Gut Health and Surgery

Achieve and maintain
GI health in horses
pre- and post-surgery

freedom health llc

By Freedom Health, LLC

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Introduction

This article summarizes evidence-based research that will contribute to the veterinarian's understanding of what can be done to optimize GI health of the horse requiring surgery. Achieving and maintaining a high nutritional plane with a high-functioning gut microbiota of the clients' horses may be the biggest challenge, but it is also one that can be rewarding for both the vet and the client. Increasingly the practitioner's business is shifting to one of prevention and not solely one of treatment. This paper discusses some of the things that can be done to improve post-surgical outcomes and recovery of the surgical horse, focusing on the GI tract.

Most everything associated with surgery is stressful, and stress is an enemy of the GI tract. There are many stresses associated with surgery that can have a negative impact on GI health. One should wonder that the incidence of post-surgical complications is not higher than it is, and this speaks to the very high quality of care provided in modern equine surgeries (Freeman, 2018; Potenza et al., 2020).

The more severe the surgery, the greater the impact on GI health and the more challenging the effort required to restore a healthy GI tract. The focus of this paper is on the more severe surgeries, particularly colic surgery, and the strategies that can be tailored to meet different types of surgery. This is important because of the relationship between the intestinal microbiota, gut health and immune health, the gut-brain axis (Bulmer et al., 2019; Mach et al., 2020), and the gut-muscle axis (De Graaf-Roelfsema, 2014).

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Factors Contributing to Stress in the Peri-Surgical Horse

Cortisol is the primary stress hormone and the end product of the hypothalamic-pituitary-adrenal (HPA) axis. It upregulates glucose metabolism, providing the horse with the energy needed to respond to stressors. Thus in the short term, cortisol is adaptive and beneficial (Karaca et al., 2021). Cortisol is detectable in both saliva and blood, although the levels are highly variable, especially in saliva. However, some vets use blood cortisol levels to monitor endocrine disorders such as Cushing's, a disease marked by persistently elevated cortisol levels. Chronically high levels of cortisol compromise gut integrity and immunity and may affect recuperation.

Acute and chronic responses are cardiovascular (chronotropic and inotropic effects), metabolic (increased energy demands), and immunity, producing adaptation to cope with the stressors (Ortega et al., 2021). The downstream effects of stress may impact the GI tract (Łoś and Waszkiewicz, 2021) because most stresses result in altered feeding, increased gastric acid production, and altered digesta transit duration (McGreevy et al., 2001). These, in turn, have effects on the gut microbiota, altering the proportions of beneficial and detrimental microbes in one or more regions of the cecum and large intestine (Destrez et al., 2019; Garber et al., 2020). The stress associated with surgery may include one or more of the following:

- Pain which leads to altered behavior, increased gastric acidity, altered feeding and drinking, and the need for analgesics, all of which, in turn, will have some impact on GI health
- Analgesics used to relieve pain
- Transport to surgical facilities, particularly transport of more than 1 hour in duration
- Level of care and quality of the environment at the clinic
- Dietary alterations, including grains, forage, water, and supplements
- Anxiolytics and sedatives
- General anesthetics
- Antibiotics
- The nature of the surgery itself, i.e., intestinal vs non-intestinal
- The post-surgical environment and level of care



Pain

The need for surgery is often associated with pain, whether it is an abdominal pain associated with colic, laminitis, degenerative joint disease, or bowed tendon (Guedes, 2017). Pain produces a physiologic cascade of effects that is initially associated with an increased sympathetic tone (increased production and release of norepinephrine). Accordingly, there is an increase in cardiac output, stroke volume, and systemic vascular resistance which increases the work of the heart. This is often associated with altered breathing. GI effects include decreased GI motility and tone, and can result in ileus (temporary cessation of peristalsis). Even acutely there is an increased breakdown of fat and protein in the body, which results in decreased healing and the retention of sodium and water in the body. Inadequate analgesic is associated with increased morbidity and mortality in horses and for this reason pain usually needs to be treated.

Analgesics

Effectively treating pain without causing negative side effects is very challenging for the equine practitioner. Horses suffering from both acute and chronic pain are often administered nonsteroidal anti-inflammatories (NSAIDs, such as phenylbutazone or flunixin) or kappa opioid agonists such as butorphanol (Guedes, 2017; Mama and Hector, 2019; Rangel-Nava et al., 2019). Side effects of NSAIDs include gastrointestinal disease (such as stomach ulcers, colonic ulcers, and diarrhea) and kidney damage. The negative effects of analgesics on the GI microbiota are significant within 10 days (Whitfield-Cargile et al., 2018). The risk of side effects is greater in sick or dehydrated horses. Clinical signs of analgesic toxicity include loose droppings, colic, ulceration of the gastrointestinal tract (seen as low protein and/or anemia on blood work or as ulcers on an endoscopic examination), poor hair coat, increased drinking or urination, and weight loss (Andrews et al., 2009). Detrimental effects of bute (phenylbutazone) on the dorsal colon (McConnico et al., 2008) and stomach (Reed et al., 2006) can be evident within three days of administration and clinically significant by 10 days.

Effective treatment of severe, acute pain is necessary. However, the science now shows that minimum amounts and durations of analgesic drug use are best because of the negative side effects. Chronic pain management is beyond the scope of this paper, but it is worth pointing out that novel nutraceutical approaches may be associated with a significant reduction of negative side effects (Gugliandolo et al., 2020).



Transport

The horse in transport is a horse that is performing continuous exercise to maintain posture and balance while in motion. Research has shown that horses in transport can lose three or more gallons of fluid per hour though increased sweating—which contributes significantly to dehydration (for review see Lindinger, 2008). Dehydration is a major contributor to the development of impaction-type colics, and this should be avoided by provision of nasogastric and/or i.v. fluids (with electrolytes) before and after transport for horses that are not drinking. Transport itself has been shown to be a contributor to alterations in the gut microbiota that are associated with dysbiosis (Schoster et al., 2016). Whenever possible, transport the horse in the cooler parts of the day, minimizing transport duration, and in very ill horses one can provide i.v. solutions while in transport.

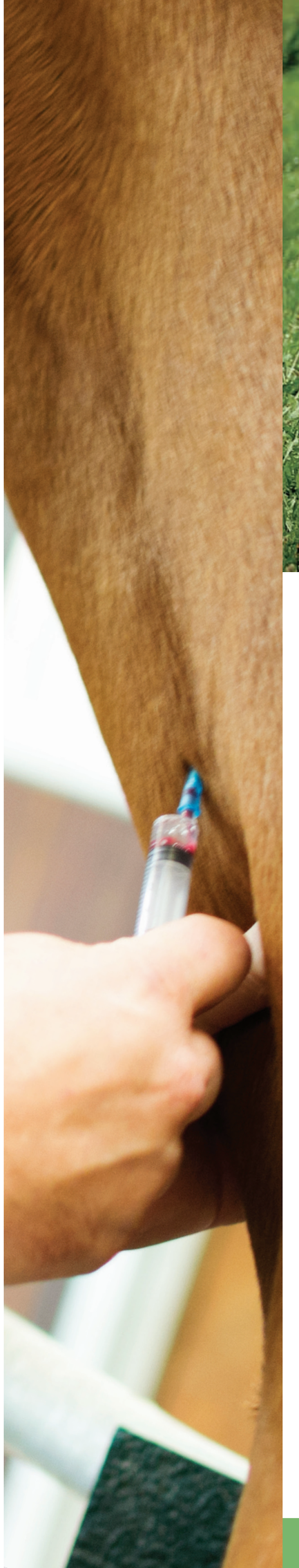
Level of Care and Quality of the Environment at the Clinic

The equine clinic is a new environment for the horse, and for many it is a scary environment with new, scary people. The level of associated stress may be high, which can put the horse off feed and water. Anxiety and stress can be managed with the provision, prior to or during transport, of natural anxiolytic products that do not have negative effects on the GI microbiota. This is as important as pain management and helps with a return to eating (if permitted) and drinking.

Anxiolytics and Sedatives

A calm horse is very important for the safety and well-being of the animal and that of all personnel working around it. Thus, people handling the horse should also be calm and reassuring. In acute situations, anxiolytic or sedative medications may be warranted, but should be discontinued as soon as practical because of negative effects on the GI microbiota. Anti-anxiety drugs such as clomipramine (Clomicalm) and fluoxetine (Prozac) reduce the re-uptake of the chemical serotonin in the brain. The increased serotonin provides a feeling of comfort and happiness. Sedatives are usually used for short veterinary procedures, and include xylazine (Rompun), detomidine (Dormosedan), and romifidine (SediVet). Buspirone appears to provide some level of protection of the GI microbiota according to a recent study in mice (Kim et al., 2021), and may be considered for use in the horse. In a long-term human study, the authors reported that sedatives, but not anxiolytics, had detrimental effects on the gut microbiota (Bastiaanssen and Cryan, 2021). In addition, horses that have been administered sedatives may be unaware of their surroundings, but there is still a risk of reactions like kicking and biting when being handled.

Many commonly used drugs for sedation and anti-anxiety have significant side effects, and some other drugs are used off-label for this purpose. As a result, many horse owners are using high-quality nutraceutical





supplements to calm the horse. The most commonly used supplements are magnesium, vitamin B1 (thiamine), valerian root extracts, Passiflora incarnata extracts, and other natural ingredients. While natural does not always mean better, a high-quality natural anxiolytic is less likely to be associated with negative side effects and negative effects on GI health (Wynn and Fougère, 2007).

Dietary Alterations (Grains, Forage, Water, Supplements)

Abrupt dietary alterations, such as occurs upon injury, pain, transport, and introduction to a new environment are a major contributor to colic. As much as possible the horse requiring surgery should receive adequate forage frequently through the day, and this will also help ensure regular drinking behavior. While grains may be contraindicated, provision of hay should continue until surgical procedures require they be discontinued. Most clinics provide a good-quality forage—this is necessary for supporting healthy intestinal motility and a healthy microbial environment. Some clinics may recommend that the horse arrive with its own forage, feeds, and supplements. This can be very helpful in trying to maintain a normal feeding routine for the horse and its gut environment. It is also important that the water is free from chlorine, whose antibiotic effects are detrimental to the healthy gut microbiota. This is often achieved by passing the local water through an activated charcoal filtration system. In addition, there is typically a fasting period of 12 hours or more prior to surgery, and this contributes to alterations in intestinal microbiota (Schoster et al., 2016). The best way to minimize the negative effects is to be proactive during the pre-surgical period.

General Anesthetics

In a recent study, Weese's group simulated the effects of transport, diet change, environment change, and anesthesia (without surgery), and evaluated their separate and combined effects on the GI microbiota (Schoster et al., 2016). Research horses were transported for one hour to the clinic, then the next day were fasted overnight prior to a six-hour period of maintained anesthesia. After six hours of recovery from anesthesia, the pre-anesthesia feed was reintroduced. Fresh fecal samples were collected as often as possible and analyzed. Shifts in genus-level microbes, including **Anaerostipes, Ethanoligenens,** and **Enterococcus (Firmicutes)**, occurred at 24 hours of recovery, while an increase of **Ruminococcus (Firmicutes)** occurred after 48 hours. It is likely that the period leading up to the anesthesia was the most stressful in this particular study, which can be compared to the mildest types of surgeries requiring general anesthesia. The study clearly showed negative effects of the stresses on the intestinal microbiota. It is safe to say that an actual protracted surgery, with associated pain, analgesics, antibiotics, would have a much more profound effect and should not be ignored.

Antibiotics

Antibiotics are commonly prescribed to protect the horse against pathogenic infection in tissues that have been exposed during surgery. Antibiotics will always have effects on the intestinal microbiota, killing some microbes better than others. The severity of the effect on the microbiota is dependent on the antibiotic product, the dose, the severity of the condition being treated, and the prior state of GI tract health. Because of the negative side effects on GI health, antibiotic use should be reduced and discontinued as soon as possible. At the same time, it is also important to not discontinue antibiotic use too early because this contributes to antibiotic resistance, which may reduce its effectiveness when needed in the future.

In one research study three antibiotics—one oral and two different intramuscular—were administered to horses for a period of five days. Fecal samples were then collected at days 1, 5, 14, and 30 (Costa et al., 2015). All three antibiotics altered the population structure and community membership at "higher taxonomic levels including a significant decrease of richness and diversity." The most detrimental effects were observed at day 5, and likely progressed further for 2–3 days prior to initiating a recovery of the microbiota. Importantly, more than three weeks of feeding the normal pre-treatment diet were required to restore

bacterial profiles towards pre-treatment patterns. This very long recovery suggests that nutritional strategies aimed at restoring the GI microbiota may be very beneficial to the recovery and to support the health of the GI tract and the horse.

Surgery and Post-Surgery

There is little published science on the effects on GI health of the nature of a particular surgical procedure (such as intestinal as compared with non-intestinal) or the post-surgical environment. It should be apparent, based on the preceding discussion, that the more severe the stress in this context, the greater the negative impact on GI health. It is also clear that surgery is associated with negative effects on the intestinal microbiota, as shown in a series of studies by Salem and coworkers (Salem, 2016; Salem et al., 2019). In one of these studies, it was already apparent at time of admission to the clinic that horses requiring colic surgery, as compared to horses arriving for elective surgery, had fewer species and lower diversity of microbial species (Stewart et al., 2019). Notably the relative abundance of known commensal (beneficial) bacteria was reduced, whereas some important non-commensal species were increased in horses with colic.



Strategies for Supporting GI Health in the Surgical Horse

As described above, research studies have shown the negative effects of transport, fasting and anesthesia (Schoster et al., 2016), and antibiotics (Costa et al., 2015) on the GI microbiota. The effects of these surgical stresses are at the least somewhat additive, and the detrimental effects on the microbiota have been partially characterized (Salem, 2016; Salem et al., 2019; Stewart et al., 2019). It is also known that impaired GI health is directly associated with impaired immune health (Schley and Field, 2002; Artis, 2008; Jarchum and Pamer, 2011). Compromised GI health and immune health in the immediate post-surgical period may be unavoidable but based on what we currently know it is almost certainly possible to minimize the impairments. It is important, therefore, to present the GI tract in the surgical horse in the best possible condition and to provide the best nutritive support as soon as possible after surgery. This will help to support a rapid and complete recovery.



Prevention

The best strategy for ensuring GI tract health is prevention. Prevention is not only the best way to optimize surgical outcomes, it also reduces the likelihood of colic. Gut health of the horse is strongly dependent on continuous access to good-quality water and a continuous supply of dietary fiber—horses are foragers that graze continuously in nature. If a horse is currently being 'meal fed' hay, support breaking this practice and permit the horse to always have access to forage or hay. Once the horse has learned that the hay will always be there (usually within one week), it generally will not overeat the forage. The exception to this is fresh spring grass which needs to be restricted due to the association between excessive intake and incidence of laminitis. Overweight and obese horses may lose significant weight (100 pounds in about 6 weeks) just by providing 24/7 access to hay with appropriate reduction in grains, while weight gain may occur in conditioned horses (Ellis et al., 2002). Grains may be reduced or eliminated, but not the access to forage.

Ensuring a healthy gut microbiota for your horse is challenging because one cannot see it. Careful examination of the horse's fresh manure for color, texture, smell provides a pretty good idea of how things are going inside—all of these are affected by the microbial populations in the large intestine.

Many studies have reported various health benefits associated with daily supplementation of the diet with probiotics and prebiotics and they do not have any detrimental effects when fed according to manufacturer recommendations (Flickinger et al., 2003; Elghandour et al., 2020; Cooke et al., 2021). More important, daily use helps to provide a consistent and stable gut microbiota that is less prone to the challenge of stress and the challenges of having ingested something unpleasant.

If the horse has been requiring medications (analgesics, sedatives, antibiotics) for more than a few days, then there is an increased likelihood of developing both gastric and colonic ulcers (Andrews and McConnico; Jones et al., 2001; Andrews, 2009). One way of determining the presence of gastric or colonic ulcers is to perform a fecal occult blood test. It is not unusual that a horse has minor gastric and/or colonic ulcers; however, these are problematic when they are bleeding into the intestinal lumen. If left untreated, ulcerations may become more severe, resulting in increased bleeding and disruption of the microbiota or dysbiosis (Sen et al., 2017). The fecal occult blood test can be performed using the SUCCEED® Equine Fecal Blood Test.


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The longer the horse is on most commonly-used medications, especially for pain, the more likely is the presence of GI ulceration and bleeding—so weekly or monthly tests for bleeding would be warranted.

Omeprazole, a proton-pump inhibitor, remains the recommended treatment for gastric ulcers (Bell et al., 2007; Kerbyson et al., 2016). However, omeprazole is costly, and there is increasing evidence that proton pump inhibitors lose their effectiveness over time, although this is not supported by one study (Kerbyson et al., 2016). The stomach requires a certain acidity in order to properly digest food stuffs and when stomach acidity is not adequate there is a gradual adaptation to increase the number of proton pumps there (Bell et al., 2007).

Because of the potential for negative effects of proton pump inhibitors on food digestion and reduced effectiveness, people have long looked for more natural alternatives to treating gastric ulcers and intestinal ulcers. SUCCEED® Digestive Conditioning Program (DCP) is a once-daily supplement program that supports a healthy GI environment through a combination of oat polar lipids, beta glucan, amino acids, and yeast products.

Preparation

To prepare the horse going for surgery, one should take advantage of every opportunity to ensure full support of GI health and immune health. This includes simple things like always having access to high-quality forage and high-quality water (when permitted by the surgical schedule). It also includes the use of effective supplements such as SUCCEED® DCP to support GI health and immune health. If the horse is in distress, then select a natural anxiolytic to reduce stress, so that eating and drinking approaches normal and negative effects on the gut microbiota are minimized. Keep the horse in a quiet environment, usually with a “friend” so that it does not feel isolated.

Practitioner

It is important for the practitioner to be an advocate for the horse and the horse’s owner when communicating with the clinic veterinarians and other care providers. Speak with them about the GI health of the horse and try to ensure that your nutritional approaches are in line with their standard of care. If you find that the nutrition or some aspect of the standard of care may be lacking, then this should be discussed and appropriate solutions found. Most care providers are

sensitive to requests so long as these are in keeping with best practices and evidence-based research. But do not expect the care providers to be as knowledgeable on topics of nutrition as you may be, and be prepared to share information with them. Most are very receptive to solid, evidence-based research and increasing post-surgical nutrition continues to improve.

Post-surgery

Nutritional support for effectively dealing with the effects of surgery on the tissues and on the intestinal microbiota are of paramount importance. The sooner the GI tract can get back towards a healthy microbiota the less will be the negative effects of the altered microbiota on all aspects of hindgut function. This includes breakdown of non-digestible fiber, short chain fatty acid production and absorption, and absorption of other nutrients and water. It also includes support for a healthy mucosal layer over the intestinal epithelial cells (part of the barrier function) and maintenance of tight junctions between intestinal epithelial cells, also part of barrier function (Kauter et al., 2019; Lindinger, 2019).

Restoring barrier function, particularly after colic surgery, is crucial both for keeping intestinal luminal contents from entering the body, and blood and body fluids from passing into the intestinal lumen. Impaired barrier function is often referred to as leaky gut syndrome, and this can be manifest by either very loose stools or constipation. Nutritional support should include good-quality water and hay, as well as probiotics and prebiotics. Most commercially available probiotics are not comprised of species native to the equine GI tract, so they tend to diminish in concentration over time, and thus should be replenished with every meal. Prebiotics are beneficial nutrients, or substances that when broken down by the intestinal microbiota, provide beneficial nutrients for the gut microbes. These nutrients support the commensal microbial populations, permitting their growth and proliferation, which keeps the pathogenic microbes in check.

A healthy gut microbiota is a very important component of a strong innate immune system which, in turn, is essential for dealing with infections that may arise from surgical procedures and for rapid wound healing.


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The Long Road to Recovery

The road to recovery following surgery can be a long one. Post-surgery recovery requires changes in environment, transport, a gradual and progressive return to performance training, and gradual changes in diet to meet the changing physical needs of your horse. Re-establishing a healthy gut microbiota may not take very long when nutrition is optimized; however, re-establishing an optimum and high-functioning microbiota may require months (Mach et al., 2021). It is clear that the post-surgical microbiota becomes altered in less than 24 hours to one that is less supportive of GI health, immune function, and wound healing (Schoster et al., 2016). Plus, this occurs at a time when the horse needs a high-functioning GI tract the most. The evidence so far indicates that it takes much longer to restore the microbiota, perhaps weeks. But a good start, using the strategies outlined above, will at the least minimize and eventually reverse the negative effects of pre-surgical stresses, antibiotics, analgesics, anesthetics, and the surgeon's scalpel on the microbiota.



Summary and Conclusions

A number of challenges have been described with regard to achieving and maintaining GI health in horses requiring surgery. Major surgery is associated with rapid deterioration of the healthy gut microbiota. Effective strategies are required to restore the microbiota specifically and gut health generally over a period of weeks, particularly in the face of post-surgical antibiotic treatment. Prevention is also important and maintaining a relatively healthy gut microbiota can often be achieved.

A healthy, high-functioning gut microbiota directly affects all aspects of the health and well-being of the horse. We now know of the gut-brain axis (direct neural and indirect chemical communications between the GI tract and regions of the brain), the gut-hoof axis, the gut-muscle axis, and so on. Gut function likely interacts with and influences every major organ system in the body. The GI tract is not just a channel for bringing nutrients into the body; it is the organ system that is in intimate communication with the entire horse. A happy gut will manifest in a happy horse.

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