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Risk Factors for Colic

Effective prevention begins with an understanding of what could be causing the problem or contributing to the situation. In the past 10 years or so, there have been several studies aimed at identifying the factors that contribute to colic. Some of these studies have involved over a thousand horses, which has been important in defining both the overall incidence of colic and the incidence of specific types of colic in the general horse population.

But with respect to factors that increase or decrease the potential for colic to occur (colic risk factors), this research has provided a mixed bag of information: some new perspectives, some affirmation of age-old horsemen's wisdom, and some information whose relevance remains to be fully understood. This chapter discusses what is known about the factors that contribute to colic in horses.

Interpreting Study Results

Even though there have been several studies examining colic risk factors, only a few definite conclusions have been reached. The general trends may be similar among studies, but details regarding specific risk factors often differ.

There are a few possible reasons for differences among studies. One is variation in study design — asking different questions. Another is variation in geographic location — studying horses in different parts of the country (or in another country entirely).

A third reason may be that most types of colic have more than one contributing factor, sometimes several, and many of the colic risk factors (particularly those involving management) are inter-related. For example, to some extent breed, activity, diet, and housing are all inter-related: the horse's breed may dictate its use or activity, which can impact how the horse is fed and housed.

At times it is difficult, if not impossible, to tease apart the specific factors in order to study them individually. Using breed as an example, when breed is analyzed in isolation, with no consideration of the horse's primary use or activity, and therefore the associated management factors, the results can be misleading.

Another important consideration is the particular population of horses being studied. Most studies to date have been *hospital-based*, meaning that the data were compiled from horses referred to a university veterinary hospital because of colic.

The problem here is that most cases of colic are mild and resolve either on their own or with simple medical treatment on the farm (see Chapter 1, page 16). Relatively few cases of colic require more intensive medical treatment, and even fewer need surgery. But from looking at the statistics in many hospital-based studies, such as the first one discussed in Chapter 1 (page 14), you could be left with the false and alarming impression that most cases of colic are serious and many require surgical correction.

Manager- and veterinarian-based studies

Five important studies have been published in the past 10 years, in which the information was recorded either by owners, trainers, or farm/barn managers (two studies)^{1,2} or by equine veterinarians attending colic cases on the farm (three studies).³⁻⁵ These are all *farm-based* studies that attempted to uncover the actual incidence of colic, including the incidence of specific types of colic, and identify the contributing factors. These studies are summarized in Tables 2.1 to 2.5 at the end of the chapter.

The two owner/manager-based studies are particularly important because they included colic cases that were too mild to warrant veterinary attention and either resolved without treatment or were treated by the owner or manager. These cases would not have made it into a hospital-based study, nor into the farm-based studies by participating veterinarians, yet clearly they are essential pieces of the colic puzzle.

In this chapter, colic risk factors are divided into three categories:

Intrinsic (horse) Factors	Management Factors	Environmental Factors
breed	diet	geographic location
gender	housing	weather/season
age	water intake	poisonous plants
use/activity	internal parasites	
behavior (e.g., stable vices)	dental care	
previous colic or surgery	stress	
genetics	drugs and chemicals	

Intrinsic Factors

Breed

The importance of a horse's breed on colic risk is unclear. Results varied among studies, and in some cases one study reported a higher risk for colic in a particular breed while another study reported a lower risk in that same breed. One explanation is that different populations of horses were being compared (e.g., hospital-based vs. farm-based studies).

Another likely reason is that the effect of breed is compounded by the horse's use or activity and the associated management factors, especially diet and housing. The range of activities undertaken by a particular breed can be wide. For example, Quarter Horses are used for anything from halter classes to racing; and the list of activities involving Arabians ranges from showing to endurance. So, unless the horse's use is taken into account when analyzing the effect of breed, it is likely that few definite conclusions will be reached. Certain breeds are more prone to particular types of colic, but whether this too is management-related is not yet clear.

Breeds in which colic risk is reported to be different from that in most other breeds, or in which specific types of colic may be more likely, are discussed in the following pages.

Arabians

Findings have varied widely among studies. Several studies reported a significantly higher incidence of colic in Arabians, others found no difference between Arabians and other breeds, and one of the owner/manager-based studies reported a *lower* colic risk in Arabians.

Owner/manager-based studies. The owner/manager-based study in Virginia and Maryland¹ found that Arabians had the lowest colic incidence among the breeds represented in that population of horses. The annual incidence of colic for all breeds combined was 10.6 cases per 100 horses, but in Arabians it was only 3.2 cases per 100 horses — less than one-third of the incidence for all breeds combined.

In the owner/manager-based study in Michigan,² the Arabian breed was not a significant risk factor for colic, although there was a trend toward colic being slightly more likely in Arabians.

Veterinarian-based studies. Both veterinarian-based studies in Texas^{3,4} found that colic was slightly more likely in Arabians than in other breeds. The authors proposed three possible explanations: (1) different management practices compared with other breeds; (2) increased awareness and concern about colic among owners and caretakers of Arabians; or (3) genetic predisposition for gastrointestinal disorders in Arabians. Given that the VA/MD study¹ showed a significantly lower colic risk in Arabians, management factors probably are the key, rather than an inherent predisposition toward colic in Arabian horses.

Specific conditions. Enteroliths (intestinal ‘stones’; see page 36) reportedly are more common in Arabians. In a hospital-based study at the University of California at Davis (UC Davis)⁶ of colic caused by enteroliths, 39% of the 900 horses with enteroliths were Arabians or Arabian crosses, whereas this breed comprised only 13.5% of the total horse population seen at the UC Davis veterinary hospital. (Incidentally, Morgans, American Saddlebreds, and donkeys also had a higher incidence of enteroliths in that study.)

In a hospital-based study at the University of Georgia,⁷ ileal impaction was more common in Arabians than in other breeds, but this has not been the case in other studies. (As discussed later in this chapter, diet and tapeworm infestation are the primary factors involved in ileal impaction.)

Thoroughbreds

Some studies reported an increased incidence of colic in Thoroughbreds, while others showed either no difference or a decreased colic risk in this breed. The horse’s use (*e.g.*, racing vs. less demanding activities) probably is the key, in combination with associated management factors such as diet and housing, as shown in the owner/manager-based study in VA/MD.¹

This study found that the colic incidence was higher in Thoroughbreds than in most other breeds. The annual colic incidence in Thoroughbreds was 12.6 cases per 100 horses, whereas in all breeds combined it was 10.6 cases per 100 horses. In comparison, the annual colic incidence in crossbreds, Quarter Horses, and Arabians was less than 6 cases per 100 horses — less than half the rate in Thoroughbreds. In that study, eventing and training for racing or other strenuous sports were the activities with the highest colic incidence (see page 27). Presumably, Thoroughbreds dominated these groups, which could account for the higher colic incidence in this breed.

In the owner/manager-based study in MI² and the veterinarian-based studies in TX,^{3,4} the colic incidence in Thoroughbreds was similar to that in other breeds.

Standardbreds

Some studies showed a significantly lower colic risk in Standardbreds; others showed no difference between this and other breeds. The owner/manager-based study in MI² showed a slightly lower risk for colic in Standardbreds. Only about 3% of the horses with colic were Standardbreds, whereas this breed comprised over 16% of the total horse population studied. However, in the final analysis, the difference was not statistically significant.

Standardbreds do, however, appear to be more prone to scrotal or inguinal hernias, in which a section of bowel becomes trapped in the scrotum or inguinal canal (groin; see page 23). Also, in a recent hospital-based study at the University of Pennsylvania,⁸ intussusception involving the cecum was more common in this breed. (In this condition, part of the cecum folds in on itself, or the first part of the large colon telescopes into the cecum.)

Miniature Horses

Miniature Horses are prone to small colon obstruction, especially impaction with fecaliths (hard masses of manure). Small colon obstruction is more common in young Minis, probably for two reasons: (1) the relatively narrow diameter of their small colon; and (2) their inquisitive nature, which makes them more likely to swallow foreign materials such as baling twine and plastic that can become lodged in the small colon. (More on small colon obstruction in Minis on page 34.)

Morgans

In a hospital-based study that used Arabians as the reference group, Morgans tended to be referred for colic more often than Arabians. As a point of comparison, Quarter Horses and crossbreeds were admitted significantly less often than Arabians, and therefore Morgans, in that study. And as mentioned earlier, in a recent study at UC Davis,⁶ Morgans were one of the breeds in which enteroliths were more common. But in most other studies, Morgans were at no greater risk for colic than any other breed.

Other breeds

One report suggested an increased incidence of scrotal hernias in Tennessee Walking Horses. In another study, Appaloosas were at slightly higher risk for colic, but that is not supported by other studies. 'Lethal white foal syndrome' is a fatal condition that causes colic in newborn American Paint Horse foals (see page 30).

Gender

The effect of gender is a little more clear, as some types of colic are gender-specific (occurring in only one gender) or more likely in a particular gender, as discussed below. However, study results differed in the association between gender and overall colic risk.

Studies

The owner/manager-based study in VA/MD¹ found no difference in colic risk by gender (female, intact male, gelding). However, the authors noted that some of the broodmares left the farms just before or just after foaling, so they were excluded from the study when their colic risk may have been highest.

In the owner/manager-based study in MI,² mares were at no greater risk for colic than were males, but foaling was a significant risk factor for colic (see Use/Activity on page 27). Geldings were slightly less likely to develop colic than were mares or stallions in that study.

In the veterinarian-based study in the United Kingdom,⁵ there was a significantly lower incidence of colic in stallions than in mares and geldings. But in neither of the two veterinarian-based studies in TX^{3,4} was gender found to have a significant effect on colic risk.

Mares

Specific causes of abdominal pain that are more common in mares or found only in mares include these:

- large colon volvulus (twist) — most common in the first few weeks after foaling
 - this potentially fatal condition also occurs in nonpregnant mares, as well as in geldings and stallions, but much less often than in mares post-foaling
- painful ovarian follicles or ovulation — most common in young mares
- uterine torsion (twisting of the uterus) — an uncommon but important cause of colic in the last 1 to 2 months of pregnancy

In a hospital-based study at the University of Georgia,⁹ 100% of the horses with acute peritonitis (infection of the abdominal cavity) were mares. How many of these mares were broodmares was not reported.

Colts and Stallions

Inguinal or scrotal hernias can cause strangulating obstructions in intact (uncastrated) males. These conditions develop when a section of bowel, usually small intestine, works its way into the inguinal canal, which is the slit-like opening in the floor of the abdomen through which the testicle and its spermatic cord descend into the scrotum. Bowel that enters the inguinal canal can become trapped either in the canal (inguinal hernia) or further down, in the scrotum (scrotal hernia).

Most cases of inguinal/scrotal hernia are found in intact males (colts or stallions), although inguinal hernias can also occur as a complication of recent castration in geldings. Scrotal hernias cause obvious swelling on one side of the scrotum or beneath the skin beside the scrotum (more likely in young foals). Inguinal hernias usually are much less obvious because the bowel is trapped deep within the groin, out of sight. Although scrotal and inguinal hernias can occur in young foals, they are more likely to cause an obstruction and colic in adult horses.

Meconium impaction in foals. Meconium is the first manure a newborn foal passes. It is produced *in utero* (while the foal is still a fetus) and consists of a mix of amniotic fluid, digestive secretions, and cells naturally sloughed from the lining of the intestinal tract. Meconium is usually pasty in consistency, but in some foals it forms firm pellets or a large mass that is difficult to pass. Meconium impaction is the most common cause of colic in newborn foals (see page 25), and it occurs more often in colts than in fillies, possibly because the pelvic canal in males is more narrow than in females.

Geldings

An uncommon but potentially serious cause of colic in recently castrated geldings is obstruction from adhesions between the bowel (usually small intestine) and the inner opening of the inguinal canal. In effect, a portion of bowel becomes stuck to the inguinal canal or to the remnant of the spermatic cord, and the bowel becomes kinked. Colic caused by these adhesions usually develops within a few weeks of castration, but it may begin several months later.

Strangulating lipoma. Geldings are also more prone to colic caused by lipomas. These benign, fatty masses within the abdomen can cause strangulating obstructions if the thin stalk on which they are suspended stretches and allows the mass to wrap around a section of bowel, like swinging a baseball in the toe of a stocking. This condition, called strangulating lipoma, is seen almost exclusively in senior horses, and most often in geldings.

Recurrent colic. The principal researcher who conducted the veterinarian-based studies in TX also published the findings of a related study involving horses with repeated (recurrent) episodes of colic.¹⁰ Geldings were significantly more likely to have 'chronic intermittent colic' compared with mares; but whether this finding is management related was not clear.

Age

As with gender, certain conditions are more common or are found exclusively in particular age groups. However, study findings differ somewhat in the association between age and overall colic risk.

Owner/manager-based studies

In the study in VA/MD,¹ the incidence of colic was greatest in horses between 2 and 10 years of age. The annual colic incidence in horses less than 2 years of age was 4.6 cases per 100 horses, and in horses over 10 years of age it was 7.4 cases per 100 horses. But in the horses 2 to 10 years of age, the annual colic incidence was 14.5 cases per 100 horses — almost twice the incidence in older horses, and over three times the incidence in younger horses.

However, this finding probably reflects an effect of activity more so than of age. Eventing and training for racing or other strenuous sports were the activity groups with the highest colic risk in this study (see page 27), and the majority of horses involved in these activities would have been between 2 and 10 years of age. In the owner/manager-based study in MI,² colic was slightly more likely in older horses.

Veterinarian-based studies

The first of the veterinarian-based studies in TX³ found no significant effect of age on overall colic incidence, but the second study⁴ found that the incidence of colic was higher in horses over 10 years of age than in younger horses.

The UK study⁵ showed no effect of age on overall colic risk, but spasmodic and undiagnosed colic each occurred more often in horses 5 to 10 years of age. Also in that study, significantly more horses over 15 years of age needed surgery than did younger horses. This finding agrees with a hospital-based study in Minnesota in which horses over 15 years of age required surgery significantly more often than did younger horses. Most of the surgical cases in older horses involved strangulating obstructions.

Recurrent colic. In a related study by the TX researchers,¹⁰ horses over 8 years of age were significantly more likely to have recurrent or chronic, intermittent colic than were younger horses. Several other factors were associated with chronic/recurrent colic, so age alone probably is not a deciding factor in most cases. As the authors suggested, the older the horse, the more opportunities it has to develop colic and so be included in such a study. But it could also reflect an increased incidence of dental problems, tumors, and other causes of colic in older horses.

Age-related conditions

Young foals. The following conditions are more common or found only in foals less than about 3 months of age:

- meconium impaction — inability to pass the material that accumulated in the colon before birth (meconium; ‘first manure’)
 - foals normally begin passing their meconium within 6 to 8 hours after birth
 - meconium usually is pasty in consistency, but in some foals it forms hard pellets or a large mass that is difficult to pass
 - straining and tail-flagging are common signs of meconium impaction; bloating sometimes develops after several hours of unproductive straining
 - all newborn foals have meconium, but why impaction occurs in only some foals is not fully understood and probably involves multiple mare and foal factors
- enteritis — inflammation of the small intestine, usually caused by bacterial infection
 - diarrhea often becomes the predominant sign in these foals
- atresia (absence or incomplete development of a portion of bowel) and other congenital abnormalities
- gastric (stomach) ulcers — common in sick or stressed foals (see page 46)
- inguinal or scrotal hernia in male foals (discussed on page 23)
 - in many cases the hernia is obvious but it does not cause bowel damage or colic
- umbilical hernia — a gap in the abdominal wall where the umbilical cord was attached
 - the typical umbilical hernia is a small, nonpainful swelling beneath the skin on the underside of the foal’s belly
 - most are present at birth or first noticed a day or two later
 - most umbilical hernias do not cause bowel damage or colic
- ruptured bladder or urachal abscess
 - the urachus is the narrow passage between the bladder and the umbilical cord in the fetal foal; it is supposed to close after birth, but as with the umbilical stump, it can become infected after birth, resulting in a urachal abscess
 - ruptured bladder and urachal abscess can each cause straining and colic-like signs in young foals
 - these conditions are also accompanied by other signs of illness, such as depression, decreased activity, less vigorous nursing, and with urachal abscess, fever

Older foals and growing horses. The following conditions are more common between about 3 months and 2 years of age:

- intussusception — folding of the bowel into itself, like closing the barrel of a telescope
 - most intussusceptions occur in the ileum or cecum
- impaction with roundworms (*Parascaris equorum*; ascarids)
 - this condition is seen most often in foals that are dewormed for the first time after 3 months of age (see page 45)
- gastric and duodenal ulcers — colic can result from the ulceration itself or from its consequences, such as scarring and narrowing (stricture) of the duodenum
 - depending on the severity, duodenal strictures can cause either chronic, low-grade colic or severe, obstructive colic
- *Rhodococcus equi* infection — this bacterial infection typically causes pneumonia, but enteritis/colitis or abdominal abscesses can also develop, often resulting in diarrhea or chronic colic
- small colon impaction in Miniature Horses (see page 22)

In addition, horses in this age group are more susceptible to internal parasites than are adult horses. These young horses are immunologically naïve: they do not yet have the natural resistance to internal parasites that develops with exposure. Perhaps for this reason, some studies have suggested that anthelmintics (dewormers) may be less effective in foals and yearlings than in adult horses. Thus, immunological naïvety could predispose young horses to parasite-induced colic in management situations that do not consider young horses in the deworming program.

Young adult horses. Intussusceptions also occur in young adult horses. In one study in England, tapeworm infestation was more common in horses 3 to 5 years of age (and also in those over 15 years of age) than in horses 5 to 15 years of age.¹¹ Incidentally, tapeworm infestation and intussusception are related in some cases.

Older horses. Horses 15+ years of age are more prone to the following conditions:

- strangulating lipoma (see page 24)
- entrapment of small intestine in the epiploic foramen (a narrow gap between the liver and adjacent structures)
 - a probable contributing factor in these cases may be shrinkage of the liver, and thus enlargement of the epiploic foramen, with age
- lymphosarcoma — a malignant tumor of lymph nodes and other lymphoid tissue
 - abdominal lymphosarcomas can cause obstruction either from infiltration and thickening of the bowel wall or from compression of the bowel by an enlarged lymph node adjacent to it
 - lymphosarcoma is a rare cause of colic in horses; in young horses it typically causes weight loss and general signs of ill thrift, whereas in old horses the predominant sign may be chronic colic
- squamous cell carcinoma of the stomach
 - squamous cell carcinoma is a relatively common skin tumor in horses, but it can also develop in other sites; in rare cases, the stomach is the primary tumor site
 - signs are similar to those of gastric ulcers (see page 46)

- disorders of the cecum, such as impaction
- tapeworm infestation (see page 43)

Influence of management factors

Management can play a significant role in the incidence of colic in older horses. For example, in one study,¹² the odds that a horse would develop colic increased with age in horses kept on a dry lot. (A dry lot in that study was defined as any exercise area less than half an acre that was not grass covered.)

Horses 10 years old that were kept on a dry lot were almost twice as likely to develop colic as those of the same age that were stabled. Colic was almost four times more likely in 15-year-olds, and over seven times more likely in 20-year-old horses kept on dry lots, compared with stabled horses of similar age. The authors suggested that this might relate to the quality of daily care: older horses may be more likely to develop colic when left outside in dry lots if they have little direct monitoring or care.

Use/Activity

Once again, study results differ somewhat in the association between a horse's use or activity and colic risk. However, most studies support the general conclusion that colic risk tends to be greater in horses in 'high-stress occupations' such as athletic competition and showing.

Owner/manager-based studies

In the VA/MD study,¹ the incidence of colic was highest in eventers and horses in training for strenuous activities such as racing, steeplechasing, and eventing. Colic incidence was lowest in horses used for lessons and in young horses not yet in use. Following are the annual colic rates (per 100 horses) for specific activities in that study:

- adults used for lessons, 1.6 cases
- young horses not yet in use, 3.2 cases
- hunters, 6.6 cases
- adults with no specific use, 6.7 cases
- pleasure horses, 10.4 cases
- breeding, 11.7 cases
- dressage, 14.0 cases
- showing, 14.4 cases
- racing, 15.4 cases
- training for strenuous activities, 23.6 cases
- eventing, 24.0 cases

In the MI study,² the activities that significantly increased the risk for colic were showing and foaling. (Incidentally, hunter-jumpers were analyzed separately from the "showing" group, and were not at increased risk for colic.) While not statistically significant, colic also tended to be more prevalent in horses used for dressage, breeding, or training for showing.

No racehorses developed colic during the two years of observation in that study, but only about 4% of the population studied (171 of more than 3,900 horses) were racehorses.

Veterinarian-based studies

In the first TX study,³ racing was the only activity significantly associated with colic incidence — and that association was of colic being *less* likely in racehorses. In the second TX study,⁴ use or activity was not significantly associated with colic incidence for any group or type of horse.

Foaling

Mares that foaled during the study period were at increased risk for colic in the MI study.² But in the VA/MD¹ and TX^{3,4} studies, foaling was not a significant colic risk. However, in the VA/MD study the odds of a mare developing colic between 60 and 150 days (2 to 5 months) after foaling were almost six times higher than that of other horses. This period is the time of peak lactation, and therefore nutritional demand, so the amount of grain fed could have been a key factor (see page 31).

A recent hospital-based study in Germany found that mares may be more prone to colic in the post-foaling period than during pregnancy. Mares that had recently foaled were more likely to have colic severe enough to need referral to a veterinary hospital than were mid- or late-term pregnant mares. Almost half (46%) of the broodmares referred for colic were mares that had recently foaled. The remainder were equally divided between mares in their second trimester (4 to 7 months) and mares in their third trimester (8 to 11 months) of pregnancy.

In that study, three-quarters of the colic cases in broodmares involved digestive tract problems, and one-quarter involved the reproductive tract or other internal organs. The most common intestinal causes of colic were large colon impaction and large colon volvulus (twist).

Behavior

Few studies have examined the effect of behavior on colic incidence. Yet many owners and trainers have found that colic is more common in crib-biters ('cribbers'), horses with a nervous disposition, and those that display other undesirable behaviors of confinement (*i.e.*, stable vices). In the owner/manager-based study in VA/MD,¹ there was a tendency for colic to be more likely in horses that cribbed and in those at the bottom of the 'pecking order' (*i.e.*, horses that are not dominant and are often picked upon in a herd situation.)

Crib-biting or wind-sucking

It was long thought that colic in cribbers was caused by overinflation of the stomach with swallowed air, but it has since been proven with radiography (x-rays)¹³ that these horses do not swallow the air they 'gulp' when they crib-bite or wind-suck. The air they gulp in the process does not get any further than the first few inches of the esophagus. It is then expelled into the back of the throat, making the grunting or belching noise that is heard when horses crib.

One reason why colic may be more common in cribbers is that they spend much of their time cribbing, rather than grazing or eating hay. Thus, their food intake, when they do stop to eat, is intermittent and their overall roughage intake may be inadequate (see Chapter 3). In addition, because these horses tend to be underweight, their ration usually includes a good deal of grain. As discussed later, colic risk

increases as the amount of grain in the diet increases. For the same reasons, horses that compulsively fence-walk, stall-walk, or weave may also be at increased risk for colic.

Rolling and displacements or twists

It is commonly thought that intestinal displacements and twists are caused by the horse rolling, but that is simply not true. Horses roll every day without causing these problems. Although not fully understood, displacements probably begin with altered bowel motility and/or buildup of gas in a particular segment, whether from rapid fermentation of feed or backup behind some fibrous feed material that is slow to pass. The gassy segment, being lighter, is more easily moved out of its normal position by bowel activity, which can lead to a displacement, and to further gas distention.

But can a horse make a displacement worse, or even cause the displaced bowel to twist, by rolling? It is possible, but extremely unlikely. When a segment of bowel is distended with gas, it tends to fill the abdomen, leaving little room for further displacement. The main reason most veterinarians recommend that you try to keep a colicking horse from rolling by getting it up and walking it around is to prevent the horse from injuring itself. (Dealing with a colicking horse is discussed in Chapter 4.)

In fact, some displacements (notably, nephrosplenic entrapment of the large colon) may be corrected by carefully rolling the anesthetized horse. However, rolling doesn't always work; sometimes surgery is necessary to correct the problem and prevent its recurrence.

History of colic

One consistent finding among studies is that if a horse has had colic before, it is more likely to have colic again. In the owner/manager-based study in VA/MD,¹ colic was almost four times more likely in horses that had colic in the past 5 years than in horses with no history of colic. During the study, 16% (or about 1 in 6) of the horses that developed colic had at least one other episode of colic within the study year.

In the first veterinarian-based study in TX,³ colic was almost six times more likely with a history of colic than in horses with no history of colic. Around 30% of the horses with colic had a history of colic.

In the VA/MD study, the information was recorded by owners, trainers, and farm managers, and there was a significant number of colic cases (33%) that were not severe enough to warrant veterinary attention. In contrast, the information in the TX study was recorded by veterinarians called out to examine the colicking horses. In other words, the VA/MD study comprised more horses with mild, transient colic. Presumably, the underlying problem was also transient, and it would be reasonable to conclude that these incidents of mild colic do not significantly increase the risk for future colic episodes — unless, of course, any contributing management factors persisted.

Colic surgery

In both veterinarian-based studies in TX,^{3,4} colic was about five times more likely in horses with a history of abdominal surgery (most often for colic). In a related study by the same researchers, a history of abdominal/colic surgery was the risk factor most highly associated with recurrent or chronic intermittent colic.¹⁰

Adhesions. An important cause of colic following abdominal surgery is the presence of adhesions, which are fibrous bands that form where the bowel wall has been inflamed or damaged (including by surgical incision). When adhesions cause colic, problems usually begin within the first 2 months after surgery.

The incidence of adhesions following colic surgery, and the percentage of those adhesions that cause problems, is unknown because only a small proportion of horses are re-examined surgically, which is the only way of definitively identifying adhesions, other than postmortem examination. It is estimated that adhesions will cause a significant problem in about 20% of surgery patients (or 1 in 5);¹⁴ but not all of these horses will need a second surgery.

Other factors. Another possible cause of chronic or recurrent colic following surgery is narrowing (stricture) of the inflamed, damaged, or repaired portion of bowel. As with adhesions, the incidence of this problem is difficult to determine, but it appears to be quite low with good surgical technique. Also a consideration is persistence of the intrinsic, management, or environmental factors that caused or contributed to the problem which required surgery.

Caretaker vs. owner

An intriguing finding in one hospital-based study¹² was that the risk for another episode of colic nearly doubled if the horse was cared for by someone other than the owner (*i.e.*, a trainer or barn manager). No explanation was obvious from the other data, so two possibilities were suggested: (1) owners take better care of their horses than trainers or managers, or (2) trainers/managers are more likely than owners to call a veterinarian when a horse in their care develops colic.

Herein lies a common problem with statistics: determining the practical value of the information. The level of management varies widely within the equine industry, and it even varies to some extent on an individual farm (*e.g.*, a boarding barn with many different horses and owners). There are just as many conscientious trainers and managers as there are conscientious owners; and the same holds true for lax or penny-pinching trainers/managers and owners.

As a counterpoint, the number and type of caretakers was not significantly associated with colic incidence in the owner/manager-based study in VA/MD.¹ Also, in the second TX study,⁴ there was no difference in colic incidence between horses that were boarded and those that were kept on the owner's farm.

Genetics

Lethal white foal syndrome

To date, there is only one confirmed instance in which genetics play a direct role in colic: lethal white foal syndrome, a fatal condition affecting newborn Paint Horse foals. Also called aganglionosis (absence of ganglions), it involves incomplete development of the nerves that supply the muscles in the bowel wall, particularly in the ileum and large colon. Affected segments of bowel are nonfunctional and act like an obstruction. Milk, digestive juices, and gas build up within and behind the paralyzed segment. The result is colic that begins within 12 to 24 hours of birth, worsens despite medical treatment, and cannot be corrected surgically. Affected foals die or are euthanized (humanely killed).

This condition is an inherited trait that most often occurs in foals born to matings between two overos of the "frame" color type. (Frame overos have continuous color along the topline from wither to tail [*i.e.*, white does not cross the back] and the colored areas "frame" the white areas.) Affected foals are born white, or almost so, with few or no areas of colored skin or hair, and blue eyes. Hence the name, lethal *white foal syndrome*.

Possible genetic links

As discussed under Breed (pages 20–22), several specific conditions tend to be more common in certain breeds, which could indicate a genetic factor or propensity. Examples include inguinal or scrotal hernia in Standardbreds and Tennessee Walking Horses; cecal intussusception in Standardbreds; and enteroliths in Arabians (and in one study also in Morgans, American Saddlebreds, and donkeys). However, management factors probably play as much of a role, particularly with cecal problems and enteroliths. Umbilical hernias appear to be more common in certain Thoroughbred lines, but a direct genetic link has yet to be proven.

Management Factors

Diet

As with many of the factors discussed thus far, study findings regarding diet and colic incidence sometimes are inconclusive or contradictory. One possible reason is that, even within the US, feeds and feeding practices vary widely. Also, the effects of diet and feeding schedule often cannot be separated from other management practices, and may also depend on the horse's use.

Amount and type of grain

Colic tends to be less common in horses fed roughage-only diets (pasture and/or hay), and colic risk increases as the amount of grain-based concentrates (plain grain, grain-based pellets, "sweet feed," *etc.*) increases. In the VA/MD study,¹ significant findings related to diet included the following:

- colic incidence was low in horses on pasture (*i.e.*, those receiving no grain-based feeds)
- colic incidence increased as the amount of grain-based concentrate increased
 - horses fed up to 2.5 kilograms (5.5 pounds) of concentrates per day were only slightly more likely to develop colic than horses fed no concentrates
 - horses fed 2.5 to 5 kg (5.5 to 11 lb) of concentrates per day were almost five times more likely to develop colic than horses fed no concentrates
 - horses fed more than 5 kg (11 lb) of concentrates per day were over six times more likely to develop colic than horses receiving no concentrates
- feeding the more processed types of concentrate, such as pellets, rather than plain grain increased the colic risk
 - horses fed plain grains (whole or coarsely processed, *e.g.*, rolled, cracked, steamed) were only slightly more likely to develop colic than horses fed no concentrates
 - horses fed sweet feed were more than four times more likely to develop colic than horses fed no concentrates
 - horses fed grain-based pellets (in which the grains were finely ground during processing) were over six times more likely to develop colic than horses fed no concentrates

The explanation given for the last point was that highly processed feeds are more easily digested than whole grains, and therefore may alter conditions within the colon to a greater extent when fed in large amounts. (This concept is discussed below, in the section *What's the big deal with concentrates?*)

The second veterinarian-based study in TX⁴ found that neither the amount nor type of concentrates fed was significantly associated with colic risk. However, in that study the amount of concentrates fed ranged from less than 100 grams (less than half a cup) to more than 11 kg (24 lb) per day. The average was 2 to 3 kg (4.4 to 6.6 lb) per day, which in the VA/MD study carried only a slightly higher colic risk than feeding no concentrates. So, perhaps there were too few horses in the TX study that were receiving large amounts of grain for an effect of grain feeding to be significant.

Another possible reason for the discrepancy between studies is a difference in other dietary or management factors between the mid-Atlantic states and Texas. As discussed later, hay was the key dietary colic risk factor in the TX study; both the type of hay fed and recent changes in hay feeding were significantly associated with colic risk.

In a study involving several university veterinary teaching hospitals in the northeastern United States and Ontario, Canada,¹² feeding corn increased the risk for colic. For each 1 kg (2.2 lb) of corn fed, the colic risk was increased more than three-fold. However, this finding should not be interpreted to mean that corn causes colic. Corn is simply another grain, and when incorporated into a balanced ration, it has some worthwhile nutritional benefits. But like any grain or grain-based (*i.e.*, high-carbohydrate) feed, colic risk increased with the amount fed.

Frequency of concentrate feeding

The VA/MD study¹ also found that dividing the daily concentrate ration into two or more meals did not reduce the colic risk when feeding large amounts of concentrates. Horses fed concentrates twice a day were more than four times more likely to develop colic, and those fed concentrates three or more times a day were over five times more likely to develop colic, than horses fed no concentrates.

As the horses being fed grain two or more times a day were probably being fed more grain per day than horses receiving grain only once a day, these results support the following conclusions:

- horses fed large amounts of grain-based concentrates are more likely to develop colic than horses fed small amounts or no concentrates
- dividing the daily concentrate ration into two or more meals did not reduce the colic risk when large amounts of concentrates were fed

What's the big deal with concentrates?

The horse's digestive system is adapted to handle fairly continuous input of high-fiber food. The easily digestible components (simple sugars, starch, fats, proteins) are broken down and absorbed in the small intestine. Bacteria and other microbes in the cecum and large colon handle any overflow and break down the indigestible plant fiber. When a large* amount of readily digestible carbohydrate, such as grain or a grain-based concentrate, is fed in a single meal, the small intestine cannot digest and absorb it all. As a result, significant amounts of carbohydrate reach the cecum and large colon. (**What constitutes a 'large' amount is discussed on the next page.*)

Starch and simple sugars are rapidly fermented by the resident gut microbes, which causes rapid increases in acidity and gas production in the bowel. These changes are the same as those that occur with grain overload (which can lead to colic and laminitis), but on a smaller scale. In fact, this dietary effect has been referred to as 'subclinical grain overload.'

Rapid fermentation of carbohydrates also draws water from the bloodstream into the cecum and large colon, causing a temporary state of mild dehydration. For the first 8 hours after a large grain meal, the body adds fluid into the bowel contents (a process called secretion). Most of the fluid is then absorbed back into the bloodstream over the next several hours (a process called resorption) as digested material moves down the colon.¹⁵

Association with colic. When large amounts of grain are fed twice a day, a cycle of rapid fermentation and fluid secretion/resorption develops which can easily be upset. Just as balance is being restored after the last meal, another load of carbohydrate is dumped into the cecum, and the cycle must begin again.

Possible consequences of an upset in this cycle include the following:

- spasmodic or gas colic from rapid gas buildup in the colon
 - the products of carbohydrate fermentation can alter bowel motility, resulting in disordered forward motility, cramping, and further gas buildup
- feed impaction from dehydration of the bowel contents further downstream, particularly at the pelvic flexure of the large colon, at the transverse colon, or in the small colon
- large colon displacement from fluctuations in the amount of colonic gas (especially rapid increases caused by microbial fermentation) and consequent alterations in bowel motility
 - in a study at the University of Georgia,⁹ large colon displacement was significantly associated with feeding pelleted grain
- proximal enteritis (duodenitis-proximal jejunitis; see Chapter 1, page 7)
 - some fermentation of carbohydrates also occurs in the stomach and small intestine, and under certain circumstances it may contribute to this serious condition
 - most horses with proximal enteritis are on grain-based concentrates

It's now easy to understand why, in the VA/MD study, feeding grain more often than twice a day did not decrease the risk associated with feeding large amounts of grain: the colon has little time to restore its balance when carbohydrates are being delivered in bulk more often than every 12 hours.

“Although horses can be maintained indefinitely with twice-daily feedings, one should recognize that a delicate balance has been achieved in the cycling of certain physiological systems. Disruption of this balance may result from insidious disease conditions, such as internal parasitism, or from subtle changes in management, such as altered feeding intervals or temporary lapses in water or salt availability.”¹⁵

But what constitutes a ‘large’ amount? There is little published data on just how much carbohydrate it takes to overwhelm the ability of the small intestine to digest and absorb it, and therefore to upset the balance in the large intestine. No doubt it depends on the horse's size.

It may also depend on the horse's diet. To some extent, the microbial population in the large intestine adapts to the materials that are supplied (see Chapter 3). Nevertheless, the changes in acidity, gas production, and fluid balance still occur in horses that are adapted to high-grain diets, just not to the same extent as those fed or allowed access to an unusually large amount of readily fermentable carbohydrate (including lush pasture).

In the VA/MD study,¹ which is currently our best “real world” examination of colic risk factors, the colic risk became significant when more than 2.5 kg (5.5 lb) of grain-based concentrate was fed per day.

Whether that figure is valid for other types of horses (*e.g.*, ponies and draft breeds) and horses in other parts of the country remains to be seen. It would be useless to set an arbitrary figure, given the wide variation in horse sizes, types, diets, activities, and environments, but this study finding is a good start:

Feeding more than 2.5 kilograms (5½ pounds) of grain-based concentrate per day may not *cause* colic, but it may well increase the colic risk, especially if other risk factors are present.

Roughage

The horse's digestive system is designed to process high-fiber diets. So, it is not surprising that the VA/MD study¹ showed a lower incidence of colic in horses fed roughage diets (pasture and/or hay).

One hospital-based study¹² showed a slightly lower incidence of colic in horses fed some concentrates, compared with horses on roughage-only diets, but management factors likely played a role. Many of the horses fed only roughage were kept on pasture, and, according to the authors, may have been less well managed in other respects than the stabled horses.

Fresh grass. Although considered roughage, fresh grass can be high in readily fermentable carbohydrates when young and rapidly growing, such as in the spring, after a drought, and often in the autumn if the weather is mild and wet. So, lush pasture can cause colic by the same means as grain: an excess of readily fermentable carbohydrate reaching the large intestine. Mild spasmodic or gas colic is the most common type of colic caused by lush pasture.

In the veterinarian-based study in the UK,⁵ a recent management change was blamed for at least 40% of the cases of spasmodic colic or mild, undiagnosed colic. The most common management change was turnout onto lush pasture in the spring. In most parts of the US, fresh grass is a potential colic risk for only a few weeks of the year. Preventing this type of colic is discussed in Chapter 3.

Hay quality

In the second veterinarian-based study in TX,⁴ feeding a hay other than coastal Bermuda grass or alfalfa significantly increased the colic risk. However, hay quality and digestibility appeared to be the key. Hays listed as "other" included haygrazer, peanut, red-top cane, sorghum, and Sudan grass, all of which are harvested at a fairly mature stage of growth and tend to be less digestible than coastal Bermuda grass and alfalfa hays.

Other types of hay included prairie grass (average to poor in quality), Bahia grass (which is susceptible to mold and mildew), and kleingrass (which many horses do not find very palatable). Of the 35 horses in the study that were fed one of these other hays, 29 horses (83%) were in the colic group.

Also in that study, a recent change in hay feeding significantly increased the colic risk (see page 36). Changes included switching to a different type of hay, and even feeding a new batch of the same type of hay (*e.g.*, a different cutting or another source). The authors suggested that changes in digestibility may be involved. For example, changing to poorer quality hay may predispose the horse to large colon impaction, which was the second most common type of colic in that study.

Roughage quality and Minis. Miniature Horses are susceptible to small colon obstruction. In many cases (73% of surgical cases in one study),¹⁶ the obstruction is composed of dry, firm, fibrous feed material. It has been suggested that hay of a quality that is adequate for larger horses may be too coarse for Minis. Another consideration is that dental problems, which are fairly common in this breed, could interfere

with proper chewing of an otherwise acceptable foodstuff. (Preventing colic in Miniature Horses is discussed in Chapter 3.)

Coastal Bermuda grass hay

A researcher at the University of Georgia¹⁷ recently conducted a survey of 36 equine surgeons in the southern US, in which he asked their opinions of a possible link between ileal impaction (obstruction of the ileum, the last part of the small intestine) and the feeding of coastal Bermuda grass hay. From their answers, he compiled the following statistics:

- 58% considered coastal Bermuda hay to be a contributing factor in ileal impaction
- 36% felt that horses recently moved to the southern US were more likely to develop ileal impaction than those raised in that part of the country
- 64% reported an association between ileal impaction and changing to coastal hay from pasture or from another type of hay
- 39% had observed repeated episodes of ileal impaction, which were often associated with the continued feeding of coastal hay

This study was simply an opinion-based survey. No 'hard data' (numbers of cases) were collected. But a recent report from Auburn University in Alabama¹⁸ supports the opinion that coastal Bermuda grass hay does play a role in ileal impaction. Of 28 horses requiring surgery for ileal impaction, 27 horses were fed coastal Bermuda hay as the primary hay source. However, it must be noted that coastal Bermuda hay is commonly fed in the southern US, which partially accounts for the high percentage of cases fed this hay.

In a related study by the principal author of the two TX studies,¹⁰ coastal Bermuda grass hay was found to be a significant cause of recurrent or chronic, intermittent colic.

By the same token, some equine nutritionists feel that coastal hay is unfairly maligned. In a paper titled "*Myths and wives' tales of feeding horses: some truth, some fiction,*" an equine nutritionist in Kentucky had this to say about coastal hay:

"I have fed coastal hay all of my life with no increase in the amount of gastrointestinal upset over that experienced by horse owners that do not choose to feed coastal Bermuda hay. My family raises coastal Bermuda hay in Texas and are able to harvest more nutrients per acre using this hay than for any other appropriate forage crop that they could raise. Coastal Bermuda grass is very responsive to the application of nitrogen fertilizer and this is reflected in the variability one sees in looking at the composition of coastal hay grown in different parts of the country, or indeed within a given state."¹⁹

According to nutritionists at the North Carolina State University Co-operative Extension Service, plant maturity is probably the single most important factor influencing the nutrient content and quality of hay.

The bottom line seems to be that *good quality* coastal hay is a good feed source for horses and is no more likely to cause impaction colic than any other hay. But *poor quality* coastal hay, which is very stemmy and poorly digestible, can cause impactions, both in the ileum and in the large colon. (Evaluating hay quality is discussed in Chapter 3.)

Alfalfa hay

There is a reported association between feeding alfalfa hay and colic caused by enteroliths, which are rock-hard masses of accumulated struvite, a crystal formed of magnesium, ammonium, and phosphorus.

Enteroliths. These 'stones' form in the large colon, around some sort of foreign material (*e.g.*, wire, pebble, baling twine) or fibrous feed material, much like an oyster forms a pearl around a grain of sand or other irritant. Most enteroliths are passed in the manure while still small. Those that remain in the colon gradually enlarge over time as more struvite is laid down around the outer surface. These enteroliths (single or multiple) may be 'silent' for years, but eventually most cause an obstruction and must be surgically removed.

Enteroliths can occur in any part of the country, but they tend to be more common in the western US, where alfalfa is often used as the primary hay source. Alfalfa is implicated in enterolith formation because of its high magnesium and protein content.

Protein may be as important as the mineral content because protein breakdown in the large colon releases ammonium, which is then free to form complexes with available magnesium and phosphorus. In addition, enteroliths tend to form when the contents of the colon are less acidic than normal, so alfalfa may further contribute by reducing the acidity of the colonic contents.

Surgeons at UC Davis compared the bowel contents from two groups of horses that underwent colic surgery: those with enteroliths and those with other simple large colon obstructions. They found that the bowel contents from horses with enteroliths were less acidic (higher pH) and had higher levels of calcium, magnesium, phosphorus, sodium, potassium, and nitrogen than horses without enteroliths.

When feeding practices were compared, horses with enteroliths were fed a diet that contained an average of 87% alfalfa, whereas the other horses were fed a diet that comprised about 60% alfalfa. In another study by researchers at UC Davis, two-thirds of the horses with enteroliths were fed a diet that consisted exclusively of alfalfa.

Alfalfa and gastric ulcers. In alfalfa's favor, researchers at the University of Tennessee²⁰ reported that fewer and smaller gastric ulcers were found in horses fed a diet consisting of alfalfa hay and grain than in those fed only bromegrass hay. Apparently, because of its high protein and calcium content, alfalfa may act as a natural antacid, which could help protect the stomach from ulceration. (Whether this diet is of use in preventing colic caused by gastric ulcers, or in healing existing ulcers, remains to be seen.)

Feeding changes

Colic risk tends to increase when the horse's diet is change. In the owner/manager-based study in VA/MD,¹ changing the amount or type of concentrates fed during the year increased the colic risk by almost four times; and more than one change per year in hay feeding doubled the colic risk.

In the first veterinarian-based TX study,³ a recent change of diet significantly increased the colic risk. Colic was over three times more likely in the 1 to 2 weeks after a diet change, and five times more likely in the 48 hours after a diet change. But to put things into perspective, 80% of the horses in the colic group had not had any recent changes in diet.

A recent diet change also significantly increased the colic risk in the second TX study.⁴ Of the changes evaluated, a change in hay feeding was most highly correlated with colic risk. In fact, a change in hay feeding carried the highest colic risk of all the dietary and management factors evaluated. The odds

of a horse developing colic within 2 weeks of a change in hay were almost ten times greater than if the horse had no change in hay. (In comparison, previous colic surgery increased the colic risk by only five times.)

While the researchers did not analyze the specific changes in hay feeding, even using a new batch or source of the same type of hay was recorded as a change in hay feeding. As mentioned earlier, a decrease in hay quality was probably a key factor.

Colic associated with eating

In some horses with recurrent or chronic (persistent) colic, the colic episodes begin during a meal or shortly afterward. Three conditions to consider in this situation are these:

- gastric ulcers, especially if the horse is fed grain-based concentrate
 - colic after nursing or eating is also common in foals with duodenal ulcers, especially if the duodenum has become narrowed (stricture)
 - although rare, squamous cell carcinoma of the stomach creates erosions in the stomach lining that may cause colic associated with eating
- adhesions (see pages 29–30)
- partial ileal obstruction
 - narrowing of the ileum can cause colic associated with movement of food, especially hay, along the small intestine that is stimulated by eating
 - examples include tapeworm infestation and ileal hypertrophy (thickening of the muscular layer of the ileal wall; cause unknown)

Unusual feed materials

Acorns can cause colic in horses, although many horses eat the occasional acorn without any ill effects. Apples, other sweet fruits, and bread, in large quantities, can cause spasmodic or gas colic because they are high in readily fermentable carbohydrates. Grass clippings often cause colic for the same reason; they can also cause choke (esophageal obstruction) or obstruction further down the digestive tract. When eaten in large quantities, persimmons (a type of fruit) can cause impaction of the stomach.

Feed contaminants

Objects such as wood, plastic, rubber, and baling twine can cause colic by obstructing the bowel or by stimulating the formation of an enterolith (described on page 36).

Blister beetles. Blister beetles are small insects that infest alfalfa fields. They are most prevalent in the central and western US. When the hay is cut and baled, the blister beetles are killed and baled with the hay. These insects contain a highly irritating toxin, cantharidin, which causes severe ulceration of the digestive tract and kidney damage. Colic and severe diarrhea are typical findings in horses with blister beetle toxicity. This problem is more likely with blister beetle-infested alfalfa that has been crimped or otherwise “conditioned” during cutting and baling, because these processes crush the beetles, potentially exposing the horse to more cantharidin.

Mycotoxins. Moldy hay or grain can also cause colic. In most cases, the culprit is a fungal toxin, or mycotoxin. In a study at North Carolina State University, a correlation was found between the incidence of colic and the presence of mycotoxins in grain and hay. Liver damage, which is a rare cause of colic, can also be caused by certain mycotoxins in grain or hay.

Ideally, all horse feeds should be completely free of mycotoxins. But as this goal is not always attainable, the North Carolina State University Co-operative Extension Service has listed the following *maximum acceptable levels* of these specific mycotoxins in horse feeds:

- aflatoxin: 50 parts per billion (ppb)
- T₂ toxin: 50 ppb
- deoxynivalenol (DON): 400 ppb
- zearalenone (F₂): 100 ppb
- fumonisin (FB₁): zero

In terms of colic risk, T₂, F₂, and DON may be the most important mycotoxins, particularly when they are present in combination.

Housing

Study results concerning housing and the horse's environment are perhaps the least conclusive. It makes sense to presume that confining an animal which, in its natural state, spends most of the day and night roaming around and grazing, would have some impact on its health and well-being.

Add to the mix a diet that is substantially different from what the horse's system is designed to handle, and it's no surprise that various conditions, including lung disease and exercise-related muscle disorders, not to mention undesirable behaviors, are more common in horses that are kept in stalls most or all of the time. So why not digestive problems too?

One explanation for the inconclusive results is that several factors related to housing are interconnected. 'Housing' incorporates the horse's environment, feeding and turnout/exercise schedules, water sources, and even social interactions, from the need for company to competition for food. In fact, the first veterinarian-based study in TX³ showed that changes in activity level, diet, and stabling conditions are all significantly associated with one another. So, it can be difficult, if not impossible, to study the effects of individual factors, such as housing, independently.

Inside vs. outside

Another reason why there is little conclusive evidence for an effect of housing on colic risk is flawed study design — not asking the right questions. For example, the owner/manager-based study in MI² merely compared access to indoor housing with access to outdoor housing. Time spent indoors versus outdoors (*i.e.*, how much access) was not reported. Not surprisingly, no significant difference in colic incidence was found between the two housing situations.

The owner/manager-based study in VA/MD¹ also found no significant effect of housing on colic risk, although colic incidence was slightly higher in horses stalled for more than 8 hours per day, and colic incidence was generally low in horses kept at pasture.

The first veterinarian-based study in TX³ showed no significant effect of housing on colic incidence, but most of the horses were kept outside for at least 12 hours per day. In the second TX study,⁴ colic was slightly more likely in horses that were stalled for more than 12 hours per day.

Large colon impaction. A British study²¹ of horses with chronic colic (defined as signs of colic that persisted for 3 days or more) produced some interesting results. Large colon impaction was the most common cause of chronic colic, and it was far more common in horses that were stabled full-time:

Housing	All horses with chronic colic	Horses with large colon impaction
	106 cases	32 cases
stabled full-time	38 (36%)	22 (69%)
stabled part-time	55 (52%)	9 (28%)
pastured full-time	13 (12%)	1 (3%)

Of all the horses with chronic colic, only about one-third (36%) were stabled full-time, yet the majority (69%) of large colon impactions occurred in horses that were stabled full-time. The implication here is that regular turnout is important in preventing large colon impactions. Notice, too, that the incidence of chronic colic was lowest (by three-fold to more than four-fold) in horses kept on pasture full-time.

Changes in housing

The incidence of colic tends to increase when changes are made in a horse's routine, activity level, and/or environment. In the owner/manager-based study in VA/MD,¹ colic risk was slightly increased in horses that had more than four changes in housing during the study year.

Veterinarian-based studies. In both of the veterinarian-based studies in TX,^{3,4} a change in stabling conditions within the past 2 weeks increased the colic risk. Details were not provided, but the authors did note in the first study that changes in housing were more common during the early summer and autumn, which could reflect a change in pasture access or turnout time.

Also in the TX studies, colic was more likely in horses that had a change in activity level in the past 1 to 2 weeks. Details were not reported. Nevertheless, this finding highlights the importance of consistency in a horse's routine.

In the veterinarian-based study in the UK,⁵ a recent management change was a possible cause of spasmodic colic or mild, undiagnosed colic in at least 40% of cases. The most common change was turnout onto lush spring pasture, which reflects a dietary change as much as a housing change. This is consistent with the findings of the TX studies: changes in activity level, diet, and stabling conditions were all significantly associated with one another, but of these factors, recent dietary change carried the highest colic risk.

Bedding type

The type of stall bedding was not significantly associated with colic risk in either the manager-based study in VA/MD¹ or in the first veterinarian-based study in TX.³

Pasture access and rotation

A hospital-based study in the northeastern US and Ontario, Canada¹² found that horses with access to three pastures in the past month were about half as likely to develop colic as were horses with access to only one pasture. The number of horses with access to three pastures was small (15 horses), so this result must not be overinterpreted. But it does raise the possibility that roughage intake or quality was greater in the horses with access to more than one pasture.

Pasture rotation. However, also in that study,¹² horses with access to four pastures in the past month were twice as likely to develop colic as those with access to one pasture. This result is not easy to explain. The authors noted that most of the horses with access to four pastures were on a paddock rotation system, as opposed to a less structured grazing system. If the routine was that the horses were not moved to a fresh pasture until the one they were on was eaten down, then roughage intake and quality may not have been as high as horses grazing fewer pastures in a less structured system. Also, internal parasites and intake of sand could become a problem in such a rotational grazing system.

Farm size and stocking rate

The second veterinarian-based study in TX⁴ found that colic was slightly more likely on farms smaller than 25 acres and on those with more than 1 horse per 4 acres. Also in that study, horses receiving no exercise other than pasture turnout were significantly less likely to develop colic than horses that were exercised at least once a week.

In addition, each of these factors (farm size, stocking rate, and activity level), as well as housing and water source, were all inter-related. The authors interpreted these findings to indicate that horses kept at pasture — which generally were from the larger farms with the lower stocking rates — were at decreased risk for colic (or, more precisely, they were less likely to be observed to have colic).

Water

The study that reported on pasture rotation¹² also found that horses in outside enclosures (pasture or drylot) without constant access to water were more than twice as likely to develop colic as horses that had a continuous supply of water. Typically, owners or trainers put the horses outside without water for “just an hour or two.” But it is easy to imagine how that hour or two could have stretched into a whole morning or afternoon in some cases.

The minimum water requirement for mature, nonlactating horses under comfortable environmental conditions is 30 milliliters of water per kilogram of body weight per day (30 ml/kg/day). For a 500-kg (1,100-lb) horse, that’s at least 15 liters (just under 4 gallons) of water per day. Water requirements substantially increase with exercise, lactation, rises in environmental temperature and humidity, and the amount of hay in the diet (see Chapter 3).

In the manager-based study in MI,² horses that were provided with group drinking water from a source other than a bucket, tank, or automatic waterer were almost seven times less likely to develop colic than horses provided with one of these water sources. The researchers noted that on farms listing “other” for group water source, most horses were provided with water from more than one source. So, the type of water source probably is not as important as ready access and a plentiful supply of water. Another key factor may be that the horses provided with more than one group water source were kept at pasture, and were therefore at less risk for colic.

In the second TX study,⁴ horses with access to a pond were significantly less likely to develop colic than horses provided with other water sources. Also in that study, stalled horses provided with water from a bucket were at slightly increased risk for colic.

Heating drinking water in winter. In the MI study,² heating the drinking water in freezing weather had no significant effect on colic incidence. Nevertheless, this practice is important at times when water sources are likely to freeze because inadequate water intake is often a contributing factor in large colon impactions.

A study at the University of Pennsylvania showed that ponies kept in an unheated barn in winter and offered unheated (near-freezing) water drank 40% less than when they were offered heated water. Two methods of providing heated water were studied:

- bucket heater which continuously warmed the water
- filling the buckets twice a day (at meal times) with hot tap water (46–49 °C, or 115–120 °F)

Water intake was similar for both methods. In all ponies, water intake was greatest within 3 hours of feeding, by which time the hot-tap-water buckets had cooled to around 21 °C, or 70 °F. The authors concluded that providing hot tap water twice a day is a simple and effective way of ensuring adequate water intake during the winter months.

Internal parasites

Internal parasites (“worms”) remain an important cause of colic in horses. Before the arrival of anthelmintics (dewormers) that are highly effective against the immature or larval stages, severe colic caused by large strongyles was relatively common and had a fairly high mortality rate. Nowadays, this type of colic is very uncommon* and the focus of internal parasite control has shifted from the large strongyles to the small strongyles (cyathostomes) and tapeworms. In young horses, roundworms are also a consideration.

(*See note on next page.)

Large strongyles

Large strongyles (*Strongylus vulgaris*, *edentatus*, and *equinus*) are an important cause of colic where deworming programs are inadequate. *Strongylus vulgaris*, commonly known as redworm or bloodworm, has the potential to cause the most damage. During its life cycle, larvae on the pasture are swallowed by the horse, penetrate the bowel lining, and migrate along the blood vessels in the bowel wall. Eventually, some of the larvae migrate as far as the cranial mesenteric artery, which is the major blood vessel that branches off the aorta and supplies most of the intestine with blood.

These parasites can cause colic by two mechanisms:

1. Penetration of the bowel lining and migration into the small vessels within the bowel wall causes inflammation, blood vessel constriction, and altered bowel motility. The result typically is mild, spasmodic colic within a few days of the horse grazing infected pasture. Spasmodic colic may also occur several months later, when late-stage larvae return to the interior of the bowel to mature into egg-laying adults.

2. Larval migration within the arteries of the bowel narrows the vessels by causing constriction, inflammation and thickening of the vessel wall, and sometimes blood clots within the vessels. These changes reduce blood flow to the bowel, which can alter bowel motility and cause spasmodic colic.

When large numbers of larvae migrate into the cranial mesenteric artery or its branches, the damage they cause can severely reduce blood flow through the affected artery. As a result, the section of bowel wall supplied by that artery may die, causing severe and sometimes fatal colic. Fortunately, this type of colic — verminous arteritis or thromboembolic colic — is now very uncommon* (less than 1% of cases in the MI study²), owing to the widespread use of highly effective anthelmintics such as ivermectin.

(*2016 Note: Colic caused by *Strongylus vulgaris* is once again on the rise, owing to casual deworming practices in this post-ivermectin era.)

Small strongyles (cyathostomes)

Small strongyles (*Cyathostomum*, *Cylicocylus*, *Cylicostephanus*, and others) were originally considered to be of only minor importance. But now that the large strongyles are readily controllable, it has become clear that small strongyles are important internal parasites in horses, even though their effects on the horse may not be as dramatic.

The impact of small strongyles is two-fold: (1) their ability to be present in large numbers without causing severe disease, and (2) their resistance to most anthelmintics during certain stages of their life cycle. Heavy loads of small strongyles can cause weight loss, lethargy, poor coat condition, slowed growth, colic, and diarrhea. This condition is termed larval cyathostomosis. Lighter infestations are not obvious, although it is common for a horse's general health and performance to improve after larvicidal treatment (discussed in Chapter 3).

Unlike large strongyles, the larvae of small strongyles do not migrate through the bowel wall. Instead, they burrow into the lining and become dormant (encysted) for part of their life cycle. These encysted, or hypobiotic, larvae are resistant to most anthelmintics. They remain encysted for months (sometimes for more than 2 years) before awakening and emerging into the interior of the bowel and maturing into egg-laying adults.

Colic associated with small strongyle infestation is caused by inflammation of the bowel lining and altered bowel motility. The mere presence of strongyle larvae in the intestine can alter bowel motility, potentially leading to colic. But penetration of the bowel lining by the larvae, and later the emergence of many larvae at once (*en masse*), cause more pronounced inflammation and motility changes.

What triggers the hypobiotic larvae to resume their development and emerge into the bowel interior all at once is not yet known. But it is probably some type of environmental trigger. In temperate climates, the larvae tend to emerge in the late winter or early spring, whereas in warmer areas, the larvae may emerge in the late summer or autumn.

'Effect of three anthelmintic schedules on colic incidence.' Proof that small strongyles are a significant cause of colic was provided by a study in southeastern Pennsylvania.²² Four groups of horses were observed for 5 years. The herds consisted mostly of adult performance horses, and averaged 30 to 40 horses each.

Even though the horses had been dewormed with anthelmintics other than ivermectin every 2 months for at least 2 years before the study began, average fecal egg counts were 900 to 2,200 eggs per gram of

manure. (Effective deworming programs should keep fecal egg counts below 200 eggs/gram.) Culture of the manure showed these eggs to be from small strongyles.

Three anthelmintic programs were evaluated during the study: (1) a product other than ivermectin (*e.g.*, pyrantel, thiabendazole, or piperazine) every 2 months; (2) a product other than ivermectin every 1 month; and (3) ivermectin every 2 months.

With the first program, the annual colic incidence was 24 to 46 cases per 100 horses, depending on the herd. With the second protocol (deworming every month with something other than ivermectin), the annual colic incidence was 2 to 5 cases per 100 horses — one-tenth the rate of the first program. However, the drop in the number of colic cases was gradual, not reaching its lowest point until 2 to 3 years after the new program had been instituted. The ivermectin program also reduced the annual colic incidence to 2 or 3 cases per 100 horses after 2 to 3 years.

The study conclusions were as follows: (1) a high proportion of colic cases in these herds were parasite-related, and small strongyles (cyathostomes) were the primary cause; (2) treatment with anthelmintics other than ivermectin every 2 months may not maximize horse health in all management systems.

Other studies. Few recent studies are as clear in the association between colic incidence and strongyle infection (whether large or small strongyles). One explanation is that worm burdens, as indicated by fecal egg counts, in that study were unusually high for well-managed adult horses.

In a recent study at the University of Liverpool, England,²³ there was no correlation between the number of strongyle eggs in manure and the incidence of spasmodic colic. However, the average fecal egg count was only 131 eggs/gram (upper limit, 650 eggs/gram), which indicates that the deworming programs use on those horses were fairly effective. In the manager-based study in VA/MD,¹ no association was found between colic incidence and the presence of strongyle eggs in manure.

So, it could be concluded that on farms where strongyles are not adequately controlled, these parasites account for a significant proportion of colic cases. But on farms in which an effective deworming program is in place, strongyle infection is not a major cause of colic.

Tapeworms

There has long been debate as to whether tapeworms (especially *Anoplocephala perfoliata*) are a significant problem in horses. These parasites do not migrate from the bowel during their life cycle, nor do they “hibernate” in the bowel wall; they simply remain attached to the bowel lining.

In many cases, perhaps even in the majority of horses, tapeworms can be present without causing any obvious problems. But tapeworms damage the lining of the bowel, and in large numbers they have been known to cause obstruction, particularly in the ileum, cecum, and the start of the large colon, where they tend to gather.

Ileal obstruction may simply be a physical effect of many tapeworms in an anatomically narrow portion of the bowel, with the result that food can become slowed or stopped at that site (ileal impaction). But these parasites also alter bowel motility, which can lead to spasmodic colic, impaction, and sometimes even intussusception (telescoping of the bowel into itself) at the ileum or cecum. Although rare, tapeworm infestation has also resulted in perforation of the cecum and subsequent peritonitis (bacterial infection of the abdominal cavity, which can be fatal).

Studies. In the aforementioned study at the University of Liverpool,²³ tapeworm infestation increased the risk for ileal impaction by up to 44 times and the risk for spasmodic colic by up to 8 times. From examination of manure for tapeworm eggs and measurement of antibodies against tapeworms in a blood sample, it was calculated that tapeworms accounted for 22% of the spasmodic colic cases and 81% of the ileal impaction cases seen in the horses in that study.

Tapeworm infestation can be difficult to detect by routine fecal-egg-count methods. Special procedures must be used; and even then, tapeworm infestation may go undetected or its severity underestimated. Recently, a blood test has been developed which measures specific antibodies produced by the horse in response to tapeworm exposure. Preliminary studies are promising in terms of accurately detecting tapeworm infestation and determining its severity.

In a recent study at the University of Pennsylvania,⁸ tapeworms were found in 52% of horses that had cecal intussusception (diagnosed during surgery or at postmortem examination). This condition occurs when a portion of the cecum folds in on itself or the first part of the large colon telescopes into the cecum. The authors commented that the incidence of tapeworm infestation could have been even higher than 52%, as the bowel was not opened (and therefore its lining was not examined) in every case.

However, there could be a regional effect here. In a recent study of horses with ileal impaction that required surgery at Auburn University in Alabama,¹⁸ tapeworms were not identified as a significant cause of ileal impaction. (Coastal Bermuda grass hay was awarded that dubious honor; see page 35.)

Deworming program and colic incidence

In none of the four manager- or veterinarian-based studies¹⁻⁴ discussed in this chapter were parasites found to be a significant cause of colic. This is probably because most of the horses in those studies were regularly dewormed. For example, in the first TX study,³ only 34 out of more than 1,600 horses (2%) were never dewormed or had an unknown deworming history. The rest of the horses were regularly dewormed, most commonly with ivermectin.

So, although fecal egg counts were not reported, it could be concluded that most of the horses in these studies were on an adequate deworming program, at least in terms of colic risk.

The second veterinarian-based study in TX⁴ supports the conclusion that regular deworming decreases the horse's colic risk. In that study, horses that were not on a regular deworming program (defined as deworming at least once every 3 months) were more than twice as likely to develop colic as horses that were regularly dewormed.

Deworming program details. The first TX study³ provided the most detailed information on the use of anthelmintics. No significant associations were found between colic incidence and the following: frequency of deworming, number of anthelmintics used in the deworming program, whether or not anthelmintics were used on a rotating basis, and use of a particular anthelmintic. Nor was there any significant association between the type of colic and the anthelmintic used most recently.

These results suggest that the specific anthelmintic used, or the particular deworming program chosen, may not be as important as regular use of an effective product.

Strongid C. Neither of the TX studies^{3,4} found a significant effect of daily pyrantel tartrate (Strongid C® or its generic equivalent) on colic incidence. However, this finding should not be interpreted to mean

that Strongid C is ineffective for preventing colic. It simply indicates that daily pyrantel tartrate was as effective as other deworming programs used on the horses in these studies. (Also, parasites are only one possible cause of colic in horses.)

Recent deworming and colic

Occasionally, horses develop mild colic within a couple of days of being dewormed. In the second veterinarian-based study in TX,⁴ deworming in the past 7 days slightly increased the risk for colic. In the veterinarian-based study in the UK,⁵ recent anthelmintic administration was a possible contributing factor in horses with spasmodic colic or mild, undiagnosed colic. But to put things into perspective, in each of these studies, less than 10% of horses with colic had recently been dewormed.

A possible explanation for this association is altered bowel motility, either in response to dead or dying parasites or from the drug itself. At least one benzimidazole anthelmintic (mebendazole) has been shown to disrupt intestinal motility in the presence of strongyle infection. In support of the altered motility theory, a hospital-based study at the University of Georgia found a significant association between recent deworming and colic caused by large colon displacement. But with one exception (roundworms), colic following deworming usually is mild and resolves either on its own or with simple medical treatment.

Roundworms. A more serious problem occurs in foals and young horses that are heavily infested with roundworms (*Parascaris equorum*, or ascarids). Adult roundworms are large, being about half the diameter of a pencil and several inches long. It doesn't take very many roundworms to cause an obstruction when the worms are paralyzed or killed (depending on the product) all at once. In some cases, impaction with roundworms can rupture the intestine, which is fatal.

Foals dewormed for the first time after 3 months of age are most susceptible to roundworm impaction because it takes 3 to 4 months from the time the eggs are swallowed for these parasites to reach mature size in the intestine. Starting a foal's deworming program at 6 to 8 weeks of age prevents this problem.

Dental care

Adult horses have 24 large 'cheek' teeth (premolars and molars): 6 each, upper and lower, left and right. On the surface that faces the matching tooth, each cheek tooth has a broad, rectangular, roughened surface that is designed to grind fibrous plant material into finer particles.

By breaking up the otherwise poorly digestible leaves, stems, and seeds, effective chewing ensures proper digestion by exposing the more digestible inner parts of the plant to digestive enzymes. It could also reduce the potential for long or large particles of plant material to obstruct the intestine.

Studies. While it therefore makes sense that dental problems could increase the risk for certain types of colic, especially impactions, to date this association has not been proven. In the first veterinarian-based study in TX,³ there was no significant association between the frequency of dental care and the incidence of colic. However, most of the horses had routine dental care at least once a year; only about 5% had never had dental care. So, there were too few horses that did not receive regular dental care to draw any definite conclusions. In the second TX study,⁴ dental care at least once a year slightly decreased the colic risk, but the difference was small.

Stress

Stress is a difficult concept to define in people, and even more difficult in animals. Our notion of what stresses a horse is based on an understanding of normal horse behavior and observation of a horse's behavior in 'stressful' situations. Researchers have attempted to measure stress based on increases in blood cortisol levels (a hormone released during stress) and changes in the white blood cell count. But as each individual's tolerance for, and response to, stressful situations is a little different, stress is virtually impossible to measure in horses. Thus, any link between stress and colic is based on assumption. In humans, there is plenty of evidence that stress increases the incidence of gastrointestinal complaints, and it could reasonably be assumed that the same holds true for horses.

Gastric (stomach) ulcers

Gastric ulceration is one cause of colic that seems to have a stress component. It is fairly common in young foals that are stressed by illness and, presumably, the extra handling that is required for treatment. In adult horses, ulcers are common in horses performing strenuous activities.

Gastric ulcers reportedly occur in 80–100% of racehorses in active training and in about 75% of three-day-event horses. Possible factors include these:

- stress — confinement, excitement in anticipation of fast work or competition, frequent transport, strange surroundings, *etc.*
- high-intensity exercise — reduces blood flow to the stomach and increases the contact of gastric acid with the less protected parts of the stomach (squamous mucosa; see Chapter 3)
- high-grain diets — fermentation of carbohydrates in the stomach increases gastric acidity (a key factor in ulcer formation)
- intermittent feeding or withholding feed for several hours before fast work or competition (fasting alone causes gastric ulcers in horses)

However, gastric ulcers usually do not cause obvious signs of colic in adult horses. Instead, the signs typically are vague: poor appetite (particularly for grain), loss of coat and body condition, reduced performance, and changes in temperament.

Cecal impaction

Cecal impaction (obstruction of the cecum with feed material) also may have a stress component. This problem is more common in horses with chronic pain (*e.g.*, painful eye conditions, laminitis) and those that are hospitalized for illness or surgery. Presumably, the biochemical processes triggered by pain, illness, or anesthesia and surgery alter bowel motility, leading to cecal atony (loss of tone and motility) and impaction. In some cases, cecal impaction ends in rupture of the cecum, which is fatal.

Salmonella infection

Hospitalization for illness or surgery also increases the incidence of colitis caused by *Salmonella* bacteria. However, diarrhea is the main feature of this condition. Colic may precede or accompany the diarrhea (which typically is profuse and watery), but it is not the primary complaint.

Transport/shipping

Long-distance transport may increase the potential for colic, particularly large colon impaction. But in the majority of cases, the cause probably is inadequate water intake and altered feeding and exercise schedules rather than stress.

In the manager-based study in VA/MD,¹ recent transport (travel in the past 2 weeks) increased the colic risk by about three times. Two possible reasons were proposed: (1) transport causes a physiological response that alters gastrointestinal function, or (2) transport interrupts feeding or exercise routines and/or affects water intake. However, in the second veterinarian-based TX study,⁴ neither recent transport nor the distance traveled had any significant effect on colic risk.

Illness

Also in the VA/MD study,¹ recent illness involving a fever was found to significantly increase the colic risk. Horses that had a fever in the past 2 weeks were 11 times more likely to develop colic than were healthy horses. The reasons proposed for why transport may increase colic risk are good initial explanations for this finding as well.

Although the second TX study⁴ did not specifically evaluate fever or other illness, medical or surgical treatment in the past 7 days had no significant effect on colic risk in that veterinarian-based study.

Certain infectious conditions, in particular strangles (*Streptococcus equi* infection) and *Rhodococcus pneumonia*, can lead to 'seeding' of the abdomen with bacteria. Abscessation of the bowel wall or associated lymph nodes may result and can cause chronic colic. But abdominal abscesses are uncommon complications of these common respiratory infections.

Drugs and chemicals

The following drugs and chemicals have been associated with colic in horses, although colic usually is only one of the signs, and may not be the most obvious abnormality.

Amitraz

Amitraz is an acaricide (a chemical that kills ticks and mites) that is used to treat or prevent tick infestation in cattle. It is highly toxic to horses and causes severe, often fatal impaction colic. *Amitraz should never be used in horses.*

Antibiotics

Certain antibiotics alter the normal balance of micro-organisms in the bowel, which can lead to enterocolitis (inflammation of the small and large intestines). The most obvious signs are depression, loss of interest in food, and diarrhea (which can be severe and life-threatening). Colic may precede or accompany the diarrhea.

The problem can occur with any antibiotic, whether given orally or by injection, although it is quite uncommon. It is more likely in stressed horses on high-grain diets (*e.g.*, young racehorses), and with

the following drugs: trimethoprim-sulfonamides (TMPS), ceftiofur (Naxcel®), erythromycin, and tetracycline. Lincomycin often causes potentially fatal colitis in horses, so should not be used in horses.

Arsenic-containing products

Acute overdose of arsenic (as distinct from small amounts taken over a long period of time) can cause severe inflammation of the digestive tract, which can be fatal. One oral source of arsenic is Fowler's Solution, a 'tonic' used to stimulate the horse's appetite and improve coat condition. Legend has it that accidental overdose of this or a similar arsenic-containing tonic is what killed *Phar Lap*, the famous Australian racehorse who raced in the US in the 1930s.

Atropine and opiates

Atropine was originally discovered from an extract of the plant *Atropa belladonna*. Products containing belladonna extract were once popular as colic remedies (*e.g.*, Dr. Bell's). These products were effective for mild, spasmodic colic because they decreased bowel motility (and hence cramping). But overuse or use in horses with more serious types of colic can be disastrous.

Atropine is often prescribed by veterinarians to treat a variety of eye problems in horses. It is used to keep the pupil dilated, and thus reduce pain and prevent adhesions within the eye. But when using atropine, it is important to follow the dosing instructions carefully. Even when used topically, atropine is absorbed into the system and can slow bowel motility, which may lead to impaction colic.

Opiate pain-relievers such as morphine also slow intestinal motility, and can cause impaction colic when overused.

Castor oil

Castor oil is sometimes used as a purgative in people. However, in horses it can cause painful colitis (inflammation of the colon) which can be fatal. Profuse, watery diarrhea and toxic shock can readily be induced by giving a horse castor oil (or access to castor beans; see page 52).

DSS

Diocetyl sodium sulfosuccinate (DSS) is a laxative that is sometimes given orally to adult horses with impactions, and either orally or as an enema to young foals with meconium impaction. Overuse can cause cramping, colic, and diarrhea.

Levamisole

Levamisole is an anthelmintic (dewormer) that is used most often in cattle, sheep, and goats. It is sometimes used in horses as an immune system stimulant, although more specific products are now available for this purpose. Levamisole has a narrow safety margin in horses. Overdose can cause colic, sweating, hypersensitivity to sound, and head-pressing (pressing the head against a solid object).

Monensin

Monensin is a feed additive sometimes used in poultry and cattle rations. It is highly toxic to horses. Toxicity has occurred when feeds containing or contaminated with monensin have been fed to horses. Weakness and collapse, with abnormalities in heart rate and rhythm, are the most prominent signs of monensin toxicity in horses. Mild colic may also be seen.

Salinomycin is a related compound that is also used as a feed additive and can cause similar signs in horses. To avoid toxicity with either of these compounds, *feeds formulated for poultry or cattle should not be fed to horses.*

Nonsteroidal anti-inflammatory drugs (NSAIDs)

This class of drugs includes phenylbutazone (“bute” or PBZ; formerly known as butazolidin or BTZ), flunixin (Banamine®), ketoprofen (Ketofen®) naproxen, indomethacin, diclofenac, meclofenamic acid, and aspirin. Any NSAID can cause colic by creating ulceration in the stomach or in the right dorsal colon (right dorsal colitis). In addition, NSAIDs have been associated with an increased incidence of large colon impaction, apparently by altering bowel motility.

Signs of ulceration. Gastric (stomach) ulcers do not always cause obvious signs in adult horses, although they are a possible cause of colic associated with eating. The more common signs of gastric ulceration are mentioned on page 46.

Right dorsal colitis typically causes mild-to-moderate colic, sometimes with diarrhea. Ulceration may be extensive enough that protein is lost from the bloodstream through the damaged bowel. When large amounts of protein are lost, edema (fluid accumulation in the tissues) develops in the legs and along the underside of the belly and chest. Horses in this condition can be difficult to save. In those that survive, the right dorsal colon may become permanently narrowed by scar tissue (strictured), which can be a cause of chronic or recurrent colic.

Circumstances of NSAID-induced ulceration. In most cases, gastric ulcers form only after high doses of NSAIDs are given for several days, although they can develop in young foals even at normal dosages. Stress, intermittent feeding, and dehydration make ulceration more likely both in foals and adult horses.

Right dorsal colitis can occur with even normal doses of NSAIDs. It is thought that certain horses are peculiarly sensitive to these drugs, or the mechanisms that normally protect against ulceration are impaired in these horses. The same factors that increase the risk for gastric ulcers (stress, dehydration, *etc.*) may increase the potential for right dorsal colitis to develop in susceptible horses.

Given the frequency with which NSAIDs are used in horses, it is fair to say that these are very safe drugs. However, it is best to keep in mind that adverse effects (gastric ulcers, right dorsal colitis, and kidney damage) can occur in any horse given NSAIDs. The risk increases when high doses are given for several days, when two NSAIDs are used together (*e.g.*, bute and Banamine), or when the horse is dehydrated.

Organophosphates

Organophosphates (OPs) are relatively common topical insecticides, applied on the skin as powders or liquids. Examples include diazinon, malathion, ronnel, and chlorpyrifos. Some OPs, such as trichlorphon

and dichlorvos, are used orally as boticides (dewormers that target stomach bots), although ivermectin and moxidectin are much safer and are now the most commonly used boticides.

Organophosphates have a narrow safety margin, so accurate dosing based on the horse's body weight is important. Toxicity can occur with overdosing, frequent use, or accidental ingestion (by eating or drinking contaminated food or water). Signs of toxicity include anxiety, salivation, sweating, trembling, colic, and diarrhea. Acepromazine, a commonly used sedative, increases the potential for OP toxicity to occur when used at the same time. Note: These insecticides should not be used in young foals.

Prostaglandin

Prostaglandin $F_{2\alpha}$ (Lutalyse®, Estrumate®, *etc.*) is often used in broodmares to short-cycle or synchronize estrus ('heat'). Even at routine dosages, it can cause cramping, sweating, and other signs of colic which can last from a few minutes to a couple of hours.

Vaccines

In the manager-based study in VA/MD,¹ recent vaccination increased the colic risk by a little over three times. No single type of vaccine was found to carry a higher risk than any other. Basically, colic risk was slightly increased in the 2 weeks following vaccination, regardless of the type of vaccine given. But in the first veterinarian-based study in TX,³ recent vaccination did not increase the incidence of colic.

The VA/MD study also found that horses vaccinated against Potomac horse fever (PHF) during the study year were twice as likely to develop colic as horses that were not vaccinated against this disease. But rather than the vaccine causing colic, the authors concluded that vaccination against PHF was simply an indicator of the level of preventive care on a farm. For example, farms with a history of PHF had a slightly higher incidence of colic, and managers on those farms may therefore have been more likely to vaccinate against the disease. This gives the impression that vaccination against PHF increases the colic risk, when vaccination could simply have been implemented *in response to* an episode or history of PHF.

Environmental Factors

Geographic location

There is no evidence that overall colic risk is affected by the region or state, or even country, in which a horse lives. But location can be important with specific types of colic. The following geographic associations have been reported in the US:

- enteroliths — most common in California, but an increased incidence has also been reported in Florida and Indiana
- sand colic — most common in desert areas, Florida, and coastal areas of the mid-Atlantic states
- ileal impaction — southeastern states
- proximal (anterior) enteritis — southeastern states
- Potomac horse fever — mid-Atlantic states, northeastern states, and the Midwest
 - as the carrier appears to be an aquatic snail, PHF is most likely to occur in horses that have access to natural water courses, such as rivers and streams

Note: These conditions can occur anywhere in the US; they are simply more common in the areas listed. For example, sand colic can occur on any farm with sandy soil, especially when the pasture quality is relatively poor.

Grass sickness is a foreign example of a specific type of colic with a regional incidence. To date, grass sickness has been reported only in the UK and certain European countries (typically in horses imported from the UK), although a similar disease has been reported in South America. This debilitating and sometimes fatal disease involves degeneration of the nerves that regulate bowel motility. It is most common in pastured horses, which has led to speculation that an environmental toxin (possibly a fungal toxin) is involved.

(2016 Note: The cause of equine grass sickness remains unknown; recently, the research focus has shifted from a clostridial toxin [a form of botulism] to suboptimal mineral content of the soils in high-risk areas.)

Weather or season

Most equine veterinarians agree that colic caused by large colon impaction is more common in very hot, dry weather and in very cold weather (cold enough to freeze unheated water sources). More than one study has reported an increased incidence of ileal or small colon impaction in the autumn, possibly as the amount and quality of pasture decreases or the roughage source changes from pasture to hay. But there does not appear to be a consistent effect of season or weather on the overall incidence of colic.

Manager- and veterinarian-based studies

In the VA/MD study,¹ most cases of colic occurred in March (early spring), August (summer), and December (early winter), with a steady increase in colic incidence between April and August. The first TX study³ found no significant association between colic incidence and season, but a recent change in housing increased the risk for colic, and these housing changes were more common in the early summer and in the autumn.

The seasonal incidence of colic in the UK study⁵ varied widely in the two-year study period. However, in both years there were two major peaks: April/May (spring) and September (late summer-early autumn). The monthly colic incidence was compared with the average monthly rainfall and temperature, but no significant correlations were found.

Weather changes

In the second veterinarian-based study in TX,⁴ a substantial change in the weather in the past 3 days significantly increased the colic risk. However, the authors cautioned that the association was not strong, details were often inadequate, and recall by owners and managers could have been biased because of the common belief that weather influences colic risk.

They summed up by saying, “although clinical experience would suggest that weather-related factors are associated with development of colic in horses, the precise conditions that predispose to colic remain ill-defined.” But it is tempting to speculate that the key factors probably are changes in water intake, activity level, and roughage intake, especially in hot, dry weather and when horses are kept inside because of inclement weather.

The manager-based study in VA/MD¹ did not find a strong association between weather and colic incidence, but the colic risk was slightly higher on the days on which it snowed and when the humidity on the previous day was less than 50%.

Internal parasites

Climate and season have considerable influence on the life cycles of internal parasites, which could cause regional and seasonal differences in the incidence of parasite-induced colic. For example, the number of infective strongyle larvae on the pasture varies with region and season. Strongyle eggs hatch at temperatures between 45 °F and 100 °F. Infective larvae can survive short freezes, but they are very susceptible to heat, especially if the humidity is also very low. According to one authority, temperatures above 85 °F can kill strongyle larvae.

So in warmer regions, the number of infective strongyle larvae on the pasture may be lowest in the summer months and higher in the autumn and spring. But in cooler climates, larval numbers on the pasture may peak in the summer and early autumn. Given that colic is more common in the spring and autumn in some studies, perhaps parasites should be added to the list of possible causes.

Poisonous plants

Several species of plants can cause colic in horses, but usually in association with other signs. With one or two exceptions, grazing horses avoid poisonous plants unless they are very hungry, so toxicity is usually restricted to horses grazing poor quality pasture. Toxicity can also occur in horses fed poor quality hay that contains a lot of weeds. The plants most likely to cause colic are briefly discussed below.

Black locust (*Robinia pseudoacacia*)

The highest concentration of toxin is found in the bark of the black locust tree. Only a very small amount is needed to cause signs of toxicity, which include colic and diarrhea, often accompanied by depression, weakness, pale gums, and irregular heartbeat.

Castor bean (*Ricinus communis*)

Castor beans contain substances that are extremely irritating to the horse's digestive tract. They cause painful colitis (inflammation of the colon) which can be fatal. But signs of toxicity may not be apparent for several hours. Accidental poisoning has been reported in horses permitted to graze around castor plants (which are sometimes used ornamentally in garden landscapes) or that ate lawn clippings containing castor beans.

Nightshades (*Solanum* species)

Common names in this group include climbing, silver-leaf, cut-leafed, black, and deadly nightshades; European bittersweet; white horsenettle; and buffalo burr. Central nervous system abnormalities (depression, weakness, collapse, *etc.*) are usually more obvious than digestive system signs (salivation, spasmodic colic, and diarrhea).

Oak (*Quercus* species)

Oak or acorn toxicity occasionally occurs in horses that eat large quantities of oak buds, leaves (either fresh or dried), or acorns. The signs appear suddenly and include colic, straining, and bloody diarrhea. Loud intestinal sounds may be heard, and acorn husks are sometimes found in the manure. The horse's urine may be discolored red or brown as a result of kidney damage. Sudden death has also been reported. However, horses can eat small quantities of oak leaves and acorns without apparent ill effect.

Oleander (*Nerium oleander*)

The lethal dose of oleander in horses is 30–40 dried leaves, but as few as 10 fresh leaves may be deadly. The toxin primarily affects the heart, but profuse diarrhea and colic may also be seen. The plant has a very bitter taste, but poisoning has occurred when horses were fed grass clippings containing oleander leaves. In at least one case, poisoning occurred when the horse was tied near an oleander bush and nibbled on the leaves out of boredom.

Pokeweed (*Phytolacca americana*)

Gastrointestinal irritation, manifested as colic and diarrhea, is the predominant sign of pokeweed poisoning in horses. Other signs include oral ulceration and anemia from red blood cell damage. Death can occur from respiratory failure. All parts of the plant contain the toxin, but the roots are most toxic and the berries least toxic.

Tobacco (*Nicotiana* species)

Nicotine is the principal toxin in this group of plants. Eating tobacco leaves or the bark or leaves from wild tree tobacco causes salivation, intestinal cramping, and diarrhea. Muscle tremors, weakness, collapse, and respiratory failure can also develop.

Bibliography

Note: The 1999 edition of *Preventing Colic in Horses* was not extensively referenced with its source materials. In editing the text for republication in 2016, as many of the references as possible have been added. (Unfortunately, some have been lost over the years and are not readily retrievable on-line.)

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Table 2.1 Owner/manager-based study of colic incidence and risk factors in Virginia and Maryland (VA/MD)¹

This study was conducted between November 1990 and January 1991:

- **farms with more than 20 horses** were randomly selected in two neighboring counties in VA and MD, just west of Washington, DC; a total of **31 farms** participated
- detailed records were kept on **1,427 horses** during the study year
- **all colic incidents** were recorded by the **owner or manager**, regardless of whether a veterinarian was called; even minor colics needing no treatment or treated by the owner/manager were recorded
- more than 170 farm and horse variables were analyzed for their possible role in colic
- **farm-level factors** were divided into the following categories
 - **farm** — *e.g.*, major use of horses, length of time farm owned by current owner
 - **horses** — *e.g.*, number of resident and visiting horses
 - **employees** — *e.g.*, number, proportion of part-time employees
 - **feedstuffs** — *e.g.*, sources, feeding frequency, use of supplements, storage
 - **water** — *e.g.*, source, delivery system in stable and pasture
 - **habitat** — *e.g.*, bedding type, frequency of stall cleaning and bedding changes
 - **pasture** — *e.g.*, forage and soil types, rotation, manure removal
 - **health** — *e.g.*, disease history, parasite control program
- **horse-level factors** were divided into the following categories
 - **horse** — *e.g.*, age, breed, gender, vices, residence time on farm
 - **housing** — *e.g.*, time spent stalled or pastured, stall bedding, pasture size
 - **use** — predominant use, work schedule
 - **nutrition** — specifics of diet and feeding schedule
 - **health history for year before study** — *e.g.*, past illness, preventive programs
 - **events during study year** — *e.g.*, breeding, transport, illness, deworming
 - **changes during study year** — *e.g.*, housing, nutrition, exercise

Table 2.2 Owner/manager-based study of colic risk factors in Michigan (MI)²

This study used data from the Michigan Equine Monitoring System (a project designed to monitor health and economic activity on equine farms in Michigan), collected between February 1992 and April 1994:

- each month, data on all types of equine health and activity on the participating farms were recorded by the **owner, trainer, or farm/barn manager**
- records were collected for a total of **3,925 horses** on **138 farms**
- **farm-level risk factors** included the following
 - **year** — 1992–93 or 1993–94
 - **geographic region** — northern, central, southwestern, or southeastern MI
 - **average number of horses** on the farm during study period
 - individual and group **grain-feeding methods** — loose on ground, in container on ground, in raised container, other
 - individual and group **forage-feeding methods** — as above for grain feeding
 - individual and group **watering methods** — bucket, automatic, tank, other
 - **water heated in freezing weather** — yes/no
- **horse-level risk factors** included the following
 - **age**
 - **breed**
 - **gender** — mare, stallion, gelding
 - **housing** — access to indoor housing, access to outdoor housing
 - **activity** — breeding, training, draft, dressage, racing, hunter/jumper, *etc.*
 - **reproductive status and activity** (breeding, foaling) during study period
 - **deworming** — number of dewormings during study period
 - **health events** during study period — preventive programs, illness, injuries

Table 2.3 First of two veterinarian-based studies of management factors associated with colic in Texas (TX)³

This study comprised data collected by equine veterinarians working in private practice in Texas, between October 1991 and December 1992:

- **82 participating veterinarians** kept records of the first colic case they were called to treat each month and the next noncolic emergency case seen that month
- **821 horses** were examined for colic and another 821 horses were examined for other medical emergencies (*e.g.*, skin lacerations, musculoskeletal disorders, acute respiratory disease)
- data compared for each colic case and next noncolic emergency included the following
 - **age, breed, gender**
 - **farm size** — acreage, number of horses on the farm
 - **housing** — conditions under which the horse was kept, type of stall bedding
 - **recent change in housing** or stabling conditions (within the past 2 weeks)
 - **feeding practices** and feed offered
 - **recent change in diet** (within the past 2 weeks)
 - **performance level** or type of activity
 - **recent change in activity level**
 - **recent transport**
 - **frequency of dental care**
 - **parasite control program**, including when the horse was last dewormed
 - **vaccination program**, including when the horse was last vaccinated
 - **colic history** (any previous episodes of colic)

Table 2.4 Second of two veterinarian-based studies of management factors associated with colic in Texas (TX)⁴

This study comprised data collected by **145 equine veterinarians** working in private practice in Texas, between March 1997 and February 1998:

- methods were as described for the first TX study (Table 2.3), except that the various dietary and management factors were recorded and examined in greater detail in this second study
- **1,030 horses** were examined for colic and another 1,030 horses were examined for other medical emergencies

Table 2.5 Veterinarian-based study of colic types and management factors in the United Kingdom (UK)⁵

This study involved data collected by **7 equine veterinarians** in a private practice in Buckinghamshire, England, between January 1989 and December 1990:

- data were recorded for **200 colic episodes in 179 horses** and for another 100 horses without colic that were attended for routine health care or nondigestive system problems during the study period
- data examined included the following
 - **age, breed, gender**
 - **recent changes in management and diet** (within the past 24 hours)
 - **recent drug administration**
 - **history of colic** (any previous colic episodes)
 - **findings of clinical examination**
 - **type of colic** — spasmodic/undiagnosed, flatulent, pelvic flexure impaction, other impaction, 'surgical' colic, colitis
 - **method of treatment**
- **average monthly temperature and rainfall** were also recorded