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Equine Endocrinopathic Laminitis (EL) – What is it and how is it managed?

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What is Endocrinopathic Laminitis?

Laminitis is a very well-known term in the horse community. What many do not know is that underlying endocrine disease such as equine metabolic syndrome (EMS), insulin dysregulation (ID), and pituitary pars intermedia dysfunction (PPID; also known as Cushing's disease) is now the leading cause of laminitis (Rumfola et al., 2022). Also called endocrinopathic laminitis (EL) or hyperinsulinemia-associated laminitis (HAL) (Frank et al., 2022), this type of laminitis occurs when high levels of insulin cause the laminae in the hoof to become inflamed and painful. In severe EL cases, this inflammation can allow the distal phalanx or coffin bone to rotate down toward the soul of the hoof, which is also known as founder.

ID is a collective term for tissue insulin resistance (i.e., tissue's inability to respond to an adequate amount of insulin) and hyperinsulinemia (i.e., high insulin levels in the blood). One component of ID, hyperinsulinemia, has been shown to be the root cause for the development of EL (Asplin et al., 2007). Therefore, in horses, it is essential to limit hyperinsulinemia to avoid bouts of EL. When a horse consumes their morning grain meal, the food bolus slides down the esophagus to the stomach and small intestine, subsequently initiating a metabolic cascade to help digest and absorb the nutrients from that meal. For the body to absorb glucose, one of the body's main sources of fuel from this meal, the pancreas must release insulin, which is responsible for shuttling glucose to all the important tissues of the body.

Certain nutrients, namely non-structural carbohydrates (i.e., sugar and starch), from horses' diets can dramatically exacerbate the post-meal insulin response, thereby putting the horse at risk for an episode of EL. Often, owners do not know their horse has hyperinsulinemia until an episode of laminitis occurs. Therefore, it is prudent to screen susceptible horses for the presence of hyperinsulinemia at annual wellness evaluations with a veterinarian. The treatment and management of a horse diagnosed with ID is manageable with specialized diets and nutritional practices.

Identifying At-risk Horses

As mentioned above, it is crucial to identify horses that could have ID to prevent a future episode of EL. Susceptible horses often have increased adiposity (Carter et al., 2009), as depicted in Figure 1, have a history of previous laminitis (de Laat et al., 2009), and can maintain their body condition on limited feedstuffs. However, some horses will not necessarily fit the classical obese phenotype of an ID animal. Some ID horses can be lean with regional adiposity or simply a lean phenotype (Fig. 2) (Frank et al., 2022). While the mechanism behind the development of hyperinsulinemia is still unknown, there are certain risk factors that increase the likelihood of ID development.

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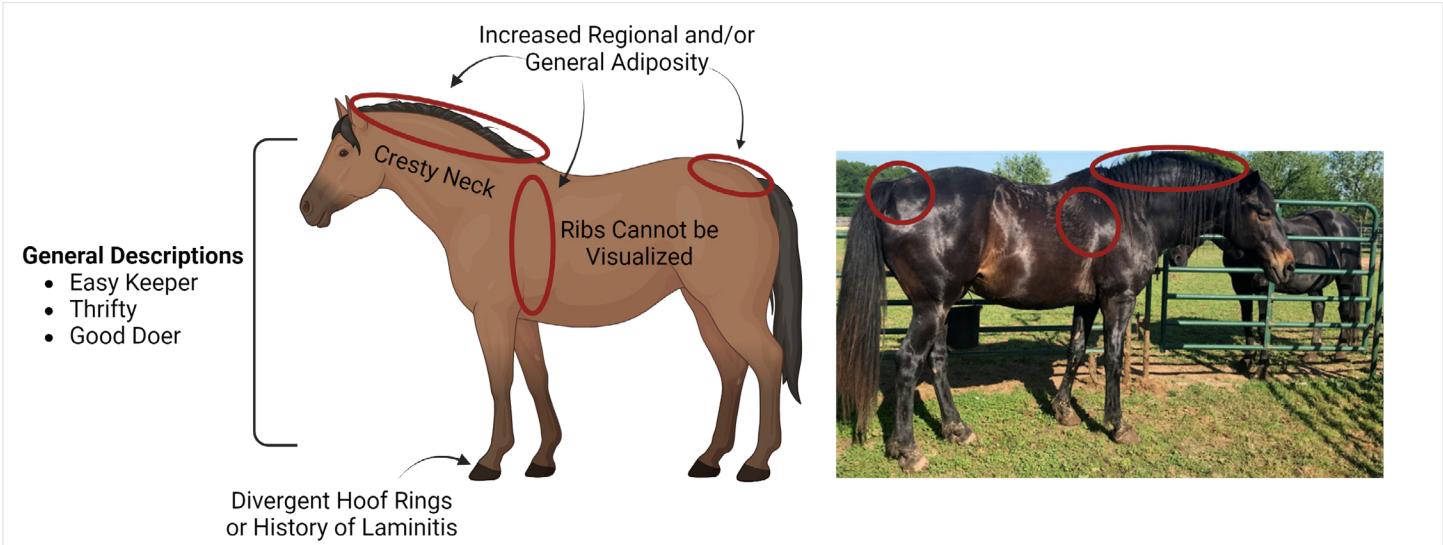


Figure 1. Obese horse susceptible to endocrinopathic laminitis. *Created with BioRender.com.*

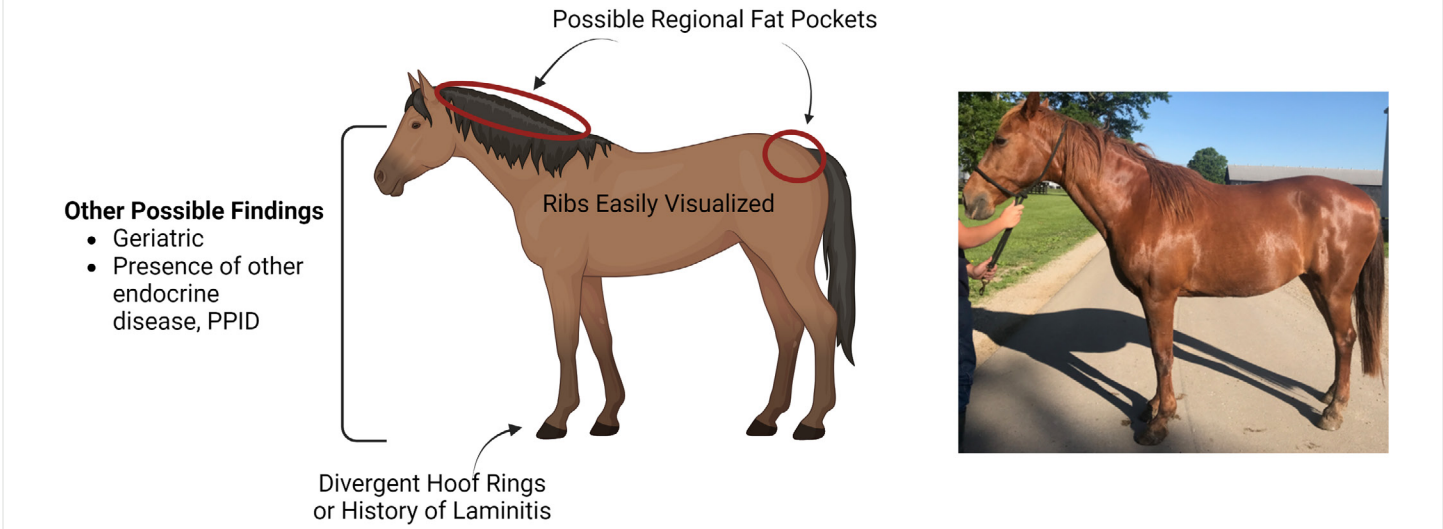


Figure 2. Lean horse susceptible to endocrinopathic laminitis. *Created with BioRender.com.*

Horses and ponies that are sedentary (Karikoski et al., 2022), are overfed (Ribeiro et al., 2020), have increased regional fat deposits or generalized obesity (Karikoski et al., 2022; Ribeiro et al. 2020), and certain breeds, such as Paso Finos, Morgans, Pony breeds, Saddlebreds, Mustangs, Warmbloods, and Donkeys (McCue et al., 2015), are at an increased risk of developing ID. There are currently no studies that have estimated the rate of ID in the United States. However, other countries have estimated it to be between 16 and 61 percent (Clark et al., 2024; Box et al., 2020; Al-Ansari et al., 2023). Granted, those studies estimated disease prevalence in breeds native to Finland and pony breeds, which is not representative of the United States horse population. While U.S. estimates are not available, horses that display phenotypic characteristics or have an unknown cause of an episode of laminitis may be affected and should be screened for endocrine disease.

When evaluating laminitis cases, 90 percent of veterinarians in the United States now screen for endocrine disease (Rumfola et al., 2022). To test a horse for ID, veterinarians can either take a fasted blood sample and measure insulin or perform a dynamic test like the oral sugar test (OST). Diagnosing ID from a fasting blood sample is not currently recommended because some horses with ID do not have resting hyperinsulinemia (Knowles et al., 2016). Additionally, resting insulin levels could be affected by seasonal changes (Macon et al., 2019).

In Table 1 are the thresholds for diagnosing ID from resting or OST blood samples (Frank et al., 2022). There is a gap between a non-ID (<20 µIU/mL) animal and an ID (>50 µIU/mL) animal (i.e., 21 to 49 µIU/mL). This range (21 to 49 µIU/mL) is known as an equivocal range, meaning that horses that have resting insulin concentrations within this range could or could not be

Table 1. Thresholds for the diagnosis of insulin dysregulation from resting and OST blood samples

	Resting (Basal) Insulin Concentrations	Low-dose Oral Sugar Test Insulin Responses	High-dose Oral Sugar Test Insulin Responses
Healthy, Non-insulin Dysregulated	<20 µIU/mL	<45 µIU/mL	<65 µIU/mL
Insulin-dysregulated	≥50 µIU/mL	≥45 µIU/mL	≥65 µIU/mL

Adapted from Equine Endocrinology Group's Recommendations for the Diagnosis and Management of Equine Metabolic Syndrome (EMS) (Frank et al., 2022). Values reflect diagnostic thresholds from a radioimmunoassay. Therefore, if a different assay is used, these thresholds will not be applicable. The veterinarian will know what cutoffs to use based on the laboratory performing the assay. Low-dose OST uses 0.15 mL/kg bodyweight (BW) of Karo Light Corn Syrup, whereas the high-dose OST uses 0.45 mL/kg BW.

affected by disease. If a horse's resting blood insulin falls within this range, it is highly recommended to perform a dynamic test. All the scenarios described above could result in a false negative or false positive diagnosis and could affect the way a horse is medically and nutritionally treated. Therefore, the OST is recommended. However, if a horse is undergoing an episode of laminitis, it is recommended to only quantify resting insulin and not perform a dynamic test because the oral sugar could exacerbate insulin responses and potentially increase the severity of laminitis.

The OST is a practical, simple test that a veterinarian can perform at a routine exam. The test uses Karo Light Corn Syrup to mimic the consumption of carbohydrates, which stimulates an insulin response. Karo syrup is predominately made up of simple sugars that can be easily absorbed in the small intestine, thereby creating the highest insulin response. Remember, horses with ID could have insulin resistance and/or hyperinsulinemia. Thus, their insulin responses will be greater than that of a healthy horse that will only need to produce and secrete a small amount of insulin to shuttle the simple sugars out of the intestine and into the bloodstream for metabolic use and energy storage.

Currently, there are two doses of the OST used in clinical practice: a low dose (0.15 mL/kg BW) (Schuver et al., 2014) and a high dose (0.45 mL/kg BW) (Knowles et al., 2016). The low dose was the first test created by Schuver et al. (2014) and proved to be effective at diagnosing ID. However, the high-dose test was created to increase the sensitivity (i.e., the ability of the test to correctly identify diseased animals). The dose of the OST used will be at the discretion of the veterinarian. Prior to the OST, the horse should be fasted for 3 to 6 hours, after which the veterinarian can take a resting sample (not required) and then administer the appropriate amount of Karo syrup based on the horse's bodyweight.

One hour after the horse receives the syrup, the veterinarian will take a blood sample. The blood sample(s) will then be sent to a lab to have insulin concentrations quantified. The diagnostic thresholds have been set by the Equine Endocrinology Group, a group of experts in the field of equine endocrine disease. The thresholds do not account for seasonal variation, which has been shown previously by Macon et al. (2019). The seasonal variations that Macon et al. (2019) found were in horses housed on pasture in Kentucky. Thus, horses in Texas may or may not experience similar seasonal fluctuations, but it is warranted to mention the possibility. Once an equid has been diagnosed with ID, the owner should modify their nutritional and general management practices with the goal of decreasing resting and post-meal hyperinsulinemia.

Nutritional and General Management Practices

Multiple studies have shown that ingestion of feedstuffs with high nonstructural carbohydrate (i.e., starch and sugar) concentrations can induce an episode of EL (Meier et al., 2018; Delarocque et al., 2021). Therefore, it is crucial to limit the amount of nonstructural carbohydrates in affected horses' diets. In addition, for animals that are obese, exercise and reducing weight can greatly reduce the horse's insulin levels. However, for the lean phenotype of the disease or animals that are currently undergoing a bout of EL, strenuous exercise is not recommended. Exercise and feeding recommendations for both the obese and lean phenotypes can be found in Table 2.

For the obese (Fig. 1) ID horse, an exercise regimen to reduce weight and lower insulin levels is recommended. Exercise is generally known to reduce inflammation and body fat, which leads to improvements in glucose and insulin metabolism (Gleeson et al., 2011). It is recommended that horses undergo low- to moderate-intensity exercise, which is equivalent to a fast trot or canter, unridden 3 times/week to a fast canter, ridden 5 times/week, respectively (Frank et al., 2022; Pratt-Phillips, 2024). If owners want to make sure their horse is reaching low- to moderate-intensity exercise, they could attach a heart rate monitor to the saddle or surcingle and have a target heart rate of 130 to 150 beats per minute and

Table 2. Exercise and feed recommendations for the obese and lean phenotypes of insulin dysregulation	
Lean Phenotype: Exercise and Feed Recommendations	
Exercise[a]	Low-intensity exercise for 30 minutes Low example: Mixture of fast trot or canter on a lunge line 3x/week
Concentrates/Grains	Weight gain: Low nonstructural carbohydrate commercialized grain—feed based on manufacturer's instructions for ideal bodyweight[c] Maintain weight: Ration balancer—feed based on manufacturer's instructions for ideal bodyweight[c]
Forages	Weight gain: Feed 2–2.5% of ideal bodyweight[c] in warm-season grass hays[d]; alfalfa hay pellets can be added to encourage weight gain (1 lb./1,000 lb. horse/feeding) Maintain weight: 1.75–2% of ideal bodyweight in warm-season grass hays[d] *Forage should be fed in a hay net that has smaller holes (1–1.5 inches to maximize foraging time.*
Obese Phenotype: Exercise and Feed Recommendations	
Exercise[a]	Low- to moderate-intensity exercise for 30 minutes[b] Low example: Mixture of fast trot or canter on a lunge line 3x/week Moderate example: Warm-up (walk/trot) and fast canter 5x/week
Concentrates/Grains	Ration balancer—feed based on manufacturer's instructions for ideal bodyweight[c]
Forages	1.5% of ideal bodyweight in warm-season grass hays *Forage should be fed in a hay net that has smaller holes (1–1.5 inches) to maximize foraging time.*

[a]Exercise should be discontinued if the horse becomes lame or is undergoing a bout of laminitis.
[b]When adapting horses to exercise, gradually increase from low-intensity to moderate-intensity exercise.
[c]To estimate ideal bodyweight, download the Healthy Horse App.
[d]Warm-season grass hays include bermudagrass, crabgrass, sudangrass, Teff, etc.

150 to 170 beats per minute for at least 30 minutes, respectively (Frank et al., 2022). The goal of this exercise regimen is to reduce weight and improve the horse's insulin sensitivity (i.e., the body's ability to respond to adequate levels of insulin). However, if the horse becomes laminitic during exercise, all exercise should be discontinued, and a veterinarian should be contacted. In the meantime, owners can focus on tailoring their horse's diet to decrease insulin levels.

To limit post-meal hyperinsulinemia, it is currently recommended that horses be fed feedstuffs with <10 percent nonstructural carbohydrates (i.e., starch + sugar) (Macon et al., 2021; 2022; 2024). When formulating any horse's diet, the first thing that should be fed is forage. For both the lean and obese phenotype ID horse, warm-season grasses (e.g., Bermudagrass, Crabgrass, Sudangrass, Teff, etc.) are currently recommended due to their lower sugar and starch content compared to cool-season grasses (e.g., Orchardgrass, Tall Fescue, Rye, Timothy, etc.).

Obese ID horses should receive ~1.5 percent (this can be decreased to 1.2 percent, but it is suggested to do this gradually for animals that are resistant to weight loss) of their bodyweight (Catalano et al., 2016) in forage, which for a 1,000-pound horse equates to 15 pounds of forage per day. Lean phenotypes should receive ~2.0 percent of their bodyweight in low nonstructural carbohydrate forage (see *Forage Evaluation for Horses*), which for a 1,000-pound horse, would equate to 20 pounds of forage per day. Some grass hays will fall short of meeting some of the nutrients that the horse requires for optimum health and performance. Thus, concentrates are added to the diet to supplement forage and meet those nutritional requirements, namely protein, vitamins, and minerals.

For the obese ID horse, a ration balancer is often recommended, whereas a low-nonstructural carbohydrate concentrate is recommended for the lean phenotype. A ration balancer is a commercialized concentrate that, if fed at the manufacturer's recommendations, meets the horse's protein, vitamin, and mineral requirements. All major equine feed companies have a version of a ration balancer and are titled with "Balancer." Contact a local feed store for ration balancers that are available in local areas. Unfortunately, most balancers are not low in nonstructural carbohydrates unless stated on the bag. However, if the amount of feed is split into multiple, smaller feedings, the post-meal insulin response can be drastically reduced and is therefore recommended

when feeding ID horses (Macon et al., 2021). Owners should feed their obese ID horse based on the manufacturer's recommendations for their horse's ideal weight (Catalano et al., 2016). This should be the bodyweight that the owner is trying to achieve for their horse (see *Estimating Actual and Ideal Bodyweight of Adult Horses*), not its actual weight (i.e., what the horse weighs in real-time).

For the lean ID horse (Fig. 2), balancers are still recommended. However, often, these horses need more calories to continue to maintain their body condition. Thus, for these types of horses, it is recommended to feed commercialized concentrates low in nonstructural carbohydrates, which tend to have higher concentrations of added fat. When locating these commercialized grains, look at the guaranteed analysis for either "starch and sugar" or "nonstructural carbohydrates or NSC" and determine if it is indeed low in nonstructural carbohydrates. Again, contact a local feed store to see what low nonstructural carbohydrate concentrates are available in the local area. Similar to feeding the obese ID horse, concentrate meals consumed by lean ID horses should also be split into multiple, small (~1-pound) feedings. In addition to commercialized grains, lean ID horses that need to gain weight can also be fed alfalfa hay pellets to encourage weight gain. A recent study showed that ID horses do not have exacerbated post-meal insulin responses after being fed alfalfa hay pellets when fed in small quantities (1 pound pellets/1,000 pounds bodyweight/meal) (Macon et al., 2024). If the horse needs to gain weight, feed the horse based on the goal weight (i.e., ideal bodyweight) and balance that with the manufacturer's recommendations. For assistance balancing a horse's diet contact a local equine extension agent.

In addition to reducing nonstructural carbohydrates in the feedstuffs of ID horses, certain management practices can be implemented to support lowering insulin levels. Horses not only receive nutrients from hay and concentrates, but also during turnout when grazing. Pasture forage's sugar content will fluctuate throughout the day with photosynthesis, with sugar content being highest in the early to mid-afternoon hours. Therefore, it is recommended that ID horses not be turned out during these periods. Instead, these horses could graze in the early morning hours. In addition, a grazing muzzle could be utilized. Muzzles can reduce the amount of fresh forage horses consume by an average of 30 percent (Glunk et al., 2014), which could reduce insulin levels.

When horses are confined to a stall or a dry lot they could be provided forage in a hay net (3.2-centimeter openings), which has been shown to lower insulin responses as a result of slower consumption (Glunk et al., 2015). Finally, to reduce spikes in insulin concentrations after feeding concentrates, it is recommended to slow the consumption of the concentrate. In one study, balls were placed in a bucket, and the horses had to move them around to consume the pellets (Kutzner-Mulligan et al., 2013). By extending consumption time, horses had lower insulin responses after the meal.

Altogether, feeding forages and concentrates low in nonstructural carbohydrates in combination with nutritional management practices greatly reduces ID horses' insulin responses. Implementation of these management practices in the day-to-day care of an ID horse could decrease the risk of developing EL, leading to increased life expectancy and improved welfare of a horse suffering with endocrine disease.

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