Short- and long-term survival rates after colic surgery

A retrospective study of colic horses operated at UDS between 2019-2022

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Kort- och långsiktig överlevnad efter buköppning – en retrospektiv studie av kolikhästar opererade på UDS mellan 2019–2022

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Abstract

Colic can be a serious condition in horses, that may require surgery. In this study, survival after colic laparotomy was investigated both in the short-term (until discharge from the hospital) and in the long-term (until 1-year after surgery). Survival of different diagnoses found during surgery was explored. Furthermore, factors associated with the survival of colic surgery was analysed, along with complications and the return to previous performance level**.**

137 acute colic surgeries at UDS between 2019-2022 met the inclusion criteria and were reviewed. Kaplan-Meier curves were used in survival analysis, along with Cox-regression. Journals of the operated cases were retrospectively reviewed, and a questionnaire was sent out to owners with a horse discharged alive from the hospital.

The overall short-term survival, from induction until discharge, was 62%, with 25% of cases euthanised during surgery. The long-term survival, from discharge until one year after surgery, was 92%. Cases with strangulating lesions, cases with resection of the intestine, and cases experiencing post-operative colic in the hospital were associated with decreased survival-time.

This retrospective study can be applied to veterinary practice to provide recent and accurate data on the prognosis after colic surgery.

Keywords: colic, surgery, survival, complications, short-term, long-term

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Abbreviations

ICU	Intensive care unit
LI	Large intestine
LTS	Long-term survival
OLTS	Overall long-term survival
OR	Operating room
OSTS	Overall short-term survival
POI	Post-operative ileus
RDD	Right dorsal displacement
SI	Small intestine
SLU	Swedish University of Agricultural Sciences, Uppsala
SSI	Surgical site infection
SD	Standard deviation
STS	Short-term survival
UDS	SLU University Animal Hospital, Uppsala
UHLA	University Hospital for Large Animals, Copenhagen

Definitions

Short-term survival	Short-term survival from recovery box until discharge.
Overall short-term survival	Short-term survival from induction of surgery until discharge.
Long-term survival	Long-term survival from discharge until ≥1 year after surgery.
Overall long-term survival	Long-term survival from induction of surgery until ≥1 year after surgery.
Survival-time	Time until death censored at one year after surgery.
Strangulation	A torsion of 360 degrees or more of the intestine found during surgery.
Early relaparotomy	Relaparotomy without the horse being discharged home from the hospital.
Repeat laparotomy	Experiencing more than one laparotomy.
Resection	Intestinal resection with anastomosis.
In need of resection	Intestine in a condition requiring resection and anastomosis for the horse to survive.
Post-operative colic	Signs of pain from the abdomen in the hospital and receiving a dose of metamizole or being euthanised.
Post-operative reflux indicating ileus	Gastric reflux of ≥4 litres upon any given intubation or >2 litres per hour on repeated intubation.
Surgical site infection	Drainage from the incision continuing or beginning after 24 hours, regardless of the appearance of the fluid. Mild serosanguinous drainage up to 24 hours after surgery was considered within normal limits.

1. Introduction

Colic is a common dilemma for horse owners and abdominal surgery is expensive and associated with risks of complications and uncertain outcomes. The survival rates and prognosis for equine laparotomy have been described in several different studies around northern Europe (Mair & Smith 2010a; Christophersen et al. 2014; Wormstrand et al. 2014; Immonen et al. 2017; Van Loon et al. 2020; Dybkjær et al. 2022), but have not to the author's knowledge been published in Sweden.

The main objective of the study was to examine the short- and long-term survival rates of colic surgery at the SLU University Animal Hospital (UDS), as well as the prevalence of short- and long-term complications after surgery. Together with the survival rates, the return to previous function in the horses operated for colic was assessed. Horses who survived until discharge from the equine hospital were followed for at least one year after the surgery or until euthanasia. Furthermore, factors that could be associated with survival were investigated, such as age, breed, sex, diagnosis category, surgical procedures, and complications after surgery. In addition to that, horse owner satisfaction with the care provided at UDS was reviewed.

To have knowledge of the survival rates and to understand what factors are associated with survival are of high interest to both veterinary clinicians and horse owners. Obtaining more information about horses operated because of colic can help in future decision-making when it comes to prognosis, economy, and whether treatment should continue or not.

2. Literature overview

2.1 Colic

Acute visceral pain from the abdomen, also defined as colic, is in Sweden the third most common reason of death in adult horses, after old age and trauma (Egenvall et al. 2008). It is therefore one of the most prominent problems in equine medical practice. The nature of the horse´s physiology as a hindgut fermenter, with intestines that are long, large, and mobile, puts the gastrointestinal system at risk of obstructions, displacements, and strangulations. These conditions are often associated with acute onset of symptoms and treatment should be quick and well thought-out to give the horse the best chance of survival (Marshall & Blikslager 2019).

2.1.1 Medical or surgical colic

Colic cases can be placed into two different categories depending on the treatment required: medical or surgical colic. For a medical colic case, a conservative approach is enough to treat the horse. However, for the more severe cases of colic, surgical treatment is needed for the horse to survive. In the study of Dybkjær et al. (2022), from the University Hospital for Large Animals (UHLA) in Copenhagen, 22.9% of the referred colic cases had to be treated surgically.

To decide if a horse is a surgical candidate, a history and a physical examination is needed (Marshall & Blikslager 2019). The circulatory system is of high importance in evaluating the physiologic response to pain, dehydration, and toxaemia. Parameters, such as body temperature and respiratory rates, are also important in the assessment of the patient's general condition. Complementary blood samples can be taken to evaluate dehydration and to see if there is any deviation in the blood parameters. In example a high packed cell-volume (PCV) indicate endotoxemia and a low total protein (TP) may reflect a loss of protein to the abdominal cavity. Both these measurements have been associated with worse prognosis concerning intestinal disease in horses. Deviations in the haematology such as leukopenia, neutropenia and thrombocytopenia are nonspecific but can also help to diagnose inflammation and sepsis. The degree of pain is a crucial factor in deciding whether surgery is indicated or not. Horses that don't adequately respond to pain relief require surgical intervention. Palpation of the abdomen per rectum is perhaps the most specific diagnostic step that can be performed on horses with colic. A finding of dilated small intestine during palpation is seen as an abnormal finding and may be an indicator of surgery. Nasogastric intubation is also a helpful diagnostic method to decide if surgery is necessary. It also functions as a therapy by decompressing the stomach, helping to prevent stomach rupture. The presence of

reflux suggests functional ileus or an outflow obstruction. In addition to nasogastric tubing, percutaneous ultrasound helps to assess if the small intestine is dilated, which is also a sign of functional or obstructive ileus. Lastly, abdominocentesis should be performed to assess changes in the peritoneal fluid. Alteration in the macroscopic appearance, cell and protein count could indicate a surgical condition. As well as the peritoneal lactate which can be utilised as an indicator of a strangulated intestine.

2.1.2 Colic surgery

A colic surgery involves the patient being placed in dorsal recumbency under general anaesthesia (Marshall & Blikslager 2019). A ventral midline incision is made, and the complete intestinal tract is examined. This is done with a combination of exteriorisation, visualisation, and palpation. Gas decompression of the intestine is usually performed to enable abdominal exploration, repositioning, and closing of the abdominal wall. In some cases, an enterotomy is needed to evacuate content from the intestine. If the bowel is severely compromised, resection and anastomosis may be required for the horse to survive. The incision is most commonly closed in three layers, often using staples to close the outermost skin layer.

2.1.3 Categories of colic surgery based on anatomy and diagnosis

In many papers studying survival, surgical colic cases are categorised according to which part of the gastrointestinal tract is the primary cause of colic. Cases are usually divided into large- or small intestinal causes (Immonen et al. 2017; Van Loon et al. 2020). The large intestine (LI) and small intestine (SI) are then sometimes divided into further subcategories depending on which anatomical part of the intestine is affected, for example, the jejunum of the SI or the large colon of the LI. Another way of categorising cases is by surgery diagnosis. This can be useful in presenting descriptive data of the surgeries performed at the hospital. Examples of surgery diagnosis are colon volvulus, epiploic foramen entrapment, and right dorsal displacement.

Although specific anatomical and diagnostical subcategorisation can be useful for descriptive data, it can be limited when it comes to analysing data. In Mair & Smith (2010a) the SI and LI cases are therefore divided into strangulating or non-strangulating cases. This categorisation is useful when it comes to survival analysis and is well established within the practice of equine surgery (Freeman 2019; Southwood 2019). However, a limitation of this categorisation is that sometimes strangulating cases do not require resection, and the resection factor in relation to survival is also of interest to research. In the study of Van Loon et al. (2020) from

Utrecht, the SI cases are instead categorised based on surgical resection. The LI cases were, however, still categorised according to strangulation or non-strangulation in that study.

2.2 Colic related to the small intestine

2.2.1 Small intestine anatomy

The SI of the horse involves three parts: the duodenum, the jejunum, and the ileum (Freeman 2019). The total length is approximately 25 meters long, ranging from 10 to 30 meters. The duodenum forms the first part of the intestine after the pylorus. It is positioned to the left and dorsal side of the abdomen. At the duodenojejunal flexure, it turns into the jejunum, which contributes a large proportion of the SI. The last part of the SI is the ileum, and it consists of approximately the last meter. The ileum can be identified by the ileocecal fold and empties into the cecum.

2.2.2 Non-strangulating lesions of the small intestine

The blood flow has not initially been compromised to the affected segment of the SI in non-strangulating lesions (Freeman 2019). Simple obstruction, such as an ileal impaction, is the most common non-strangulating lesion affecting the SI. It can be a primary lesion but can also occur secondarily to other ileal diseases, for example muscular hypertrophy and *Parascaris equorum* infection in young horses. A primary ileal impaction usually has a doughy to solid texture and extends proximally from the ileocecal junction. It can be treated either medically or surgically depending on the severity. Surgical treatment involves loosening the impaction by massaging and mixing it with fluids so that the ingesta can continue to the cecum.

Proximal enteritis is an important differential diagnosis when it comes to SI lesions (Freeman 2019). It is characterised by inflammation of the proximal part of the SI and a large volume of gastric reflux. It is not necessary to perform surgery in most of these cases, even though a significant amount of nasogastric reflux is produced, usually over 48 litres in 24 hours. It can, however, be difficult to differentiate a proximal enteritis from a strangulating lesion of the SI and therefore many of these cases are operated upon.

2.2.3 Strangulating lesions of the small intestine

A strangulating lesion, on the contrary to non-strangulating lesions, leads to the blood supply being compromised and causes ischemia to the affected intestine (Freeman 2019). The strangulated intestine also results in release of certain cyto-

kines, for example tumour necrosis factor and interleukin 1, associated with endotoxemia (Proudman et al. 2010a). Volvulus is one example of a strangulating lesion (Freeman 2019). It is defined as when a segment of jejunum or ileum rotates around the mesentery and becomes twisted into distinct spirals. Most of these SI volvulus lesions involve a torsion of at least 360 degrees.

A pedunculated lipoma, which is a benign adipose tumour, can also wrap around the intestine, especially the jejunum, and cause a strangulating lesion (Freeman 2019). It is a disease affecting older horses and leads to a condition in need of surgical intervention. The strangulated intestine can become nonviable, so a resection is often needed.

Herniation is another cause of strangulation of the SI (Freeman 2019). The epiploic foramen entrapment is an example of this type of herniation. The foramen is an approximately 4 cm long entry into the omental bursa from the peritoneal cavity. The SI can get entrapped in the space, which will lead to strangulation. The entrapped intestine can be surgically corrected by careful manipulation. Another herniation that can affect the SI is inguinal herniation.

Intussusception is the invagination of the intestine into itself (Freeman 2019). The most commonly reported intussusception in horses is the ileocecal. Tapeworms in the form of *Anoplocephala perfoliate* can cause this type of lesion by colonising the ileocecal junction and therefore predisposing the intussusception. If an ileocolic intussusception occurs, resection has to be performed via a typhlotomy, with measures taken to avoid contamination.

2.2.4 Resection of the small intestine

As mentioned above, Van Loon et al. (2020) used resection/in need of resection and no resection to categorise the lesions of the SI rather than strangulating or non-strangulating. To decide if a resection of the SI is needed, the viability of the intestine is assessed (Freeman 2019). Sometimes previously strangulated intestine can be in good enough condition that no resection is necessary. Following resection, different forms of anastomosis are possible, for example: jejunojejunostomy, jejunocecal, jejunoileal and ileocecal. The anastomosis can be performed end-to end with the two ends aligned and sewn together. The side-to-side or end-to-side anastomosis involve a blind stump and the major disadvantage of such procedures is the interference with the normal physiological and anatomical shape of the intestine. The inverted edges are also larger and require additional sutures which can cause more severe inflammation in the intestine. The length of the resection varies depending on the size of the affected lesion, and although the length has no

clear influence on outcome, there are indications that resection of more than two meters of SI has a lower survival rate.

2.3 Colic related to the large intestine

2.3.1 Large intestine anatomy

The LI involves the cecum, and the ascending-, transverse-, and descending colon (Prange et al. 2019; Sherlock 2019; Southwood 2019). The cecum is the most oral part of the LI, and it is located on the right side of the abdomen. The cecum empties into the ascending colon, also known as the large colon. It consists of four different sections, where digesta moves in the following order: right ventral colon, left ventral colon, left dorsal colon and right dorsal colon. In between these four parts, there are three flexures: the sternal flexure, the pelvic flexure, and the diaphragmatic flexure. The last part of the ascending colon turns into the transverse colon at the position of the cecum base. Here, the intestine decreases significantly in diameter and crosses the abdomen dorsally from right to left. The last part of the LI is the descending colon, also known as the small colon, which is approximately 3.5 meters long in the adult horse. The small colon turns into the rectum and exits through the anal sphincter.

2.3.2 Non-strangulating lesions of the large intestine

Simple obstructions of the LI, like those in the SI, fall under the category of non-strangulating lesions (Southwood 2019). They can for example be caused by feed impactions. In many cases, these LI impactions can be resolved conservatively with aggressive enteral or intravenous therapy. However, in some cases, complications such as deterioration of the bowel or displacement of the intestine can necessitate surgery.

Displacements of the large colon are also categorised as non-strangulating lesions (Southwood 2019). Right dorsal displacement occurs when the colon moves around the cecum ending up between the cecum and the right body wall. Left dorsal displacement occurs when the colon is displaced to the left side of the abdomen, either between the left body wall and the spleen, or becomes entrapped over the nephrosplenic ligament. In some cases, displacements can be solved with conservative treatment, but depending on the severity, surgery may be the only option. The pathogenesis behind displacement of the large colon is explained by alternations in colon motility, which has several theories (Whyard & Brounts 2019). One theory involves pacemaker cells in pelvic flexure moving it cranially towards

the diaphragm. Other possible theories include excessive fermentation, gas distension, and changes in faecal microbiota.

Other non-strangulating LI lesions include sand accumulation in the colon (Southwood 2019). In some instances, these are surgical cases where sand has to be manually removed during surgery. The procedure must be performed with great caution, because of the risk of rupturing the heavy intestine. Primary gas accumulation is an exclusion diagnosis that can be made when no other obvious findings are observed during surgery. In such cases, it is recommended to take a biopsy for histology to examine for any microscopic changes in the intestine.

2.3.3 Strangulating lesions of the large intestine

A large colon volvulus is a torsion around the colon's mesentery (Southwood 2019). A torsion of 360 degrees or more is considered a strangulating lesion. Cases with strangulating colon volvulus must be treated surgically with repositioning of the colon. The viability of the previously strangulated intestine is determined by assessing the colour of the serosa, peristalsis, and the severity of oedema on the colon and mesocolon. Though resecting nonviable parts of the colon can be attempted, it is often not possible to make a complete resection of the affected area and an anastomosis can be forced to include compromised tissue.

Another instance of strangulating lesions affecting the LI is the previously mentioned pedunculated lipoma, which can also impact the small colon (Prange et al. 2019). Interestingly, these cases are often associated with only mild to moderate abdominal pain, in contrast to other strangulating lesions of the intestinal tract where severe colic signs are frequently observed. Similar to the strangulating lipomas affecting the SI, these cases often necessitate resection.

2.3.4 Resection of the large intestine

The categorisation of non-strangulating and strangulating lesions can also in the LI have its limitations, because as previously mentioned resection of the LI can also be attempted (Southwood 2019). Colonic infarction is one example where resection may be indicated Surgery is often the only treatment possible, with resection performed depending on the area affected. However, sometimes the lesion is spread out to different areas of the intestine making resection difficult and the prognosis pessimistic. Infarction of the colon has traditionally been associated with the parasite *Strongylus vulgaris*, which can cause thrombus formation in the cranial mesenteric artery (Hedberg-Alm et al. 2022).

Segmental eosinophilic colitis is another example of a condition that might require resection (Edwards et al. 2010). It can typically occur in the left dorsal colon by the

pelvic flexure. The affected segment of the large colon requires resection. Other examples of LI lesions in need of resection are cases of cecum malfunctioning, which necessitate an ileocolic bypass (Sherlock 2019).

2.4 Survival after colic surgery

2.4.1 Survival from other studies

All studies in Table 1 describe horses with colic where a ventral mid-line laparotomy was performed. The inclusion criteria, however, varied, where some studies included horses of all ages (Wormstrand et al. 2014; Immonen et al. 2017; Spadari et al. 2023), whereas others excluded foals under the age of one (Mair & Smith 2010a; Christophersen et al. 2014; Van Loon et al. 2020; Dybkjær et al. 2022).

Relaparotomies were excluded from some study populations (Christophersen et al. 2014; Wormstrand et al. 2014; Dybkjær et al. 2022). The two Danish studies (Christophersen et al. 2014; Dybkjær et al. 2022) also excluded horses undergoing a second hospitalisation, while Wormstrand et al. (2014) excluded four horses that had to be euthanized in the recovery stall due to injuries: fractures (n=3) and femoral nerve paralysis (n=1).

Table 1. Short-term survival from different studies

	Country	Horses n=	Euthanasia in OR %	STS from recovery box until discharge %	OSTS from induction to discharge %
(Gorvy 2009)	Sweden (Strömsholm)	162	16	77	65
(Van Loon et al. 2020)	Netherlands	283	25	80	59
(Immonen et al. 2017)	Finland	236	17	75	62*
(Wormstrand et al. 2014)	Norway	297	26	74*	55
(Dybkjær et al. 2022)	Denmark (UHLA)	320	17	77	61
(Christophersen et al. 2014)	Denmark (UHLA)	336	44	75	42
(Mair & Smith 2010a)	UK	300	14	83	70
(Spadari et al. 2023)	Italy	451	15	80	69

*Have been manually calculated based on the numbers provided in the study

2.4.2 Euthanasia during surgery

The reason for euthanasia in the operating room (OR) was predominantly due to a poor prognosis because of non-viable intestine or rupture of intestine (Wormstrand et al. 2014; Immonen et al. 2017; Van Loon et al. 2020). In a few cases, horses died during induction, anaesthesia or in the recovery room after surgery. Various studies reported varying numbers on this subject, ranging from 1.2% to 3.9% (Mair & Smith 2010; Christophersen et al. 2014; Wormstrand et al. 2014; Dybkjær et al. 2022).

Wormstrand et al. (2014) also explained the decision for euthanasia during surgery was, to some extent, decided by the owner. In some instances, typically where a need for resection of the intestine was found, surgeons would call the owner during the operation. The owner could then decide to opt for euthanasia instead of the guarded prognosis for the horse to manage post-operative recovery.

Furthermore, Wormstrand et al. (2014) discuss that the difference in mortality during surgery could also be explained by the distances that horses being referred had to travel. Horses referred to Oslo in Norway generally travel longer distances to the referral hospital compared to horses in more horse-dense areas, such as Kent in the UK in the study by Mair & Smith (2010a), with a lower mortality rate in the surgery room (14%).

Further notable in Table 1 is the study from UHLA in Denmark, reporting 44% of horses euthanised during surgery in the period 2000-2009 (Christophersen et al. 2014), which is considerably higher than numbers from the other studies in Table 1. The same university hospital published another study on the subject from the period 2010-2018 (Dybkjær et al. 2022), where the number of horses euthanised during surgery was 17%, which is more in line with other comparable studies (Table 1). The authors attributed this to improvements in quality of diagnostics, earlier referrals, increased trust in surgical intervention, and enhanced surgical skills.

2.4.3 Short-term survival - discharge from hospital

In most of the studies, short-term survival (STS) was reported both as recovery from anaesthesia until discharge from the hospital, and as the overall short-term survival (OSTS) from induction of surgery until discharge from the hospital (Mair & Smith 2010a; Christophersen et al. 2014; Van Loon et al. 2020; Dybkjær et al. 2022; Spadari et al. 2023). In the studies by Immonen (2017) and Wormstrand (2014), the STS was not presented in both these ways and was therefore manually calculated from the data provided in these papers.

The primary reason for euthanasia in the hospital after surgery was due to colic or post-operative ileus (Mair & Smith 2010a; Wormstrand et al. 2014). Animal welfare concerns and laminitis were other reasons for euthanasia in the hospital postoperatively (Wormstrand et al. 2014).

2.4.4 Mean hospital time after surgery

The mean average time a horse stayed in the hospital after surgery was reported by Immonen et al. (2017) to be 7.2 days, ranging from 0-31 days. Van Loon et al. (2020) presented the total mean time spent in the hospital post-operatively to be 10.6 days with standard deviation (SD:4.9), but also reported how many of these days were spent in the intensive care unit (ICU) of the hospital, which was 3.3 days (SD:1.6). The other studies from Table 2 did not include values in how long the horses stayed in the hospital after the surgery.

2.4.5 Kaplan-Meier curves

The survival during a time period can be presented by using Kaplan-Meier curves (IBM 2021; DATAtab 2023b). These curves are survival-time analysis. They describe time-to-event data, in the case of survival-analysis, time until death. Survival rate (%) is plotted on the y-axis and time on the x-axis. Groups can be compared, by looking at curves and patterns. With the log-rank test, a comparison can be made to see if there is any statistically significant difference between the groups.

2.4.6 Long-term survival - one year after surgery

Long-term survival (LTS) was defined as the horse being alive one year after surgery in several colic studies (Mair & Smith 2010c; Van Loon et al. 2020). This definition has therefore been adopted for the present study. Of horses discharged from the hospital, reports range from 82% to 96% in LTS (Table 2). The most common reason for euthanasia at home after discharge was recurrent colic (Mair & Smith 2010c; Immonen et al. 2017). Other reasons for euthanasia at home included diagnoses not directly linked to the colic surgery, in the form of laminitis, fractures, neurological problems, arthritis, and unknown causes of death (Krista & Kuebelbeck 2009). Overall long-term survival (OLTS) describes the survival from induction until one year after surgery. The percentage of horses that were lost to follow-up and had to be excluded from the studies (Table 2) varied between 1.3% (Immonen et al. 2017) and 12% (Van Loon et al. 2020). The reason for less loss of follow-up in Immonen et al. (2017) was that information was retrieved from national databases, where hospital records and reasons of death could be attained.

Table 2. Long-term survival from different studies

	Country	Horses discharged with follow-up n=	LTS from discharge until 1 year after surgery %	OLTS from induction until 1 year after surgery. %
(Gorvy 2009)	Sweden (Strömsholm)	105	86	56*
(Van Loon et al. 2020)	Netherlands	133	96	51
(Immonen et al. 2017)	Finland	143	84	52*
(Christophersen et al. 2011)	Denmark	88	87	-
(Mair & Smith 2010c)	UK	204	84	65,5

*Have been manually calculated based on the numbers provided in the study

2.5 Factors associated with survival of colic surgery

2.5.1 Cox-regression

To assess if factors were associated with survival-time, Cox proportional hazard survival regression, or Cox-regression, can be utilised (DATAtab 2023a; IBM 2023). This statistical analysis predicts the probability of death having occurred, at any given time during a time-period, depending on different factors. In Cox-regression, factors are assessed using a hazard ratio. If the hazard ratio is greater than one, it indicates that the factor is associated with decreased survival-time. The p-value determines whether the factor is statistically significant in relation to survival-time.

For example, Van Loon et al. (2020) used Cox-regression and found that post-operative complications in the ICU, had a statistically significant negative influence on survival-time, up to one year after surgery where the data was censored.

2.5.2 Repeat laparotomy

An option for surgically treated horses reexperiencing colic is repeat laparotomy which can be performed at any time after the initial first surgery. In Mair & Smith (2010d) the term early relaparotomy was applied to describe horses reoperated on without being discharged home from the hospital. In the study, the 27 horses (10.6%) undergoing early relaparotomy demonstrated a lower OSTS (48%) compared to the total OSTS (70%), shown in Table 1.

Gorvy et al. (2008) presented 113 (10.1%) horses experiencing repeat laparotomy at any time after the surgery, out of which 99 had complete records and were

compared to horses with a single laparotomy using a Cox-regression model. For cases with repeat laparotomy no significant difference in time of survival, up to six years after surgery, was recorded. Neither in the study by Van Loon et al. (2020) were the number of laparotomies significant in affecting the survival-time, although the sample size was only 17 patients (6%).

Common for many studies that reviewed survival after colic surgery was the small number of horses experiencing repeat laparotomy, since it usually only accounts for less than 10% of the total study population (Immonen et al. 2017; Van Loon et al. 2020; Spadari et al. 2023).

2.5.3 Strangulation and resection

Van Loon et al. (2020) reported that the SI lesions in need of resection had the lowest STS (25.0%) and the highest percentage (53.4%) of horses euthanised during surgery, followed by strangulating LI lesions with an STS of 57.8% and 28.9% euthanised in the OR. In contrast, the SI lesions without resection and the non-strangulating LI lesions had considerably higher STS values, at 78.7% and 79.8%, respectively.

This difference in STS between the colic categories was also found in Spadari et al. (2023), where non-strangulating cases, including both the LI and the SI, had a 2.18 higher probability of STS than strangulating lesions. Furthermore, horses without resection had a 2.3 higher probability of STS than those where resection was performed.

2.5.4 Age

The success of colic surgery relating to the age of the horse is a topic many studies have investigated, and the results vary. Rudnick et al. (2022) found no differences between age groups (<16 and ≥16) on STS. Neither did Immonen et al. (2017) find any difference in LTS between age groups (<15 and ≥15). Van Loon et al. (2020) stated that age was not significantly associated with survival-time in Cox-regression. However, the study by Spadari et al. (2023) found, based on the evaluation of ROC curves, that horses of ages ≥14 years had a 2.3 times higher likelihood of a negative outcome, compared with horses aged 10 to 14.

Krista & Kuelbeck (2009) compared geriatric horses to non-geriatric (aged ≥20 and aged <20). In the study, the survival rate in the OR was higher for the younger horses (72%) compared to the older horses (50%). The authors point out two factors mainly contributing to this. Firstly, an increase in strangulating SI lesions in the geriatric population, mainly because of the prevalence of strangulating lipoma.

Secondly, there were more financial constraints when surgically treating older horses. Even though the study found a difference in the survival of surgery, the STS from anaesthetic recovery until discharge, was not significantly different between the two groups.

2.6 Complications post-operatively

Table 3. Overview of complications from other colic survival studies

	Colic after surgery in hospital %	SSI in hospital %	Reflux after surgery in hospital %	Owner reported colic within the first year after surgery %	Owner reported hernia developed after discharge %
(Mair & Smith 2010b; c)	28.2	26.9	13.7	35,1	-
(Spadari et al. 2023)	23.5*	25.1	20.4*	-	-
(Van Loon et al. 2020)	-	-	15,2*	59,8	6.1
(Immonen et al. 2017)	-	28,9	27.2	20	11.1

*No definition provided in the studies

2.6.1 Post-operative colic

Recurrent colic post-operatively is one of the most common complications after colic surgery, both in the hospital and at home after discharge (Mair & Smith 2010b; c). When assessing the journals and by discussing with the personnel at UDS it became clear that the first choice of additional analgesia for horses showing signs of post-operative colic in the hospital was administration of intravenous metamizole. It has therefore been chosen as a definition of a patient presenting with post-operative colic in-hospital in the current study. Mair and Smith et al. (2010a) described in-hospital colic after surgery as a horse showing signs of persistent pain from the abdomen, as assessed through the horse´s behaviour.

The incidence of at-home colic reoccurrence, investigated by asking owners using questionnaires, is compiled in Table 3. The study from Mair & Smith (2010b) reported 35.1% of the horses experiencing colic in the first year after surgery. Eleven percent of these horses had such severe colic that it required euthanasia or relaparotomy. In the study by Van Loon et al. (2020), over half of the horse owners (59.8%) reported colic in their horse within the first year after surgery. In 45.1% of these cases, colic occurred in one or two instances, while 14.6% said that their horse suffered from colic in three or more instances.

2.6.2 Post-operative ileus and reflux

Post-operative ileus (POI) describes the decrease in gastrointestinal transit following surgical intervention and is normally diagnosed clinically using a nasogastric tube, revealing presence of reflux (Lisowski et al. 2018). However, there is currently no widely accepted clinical definition for amount of reflux to be associated with POI.

The present study therefore adopted the definition proposed by Merritt & Blikslager (2008) classifying postoperative reflux indicating POI as gastric reflux of ≥4 litres upon any given intubation or >2 litres per hour on repeated intubation. Mair & Smith (2010a) and Immonen et al. (2017) both defined postsurgical ileus as more than two litres of net reflux received in-hospital, with no more specific definitions of time, or amount of reflux provided. This was documented in 13.7% and 27.2% of the cases, respectively, as shown in Table 3.

Post-operative ileus is considered to be caused by manipulation and resection of the intestine (Lisowski et al. 2018). The surgical procedures are thought to damage the tissue and trigger an inflammatory response in the intestine leading to ileus. Post-operative ileus can also occur as a result of systemic endotoxemia which also can cause decreased intestinal motility. Ileus is described to prolong the hospitalisation of the horses, who need continuous intubation and are introduced slower to feed.

Post-operative reflux was, in the Cox-regression analysis performed by Van Loon et al. (2020), not associated with decreased survival-time. Neither did Spadari et al. (2023) show that reflux decreased the odds of STS. However, neither of the two studies stated the definition of post-operative reflux.

2.6.3 Surgical site infection

Surgical site infection (SSI) of the abdominal surgery wound is another complication that can occur, especially in the short-term postoperative stage (Mair & Smith 2010b). However, it is difficult to compare the prevalence of SSI between colic survival studies (Table 3) since the definition varies. In the present study, the definition of infection was based on Gustafsson (2021), who defined SSI as drainage from the incision continuing or beginning 24 hours after surgery, regardless of appearance of fluid. Mild serosanguinous drainage up to 24 hours after surgery was accepted.

The definition of SSI in the colic survival studies from Table 3 was as follows: Immonen et al. (2017) described it as excessive incisional drainage from the surgery site (28.9%) and Spadari et al. (2023) as any discharge from the wound (25.1). Mair and Smith (2010b) divided incisional complications (26.9%) into drainage (non-

painful serous or purulent discharge (23.8%)) and wound infection (purulent discharge with local wound heat and pain [3.1%]).

2.6.4 Ventral hernia

Ventral herniation of the abdominal incision is a long-term complication that might occur, usually developing within the first two or three months after colic surgery (Mair & Smith 2010c). In the survey by Van Loon et al. (2020), five horse owners (6.1%) reported incisional herniation. Immonen et al. (2017) reported that 11.1% of the discharged horses developed an incisional hernia. In these studies, the return to usage and performance in these horses was not affected, although it contributed to a prolonged rehabilitation period.

2.7 Return to previous function and owner satisfaction

2.7.1 Performance

The performance of the horses following colic surgery is another important factor to investigate. In the study by Immonen et al. (2017), out of 135 horses who returned home and where owners responded to the questionnaire, 118 (87.4%) were reported successfully back to a satisfactory condition. The convalescent period in the study was reported by owners to be a mean of 6.0 months with a range of 0-20 months.

In the study by Van Loon et al. (2020), 52 (63.4%) of the horse owners reported that their horse had equal or improved performance compared to before the surgery, while 22 (26.8%) reported reduced performance. Seven of the horses (8.5%) were reported to have been retired after surgery.

2.7.2 Owner satisfaction

Owner satisfaction with the surgery and the care their horse had received in the hospital were also investigated in some of the forms sent out in the long-term studies. Almost all of the owners (96.3%) in the study by Immonen et al. (2017) rated veterinary care as satisfactory to good. Similarly, 98.5% responded satisfactory to good toward colic surgery. Christophersen et al. (2011) also supported this by saying that a majority of the owners with a horse discharged from the hospital, were satisfied with the colic surgery.

Important to note is that both these studies sought answers from horse owners with a horse sent home alive from the hospital and did not include all the owners of horses operated for colic surgery. The horses that could not be saved during surgery

and those euthanised in the postoperative hospitalisation period were not included in the long-term questionnaires.

3. Materials and Methods

Horses that underwent a laparotomy due to colic from August 2019 to August 2022 at UDS were included in the study. The inclusion criteria were horses over one year of age, and only those with an acute onset of colic originating from the gastro-intestinal system. Horses undergoing exploratory laparotomy due to chronic problems and those presenting with diagnoses related to the reproductive organs, such as uterine torsion or dystocia, were not included in the study population. Foals were not included in the study due to the nature of colic in foals, which can also have other aetiologies such as urinary bladder ruptures and hernias, rather than solely colic originating from the gastrointestinal system.

Patient journals were assessed for information about the study population. Short-term survival (STS) was described in two ways: STS from recovery of anaesthesia until discharge, and overall short-term survival (OSTS) from the induction of anaesthesia ´until discharge. This differentiation was critical to enable cases where euthanasia occurred during surgery to be distinguished. Long-term survival (LTS) was described in the study as a survival from discharge until at least 365 days after the first surgery. Overall long-term survival (OLTS) described survival from induction of surgery until 365 days after surgery.

A questionnaire (Appendix) was sent out to the horse owners with a horse that was discharged alive from the hospital to investigate the LTS and address the following questions:

- Return to the previous function? (yes/no and better/same/worse performance)
- How long until return to function after surgery (less than 3 months, 3-6 months, 6-9 months, more than 9 months)
- What is the prevalence of recurrent colic after surgery? (one colic episode, two colic episodes, >2 colic episodes)
- What is the prevalence of other complications? (hernia, wound infection, other complications)
- Owner satisfaction with the care of their horse at UDS? (good/satisfied/poor)
- Would they recommend colic surgery to other horse owners? (yes/no)

The questionnaire was distributed via email and text message. Owners who did not respond to either of these methods were contacted by phone and completed the form verbally. For owners who could not be reached in this manner, information about

the horse's survival was searched in competition databases. Horses for which information could not be found were reported as lost to follow-up.

The colic diagnosis was categorised into five different groups: small intestine with no resection, small intestine with resection or in need of resection, large intestine with no strangulation, large intestine with strangulation, and finally large intestine with resection or in need of resection. The definition of resection or in need of resection was applied when the intestine was in a condition requiring resection and anastomosis for the horse to survive. Strangulation was defined as a lesion with a torsion of at least 360 degrees, resulting in compromised blood supply to the intestine. Horses who died during anaesthesia or had a ruptured bowel already at surgery were not classified into any of the surgery diagnoses groups.

Average hospitalisation after surgery (days) was described along with the prevalence of the following post-operative in-hospital complications: colic, gastric reflux, and surgical site infection. Post-operative in-hospital colic was defined as a horse showing signs of pain from the abdomen, as noted in the journal, and either receiving a dose of metamizole for additional analgesia or being euthanised due to colic. Reflux after surgery indicating ileus was defined as gastric reflux of ≥4 litres upon any given intubation or >2 litres per hour on repeated intubation. Surgical site infection (SSI) was defined as drainage from the incision continuing or beginning after 24 hours, regardless of the appearance of the fluid. Mild serosanguinous drainage up to 24 hours after surgery was considered within normal limits.

Data analysis

Kaplan-Meier curves were performed for survival analysis to describe the cumulative survival and the survival for the five diagnosis categories. These were then compared using log-rank tests. Unadjusted univariate Cox-regression was used to assess if factors were statistically significant to survival-time, censored at one year after surgery. The following factors were analysed: age at surgery (years), sex (mare, stallion, gelding), breed (warm-blooded, cold-blooded, thoroughbred, ponies, icelandic, other breeds)**,** time from surgery to discharge (days), enterotomy (yes/no), colic in hospital after surgery (yes/no), resection of intestine (yes/no), strangulation (yes/no), affected intestinal segment (SI/LI), post-operative colic in the hospital (yes/no), SSI in hospital (yes/no) and post-operative reflux indicating POI in the hospital (yes/no). Data analysis was performed using IBM SPSS Statistics, version 29. Significance was set to $p<0.05$.

4. Results

4.1 Descriptive data of study population

A total number of 137 acute colic surgeries met the inclusion criteria during the study period (2019-2022) and were reviewed. The study population consisted of 66 mares, 65 geldings, and 6 stallions (Table 4). The breeds of the study population are also described in Table 4. The average age of the horses at the time of surgery was 10.81 years and the age distribution is shown in Figure 1.

Table 4. Patient descriptive data

Sex	Number	Breed	Number
Geldings	65	Warm-blooded	69
Mares	66	Cold-blooded	9
Stallions	6	Thoroughbred	4
		Ponies	16
		Icelandic	16
		Other breeds	10

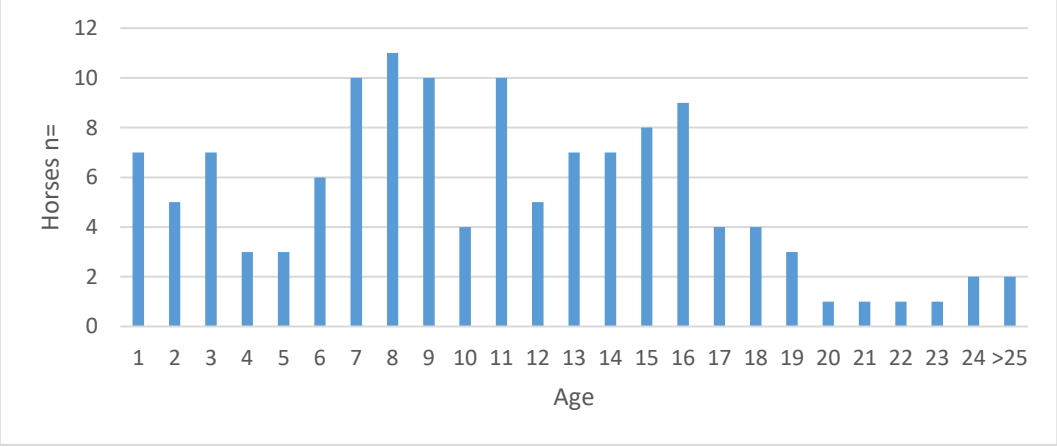

Figure 1. Age distribution in the study population.

4.2 Survival of colic surgery

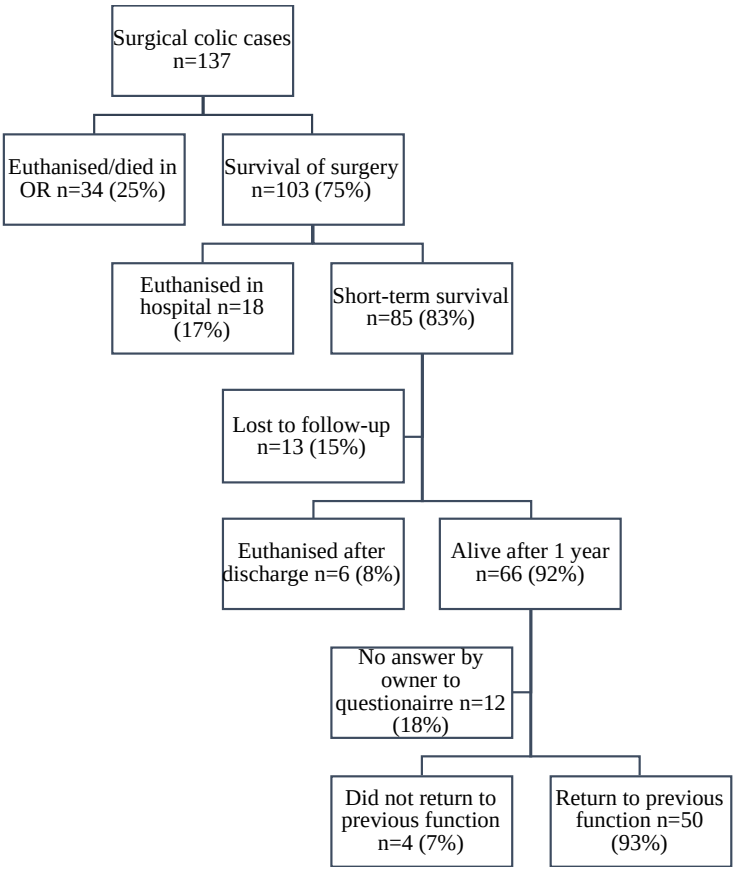

Figure 2. Overview of survival after colic surgery.

4.2.1 Short-term survival at UDS

Of all the surgical colic cases, 103 recovered and were post-operatively treated in the ICU of the hospital. A total of 34 horses (25%) were euthanised or died in the OR. Six of these deaths were related to anaesthesia, with three dying in induction, two during surgery, and one in the recovery box. Deaths related to anaesthesia represented 4.3% of the total study population's cases. Euthanasia in the OR was performed in 28 cases, and in the majority of these cases (86%), it was due to a poor prognosis. Examples of a poor prognosis included non-viable intestine or rupture during surgery, causing faecal contamination of the abdomen. The remaining (14%) of euthanasia in the OR occurred due to a guarded prognosis, with the owner choosing euthanasia.

The diagnostic categories found during surgery are described in Table 5. Six cases could not be categorised into any of the regular five categories, including one lymphoma, two stomach ruptures, and three ruptured bowels. The ruptures were present before the beginning of surgery. All six cases that were not categorised were euthanised. Four of the six deaths related to anaesthesia were also not categorised

due to the surgery diagnosis not being made before the horse died before abdominal exploration.

Table 5. Short-term survival for various diagnosis categories

	Number	Euthanised /died in OR (%)	Euthanised in hospital (%)	STS from recovery box until discharge (%)	OSTS from induction until discharge (%)
Other diagnosis/not categorised	10	9 (90)	1 (10)	-	-
SI; no resection	25	1 (4)	2 (8)	22 (92)	22 (88)
SI; resection/in need of resection	34	12 (35)	7 (21)	15 (68)	15 (44)
LI; no strangulation	39	1 (3)	3 (8)	35 (92)	35 (90)
LI; strangulation	23	8 (35)	3 (13)	12 (80)	12 (52)
LI; resection/in need of resection	6	3 (50)	2 (33)	1 (33)	1 (17)
Total	137	34 (25)	18 (17)	85 (83)	85 (62)

The most common reason for euthanasia in the hospital was recurrent colic, with an inability to provide adequate analgesia. The average hospitalisation duration for discharged horses after surgery was 7 days, ranging from 2 to 28 days (SD: 4.62), with one outlier, who stayed at the hospital for 138 days, excluded.

4.2.2 Long-term survival at UDS

The Kaplan-Meier curve in Figure 3 involves 124 cases. In 13 cases, information about the horse's LTS could not be attained, resulting in loss to follow-up. The OLTS, from induction until one year after surgery, was 53%. However, the LTS from discharge until one year post-operatively was 92%.

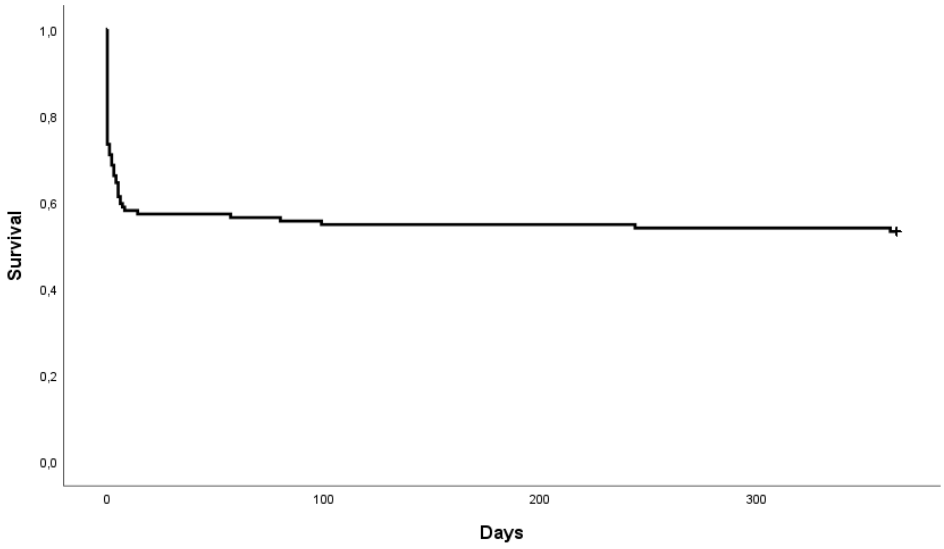

Figure 3. Kaplan-Meier curve for 1-year survival probability.

The cumulative survival for the various diagnosis categories is described for 114 cases in Figure 4. The log-rank test showed a significant difference between the diagnostic categories, with LI strangulation, LI resection/in need of resection and SI resection/in need of resection having worse survival probability compared to LI no strangulation and SI no resection (p-value<0.01).

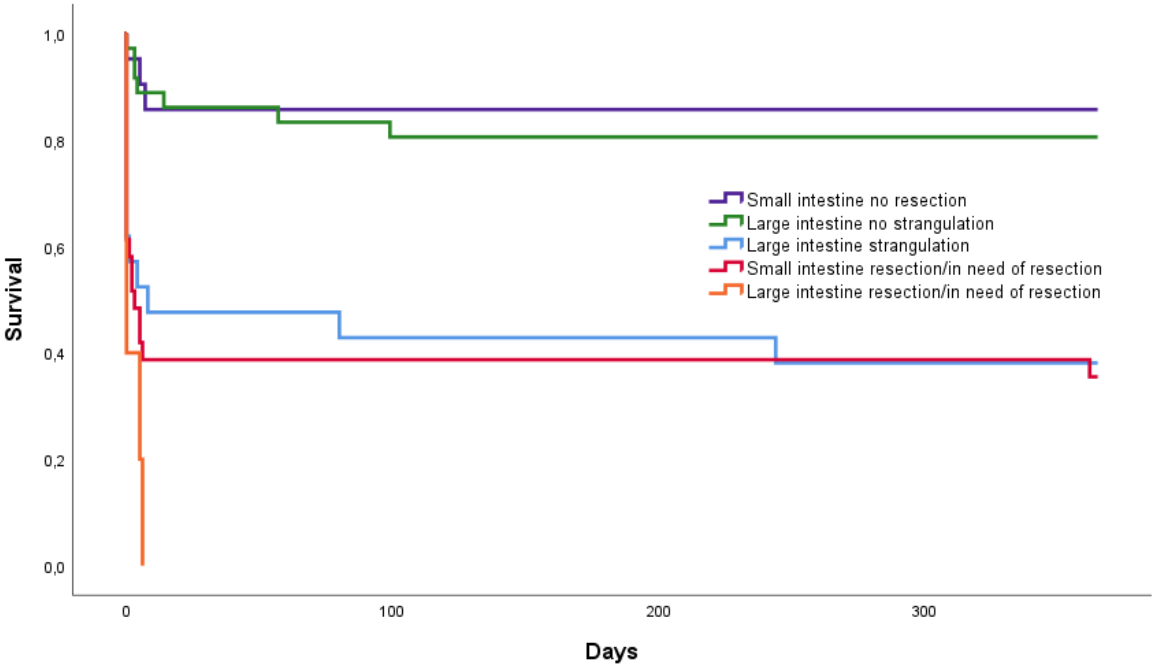

Figure 4. Kaplan-Meier curves for various diagnostic categories survival probability.

The horse owners reported that the reason for euthanasia at home within one year was recurrent colic in all six cases, with four of these cases diagnosed with right dorsal displacement during surgery.

Table 6. Long-term survival for various diagnosis categories

	Horses with colic surgery	Lost to follow-up	Horses discharged with follow-up	LTS from discharge until 1 year after surgery (%)	OLTS from induction until 1 year after surgery (%)
Other diagnosis/not categorised	10	0	0	0	0
SI; no resection	25	4	18	18 (100)	18 (86)
SI; resection/in need of resection	34	3	12	11 (92)	11 (35)
LI; no strangulation	39	3	32	29 (90)	29 (81)
LI; strangulation	23	2	10	8 (80)	8 (38)
LI; resection/in need of resection	6	1	0	0	0
Total	137	13	72	66 (92)	66 (53)

4.3 Factors association to survival-time

Univariate Cox-regression analysis (Table 7) was performed to assess which factors were significant in affecting survival-time, censored one year after surgery. Cases lost to follow-up were excluded from the analysis. Statistical significance in survival-time was observed in relation to resection, strangulation and colic post-operatively in the hospital. Fifty-two of the cases involved the SI and 62 involved the LI. Enterotomy was performed in 27 cases. Strangulation was noted in 55 cases and resection was performed in 21 cases.

Table 7. Univariate Cox-regression analysis censored one year after surgery

	Number	df	p-value	Exp (B)	Lower 95% CI for Exp (B)	Upper 95% CI for Exp (B)
All cases with follow-up						
Age at surgery (years)	124	1	0.061	1.044	0.998	1.092
Gelding	124	2	0.622			
Mare		1	0.983	1.006	0.598	1.690
Stallion		1	0.335	0.375	0.051	2.758
Warm-blooded	124	5	0.703			
Cold-blooded		1	0.143	3.307	0.666	16.406
Thoroughbred		1	0.457	1.837	0.371	9.101
Ponies		1	0.177	2.667	0.641	11.098
Islandic		1	0.296	2.845	0.400	20.223
Other breeds		1	0.317	2.232	0.463	10.749
Cases surgically categorised						
Intestine (SI compared to LI)	114	1	0.620	0.866	0.492	1.527
Strangulation	114	1	0.001	2.670	1.460	5.881
Strangulation of LI (compared to non-strangulated LI)	57	1	0.002	4.362	1.726	11.020
Cases surviving surgery and treated in the hospital						
Resection	89	1	0.011	2.874	1.274	6.487
Resection of SI (compared to non-resected SI)	39	1	0.037	5.210	1.104	24.587
Enterotomy	89	1	0.870	0.929	0.385	2.240
Colic in hospital after surgery	89	1	<0.001	5.877	2.309	14.958
Reflux in hospital after surgery	89	1	0.453	1.390	0.589	3.280
SSI in hospital	89	1	0.083	0.342	0.101	1.150
Cases discharged from the hospital						
Hospitalisation after surgery until discharge (days)	72	1	0.964	1.001	0.955	1.049

4.4 Complications after colic surgery

4.4.1 Short-term complications

Short-term complications for the 103 cases treated in the ICU at UDS are detailed in Table 8.

Table 8. In-hospital complications after surgery.

	Post-op colic in hospital (%)	SSI in hospital (%)	Post-op reflux in hospital (%)
SI; no resection	11 (46)	8 (33)	7 (29)
SI; resection	12 (55)	3 (14)	12 (55)
LI; no strangulation	9 (24)	12 (32)	8 (21)
LI; strangulation	6 (40)	3 (20)	1 (7)
LI; resection	2 (67)	1 (33)	0
Total	40 (39)	27 (26)	28 (27)

4.4.2 Repeat laparotomy at UDS

Eight horses in the study population underwent repeat laparotomy (5.8%), of which one case was lost to follow-up and five had survived one year after their most recent surgery (OLTS:71%). Two of the cases had early relaparotomy, without the horse being discharged prior to repeat surgery, while three cases had a repeat laparotomy within a time frame of 5-10 months. In the remaining three cases, only the second or third surgery were reviewed because the initial previous surgeries were not performed within the time period of the study.

4.4.3 Long-term complications

In the questionnaire sent out to the 85 owners who had horses discharged alive from the hospital, 57 responded (response rate 67%), see Appendix. Figure 5 reviews the prevalence of colic episodes at home, while Figure 6 assesses the healing of the abdominal wound, as reported by the owners.

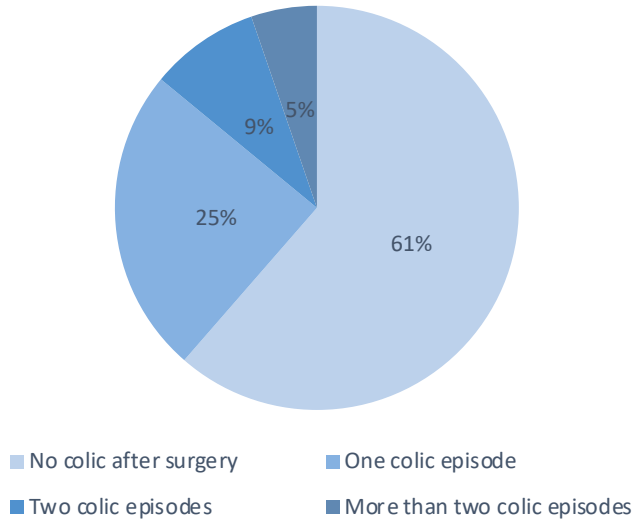

Figure 5. Prevalence of colic in need of veterinary care after (1-4 years) surgery.

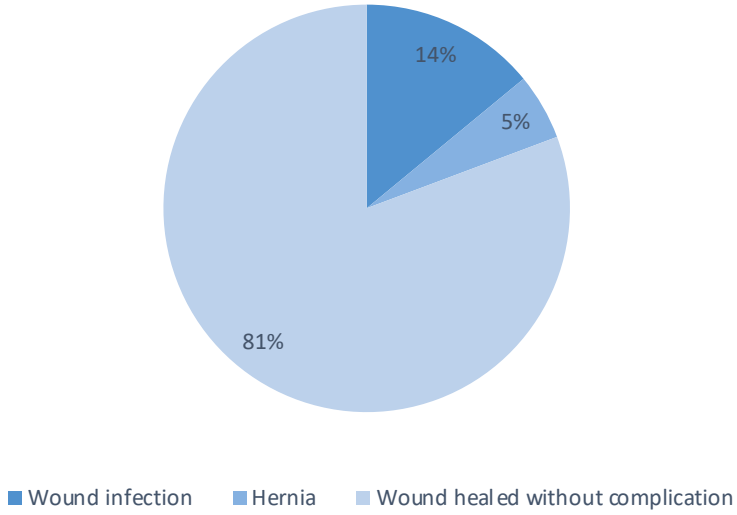

Figure 6. Healing of the abdominal wound after surgery.

4.5 Return to the previous function

As shown in Figure 7, 88% of responders to the form reported that their horse was back to work after the surgery. The performance level and the time until return to function were also assessed by the horse owners, as illustrated in Figure 8 and Figure 9.

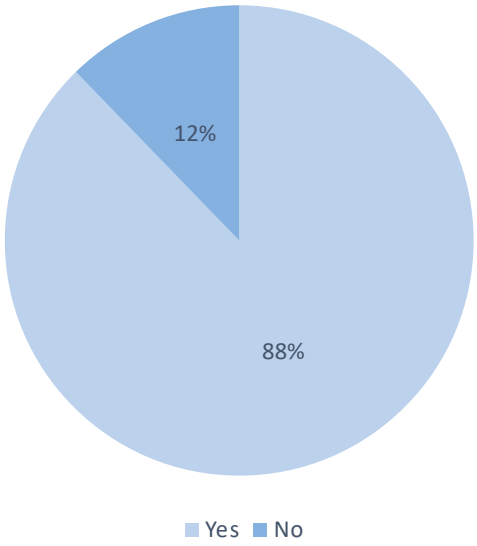

Figure 7. Percentage of horses who returned to previous function after surgery.

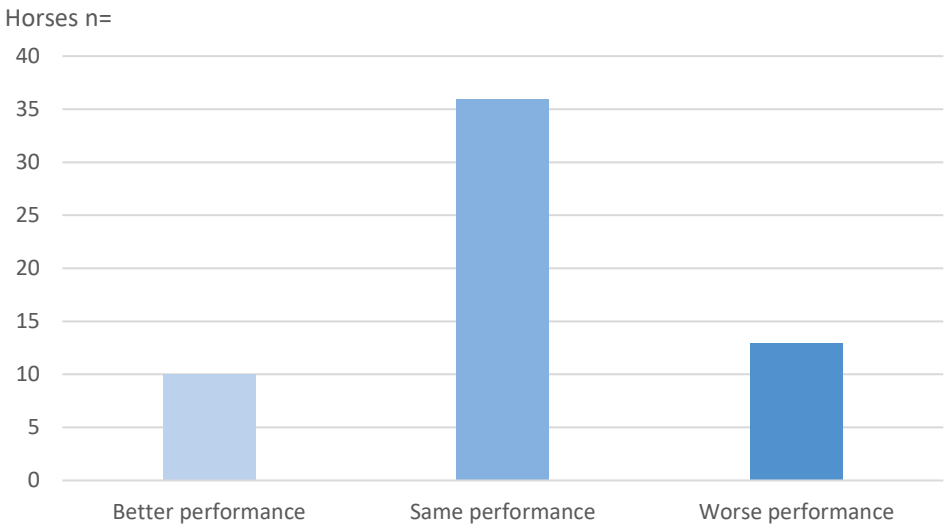

Figure 8. Performance level after surgery.

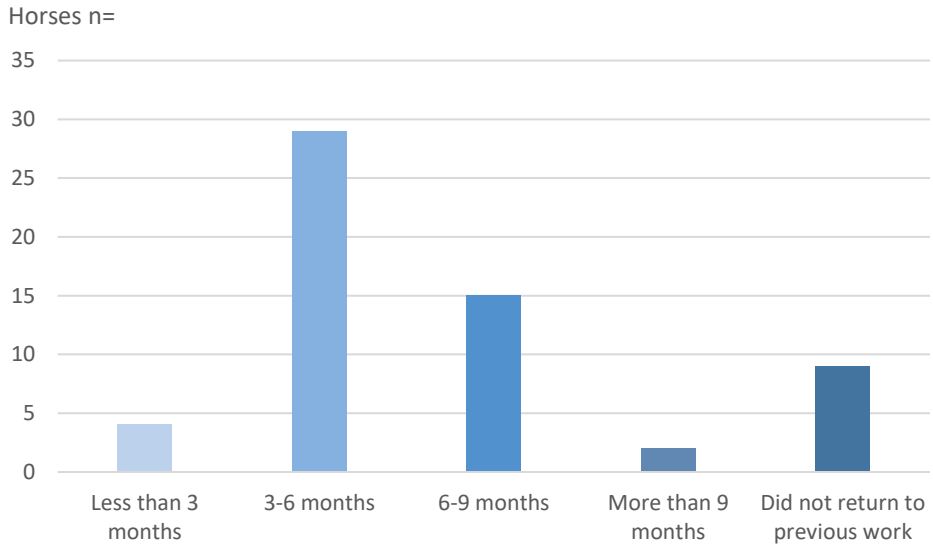

Figure 9. Time until return to previous function after surgery.

4.6 Owner satisfaction with colic surgery

The owner satisfaction with the colic surgery is illustrated in Figure 10. Only owners with a horse sent home alive from the hospital were selected to take part in the survey, which means owners with a horse euthanised during surgery, or in the hospital were not included. No owner with a discharged horse judged the care at UDS to be bad. Of the responding owners, 95% would recommend colic surgery at UDS to others, as indicated in Figure 11, although some commented that it must be judged from case to case.

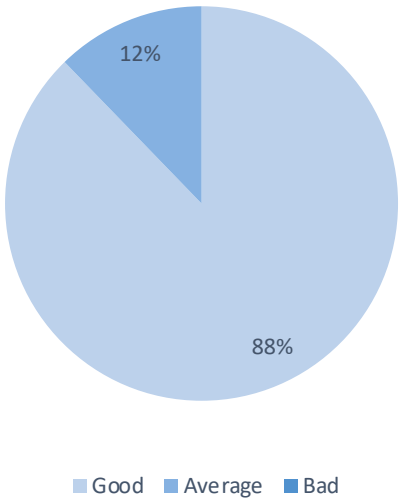

Figure 10. Owner satisfaction with the care of their horse at UDS.

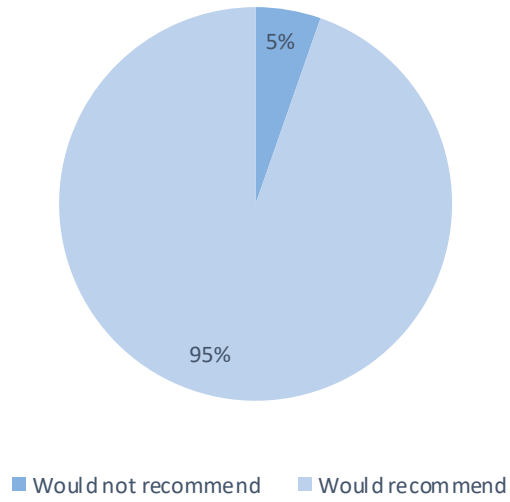

Figure 11. Would horse owners recommend colic surgery to other owners?

5. Discussion

5.1 Study population

The distribution of sex, age and breed in the study population was interpreted as representative of the equine population in Sweden (Jordbruksverket 2005), highlighted by the gender distribution being equal between mares and geldings. However, it is important to note that foals under the age of one were not included. Although the selection in the present study was relatively small compared to the other published papers (Table 1), statistical significance was still achieved in a large proportion of the survival analysis.

The long-term survival questionnaire was performed within a time frame of one to four years after surgery. This helped owners recall details accurately and provide informed responses. Thirteen cases (9.2%) were lost to follow-up, which was slightly less than in the study by Van Loon et al. (2020) but more than in the study by Immonen et al. (2017). The reason for the loss of follow-up in the present study was likely because many of the owners had travelled a considerable distance to UDS and were assumingly more prone to seek help from a local veterinarian, rather than returning to UDS and therefore not present in the journal system, after discharge.

5.2 Survival and factors influencing survival

5.2.1 Short-term survival and euthanasia in the operating room

The overall short-term survival (OSTS) after colic surgery at UDS (62%) was similar to that reported in other European studies, ranging from 55-70%, as shown in Table 1.

Furthermore, UDS had a short-term survival (83%), from recovery until discharge, which was one of the highest values compared to other studies (Table 1). However, studies with higher in-hospital STS also potentially had a higher mortality during

surgery (Table 1). This trend was also observed at UDS, where 25% of colic cases were euthanised or died in the OR.

Pre-operative factors may also contribute to the number of cases euthanised in the OR. Wormstrand et al. (2014) theorised that horses in their study from Oslo travelled long distances to the referring hospital and therefore experienced colic over an extended period. This could result in more severely compromised patients at surgery compared to those with closer referral for example Kent in the UK presented by Mair & Smith (2010a). While the present study did not investigate this further, it is true that UDS also serves a large area being the northernmost equine hospital in Sweden, but still located in the geographical south of the country. Therefore, examining the time between the start of colic symptoms and surgery, along with other preoperative factors that could influence STS, would be an interesting topic for future research.

An additional factor to consider regarding mortality in the OR at UDS relates to the four cases which were euthanised because the owner did not want to proceed with intestinal resection. The reason was in one case financial and in three cases because the owner preferred euthanasia due to the perceived poor prognosis. This further enhances the value in being able to give advice based on accurate and recent data on different types of diagnoses found at colic surgery.

5.2.2 Long-term survival and patterns of long-term survival

The long-term survival (LTS) from discharge until one year after the surgery was 92% at UDS, with only six (8%) of the discharged horses being euthanised at home. Long-term survival ranged from 82-96% in other studies as shown in Table 2. The overall long-term survival (OLTS) at UDS (53%) was also similar to other studies (Table 2).

In the Kaplan-Meier curve (Figure 3) it can be seen that euthanasia predominantly occurs in the immediate post-operative period, with the curve having a less steep gradient once horses are discharged from the hospital. This indicates that a majority of horses surviving the high-risk period at the hospital were alive within the first year after surgery. This was also described by Proudman et al. (2010b), where the first 100 days postoperatively represented the highest risk period for a horse to be euthanised.

When further analysing the Kaplan-Meier curves (Figure 4), variations in post-operative long-term survival patterns were also noted among the different diagnostic groups. For instance, the non-strangulating LI lesions had a relatively low LTS (90%) compared to the STS, which was the highest among the diagnosis

groups. One explanation could be that the primary problem for the non-strangulating LI cases, such as an abnormal motility issue, remains unresolved after surgery. In particular, the non-strangulating LI cases with right dorsal displacement (RDD) have been associated with an increased risk of reoccurring colic after surgery (Smith & Mair 2010; Whyard & Brounts 2019). This study also found that four out of the six euthanised cases after discharge, due to recurring colic, had a RDD at surgery. A larger number of cases would be needed in order to investigate this further.

5.2.3 Cases experiencing resection and strangulation

The overall short-term survival (OSTS) was lowest in patients requiring intestinal resection, as shown in Table 5. The group "SI resection/in need of resection" demonstrated an OSTS of 44%, which can partially be explained by euthanasia during surgery being high for these cases (35%). This explanation, however, does not clarify why the resected cases also were associated with decreased survival-time once leaving the OR (Table 7). In these cases, the post-operative clinical effects were likely to be more pronounced, such as endotoxemia, making it more challenging for these individuals to recover in general. Additionally, the resected cases exhibited the highest prevalence of post-operative colic and post-operative reflux in the hospital (Table 8).

The current study also identified a correlation between cases with strangulating lesions and decreased survival-time (Table 7). It is important to recognise that the Cox-regression for the strangulated cases included the cases euthanised intra-operatively. This inclusion likely had an impact on the survival analysis, since more strangulating cases were euthanised during surgery. The reason for strangulating conditions having a worse prognosis is because the strangulation interrupts the blood flow to the intestine, leading to ischemia and serious consequences such as intestinal necrosis, if not operated on as soon as possible. The strangulating lesions additionally result in release of cytokines associated with endotoxemia (Proudman et al. 2010b).

5.2.4 Factors not associated with survival-time

Several factors in the present study were not associated with decreased survival-time, one being age (Table 7). Age is a complex subject due to various underlying determinants. On one hand, older horses are more prone to strangulating SI lesions, due to the higher prevalence of pedunculated lipomas, with a worse prognosis. On the other hand, there is possibly a tendency for owners to not treat older horses surgically when their horse´s condition is very critical. For example, older horses presenting with a potential strangulating lesion with severe endotoxemia are more

likely euthanised instead of proceeding with surgery. This could lead to a bias of older horses having less serious conditions found during surgery.

The eight cases experiencing repeat laparotomy did not show a lower OLTS (71%). However, similar to many other colic survival studies, more cases are needed for accurate statistical analysis on the subject.

5.2.5 Complications in the hospital after surgery

Post-operative colic in-hospital at UDS was associated with decreased survival-time (Table 7). In fact, the reason for the majority of horses to be euthanised in the hospital was due to recurrent colic. Those who suffered from colic again and which could not be relieved by pain medication had to either be reoperated or euthanised. Unfortunately, in Sweden, a second surgery is rare, since the standard veterinary insurance is only enough to cover the costs of one operation.

In the present study, post-operative reflux was not associated with decreased survival-time (Table 7). Post-operative reflux in the present study was defined as a single intubation of over four litres of reflux as post-operative ileus. In other studies, however, reflux over two litres at any point was defined as ileus (Smith & Mair 2010; Immonen et al. 2017). Both these definitions can be considered strict and can result in an artificially large number of horses recorded with ileus after surgery.

The prevalence of surgical site infection (Table 3) was similar to previously published studies (Mair & Smith 2010b; Immonen et al. 2017), who also used a strict definition of SSI, concerning drainage from the abdominal wound. Likewise, the time spent in the hospital postoperatively was similar to Immonen et al. (2017), averaging seven days.

5.3 Questionnaire and long-term follow-up

The long-term questionnaire was filled in by 57 (67%) of the 85 owners with a discharged horse. This was an acceptable response rate. Only owners with a horse sent home alive from the hospital were asked to fill in the questionnaire. Owners with a horse euthanised intra-operatively or in the hospital were not included. This likely affected the results of the owner satisfaction rating and how many owners would recommend surgery. Owners with a horse alive are almost certainly more prone to recommend surgery and be satisfied. However, this was also the method by which other long-term studies evaluated satisfaction (Christophersen et al. 2014; Immonen et al. 2017). To the author's knowledge, no long-term study in survival of colic surgery has evaluated the true owner satisfaction rate.

When conducting a questionnaire, it is also important to consider the respondent's subjectivity. Regarding colic, this subjectivity was minimised by including a question as to whether the horse had been seen by a veterinarian. However, the owners were left to interpret many of the questions based on their own knowledge and experience. Therefore, the study only presented descriptive statistics and no data analysis from the questionnaire.

5.3.1 Return to previous function

The results with regards to return to function and performance level was generally positive with a majority of horses achieving the same level, as shown (Figure 7) and (Figure 8). The time to recovery ranged from 3-9 months. A limitation to the questionnaire was that the initial performance and usage of the horse was not researched. The use of the horse before the surgery probably affected the results since horses performing at a higher level prior to surgery likely had a harder time reaching the same performance level. This compared to horses who functioned at a lower level before surgery.

5.3.2 Long-term complications

Colic at home after being discharged from the hospital was reported by 39% of the owners who answered the questionnaire (Figure 6). This percentage varied considerably between previous studies (Table 3). However, it is not possible to directly compare the results in this study to those in Table 3 since the questionnaire in this study did not take time into consideration regarding colic re-occurrence. The present study solely investigated the prevalence of colic after discharge, with owners being contacted at different times after surgery. Consequently, their horses were at different risks of developing colic during varying time periods.

Some horses were also reported dead in the survey of this study, but not within the time frame of one year after surgery. It would therefore also be interesting to perform a longer follow-up after surgery.

6. Conclusion

At UDS, the overall short-term survival (62%), from induction until discharge, was similar to other northern European studies. The STS, from anaesthetic recovery to discharge, was amongst the highest (83%), although the number of horses euthanised during surgery was also high (25%). The long-term survival from discharge until one year after colic surgery was 92%. Cases with strangulating lesions, cases requiring resection of intestine, and cases experiencing post-operative colic in the hospital, were associated with a decreased survival-time. These results can help veterinary clinicians at UDS and throughout Sweden to give horse owners the best advice regarding the prognosis for colic surgery.

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Popular science summary

There have been many studies reporting the survival rate after equine colic surgery, however, there has been no study published in Sweden. Obtaining this information will help both horse owners and equine veterinarians decide whether to proceed with surgery and provides a prognosis for the diagnosis found.

The short-term survival of colic surgery, from the horse recovering from surgery until leaving the hospital, was 83% at UDS. This is similar to that reported in other Nordic countries (Wormstrand et al. 2014; Immonen et al. 2017; Dybkjær et al. 2022). In this way of presenting short-term survival deaths during surgery were not included, where the highest rate of mortality occurred in the present study (25% of all cases). This was predominantly due to a decision of euthanasia, because the chance of survival for the horse was poor, despite surgery. Examples of cases with poor chances of survival were those with an intestine that was not functioning and necrotic. Although not part of this study, there are also many horses that do not reach the surgery table because of owners' perception that colic surgery carries a poor prognosis.

This study also describes how many of the horses operated on were alive one year after surgery, that is, the long-term survival. The majority (92%) of the horses that were sent home from the hospital after surgery were alive within one year. The overall long-term survival, including all cases surgically treated, was 53% at UDS, which is comparable to other studies.

Additionally, the horses were categorised based on the diagnosis found during surgery. This categorisation was performed by assessing which part of the intestine was the primary cause of the colic, such as the large or the small intestine. It was also noted whether the blood supply was cut off to the intestine, as a result of strangulation or if parts of the intestine required removal, with the remaining ends sewn together. In this part of the study, it was found that cases with strangulated intestine and cases with intestinal removal had a worse survival rate.

In the present study, complications in the hospital were also reviewed. The most common complication was experiencing pain and colic again after surgery (39%). Other complications were wound infection (26%) and ileus (27%), i.e. the loss of

motility in the intestine. Of these complications, colic in the hospital after surgery was negatively correlated to survival. In fact, the most common reason for euthanasia at the hospital was recurring colic.

Other factors that were researched in relation to the survival of surgery were age, breed, sex, and time spent in the hospital. These factors were not associated with decreased survival-time, up until one year after the surgery.

Complications of colic surgery can also occur at home after the horse has left the hospital. Examples of such complications are colic, infection- and herniation in the abdominal surgery wound. To assess these complications, a questionnaire was sent to the owners who had a horse sent home alive from the hospital. In this study, 25% of the owners who responded reported reoccurring colic in their horses, while 14% reported wound infection and 5% reported herniation.

In the questionnaire, the owners were also asked whether the surgically treated horse had returned to its previous function. A large proportion of the owners (93%) reported that the horse had returned. Ninety-five percent of the horse owners who responded to the questionnaire would also recommend colic surgery to other owners.

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Appendix

Questionnaire sent out to owners in its original language, Swedish.

1.Vad heter/hette din häst som opererades på UDS?

2.Är din häst vid liv idag? (Ja/Nej)

3.Om din häst är avliden, vilket datum avled din häst?

4.Om din häst avlivats, varför avlivades hästen? (Hästen är vid liv/Kolik/Annat)

5.Har din häst haft kolik igen efter operationen? (Ja/Nej)

6.Har din häst sökt veterinärvård för kolik efter operationen? (Ja/Nej)

7.Om din häst sökt veterinärvård för kolik, hur många gånger har din häst behövt veterinärvård för kolik?

- Har inte sökt veterinärvård för kolik
- Sökt vård 1 gång för kolik
- Sökt vård 2 gånger för kolik
- Sökt vård återkommande för kolik (över 2 gånger)

8.Läkte operationssåret utan komplikationer och utan att behöva söka veterinärvård?

- Ja, läkte utan komplikationer
- Uppkom sårinfektion som behövde veterinärvård
- Uppkom bråck som behövde veterinärvård
- Annat

9.Har din häst återgått till det arbete/funktion som hästen hade innan operationen? (Ja/Nej)

10.Har din häst återgått till samma nivå av prestation i sitt arbete/funktion?

- Bättre prestation
- Likvärdig prestation
- Sämre prestation

11.Hur lång tid tog det innan din häst kunde återgå till tilltänkt arbete/funktion?

- Mindre än 3 månader
- 3–6 månader
- 6–9 månader
- Mer än 9 månader
- Återgick inte till tilltänkt arbete/funktion

12.Vad är ditt övergripande intryck av vården din häst fått i samband med sin kolikoperation på UDS? (Gott/Medel/Dåligt)

13.Skulle du rekommendera bukkirurgi vid UDS till andra hästägare? (Ja/Nej)

14.Är du intresserad av att ta del av studien när den är färdigställd? (Ja/Nej)

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