How to Refeed Starved, Malnourished Horses — A Work in Progress

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1. Introduction

"Hard Times Leaving Animals Homeless"

“At MSPCA (Massachusetts Society for the Prevention of Cruelty to Animals) Nevins Farm, the number of private horse surrenders surged from 21 in 2007 to more than 70 in 2009.” Brian Benson, Boston Globe, January 14, 2010.

“Neglected Horses in Maryland Multiply as Economy Continues to Sag”

“Horse rescue operators are wrestling with a staggering number of horses in need of homes, a byproduct of the region’s crumbling economy, struggling racetracks and the closure of U.S. slaughter plants.” Megan Miller, Capital News Service, March 13, 2009

It is common knowledge that the number of horses with low body condition scores (BCS < 3/9) due to simple (absence of primary disease) starvation have dramatically increased in humane shelters since 2007, yet there is very little information clearly outlining the nutritional rehabilitation plan for the spectrum of such cases. In the worst-case scenario, an adult horse will lose approximately 40% of optimal body weight (BW) due to a complete lack of feed for 60–90 days, and will no longer be able to support itself, become sternal initially, and then laterally recumbent, and then most will die within 72–96 hours if they cannot rise.1,2 Once 40–45% of optimum BW has been lost, survival is unlikely regardless of aggressive treatment. Fortunately, most low-BCS equine cases do receive some fraction of an inadequate diet, often of poor quality, for more than 3–4 months and are presented to humane shelters or rescue leagues before becoming recumbent.3 The objective here is to suggest a nutritional rehabilitation plan for low BCS (1–3/9) horses due to simple starvation-based on initial BCS and laboratory data uncomplicated by primary disease.

2. Materials and Methods

Physical Examination

An immediate and thorough examination of each animal will help to pinpoint the cause of the weight loss and identify any concurrent diseases or preexisting condition. BW should be accurately recorded using a weigh scale as opposed to weight tapes measurements, which, even if performed correctly can be off by ±5% (50 lb in 1000 lb horse). Most starved equine cases occur through the winter months when hair coats are long, dull, and unkempt that tend to mask loss of body fat and muscle; hence, proper BCS determinations and assessment of muscle wasting must be completed using physical palpation. It is
important to remember that BCS is directly related to the body fat content and does not include an assessment of muscle mass. It is presently assumed that horses, similar to other species, at optimal BCS have approximately 15–20% body fat (subcutaneous [SC], intramuscular [IM], abdominal). However body fat as percentage of weight may not be linear at low BCS; ie, as BCS decreases, percentage of body fat loses are exponential. In the face of decreasing fat stores with continued caloric deficiency, more muscle (skeletal and visceral) is catabolized for energy. Given that the half-life of serum albumin in the horse is approximately 19 days, a low serum albumin in the absence of protein losing enteropathy, renal or liver disease would suggest inadequate feed intake for many weeks.

Measurement of BW and condition do not provide sufficient evidence of emaciation. Muscle wasting in the absence of fat is a relatively better assessment of malnutrition and extent of suboptimal nutrient intake. Extent of muscle loss is the primary determinant of survival because without treatment, as seen in several species, a greater than 25–30% loss of body protein compromises cardiac and pulmonary muscle strength. Cause of death is usually due to cardiac/respiratory arrest as a result of cardiac/respiratory muscle degradation and electrolyte imbalances. Muscle scoring has been recently introduced into the physical examination of dogs and cats, which is assessed by visualization and palpation of the spine, scapulae, skull, and wings of the ilia. Muscle loss is typically first noted in the epaxial muscles on each side of the spine. Muscle loss at other sites can be more variable, and is graded as normal, mild, moderate loss, or severe loss. A standardized muscle scoring system does not yet exist for horses to my knowledge. However, the BCS and some assessment of muscle wasting combined can be important information when triaging limited resources because approximately 20% of severely malnourished (BCS 1) horses will die regardless of attempts to treat due to extensive muscle wasting.

Blood Biochemical Evaluations
Knowledge of the laboratory findings in emaciated horses is useful in scoring the intensity of emaciation, and in establishing a prognosis. Blood work results (i.e., increased free fatty acids [FFA], glyc erol, total lipids, triglycerides [TG], phospholipids, cholesterol, B-hydroxybutyrate, lactate, bilirubin, cortisol, and lower Mg, Ca, K, and insulin) may aid in the determination of the extent and severity of starvation, and in conjunction with BCS, may help with the decision to treat given financial, logistic, and time constraints.

If the decision is to initiate treatment, based on initial blood work, the patient should be rehydrated orally if possible; however, IV correction of electrolyte and acid base imbalances (without glucose) may be necessary and should be started before the reintroduction of feed. A parenteral B-vitamin product containing thiamine, riboflavin, niacin, and pyridoxine may be administered at 10–50 mL/500 kg BW in conjunction with IV fluid therapy for 1–3 days to begin repletion of those vitamins essential to energy metabolism.

Feeding Plan
Once the physical examination and laboratory data have been collected and the commitment to rehabilitate and refeed the patient has been made, a feeding plan based on BCS (Table 1). One must resist the human urge to provide these horses with large amounts of hay and grain. In my experience, it was very important to explain specifically to owners, veterinary technicians, barn help, and whomever may have access to the patient, the importance of a slow and methodical reintroduction to feed that must exclude them from feeding the patient any feeds other than the type and amount prescribed. The well-intentioned attendant feeding outside of the prescribed plan may initiate a refeeding syndrome and possible death of the animal. The refeeding syndrome has been well described previously, and so will not be described here other than to say it must be avoided.

Refeed the Gut First
It should be cause for pause when considering the first feed into a compromised small intestine (SI). The SI itself is universally dependent on intraluminal nutrition, and within days of no food, will show evidence of compromise. As seen in other species, by day 7 without food, small-bowel weight will have decreased by 22%, mucosal weight (~28%), protein (~35%), and DNA (~25%) will be significantly less than day 1; all of which compromises SI function. SI atrophy is characterized by decreased villus height and crypt depth, surface area and motility, brush border enzymes, secretions, and immunity with an increased risk of bacteria (including probiotics), endotoxin, and cytokine translocation. Overall, the net effect of not feeding the SI is decreased end-stage digestive enzymes, nutrient-absorptive processes with an increased risk of systemic infection.

Microbiome
Large intestine in a mature horse is composed of the cecum (25–30 L), large colon (50–60 L), small colon (18–20 L) and when emptied, constitutes 4–5% of BW in a mature horse. The SI itself is universally dependent on intraluminal nutrition, and within days of no food, will show evidence of compromise. As seen in other species, by day 7 without food, small-bowel weight will have decreased by 22%, mucosal weight (~28%), protein (~35%), and DNA (~25%) will be significantly less than day 1; all of which compromises SI function. SI atrophy is characterized by decreased villus height and crypt depth, surface area and motility, brush border enzymes, secretions, and immunity with an increased risk of bacteria (including probiotics), endotoxin, and cytokine translocation. Overall, the net effect of not feeding the SI is decreased end-stage digestive enzymes, nutrient-absorptive processes with an increased risk of systemic infection.
without the other. The microbiome is a very large number and diverse group of microbes, outnumbering the horse itself in terms of total cell number and DNA. Our understanding of the composition and function of this population have been extremely limited but we do know the microbiome is profoundly altered in certain disease states to the detriment of its host. We are only now developing the computational abilities to collect and analyze the data by which to identify species and numbers within the normal microbiome of a horse. The development and increasing availability of next generation sequencing and evolving bioinformatics offer never-before-available tools by which to study the equine microbiome. Probiotics are widely used presently because they are thought to do no harm but we should have a specific end goal in mind when we prescribe a treatment. As such, I believe the use of probiotics at this time to reestablish the microbiome in malnourished horses a waste of dollars better spent otherwise, at least until we know what we are trying to achieve and there are known efficacious products available.

By way of an example on how to reestablish the equine microbiome, foals born with a sterile gut obtain a mature microbiome similar to their mares within the first few weeks of life. The source of microbes is thought to begin during passage through the mare’s vagina, but then maternal contact (nursing, grooming) and exploring behaviors provide contact with bedding, dirt, and feces, etc. Foals preferentially consume fresh over dried feces from their dams. They have also been known to consume pasture, hay, or grain as early as a day old and by week 5 may spend more than 20% of their time grazing or eating nonmilk foods. Therefore, I am suggesting that in the rehabilitation of starved horses, that they be “housed” surrounded by other horses, feeds, dirt, and manure which should be more conducive to replenishing their microbiome as it proceeded once before in their lives as foals, rather than isolated in a frequently picked stall.

Feeding Plan
At this time, it would seem prudent to begin with rations containing less than 20% readily available carbohydrate estimated by nonstructural carbohydrate (NSC) and higher fiber (15–25%), preferably a mix of soluble and insoluble, respectively, to avoid causing the refeeding syndrome and refeed the microbiome. There are several other terms (nitrogen free extract [NFE], water-soluble carbohydrates [WSC], ethanol-soluble carbohydrates [ESC], nonfiber carbohydrates [NFC] starch, sugar) used to describe carbohydrates in rations; however, NSC is a technically accurate term and should be used to compare feeds. Currently the best fiber estimate we have is crude fiber.

Forage Rations
There are only a few studies on the refeeding of starved horses, but feeding high-forage ration first is a common recommendation. The lower the BCS and the greater the muscle loss in patients, the higher the protein level should be in the initial forage fed because it takes protein synthesis to regenerate a full complement of digestive enzymes and serum carrier molecules to transport nutrients from the intestines and liver to other tissues. In general, legume hays contain 18–23% protein with 11% NCS whereas grass hays (timothy, orchard, and fescue) contain 6–14% protein with 13% NCS. A forage-first plan also refeeds the microbiome, which is in turn essential to regenerating gastrointestinal tract physically (mucosa) and functionally (motility) and provides nutrients (energy, protein and vitamins) to the host.

Grain and Concentrates
Grains should be used sparingly during the initial feeding plan as the more debilitated the patient, higher is the risk for the deadly refeeding syndrome, which will often occur within the first 10–14 days due to a sudden increased carbohydrate intake. NSC is highest in grains such as corn (73%), oats (48%), and wheat (66%). In addition, these grains are relatively low in protein (8–13%) and crude fiber (2–9%) and as such are not the best feeds fed initially to starved horses.

The term concentrate generally implies a grain mixed with minerals and vitamins in a pelleted or “sweet” feed form to keep the micronutrients well mixed throughout the feed. Although feeding minerals and vitamins initially to starved horses will help in reviving co-factors and co-enzymes of metabolism, feeding these micronutrients with a grain is not advisable initially, again to avoid a refeeding syndrome. Complete “Senior” feeds have been suggested with caution because they may contain more than 20% NSC. Another option might be those complete feeds marketed as “Low carb” that report a NSC less than 20%, eg, “Lite” feeds with 10% NCS, or “Senior” feeds with a starch + sugar maximum of 20%. Better-formulated and more-specific products for refeeding horses are appearing on the market. These contain high-protein quality ingredients such as alfalfa, soy, and whey, a mix of fiber types (14%) with minerals and some B- and fat-soluble vitamins was designed and tested clinically in hypophagic horses. A powdered product reportededly containing 11% starch + sugar can be offered for voluntary consumption or tube fed after adding water.

Appetite Stimulation
Assuming there are no contraindications to significant oral feeding such as dental, pharyngeal, or esophageal lesions, feed offered for oral consumption is preferable to tube feeding or parenteral nutrition. In cases with oral lesions that inhibit or decrease
oral food consumption, in addition to treating the lesions and analgesics, offering soft green grass or a mash (a complete low-NSC-extruded pellet soaked in water) may decrease the pain of eating sufficiently to improve intakes. Grass pastures on average have 7–23% protein and 6–20% NSC and mostly mixed-grass (MMG) pastures have 11–25% protein and 7–18% NSC and so are appropriate for starved horses as an appetite stimulant. Fever or pain elsewhere may also decrease appetite and in such cases administering antipyretics and analgesics may improve feed intake.23–24

Feeding at least 10–25% of daily requirement using the gastrointestinal tract has been shown (in G. pigs) to significantly decrease SI atrophy, which in turn should promote appetite.25 Offering small amounts (0.1–0.3% BW), removing discarded feed after a few hours, and frequently replacing with a variety of fresh forages is stimulating and palatable to most horses as well as being in the presence of other horses eating. Bran mashes, although popular, alone are not that palatable to horses, and so mixing with oats, barley, or a sweet feed with 1 cup of molasses and 1–3 tsp of salt may improve consumption.

Although some horses will eat lying down, most prefer to be standing and so use of a sling or other upright supportive measures may improve feed consumption. If able to walk, grazing in hand even upright supportive measures may improve feed consumption.26 Diazepam administered at low dosages IV may induce a horse to consume feed immediately after treatment but only for 15–20 minutes and only if there are no distractions, etc.; hence, it is not advisable. In addition, debilitated horses may become tranquilized and ataxic unless lower dosages are used. Repeated dosing does not produce consistent results and should be avoided in patients with hepatic compromise. Anabolic steroids and corticosteroids do not have an immediate effect but may increase feed intake after several days.26

Psychological Needs

In tempting a partially anorexic or hypophagic horse to eat, satisfying their psychological needs are essential. Horses are a prey species and therefore safety (from harm) and comfort (lack of pain and social separation/pressures) take higher priority over food consumption, and only after the patient feels safe and comfortable, will they consider eating. Oftentimes hospitalizing a patient, although most convenient for the veterinary staff, is sufficiently frightening to inhibit food consumption. Unfamiliar sights, sounds, smells, aggressive (as seen from the horse's view) human behaviors, unaccustomed to being boxed indoors (limited sight line), all are not conducive to stimulating appetite. In most cases, keeping herd mates together or close but separated to avoid feed competition and allow for measurement of individual feed intake in relatively open spaces is the best situation conducive to appetite improvement.

Tube Feedings

Completely anorectic or severely hypophagic horses may need to be tube fed to meet all or some of its nutritional needs. There are a limited number of feed options: complete feed slurries, homemade recipes, liquid products designed for horses. Each option has disadvantages.22,27,28 There are potentially advantages to include glutamine and soluble fiber into liquid tube feeding product. Glutamine, a conditionally essential amino acid is needed during periods of physiologic stress to stimulate SI DNA synthesis and will increase SI mucosal mass early in recovery.24 Fiber (~5%) modulates intestinal motility, correcting hypomotile, provides intraluminal stimuli to re-establish normal peristaltic action and transit time, and nondigestible bulk to buffer toxins and holds water to minimize diarrhea. It would be advised, therefore, that tube-fed rations contain both of these nutrients.

There are some disadvantages to tube feeding in that horses may become resistant to nasogastric intubation after 4–5 days with mild epistaxis.21 Metabolic disadvantages to tube feeding vs voluntary consumption of the same low-NSC diets have been reported. Adult horses with good BCS consuming a low-NSC feed voluntarily had lower insulin concentrations (P < .05) at 120 and 140 minutes and lower blood glucose levels at 30 minutes postfeeding than similar horses receiving the same dose of feed via nasogastric tube.21,29

Parenteral Nutrition

Although it is possible to meet the daily caloric and amino acid requirements of an adult horse, the technical and financial obstacles are much greater than rehabilitating a patient using oral voluntary consumption or tube feeding and hence rarely implemented in horses under the care of humane shelters or rescue leagues.30,31

Amount and Frequency of a Refeeding Plan

Beginning digestible energy (DE) intake is based on current (not optimal) BW of the patient using the National Research Council (NRC) 2007 minimum maintenance (low voluntary activity) equation: DE Mcal/day = BW<sub>kg</sub> × 0.03.32 It is recommended that several transition days be used initially to bring the patient up to this initial minimum DE goal, i.e., 3–4 days for a BCS 3 horse vs 6–10 days for a BCS 1 horse using a low NSC feed (Table 1). In addition, the daily amount of feed should be initially divided into multiple feedings per day, again depending on BCS, i.e., 3 meals/day for a BCS 3 horse vs 6 meals/day for a BCS 1 horse. The amount of feed consumed (feed in – feed out) should be re-
corded and consumption as a percentage BW should be calculated (total kg of feed consumed per day/BW kg) and reviewed frequently in the early phases of rehabilitation. Ration DE, protein, NSC, fat, and crude fiber concentrations are suggested by BCS (Table 1).

Example: A 14-year-old mare with BW 314 kg, BCS 2 with moderate muscle wasting.

**Step 1**
An initial daily minimum DE goal would be 9.4 Mcal/day (314 kg x 0.03), using a 4–6-day transition period to reach that minimum and with each days’ feed total divided into 4 meals/day using a MMG hay (with 2.1 Mcal/kg, 12% protein and 12% NSC) (per Table 1; BCS column 2), the initial feeding plan would be as follows (Table 2).

**Step 2**
If the mare consumed 4.5 kg of hay on day 4 (1.4% BW) and if there were no complications, the daily DE intake should be increased (1.2 x) to 11.3 Mcal/day fed in 4 or 3 meals/day depending on her clinical response. So the daily feeding orders at this point would be 5.3 kg MMG hay/day (1.7% BW) divided into 3 meals of 1.8 kg/each.

**Monitoring**
Body weight should be measured weekly using a weigh scale rather than a weight tape. It should be expected that weights may initially decrease or not change during the initial feed transition days to full DE intakes or may increase due to rehydration and increased gut fill.**33,34** Hence, it will be several weeks before a pattern of weight gain can be discerned and considered reliable. Minimizing energy losses by attempting to maintain the horse in a near neutral thermic environment and/or use of light feed may be helpful.

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**Table 1. Refeeding Plan for Horses Based on Initial BCS and Laboratory Data**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>BCS</th>
<th>1</th>
<th>2</th>
<th>&gt;3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Examination</td>
<td>BW % of optimal</td>
<td>70% or less</td>
<td>75 to 85%</td>
<td>85 to 95%</td>
</tr>
<tr>
<td>Muscle loss</td>
<td>Severe</td>
<td>Moderate</td>
<td>Mild</td>
<td></td>
</tr>
<tr>
<td>Lab Data*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBC</td>
<td>RBC, Hb, Lympho</td>
<td>Low</td>
<td>Low</td>
<td>Normal</td>
</tr>
<tr>
<td>Serum bio chem</td>
<td>Proteins</td>
<td>Low</td>
<td>Low normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Lab Data*</td>
<td>Glob alpha 1</td>
<td>High</td>
<td>High</td>
<td>Normal</td>
</tr>
<tr>
<td>Glob alpha 1</td>
<td>&lt; 15 mg/dL</td>
<td>Low</td>
<td>High normal</td>
<td>Normal</td>
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<tr>
<td>TG</td>
<td>FFA</td>
<td>High</td>
<td>High normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>Alk Phos</td>
<td>Low</td>
<td>High normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>Na, Cl, K, Ca, P, Mg</td>
<td>Below or low normal</td>
<td>Low normal</td>
<td>Normal</td>
</tr>
<tr>
<td>SI integrity</td>
<td>Poor</td>
<td>Moderately weakened</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>LI microbe</td>
<td>Hydration</td>
<td>✓</td>
<td>✓</td>
<td>pm***</td>
</tr>
<tr>
<td>Fluid therapy to correct w/o glucose</td>
<td>Acid base</td>
<td>✓</td>
<td>✓</td>
<td>pm</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>✓</td>
<td>✓</td>
<td>pm</td>
<td></td>
</tr>
</tbody>
</table>

**Refeeding Plan**
- Water: IV stabilization then free choice
- Salt / TM block: IV stabilization then free choice
- Digestible energy intake goal after transition days:
  - Min DE = 0.03 BW kg
  - x 1.3 after 6–10 d
  - x 1.2 after 4–6 days
  - x 1.1 after 3–4 d
- Meals/d for min DE: 6 meals/d
- Consumption (% of BW): 1.5 to 2.0%
- Ration composition Ration Ranges:
  - DE: 1–4 Mcal/kg DMB
  - Protein: 8–30% DMB
  - NSC: 10–50% DMB
  - Fat: 5–20% DMB
  - Fiber: 5–25% DMB
- BW gain: 0–1 lb/d
- Weeks to optimal BCS: 30–40

**Table 2. A 14-Year-Old Mare With BW 314 kg, BCS 2 With Moderate Muscle Wasting**

<table>
<thead>
<tr>
<th>Target</th>
<th>Day 1 (25%)</th>
<th>Day 2 (50%)</th>
<th>Day 3 (75%)</th>
<th>Day 4 (100%)</th>
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</thead>
<tbody>
<tr>
<td>DE, Mcal</td>
<td>2.5</td>
<td>5</td>
<td>7</td>
<td>9.4</td>
</tr>
<tr>
<td>MMG hay, kg</td>
<td>1.2</td>
<td>2.4</td>
<td>3.3</td>
<td>4.5</td>
</tr>
<tr>
<td>MMG hay/meal, g</td>
<td>300</td>
<td>600</td>
<td>830</td>
<td>1100</td>
</tr>
</tbody>
</table>

* After correcting hydration.
** Dry matter basis.
*** As needed.
3. Results

There are a limited number of studies available by which to estimate progress in these equine cases. Broad estimates of average daily weight gain and weeks to achieve an ideal BCS of 4 or 5/9 are estimated in Table 1.2,3,10,12,32

4. Summary

The objective here was to propose a nutritional rehabilitation plan for low-BCS horses1–3 due to simple (uncomplicated) starvation based on initial BCS and laboratory data to help rescue organizations and shelters assess the resources needed to rehabilitate such a patient. As in medicine, each case is unique. Veterinarians employed by or assisting equine shelters should not hesitate to consult with a veterinarian nutritionist, given various case complexities and limited feed options available to some shelter groups may not fit well into this proposed refeeding outline.

Acknowledgments

Declaration of Ethics

The Author has adhered to the Principles of the Veterinary Medical Ethics of the AVMA.

Conflict of Interest

The Author declares no conflicts of interest.

References and Footnotes


25. Remillard RL, Guerino F, Dudgeon DL, et al. Intravenous glutamine or limited enteral feedings amelioration of small...


*Vitamin B Complex 150 Injection, Henry Schein Animal Health, Dublin, OH 43017.

*NCS, nonstructural carbohydrate, which is starch plus sugar content of a feed. This term should not be confused with “low carb” or “low starch” or “low sugar” claims.


*SafeChoice Senior Horse Feed, Nutrena, Minneapolis, MN 55440.

*WellSolve W/G, Purina Mills LLC, St. Louis, MO 63166.