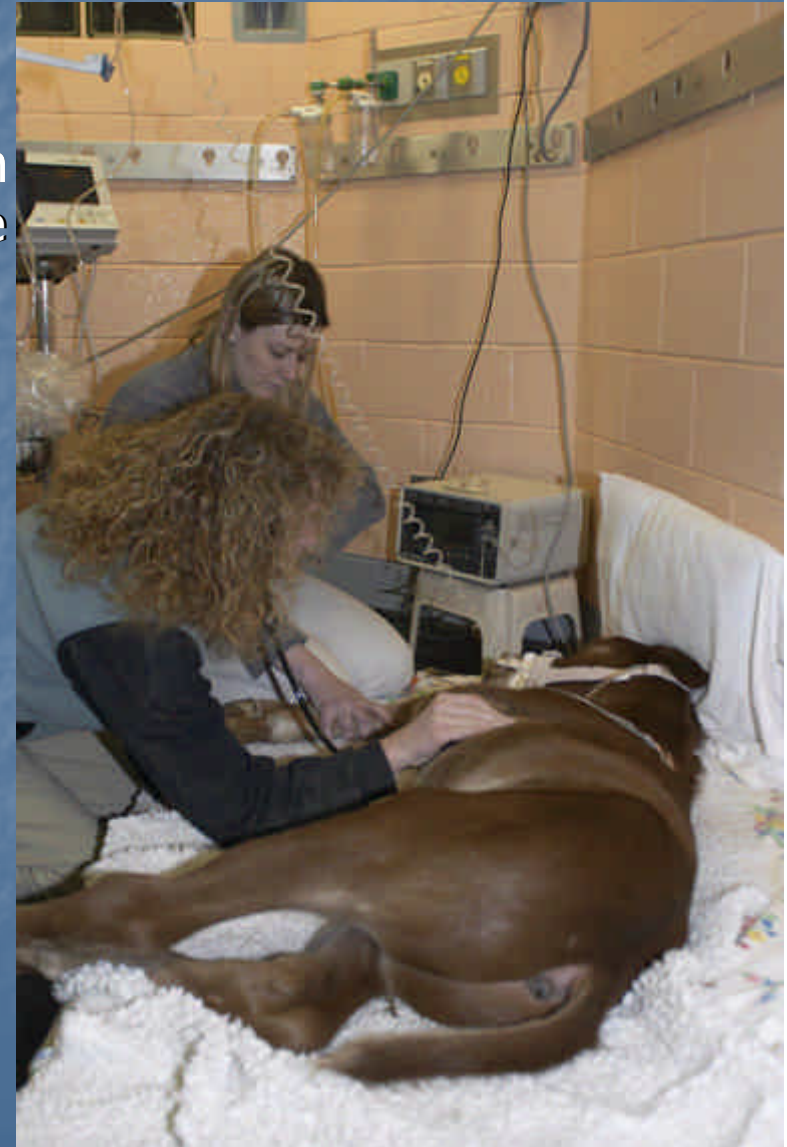
- Assess effectiveness of perfusion
  - Cold extremities as blood is shunted centrally
    - Do not be treated with active warming
  - Depressed mental status
  - Decreased borborygmi
  - Urine production
- Pulse assessment
  - Pulse quality
  - Arterial tone
  - Arterial fill
- Unreliable signs
  -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





# *Cardiovascular Examination*

- Heart rate appropriate for state of perfusion
  - Poor perfusion, BP low - high HR appropriate
  - Good perfusion, BP - low HR appropriate
  - Cause of the disparity
    - Level of discomfort
    - Abnormal central control
    - Primary myocardial disease
    - Excitement
  - Inappropriate bradycardia
    - Relate to retention of fetal physiology
- Heart rhythm
  - Primary myocardial disease
  - Trauma from fractured ribs
  - Metabolic abnormalities
- Cardiac murmurs



# *Abdominal Palpation*

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





# *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
    - Periodic apnea
    - Cluster breathing
    - Apneustic breathing
    - Ataxic breathing
  - Seizures
  - Abnormal vocalization



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





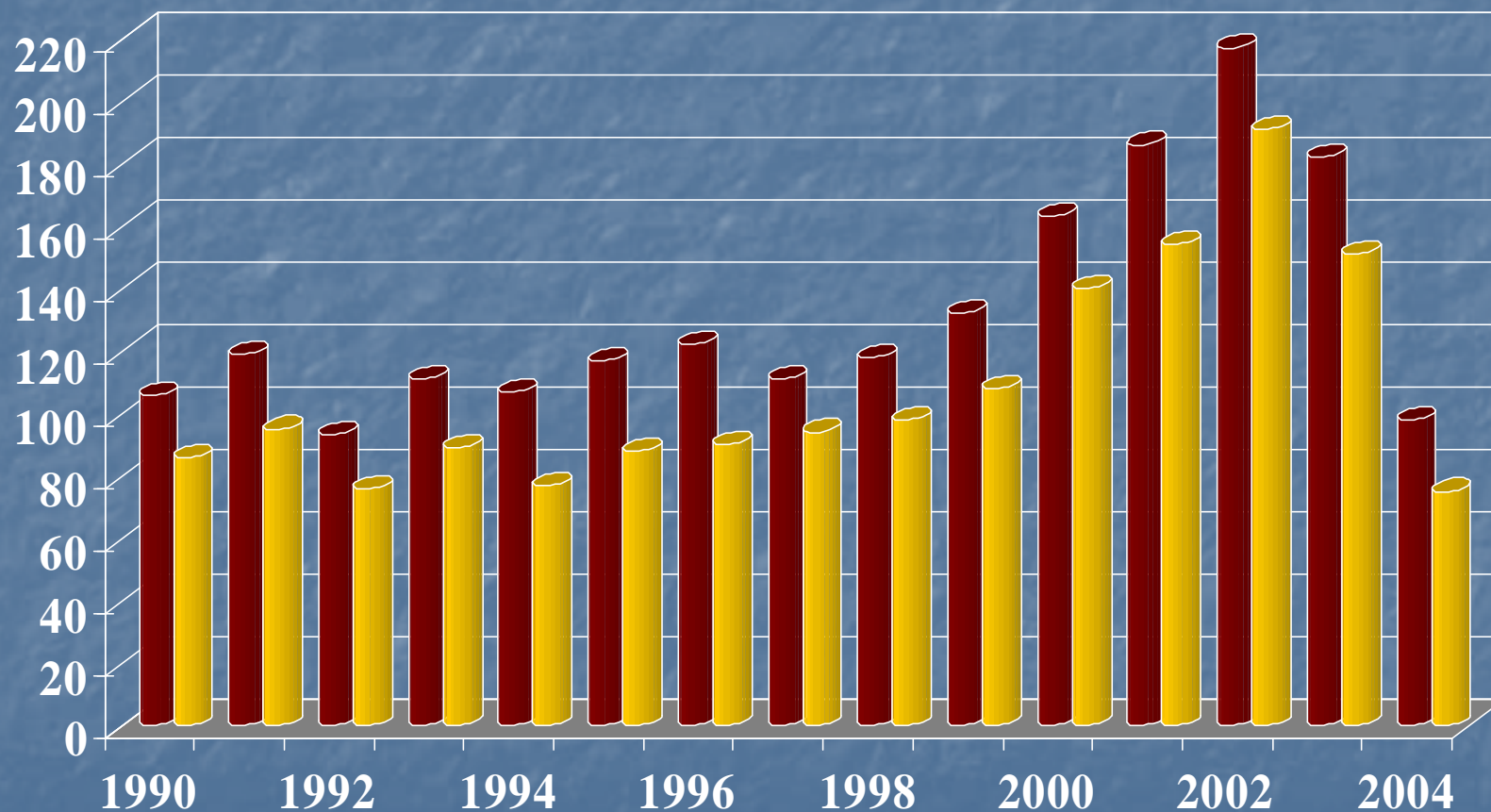
A photograph of a brown horse rearing up on its hind legs in a grassy paddock. The horse is facing left. In the background, there is a wooden fence, a blue metal gate, and a large house with a brown roof. The sky is overcast. A semi-transparent blue box with white text is overlaid on the upper part of the image.

Is treatment at a  
tertiary care facility  
worth while?

Outcome

# Neonate Admissions by Year

## *Short Term Survivors by Year*





# Short-term Losses

- Septic Shock
- Sepsis
  - Infectious orthopaedic conditions
  - Meningitis
- Prematurity complicated by sepsis
- Financial constraints

# How successful have we been?



- Racing graduates (TB & STD)
- Control population - siblings
- Racing
  - NICU survivors 60%
  - Siblings 75%
- Racing results
  - Standardbreds No difference
    - Places per start
    - Earnings per start
    - Earnings
  - Thoroughbreds No difference after 1<sup>st</sup> year
    - Places per start
    - Earnings per start
    - Earnings





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Neonates with inconsistent or complete lack of nursing behavior, who are weak or develop progressive weakness and who become recumbent during the first 48 hours after birth, are critically ill and require immediate intervention with supportive therapy. In our tertiary care practice, 70-80% of neonatal admissions are within the first 48 hours after birth. Of the neonates that we can't save, 70% die within this initial 48 hour period.

Neonates which become weak and recumbent during this critical period require immediate attention. Immediate assessment of essential organ function and immediate directed, supportive therapy are essential. Although, in some cases, the level of care needed can be delivered on the farm, the ability of the busy practitioner to dedicate the time needed without compromising the rest of his practice, the availability of sufficient trained help on the farm with the energy and dedication to deliver care and the lack of adequately equipped facilities on the farm significantly limits this possibility. The establishment of tertiary referral centers with the availability of resources needed to deliver dedicated care can significantly increase the rate of successful outcomes in these cases. The most powerful therapeutic modality in the established NICU is the well coordinated care delivery team. These cases demand a team approach to insure rapid delivery of lifesaving supportive therapy.

The initial step in delivering life saving care, whether treatment is to be delivered on the farm or at a referral center, is recognizing the seriousness of the problem. The foal that is weak from birth or initially seems normal and then fades during the first 48 hours of life may have a number of different underlying problems. These problems can be generally classified as those secondary to fetal distress/maladaptation, those secondary to sepsis/infection and those secondary to trauma/hemorrhage. Problems associated with fetal distress/maladaptation include the hypoxic ischemic asphyxial disease complex of neonatal encephalopathy (maladjustment syndrome), neonatal nephropathy, neonatal enteropathy (NEC), neonatal metabolic/endocrine maladjustment (hypo/hyperglycemia, hypo/hypercalemia, poor insulin response, autonomic failure, vasopressin deficiency, cortisol deficiency, etc.), neonatal cardiovascular failure (hypoperfusion secondary to lack of adrenergic sensitivity, vasoplegia, central failure; myocardial dysfunction), prematurity/dysmaturity, IUGR, sick cell syndrome, etc. Problems associated with sepsis/infection include SIRS, generalized sepsis, localized or systemic infection (bacteremia, aspiration pneumonia, umbilical infections, etc.), infectious enteritis (clostridiosis, salmonellosis), coagulopathies, immune dissonance, MODS (ARDS, NEC, etc.), severe sepsis, septic shock, etc. Finally those problems associated with trauma/hemorrhage include birth trauma (fractured ribs with associated damage, gastrocnemius rupture), anemia (umbilical hemorrhage, fractured rib associated hemorrhage, gastrocnemius associated hemorrhage, femoral fractures), etc. In reality,



there is rarely one problem but a combination of problems with varying severities. In fact there is a seemingly endless array of possibilities.

Fortunately, it is not necessary to identify the exact nature of the underlying problem to successfully treat the neonate. Instead, the clinician should identify which vital organ functions have been disrupted and institute therapeutic interventions which support normal function while simultaneously attempting to control any infection which is present. With these 2 goals met, the foal has the opportunity to heal and recover. So the object of the initial assessment of the critically ill foal is to identify organ dysfunction as will be described below, and then to tailor therapy toward supporting vital organ function as described in the next article. The questions which need to be answered by the initial assessment of the neonate include: is there evidence of sepsis; is cardiovascular support to insure tissue perfusion necessary and if so to what degree; is respiratory support required; will enteral nutrition and fluid maintenance be possible or is parenteral nutrition necessary; will assisted thermoregulation be necessary; what type of intervention will be necessary to control behavioral abnormalities; what level of metabolic support is to be expected; will renal support be necessary; and are there requirements for other specific supportive care (assisting to stand, musculoskeletal physical therapy, special restraint, etc.). With a careful, complete physical examination and with simple laboratory analysis (e.g. patient side glucose determination), the practitioner can rapidly make an assessment of what level of supportive therapy is necessary and whether or not this level will require local hospitalization or referral to a tertiary support facility.

*Body Condition:* A thin to emaciated foal at birth suggests intrauterine growth restriction (IUGR). In this condition, abnormal placental metabolism, such as may occur with placentitis, may result in an energy drain from the fetus producing fetal weight loss and emaciation. Alternately, fetal SIRS may result in the same outcome. Finding a small body frame with fine bones along with a fine, short hair coat, domed forehead and poor ear cartilage development suggests prematurity. A foal with a large body frame (large bones and large joints), with long hair coat suggests post maturity. A careful search for fractured ribs and other musculoskeletal abnormalities (fractures, gastrocnemius disruption, contracture, laxity, etc.) should be made.

*Mucous Membrane Evaluation:* Mucous membranes should be carefully evaluated for signs of icterus, injection (including large vessel injection where individual vessels are easily identifiable and small vessel injection caused by generalized capillary filling), petechia (oral, aural, scleral), erythema (lingual, periocular, nasal, nasal septum, aural, segmental oral) and coronitis. The presence of icterus suggests sepsis/SIRS, retained meconium, hemolytic disease (isoerythrolysis) or hemorrhage (internal umbilical remnant, fractured ribs, thrombocytopathies, intestinal bleeding associated with NEC, etc.). Large vessel injection is associated with excitement, hypoxic ischemic disease, local irritation, drying injury and occasionally sepsis/SIRS. Small vessel injection is associated primarily with sepsis/SIRS but also equally with hypoxic ischemic disease with loss of vascular control. Oral, aural and scleral petechia may all be induced by birth trauma but are more commonly associated with sepsis/SIRS. When examining the foal for petechia, care must be taken not to mistake the end-on vessels in the oral mucous

membranes for petechia. These vessels, when engorged, resemble petechia (I refer to them as “pseudopetechia”), but can easily be differentiated since they blanch when pressure is applied. Also, although *Culicoides* may occasionally cause bleeding aural petechia, similar bleeding petechia can be caused by sepsis/SIRS. Palpable petechia are not common and when identified should direct attention towards coagulopathies. Erythema is most often identified around the head affecting the lingual, aural, periocular, nasal skin, nasal septum and oral membranes. Lingual erythema is most commonly associative with hypoxic ischemic syndrome but occasionally is striking even in normal foals when they initially begin to suckle. Aural, periocular and nasal skin erythema are primarily associated with uncontrolled SIRS. Nasal septum erythema may be associated with sepsis/SIRS or with hypoxic ischemic syndrome. Regional erythema of the oral membranes may be striking because of the sudden transition from normal to erythematous membranes. Although on casual inspection, these areas may look like submucosal hemorrhage, the fact that they will disappear within hours rules out this possibility. It is more likely the result of regional loss of vascular control associated with hypoxic ischemic syndrome. Finally, coronitis is also a sign associated with sepsis/SIRS and occasionally severe hypoxic ischemic syndrome. Initially, coronitis is more noticeable on non-pigmented hooves, especially beginning at the heels. The hemorrhagic line will become more noticeable as the foal's disease progresses and over and several days it makes a transition to a purple, bruised appearance.

*Auscultation:* Careful attention to heart rate and rhythm is important noting whether inappropriate bradycardia is present (heart rate inappropriately low in the face of marginal perfusion) and noting the occurrence of any premature contractions or other arrhythmias. Flow murmurs are very common in foals and should not be over interpreted. They may be identified as flow murmurs if there are significant changes in a quality and volume with changes in the foal's body position or heart rate. Most foals with retained fetal circulation do not have unusual murmurs. Careful auscultation of the lungs is important. Moist bronchovesicular sounds should be heard for the first few hours after birth as resorption of fetal fluids may take some time. Because of the stiff nature of neonatal lungs, fine crackles associated with collapsing and reinflation of alveoli should be expected. Recumbent foals, because of the compliant nature of their chest wall and the stiffness of the lungs, will consistently have rales in the recumbent lung. Sick, recumbent foals are particularly susceptible to aspiration resulting in pneumonia. Careful auscultation of non-recumbent lungs with deep breaths is important in identifying pneumonia. Auscultation of the GI tract should reveal frequent but not constant borborygmi if the foal is receiving oral nutrition. Sometimes the GI tract will remain quiet when milk is being withheld. Identification of a good variety and frequency as well as quality of borborygmi is important in ensuring gastrointestinal health. Foals with hypoxic ischemic intestinal disease, such as necrotizing enterocolitis, frequently have quiet and distant borborygmi with occasional loud gas sounds.

*Abdominal Palpation:* Just as a careful rectal examination can be revealing in adults, careful and thorough abdominal palpation can be an important adjunct to the physical examination of the neonate. In order to be successful, the foal should be quiet and have a relaxed abdominal wall as occurs in depressed, septic foals, foals with hypoxic ischemic



syndrome or normal foals in the somnolent postprandial state. Although the technique is usually practiced on the quiet, recumbent foal, it can be adapted to the standing foal. With practice, many structures can be readily identified and abnormalities recognized. The internal umbilical remnants, especially the umbilical triad (2 arteries and urachus) should be palpated to identify recent hemorrhage or inflammatory disease (omphalitis). Also, palpation of the umbilical arteries may reveal retained pulses and their juxtaposition will indicate whether or not the urinary bladder contains urine. The urinary bladder can often be identified and both luminal and bladder wall hematomas recognized. The intestines should be palpated to detect retained meconium (most often felt in the right colons just under the rib cage or in the caudal abdomen near the bladder). In cases of necrotizing enterocolitis, thickened intestinal wall, pneumatosis intestinalis and intussusceptions may all be palpated. The kidneys and the liver can be evaluated. Hepatomegaly is not an unusual finding in the critically ill neonatal foal. Identification of inguinal or umbilical hernias and other body wall defects can also be important.

*Cardiovascular System:* Evaluating perfusion and volemia is essential in managing sick neonates. The distinction should be made between volemia and hydration. Hydration refers to the adequacy of cellular fluid volume and to a lesser extent, adequacy of the cellular reserves, which is the interstitial volume. Volemia refers to adequacy of circulating volume. Almost universally, neonates are born with excessive hydration, having a higher percent total body water than adults. With fetal distress, often the neonate is born with even more body water secondary to greater fluid shifts from the fetal fluids to the interstitium. So rehydration is almost never required except in rare circumstances such as after extensive external hemorrhage. However, hypovolemia is common in ill neonates resulting in hypoperfusion. In such cases, hypovolemia needs to be addressed aggressively.

The object of the cardiovascular examination is to assess effectiveness of perfusion. Physical examination signs of hypoperfusion include cold extremities as blood is shunted centrally. The cold limbs should not be treated with active warming as this will defeat the circulatory compensation. The ears and nose may also be cool to cold and hypoperfusion can result in a depressed mental status and decreased borborygmi. Urine production is a very reassuring sign indicating perfusion of the kidneys. However, it should be remembered that unlike other neonates, foals usually don't urinate for the first 12 hours after birth. Lack of urine production in the foal that is only hours old, even in the face of fluid therapy can not be taken as evidence of poor kidney perfusion. Other physical findings that relate to perfusion are pulse quality, arterial tone and arterial fill. Careful assessment of pulse quality can help determine pulse pressure (difference between systolic and diastolic pressure). Arterial wall tone is assessed by the amount of finger pressure required to feel the pulse and the amount required to eliminate the pulse. If the pulse can only be felt by a very light touch, there's little tone to the arterial wall. On the other hand if even with firm pressure the pulse still can be felt there may be increased arterial wall tone. This quality roughly corresponds to blood pressure and responsiveness to adrenergic tone. Arterial fill is assessed by feeling the size of the artery's lumen as finger pressure is applied. Arterial fill relates to the blood volume on the arterial side of the circulation. These clues can relate much information about blood

pressure and perfusion. Dry oral membranes are an unreliable aid in determining hydration status since many ill foals keep their mouths open allowing the mucous membranes to dry. Likewise, capillary refill time is not particularly helpful since it may be determined more by the state of mucous membrane injection and venous pressure/return than by volemia. Skin turgor is an unreliable sign in the neonate.

The heart rate should be appropriate for the state of perfusion. When perfusion is poor and blood pressures low, a high heart rate is appropriate. When perfusion is good and blood pressures adequate, a low heart rate is appropriate. If the heart rate is not appropriate, the cause of the disparity (e.g. level of discomfort, abnormal central control, excitement or primary myocardial disease) should be identified. Inappropriate bradycardia is a frequent finding in critically ill neonates and may relate to retention of fetal physiology in which bradycardia is an important part of the response to distress. The rhythm should be carefully evaluated since it is common to have arrhythmias in the neonatal period secondary to primary myocardial disease, trauma from fractured ribs and metabolic abnormalities. Transient cardiac arrhythmias which spontaneously resolve are not unusual during the first hours after birth. Cardiac murmurs are almost universally present during the neonatal period (first 30 days of life). It is a widely held misconception that these are from a patent ductus arteriosus. Most neonatal murmurs, even during the first 24 hours of life, are in fact flow murmurs which often change character as the foal's body position or heart rate changes. Murmurs associated with significant cardiac anomalies are often coarse whereas flow murmurs are generally soft. The presence of a persistently loud, coarse murmur should raise the suspicion of a significant congenital defect which will require further investigation.

*Central Nervous System:* When evaluating the nervous system of neonatal foals, it is important to evaluate strength, muscle tone, responsiveness and ability to arouse the foal. Clinicians commonly think about behavioral changes such as loss of suckle and search behaviors as well as loss of tongue control and coordination (hypertonic lingual dissociation). Other neurologic signs may be equally as important including the development of facial nerve and vestibular signs, becoming hyperresponsive or hyporesponsive, developing hypertonus or hypotonus, becoming hyperactive or hyperkinetic or developing somnolence. Careful observation of respiratory patterns may show periodic apnea (>20 seconds without breathing), cluster breathing (several rapid breaths followed by a respiratory pause or apnea), apneustic breathing (breath holding) or ataxic (irregular) breathing. Severely affected foals will have seizures. Most of these are generalized clonic tonic activity centered on the front of the body (head, neck and front legs) or more generalized animated seizures with clonic tonic paddling motion (galloping). A dramatic sign sometimes present is abnormal vocalization which may mimic a barking dog but more often mimics a squealing pig.

A careful physical examination will help the clinician detect major organ dysfunction indicating the seriousness of the condition. Further important information can be gained by dynamic monitoring of organ function and by laboratory analysis of blood samples. Simple monitoring, such as serial blood glucose levels can be easily achieved using inexpensive patient side monitors. But vital information, such as arterial blood gas, blood



electrolyte and lactate levels require more sophisticated equipment which is better suited to be used in a hospital. Many therapeutic modalities, although possible on a farm, are much more manageable in a referral hospital practice. The most advanced therapeutic modalities, such as mechanical ventilation, are only possible in a tertiary referral center. But therapy at a referral center is expensive. Patients treated at our tertiary care facility have average bills ranging from \$4000 to \$6000 (3000-4500 euros) or more.

Is treatment at a secondary care facility worth while? While there are no studies comparing outcome from therapy on farms compared to referral centers, our experience has been very positive. Although we treated critical neonates for many years before it opened, our current Neonatal Intensive Care Unit is 15 years old. As of the end of 2004, we have treated 1978 neonates. Of these 84% survived. Foals with complicated conditions such as neonatal encephalopathy (maladjustment syndrome) with renal and GI involvement (neonatal nephropathy, neonatal enteropathy) have a survival rate of 87%. The foals with the poorest outcome are those presenting in septic shock where less than 50% survive.

What about long term outcome? We performed a long term outcome study on our graduates who were bred for racing (both Thoroughbreds and Standardbreds). We used the siblings of our patients as controls to insure that we were gauging outcome based on the potential of our NICU patients. We found that 60% of our NICU survivors raced compared to 75% of their siblings. The 15% dropout from the NICU survivors included foals with significant musculoskeletal abnormalities, premature foals and twins. The dropouts primarily had conditions that intuitively have poor prognosis for racing. Of those Standardbreds who raced, during the first 2 years of racing there was no difference between the places per start, earnings per start or total earnings. With the Thoroughbreds, there was less earnings per start and less total earnings during the first year of racing but these differences disappeared during the second year or if the first and second year results were combined. During both years there were no differences in the places per start, suggesting that during the first year of racing, the thoroughbred NICU survivors were entered in races with smaller purses.

Both the short term and long term outcomes are very encouraging. Neonatal intensive care can make a significant difference in the recovery of patients with critical conditions during the first days of life. Most survivors will perform up to their expectations. The viability of equine neonatal intensive care depends on whether the owner feels that the investment in care is worth the likelihood of a positive outcome. In our practice many of our owners are repeat customers.