# Equine Therapeutic Nutrition II:

## Customizing an Enteral Nutrition Program for the Critical Care Patient

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**Introduction**

It is established that hypophagic or dysphagic horses can benefit from enteral nutrition.[1] However, conditions such as colitis, enteritis, hepatic disease, renal disease, neoplasia and post-operative recovery require different nutritional considerations.[2] Catabolic states that result from disease or surgical procedures often reduce the prognosis for recovery or unnecessarily lengthen the recovery period.[3] Customized nutritional support not only provides calories in the form of carbohydrates, fats and proteins, but it can address specific nutritional needs and help alter the disease process to promote healing.

Currently practitioners depend largely on ground pelleted feeds when enteral nutrition is deemed necessary. Pelleted feeds are able to provide adequate calories but fall short of providing specific nutrients that may be beneficial in certain patients. Human enteral formulas have been used with some degree of success.[4] However, these diets fall short in dietary fiber, are very high in fat and due to the volume of formula used are often cost-prohibitive. Customization of the feeding program provides much more flexibility to the practitioner in terms of devising a strategic approach to feeding horses in different disease conditions. This can be achieved in a simple and cost-effective manner.

The goal of this paper is to provide guidelines for the equine practitioner that will allow easy and cost-effective formulization of a component based critical care feeding program that can be customized to each horse's individual needs.

**Materials**

1. General Categories of Nutrients

Energy: Energy in the normal healthy horse can and should be supplied to a large extent by fat[5]. Fats (oils) are the densest forms of dietary energy, providing 9 calories per gram. Energy density is very important when designing an enteral nutrition program. However, in most critical care cases the energy requirements should be met primarily by carbohydrates (CHO). Even though CHO only provide 4 calories per gram, there are reasons for them to be chosen preferentially over fats. Horses that do not receive enough energy in the form of CHO will begin to catabolize muscle tissue and mobilize fat stores. This will result in a wasting syndrome clinically. Protein will be used for energy at the expense of anabolic processes. The by-products of this catabolic process (primarily urea and creatinine) place an extra workload on the liver and kidneys. This can be life threatening in many cases. Fat mobilization can result in a fatty liver syndrome in anorexic overweight equine patients, especially ponies[4]. Therefore, adequate CHO intake results in the two benefits of protein sparing and decreased and decreased fat mobilization. Adequate CHO intake should be provided early in order to prevent the catabolic process and the proverbial train going down the track in the wrong direction, which becomes difficult to stop as time goes by. A dense CHO source should be provided taking into consideration the hazards associated with too much too soon (laminitis and colic). Grain diets may not provide adequate CHO due to the fact that the CHO must be extruded in the digestion process. It is the authors' opinion that, in critically ill patients, CHO sources that require minimal processing are the most appropriate way to meet energy needs in patients that are already in a negative energy state at presentation. In horses that are not experiencing hepatic compromise, energy requirements can be addressed through the addition of vegetable fats to the enteral feeding program.

Protein: When supplying protein requirements, consideration must be given to quality as well as quantity. Without high quality protein, a normally adequate quantity can still result in a horse that is protein starved[5]. This will lead to continued catabolism of muscle to meet the protein needs, especially in the face of disease. High quality protein also reduces the amount of work required by the liver and kidneys, which is critical in many disease states[2]. Amino acid (AA) content and digestibility of the protein determines the quality of a protein. Certain amino acids are considered rate limiting such as lysine and threonine[5]. These must be supplied in the enteral diet. Other amino acids such as arginine, carnitine and glutamine contribute to glycogenisis. Arginine is also capable of accelerating wound healing and inhibiting the development of neoplasia. Carnitine, which is not an essential amino acid, stimulates protein synthesis in the face of stress and may accelerate fatty-acid oxidation, which lowers lactic acid production[5]. Carnitine has also been shown to reduce hepatic fat in several species. Glutamine is a non-essential amino acid that has received attention lately in human literature. Glutamine acts as an important energy source for the enterocytes of the entire intestinal tract and renal cells. In humans it has been postulated that during periods of stress glutamine serves as the primary precursor for glutathione,

a powerful antioxidant[6]. It has also been suggested that glutamine shortens recovery periods in surgery and critically ill patients[7]. Supplementation of the enteral feeding program with individual AA's can be therapeutic in a wide variety of disease states.

Fiber: Fiber is the hardest type of nutrient to supply a horse through a feeding tube. A reasonable goal for an enteral program is 25% of estimated need. Fiber is not soluble, so the particle size must be small enough to be suspended in the liquid meal and pass through the delivery system. As much as possible needs to be given to provide mechanical stimulation of the digestive tract.

Vitamins: Vitamins are organic nutrients that are essential for normal metabolism. Well-balanced horse feeds contain enough vitamins so that frank deficiencies are not as common as in the past. However, critically ill equine patients may be in need of vitamin supplementation in order to replace depleted vitamins, overcome ingredient deficiencies, or to address increased metabolic demands. Supplemental sources should be critically evaluated for quality as well as quantity.

Minerals: Though often overlooked, minerals and trace minerals are extremely important in the critically ill patient. Minerals act as cofactors for enzymes for almost every reaction in the body. Everything from immune system function, to bone density, to protein, fat and CHO metabolism is affected by mineral deficiencies. Mineral supplementation should be critically evaluated. The authors suggest amino acid chelated minerals, due to the increased bioavailability of these formulations. Other organic complexes (citrates, gluconates, and lactates) have a higher biological value than the inorganic complexes (oxides, carbonates) with sulfates being in the middle. Unless minerals are supplied in the correct balance and form, minimal benefit will be obtained by supplementation.

2. Specific Ingredients

Pelleted Feeds: Pelleted commercial feeds may provide the simplest method by which to deliver some enteral nutrition. This is due to the fact that as a feed it is formulated for balance and completeness. It provides a balance of protein, CHO, some fat, vitamins, minerals as well as some fiber. Vegetable oil is often added to create a pellet-oil slurry in water that can be passed through a nasogastric (NG) tube. Pelleted feeds are nutrient dense and make meeting calculated daily needs relatively easy. Pelleted feeds must be pulverized dry in a kitchen blender and mixed with oil and water just prior to feeding. If liquid is mixed with the feed too long the cellulose will swell making administration difficult. Pelleted feeds were not designed to be soluble or suspendible and may be time consuming and frustrating. They were also balanced for the average healthy horse. A complete feed may be inadequate for the critical patient and does not allow for the customization of a component program.

Liquid Preparations: Human health care products such as Ensure®, Osmolite®, and Vital HN® have been used with some success in equine enteral feeding programs. These are easily administered via a NG tube due to a relatively low viscosity and no particulate matter. These diets have very little fiber content and may be cost prohibitive due to the large volume that must be fed. Liquid diets should be evaluated closely in light of metabolic conditions, being careful to choose diets that are not contraindicated in certain disease states. Many liquid products rely heavily on fat as an energy source (9-30%). Fat is contraindicated in many critical patients. Some solids need to be added to the feeding program at the appropriate time to properly stimulate the digestive tract.

Ground hay: Fiber may be provided from several sources such as powdered fiber supplements for people (not economical), fresh grass clippings, grinding baled hay, soaking hay cubes, or commercially ground or mealed hays. Larger particle sizes are more physiologically valuable, but in this case must be sacrificed so that more total fiber may be reasonably delivered. You will be able to deliver more with the commercially mealed hays than with other forms. Since the total amount will be limited, it is best to use the available source that is the most nutrient dense. This is alfalfa meal in most areas.

Corn meal not wheat flour: The authors have found that the most economical way to add a grain component (considering particle size) is to use corn meal from the grocery store. This form of corn meal is fortified with vitamins and minerals, has a very small particle size, will not "paste-up" in solution, is packaged in convenient sizes and is cheap. As long as an accurate estimation of need is used, the risk of excess fermentation and colic is limited. The same is not true of wheat flour. Even though flour is of a smaller particle size, it is not a good choice for an equine feeding program. Wheat is highly fermentable and the authors have seen signs of colic using relatively small amounts. When at the store, make sure to purchase corn meal not corn meal mix. The latter contains almost half wheat flour. The other advantage to corn meal is that it is only approximately 1.5% fat. By leaving the fat out, a greater opportunity for customization exists.

Whey: The authors have found whey (not whey protein concentrate) to be an extremely useful ingredient in the enteral feeding programs of several species. Whey ranges from 60-70% lactose and 7-11% protein. Lactase should be added to the whey to produce equal amounts of glucose and galactose from the lactose (see **Formulas Used**). Both of these

simple sugars are very good sources of carbohydrate energy and are readily absorbed high in the small intestines. They do have different absorption rates so there is an advantage over feeding straight table sugar. Since absorption occurs high in the digestive tract, the authors have not experienced signs of excess fermentation or colic when using this ingredient. The protein found in whey is of extremely high biological value. It is easy for the body to digest and utilize and the authors have used this protein source in the face of very depressed hepatic function, elevated blood ammonia levels, and hepatic encephalopathy. Whey is completely soluble in water. Whey is also only 1% fat, which leaves maximum room for customization.

Oils: Oils are an excellent way to provide fat to the enteral diet. One cup (8 ounces) of vegetable oil contains the energy equivalent of 3.5 cups of corn or 6 cups of oats. Animal fats such as tallow are between 88-92 percent digestible. Plant sources of fats such as corn oil or soybean oil are up to 94 percent digestible by the equine digestive tract. Horses have been found to prefer corn oil over other oils.[5] Oils are also an excellent source of fatty acids which are essential in many metabolic processes. Oils such as safflower oil, olive oil, and canola oil have high contents of omega-3 and omega-6 fatty acids. Currently the benefits of supplementing fatty acids in horses are unclear. Corn oil is the most cost effective way to add energy from fat into an enteral feeding program. The rule of thumb is that an adult equine patient (with no metabolic contraindications) can readily tolerate one quart of vegetable oil per day (divided between at least two meals).

Amino acids: There are oral veterinary products that supply a combination of purified AA's in a dextrose solution. For individual AA's in significant amounts, health food stores may be the most convenient last minute option. Equine supplement manufactures market a variety of products that may be incorporated into a support program.

Vitamins: Addition of individual vitamins is not usually recommended. General supplements are more economical and are usually closer to a proper balance than a collection of individuals. Vitamin supplements usually also include minerals.

Minerals and trace minerals: A good general supplement will provide a wide variety of minerals, trace minerals, and vitamins. Commercial equine supplements are available in powder form and most are at least suspendable in an enteral program. The quality level of the mineral components is often marginal though. Grinding tablets, opening capsules, or utilizing a human liquid supplement may be economical alternatives when the amount of bioavailable nutrients provided is considered. Electrolyte mineral levels should be monitored via bloodwork, and individual supplementation, either oral or by injection may be required.

Antioxidants: Vitamins, minerals, and other molecules which act in the body to scavenge oxygen radicals are antioxidants. Most patients that need nutritional support will benefit from a high level of dietary antioxidants. Antioxidants should be supplemented as a group instead of high levels of individual ones, due to the fact that any antioxidant can act as a pro-oxidant if present in high enough amounts.

Salt: The thumb-rule for salt (NaCl) requirement in an adult horse is 30 grams per day (approximately 1 tablespoon). Even though the other ingredients in a program will contain some salt, the authors add the full requirement as straight salt due to the high margin of safety and probable increased losses in most cases requiring enteral nutrition.

Pre- and probiotics: Prebiotics are ingredients that when provided to the digestive tract selectively support the growth of beneficial bacterial species over pathogenic ones. Prebiotics do not directly colonize the digestive tract. Prebiotics include yeast, yeast cultures, fungal cultures, and certain fibers (FOS-fructooligosaccharides). Probiotics are the actual bacterial species that, when introduced to the digestive tract, actually colonize and produce beneficial effects. Synbiotics are products that contain both prebiotic and probiotic ingredients. Ingredients of this type are very important to include in a nutritional support program. When normal dietary intake is interrupted, changes in the balance of normal digestive tract flora occur. Especially when the intake of fiber is reduced, support of the beneficial bacterial species is vital to the health and function of the digestive tract.

N-acetyl-D-glucosamine: A structural component of all mucosal surfaces. Supplementation with N-acetyl-glucosamine may help firm up the structural matrix of the intestinal tract. Though glucosamine appears to be highly absorbable, N-acetyl-glucosamine is directly incorporated into the intestinal mucosa and is not absorbed when provided orally. This improves the overall health of the intestinal tract under stress thereby contributing to its healing and increased absorption of other nutrients.

**Methods**

1. Delivery

Initiation of Feeding: The authors do not feel that a set amount of time needs to pass before enteral nutrition support is started. Some amount of support can be provided in almost all situations, except for complete GI obstruction or the presence of reflux through the nasogastric tube. In the case of the mechanically dysphagic patient, with no metabolic or

GI concerns, 25% of maintenance can be provided the first day with an increase of 25% each day in the absence of colic signs. The rate of increase should be slowed according to metabolic and GI tolerances in other cases. GI surgery cases can be fed the completely soluble (no particulate matter) components of the program almost immediately post surgery.

Volume limits: An appropriately designed program can provide an adult equine patient (with normal hepatic function) full maintenance calories and 80-100% of maintenance protein at a very reasonable cost. These nutrients can be delivered in 2 feedings of 2 gallons each. This frequency and quantity can be easily done with few complications due to tube placement in both ambulatory and hospital settings. More frequent, smaller feedings are slightly preferred and can deliver extra nutrients, but are not necessary in most situations.

Solubility: Selection of highly soluble ingredients is very important to a successful enteral feeding program. A limited amount of suspendable (not soluble) material may be included. This should be limited to the fiber portion as much as possible so that the maximum amount of fiber is included. Depending on how fine a grind is used, approximately 2 pounds of grain and 2 pounds of roughage can be provided in 2 feedings of 2 gallons each. The other components of the program need to be highly soluble. The contents should be continuously agitated and can pass through a bilge pump, funnel and stomach tube easily, but may be a problem with the smaller stomach pumps.

2. Estimating Needs and Amounts Delivered

Tables: The National Research Council's (NRC) publication of the Nutrient Requirements for Horses[8] has tables listing the required amounts of energy, protein, forage, vitamins, and minerals. The tables list different requirements for several age, weight, and reproductive situations. The requirements are listed in the same units as most guaranteed analysis for commercial feeds. The NRC also has tables of analysis for most common feed ingredients. If a guaranteed analysis is not available for the specific product you are using, these tables will provide a good estimate of the nutrient amounts being provided.

Formulas: The NRC formulas used to develop the tables mentioned above are also available. Using the formulas will provide a much more accurate estimate of nutrient needs because the actual weight of the patient can be input. As an example, the formulas for several major nutrients for an under 200 kg lactating mare have been included (see **Formulas Used**). The basic formulas for maintenance requirements are adjusted for age, sex, weight, growth rate, activity level, gestation, and lactation. The starting point for estimating electrolyte needs should be calculated using the formulas. However, since metabolic conditions greatly effect individual needs, laboratory analysis of blood samples will heavily influence the appropriate amount to deliver.

When calculating the amount of protein deficit in a feeding program, the authors recommend including a protein adjustment factor. The NRC formulas assume a protein digestibility of 55%. Most of the ingredients of an enteral support program are much more bioavailable than this. Single amino acids, amino acid complexes and special protein sources such as whey will be adjusted upward the maximum amount of a multiple of 1.8. The amount of calories provided via IV dextrose infusion should be calculated as amount of dextrose provided in grams * 3.4 calories. Whenever possible, the guaranteed analysis of individual ingredients should be used to calculate their nutrient contribution.

Spreadsheets: The formulas mentioned above can be used in the most basic computer spreadsheet program to estimate daily nutrient requirements, daily nutrient intake, and the difference between the two. Once the basic spreadsheet is designed, it is very easy to adjust the formulas to create new sheets for subsequent cases having different requirements.

3. Examples of Special Metabolic Needs

Hepatic dysfunction: High quality protein is essential in order to prevent increased levels of circulating ammonia leading to hepatic encephalopathy. Protein should contain branched chain amino acids to prevent further ammonia formation.[2] Glucose should be provided through the diet in order to prevent the need for hepatic glucose synthesis.[2] Dietary fat should be reduced to the lowest possible level to decrease hepatic lipidosis and the amount of processing the liver must perform to make energy available to somatic cells.

Renal dysfunction: Since horses excrete calcium via the kidneys, calcium levels should be monitored and adjusted accordingly in the enteral diet. As with hepatic disease protein should be of the highest biological value to prevent ammonia accumulation.

Digestive tract disease: As a general rule small intestinal disorders require more fiber to maximize large intestine fermentation along with highly digestible protein.[2] Glutamine should be incorporated to meet increased energy needs of the enterocytes in diseased or stressed states. In large intestine disorders pre- and probiotics are beneficial in re-colonizing depleted microbe numbers. Electrolytes should be carefully monitored with bloodwork in diarrhea cases and adjusted (both enterally and parenterally) accordingly. Horses with diarrhea may benefit from probiotics, glutamine and N-

acetyl-glucosamine. Protein losing enteropathy should be aggressively addressed by providing large amounts of high biological value protein. Colic signs should be closely monitored as feedstuffs are reintroduced to the diseased equine digestive tract.

**Results**

In the clinical setting, component based feeding has been encouraging in the hands of the authors. Simple diarrheas have responded well to treatment with a combination of glutamine, pre- and probiotics, N-acetyl-glucosamine, arginine and carnitine. In one horse with diarrhea secondary to heavy parasitism, response was seen within 12 hours of administration. This combination has been used in all ages from newborns to the geriatric. Hypoproteinemic and anemic cases have responded well with this combination along with the addition of whey (lactase incubation) and a liquid vitamin/mineral supplement. Administration to newborns that are hypoglycemic is very encouraging. Horses that are not hypophagic have ingested top dressed supplemental nutrients well. Some of the lower quantity nutrients may also be syringe fed.

Example Cases: Two specific cases can be used to highlight the flexibility of a customized enteral nutrition support program. The first was a 100 kg, lactating, hyperlipemic miniature horse that was successfully fed and left the clinic still lactating. This case had several difficulties to overcome: triglycerides > 2000 mg/dL (so dietary fat had to be severely limited), hepatic encephalopathy (protein had to be of the highest quality and limited quantity), small body size (small meal sizes and delivery tubes), and lactation (greatly increases requirements for energy, protein, and other nutrients; owner was unwilling to wean foal)[a] . The second was an 800 kg warmblood gelding with no symptoms except facial and glossal paresis. This gelding was economically maintained until enough coordination returned so that he could eat normally. A very basic set of ingredients was adequate to treat both extremes.

**Discussion**

The goal of this paper is to provide guidelines for the equine practitioner that allow easy and cost-effective formulization of a component based critical care feeding program that can be customized to each horse's individual needs. Enteral feeding of critically ill equine patients can be challenging, due to the vast spectrum of needs that should be addressed. These needs are effected by both the specific disease and its duration. Traditionally, equine practitioners have relied heavily on diets that may fall short of nutrient requirements for critically ill patients or they provide no nutritional support at all. By using a component based feeding program practitioners can customize enteral diets to meet the needs of their critically ill equine patients. This allows for a large range of flexibility in nutritional support that is not currently utilized. Addressing nutritional needs more specifically in critical equine patients may improve prognosis and decrease hospital stays. There is a trend in human medicine to provide enteral nutritional support as soon as possible to avoid ischemic ulcers. These ulcers occur due to a lack of blood flow to the unstimulated digestive tract.

**Formulas Used to Calculate Rations**

Requirement formulas from the 1989 NRC Nutrient Requirements for Horses will provide a good estimate of requirements. The following uses the formulas for an under 200 kilogram, lactating mare, foaling to 3 months category. Body Weight (BW) is in kilograms.

Estimation of digestible energy (DE) requirements (Mcal of DE/d)
DE = (1.4 + .03BW) + (.04BW * .792)

Estimation of crude protein (CP) requirements (g/d)
CP = {(40 * Mcal of DE/d) + [(.04BW * .021 * 1000)/.65]} / .55

Estimation of calcium (Ca) requirements (g/d)
Ca = (.04BW) + [(.04BW * 1.2) / .5]

Estimation of magnesium (Mg) requirements (g/d)
Mg = (.015BW) + [(.04BW * .09) / .4]

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**Disclosure:** J. Eric Martin, D.V.M. is V.P. of Research and Development and David F. Davenport, D.V.M., M.S. (Ag. Econ.), M.S. (Nutr.), C.N.S. is CEO of MD's Choice, Inc which sells individual and combined nutrients that are used in feeding programs such as those described in the above paper.

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