Ultrasonography of the gastrointestinal tract in cattle

Braun, U

Postprint available at:
http://www.zora.uzh.ch

Posted at the Zurich Open Repository and Archive, University of Zurich.
http://www.zora.uzh.ch

Originally published at:
Ultrasonography of the gastrointestinal tract in cattle

Abstract

Ultrasonography is an ideal diagnostic tool for the investigation of bovine gastrointestinal disorders, the most common of which are traumatic reticuloperitonitis, left and right displacement of the abomasum, ileus of the small intestine, and dilatation and displacement of the cecum. An ultrasonographic examination is performed on nonsedated, standing cattle using a 3.5 MHz to 5.0 linear or convex transducer. When a tentative diagnosis has been made based on the clinical findings, often only the region in question is examined. For example, in cases with suspected traumatic reticuloperitonitis, the examination is performed in the sternal and parasternal regions, and in cattle suspected of having cholestasis, only the costal part of the abdominal wall on the right side is examined. Even experienced clinicians may not be able to pinpoint the organ affected and make a diagnosis in patients in which abdominal disease is suspected, however. In such cases, both sides of the abdomen are examined. Normally, the reticulum,1,2 spleen,1-4 rumen,2 and parts of the abomasum5,6 are seen on the left side, and the liver,7-9 omasum,10,11 parts of the abomasum,5,6 small intestine,12,13 large intestine,14,15 and right kidney16 are seen on the right. The uterus may be seen on either side depending on the stage of pregnancy. This article describes the ultrasonographic techniques used for examination of the reticulum, rumen, omasum, abomasum, small intestine, and large intestine. The normal findings are presented followed by a description of the most important diseases of these organs.
Ultrasonography of the gastrointestinal tract in cattle

Ueli Braun, Prof Dr med vet, Dr med vet h c

Dipl. ECBHM

Ueli Braun, Prof Dr Med Vet, Professor for Internal Medicine of Cattle, Department of Farm Animals, University of Zurich, Winterthurerstrasse 260, CH-8057 Zürich, Switzerland

E-mail address: ubraun@vetclinics.uzh.ch

Telephone number: 0041-44-6358241

Fax number: 0041-44-6358904

Key words: Cattle, ultrasonography, reticulum, omasum, abomasum, intestine
Abstract

Ultrasonography is an ideal diagnostic tool for investigating gastrointestinal disorders in cattle. It is performed on standing non-sedated cattle using a 3.5 to 5.0 MHz linear or convex transducer. In animals with traumatic reticuloperitonitis, inflammatory fibrinous changes and abscesses can be imaged. Ultrasonography can be used to assess the size, position and contents of the abomasum. In left displacement of the abomasum, the abomasum is seen between the left abdominal wall and the rumen. It contains fluid ingesta ventrally and a gas cap of varying size dorsally. Occasionally, the abomasal folds are seen in the ingesta. In cattle with right displacement of the abomasum or abomasal volvulus, the liver is displaced medially from the right abdominal wall by the abomasum, which has an ultrasonographic appearance similar to that described for left displacement. Motility and diameter of the intestine are the most important criteria for ultrasonographic assessment of ileus. However, the cause of the ileus is rarely determined via ultrasonography. In cases with ileus of the small intestine, there is at least one region of dilatation of the intestine and motility is reduced or absent. In cattle with caecal dilatation, the caecum can always be imaged from the right lateral abdominal wall. The wall of the caecum closest to the transducer appears as a thick, echogenic, semi-circular line.

Introduction

Ultrasonography is an ideal diagnostic tool for the investigation of bovine gastrointestinal disorders, the most common of which include traumatic reticuloperitonitis, left and right displacement of the abomasum, ileus of the small intestine and dilatation and displacement of the caecum. An ultrasonographic examination is performed on non-sedated, standing cattle using a 3.5 MHz to 5.0 MHz linear or convex transducer. When a tentative diagnosis has been made based on the clinical findings, often only the region in question is examined. For
example, in cases with suspected traumatic reticuloperitonitis, the examination is carried out in the sternal and parasternal regions, and in cattle suspected of having cholestasis, only the costal part of the abdominal wall on the right side is examined. However, even experienced clinicians may not be able to pinpoint the organ affected and make a diagnosis in patients in which abdominal disease is suspected. In such cases, both sides of the abdomen are examined. Normally, the reticulum [1, 2], spleen [1-4], rumen [2] and parts of the abomasum [5, 6] are seen on the left side and the liver [7-9], omasum [10,11], parts of the abomasum [5, 6], small intestine [12, 13], large intestine [14, 15] and right kidney [16] on the right. The uterus may be seen on either side depending on the stage of pregnancy. This review describes the ultrasonographic techniques used for examination of the reticulum, rumen, omasum, abomasum, small intestine and large intestine. The normal findings are presented followed by a description of the most important diseases of these organs.

**Reticulum/Rumen**

*Ultrasonographic examination of the reticulum and normal findings*

For ultrasonographic examination of the reticulum, the transducer is applied to the ventral aspect of the thorax on the left and right of the sternum as well as to the left and right lateral thorax up to the level of the elbow [1, 2, 17, 18]. The reticulum is first examined from the left side and then the right. The normal reticulum appears as a half-moon-shaped structure with an even contour (Fig. 1). It contracts at regular intervals and when relaxed, is situated immediately adjacent to the diaphragm and ventral portion of the abdominal wall. The different layers of the reticular wall usually cannot be imaged, and the honeycomb-like structure of the mucosa is not often seen clearly. In cattle with ascites, the tunica serosa of the reticulum appears as a narrow echogenic line, the tunica muscularis is seen as a hypoechogenic line and the tunica mucosa as a wider echogenic line (Fig. 2). Contents of the reticulum cannot be normally imaged because of their partly gaseous composition. Foreign bodies and magnets also cannot usually be seen in the reticulum because of the gas content of
the reticulum. Radiography is the method of choice for identifying radiodense foreign bodies and magnets [19]. The craniodorsal blind sac of the rumen and the transition to the ventral sac of the rumen can be seen caudal to the reticulum (Fig. 3). The abomasum is frequently seen between the craniodorsal blind sac of the rumen or rumen and ventral abdominal wall, immediately caudal to the reticulum. For assessment of reticular motility, the transducer is placed on the left ventral thoracic region. The reticulum is located and observed for three minutes without moving the transducer. The number, amplitude and speed of reticular contractions and the duration of the interval of relaxation between two biphasic reticular contractions are assessed. The reticulum normally contracts once per minute in a biphasic manner, in which the first contraction is incomplete [1, 2]. Thus, in the three-minute-observation period, the reticulum has three biphasic contractions. Contraction of the craniodorsal blind sac of the rumen is seen immediately after the second reticular contraction. Rumination is associated with an additional ruminal contraction, which occurs immediately prior to the biphasic contraction.

Control of reticular motility

Reticular motility is initiated and controlled by the vagus nerve, which in turn is under the influence of the gastric center in the medulla oblongata [20]. A number of factors, including eating, rumination and stress, affect reticular motility [21, 22]. The number of reticular contractions is highest during eating (approximately 1.5/min) and lowest when the cow is stressed (a little less than 1.0/min).

In cattle with vagal indigestion, the number of reticular contractions may be reduced, normal or increased [21, 23]. In 144 cows with vagal indigestion, the number of contractions ranged from 0 to 12 per 3 minutes. Cows with reticulo-omasal stenosis had significantly more reticular contractions (4.6 contractions/3 min) than cows with functional stenosis of the pylorus (3.6 contraction/3 min). Reticular hypermotility also commonly occurs in cows with
mechanical stenosis in the region of the reticulum [24]; two of three cows with reticulomasal stenosis caused by a rope foreign body had 6 contractions per 3 minutes. (for reticular motility in traumatic reticuloperitonitis, see traumatic reticuloperitonitis).

Drugs also affect reticular motility. Atropine, scopolamine and xylazine inhibit reticular motility [25, 26]. Reticular atony occurred within 0 to 3 minutes of intravenous administration of these drugs and lasted 3 to 111 minutes. The drug dose was directly proportional to the onset and duration of atony.

Rumen
The rumen can be imaged in the region of the left costal part of the abdominal wall. From dorsal to ventral are the dorsal sac of the rumen, the longitudinal groove of rumen and the ventral sac of the rumen. The ruminal wall appears echogenic. Reverberation artefacts running parallel to the ruminal wall are seen in the region of the dorsal gas cap [27]. The ingesta are located in the middle of the rumen and appear echogenic with gaseous inclusions. The fluid in the ventral aspect of the rumen is hypoechogenic [27].

Spleen
The spleen is located craniodorsally on the rumen. The spleen can be seen in the intercostal spaces 7 to 12 [3, 4]. It is 2.0 to 5.0 cm thick, and tapered ventrally. The splenic capsule appears as an echogenic line. The splenic parenchyma consists of numerous small regularly spaced echoes, and vessels within the parenchyma appear as anechoic round to oval or elongated images (Fig. 4). The long axis is oblique, running from caudodorsal to cranioventral.

Traumatic reticuloperitonitis
In cattle with traumatic reticuloperitonitis, ultrasonography can be used to identify morphological changes in the region of the cranial, ventral or caudal reticular wall [28]. The caudoventral reticular wall is the most frequently affected, often in association with the craniodorsal blind sac of the rumen. The changes in the contour of the reticulum depend on the severity of the inflammatory changes. Deposits of fibrinous tissue interspersed with fluid pockets are frequently seen on the reticular serosa and structures adjacent to the reticulum (Fig. 5 - 8). The extent of the inflammatory lesions varies greatly, but may occasionally extend to the region of the flank fold. Remarkably, these inflammatory lesions can resolve within six months of effective treatment [29]; ultrasonography revealed that nine of 16 cows had no remaining adhesions six months after treatment and the adhesions in the other seven cows had markedly regressed [29].

Reticular abscesses have an echogenic capsule of varying thickness, which surrounds a homogeneous hypoechogenic to moderately echogenic centre (Fig. 9, 10). The contents of an abscess are frequently partitioned by echogenic septa. Abscesses are usually caudoventral to the reticulum, but may be cranial or lateral to the reticulum. Abscesses are often seen between the reticulum and spleen, reticulum and liver or reticulum and omasum or abomasum. Reticular abscesses vary in diameter from a few centimetres to more than 15 cm. In certain cases, it is possible to drain abscesses through an ultrasound-guided transcutaneous incision [30]. However, the abscess must be immediately adjacent to and attached to the abdominal wall, and the intercostal space over the abscess must be large enough.

Reticular activity is almost always affected in cattle with traumatic reticuloperitonitis. The frequency, amplitude or speed of contractions, singly or combined, may be abnormal. The frequency can be reduced from three to two, one or no contractions per three minutes. The reduction in the amplitude of contractions varies; when formation of adhesions is extensive, reticular contractions appear indistinct via ultrasonography. Although the pattern of
biphasic contraction often is maintained, the reticulum contracts by only 1 to 3 cm. The speed of reticular contractions may be normal but can be markedly reduced.

An inflammatory effusion is often seen near the reticulum in cattle with traumatic reticuloperitonitis. Peritoneal effusion is visible ultrasonographically as an accumulation of fluid without an echogenic margin and restricted to the reticular area (Fig. 11). Depending on the fibrin and cell content, the fluid may be anechoic or hypoechoic. Fibrinous deposits are easily identified in the fluid, and sometimes, bands of fibrin are seen within the effusion. Occasionally, the peritoneal effusion is considerable and extends to the caudal abdomen (Fig. 12). The lesions may be within (omental bursitis) or outside the omentum (peritonitis). In such cases, the greater omentum is commonly seen as an echogenic structure surrounded by fluid.

The spleen, particularly its distal portion, is often affected in cattle with traumatic reticuloperitonitis. Fibrinous changes are frequently seen as echogenic deposits of varying thickness (Fig. 13), often surrounded by fluid, between the spleen and reticulum or rumen. The spleen may be covered with fibrinous deposits. Occasionally, one or more splenic abscesses are visible (Fig. 14), and the vasculature may be dilated indicating splenitis.

**Omasum**

The omasum is visible in the 6th to 11th intercostal spaces [10, 11]. It has a crescent shape with only the wall closest to the transducer visible as a thick echogenic line (Fig15). The size of the omasum varies with the intercostal spaces from 16.3 ± 1.5 cm to 56.9 ± 10.0 cm. The size of the omasum is greatest in the 9th intercostal space and decreases cranially and caudally. The omasum is located closest to the right abdominal wall in the 8th and 9th intercostal spaces and in many cows it is immediately adjacent to it in this region. Unlike the reticulum, the omasum of healthy cows does not have any apparent active motility of its own. The omasal laminae cannot be imaged in healthy cows because of intraluminal gas.
Occasionally, the attachments of the omasal laminae are seen as short echogenic cone-shaped structures that protrude from the inner wall of the omasum. Occasionally the omasal laminae can be seen in ill cattle (Fig. 16) with an increased fluid content in the omasum, usually caused by abomasal reflux. The position and size of the omasum change in cattle with right and left displacement of the abomasum, abomasal volvulus, traumatic reticuloperitonitis, ileus and reticulo-omasal stenosis [10, 31]. Omasal motility can be observed in rare cases of reticulo-omasal stenosis. Primary diseases of the omasum are rare; one publication described the ultrasonographics findings in a cow that had a leiomyoma in the omasum [32].

Abomasum

Ultrasonography is a valuable technique for the assessment of the size, position and content of the abomasum. The abomasum can be visualised approximately 10 cm caudal to the xyphoid process from the left and right paramedian regions and from the ventral midline [5, 6]. The bulk of the abomasum is situated to the right of the ventral midline. The abomasum is frequently seen immediately caudal to the reticulum between the craniodorsal blind sac of the rumen, or the rumen, and the ventral abdominal wall (Fig. 3). The wall of the abomasum appears at the most as a thin echogenic line. However, the abomasum is easily differentiated from neighbouring organs by the ultrasonographic appearance of its contents, which are seen as a heterogeneous moderately echogenic mass with echogenic stippling. Parts of the abomasal folds can occasionally be seen as echogenic structures within the content of the abomasum. Passive and slow movement of the abomasal contents are frequently seen.

The position of the abomasum changes in late pregnancy because of the expanding uterus [33-35]. The abomasum changes from a more longitudinal to a transverse position, but within 14 days of parturition resumes its normal longitudinal position.

Abomasocentesis
Percutaneous ultrasound-guided abomasocentesis can be performed to evaluate the nature and chemical composition of abomasal contents [36]. Centesis is performed at a site where the abomasum appears large and where no other organs are in the way. Abomasal fluid is assessed mainly for colour, smell and the presence of blood, and the pH is determined. Blood does not normally occur in abomasal fluid. In the majority of cases, blood originates from an abomasal ulcer [36] and rarely from the rumen or small intestine.

Left displacement of the abomasum

An ultrasonographic examination is useful to confirm the diagnosis of left displacement of the abomasum in unclear cases [37]. The last three intercostal spaces on the left side are examined ventrally to dorsally with the transducer held parallel to the ribs. Normally, the rumen is immediately adjacent to the left abdominal wall. Thus, on ultrasonograms, the ruminal wall is medial to the abdominal wall and from ventral to dorsal appears as a smooth, thick, echogenic line, which is indented at the left longitudinal sulcus. With left displacement of the abomasum, the wall of the rumen often is still immediately adjacent to the abdominal wall in the ventral region. When the transducer is moved dorsally, it becomes apparent that the wall of the rumen is pushed medially and then can no longer be imaged ultrasonographically. Instead the abomasum is seen, located between the abdominal wall and rumen. Moving the transducer further dorsally, the abomasum disappears and the rumen reappears on the screen. The abomasal contents do not appear uniform because, ventrally, there are fluid ingesta, and dorsally, there is a gas cap that varies in extent. The ingesta visible ventrally in the abomasum appear hypoechogenic (Fig. 17). Occasionally, the abomasal folds are visible among the ingesta and appear as elongated, echogenic, sickle-shaped structures. The ruminal wall can often be seen medial to the ingesta. The abomasal gas cap, seen further dorsally, is characterised by reverberation artifacts (Fig. 18) similar to those observed during the ultrasonographic examination of lung.
Right displacement of the abomasum and abomasal volvulus

Ultrasonography also is a useful diagnostic tool in doubtful cases of right displacement of the abomasum and abomasal volvulus. The area immediately caudal to the last rib and the caudal three to four intercostal spaces on the right side are examined from ventral to dorsal with the transducer held parallel to the ribs [18, 38, 39]. Normally, loops of small intestine are imaged in cross-section and, less commonly, longitudinally in the ventral abdomen, and further dorsally, the liver is seen immediately adjacent to the right abdominal wall. In animals with right displacement of the abomasum or abomasal volvulus, the liver is displaced from the abdominal wall. The abomasum is seen where the liver would normally be, immediately adjacent to the right abdominal wall. Its ultrasonographic appearance is the same as that described previously for left displacement. The ultrasonographic appearance of right displacement of the abomasum cannot be differentiated from abomasal volvulus [38, 39]. In both disorders, the liver, omasum and small and large intestine may be displaced depending on the size of the abomasum [38, 40]. In contrast to healthy cows in which the liver can always be imaged on the right side, there is a significant decrease in the frequency with which the liver is seen from the different intercostal spaces in cows with abomasal displacement or volvulus; in fact, sometimes the liver cannot be imaged on the right side at all. This is because the liver is displaced from the abdominal wall by the abomasum. The omasum and small and large intestine are also less frequently seen in cows with right displacement of the abomasum and abomasal volvulus compared with healthy cows.

Defects in abomasal emptying

Defects in emptying of the abomasum occur with functional or mechanical pyloric stenosis. Abomasal emptying can also be impaired secondary to intestinal ileus. With all these disorders, the abomasum is dilated but not displaced dorsally or torsed. Depending on its
degree of fill, the dilated abomasum can be imaged on the right side from the ventral region of intercostal spaces 8 to 12 or even from the ventral abdomen caudal to the ribs. In contrast to left or right displacement, there is no accumulation of gas in the non-displaced, dilated abomasum. The abomasal contents appear predominantly hypoechogenic and homogeneous, and because of sequestration of hypochloric acid, are frequently fluid in nature. This often allows for good visualisation of the abomasal folds, which appear as thin, echogenic, wavy structures (Fig. 19). In animals with ileus, the loops of intestine are dilated and clearly visible. With pyloric stenosis, the small intestine is empty.

Abomasitis/abomasal ulcers

Discrete lesions of the abomasal mucosa such as chronic abomasitis, parasitic nodules, erosions and type 1 ulcers cannot be imaged ultrasonographically using a 3.5 MHz or 5.0 MHz transducer. Type 3 abomasal ulcers produce abdominal changes similar to those of fibrinous traumatic reticuloperitonitis with abscessation. Type 4 abomasal ulcers produce signs of generalized peritonitis with ascites, fibrinous adhesions and thickening of the intestinal wall. Abomasal ulcers have never been imaged with ultrasound.

Intestine

Normal small intestine

For ultrasonography of the small intestine in cattle, 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 is examined [12, 13]. The appearance of loops of small intestine and their diameter, contents and motility are assessed. The wall of the normal small intestine is 2 to 3 mm thick and its luminal diameter is 2 to 4 cm [13]. Evaluation of the contents of the small intestine in cattle is usually straightforward because there is generally no gas. This is because, unlike small animals and humans, ruminants digest carbohydrates principally in the forestomachs, from which the gas is eructated [41]. The ultrasonographic appearance of the
contents of the small intestine varies. Most commonly, the intestine contains mucus or feed, which appears hyperechogenic. In these cases, not only the intestinal wall closest to the transducer, but also the intestinal contents and the wall furthest from the transducer can be visualised. This is also true for intestine filled with fluid, which is hypoechogetic. In rare cases with gaseous intestinal contents, the intestinal wall closest to the transducer appears as a hyperechogenic line adjacent to an acoustic shadow. Because of reflection of the ultrasound waves at the soft tissue-air interface, the intestinal contents and the intestinal wall furthest from the transducer cannot be visualised. In contrast with results in dogs [42], there is no difference between the diameter of most of the small intestine before and after feeding in cattle. This uniformity is probably because the forestomachs constitute a feed reservoir and ingesta pass along the intestine continuously, independent of feed intake, and without changes in the diameter of the intestinal lumen, which would be measurable by ultrasonography.

The cranial part of the duodenum is relatively easy to identify because it originates from the abomasum and is in close proximity with the liver and gallbladder. It is seen in cross section or longitudinally medial or ventral to the gallbladder and almost always from the 10th or 11th intercostal space. The diameter of the cranial part of the duodenum ranges from 0.9 to 5.5 cm [13]. The descending duodenum also is quite easily imaged in most cattle. From the 10th, 11th or 12th intercostal space and from the dorsal region of the right flank, it is observed in cross section or longitudinally. The following characteristics allow accurate identification of the descending duodenum: it is situated immediately adjacent to the abdominal wall and runs horizontally and caudally between the serosal lamellae of the omentum, which appears as an echogenic envelope around the descending duodenum. It then courses caudally to form the caudal duodenal flexure at the level of the tuber coxae. After this, it runs medially and cranially to form the ascending duodenum. The diameter of the descending duodenum varies from 1.5 to 3.5 cm. The ascending duodenum is situated more than 20.0 cm from the right abdominal wall and as a result cannot be imaged via ultrasonography.
The jejunum and ileum form the longest part of the small intestine and cannot be differentiated from one another ultrasonographically. It is typical to see more than ten loops of jejunum and ileum immediately adjacent to one another from the flank and lateral abdominal wall and from intercostal spaces 9 to 12 [13]. The loops of small intestine are usually seen in cross-section and occasionally longitudinally. They can be differentiated from the descending duodenum because they are not surrounded by omentum and because they are constantly in motion (Fig. 20). Loops of jejunum and ileum are seen from the 10th intercostal space in approximately 70% of cows and from the 9th intercostal space in approximately 10% of cows. The diameter of the jejunum and ileum ranges from 2.0 to 4.0 cm. The number of loops of jejunum and ileum visible longitudinally and in cross-section are approximately the same when imaged from the flank and the 12th intercostal space, but it decreases when imaged from the successive intercostal spaces.

**Ileus of the small intestine**

When ileus of the small intestine is suspected, an ultrasonographic examination should evaluate the diameter, motility and anatomical arrangement of the small intestine, evidence of peritonitis and the possible cause of the ileus [18, 43]. The most important parameters are diameter and motility of the small intestine; identification of the cause of ileus via ultrasonography is rarely possible. In cattle with ileus, the small intestine is dilated in at least one area and has a diameter of more than 3.5 cm [43]. Moreover, the motility of the small intestine is usually reduced or absent. Sometimes, hypoechogenic fluid, attributable to transudation, is visible between the dilated loops of intestine. Independent of the localisation of ileus and its cause, the loops of small intestine are most commonly imaged in cross-section (Fig. 21), often in both cross-section and longitudinally (Fig. 22) but rarely only longitudinally.
The site of ileus markedly affects the number of dilated loops of intestine seen in cross-section and longitudinally from either the flank or each intercostal space. When only one or a few, usually markedly dilated, loops of small intestine are seen (Fig. 23), ileus of the duodenum is most likely [43, 44]. More than five loops of small intestine seen in one area usually indicates ileus of the jejunum or ileum. Rarely, when the ileus is localised in the proximal jejunum, only one or two dilated loops of small intestine are imaged. The number of dilated loops of small intestine increases if the localisation of the ileus is more distal. Conversely, in the 8th and 9th intercostal spaces, the number of dilated loops of small intestine generally decreases.

The loops become more dilated with ileus of the proximal small intestine. The largest diameter of intestine measured from the 12th intercostal space varied from 6.5 to 9.9 cm (7.7 ± 1.9) in animals with ileus of the duodenum, from 3.5 to 9.8 cm (5.5 ± 1.7) in animals with ileus of the jejunum and from 4.4 to 5.5 cm (5.0 ± 0.4 cm) in animals with ileus of the ileum [43]. When interpreting the diameter of the intestine, it is important to remember that in healthy cows, in which the intestine is full of ingesta, all parts of the intestine will have a similar diameter. By contrast, in animals with ileus, in addition to the extremely dilated loops of intestine proximal to the ileus, there are usually empty loops of intestine distal to the ileus. Furthermore, the intestinal lumen of a healthy cow is constantly changing, whereas the increased intestinal diameter of a cow with ileus remains unchanged because the intestinal motility is markedly reduced or absent.

The contents of the small intestine appear predominantly echogenic and rarely anechoic. Different parts of the intestine of the same animal may be echogenic or anechogenic. Intraluminal gas, which is associated with reverberation artifacts, is rarely observed.

In the majority of cows with ileus of the small intestine, intestinal motility is markedly reduced or absent. However, movement of intestinal contents often is apparent although no intestinal contractions are visible. This flowing movement is presumably due to the passive
movement of the intestine by respiratory activity and possibly by the movement of adjacent organs such as the rumen or abomasum.

The cause of ileus can seldom be determined ultrasonographically. Often, this is because the cause of ileus is further from the abdominal wall than the penetration capacity of the transducer. A common cause of ileus is intussusception, the ultrasonographic appearance of which in cross-section has been described as bowel within bowel, bull's eye lesion, target pattern or as multiple layered, onion ring-type mass with varying echogenicities. Typically, the invaginated intestinal wall is swollen. Depending on the severity of oedema and the imaging plane, the affected area of intestine may appear hyperechogenic or hypoechogenic. Viewed longitudinally, the typical lumen-within-a-lumen can be clearly identified and has been described as a "sandwich" configuration. In rare cases, compression of the small intestine by abscesses in the region of the liver or compression of the duodenum between the liver and gallbladder can be identified. Ileus can also be caused by generalised peritonitis with fibrinous adhesions involving the small intestine. In such cases, thickening of the intestinal wall, fibrinous deposits and accumulation of intraabdominal fluid are usually seen. In cattle with hemorrhagic bowel syndrome (HBS), the blood clots can occasionally be imaged as an echogenic masses in the lumen of the small intestine (Fig. 24) [45]. In a heifer with duodenal ileus, ultrasonography showed that the gallbladder was not in its normal position, and exploratory laparotomy revealed that the displaced gallbladder was causing obstruction of the duodenum [46].

Failure of ingesta to pass through the small intestine results in delayed passage of ingesta through the abomasum, omasum and rumen, which consequently become dilated (see Defects in abomasal emptying).

Uncomplete perforation of the intestine usually leads to chronic peritonitis. Ultrasonographically, this is seen as intraabdominal fluid with bands of fibrin, which may have a spiderweb-type of appearance among the loops of intestine and organs. Free intra-
abdominal gas with its associated reverberation artifacts may be seen if intestinal gas has leaked through the perforation.

**Normal large intestine**

Carbohydrates remaining in the ingesta after their passage through the forestomachs are fermented in the large intestine, and the gas produced makes it more difficult to image this section of the bowel [12]. The large intestine is always visible from the flank and is situated medial to the descending duodenum, whereby the colon is more dorsal and the proximal loop of the colon and caecum are more ventral. The large intestine is usually easy to differentiate from the small intestine based on its marked gas content [12, 14, 15]. Because of the gas, only the wall of the large intestine closest to the transducer can usually be imaged and appears as a thick echogenic line. However, reverberation artifacts originating from the tissue-gas interphase may become superimposed on the image of the wall and obscure it. The wall of the large intestine furthest from the transducer cannot be imaged. Usually, the proximal loop of the large colon, the caecum and the colon can be visualised. The proximal loop of the large colon and the caecum appear as thick, echogenic, continuous and slightly curved lines. The spiral loop of the colon has the appearance of a garland with a number of echogenic arched lines next to each other. In contrast to the small intestine, which has vigorous peristaltic activity and segmental contractions, very few contractions are observed in the large intestine.

**Caecal dilatation**

Diagnosis of caecal dilatation usually is straightforward but may be difficult when the dilatation is complicated by retroflexion of the caecum. In that case, either no abnormal transrectal findings can be palpated, or a distended viscus can be palpated only with the tips of the fingers. The differential diagnoses must include ileus of the small intestine and right displacement of the abomasum, respectively. A diagnosis by clinical examination alone may
not be possible, but ultrasonography allows the differentiation between right displacement of
the abomasum, ileus of the small intestine and caecal dilatation. A dilated caecum can always
be imaged from the lateral abdominal wall [14, 47] and in some cases, it may be seen from the
12th, 11th and 10th intercostal spaces. The dilated caecum and the proximal loop of the colon
are almost always immediately adjacent to the abdominal wall. Because of the gaseous
contents, only the wall of the dilated caecum and proximal loop of the colon closest to the
transducer are seen ultrasonographically and appear as thick, echogenic, semi-circular lines
(Fig. 25). In cases with fluid ingesta instead of gaseous contents in the caecum and proximal
loop of the colon, the lumen appears moderately echogenic. Differentiation of caecum and
proximal loop of the colon may be difficult ultrasonographically unless the ileocaecal fold of
the peritoneum between the two can be identified.

References
Faculty of Veterinary Medicine, University of Zurich, 1992.
Vetsuisse Faculty, University of Zurich, 1995.


[38] Feller B. Sonographische Untersuchungen bei Kühen mit rechtsseitiger Labmagenverlagerung mit und ohne Torsion. Dissertation, Vetsuisse Faculty, University of Zurich, 2006.


Legend to Figures

Fig. 1: Ultrasonogram of the normal reticulum imaged from the left sternal region. 1 Ventral abdominal wall, 2 Reticulum, Cr Cranial, Cd Caudal.

Fig. 2: Ultrasonogram of the normal reticulum in a cow with mild ascites imaged from the left sternal region. 1 Ventral abdominal wall, 2 Musculophrenic vein, 3 Diaphragm, 4 Tunica serosa of the reticulum, 5 Tunica muscularis of the reticulum, 6 Tunica mucosa of the reticulum, 7 Mild ascites, Cr Cranial, Cd Caudal

Fig. 3: Ultrasonogram of the reticulum, craniodorsal blind sac of the rumen and abomasum imaged from the left sternal region. 1 Ventral abdominal wall, 2 Musculophrenic vein, 3 Diaphragm, 4 Reticulum, 5 Abomasum, 6 Craniodorsal blind sac of the rumen, Cr Cranial, Cd Caudal.

Fig. 4: Ultrasonogram of the normal spleen imaged from the distal portion of the 6th intercostal space. 1 Lateral thoracic wall, 2 Spleen, 3 Spleen vessels, 4 Rumen, Ds Dorsal, Vt Ventral.

Fig. 5: Ultrasonogram of echogenic deposits on the reticulum and accumulation of fluid in a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Musculophrenic vein, 3 Diaphragm, 4 Reticulum, 5 Echogenic deposits of fibrin, 6 Accumulation of fluid, Cr Cranial, Cd Caudal.

Fig. 6: Ultrasonogram of fluid accumulation interspersed with fibrin in a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Caudal
wall of the reticulum, 3 Craniodorsal blind sac of the rumen, 4 Strands of fibrin, 5 Fluid accumulation, Cr Cranial, Cd caudal.

Fig. 7: Ultrasonogram of echogenic deposits on the reticulum and accumulation of fluid in a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Reticulum, 3 Echogenic deposits of fibrin, 4 Accumulation of fluid, Cr Cranial, Cd Caudal.

Fig. 8: Ultrasonogram of echogenic deposits between the reticulum and the craniodorsal blind sac of the rumen in a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Reticulum, 3 Echogenic deposits of fibrin, 4 Craniodorsal blind sac of the rumen, Cr Cranial, Cd Caudal.

Fig. 9: Ultrasonogram of an abscess ventral to the reticulum of a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Reticulum, 3 Abscess, Cr Cranial, Cd Caudal.

Fig. 10: Ultrasonogram of an abscess ventral to the reticulum in a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Abscess capsule, 3 Abscess lumen, 4 Reticulum, Cr Cranial, Cd Caudal.

Fig. 11: Ultrasonogram of a small fluid accumulation caudal to the reticulum in a cow with traumatic reticuloperitonitis imaged from the sternal part of the ventral abdomen. 1 Ventral abdominal wall, 2 Musculophrenic vein, 3 Diaphragm, 4 Reticulum, 5 Craniodorsal blind sac of the rumen with fibrin deposits, 6 Hypoechoic (due to inflammation) fluid accumulation, Cr Cranial, Cd Caudal.
Fig. 12: Ultrasonogram of a large fluid accumulation due to peritonitis in a cow with traumatic reticuloperitonitis ventral the rumen imaged from the left side of the ventral abdomen. 1 Ventral abdominal wall, 2 Omentum, 3 Fluid accumulation, 4 Rumen, Cr Cranial, Cd Caudal.

Fig. 13: Ultrasonogram of inflammatory changes between the reticulum and the spleen in a cow with traumatic reticuloperitonitis imaged from the left ventral thorax. 1 Ventral abdominal wall, 2 Spleen with dilated vessels, 3 Fluid containing fibrin between the reticulum and the spleen, 4 Reticulum, Cr Cranial, Cd Caudal.

Fig. 14: Ultrasonogram of a large abscess in the spleen imaged from the left ventral thorax. 1 Ventral thoracic wall, 2 Musculophrenic vein, 3 Diaphragm, 4 Spleen, 5 Abscess in the spleen, 6 Reticulum, indented by the spleen, Cr Cranial, Cd Caudal.

Fig. 15: Ultrasonogram of the normal omasum imaged from the 8th intercostal space of the right side. The wall of the omasum appears as a curved echogenic line. The liver is situated on the omasum dorsolaterally. 1 Costal part of the abdominal wall, 2 Liver, 3 Omasal wall, Ds Dorsal, Vt Ventral.

Fig. 16: Ultrasonogram of the omasum of a cow with abomasal volvulus imaged from the 10th intercostals space. The omasal laminae appear as thin echogenic lines. 1 Costal part of the abdominal wall, 2 Omasal wall, 3 Omasal laminae, 4 Greater omentum, Ds Dorsal, Vt Ventral.
Fig. 17: Ultrasonogram of left displacement of the abomasum imaged from the ventral region of the 12th intercostal space. 1 Abdominal wall, 2 Abomasum with hypoechogetic ingesta, 3 Abomasal fold, Ds Dorsal, Vt Ventral.

Fig. 18: Ultrasonogram of left displacement of the abomasum imaged from the dorsal region of the 12th intercostal space. The abomasal gas cap is not visible because of reverberation artifacts at the abomasal surface. 1 Abdominal wall, 2 Abomasal wall, 3 Reverberation artifacts, Ds Dorsal, Vt Ventral.

Fig. 19: Ultrasonogram of the abomasum dilated secondary to ileus of the jejunum imaged from the right paramedian region. The abomasal contents appear hypoechogetic and the abomasal folds are clearly visible as thin, echogenic wavy structures. 1 Abdominal wall, 2 Abomasum, 3 Abomasal folds, Cr Cranial, Cd Caudal.

Fig. 20: Ultrasonogram of cross-sections through loops of the jejunum imaged from the right flank. Several loops of jejunum, seen in cross-section, are situated immediately adjacent to one another. 1 Abdominal wall, 2 Loops of jejunum, Ds Dorsal, Vt Ventral.

Fig. 21: Ultrasonogram of cross sections through dilated loops of the jejunum in a cow with ileus imaged from the 12th intercostal space. The contents of the loops appear echogenic. There is anechoic fluid between the loops. 1 Abdominal wall, 2 Dilated loops of the jejunum, 3 Anechoic fluid between the loops of the jejunum, Ds Dorsal, Vt Ventral.

Fig. 22: Ultrasonogram of cross and longitudinal sections through dilated loops of the jejunum in a cow with ileus imaged from the 12th intercostal space. The contents of the loops
appear echogenic. 1 Abdominal wall, 2 Loop of jejunum in cross section, 3 Loop of jejunum in longitudinal section, Ds Dorsal, Vt Ventral.

Fig. 23: Ultrasonogram of a cross-section through the dilated duodenum of a cow with duodenal ileus imaged from the 10th intercostal space. 1 Abdominal wall, 2 Dilated duodenum in cross-section, Ds Dorsal, Vt Ventral.

Fig. 24: Ultrasonogram of the jejunum in a cow with Haemorrhagic Bowel Syndrome imaged from the right lateral abdominal wall. The blood clots have the appearance of echogenic masses in the lumen of the small intestine. 1 Abdominal wall, 2 Blood clots in the lumen of the small intestine, 3 Fluid between the intestinal loops, Ds Dorsal, Vt Ventral.

Fig. 25: Ultrasonogram of a dilated caecum of a cow with caecal dilatation and torsion imaged from the right flank. The caecal wall closest to the transducer appears as a curved echogenic line. The caecal contents and wall furthest from the transducer are not visible. 1 Lateral abdominal wall, 2 Caecal wall, Ds Dorsal, Vt Ventral.