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Dilated small and large intestines combined with a severely abnormal demeanor are characteristic of mesenteric torsion in cattle

Ueli Braun, Prof Dr Med Vet, DECBHM[1]; Christian Gerspach, Prof Dr Med Vet, DACVIM[1]; Claudia Volz, Dr Med Vet[1]; Monika Hilbe, Dr Med Vet, DECVP[2]; Karl Nuss, Prof Dr Med Vet, DECVS, DECBHM[1]

[1]Department of Farm Animals, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland
[2]Institute of Veterinary Pathology, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

*Corresponding author: Ueli Braun (ueli.braun@uzh.ch)

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OBJECTIVE
To describe the clinical, laboratory, and ultrasonographic findings; treatment; and outcome of cattle with mesenteric torsion (MT).

ANIMALS
61 cattle with MT between November 1, 1986, and December 31, 2019.

METHODS
Medical records were retrospectively reviewed. Results were compared for cattle that survived versus did not survive to hospital discharge.

RESULTS
All cattle had abnormal demeanor. The most common clinical signs were tachycardia (80.3% [49/61]), tachypnea (65.0% [39/60]), and lower rectal temperature (59.3% [35/59]). Signs of colic occurred in 65.6% (40/61). The most common gastrointestinal findings were an empty or almost empty rectum (100% [59/59]), reduced or absent motility of the small intestines (96.6% [57/59]) or rumen (93.2% [55/59]), positive ballottement and/or percussion and simultaneous auscultation on the right side (91.7% [55/60]), and dilated small (49.2% [29/59]) and large intestines (spiral colon and/or cecum, 44.1% [26/59]) detected during transrectal examination. The most common laboratory findings were acidosis (82.6%, [38/46]) hypermagnesemia (74.5% [35/47]). Ultrasonographic findings included reduced or absent small intestinal motility (86.7% [26/30]) and dilated small intestines (83.8% [31/37]). The spiral colon was dilated in 32.4% (12/37) of the cattle. Eighty-two percent (50/61) of the cattle underwent right flank laparotomy and the MT could be reduced in 34.4% (21/61). Twenty-three percent (14/61) of the cattle survived to hospital discharge, and 77.0% (47/61) were euthanized before hospital discharge.

CLINICAL RELEVANCE
Dilated small and large intestines (spiral colon, cecum) combined with a severely abnormal demeanor and tachycardia are characteristic findings in cows with MT. Immediate surgical treatment is paramount.

Keywords: Cattle, small intestine, large intestine, ileus, mesenteric torsion

Mesenteric torsion (MT), also referred to as mesenteric root torsion or torsion of the intestinal mesentery, occurs when the intestinal tract twists around the mesenteric root.[1] Depending on the site of torsion, the ileum, cecum and ascending colon may be involved.[2] The only segments of the intestinal tract that are not affected by MT are parts of the duodenum and the dorsal colon, which are located in the dorsal part of the mesentery.[3,4] Clockwise or counterclockwise torsion of the intestinal tract around its mesenteric root, as viewed from above, with 180 to 720 degrees of torsion can occur.[5] Mesenteric torsion constitutes the most severe form of ileus and is the most difficult to treat.[6] The condition has been described in textbooks[1,4,7] and publications.[2,3,6,8–10] Mesenteric torsion has been reported in 16 calves[11] and 93 calves and 7 cows.[5] Two case reports involving single cows with MT[12,13] and 1 involving 4 cows[14] have also been described. Of 27 cows with 7 different forms of intestinal ileus, 4 cows had MT.[15]

Various putative mechanical factors involved in the pathogenesis of MT have been considered. Lively calves that were known to frolic or even jump from their enclosure were more often affected by MT than calm calves,[11] and cattle have been reported

to have MT after a fall.[11] Rolling cattle to correct left displaced abomasum,[8,16,17] reducing uterine torsion using the plank-in-the-flank technique[18] and cesarean section in dorsal recumbency[8] have also been reported to cause MT.

The clinical signs of MT are peracute and include severe colic, tachycardia and tachypnea initially.[3,5,7,9,12,18] Within hours of the torsion, distension of the right and often the left abdominal wall is evident, and ballottement and/or percussion and simultaneous auscultation are positive on the right side. At this stage, the abdominal muscles are tense in more than 75% of affected cattle, and analgesics typically have no effect.[1] This brief so-called colic phase is followed by nonspecific clinical signs such as apathy and anorexia. The animal rapidly ceases to defecate, and transrectal palpation reveals dilated intestinal loops and taut mesenteric tissue strands. The corrugated iron-like pattern of the dilated spiral colon can sometimes be palpated.[5] Affected cattle die 12 to 24 hours after the onset of clinical signs, which is considerably sooner than with other types of ileus.[1] The peracute course of MT means that affected cattle may be found dead with massive abdominal distension and no previous signs of illness.[9]

We are not aware of studies on the ultrasonographic findings in cows with MT. Dilated intestines and reduced/absent motility are the most important assessment criteria in cattle with suspected intestinal ileus.[19–21]

Surgery is the only treatment option in cattle with MT, and it should be carried out expeditiously.[5,10] The surgical approach is from the right flank with the cow standing, which facilitates abdominal exploration and manipulation of the intestines. The intestinal torsion is carefully reduced and intestinal viability is assessed. Intestinal resection is indicated when the intestinal viability is considered poor as evidenced by thrombosed arteries, dark discoloration of the serosa, a fragile intestinal wall, and/or severe edema.[9]

Even though most veterinary textbooks cover MT, there have been only 2 reports that analyzed large numbers of cases in cattle.[2,5] Furthermore, these reports involved almost exclusively pre-ruminant calves. Only 7 adult cattle with MT have been described and ultrasonography was not carried out in that study.[5] The findings in calves with MT cannot be easily extrapolated to adult cattle. Therefore, the goal of the present study was to further our knowledge by describing the findings, treatment, and outcome of 61 cattle with MT and determining the best tools for diagnosis and therapy in the early phases of the disorder.

Methods

Inclusion criteria

The medical records of 61 cattle diagnosed with MT between November 1, 1986, and December 31, 2019, at the Department of Farm Animals, University of Zurich, were analyzed. The present work is based on a dissertation.[22] Only medical records of cattle that were at least one year of age and had MT at the time of admission were included provided that the diagnosis could be confirmed during laparotomy or postmortem examination.

Clinical examination

All cattle underwent a standard clinical examination.[23,24] Signs of pain were classified as *non-specific*, *somatic* (parietal), or *visceral* (abdominal).[24] Non-specific signs included muscle fasciculations, bruxism, and spontaneous grunting. Tense abdominal muscles, arching of the back, and a tucked-up abdomen were signs of somatic (parietal) pain, and treading, sunken back, restlessness, kicking at the abdomen, sweating, tail swishing and frequent lying down and rising characterized visceral pain (colic, abdominal pain). The number of colic signs and their severity were recorded.[24,25] Signs of mild colic included mild restlessness, treading, looking at the flank, lifting the tail, lifting of individual limbs, and tail swishing. Signs of moderate colic were moderate restlessness, brief periods of recumbency, kicking with the hind limbs, arching of the back, and marked tail swishing. Signs of severe colic consisted of marked restlessness, frequent lying down and rising, sweating, grunting, and violent kicking at the abdomen.[25] The cattle were divided into the colic, indolence, and intoxication phases. The colic phase was the initial phase accompanied by the previously described signs of pain. The indolence phase followed the colic phase and was characterized by apathy and a markedly abnormal demeanor. The last phase was intoxication in which cattle had tachycardia, congested scleral blood vessels, pale mucous membranes, cool skin surface temperature, sunken eyes, and a dry muzzle.[25]

Laboratory analyses

The collection and analysis of blood, urine, and rumen fluid were done as described.[26] In brief, the PCV, the WBC, and the concentrations of total protein and fibrinogen were analyzed (Contraves analyzer AL820; Contraves; or CELL-DYN 3500; Abbott Diagnostics Division). The concentrations of BUN, calcium, inorganic phosphorus, potassium, chloride, bilirubin, and the activities of the enzymes AST and GGT were determined at 37 °C using an automated analyzer (Cobas Mira, Cobas Integra 700, Cobas Integra 800; Roche Diagnostics) and the manufacturer's reagents (Roche-Reagents) according to the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). The venous blood gas analysis was performed (RapidLab 248 analyzer; Siemens Schweiz AG). Urine samples were analyzed using a test strip (Combur[9]; Roche), and the urine specific gravity was determined using a refractometer (Krüss Optronic). The concentration of rumen chloride was determined using a chloride analyzer (MK-II-Chloride-Analyzer 9265, Sherwood Scientific).

Ultrasonographic examination of the abdomen

The abdomen of 37 cattle was scanned from the right side as described.[19,21] Briefly, the area from the tuber coxae to the eighth intercostal space and from

the transverse processes of the vertebrae to the linea alba on the right side was examined using a 5.0 MHz linear or convex transducer. The appearance of loops of small intestine and their diameter, contents, and motility were assessed. In addition, the appearance, position, and nature of the contents of the cecum and proximal and spiral ansa of the colon and the presence of cecal dilatation were noted.

Diagnosis

A tentative clinical diagnosis of primary ileus was made in cattle with a history suggesting ileus, in cattle that had signs of colic at the initial examination, and in cattle with little or no feces in the rectum. A diagnosis of primary ileus was made when dilated small intestine or taut mesenteric strands were identified during transrectal palpation in addition to a tentative clinical diagnosis of ileus. A diagnosis of ileus attributable to MT was made in cattle with severe clinical signs and when dilated small and large intestines could be palpated.

An ultrasonographic diagnosis of primary ileus was based on the identification of dilated small intestine with a diameter ≥ 4.0 cm and greatly reduced or absent intestinal motility in cattle with clinical signs suggesting ileus. Involvement of the large intestine in the ileus was suspected when gas or fluid-filled sections of the large intestine were seen.[21] An ultrasonographic diagnosis of ileus attributable to MT was based on sonographic signs combined with clinical signs strongly suggesting MT. A definitive diagnosis was made during laparotomy and/or postmortem examination.

Laparotomy

Right-flank laparotomy[24] was carried out in standing cattle or in left lateral recumbency. Cattle that had difficulty standing because of a severely abnormal demeanor or marked visceral pain were operated in left lateral recumbency. The sedated and recumbent cattle were secured in position using a tie-down strap around the thorax and ropes on the legs. Distal paravertebral anesthesia was mainly used until 2001, after which time proximal paravertebral anesthesia was used. A 25- to 30-cm incision was made in the mid-paralumbar fossa, which allowed initial visual and olfactory assessment of the intestines. Markedly gas-filled sections of large intestine were deflated using a hypodermic needle attached to rubber tubing. The small intestine and the mesenteric root were carefully examined to identify the site and direction of the torsion, followed by attempts to reduce the MT. To avoid possible trauma to the often distended and compromised intestines, complete abdominal exploration was delayed until after the reduction of the MT. The abdomen was closed in 4 layers using resorbable sutures, and metal clips were used to close the skin.

Postoperative treatment

The following treatment was given to the cattle that were operated successfully and eventually discharged: the cattle were fasted for a minimum of 24 hours postoperatively before feeding was gradually resumed. Medical treatment included fluid therapy, antibiotics, analgesics, prokinetic drugs, and electrolyte replacement as described.[24]

Euthanasia/slaughter

Cattle were euthanized[24] using pentobarbital or slaughtered for zoo-animal feeding during or after the initial examination when they were in the intoxication phase or when the owner did not consent to surgery. Cattle were euthanized intraoperatively when catastrophic lesions were seen or complications occurred and postoperatively when the clinical condition deteriorated.

Postmortem examination

All cattle that died or were euthanized underwent postmortem examination, whereas only the internal organs were inspected in slaughtered cattle.

Statistical analysis

The SPSS Statistics, version 26.0 (IBM Corp) program was used for analysis. Frequencies were determined for all variables, and the Shapiro-Wilk test was used to test the data for normality. Means ± SD were calculated for normal data and medians (with range) for nonnormal data. In addition, the 95% CI were calculated for the means and medians, respectively. Differences in nonnormal data between surviving (from admission to hospital discharge) and non-surviving cattle were analyzed using the Mann-Whitney *U* test, and differences in nominal data were analyzed using the χ^2 test. A value of $P < .05$ was considered significant.

Results

Cattle and history

There were 57 cows, 3 heifers, and 1 bull, ranging in age from 1.5 to 10 years (median, 4 years). Breeds included Swiss Braunvieh (62.3% [38/61]), Swiss Fleckvieh (19.7% [12/61]), Holstein Friesian (14.7% [9/61]), and others (3.3% [2/61]). 37.7% (23/61) of the cows were pregnant, 31.1% (19/61) were open and the pregnancy status was not recorded in the medical history in another 31.1% (19/61). The duration of pregnancy ranged from 5 to 36 weeks (median, 14 weeks). The last calving date was known in 24 cows and was between 1 and 26 weeks (median, 8 weeks) before enrolment in the study. The duration of illness before admission ranged from 4 to 72 hours (median, 12 hours). 73.8% (45/61) of the cattle were anorexic and 19.7% (12/61) had a reduced appetite. Signs of colic had occurred before admission in 73.8% (45/61) of the cattle.

Demeanor, abdominal contour, signs of pain, and vital signs

The demeanor was mildly abnormal in 3.3% (2/61) of the cattle, moderately abnormal in 37.7% (23/61), and severely abnormal in 59.0% (36/61). Of the 61 cattle, 14.8% (9/61) were recumbent on admission and another 11.5% (7/61) became recumbent during the physical examination. Bilateral abdominal

distension was seen in 32.8% (20/61) of the cattle and unilateral distension on the right side in 9.8% (6/61).

Nonspecific signs of pain were recorded in 45.9% (28/61) of the cattle and included twitching of the anconeus muscle (18.0% [11/61]), grunting (14.8% [9/61]), bruxism (8.2% [5/61]) and piloerection (4.9% [3/61]). Of the 61 cattle, 65.6% (40/61) were in the colic phase (visceral signs of pain) but a detailed description was available in only 25 cattle. Signs included treading (27.9% [17/61]), frequent lying down and rising (23.0% [14/61]), a sunken back (19.7% [12/61]), kicking at the belly (18.0% [11/61]), restlessness (16.4% [10/61]) and sweating (9.8% [6/61]; **Figure 1**, **Supplementary Video S1**). One sign of colic was seen in 16.4% (10/61) of the cattle, 2 signs in 8.2% (5/61), and 3 signs in 18.0% (11/61). Signs of visceral pain were mild (14.8% [11/61]), moderate (22.9% [14/61]), or severe (27.9% [17/61]). Of the 61 cattle, 29.5% (18/61) were in the indolence phase and 4.9% (3/61) were in the intoxication phase at the time of admission. Somatic (parietal) signs of pain in the form of abdominal guarding or tense abdominal muscles were seen in 75.4% (46/61) of the cattle.

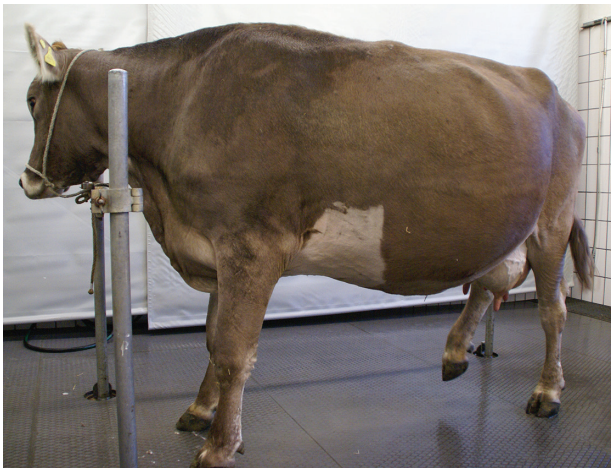

Figure 1—Image of a Brown Swiss cow with colic attributable to mesenteric torsion (MT). The cow shows signs of colic including writhing in distress, kicking at the abdomen with the right hind limb, and evidence of sweating in the dorsal neck, shoulder, and craniodorsal thoracic regions.

Of the vital signs, the most common abnormalities were tachycardia (80.3% [49/61]), tachypnea (65.0% [39/60]), and lower-than-normal rectal temperature (59.3% [35/59]) **(Supplementary Table S1)**.

Digestive tract

The most common findings were an empty or almost empty rectum (100% [59/59]), reduced or absent intestinal (96.6% [57/59]) and rumen motility (93.2% [55/59]), positive ballottement and/or percussion and simultaneous auscultation on the right side (91.7% [55/60]), and dilated small (49.2% [29/59]) and large intestines (spiral colon and/or cecum, 44.1% [26/59]) on transrectal palpation (**Supplementary Figure S1**; Supplementary Table S1). Other findings were at least 1 positive grunt test (pole test, pinching of the withers, and percussion of the abdominal wall over the region of the reticulum with a rubber hammer) in 23.8% (10/42) and rumen tympany in 22.0% (13/59) of the cattle. The feces were dark to black in 18.9% (10/53) of the cattle. Abnormal fecal contents included blood, mucous, fibrin, and combinations thereof.

Other clinical findings

Other clinical findings were reduced skin elasticity (81.7%, 49/60), reduced skin surface temperature (80.3% [49/61]), sunken eyes (70.5% [43/61]), prolonged capillary refill time (63.3% [38/60]), pale oral mucosa (48.3% [29/60]), dry and cool muzzle (45.9% [28/61]), moderately to severely hyperemic scleral vessels (44.8% [26/58]), and ammonia-like breath (14.8% [9/61]).

Urinalysis

The most common findings were aciduria (pH < 7.0, 32.0% [16/50]), increased specific gravity (> 1.040, 30.4% [14/46]), hemoglobin-/hematuria (42.0% [21/50]), and glucosuria (36.0% [18/50]).

Laboratory findings

The most common abnormalities were acidosis (82.6% [38/46]), hypermagnesemia (74.5% [35/47]), hemoconcentration (71.7% [43/60]), leukocytosis (61.0% [36/59]), increased activity of AST (59.3% [35/59]), hypocalcemia (57.4% [27/47]), and azotemia (52.5% [31/59]; **Supplementary Figure S2**; **Supplementary Table S2**). Less common were hypochloremia (49.1% [29/59]), base deficit (45.6% [21/46]), hypokalemia (44.1% [26/59]), hypercapnia (42.2% [19/45]), hypofibrinogenemia (28.1% [16/57]), hyperproteinemia (26.7% [16/60]), increased activity of GGT (25.4% [15/59]), low bicarbonate concentration (20.0% [9/45]), hyperphosphatemia (17.0% [8/47]), and hyperbilirubinemia (15.3% [9/59]). Rumen chloride was increased in 11.8% (4/34) of the cattle.

Ultrasonographic findings

The principal ultrasonographic findings were reduced or absent small intestinal motility (86.7%, 26/30), dilated small intestines (83.8%, 31/37) with a diameter of 4.0 to 10.0 cm, and fluid in the abdomen (56.8% [21/37]; **Supplementary Table S3**). The spiral colon was dilated in 32.4% (12/37) of the cattle and the cecum in 13.5% (5/37). The actual MT could not be visualized.

Comorbidities

Comorbidities including bronchopneumonia, ketonuria, mastitis, claw disease, and endometritis occurred in 14.8% (9/61) of the cows.

Diagnoses

Based on the clinical examination, a tentative diagnosis of ileus was made in 8.2% (5/61) of the cattle, a diagnosis of ileus in 36.1% (22/61), and a tentative diagnosis of ileus attributable to MT in 4.9% (3/61) of the cattle **(Supplementary Table S4)**. A tentative diagnosis of cecal dilatation[27] was made in 24.6% (15/61) of the cattle and spiral colon torsion in 21.3% (13/61).

Based on the ultrasonographic examination, a diagnosis of ileus was made in 62.2% of 37 cattle, a diagnosis of cecal dilatation[21] in 16.2% (6/37), and a diagnosis of torsion of the spiral colon (TSC) in 10.8% (4/37) of the cattle. An ultrasonographic diagnosis of TSC was made when transrectal palpation revealed the typical corrugated iron-like pattern of the spiral colon and dilatation of the spiral colon was visualized.

Treatment and outcome

Eleven cattle died or were euthanized during or shortly after the initial examination because of a hopeless prognosis or because the owner did not consent to surgery **(Figure 2)**. Of 50 cattle that underwent

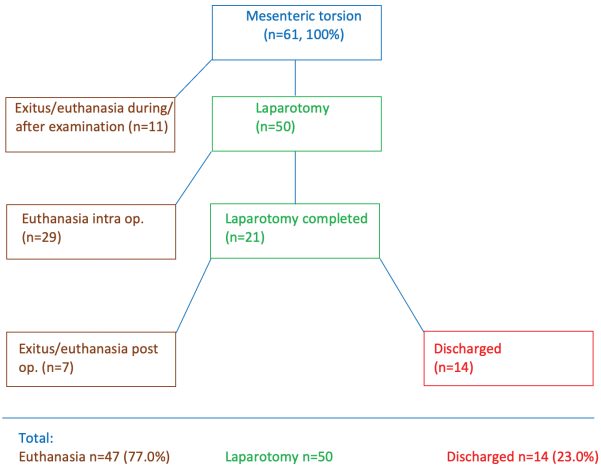

Figure 2—Treatment flowchart for 61 cattle with MT admitted from November 1, 1986, to December 31, 2019, and included in a retrospective study to describe the clinical, laboratory, and ultrasonographic findings; treatment; and outcome of cattle with MT.

right-flank laparotomy, 29 were euthanized intraoperatively because of catastrophic surgical findings or complications. Surgery was completed in 21 cattle; 7 died or were euthanized postoperatively and 14 were discharged. In summary, 47 (77.0%) cattle died or were euthanized and 14 (23.0%) were discharged.

Surgical findings and intraoperative complications

Right-flank laparotomy[24] was carried out in 43 standing cattle and in left lateral recumbency in 7 animals; of the latter, 5 were sedated and 2 underwent general anesthesia. In 2 other cases, laparotomy was started with the animals standing, but both became recumbent and thus surgery was completed with one in sternal and the other in lateral recumbency. All cattle had MT. Changes occurred in both the small and large intestines in 80.0% (40/50) of the cattle. In addition to the torsion around the mesentery, the primary lesions consisted of hemorrhagic infarction of the involved intestines, which appeared dilated and dark red to black. The cecum was involved in the MT in 76.0% (38/50) of the cattle (dilatation, retroflexion, torsion). Thirty-eight percent (19/50) of the cattle had an increased amount of abdominal fluid, which was malodorous in 22% (11/50). Sixteen percent (8/50) of the cattle had fibrin and fibrinous adhesions, and 2% (1/50) had an intestinal rupture.

Of the 50 operated cattle, the torsion could be reduced in 42.0% (21/50). In the remaining 58% (29/50) of the cattle, reduction was not possible, and the animals were euthanized intraoperatively. In addition, the cecum was drained in 44% (22/50) of the cattle.

Intraoperative complications occurred in 16.0% (8/50) of the operated cattle and included unexpected recumbency with or without ensuing intestinal contamination, severe hemorrhage, and mesenteric or intestinal tearing.

Short-term outcome

Of the 21 cattle in which surgery was completed, 3 died within 3 days and 4 were euthanized because their clinical condition deteriorated (Figure 2). In the remaining 14 cattle, demeanor, appetite, and fecal output normalized within 1 to 8 days (median, 3.5 days), 3 to 8 days (median, 3.0 days), and 2 to 5 days (median, 3.0 days), respectively. Fourteen cattle were discharged within 11 days of surgery.

Comparison of the 14 surviving and the 47 non-surviving cattle

The median duration of illness on admission was 12 hours in both groups. Likewise, the median heart rate (104 vs 116 beats/min; normal range, 60 to 80 beats/min), rectal temperature (38.4 °C vs 38.0 °C; normal range, 38.5 °C to 39.0 °C), and respiratory rate (22 vs 36 breaths/min; normal range, 15 to 25 breaths/min) did not differ significantly between the groups. In contrast, the following differences between surviving and non-surviving cattle were significant: severely abnormal demeanor (21.4% [3/14] vs 70.2% [33/47]; χ^2 =13.0; $P < .01$), bilateral abdominal distension (7.1% [1/14] vs 40.4% [19/47]; χ^2 = 8.2; $P < .05$), capillary refill time > 2 seconds (42.9% [6/14] vs 69.6% [32/46]; χ^2 = 9.4; $P < .01$), pale oral mucosa (21.4 [3/14] vs 56.5% [26/46]; χ^2 = 21.8; $P < .01$), and positive ballottement and/or percussion and simultaneous auscultation on the right side (78.6% [11/14] vs 95.7% [44/46]; χ^2 =16.8; $P < .01$; **Figure 3**). The concentrations of the following laboratory variables and the pH differed significantly between surviving and non-surviving cattle: chloride (98 vs 95 mmol/L; normal range, 96 to 105 mmol/L; $P < .05$), bilirubin (4.9 vs 3.0 µmol/L; normal range, 0.5 to 6.5 µmol/L), magnesium (1.02 vs 1.58 mmol/L; normal range, 0.80 to 1.00 mmol/L), inorganic phosphorus (1.49 vs 1.90 mmol/L; normal range, 1.30 to 2.40 mmol/L), potassium (3.4 vs 4.1 mmol/L; normal range, 4.0 to 5.0 mmol/L), pH (7.40 vs 7.33; normal range, 7.41 to 7.45), bicarbonate (26.4 vs 21.7 mmol/L; normal range, 20.0 to 30.0 mmol/L) and base excess (2.4 vs -3.5 mmol/L; normal range, -2 to +2 mmol/L; all $P < .01$).

Long-term outcome of the 14 discharged cattle

The long-term outcome was determined 2 years after discharge via telephone interview. Of

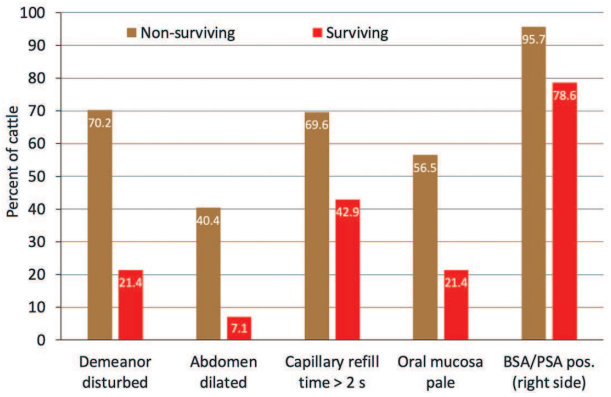

Figure 3—Clinical variables (demeanor abnormal, abdomen dilated, capillary refill time prolonged, oral mucosa pale, and right-sided positive ballottement and simultaneous auscultation/percussion and simultaneous auscultation [BSA/PSA]) that differed significantly for cattle described in Figure 2 that survived to hospital discharge (surviving; n = 14) versus did not survive to hospital discharge (non-surviving; 47).

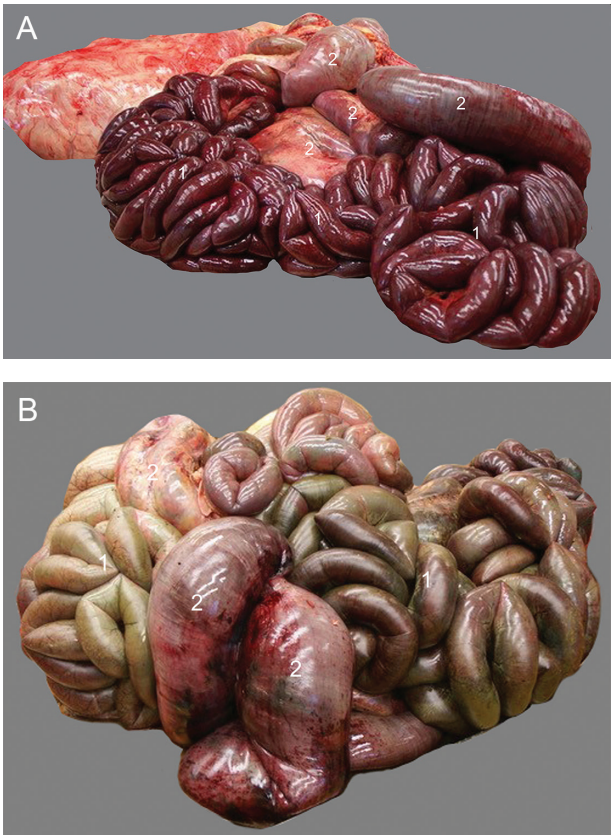

Figure 4—Postmortem images of organs from a 3-year-old Holstein-Friesian cow (A) and a 4-year-old Swiss Fleckvieh cow (B) with MT showing dilatation and severe reddish-purple or green discoloration of the small intestines (1) and large intestines (2) with fibrinous adhesions in some areas.

the discharged cattle, 42.9% (6/14) were still productive in their respective herds. One animal had been slaughtered because of complications related to MT, 35.7% (5/14) had left the herd for economic or other health reasons, and the outcome was not known for the remaining 2 cattle.

Postmortem findings

The main findings of the 47 cattle that died or were euthanized were torsion at the mesenteric root and hemorrhagic infarction of the affected intestines **(Figure 4)**. Acute fibrinous peritonitis was seen in 9 cattle and intestinal rupture in 2.

Discussion

Part of a clinician's challenge is to determine the cause of intestinal ileus based on clinical signs, severity of signs of colic, and disease course.[15] For instance, a peracute course accompanied by severe signs of colic and rapid deterioration of the general health status, and abdominal distension as an early clinical sign, are typically attributed to small intestinal volvulus or MT,[28–30] whereas intestinal obstipation and intussusception are more likely to have a less acute course and milder signs of colic.[31,32,33] The frequency of colic, observed at presentation, was 65.6% (40/61) in the cattle of the present study compared with only 46.8% (59/126) in cattle with intussusception[24]; the respective frequencies of moderate to severe signs of colic were 50.8% (31/61) and 11.1% (14/126).[25] The most common signs of colic in cattle with MT were treading, frequent lying down and rising, lowering of the back, and kicking at the belly. Frequent lying down and rising were not seen in cattle with intussusception.[24] The colic phase lasts a very short time (up to 12 hours) and is the most likely reason why 34.4% (21/61) of the cattle with MT did not have colic.[25] Cattle without colic were in the subsequent indolence phase (29.5% [18/61]) or even in the intoxication phase (4.9% [3/61]). The absence of signs of colic in cattle with MT was not likely. This is in keeping with the observation of others that signs of colic are usually only seen early in the course of the disease, followed by phases of quiescence and dullness.[29,31] This means that severe colic, particularly when it fails to respond to spasmolytic drugs,[11] points to intestinal torsion, and the absence of colic does not rule out MT.

Reduced or absent rumen motility was diagnosed in 93.2% (55/59) of the cattle. This is a rather nonspecific clinical finding that signifies the severity of various gastrointestinal and extraintestinal disorders. Only 6% (29/489) of cows with traumatic reticuloperitonitis[34] but 57.0% (90/158) of cows with toxic mastitis[35] had rumen atony. In contrast, intestinal atony is a cardinal clinical sign of ileus[31] and occurred in 47.5% (28/59) of cattle with MT compared with 27.0% (34/126) of cows with intussusception.[24]

Dilatation of the small intestine is a typical rectal finding in cows with small intestinal ileus,[31] whereas a dilated cecum could be palpated in 87.9% (405/461) of cows with cecal dilatation, torsion, or retroflexion.[27] In cattle with small intestinal dilatation, the differential diagnosis must include all other types of mechanical ileus and paralytic ileus attributable to disorders such as hypocalcemia. Cecal dilation

and torsion of the spiral colon must be considered in cattle with dilatation of the large intestine. The most common transrectal finding in the cattle of the present study was dilated small and large intestines in 49.2 (29/59) and 44.1% (26/59) of the cattle, respectively. The large intestine cannot usually be palpated in cows with other forms of small intestinal ileus; it was possible in only 13.6% (3/22) of cows with ileal impaction.[33] Conversely, dilated small intestine could be palpated in only 0.9% (4/461) of cows with cecal dilatation, torsion, or retroflexion.[27]

Reduced skin elasticity, reduced skin surface temperature, sunken eyes, and prolonged capillary refill time occurred in 63.3 (38/60) to 81.7% (49/60) of the cattle and reflected a state of shock. In the present study, other signs of shock were hemoconcentration (71.7% [43/60]), azotemia (52.5% [31/59]), and acidosis (82.6% [38/46]). In cattle with MT, acidosis is due to vascular occlusion and the subsequent generation of L-lactate. Decreased glomerular filtration attributable to dehydration[36] was believed to be the cause of hypermagnesemia with concentrations of up to 2.80 mmol/L in 74.5% (35/47) of the cattle of the present study. This was supported by the difference between surviving and non-surviving cattle with respect to median magnesium (1.02 vs 1.58 mmol/L; $P < .05$) and urea concentrations (5.45 vs 8.20 mmol/L; $P = .058$; Mann-Whitney *U* test).

Dilated small intestine and reduced or absent intestinal motility are typical sonographic findings with small intestinal ileus and were seen in 83.8 (31/37) and 86.7% (26/30) of cattle with MT, respectively. Similar frequencies were reported in cows with other forms of ileus including ileal impaction,[33] intussusception,[24] ileus attributable to internal herniation,[37] and hemorrhagic bowel syndrome.[38] The latter can usually be ruled out based on characteristic findings such as bloody feces and hyperechoic material consistent with blood clots in the intestinal lumen. However, an important difference was that in the cattle with MT, 32.4% (12/37) had sonographic evidence of spiral colon dilatation and 13.5% (5/37) had cecal dilatation, both of which are rare in cows with intussusception.[24] The take-home message is that MT must be part of the differential diagnosis when dilated small and large intestines are palpated or visualized in cattle with peracute illness, and immediate laparotomy is indicated. The lethal outcome in 77.0% (47/61) of the cattle of the present study was due, at least in part, to not recognizing the seriousness of the condition in a timely fashion and wasting time on conservative treatment.

The severity of gastrointestinal dilatation and the amount of intraluminal gas played an important role in the ease of surgical correction. With limited space available because of dilation of the rumen, omasum and abomasum, a gravid uterus and large volumes of intestinal gas, correction of the torsion was challenging and sometimes impossible. The success of surgical correction was less dependent on whether the animal was standing or recumbent. The severity of disease caused by MT is also reflected by the relatively low rate of treatment success. Only 23.0% (14/61) of 61 cattle were discharged, compared with 44.4% (56/126) of cows with intussusception,[24] 55.6% (10/18) of cows with internal herniation,[37] and 100% (22/22) of cows with ileal impaction.[33] The low success rate was attributable to the poor general condition of 18.0% (11/61) of the cows even before treatment was initiated and the severity of lesions or inability to correct the torsion intraoperatively in 47.5% (29/61), all of which necessitated euthanasia. In addition, a third (7/21) of the cows died or were euthanized postoperatively. The most important factor for the improvement of the success rate in cattle with MT is to operate as soon as possible in the acute stages of the disorder. Conservative treatment prolongs the time to surgery and is an important contributor to a poor outcome.

The clinical and laboratory findings allowed some conclusions regarding the likelihood of survival of cattle with MT: of the clinical variables, severely abnormal demeanour, bilateral abdominal distension, prolonged capillary refill time and pale mucous membranes suggested a poor prognosis.

Mesenteric torsion should be part of the differential diagnosis in cattle with severe ileus. Dilated small and large intestines (spiral colon, cecum) combined with a severely abnormal demeanor and tachycardia are characteristic findings in cattle with MT. Additional evidence of MT is the presence of dilated small and large intestines seen via ultrasonography. Immediate surgical treatment is paramount.

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Supplementary Material

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