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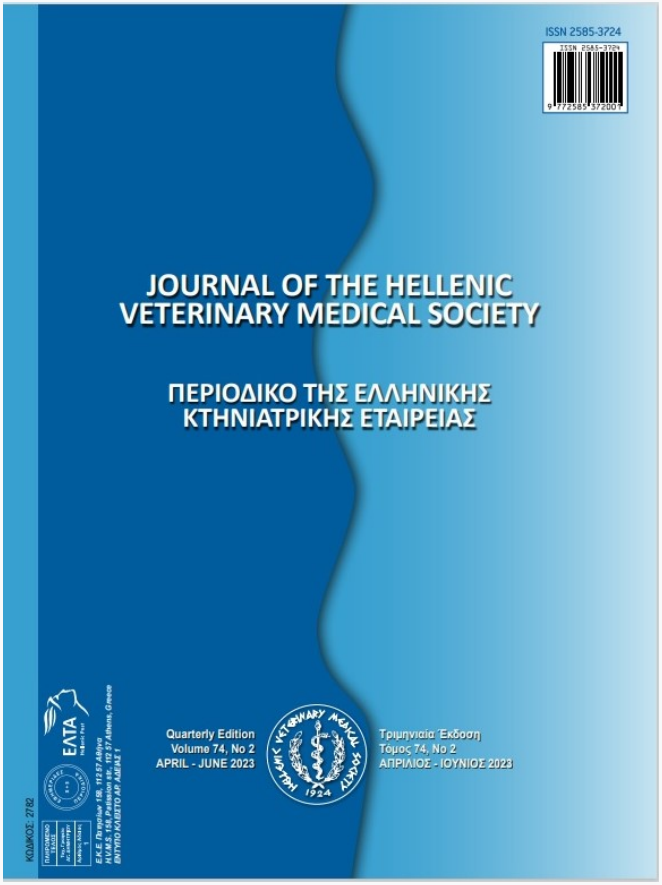

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Research article
Ερευνητικό άρθρο

Duodenal volvulus of the sigmoid flexure in five cows. A retrospective study

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ABSTRACT Medical data of five Holstein Friesian cows with duodenal volvulus of the sigmoid flexure admitted to the Clinic for Cattle, University of Veterinary Medicine Hannover, Foundation, Hannover, Germany during a two-year period were reviewed in this study. The aim of this study was to present the clinical, laboratory and surgical findings as well as the postoperative healing progress and therapy of these five cases. All cows showed a loss of appetite and were dehydrated, with a marked drop in milk yield. The rumen motility was severely reduced and an untypical tympanic resonance or ping and a splashing sound were present at the right flank at auscultation. All the cows had only a small amount of faeces. All animals had hypochloraemic metabolic alkalosis and most of them hyperlactatemia. Two of the cows were hypokalaemic. Hyperbilirubinaemia was revealed in all cows. Four of the cows had an increased haematocrit level. A standing right flank laparotomy was performed in all cows. A common surgical finding was the severely dilated, dorsally dislocated and twisted sigmoid flexure of the duodenum, and the empty descending duodenum. The abomasum of all cows was dilated, but not displaced. An enlarged gall bladder was found in four animals. The duodenal sigmoid loop was manually untwisted, followed by promoting gas and ingesta flow aborally in the descending duodenum. Omentopexy was performed in each cow. No cow had any history of omentopexy or other abdominal surgery. All cows received intravenous fluid therapy after the surgery. A total of 10-20 L 0.9 % NaCl solution containing an additional KCL (30 mmol/L) was administered intravenously via drip infusion daily for the first two days after surgery. Amoxicillin (10 mg/kg; s.c.) was administered once daily (SID) in two cases. Three of the cows were additionally drenched with 30 L water and 100-150 g KCL via an orogastric tube once per day for two days postoperatively. Four cows received neostigmine s.c. after surgery and for the following one to two days (every 8 or 12 hours; 0.02 mg/kg or 0.025 mg/kg, respectively). All cows were administered meloxicam (0.5 mg/kg; s.c.) before and on the first postoperative day. Sodium sulphate (250 g per os; SID) was administered to four cows for one to two days. Feed intake, rumen motility and defaecation were normalised gradually after surgery. All cows had a positive post-surgical outcome and were discharged from the clinic after 7 to 15 days.

Keywords: ileus; dairy cattle; duodenum; intestinal obstruction

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INTRODUCTION

Duodenal ileus is not so commonly reported in cattle. However, those animals with duodenal ileus may have more severe electrolyte disturbances and a greater metabolic alkalosis than cows with abomasal volvulus (Garry et al., 1988).

The cranial duodenum begins aborally from the pylorus and proceeds dorsally along the caudomedial side of the liver. The sigmoid flexure consists of the proximal part of the duodenum, which forms a characteristic S-shaped loop and is attached to the medial side of the liver. The next duodenal part consists of the descending duodenum, which proceeds horizontally in a caudal direction. The descending duodenum turns around the caudal edge of the great omentum from the right to the left and extends cranially, forming the ascending duodenum (Smith, 1990).

Cases of duodenal obstruction by phytobezoar (Braun et al., 1993; Garry et al., 1988), foreign body (Braun et al., 2011), blood clot (Braun et al., 1993), adhesions and fibrous strictures (Garry et al., 1988; Hackett et al., 2018) or even malposition of the gallbladder (Boerboom et al., 2003) have been described. Duodenal compression due to adhesions with a liver abscess (Braun et al., 1993), entrapment by the round ligament of the liver (Garry et al., 1988) or strangulation caused by the uterus in late pregnancy (Koller et al., 2001) have also been reported. Functional ileus of the sigmoid flexure related to a right abomasum displacement (RDA) has been described (Van der Velden, 1983).

Even rarer are cases of duodenal volvulus of the sigmoid flexure (DVSF), which have been occasionally described in dairy cattle (Russell, 2013; Vogel et al., 2012). The aetiology of the DVSF remains unclear (Desrochers and Anderson, 2016). As this condition occurs infrequently and is not well known, it may not be suspected during clinical examination or diagnosed and corrected easily during exploratory laparotomy.

The aim of this study was to present the initial clinical, laboratory and surgical findings as well as the postoperative healing progress of five cows with duodenal volvulus of the sigmoid flexure.

MATERIALS AND METHODS

From 1 January 2018 to 30 December 2019, five cows were admitted to the Clinic for Cattle of the University of Veterinary Medicine Hannover, Foundation, Hannover, Germany, which were intraoperatively diagnosed with volvulus of the duodenal sigmoid flexure. These five cases were included in this study. The data from the medical record which were reviewed included signalment, age, history, reproduction status, duration of the disease, daily milk yield and feed intake. Clinical, haematological and biochemical findings as well as venous blood gas analysis before the surgery, surgical findings, postoperative treatment and outcome were also reviewed.

Each cow was clinically examined and blood samples from the jugular vein (serum, EDTA and blood gas capillaries) were obtained for analysis before surgery.

Leukocyte count was performed in EDTA blood samples with an automatic haematology analyser using the electrical impedance method (Celltac-α, MEK-6450, Nihon Kohden, Qinlab Diagnostik, Weichs, Germany). The haematocrit level was determined via capillary centrifugation (Hettich Haematokrit centrifuge, Hettich Holding GmbH & Co. oHG, Kirchlengern, Germany).

In serum blood samples, the following parameters were determined: total protein, albumin, total bilirubin, glutamate dehydrogenase (GLDH), aspartate aminotransferase (AST), gamma-glutamyltransferase (γGT), urea, creatinine, magnesium, phosphorus, sodium, potassium and chloride using a clinical chemistry analyser (ABX Pentra® 400, HORIBA Medical, Montpellier, France). For the total calcium measurement in serum, an analyser for clinical chemistry was used (Cobas Mira® Plus, Hoffmann La-Roche AG, Basel, Switzerland).

The parameters pH, partial pressure of carbon dioxide (pCO2) corrected for the rectal temperature, actual bicarbonate ($HCO3^-$), L-lactate and glucose were measured in blood gas capillaries using the EPOC system (EPOC Host and Reader, Siemens Healthineers AG, Erlangen, Germany).

The analysis of serum and EDTA blood samples were performed approximately 12-18 hours later. The blood gas analysis and the haematocrit determination were performed within 5 minutes of collection. The diagnosis was confirmed intraoperatively.

RESULTS

History and signalments

All five cows were Holstein-Friesian. Four cows had a history of a drop in milk yield (Table 1). Four of

Table 1: History, signalment and selected preoperative clinical findings in five cows with duodenal sigmoid flexure volvulus.

Cow No.	1	2	3	4	5
Age (years)	5	4	9.3	3.3	4
Reproductive status	6 months pregnant	13 DIM	100 DIM	6 DIM	120 DIM
Symptoms before admission to the clinic (reason for admission)	hypothermia, drop in milk yield, inappetence, no rumination activity, small amount of mucus in faeces in rectum	suspected RDA	drop in milk yield, suspected RDA	drop in milk yield, suspected RDA	drop in milk yield, suspected indigestion
Durations of symptoms prior to admission(days)	1	1	1	1	2
BCS	2.75	3.25	2.75	2.75	2.75
Appetite	loss of appetite	loss of appetite	loss of appetite	loss of appetite	poor
Respiratory rate (rpm)	24	32	32	54	26
Heart rate (bpm)	96	64	80	66	78
RT (°C)	37.9	38.8	37.6	38.7	36.8
Eyeball recession into the orbit	slight-moderate	no	slight	no	slight
Skin turgor decreased	slightly-moderately	slightly-moderately	slightly-moderately	severely	slightly-moderately
Episcleral vessels	normal	normal	normal	slightly injected	normal
Rumen volume and consistency	moderate	moderate	moderate	moderate	moderate
Ruminal motility	none	none	none	reduced	reduced
Percussion and auscultation on the right flank	steel band sound	steel band sound	tympanic hollow sound in the entire paralumbar fossa	tympanic hollow sound caudal to the last rib and on the transverse processes of the lumbar vertebrae	tympanic hollow sound caudal to the last rib
Swinging auscultation on the right flank	+	+	+	-	+
Liver percussion dullness	horizontal level of dullness	absent	normal	normal	absent
Abdominal wall tension	physiologically soft	physiologically soft	physiologically soft	physiologically soft	physiologically soft
Amount of faeces	little	little	little	little	little
Faecal consistency	medium porridge-like	firm porridge-like	runny	runny	runny
Colour of faeces	olive green	dark olive green	olive green	dark olive green	yellowish green
Degree of comminution of plant fragments in faeces	normal	fine comminution	poor comminution	fine comminution	fine comminution
Mucus in rectum	no	yes	no	no	yes
Intestinal loop rectally with fingertips palpable in the right upper quadrant	no	yes	no	no	yes
Duration of hospitalisation(days)	9	8	15	10	7

days in milk (DIM), body condition score (BCS), beats per minute (bpm), breaths per minute (brpm), rectal temperature (RT), right displaced abomasum (RDA).

the cows were admitted to the clinic within 24 hours and the fifth animal after 48 hours after the onset of digestive disorder symptoms. There was no cow with any history of colic. The age and reproduction status varied among the cows (Table 1). Except for one cow with chronic mastitis, the cows included in this study had no other concurrent diseases.

Clinical findings

During the preoperative clinical examination, all five cows were inappetent. The main preoperative clinical findings are listed in Table 1. All cows were bright and alert, except for one cow, which was slightly dull. The posture of the cows was healthy, excluding one cow, which stood with a slightly arched back. The abdominal wall tension on the right side was physiologically soft in each cow. There were no obvious colic symptoms preoperatively. Heart rate, rectal temperature and respiratory rate of the cows varied before surgery. Except for one cow with tachycardia, the heart rate of the animals was within normal limits. Three cows had hypothermia and the other two cows had physiological rectal temperature. Respiratory rate was increased in three animals. All cows were clinically dehydrated. The ruminal motility of two cows was reduced and in the other three animals, ruminal motility was absent (Table 1).

During the (simultaneous) percussion and auscultation in the right flank, a tympanic hollow sound was revealed in three cows, mostly caudal to the last rib. Ping sounds (steel band effect) in the right flank were detected in two animals. A splashing sound in the right flank was induced by swinging auscultation in four cases. The physiological dull percussion field of the liver was detected in just two cows (Table 1).

All cows had only a small amount of faeces in the rectum of differing consistency (from runny to firm porridge-like). None of the cows had watery faeces. Three out of five cows showed fine comminution of plant fragments in the faeces (Table 1). In two cows with a small amount of mucus in the faeces in the rectum, a dilated intestine loop was palpable with the fingertips rectally in the right upper quadrant.

Haematological findings

Selected preoperative laboratory values are listed in Table 2. The haematological analysis revealed an increased hematocrit level in the majority of the cows (n=4). Three cows were azotaemic. Hyperbilirubinae-

Table 2: Selected haematological and biochemical findings in five cows with duodenal sigmoid flexure volvulus.

Cow No.	1	2	3	4	5	Reference Range
Haematocrit (%)	39.0	40.2	30.9	47.6	43.2	25-35
Leucocyte count (cells/μL)	8100	18900	7100	12000	4500	5000-10000
Total bilirubin (μmol/L)	15.8	21.5	11.1	20.5	18.8	<7.0
AST (U/I)	149	207	183	145	1253	<100
γGT (U/I)	35	57	82	21	566	<33
GLDH (U/I)	43.5	122	114	38.6	3.2	<14
Total protein (g/L)	80	79	98	77	76	60-80
Urea (mmol/L)	17.1	11.4	7.0	14.8	5.7	<8
Creatinine (μmol/L)	107	128	87	155	83	<150
Albumin (g/L)	35.3	39.2	31.3	38.6	39.4	30-40
Total calcium (mmol/L)	2.42	2.12	2.16	1.79	2.24	2.1-3.0
Magnesium (mmol/L)	0.93	1.19	0.98	0.87	0.89	0.7-1.2
Phosphorus (mmol/L)	2.41	2.34	1.92	3.14	1.24	1.1-2.4
Sodium (mmol/L)	136	129	142	136	140	135-145
Potassium (mmol/L)	4.02	3.81	2.93	3.51	3.18	3.5-4.5
Chloride (mmol/L)	81	84	72	67	84	90-110
pH	7.53	7.43	7.55	7.47	7.46	7.35-7.45
Bicarbonate (mmol/L)	37.9	29.3	48.6	32.3	30.5	21-28
BE (mmol/L)	15.4	5.5	26.4	9.0	6.6	-2-3.0
L-lactate (mmol/L)	8.34	4.05	0.65	11.10	7.76	0.56-1.39
Glucose (mg/dL)	183	312	79	30	132	74-100
pCO2(mm Hg)	45.9	44.9	55.9	45.4	43.0	35-48

Aspartate aminotransferase (AST), gamma-glutamyltransferase (γGT), glutamate dehydrogenase (GLDH), base excess (BE), partial pressure of carbon dioxide (pCO2).

mia was a common finding in all cows. All animals showed increased aspartate aminotransferase (AST) activity. The activity of gamma-glutamyltransferase (γGT) and glutamate dehydrogenase (GLDH) was elevated in the majority of cows. All cows had a preoperative hypochloraemic metabolic alkalosis and four of them also had hyperlactataemia. Base excess was increased in all cows. Two of the cows were hypokalaemic. Mild hypocalcaemia was revealed in only one cow. Hyperglycaemia was revealed in three cows.

Preoperative management and surgical findings

A right flank laparotomy in a standing position was performed in all cows. Meloxicam (0.5 mg/kg; s.c.) was administered before the surgery in each cow. The surgery was performed after a distal paravertebral block and local infiltration anaesthesia of the incision site with procaine hydrochloride (20 mg/mL) and epinephrine (0.025 mg/mL). Intravenous fluid therapy with 10 L NaCl 0.9 % with an additional 300 mmol KCL was administered in two cows during the surgery.

Intraoperatively, the abomasum of all cows was dilated but not displaced. A moderate to severely enlarged gall bladder was found in four cows. Common surgical findings in all cows were the severely dilated, dorsally dislocated and twisted duodenal sigmoid flexure, and the empty descending duodenum (Figure 1a, b). After the twisted position had been identified and manual repositioning of the twisted loop had been successfully performed, the descending duodenum became dilated. In one cow, sandy and gravelly content was palpated in the duodenal sigmoid loop. No adhesions were found around the duodenum.

No further obstruction disorders were identified through the palpation of the aboral intestine loops. Omentopexy was performed in each cow using a plastic plate placed 5 to 10 cm caudal to the pylorus which was sutured on the inner side of the abdominal wall using non-absorbable polyamide suture (Supramid® USP 8; WDT, Garbsen, Germany) as previously described (Heimberg and Scholz 2002). The abdominal wall was closed in three layers. No cow had an increased abdominal fluid content, fibrin deposition or

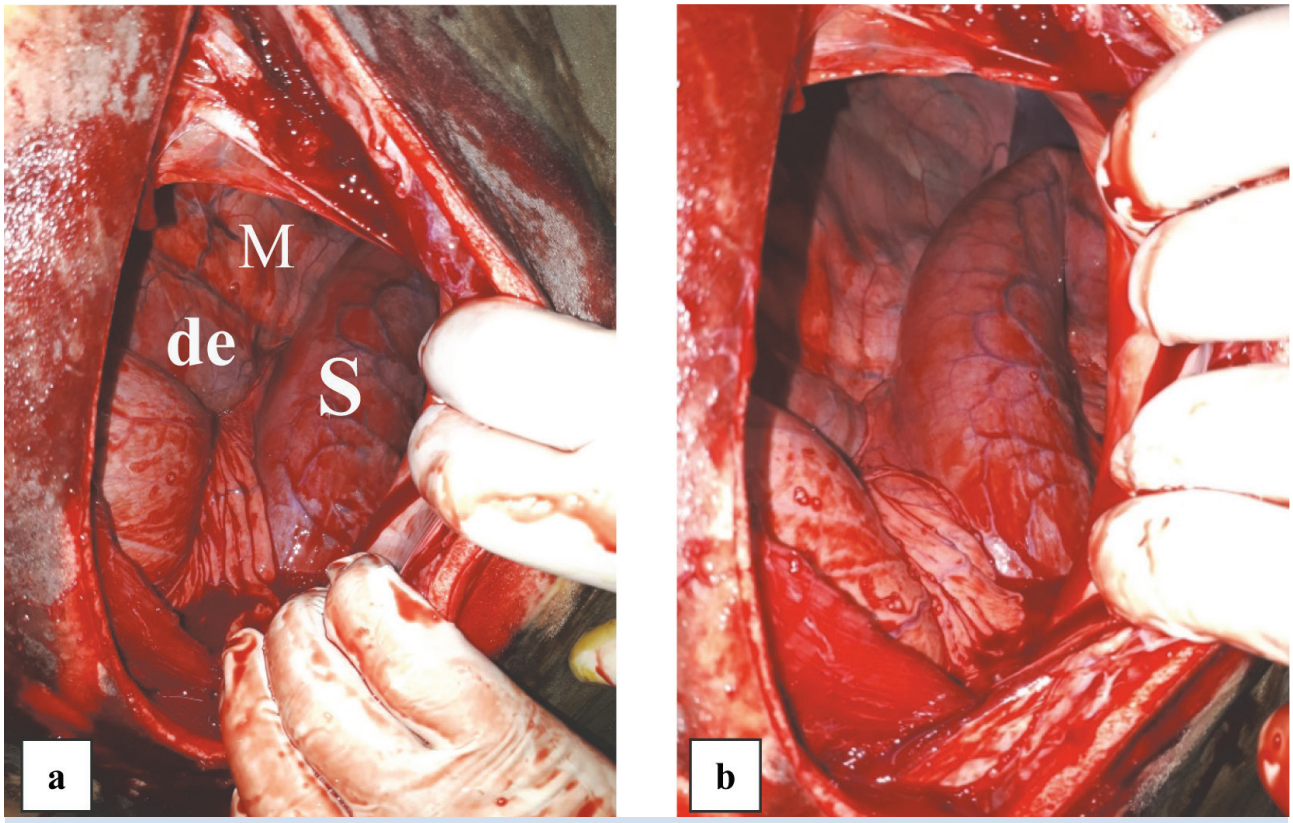

Figure 1a, b. Surgical findings from a cow with duodenal volvulus of the sigmoid flexure after laparotomy in the right flank. 1a: lateral view from the right side in the abdominal cavity. The duodenal sigmoid flexure (S) is dilated and twisted caudomedial to the liver. The descending duodenum (de) is empty. Mesoduodenum (M) is also highlighted on the image. 1b: Angular closer view from the right side in the abdominal cavity. The twisted duodenal sigmoid flexure is more clearly visible.

any previous history of abdominal surgery.

Post-surgical treatment and outcome

Post-surgical treatment was at the discretion of the surgeon. All cows were administered meloxicam (0.5 mg/kg; s.c.) also on the first postoperative day. Four cows received neostigmine (0.02-0.025 mg/kg; s.c.) immediately after surgery. The administering of neostigmine was continued (every 8 or 12 hours; 0.02 mg/kg or 0.025 mg/kg, respectively) for one or two days.

All cows received intravenous fluid therapy after surgery. A total of 10-20 L 0.9 % NaCl solution containing an additional KCL 30 mmol/L was administered intravenously via drip infusion daily to each cow during the first two days after surgery. The cow with mild hypocalcaemia additionally received via drip infusion a total of 500 mL 38.0 % calcium borogluconate and 6.0 % magnesium chloride hexahydrate solution during and after the surgery. Amoxicillin (10 mg/kg; s.c. SID) was administered in two cases six and seven days long, respectively.

Three of the cows were additionally drenched with 30 L water and 100-150 g KCL via orogastric tube once per day for two days postoperatively. Sodium sulphate (250 g per os SID) was administered to four cows (beginning on the day after surgery) for one to two days. Defaecation was observed postoperatively in all cows after six to 20 hours.

Appetite was normalised within two to four days after surgery. Ruminal motility was normalised within two to five days postoperatively. Milk yield increased progressively on the days after surgery in all cows, except for a six-month pregnant cow that was dried off after surgery. All cows had a positive post-surgical outcome and were discharged from the clinic after 7-15 days (Table 1).

DISCUSSION

The duodenal volvulus of the sigmoid flexure (DVSF) is a rare condition in dairy cows causing a mechanical obstruction of the proximal part of the duodenum (Vogel et al., 2012). In a 25-year-old retrospective study of 35 cases of small intestinal volvulus up until 1992 (Anderson et al., 1993), there was no reference to any case of a duodenal volvulus. This supports the opinion that DVSF must therefore be a recently recognized disorder of the duodenum as has been supposed by other authors (Russell, 2013; Vogel et al., 2012).

The aetiology of this duodenal obstructive disorder remains unclear (Desrochers and Anderson, 2016). Although an association of DVSF with previous laparotomy and fixation of the abomasum has been reported (Vogel et al., 2012), none of the five cows in our study had any history of omentopexy or other abdominal surgery. A previously occurring right dislocated abomasum in combination with a dilated gall bladder (probably due to anorexia) could be a contributory factor (Nuss et al., 2016). According to the history data of our cases, a right displaced abomasum was suspected in three cows. Thus, a previous condition of right displaced abomasum in single cases prior to transporting the cows to our clinic cannot be ruled out.

In one report published in 1983, a functional problem causing dilatation of the duodenal sigmoid flexure and an empty descending duodenum in cows with RDA is described. However, the duodenal sigmoid flexure was not twisted in those cases (Van der Velden, 1983).

In our study, the five cows with DVSF were dehydrated and the percussion and auscultation on the right side revealed a hollow or metallic sound accompanied in most cases by splashing sounds. The liver percussion field was clearly present in only two of the five cows. All the cows had only small amount of faeces.

Hypochloraemic metabolic alkalosis was a common finding in all cows, most likely due to the abomasal flow to the intestines being blocked by the twisted duodenum. This results in sequestration of the chloride-rich abomasal ingesta and inhibits the secretion of bicarbonate to the intestinal lumen (Garry et al., 1988). The majority of the cows had hyperlactataemia, most probably as a result of reduced tissue perfusion and anaerobic glycolysis (Boulay et al., 2014). The above findings confirm the fact that DVSF looks clinically similar to a volvulus of the abomasum and also causes abomasal outflow occlusion and abomasal reflux (Vogel et al., 2012). The hyperlactataemia, that coexisted in four cases with the hypochloraemic metabolic alkalosis, led to a decrease in blood pH to the normal range and a partial reduction in the elevated base excess value in blood (Table 2). Similar findings have been observed in cows with abomasal volvulus (Simpson et al., 1985). The hyperglycaemia found in three cows was most probably stress induced (Anderson et al., 1993). In our study, only one cow

had hyperproteinaemia, and the total protein value of the other four animals reached the upper normal range (Table 2). In previous studies that also reported duodenal obstructive disorders, elevated total protein was a common finding (Braun et al., 1993; Garry et al., 1988; Hackett et al., 2018). The hyperproteinaemia was probably a result of dehydration (Garry et al., 1988).

Intraoperatively, the duodenal sigmoid flexure was dilated, dorsally displaced and twisted. The descending duodenum was empty. The gall bladder was dilated in most of the cows. Biochemical blood analysis revealed hyperbilirubinaemia and elevated activity of the AST, GLDH and γ-GT as a result of the bile excretion disturbance and hepatocellular injury probably induced by the twisted duodenal sigmoid flexure.

Although in our cases, an ultrasound examination before surgery was not performed, this could be helpful in unclear cases (Vogel et al., 2012). Especially in cows with a prior history of abomasal fixation, the sonographical findings could play a decisive role before a relaparotomy.

All cows in our study were inappetent, but most of them were bright and alert preoperatively. All cows survived after the surgery and recovered after a few days (according to the feeding behaviour, clinical findings and milk production). However, a worse prognosis was reported in some cases in a previous study (Vogel et al., 2012). The positive outcome of our cases is probably associated with the quickly detected digestive disorders by the farmer and the rapid admission to the clinic. A longer present duodenal ileus may have caused more severe disorders and perhaps a poor prognosis.

Despite the positive post-surgical response, further information about the health and productivity of these cows would be interesting. The absence of follow-up data after the animals were discharged from the clinic, is a limitation of this retrospective study.

This duodenal obstruction disorder should not be clinically confused with a ”harmless” temporary gas-filled proximal (or also descending) duodenum. The gas accumulation in the duodenum can be transferred aborally from a previous dislocated gas-filled abomasum, which returned incidentally (for example, after a swivelling movement of the cow) to the ventral position. The same occurred often intraoperatively directly after the successful repositioning of a displaced abomasum. Thus, a just temporary gas-filled and atonic (but not obstructed) duodenum may reveal similar ping sounds during percussion and auscultation in the right flank. Symptoms like severely reduced defaecation, and severe hypochloraemic metabolic alkalosis were not common findings in those cows. Any unclear case should be clinically observed and reexamined and laboratory parameters should be controlled repeatedly. The transcutaneous ultrasound examination may help the further diagnosis (Braun et al., 2011; Vogel et al., 2012). The exploratory laparotomy should be performed in any case when the clinician suspects mechanical ileus.

In all cows with DVSF in this study, the twisted duodenum could be corrected manually and no adhesions or other lesions were found intraoperatively. Due to the anatomical position, the cranial duodenal sigmoid flexure cannot be exteriorised during a laparotomy (Desrochers and Anderson, 2016). Other mechanical obstructive disorders of this duodenal part (like intraluminal obstructions or strictures) should be ruled out through palpation.

CONCLUSIONS

Although DVSF occurs rarely, it should be always included in the differential diagnosis when a dehydrated cow has metabolic hypochloraemic alkalosis, untypical ping sounds on the right flank and a virtual absence of faeces. If the proximal part of the duodenum appears intraoperatively unusually dilated with an empty descending duodenum and a distended gall bladder, the condition of DVSF should be suspected. The majority of cows have a good prognosis. The manual repositioning of the twisted duodenal loop intraoperatively, combined with intensive fluid therapy and neostigmine application after surgery, constitute the basis for the treatment.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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