How to Feed Horses Recovering From Colic

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There is limited knowledge of the benefits and complications associated with different modes of nutritional support in horses recovering from colic, and recommendations on feeding management of these patients vary widely. In general, however, the mode of nutritional support will depend on the underlying cause of colic, whether or not complications arise during convalescence, and the horse’s appetite. Horses with simple colic (i.e., no specific diagnosis) can quickly return to normal feeding with no special dietary treatment needed during recovery. Water can be offered soon after resolution of large colon obstruction and, providing there is adequate gastrointestinal function, small and frequent feedings of high-quality forage or a low-bulk complete feed can be offered as soon as 3–6 h after surgery (or resolution of an impaction), with a return to free choice hay feeding after 24–48 h. A more conservative approach is indicated after small intestinal obstruction because of increased risk of ileus and complications associated with sites of enterotomy or anastomosis. Water should be offered after gastric reflux ceases, followed by small, frequent feedings of a soft diet, and then a gradual (2- to 4-day period) reintroduction to normal diet if clinical evidence of intestinal motility and transit of ingesta exists. Partial parenteral nutrition (~20–22 kcal/kg body weight/day) can be administered to horses with ongoing intestinal dysfunction (i.e., ileus, gastric reflux) and should be considered when the period of post-colic starvation exceeds 24–48 h. Author’s address: Middleburg Agricultural Research and Extension Center, Virginia Tech, 5527 Sullivans Mill Road, Middleburg, VA 20117; e-mail: rgeor@vt.edu. © 2007 AAEP.

1. Introduction

There is limited knowledge of the benefits and complications associated with different modes of nutritional support in horses recovering from colic, and recommendations on feeding management tend to be based on personal experiences and beliefs. A common practice is to provide only water (and/or IV fluids and electrolytes) during the early post-operative period, with a gradual return to normal feeding when there is clinical evidence of normal intestinal motility. It may be argued that this delay in post-colic feeding slows recovery and may, in fact, contribute to development of some post-operative complications including ileus. Indeed, in horses treated for surgical colic, there was a significant correlation between several serum biochemical indicators of negative energy balance and incisional complications, findings consistent with data from humans wherein nutrient deprivation delays wound healing, impairs immune function and increases morbidity and mortality in critically ill patients. Conversely, nutritional therapy in intensive care or post-operative patients decreases risk of complications, mitigates loss of muscle mass, improves wound healing, and shortens duration of hospitalization. These benefits of nutritional therapy are most evident in severely ill patients (e.g., sepsis, burn injuries) or those malnourished at the time of admission.
This paper discusses nutritional management of the colic patient, including methods for delivery of enteral and parenteral nutritional therapy and considerations for horses that have undergone colic surgery for small or large intestinal problems.

2. Nutrient Requirements

The nutritional requirements of horses after colic surgery or other gastrointestinal illnesses have not been determined. Primary considerations include requirements for energy (calories) and protein. In healthy adult horses at maintenance, daily digestible energy (DE) needs are calculated by the following formula: 

$$\text{DE (Mcal/day)} = 1.4 + [0.03 \times \text{body weight (kg)}] \text{ or } 32-33 \text{ kcal/kg body weight (BW)} \text{ per day}.$$  

In most situations, this DE requirement can be met if the horse consumes between 1.5% and 2.5% of its BW per day (on an as fed basis) as hay. However, the energy needs of hospitalized horses are probably much lower because of reduced energy expenditure. Pagan and Hintz\(^7\) reported that the DE requirement of healthy horses kept in stalls was 22-23 kcal/kg BW per day, or 70% of the DE needed by horses kept at pasture. This caloric requirement can be estimated by the following equation: 

$$\text{RER} = [21 \text{ kcal} \times \text{BW (kg)}] + 975 \text{ kcal},$$  

where RER is resting (or stall maintenance) energy requirement.\(^7\) Energy needs also may be lower during the early recovery phase because of feed withdrawal, wherein energy losses associated with digestion may be decreased by as much as 15-20%.\(^8\)

Conversely, energy demands may be increased by the underlying disease process (e.g., systemic inflammatory response syndrome [SIRS]) or the colic surgery procedure itself. Some human studies have shown that abdominal surgery increases energy needs by ~30%, whereas others have reported minimal change in energy requirements after gastrointestinal surgery, perhaps a reflection of the decrease in physical activity during hospitalization.\(^9\) On the other hand, septic complications can increase energy requirements by up to 50-100%.\(^10\) It is also possible that surgical trauma and disease states such as SIRS increase the energy needs of colic patients. However, in the absence of data on the effects of illness on the energy needs of horses, this author recommends that the caloric requirements of horses recovering from colic be based on the RER or stall maintenance equation (i.e., 22-23 kcal/kg BW/day). After 2-4 days of feeding at this level, there can be a gradual increase in the ration until true maintenance DE intake is achieved. This approach is consistent with the current trend in human clinical nutrition to slightly underfeed nonprotein calories to minimize risk of complications associated with overfeeding, particularly hyperglycemia and sepsis.\(^5,10\)

Protein requirements must be considered in light of caloric intake. When energy supply from carbohydrates and fat is limited, endogenous protein will be used for energy contributing to a loss of lean body mass. Therefore, in developing a nutritional plan, first ensure that minimal energy needs are met and then calculate protein requirements. For human patients, a protein:energy ratio of 0.8-1 g/40 kcal is suggested, equivalent to 0.8-1.0 g protein/kg BW/day.\(^11,12\) This protein requirement is similar to the crude protein (CP) requirement recommended for healthy adult horses, where CP (g) = 40 × DE (Mcal DE/day).\(^5\) For a 500-kg horse at maintenance that is consuming ~16 Mcal DE per day, this equates to 1.25 g CP/kg BW. Because the efficiency of digestion for most dietary proteins in horse feeds is ~70%,\(^6\) this level of CP will provide ~0.9 g available protein/kg BW/day. In the absence of data concerning protein metabolism in sick horses, the maintenance protein requirement is reasonable for nutritional management of colic patients. For parenteral feeding, an appropriate target is 0.6-0.8 g protein/kg BW/day (1 g/40-50 kcal), given the higher metabolic availability of amino acids administered through the intravenous route.\(^12-14\)

3. Modes of Nutritional Support

The three primary modes of nutritional therapy are (1) voluntary enteral feeding; (2) assisted enteral feeding; and (3) parenteral nutrition.\(^8,16\) In general, the mode of nutritional support is highly dependent on the underlying cause of the colic, complications that arise during convalescence, and the horse’s appetite. The preferred option is a controlled return to normal voluntary intake. Prerequisites are absence of gastric reflux, good intestinal motility, and a willingness to eat. Horses with simple colic (i.e., no specific diagnosis) rarely need special dietary management. Feed and water should be withheld during the colic episode, with resumption of normal feeding after abatement of colic signs. An evaluation of diet may be indicated when there is suspicion that diet or feeding practice contributed to the episode of colic. Some clinicians recommend the withholding of grain feedings for a few days to limit gas production in the hindgut. Horses recovering from intestinal surgery can resume feeding when there is clinical evidence of intestinal motility. Initially, the horse should be fed small amounts (e.g., 0.5 kg) of good quality forage (e.g., grass hay, alfalfa) four to six times daily, with a gradual increase in the volume of feedings over the following days, providing the horse tolerates the increase in feeding. Alternatively, the horse may be allowed to graze pasture for 20-30 min several times throughout the day or provided a highly digestible, low-bulk pelleted feed such as those marketed for use in old horses (senior feeds). Grains should be avoided for at least 10-14 days post-surgery (or colic) because of concern that an excess of starch may disrupt an already disrupted hindgut microbial community. Thereafter, grain or concentrate feeding can be resumed, starting at a rate of ~1 kg/day (for a 500- or 1100-lb horse) and increasing by no more than 0.5-0.75 kg/day. Voluntary intake should provide at
least 75–80% of the horse’s resting or stall maintenance DE requirements by the second or third day of feeding. For example, 75% of the RER of a 500-kg horse (~9 Mcal DE) would be met by the consumption of ~4 kg of first cut timothy hay that contains ~2.3 Mcal DE/kg (as fed). Although labor intensive, weighing the offered hay and the feed remaining in the stall is the only means to determine the adequacy of caloric intake.

More challenging is the nutritional management of anorexic or inappetant horses or horses with severe intestinal compromise that results in ileus and obviates enteral nutrition. Inappetant horses should be offered a variety of palatable feedstuffs, including fresh grass, in an attempt to stimulate intake. However, failure to consume at least 75% of stall maintenance DE requirements for >48 h is indication of initiation of nutritional support. Earlier intervention may be indicated for horses in poor body condition (body condition score [BCS] < 3) or a recent history of weight loss, old horses (>20 yr), horses with suspected or confirmed sepsis/endotoxemia, lactating mares or those in the last trimester, and ponies, donkeys, or miniature horses with documented hypertriglyceridemia (>500 mg/dl). Parenteral nutrition should be considered for horses with ileus and other intestinal conditions that prevent voluntary or assisted enteral feeding, particularly when the withholding of oral feeding is expected to exceed 48–72 h.

Assisted Enteral Feeding

Diet options for assisted enteral feeding include human enteral products, commercial pelleted horse feeds, and homemade recipes. Human formulations that have been administered to adult horses include Vital HN and Osmolyte HN. Because both formulas contain ~1 kcal/ml, a 500-kg horse will need 11–12 l/day of these products to meet stall maintenance energy needs. Both formulations are devoid of fiber, an advantage with respect to ease of administration. However, clinical experience has indicated that the administration of these diets increases risk of diarrhea and laminitis. A preferred option is to use a pelleted feed that contains a source of fiber, such as those designed for use in older horses. These and similar feeds contain ~2.6 Mcal DE/kg (as fed). Vegetable oils (0.25–1.5 cups or 75–375 ml/day) can be added to increase the caloric density of the ration. Alternatively, the alfalfa/dextrose/casein mixture first described by Naylor et al. can be used for enteral feeding. In healthy horses, the administration of this diet was reported to maintain body weight and serum biochemical parameters within reference limits. However, occasional diarrhea and laminitis were reported complications.

Pelleted feeds can be made into a slurry by soaking in water and mixing in a blender to reduce the size of feed particles. Intermittent nasogastric intubation or placement of an indwelling nasogastric tube can be used to facilitate feeding. An internal diameter of at least 12.5 mm (14 Fr) is recommended. The end of the tube should be open-ended, rather than fenestrated, to prevent the tube from becoming clogged. The tube should be positioned in the stomach rather than the distal esophagus to minimize risk of reflux of feed around the tube. The rate of diet administration should be gradually increased over a 3- to 7-day period. A suggested rate of introduction is to administer one quarter of the final target volume of feed on day 1, one half the total volume on day 2, three quarters the total volume on day 3, and the total volume on day 4 or 5. Ideally, the enteral diet will be administered in four to six feedings/day with no more than 6 l per feeding for a 500-kg horse. The horse must be monitored for signs of colic, gastrointestinal ileus, abdominal and gastric distension, and increased digital pulses. Ultrasonographic examinations may be useful for evaluation of gastric distension and intestinal motility. Development of gastric reflux, ileus, diarrhea, or laminitis suggests intolerance to enteral feeding and is indication to discontinue therapy or decrease the volume and frequency of feedings. In these horses, partial or total parenteral nutrition may be needed. Horses should also be monitored for development of complications associated with repeated or indwelling nasogastric intubation, including rhinitis, pharyngitis, and esophageal ulceration.

Parenteral Nutritional Support

A detailed description of methods of parenteral nutritional support is beyond the scope of this paper, and the reader is referred elsewhere for comprehensive discussion of this subject, including methods for preparation and administration of parenteral nutrition (PN) solutions. As with enteral nutritional support, the goal of PN is to provide calories and amino acids such that loss of condition is limited, if not prevented. Although there have been several reports of use of PN in colic patients, few studies have evaluated the clinical benefits of this mode of nutritional support. The exception is a study by Durham et al. that examined the effects of PN in 15 horses recovering from resection and anastomosis of strangulated small intestine. Carbohydrates and lipids are the primary sources of energy used in PN solutions. Amino acids are added to meet protein (amino acid) requirements. It is important to provide at least 100–150 nonprotein calories per gram of nitrogen in the PN formula to avoid the use of amino acids for energy. Because protein is ~16% nitrogen, the grams of nitrogen can be estimated by multiplying the grams of protein in the mixture by 0.16. PN solutions with and without lipids can be used (i.e., dextrose/amino acid or dextrose/lipid/amino acid mixtures). When the target daily energy provision is 20–22 kcal/kg/
day, a dextrose/amino acid mixture is suitable and has been successfully applied for PN support of post-operative colic patients.\textsuperscript{13,15}

Administration of PN solutions should be through a dedicated intravenous catheter, preferably one inserted into a large vein such as the jugular to minimize risk of complications associated with the infusion of hyperosmotic solutions. Alternatively, a double lumen catheter can be used, allowing the PN solution to be given through one port and medications and other fluids through the other port. The initial rate of PN solution administration should be only 30–35% of target calorie provision; the rate of administration can be increased by 25% every 6–8 h, provided that there are no complications such as development of marked hyperglycemia and glucosuria.

As with assisted enteral feeding, close clinical monitoring is imperative. Urine and blood glucose concentrations should be measured every 4–8 h because, in some horses, glucose intolerance, hyperglycemia and osmotic diuresis can occur. Serum blood urea nitrogen, triglycerides, and electrolytes should be monitored at least daily. Body weight should also be measured daily; maintenance of body weight will provide the best guide as to the effectiveness of nutritional support. Glucose intolerance (persistent hyperglycemia) requires a reduction in the rate of glucose administration and/or the administration of insulin.

Transition to Voluntary Feeding
As appetite returns (or when oral feeding is no longer contraindicated), small amounts of palatable (e.g., fresh grass) feed should be offered. If these feedings are tolerated, the level of tube or parenteral feeding can be gradually reduced as the provision of feed for voluntary consumption is increased. Nutritional support can be withdrawn when voluntary feed intake provides at least 75% of calorie and protein stall maintenance requirements.

4. Feeding Management of Specific Gastrointestinal Conditions

Small Intestinal Disorders
Disorders of intestinal motility are of primary concern after small intestinal surgery, particularly in horses requiring resection and anastomosis of the small intestine. Long-term complications include peritonitis, impaction, or leakage at the site of enterotomy or anastomosis and adhesion formation.\textsuperscript{25} There has been little study of the impact of post-operative nutrition on these complications, nor the effects of nutritional therapy on short- and long-term survival rates. There have been anecdotal reports that early application of enteral or parenteral nutritional support is associated with decreased incidence and/or severity of post-operative ileus, but few data are available from controlled studies. Durham et al.\textsuperscript{13,14} examined the effects of post-op-erative PN in 15 horses (vs. 15 control horses) recovering from resection and anastomosis of strangulated small intestine. These authors reported no beneficial effect of PN on time to first oral feeding, duration of hospitalization, costs of treatment, or short-term survival (up until 5 mo after discharge), although the PN protocol did confer improved nutritional status as reflected by lower serum concentrations of triglycerides and total bilirubin and higher concentrations of glucose. However, the duration and volume of post-operative gastric reflux were longer in the PN group than in the control horses, perhaps because of alterations in gastric and/or small intestinal motility. The authors concluded that further study of a larger number of horses is needed to determine the clinical benefits and possible harmful side effects of PN in horses recovering from small intestinal surgery.

The observations of Durham et al.\textsuperscript{13,14} notwithstanding, PN may be beneficial for the nutritional management of horses after small intestinal surgery, particularly for the first 24–72 h, when ileus or clinician preference dictates restriction of enteral feeding. Parenteral nutritional support is also advocated for horses with duodenitis-proximal jejunitis because of the protracted nature of the ileus and gastric reflux in these cases. A concern with the feeding of high bulk feeds, such as long-stem hay, in the early post-operative period is distension at the site of enterotomy and/or anastomosis. In horses with sutured esophageal wounds, a traditional hay-grain diet can result in development of fatal complications presumably because this high bulk diet promotes distension at the incision site, increasing the probability for wound dehiscence.\textsuperscript{26} On the other hand, horses with esophageal injuries that are sutured closed can make a full recovery if fed a soft diet (e.g., slurry made from pelleted feeds) for 8–10 wk after the injury.\textsuperscript{26} These findings may be applicable to the nutritional management of horses after small intestinal surgery. Enteral feeding should not be started until gastrointestinal function is adequate, as indicated by the presence of borborygmi and the absence of gastric reflux. A soft, low-bulk ration is recommended to decrease risk of anastomosis failure. Fresh grass (hand grazing) and mashes or slurries made from alfalfa pellets or pelleted complete feeds are suitable feedstuffs. Molasses may be added to the mash or slurry to enhance palatability of the ration. Small meals (0.5–0.75 kg) should be fed every 3–4 h, again in an effort to minimize physical stress at the anastomosis site. In uncomplicated cases of resection and anastomosis, there should be a gradual introduction to long-stem hay after 3–4 days of soft diet feeding. Bran mashes are not recommended for horses during the early phases of recovery from small intestinal surgery that required enterotomy and/or resection because of the aforementioned concerns regarding the possible adverse effects of high bulk feeds on the healing of incision sites.
Large Intestinal Disorders

Horses with impaction of the large intestine (cecum or colon) should not be fed until after resolution of the impaction. Fresh grass, alfalfa pellets, chopped alfalfa hay, and other sources of highly digestible fiber are preferred. It has been suggested that pelleted feeds may allow for increased rate of passage because of smaller particle size compared with long-stem roughage. Grain should be withheld until normal transit of ingesta is confirmed. A thorough oral examination should be undertaken to establish whether inadequate mastication of feed is an underlying cause of the impaction.

Diarrhea is a complication of all types of colic surgery, but the risk seems to be highest in horses undergoing celiotomy for large intestinal disorders.27 In one study, the risk for development of diarrhea after surgery was two-fold higher in horses with large intestinal disorders compared with horses with other lesions.27 There was a further increase in risk in horses that had an enterotomy. Conversely, horses fed grass hay were one half as likely to develop severe diarrhea as horses not fed grass hay. Horses should be fed small amounts of grass or soft grass hay at frequent intervals (every 2–3 h) as early as 12 h post-surgery, providing there is no evidence of gastric reflux or poor intestinal motility. First cut hay is preferred because of higher dry matter digestibility compared with more mature forages. No grain or concentrate should be introduced until 10–14 days post-surgery. However, the feeding of a low bulk pelleted feed may be beneficial during this period.

Long-term dietary modification is required for horses with extensive resection of the large colon but not when the cecum alone is removed. Bertone et al.28–30 showed that gastrointestinal passage time and fiber, protein, and phosphorus digestion are decreased after resection of >90% of the large colon. In one clinical report, chronic diarrhea, weight loss, and hypophosphatemia were complications of extensive large colon resection.31 With appropriate dietary management, however, these horses can maintain adequate body condition. In the early post-operative period, horses that have undergone extensive resection should be fed small amounts of a low-bulk feed such as alfalfa pellets or a pelleted commercial feed. Subsequently, legume forage should be the predominant component of the ration. After experimental colon resection, a ration of alfalfa hay or an alfalfa-timothy hay mix provided better results compared with straight grass hay, perhaps because of higher digestibility and protein content of the alfalfa-based rations.30 Supplemental phosphorus can be provided in supplement form or by feeding 0.5 kg wheat or stabilized rice bran daily. If additional calories are needed for weight maintenance, a “fat and fiber” concentrate rather than grain or sweet feed is recommended.

References


*Ross Laboratories, Columbus, OH 43215.
†Equine Senior, Land ‘O Lakes-Purina Feed LLC, St. Louis, MO 63141.