

Retrospective evaluation of treatment of horses with colic over a period of 15 years

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Summary: Colic is a common reason for both veterinary consultation and death in horses and to help decision making in such cases recent data on the outcome of treatment and identification of prognostic indicators is important. Patient records of all horses with colic admitted to the internal medicine section of a veterinary teaching hospital (VTH) between November 2012 and October 2013 were reviewed. Age, heart rate (HR), blood lactate concentration (BLa), packed cell volume (PCV), white blood cell (WBC) count and blood pH at admission, treatment and outcome were recorded. Results were compared to those obtained at the same institution during 2006–2007 and 1999–2000. During the present study period 867 horses were admitted and 311 (36%) of these were admitted for colic, 207/311 (67%) of these horses were treated medically, 67/311 (22%) surgically and 37/311 (12%) were euthanized on admission. The short-term survival, defined as discharge from the hospital, for surgically treated colic cases was 60%, while the survival for medically treated cases was 86%. When all colic cases were analysed together HR ($P < 0.01$), blood lactate ($P < 0.01$), PCV ($P < 0.01$) and pH ($P < 0.01$) all differed significantly between survivors and non-survivors. When only treated cases (medical and surgical) were included HR ($P < 0.01$), blood lactate ($P < 0.01$) and pH ($P < 0.05$) were still significantly different. In the medically treated group only HR ($P < 0.01$) and lactate ($P < 0.01$) were significantly lower in survivors than non-survivors, while in the surgically treated group there were no differences between survivors and non-survivors. Blood lactate (> 1.5 mmol/L), heart rate (> 60 bpm), PCV ($> 42\%$), acidosis ($\text{pH} < 7.35$) and small intestinal lesions were associated with increased odds of death. The number of horses admitted to the VTH was considerably lower during 2006–2007 compared to 1999–2000, but remained more or less constant from 2006–2007 until 2012–2013, as did the percentage of colic horses. The percentage of colic cases treated surgically has decreased slightly and the percentage of horses euthanized on admission increased slightly. Increased blood lactate concentration, heart rate, PCV, acidosis and small intestinal lesions were associated with increased risk of non-survival.

Keywords: colic, horse, treatment, prognosis, retrospective

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Introduction

Colic is a common reason for both veterinary consultation and death in horses, and the most common reason for equine admissions to the Veterinary Teaching Hospital (VTH) at Utrecht University. Estimates on the incidence of colic range from 4.2 to 10.6 colic cases/100 horse-years in the United States and Great Britain (Kaneene et al. 1997, Tinker et al. 1997, Hillyer et al. 2001, Traub-Dargatz et al. 2001). Tinker et al. (1997) reported that 28% of all equine fatalities were the result of colic and case fatality rates for horses with colic of 6.7–18.2% have been published (Proudman 1992, Tinker et al. 1997, Kaneene et al. 1997, Curtis et al. 2015).

Most cases of colic resolve spontaneously, or soon after medical treatment, but approximately 7–10% of cases, including certain displacements and especially strangulating lesions, are usually fatal without surgery (Proudman 1992, Thoenes et al. 2000, van der Linden et al. 2003). Curtis et al. (2015) found that of 822 colic cases presented for primary evaluation by veterinary practitioners, 23.6% could be categorised as 'critical' and required intensive medical treatment, surgical intervention, died or were euthanized, and early identification of these critical cases is crucial as any delay in diagnosis will negatively affect prognosis (Fischer 1997). In a referral hospital setting the colic cases seen are generally more severe and the probability that surgery is required is greater, than in the general population. Mortality rates of

16.6% and 25% have been reported for colic cases treated at a referral hospital, in Germany and Israel respectively (Johnson and Keller 2005, Sutton et al. 2009). These figures are similar to what has been reported in our VTH, with a mortality rate of 31% in 2000 and 27% in 2007 (van der Linden et al. 2003, Sloet van Oldruitenborgh-Oosterbaan 2008).

In a (teaching) hospital or referral clinic, horses requiring surgery need to be identified and when deciding on the most appropriate treatment both owners and veterinarians wish to have an estimate of the prognosis for survival. Accurate and recent data regarding the outcome of colic cases are essential for clinical decision making (Mair et al. 2007). Further, it can be useful to compare results to those obtained previously, both in the same hospital and elsewhere, as differences may provide clues as to how the management of colic cases can be improved in the future, and Mair and White (2005) suggested an international audit was indicated for the improvement of quality of care in colic surgery.

In addition to knowing the results from the past, it is valuable to know whether clinical and/or biochemical parameters reflect survival in colic cases. Many studies have been performed to identify prognostic indicators in colic horses and although it is unlikely that a single factor can be found that will accurately predict survival in all cases, various parameters have been linked to prognosis in equine colic and it can help to know which factors play a role in a particular hospital.

The objectives of the present study were to establish short-term survival rates for medically and surgically treated colic cases in our VTH and to compare these to data obtained previously. In addition, we aimed to identify potential prognostic indicators in colic horses referred to a university teaching hospital.

Materials and methods

The patient records of all colic horses admitted to the internal medicine section of the Department of Equine Sciences at Utrecht University between November 1st 2012 and October 31st 2013 (period A) were reviewed. Colic was defined as any incidence of abdominal pain as assessed by the attending veterinary surgeon. Heart rate (HR), blood lactate concentration (BLa), packed cell volume (PCV), white blood cell (WBC) count and blood pH at admission, treatment (none, medical or surgical), site of lesion (stomach, small intestine or large intestine) and short-term survival (survival to discharge) were recorded. The number of colic cases was compared to the total number of horses admitted to the hospital and the per-

centage of horses treated medically and surgically, or euthanized, was calculated. The decision to euthanize a horse was usually based on a combination of the estimated prognosis and/or estimated treatment costs. For each treatment category, statistical analysis was performed to determine whether there was a significant difference between survivors and non-survivors in age, heart rate or biochemical parameters. Results for period A were then compared to those obtained at our VTH during 2006–2007 (period B, Sloet van Oldruitenborgh-Oosterbaan 2008) and to those obtained between 1999 and 2000 (period C, van der Linden *et al.* 2003).

Statistical analysis was performed using SPSS software (IBM version 24) and the level of significance was set at $P < 0.05$. Data (HR, blood lactate, pH, PCV and WBC count) were analysed for normality using a Kolmogorov-Smirnov and Shapiro Wilk test, before and after log transformation and only log PCV was normally distributed. Therefore, a Mann-Whitney U test was used to assess differences between outcomes (survival and non-survival) for HR, BLa, pH, WBC count and lesion location (small or large intestine) and a student's t-test was

Table 1 The number of colic cases and total number of cases admitted during periods A, B and C, the type of treatment and the short-term outcome per treatment category. Different superscripts denote statistically significant differences between groups.

	Period A	Period B	Period C
	2012-2013	2006-2007	1999-2000
Total cases admitted	n=867	n=885	n=1837
Gastrointestinal colic	311=36%	350=40%	649=35%
Surgical treatment	67=22% ^a	112=32% ^b	183=28% ^b
Medical treatment	207=67%	202=58%	412=64%
No treatment	37=12%	36=10%	54=8%
Total survivors	218=70%	254=73%	450=69%
Survivors treated	218=80%	254=81%	450=76%
Surgery - survivors	40=60%	61=54%	98=54%
Medical - survivors	178=86% ^a	193=96% ^b	352=85% ^a

Table 2 Heart rate (HR), plasma lactate concentration, packed cell volume (PCV), white blood cell count (WBC) and pH of the horses admitted with colic during periods A and B. Mean \pm standard deviation. * = significant difference ($p < 0.01$) between survivors and non-survivors within a category and [§] = significant difference ($p < 0.05$) compared to horses that were not treated and ^{§§} = significant difference ($p < 0.01$) compared to horses that were not treated.

Category		HR (bpm)	Lactate (mmol/l)	PCV (%)	WBC ($10^9/l$)	pH
Period A 2012-2013	Survivors	46 \pm 14 ^{§§}	1.4 \pm 1.2 ^{§§}	33 \pm 5 ^{§§}	8.6 \pm 2.8	7.42 \pm 0.03 [§]
	All cases					
	Treated non-surv	58 \pm 22 [§]	2.4 \pm 2.3 ^{§§}	35 \pm 10 ^{§§}	8.3 \pm 3.2	7.40 \pm 0.06
	Non-survivors all	63 \pm 25*	2.9 \pm 2.4*	38 \pm 11*	8.4 \pm 3.9	7.40 \pm 0.06*
	Surgery					
	Survivors	51 \pm 13 [§]	2.1 \pm 2.3 [§]	35 \pm 4 [§]	8.6 \pm 3.2	7.40 \pm 0.03
	Non-survivors	59 \pm 21	2.5 \pm 1.9	36 \pm 9 [§]	8.5 \pm 2.7	7.39 \pm 0.06
	Medical					
	Survivors	44 \pm 14 [§]	1.2 \pm 0.7 [§]	33 \pm 5 [§]	8.6 \pm 2.7	7.42 \pm 0.03 [§]
	Non-survivors	58 \pm 22* [§]	2.3 \pm 2.6* ^{§§}	36 \pm 8 [§]	8.2 \pm 3.6	7.40 \pm 0.05
Treatment						
Treated	48 \pm 17 ^{§§}	1.6 \pm 1.6 ^{§§}	34 \pm 6 ^{§§}	8.6 \pm 2.9	7.42 \pm 0.04	
No treatment	71 \pm 27	3.6 \pm 2.5	43 \pm 11	8.5 \pm 4.8	7.39 \pm 0.06	
Period B 2006-2007	Surgery - survivors	56 \pm 20	2.4 \pm 2.3	38 \pm 7	8.9 \pm 2.7	7.38 \pm 0.06
	Surgery - non-survivors	65 \pm 22	4.0 \pm 3.1*	41 \pm 9	9.0 \pm 3.5	7.38 \pm 0.05
	Medical - survivors	47 \pm 13	1.4 \pm 1.0	36 \pm 7	8.5 \pm 2.8	7.40 \pm 0.04
	Medical - non-survivors	64 \pm 27	5.2 \pm 7.0*	52 \pm 9	7.7 \pm 6.8	7.35 \pm 0.08
	No treatment	72 \pm 28	6.3 \pm 5.6	44 \pm 10	8.2 \pm 4.4	7.35 \pm 0.07

used to assess differences in PCV. To compare results between periods a chi-squared test was used. The association between variables (HR, BLA, pH, PCV and WBC count) and outcome was analysed initially with logistic regression in a univariate fashion. Variables screened in univariate and retained with $P < 0.15$ were assessed via multivariate analysis using forward stepwise logistic regression.

Results

Number of cases

Sixty-seven per cent (207/311) of the colic cases were treated medically, 22% (67/311) surgically and 12% (37/311) were euthanized without treatment (table 1).

Survival

The number of colic cases, the total number of cases, the percentage of colic cases, the percentage of medically and surgically treated colic cases and the short-term survival (survival to discharge) are shown in table 1 for periods A, B and C.

Overall, survival for medical cases was significantly higher than for surgical cases. When comparing the different study periods there was no difference in total survival (all colic cases) or survival of surgical cases, but the percentage of medically treated horses that survived was higher in period B (2006–2007) compared to periods A and C and more horses were treated surgically in periods B (2006–2007) and C (1999–2000) compared to the present study period.

Table 3 Univariable analysis for variables from 311 colic cases, 67 surgically treated cases and 207 medically treated cases.

	all cases					surgical				medical			
	OR - death	p	95% CI		OR - death	p	95% CI		OR - death	p	95% CI		
lactate	<2	1.0											
	>1	4.36	0.000	2.41	7.91	2.19	0.13	0.72	6.66	2.98	0.009	1.25	7.14
	>1.5	5.30	0.000	3.09	9.08	2.09	0.114	0.771	5.67	3.53	0.004	1.51	8.21
	>2	5.11	0.000	2.88	9.05	2.36	0.082	0.85	6.61	2.67	0.050	1.00	7.10
	>3	7.58	0.000	3.70	15.52	1.94	0.188	0.64	5.91	5.53	0.024	1.39	22.05
	>4	10.82	0.000	4.19	27.94	3.06	0.090	0.80	11.76	10.14	0.021	1.61	63.71
	>6	13.51	0.000	2.89	63.04	1.48	0.544	0.20	11.21		0.019		
HR	<44	1.0											
	>44	5.74	0.000	3.30	10.00	1.46	0.322	0.52	4.07	4.61	0.000	1.99	10.71
	>40	3.39	0.000	1.92	5.97	0.88	0.519	0.30	2.62	2.52	0.023	1.08	5.88
	>60	8.46	0.000	4.42	16.20	2.42	0.097	.80	7.34	6.00	0.002	2.02	17.80
Ht	<42	1.0											
	>42	15.60	0.000	6.16	39.54	9.25	0.032	1.01	84.73	10.88	0.000	3.18	37.25
WBC	<12	1.0											
	>12	1.88	0.079	0.88	4.02	1.06	0.649	0.164	6.86	1.23	0.487	0.33	4.55
	<4	4.85	0.001	1.96	12.03	1.64	0.505	0.22	12.47	3.25	0.120	0.77	13.80
pH	<7.35	6.76	0.000	2.67	17.12	2.92	0.153	0.63	13.51	9.02	0.003	2.26	36.05
	>7.45	0.80	0.329	0.39	1.62	3.22	0.345	0.276	37.52	0.839	0.483	0.30	2.36
location	LI												
	SI	5.96	0.000	3.37	10.53	3.45	0.018	1.20	9.93	4.61	0.002	1.80	11.77

Table 4 Multivariable analysis for variables from 311 colic cases, 67 surgically and 207 medically treated cases.

	all cases					surgical				medical			
	OR - death	p	95% CI		OR - death	p	95% CI		OR - death	p	95% CI		
lactate	<1.5	1.00											
	>1.5	5.30	0.000	3.09	9.08					3.53	0.004	1.51	8.21
HR	<44	1.00											
	>44	5.74	0.000	3.30	10.00								
Ht	<42	1.00											
	>42	15.60	0.000	6.16	39.54	9.25	0.032	1.01	84.73	10.88	0.000	3.18	37.25
pH	<7.35	6.76	0.000	2.67	17.12								
location	LI												
	SI	5.96	0.000	3.37	10.53	3.45	0.018	1.20	9.93	4.61	0.002	1.80	11.77

Prognostic indicators

When all colic cases admitted (including those that were euthanized on admission) were analysed together HR ($P < 0.01$, $n = 299$), BLa ($P < 0.01$, $n = 297$), PCV ($P < 0.01$, $n = 301$) and pH ($P < 0.01$, $n = 292$) all differed significantly between survivors and non-survivors, whereas WBC count ($P = 0.876$, $n = 301$) did not (table 2). When only treated cases (medical and surgical) were included HR ($P < 0.01$), BLa ($P < 0.01$) and pH ($P < 0.05$) were still significantly different but PCV ($P = 0.081$) and WBC count ($P = 0.646$) were not. In the medically treated group only HR ($P < 0.01$) and blood lactate ($P < 0.01$) were significantly lower in survivors than non-survivors, while in the surgically treated group there were no differences between survivors and non-survivors.

In the final model blood lactate (> 1.5 mmol/L), heart rate (> 60 bpm), PCV ($> 42\%$), acidosis (pH < 7.35) and small intestinal lesion were associated with increased odds of death, when all cases were considered. For medically treated colic cases the odds of death were increased with increased blood lactate concentration, PCV and small intestinal lesions and in the surgically treated group only for increased PCV and small intestine location (tables 3 and 4).

Discussion

The total number of horses admitted to our hospital has fallen considerably since 1999–2000 but remained more or less constant between 2007 and 2013, while the percentage of colic horses has remained equal. The decrease in horses presenting could be a result of an increased number of equine clinics in the Netherlands in which colic surgery can be performed. In colic cases requiring surgery the prognosis for survival depends on early referral (Cook and Hassel 2014), and referring vets are likely to send horses with colic to the closest available clinic where surgery is possible. It is also possible that horses were not being referred because owners were unable, or not prepared, to pay the additional costs associated with referral and further treatment, including the possibility of surgery.

The percentage of colic cases treated surgically was approximately 30% in the first two periods and was 22% in the present study, significantly less than before. However, this figure is very similar to the 21% of horses with colic undergoing surgery reported by Christophersen et al. (2014) in Denmark. In contrast, the number of horses euthanized on admission, increased slightly in each study period, although the difference was not statistically significant. Both effects were also reported by Blikslager and Mair (2014) and could be a result of the global financial crisis, the results of which became evident after 2008. This is difficult to prove as many factors influence the decision on whether or not to terminate treatment, but Wormstrand et al. (2014) and Blikslager and Mair (2014) also speculated that economic reasons may have played a role in the decision to euthanize horses presenting with colic. A number of recent publications have suggested that attitudes towards animal welfare and euthanasia may vary and should also be taken into consideration when comparing the results of colic treatment (Sutton et al. 2009, Wormstrand et al. 2014). However, this is not likely to have influenced the results of the present study, as it seems unlikely

that these attitudes will have changed significantly since 1999 in the Netherlands. The average heart rate, blood lactate concentration and PCV were all significantly higher in horses euthanized on admission compared to both medical and surgical non-survivors, suggesting that some of those horses did indeed have a poor prognosis. However, for other horses that were euthanized on admission the decision to euthanize was based mainly on financial constraints.

The overall short-term survival did not differ significantly for the three study periods and is similar to the 75% reported by Sutton et al. (2009). Also, the short-term survival of medically treated colic cases in the present study (86%) was not significantly different when compared to period C and almost exactly the same as the 87% reported by Christophersen et al. (2014) in Denmark, and slightly lower than the 93% reported by Johnson and Keller (2005) in Germany and Sutton et al. (2009) in Israel. However, the results for period B were significantly better. The short-term survival of surgical cases was similar to results published previously, including two recent publications from Northern Europe (Christophersen et al. 2014, Wormstrand et al. 2014), but higher than the 35% reported by Elbert (1994) for horses undergoing colic surgery during the 1980's. This would suggest that the results of colic surgery have improved over the last 30 years, but that is not necessarily the case as Puotunen-Reinert and Huskamp (1985) reported that 76/105 (72%) surgical colic cases survived between November 1982 and June 1983.

In the present study PCV was significantly higher in non-survivors than in survivors, and had the highest odds ratio for death, which is in accordance with findings by Puotunen-Reinert and Huskamp (1985), Proudman et al. (2006) and Krueger et al. (2014) who reported that both intra- and post-operative mortality were positively correlated with PCV. The increased PCV probably reflects more severe hypovolemia and cardiovascular compromise.

The risk of non-survival was greater for small intestinal lesions than for those affecting the large intestine, for both surgically and medically treated horses. This is in accordance with the findings of Wormstrand et al. (2014), van der Linden et al. (2003), Mair and Smith (EVJ 2005) and Proudman (1992), and probably related to the fact that strangulating lesions are more common in the small intestine and surgical lesions have a poorer prognosis than those that can be managed medically.

The medically managed horses were cases that had a diagnosis that would normally be expected to resolve with supportive management, without surgery, or those in which surgery was advised but declined by the owner. The reason not to opt for surgery was usually based on the estimated costs, often in combination with the estimated prognosis. Other factors that sometimes played a role in an owner's decision were the age of the horse, a prior poor experience with a horse undergoing colic surgery, the fear of complications or concurrent illness or injury. In many cases the exact reason was not specified by the owner.

In medically treated colic cases the blood lactate concentration was significantly lower in horses that were discharged from the hospital (survivors) than in those that were not (non-survivors), while the difference was not significant in the sur-

gically treated group. This may have been due to limited statistical power as *Puotunen-Reinert* and *Huskamp* (1985) found that blood lactate concentrations were significantly higher in horses that died after colic surgery than in those that survived. Although an elevated blood lactate concentration is usually associated with ischemic intestine (*Cook and Hassel* 2014), and therefore may indicate the need for surgery, it is not always correlated with the outcome in individual cases. *Furr et al.* (1995) also found that some horses with a very high blood lactate concentration survived and blood lactate alone was not a good predictor of outcome. The higher blood lactate concentration in medical non-survivors is in accordance with findings during period B and those reported by *Moore et al.* (1976), *Orsini et al.* (1988) and *Delesalle et al.* (2007). In 2013 *Dunkel et al.* reported that ponies with gastrointestinal disease presented with higher blood lactate concentrations than horses. The difference in blood lactate concentrations between horses and ponies was not examined in the present study as only a small percentage of cases (<10%) were ponies.

Several studies, including those by *Latson et al.* (2005), *Delesalle et al.* (2007) and *van den Boom et al.* (2010) have been published demonstrating that the lactate concentration in peritoneal fluid can also help to predict the need for surgery and survival in horses with colic. More recently, *Peloso and Cohen* (2012) demonstrated the value of serial measurements of peritoneal fluid lactate concentrations in predicting the presence of a strangulating intestinal lesion in horses with colic. Peritoneal lactate concentrations were not routinely measured in the present study period, while in some cases serial blood lactate measurements were used to guide decision making, as lactate is considered to diffuse rapidly to the bloodstream.

During period A (2012-2013) of the present study the heart rate was significantly higher in medically treated non-survivors than survivors, while the difference was not significant in the surgically treated group, although this may have been due to a lack of statistical power. During period B (2006–2007), the heart rate did not differ between survivors and non-survivors. Finally, in period C (1999–2000), heart rate was also found to be useful as a prognostic indicator. Heart rate has previously been identified as a factor in differentiating critical from non-critical colic cases (*Jennings et al.* 2014, *Curtis et al.* 2015) and has been found to predict mortality in colic cases (*Puotunen-Reinert and Huskamp* 1985, *Orsini et al.* 1988, *Reeves et al.* 1989, *Furr et al.* 1995). *McConachie et al.* (2016) also published that post-operative HR was higher in horses with ischaemic gastrointestinal disease than in those with non-ischaemic gastrointestinal lesions. It is likely that heart rate, as PCV, reflects cardiovascular compromise in colic cases. In addition to the data regarding heart rate, *McConachie et al.* (2016) also found that heart rate variability (HRV) may be of prognostic significance, with reduced HRV being associated with non-survival.

There was a statistically significant difference in blood pH between survivors and non-survivors, and acidosis was associated with increased odds of death, although it is unclear whether this difference is clinically relevant, as mean values for both groups were within the reference range. The higher blood lactate concentration in non-survivors would likely

explain the lower pH in that group of horses, although impaired ventilation due to distended abdominal contents may also contribute, through an increase in PaCO₂.

No significant differences in white blood cell counts were identified between survivors and non-survivors in any of the study periods, although leukopenia was included in the initial univariate analysis, but not in the final model of the present study. A study by *Pihl et al.* (2015) demonstrated that the WBC count could not be used to distinguish inflammatory diseases from strangulating obstructions in horses with colic. The WBC count would be expected to be extremely low in cases of acute peritonitis from intestinal rupture or endotoxaemia and potentially elevated in cases of proximal enteritis or intra-abdominal abscesses, but generally within reference range in most horses with colic (*Mair* 2002).

The main limitations of the present study are the retrospective nature and the fact that results only apply to our VTH, although similarities to other referral centres are likely to exist. The fact that this was a retrospective study meant that the reasons for euthanasia could not be determined and also that it was not possible to collect additional data that had not been recorded at the time of admission.

In conclusion, surgery was performed on approximately one quarter of the horses admitted to our hospital because of colic. Just over half of those surgical cases survived until hospital discharge, compared to over 85% of medically treated cases and 70% of all colic cases. In our hospital, elevated PCV, small intestinal lesions, increased blood lactate concentration, elevated heart rate and the presence of acidosis were associated with increased risk of death.

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