Review of Clinically Relevant Factors to Long-Term Survival After Colic Surgery

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Practitioners and owners use available information on long-term survival data after colic surgery in the decision-making process when discussing treatment options for horses requiring exploratory celiotomy for acute abdominal diseases. Veterinarians involved in all aspects of managing horses with surgical colic can use the same survival data to provide a more accurate prognosis before and after surgery. Author’s address: University of Florida, College of Veterinary Medicine, PO Box 100136, Gainesville, FL 32610; e-mail: freemand@ufl.edu. © 2012 AAEP.

1. Introduction
In the early 1970s, a published review of outcome after colic surgery reported that only 10 of 38 horses were successfully treated by surgery, and most of those survivors had minor intestinal procedures. A later review of cases from the University of California at Davis from 1958 to 1971 reported that 48 of 75 horses with small intestinal strangulation had surgery and that 72.9% died. However, the mortality rate had improved to 46.6% in the last 14 years of the review period. A report on a substantial number of cases in 1984 described 80% short-term survival after surgery for a variety of small intestinal lesions, which was the most favorable result to that time. A study published in 1989 on 140 horses that had small intestinal resection between 1968 to 1986 reported that 51% of these horses died during hospitalization. However, this study differed from others by following up on the survivors over several years and demonstrated that 15 horses that had small intestinal resection and anastomosis, rightly regarded as the most challenging of colic surgeries, survived 3 to 9 years after surgery. It also demonstrated a trend toward improved survival rates in horses that had surgery toward the end of the study period compared with the beginning.

During the 1980s, owner attitude toward colic surgery improved and referring veterinarians demonstrated that success in colic surgery was largely dependent on their decision to refer early. Failures in colic surgery were examined, and postoperative ileus and shock seemed to account for most postoperative deaths, followed by salmonellosis/colic, long bone fracture, adhesions, hemorrhage, laminitis, wound infection, and ischemic muscle damage. This information formed the basis for current postoperative treatments and procedures to monitor postoperative progress.

Several studies reported excellent short-term results after surgery for different types of colic in the 1990s up to the early part of this century. However, a growing body of information was also emerging on long-term results, probably the product of time required to generate a sufficient database for meaningful study. The University of Liverpool emerged as a leader in the field of abdominal sur-
surgery in horses, led by Professor Barrie Edwards, in collaboration with Dr. Chris Proudman and Dr. Debbie Archer. This group has contributed substantial data on long-term survival and complications that represent advances that can improve survival of horses that undergo colic surgery.

Many studies evaluating long-term survival after colic surgery in horses have provided useful information on effects of disease, segment affected, and surgical procedure on outcome. Despite some conflicting information and variations in survival times, there is considerable evidence that survival rates have improved steadily over the years. This information should provide some encouragement to owners and veterinarians in practice about the prospects of long-term survival and acceptable quality of life for horses that have had colic surgery. Also, some recent studies have examined effects of colic surgery on return to sporting activity, which is highly relevant to an owner confronted with the prospects of an expensive surgery on a horse expected to perform at the highest level in a competitive sport.

Long-term data for survival is considerably more relevant than short-term data for an animal that could have a life expectancy of many years after colic surgery, depending on its age at surgery. Unfortunately, long-term data are considerably harder to obtain, largely due to difficulty in locating owners or trainers who have moved or locating horses that have changed ownership over a period of many years. The most commonly used method to examine long-term survival data is the Kaplan-Meier estimator (Fig. 1). This estimates the survival function as the fraction of patients living for a certain amount of time after treatment. The plot of survival function is a series of steps with each downward deflection representing loss(es) through death. An important advantage of the Kaplan-Meier curve is that it accounts forensored data, as occurs if a patient is lost to follow-up from the sample before the final outcome (death) is recorded (e.g., sale, owner move, patient still alive at last recording interval). On the plot, small, vertical tick-marks indicate when a patient’s survival time has been censored, and these patients are not counted in the denominator for the subsequent data points. Results can also be compared as median survival times, which is the time when 50% of horses are still alive.

2. Case Selection
Data from short-term and long-term studies must be interpreted with full awareness that they deal with horses in which surgery was completed and were allowed to or were able to recover from general anesthesia. Therefore, horses that died or were euthanatized before and during surgery or during recovery are missing from the denominator. One reason for this approach is that those cases that undergo full treatment (surgery and aftercare) are relevant to a study on the effects of that treatment on outcome. The remainder might have been deliberately excluded from treatment because of financial constraints, presence of a concurrent disease, advanced age, or perception of a poor prognosis. Possibly some of these exclusions could be the result of an error in judgment, misdiagnosis, owner misunderstanding, or overly pessimistic perception about prognosis (on the part of owner and/or veterinarian). Those horses that died before they could recover from anesthesia possibly succumbed to severe complications of the disease itself (endotoxemic shock, uncontrollable hemorrhage, ruptured viscus) or they incurred a catastrophic fracture in the recovery stall. Such cases arguably represent examples of failed treatment. Regardless, studies on effects of treatment on long-term survival typically focus on horses that recover fully from surgery and anesthesia, largely because the reasons for exclusion of other cases cannot be readily deduced during retrospective examination of medical records. Nonetheless, any possible errors that underlie such unwitting case selection must be addressed to improve the way we treat horses with colic.

3. Age
Owners’ concerns that old horses with colic are poor candidates for anesthesia and surgery are not supported by recent studies. Geriatric horses are typically presented with evidence of a more serious disease compared with mature horses, which explains why they are 1.5 times more likely to need surgery and 3 times more likely to be euthanatized when surgery is not an option. Compared with younger mature horses, horses ≥20 years old are 3 times more likely to have a small intestinal lesion, which is more likely to be strangulating. Strangulating lipomas probably account for these differences and should always be considered when examining an old horse with colic. The survival rate after
completed surgery for small intestinal strangulating lesions is the same for horses ≥16 years old as for younger mature horses. However, geriatric horses with colic are more likely than mature horses to be euthanized during surgery, probably because of a misconception about adverse effects of age on prognosis, short remaining life expectancy, financial concerns, or a concurrent disease (eg, Cushing’s disease). Although the effects of Cushing’s disease on survival are unknown, on an anecdotal basis, it does seem to place the horse at risk of infection and impaired healing in the abdominal incision.

In a recent study on small intestinal diseases treated by surgery, older horses (15 to 30 years) had a median survival time of 5 years compared with a median survival time of 12.5 years in horses <14 years of age. This is not surprising and does not reflect a lower tolerance for surgery in the older group but simply that older horses were closer to the ends of their lives at the time of surgery. This can adversely affect analysis of data on survival after strangulation by pedunculated lipoma, a disease of older horses, and should be considered whenever long-term survival is compared between this disease and others, including epiploic foramen entrapment (EFE),

In foals with surgical colic, 10% of those under 14 days survived to maturity compared with 45.8% of foals 15 to 150 days old. In one study, 59% of foals that had surgery for colic survived to discharge, with 25% being euthanized while under anesthesia. Although foals are considered to be especially prone to adhesion formation, adhesions in juvenile Thoroughbreds after surgery for lesions of all parts of the gastrointestinal tract has been reported at 8%, similar to the percentage reported for adult horses. Foals of 15 days to 6 months seem more likely than weanlings and yearlings to develop adhesions and require multiple surgeries.

4. Breed
Draft horses weighing >680 kg that undergo colic surgery can have longer anesthesia duration, more postoperative complications, and higher mortality rates than draft horses weighing <680 kg. Heavy draft horses that have small-intestinal surgery have a worse prognosis for short-term survival than predominantly light breed horses that have the same procedures, and than draft horses that have large-intestinal surgery. Small-intestinal obstruction is rare in American Miniature Horses, but their prognosis is complicated by their high risk for hyperlipemia/hyperlipidemia.

5. Postoperative Complications and Mortality Pattern
One of three consecutive papers published in 2002 from the University of Liverpool followed a large population of horses for a longer period than covered in previous survival studies and could therefore identify a unique pattern of mortality after surgery (Fig. 1). Most deaths were very shortly after surgery, followed by a lower death rate during the next 100 days, with an even slower decline in mortality to the end of the follow-up period. This is consistent with the observation that the risk for death diminishes markedly after 12 months in horses that had small-intestinal surgery, presumably because the period of highest risk from adhesions has passed.

A companion paper on the same cases from the University of Liverpool related complications to their effects on long-term survival, which is critical information for those caring for the horse after colic surgery. Risk factors for postoperative complications included a high packed cell volume (PCV) at admission, EFE, and strangulating lipoma. The study also demonstrated that horses with wound suppuration had 4 times greater risk of an incisional infection and that postoperative colic was significantly associated in the long-term with surgery for large-colon torsion and repeat celiotomy.

Recurrent postoperative colic is a documented long-term complication after colic surgery, especially after small-intestinal resection and anastomosis or in horses prone to recurrence of renosplenic ligament entrapment. Horses that had relaparotomy also seem prone to postoperative colic, most likely the result of adhesion formation. However, the number of colic bouts in the remainder of the horse’s life can vary considerably from none to multiple. In one study, 11 horses had a single colic event and 14 horses had multiple colic events after they were discharged, representing a total of 25 of 79 (31.6%) of total horses followed long-term. In another study, the highest risk period for first colic was within 100 days after surgery. In the same study, 32% of postoperative survivors had at least 1 postoperative colic episode, and 5% had 3 or more episodes. Horses that live a life free of colic after surgery can have a fatal, possibly unrelated colic episode years later.

Postoperative ileus (POI) has an adverse effect on long-term survival. Many horses with this complication are euthanized during hospitalization and account for most of the short-term postoperative deaths. Although horses can recover from POI and be discharged from the hospital, they do not experience the same long-term survival rates as horses that did not develop this complication. The reason for these findings is unknown, although the proposal that prolonged contact between amotile loops could favor adhesion formation seems plausible.

In an epidemiological investigation on 1014 horses undergoing surgery for an acute abdominal crisis at University of Liverpool over a 16-year period, the authors reported that adhesions were no more prevalent after surgery for a small-intestinal lesion compared with a large-intestinal lesion and could affect a segment of the abdomen distant to the primary lesion and the intestinal surgery site. This information contradicts the long-held view that small-intestinal surgery carries a higher risk of adhesions...
than large-intestinal surgery but does not provide the final answer on the issue by any means. A repeat celiotomy was required in 99 horses, 32% of which had adhesions at the second surgery, and most of these adhesions were considered pathological. Adhesions were not associated with resolution or endotoxemia, evidence that surgical trauma is the most important cause of adhesion formation. Therefore, the authors recommend that pan-abdominal rather than site-specific measures should be used in all horses that undergo exploratory laparotomy.

6. Role of Intestinal Segment in Survival

In a retrospective study on 151 horses that had surgery for gastrointestinal tract diseases, survival rate for horses that had surgery for obstruction of the cecum and colon was significantly higher (80%) than horses with small-intestinal obstruction (52%). This was confirmed in a study that demonstrated a long-term survival in excess of 90% with little change over time for nonstrangulating lesions, such as tenosplenic ligament entrapment. However, the probability of survival for strangulating colon volvulus (>360°) declined to 80% by 100 days postoperatively and then remained constant with time.

This was similar to survival data for strangulating diseases of the jejunum (excluding strangulation by EFE and lipoma). Some large-colon diseases, such as large-colon volvulus, have recurrence rates that can complicate their long-term progress.

As in adult horses, foals that had a small-intestinal lesion treated by surgery had lower survival rates (46%) than foals with large-intestinal lesions (80%). Survival in foals in cases of nonstrangulating lesions or simple obstruction is also greater than those that had a strangulating obstruction.

A study of factors associated with postoperative survival after surgery for large-intestinal disease demonstrated that heart rate and PCV on admission to the hospital, increasing age, resection of intestine, and relaparotomy were all associated with an adverse effect on long-term survival. These findings underscore the critical role of early referral in survival, most likely through reducing complications associated with advanced intestinal ischemia and associated endotoxemia. The same concerns can be applied to small-intestinal diseases.

7. Role of Intestinal Lesion

In most studies, strangulating diseases of the small and large intestines had poorer survival data than nonstrangulating lesions in the corresponding segments. In the small intestine, EFE has a negative effect on long-term outcome and is associated with a greater risk of postoperative colic than other strangulating diseases. A long-term study on a larger group of horses over a longer period of time implicated low total protein (TP) and longer surgery times on the adverse effect of EFE on survival. A linear relationship was established between a decline in TP and risk of death.

In a study on survival after surgery for small-intestinal strangulating diseases, the short-term survival rate after completed surgery for EFE was 95%, which was significantly better than survival in horses that had strangulating lipoma (84%) and miscellaneous strangulating lesions (91%). When the same horses were examined in a long-term study, horses that had surgery for EFE had similar long-term survival as horses with strangulating lipoma, a group of horses that would be expected to have a shorter long-term survival because they were older. Horses with EFE had shorter long-term survival than horses with miscellaneous strangulating lesions, a group of horses with a similar age range at time of surgery. These findings confirm previous observations that horses with EFE had a reduced long-term survival and a greater risk of postoperative colic compared with other small-intestinal diseases. However, the studies differed because one showed that EFE had a worse survival than strangulation by lipoma and the other showed a similar long-term survival with the two diseases. One possible but unexplored explanation was that many horses with EFE in one study did not require resection because an optimistic approach was used in assessing intestinal viability. Causes of colic and lower long-term survival after surgery for EFE have not been identified, although recurrence of the disease is one possibility. A trend toward lower survival after EFE was observed in a group of horses that were cribbers compared with horses with the same disease that were not cribbers. This is consistent with the previously established observation of a statistically significant association between cribbing and EFE, and presumably this vice could contribute to placing horses at risk of recurrence.

8. Role of Repeat Celiotomy

Repeat celiotomy is a valuable procedure required for 12% to 27% of small-intestinal diseases and for 4% to 12.5% of all colic surgeries. The need for repeat celiotomy is greatest after small-intestinal surgery, especially jejunocecostomy, and EFE and POI are also risk factors for repeat celiotomy. The clinical distinction between postoperative ileus and mechanical obstruction can be difficult, although horses with obstruction usually have more pain and a progressive increase in heart rate. The most common findings at relaparotomy are ileus, obstruction/impaction at an anastomosis, adhesions, and secondary intestinal ischemia. Disadvantages of a second abdominal exploratory are high risk of incisional infection and the expense; however, the benefits of this procedure include prompt termination of hopeless cases and salvage of others. Survival after a repeat celiotomy ranges from 36% to 56.4% and long-term survival can be as low as 20%. In one study, 74% of horses that recovered after a second celiotomy were alive 1 year after the second surgery. In a study on 1014 horses, a median survival time of 2000 days was...
recorded after one surgery and 1200 days after a repeat surgery.\textsuperscript{24} Most deaths after repeat celiotomy are shortly after surgery, when irreparable complications or financial constraints determine results.\textsuperscript{14} Subsequent long-term prognosis follows that of horses that had a single surgery over time, and horses can live to the end of their expected life spans after repeat celiotomy.\textsuperscript{19}

9. Role of Anastomosis and Other Perioperative Procedures

Results of recent studies agree that long-term survival is influenced by the type of anastomosis used after small-intestinal resection (Fig. 2), specifically that horses have a significantly higher mortality rate after a jejunocecal anastomosis (jejunocecostomy) compared with end-to-end jejunojejunal anastomosis (jejunojejunostomy).\textsuperscript{3,36,37} Most of the difference can be explained by more deaths during hospitalization and the early postoperative period in the jejunocecostomy horses.\textsuperscript{14} Also, the incidence of postoperative colic in horses that had side-to-side jejunocecostomy was greater than in those that had end-to-end jejunojejunostomy.\textsuperscript{36} Jejunocecostomy also requires repeat celiotomy more than jejunojejunostomy, a factor that could also affect survival (see above).\textsuperscript{14,19,20} In one study of horses that had side-to-side jejunocecostomy, there was no difference in survival between horses with hand-sewn versus stapled anastomoses.\textsuperscript{36} Another study confirmed this but also showed that the staple technique could cause significantly more postoperative complications.\textsuperscript{19}

When data for survival after discharge from two comparable studies are compared (Fig. 3),\textsuperscript{19,20} jejunocecostomy and jejunojejunostomy yield similar long-term survival results, at variance with results from other reports that jejunojejunostomy had a superior long-term survival than horses that had jejunocecostomy.\textsuperscript{3,36,37} In another study, horses that did not have a resection for a strangulating lesion had superior long-term survival and were less prone to colic after discharge than horses with jejunocecostomy.\textsuperscript{38} This finding emphasizes the need for accurate prediction of intestinal viability, especially if it leads to no resection over jejunocecostomy.\textsuperscript{38}

Although many studies have examined methods that can be used to prevent adhesions, POI, and reperfusion injury, there is little evidence that these can improve long-term survival. Although there is some evidence that the recommended regimen for infusing lidocaine to treat or prevent POI is effective for this purpose\textsuperscript{39,40} and can improve short-term survival,\textsuperscript{40} none of these studies examined long-term survival. Two recent studies\textsuperscript{19,20} on small-intestinal anastomosis demonstrated superior short-term survival and considerably lower prevalence of POI without prophylactic use of lidocaine infusion than reported in studies that did use it.\textsuperscript{39,40}

A recent report demonstrated that horses treated with intraoperative intra-abdominal sodium carboxymethylcellulose (SCMC) had a better survival rate to 6 months after surgery than horses that were not treated in this fashion.\textsuperscript{22} Necropsy results or causes of death were not described, so the authors’ conclusions about the potential benefit of SCMC in prevention of adhesions are not supported. The role of adhesions is further complicated by the finding that mortality was very similar between the treated and untreated groups from discharge to 180 days, when adhesions can continue to cause clinical problems. A temporal effect on the results\textsuperscript{3,37} could not be ruled out because horses that received SCMC followed the untreated control group in chronologically order rather than through random assignment. Also, fewer horses had resection in the SCMC-
treated group, so they might not have been directly comparable. A similar retrospective study did not demonstrate improved survival after intraperitoneal SCMC, although there were some minor differences between the two studies. However, a study that compared jejunojejunostomy with and without a membrane impregnated with SCMC and hyaluronic acid confirmed that there might be some benefit in using this method to prevent adhesions.

10. Sporting Activity After Colic Surgery in Horses

In a study on 88 discharged horses followed for 68 months, the survival rates were 95.3% at 6 months and 57.6% at 60 months after colic surgery. The intestinal segment involved at surgery was the large intestine in 69.6% of the cases and small intestine in the remainder. Enterotomy or enterectomy was performed in 45.6% of cases, with 78.2% performed on large intestine and 21.8% on the small intestine. In the 54.4% of cases in which enterotomy or enterectomy was not performed, the large intestine was also the more common location of the surgical lesion (67.5%). In this study, wound complication was the only significant predictor of poor postsurgery performance and a poor outcome, compared with horses with no wound complications and hernia. Sixty-eight of the 79 horses (86.1%) surviving beyond 6 months returned to or started a sporting activity after colic surgery, and 83.5% (66/79) achieved the same or better performance after surgery according to their owners.

These findings are similar to those reported on 195 horses that underwent exploratory celiotomy for acute colic. At 6 months, 68% of patients were performing their intended use and 56% were at or above their preoperative level of performance. At 1 year, 76% were performing in their intended activity and 69% were at or above their preoperative level of performance. An incisional hernia or diarrhea were two factors identified that could delay return to performance following colic surgery. Juvenile Thoroughbreds that had a celiotomy for colic surgery were significantly less likely to race (63%) than their unaffected siblings (82%), but affected foals able to race had similar earnings, races, and starts as their siblings. There are numerous confirmed anecdotes about Thoroughbred racehorses that had successful racing careers at the highest level after major colic surgery (Grade I races) and even of improving on their performance after surgery.

11. Conclusions

Although long-term survival studies will probably continue to provide valuable information about the success rate of colic surgery, limitations of these studies must be addressed in the future. Most of the past studies have not paid sufficient attention to the age at surgery, which means the data must be interpreted in the absence of information on the number of years remaining within the possible lifespan of each horse. However, longer times and greater case numbers will be required to allow analysis by age groups without any loss in statistical power of the study.

Studies to date have not used age-matched controls, which would resolve the preceding concern. This would demonstrate any effect that colic surgery might have on long-term survival and on the potential of subject horses to reach the end of a typical equine lifespan. A similar approach should be used in performance studies, with matched controls by breed and use. Even in the control group, some attrition can be expected through a variety of reasons that limit performance other than colic surgery. Such information would give a truer picture of the effects of colic surgery on performance.

Despite these limitations, some new information has emerged from colic surgery that can affect prognosis and treatment:

1. The established risk of EFE in cribbers and the poorer long-term survival in horses that had surgery for EFE compared with other small-intestinal strangulations underscores the need to consider surgical treatment of cribbing. This is especially so in cribbers that have had surgery for EFE, or any form of colic.

2. Owners and referring veterinarians can be more optimistic about the outcome of colic surgery in old horses.

3. Although adhesions are the most likely cause of poor long-term survival, results of many studies reveal that the prevalence of this complication is declining.

4. Most horses return to the same level of performance and even improve on performance in a variety of equestrian sports after colic surgery, especially if they have not developed an incisional hernia. The role of the latter on performance has not been established.

5. Early referral is critical, not just for short-term survival but also in the long term. An obvious benefit of early referral is avoiding resection if ischemic changes are deemed mild enough. This reduces the cost of surgery and improves survival compared with a horse that sustains more advanced changes and requires a jejunocecostomy. Early referral also reduces the risks associated with advanced ischemic changes and the associated endotoxemia.

6. A more optimistic approach can be applied to the decision for repeat celiotomy.

7. The variations in survival rates after colic surgery reported by different institutions suggest that multicenter studies could introduce variables that can complicate rather than resolve the issues they are designed to address.

References


