Ultrasonographic findings in cows with right displacement of the abomasum and abomasal volvulus

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Originally published at:
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Abstract

Seventeen cows with right displacement of the abomasum (RDA) without abomasal volvulus, nine cows with abomasal volvulus and 10 clinically healthy cows were examined ultrasonographically. A 5·0 MHz transducer was used to scan the eighth to 12th intercostal spaces and the cranial and caudal aspects of the flank on the right side. The position, size and dorsal and ventral margins of the abomasum were determined at each imaging position. In both groups of diseased cows, the ventral abomasum contained fluid ingesta, which appeared hypoechoic with diffuse echogenic stippling. The abomasal folds could be seen clearly as echogenic sickle-shaped structures within the ingesta. The dorsal abomasal gas cap varied in size and was characterised by reverberation artefacts, which appeared as echogenic lines running parallel to the body surface. Compared with the healthy cows, the abomasum was larger and located significantly closer to the midline of the dorsum in both groups of cows. Compared with the cows with RDA, the abomasum in the cows with abomasal volvulus was significantly smaller in the eighth intercostal space and significantly larger in the 11th intercostal space. It was not possible to differentiate between RDA and abomasal volvulus on the basis of the ultrasonographic findings.
Ultrasonographic findings in cows with right displacement of the abomasum and abomasal volvulus

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Summary
Seventeen cows with right displacement of the abomasum (RDA) without volvulus, nine cows with abomasal volvulus (AV) and ten clinically healthy control cows were examined ultrasonographically. A 5.0 MHz transducer was used to scan the 8th to 12th intercostal spaces and the cranial and caudal aspects of the flank on the right side. The position, size and dorsal and ventral margins of the abomasum were determined at each imaging position. In both diseases, the ventral abomasum contained fluid ingesta, which appeared hypoechogenic with diffuse echogenic stippling. The abomasal folds could be seen clearly as echogenic sickle-shaped structures within the ingesta. The dorsal abomasal gas cap varied in size and was characterised by reverberation artefacts, which appeared as echogenic lines running parallel to the body surface. Compared with the control cows, the abomasum was larger and located significantly closer to the midline of the dorsum in cows with RDA and abomasal volvulus. Compared with cows with RDA, the abomasum in cows with abomasal volvulus was significantly smaller in the 8th intercostal space and significantly larger in the 11th intercostal space. It was not possible to differentiate between RDA and abomasal volvulus based on the ultrasonographic findings.

Introduction
Right displacement of the abomasum (RDA) and abomasal volvulus (AV) are common disorders in cattle. A tentative diagnosis is usually straightforward when swinging auscultation and percussion auscultation of the costal part of the right abdominal wall are positive and rectal examination reveals a dilated and displaced viscus (Dirksen 2002). Differential diagnoses include dilation and retroflexion of the caecum and ileus of the small intestine but gas-and fluid-filled intestine without ileus, pneumoperitoneum, ascites and advanced pregnancy should also be considered when making a diagnosis. Ultrasonography can be helpful when a diagnosis cannot be made based on the results of clinical examination. The ultrasonographic findings in RDA have been briefly described
In cattle with either abomasal volvulus or RDA, the liver is apparently pushed away from the right abdominal wall and cannot be seen via ultrasonography; instead, the displaced abomasum is visualised between the abdominal wall and the displaced liver. The number of cattle in these studies was small and no differentiation between RDA and abomasal volvulus could be made. The primary goal of the present study was to describe the ultrasonographic findings in cows with RDA and abomasal volvulus in greater detail so that these disorders can be accurately diagnosed and differentiated from other diseases. A secondary goal was to determine the ultrasonographic criteria for differentiation of RDA and abomasal volvulus.

Materials and Methods

Clinical examination

Before ultrasonographic examination, the cows were examined clinically (Rosenberger 1979). The findings have been described in detail elsewhere (Feller 2006).

Controls (Healthy cows; Group A)

Group A consisted of 10 clinically healthy cows ranging in age from four to 13.0 years (mean, 5.9 years). There were seven Swiss Braunvieh, two Simmental and one Holstein-Friesian cows.

Cows with right displacement of the abomasum (Group B)

Group B consisted of 17 cows with RDA that ranged in age from 2.5 to 9.0 years (mean, 4.3 years). There were eight Simmental and nine Holstein-Friesian cows.

Cows with abomasal volvulus (Group C)
Group C consisted of nine cows with abomasal volvulus. There were six Simmental and three Holstein-Friesian cows, which were 2.0 to 10 years (mean, 4.4 years) of age.

Diagnosis and treatment

In groups B and C, the diagnosis was confirmed in all but one cow via right flank laparotomy. After releasing the gas and repositioning the abomasum, an omentopexy was carried out in the right flank (Dirksen 2002). In one cow that was slaughtered on request of the owner, the diagnosis was confirmed at postmortem examination.

Ultrasonographic examination of the abomasum

The 8th to 12th intercostal spaces and the cranial and caudal aspects of the right flank were examined dorsally to ventrally with a 5.0 MHz linear transducer (EUB 9000, Hitachi Medical Systems, Zug, Switzerland) held parallel to the ribs (Feller 2006). The penetration depth of the transducer was 17 cm. The dorsal and ventral margins of the abomasum, the fluid/gas interface and the size and position of the abomasum were determined at each imaging position in relation to the midline of the dorsum. These landmarks were assessed in a manner similar to that described for the liver (Braun and Gerber 1994), lung (Braun and others 1996), spleen (Braun and Sicher 2006) and omasum (Braun and Blessing 2006); the distances between the midline of the dorsum of the cow and the dorsal margin of the abomasum, the ventral margin of the abomasum and the fluid/gas interface were measured (Fig 1) and the size of the abomasum was determined by subtracting the distance from the midline of the dorsum to the dorsal margin from the corresponding distance for the ventral margin.

Statistical analysis

The statistical software program StatView 5.0 (SAS Institute, 8602 Wangen, Switzerland) was used for analysis. Frequencies, means and standard deviations
were calculated and results from the different groups compared using an unpaired \( t \) test and the \textit{chi-square} test for association.

\section*{Results}

\textit{Ultrasonographic examination of the abomasum}

In all the control cows, the abomasum was identified from the ventral part of the right abdominal wall. This was in agreement with the findings of a previous study (Braun and others 1997a). The parietal abomasal wall was vague or not seen at all; at best it appeared as a narrow echogenic line. The abomasal contents were hypoechoic with echogenic stippling. Occasionally, the abomasal folds were visible as echogenic sickle-shaped structures within the moving ingesta.

There was no difference between the ultrasonographic appearance of RDA and that of abomasal volvulus. The findings were similar to those described for left displacement of the abomasum (Braun and others 1997b). In groups B and C, the ventral part of the abomasum contained fluid ingesta, which appeared similar as in the control animals, i.e. hypoechoic with echogenic stippling. In all but one cow, the abomasal folds were distinct and appeared as echogenic sickle-shaped structures (Fig 2). A gas cap of varying extent was seen in the dorsal region. It was characterised by reverberation artefacts seen as echogenic lines that ran parallel to the body surface and became weaker as the distance from the transducer increased (Fig 3). The fluid/gas interface was identified in all the cows of groups B and C (Fig 4), but it was never seen in the control animals.

\textit{Visualisation of the abomasum}

There was a significant association between group (healthy versus diseased cows) and the frequency with which the abomasum could be imaged at different locations (Table 1). Of the 10 control cows, the abomasum could be imaged from the 8th and 9th intercostal spaces in all cows, from the 10th intercostal space in seven and from the 11th intercostal space in two (Table 1). In the 26
cows with RDA and abomasal volvulus, the displaced abomasum was always seen from the 10th, 11th and 12th intercostal spaces. The abomasum could also be seen from the 9th intercostal space in 20 of the ill cows and from the 8th intercostal space in 10. In 21 cows, the displaced abomasum could be seen from the cranial aspect of the right flank, and in 10 cows, it was also seen from the caudal aspect of the flank.

_Dorsal margin of abomasum_

In the control cows, the dorsal margin of the abomasum was an average of 97.5 to 100.9 cm from the midline of the back (Table 2). In the cows with RDA and abomasal volvulus, the abomasum was displaced dorsally and significantly closer to the midline of the back. The dorsal margin of the abomasum ran in a semi-circle from caudal to cranial with the highest point seen in the 12th intercostal space (distance from the midline of the back, 21.0 and 21.3 cm for RDA and volvulus, respectively; Fig 5). The maximum measurement for the dorsal margin of the abomasum was 60.3 cm in cows with RDA and 55.3 cm in cows with abomasal volvulus, both imaged from the 8th intercostal space. The values for the dorsal margin of the abomasum did not differ significantly between cows with RDA and those with abomasal volvulus.

_Ventral margin of the abomasum_

In the control cows, the ventral margin of the abomasum was an average of 106.5 to 118.1 cm from the midline of the back (Table 3). In the cows with RDA and abomasal volvulus, the ventral margin of the abomasum was displaced dorsally and significantly closer to the midline of the back (67.2 to 87.9 cm, respectively); these values did not differ significantly between RDA and abomasal volvulus.

_Size of the abomasum_
The size of the abomasum in the control cows ranged from 9.0 to 17.9 cm, depending on the intercostal space. The abomasum was 19.6 to 52.5 cm in cows with RDA and 12.0 to 65.3 cm in cows with abomasal volvulus (Table 4). Compared with the control cows, the abomasum was significantly larger in the 9th to 11th intercostal spaces in cows with RDA and in the 10th and 11th intercostal spaces in cows with abomasal volvulus. Compared with cows with RDA, the abomasum of cows with abomasal volvulus was significantly smaller in the 8th intercostal space and significantly larger in the 11th intercostal space.

Fluid/gas interface

There was no significant difference in the position of the fluid/gas interface of cows with RDA and those with abomasal volvulus. The fluid/gas interface was 46.1 to 53.6 cm from the midline of the back (Table 5).

Visualisation of the abomasal folds

In the control cows, the abomasal folds were vague and difficult to see. In contrast, in 16 of 17 cows with RDA and in all the cows with abomasal volvulus, the abomasal folds were clearly seen. The abomasal folds were seen from one intercostal space in three of the cows, from two intercostal spaces in two and from three or more intercostal spaces in the remainder of the cows. There was no significant difference in visualisation of the abomasal folds in cows with RDA and those with abomasal volvulus.

Discussion

The appearance and position of the abomasum differed substantially between the control cows and those with RDA and abomasal volvulus. In the control cows, the abomasum had a uniform hypoechogenic appearance with diffuse echogenic stippling. However, in the diseased cows, two regions were seen in the abomasum. The ultrasonographic appearance of the ventral fluid-filled region resembled that of the normal abomasum except that the abomasal folds
were distinctly visible as echogenic sickle-shaped structures in all but one cow. A gas cap, characterised by reverberation artefacts, was seen dorsally. Thus, the ultrasonographic appearance of the displaced abomasum was distinctly different from other diseases such as caecal dilation and ileus of the small intestine. Although the latter two conditions have similar clinical signs and may be positive on swinging auscultation and percussion auscultation, their ultrasonographic appearances differ (Braun and others 1995, 2002). The displaced abomasum was seen from the 10th to 12th intercostal spaces in all the cows and from the 9th intercostal space and cranial region of the right flank in 82 per cent of the cows. Thus, ultrasonographic examination from the 10th to 12th intercostal spaces is ideal for diagnosing RDA. The dorsal and ventral margins of the abomasum were significantly more dorsal in the diseased cows than in the controls, in agreement with the nature of the condition in which the dilated organ becomes displaced dorsocaudally (Dirksen 2002). The dorsal margin of the abomasum ran in a curved line, that was concave at the bottom and reached its most dorsal point at the 12th intercostal space, whereas it ran parallel to the dorsum in the control animals. In the diseased cows, this arc represented the greater curvature of the abomasum, which appears spherical when displaced (Kümper 1995). The distance from the midline of the back to the abomasum increased sharply in the 9th and 8th intercostal spaces because the lungs were superimposed and obscured the abomasum. In contrast, the ventral margin of the abomasum ran in a fairly straight line. The size of the abomasum in the different imaging locations reflected a circular to oval organ, which appeared largest from the 12th intercostal space. However, because of superimposition of the lungs, the displaced abomasum could not be imaged in its entirety from the 8th and 9th intercostal spaces. This could also explain why there was no significant difference in the size of the abomasum in diseased and healthy cows when viewed from the 8th intercostal space. One of the two significant differences between RDA and abomasal volvulus was apparent when viewed from the 11th intercostal space; the torsed abomasum was larger than the
displaced abomasum and its ventral margin situated lower. A possible reason for
this is that at the level of this imaging position, the pyloric region is folded
around the torsed abomasum (Kümper 1995). Caecal dilation can easily be
differentiated from abomasal volvulus because the caecum is much smaller
(Amrein-Schneider 1999). The fluid/gas interface of the displaced abomasum
was seen as an almost horizontal line, approximately 50 cm from the midline of
the back. This line was seen less often in the cranial intercostal spaces, and
never from the 8th intercostal space, because there the dorsal gas cap was
obscured by the lungs.

In cows with positive swinging auscultation and percussion auscultation on
the right side and inconclusive results of rectal and clinical examination,
ultrasonography is a useful diagnostic aid to differentiate RDA from other
diseases with similar clinical signs, such as caecal dilation, ileus of the small
intestine and ascites. However, differentiation of RDA and abomasal volvulus is
not possible via ultrasonography because the few significant differences found
in the present study were not distinctive enough.

References
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examination of the small intestine of cows with ileus of the duodenum,
jejenum or ileum. Veterinary Record 137, 209-215


Table 1: Number of cows in which the abomasum was visible from different locations. A total of 36 cows, divided into three groups, were used: group A consisted of 10 healthy cows, group B of 17 cows with right displacement of the abomasum and group C of 9 cows with abomasal volvulus.

<table>
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<tr>
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<td>CdAF</td>
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ICS Intercostal space
CrAF Cranial aspect of flank
CdAF Caudal aspect of right flank

* Different from healthy cows (group A); P < 0.05
** Different from healthy cows (group A); P < 0.01
Table 2: Distance (cm) from the midline of the back to the dorsal margin of abomasum in healthy cows (group A), in cows with right displacement of the abomasum (group B) and in cows with abomasal volvulus (group C)

<table>
<thead>
<tr>
<th>Location</th>
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<th>Group C</th>
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<td>6.2 (10)</td>
<td>47.4* (32-75)</td>
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<td>100.3 (83-111)</td>
<td>10.2 (7)</td>
<td>35.0* (18-64)</td>
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<td>26.1* (14-56)</td>
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<td>-</td>
<td>21.0 (14-29)</td>
</tr>
<tr>
<td>CrAF</td>
<td>ANV</td>
<td>-</td>
<td>27.1 (21-43)</td>
</tr>
<tr>
<td>CdAF</td>
<td>ANV</td>
<td>-</td>
<td>30.7 (25-44)</td>
</tr>
</tbody>
</table>

ICS  Intercostal space  
CrAF  Cranial aspect of flank  
CdAF  Caudal aspect of right flank  
ANV  Abomasum not visible at this location  
n  = Number of cows in which the abomasum was visible in the location examined  
* Different from healthy cows (group A); P < 0.01
Table 3: Distance (cm) from the midline of the back to the ventral margin of abomasum in healthy cows (group A), in cows with right displacement of the abomasum (group B) and in cows with abomasal volvulus (group C)

<table>
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<tr>
<td></td>
<td>Mean (range)</td>
<td>SD (n)</td>
<td>Mean (range)</td>
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<tr>
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<td>ANV -</td>
<td>-</td>
<td>67.2 (40-95)</td>
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<tr>
<td>CdAF</td>
<td>ANV -</td>
<td>-</td>
<td>67.7 (49-97)</td>
</tr>
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ICS  Intercostal space
CrAF Cranial aspect of flank
CdAF Caudal aspect of flank
ANV Abomasum not visible at this location
n Number of cows in which the abomasum was visible in the location examined
* Different from healthy cows (group A); P < 0.01
Table 4: Size of the abomasum (cm) in healthy cows (group A), in cows with right displacement of the abomasum (group B) and in cows with abomasal volvulus (group C)

| Location | Group A | | Group B | | Group C | |
|----------|---------|---|---|---|---|
|          | Mean (range) | SD (n) | Mean (range) | SD (n) | Mean (range) | SD (n) |
| ICS 8    | 14.9 (6-28) | 6.1 (10) | 19.6 (14-29) | 5.1 (7) | 12.0* (10-14) | 2.0 (3) |
| ICS 9    | 14.3 (7-22) | 4.4 (10) | 27.4* (11-53) | 13.9 (14) | 25.2 (8-49) | 15.7 (6) |
| ICS 10   | 17.9 (9-32) | 7.4 (7) | 40.2* (17-64) | 15.7 (17) | 46.9* (16-70) | 21.4 (9) |
| ICS 11   | 9.0 (5-13) | 5.6 (2) | 48.6* (24-69) | 14.0 (17) | 65.3*++ (47-83) | 11.0 (9) |
| ICS 12   | ANV - | | 52.5 (30-85) | 14.6 (17) | 62.9 (42-80) | 11.0 (9) |
| CrAF     | ANV - | | 40.1 (9-73) | 20.4 (14) | 50.6 (16-79) | 21.2 (7) |
| CdAF     | ANV - | | 37.0 (20-55) | 14.8 (7) | 46.0 (14-74) | 30.2 (3) |

ICS Intercostal space
CrAF Cranial aspect of flank
CdAF Caudal aspect of flank
ANV Abomasum not visible at this location
n Number of cows in which the abomasum was visible in the location examined
* Different from healthy cows (group A); P < 0.01
+ Different from cows with right displacement of the abomasum (group B); P < 0.05
++ Different from cows with right displacement of the abomasum (group B); P < 0.01
Table 5: Distance (cm) from the midline of the back to the fluid/gas interface of the abomasum in healthy cows (group A), in cows with right displacement of the abomasum (group B) and in cows with abomasal volvulus (group C)

<table>
<thead>
<tr>
<th>Location</th>
<th>Group A</th>
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<th>Group C</th>
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<td>Mean (range)</td>
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NA Not applicable
CrAF Cranial aspect of flank
CdAF Caudal aspect of flank
Legend to figures

Figure 1: Schematic representation of the determination of the position and size of the abomasum. 1a Gas accumulation in the dorsal abomasum, 1b Gas-fluid interface, 1c Ingesta in ventral abomasum, 2 Dorsal margin of abomasum, 3 Distance from the gas-fluid interface to midline of back, 4 Ventral margin of abomasum, 5 Size of abomasum

Figure 2: Ultrasonogram of the dorsal part of the abomasum in an 5-year-old Holstein Friesian cow with RDA imaged from the 12th intercostal space of the right side using a 5.0-MHz linear transducer. The abomasal gas cap appears as so called reverberation artifacts, echogenic lines running parallel to the abomasal surface. 1 Abdominal wall, 2 Abomasal wall, 3 Reverberation artefacts. Ds Dorsal, Vt Ventral

Figure 3: Ultrasonogram of the ventral part of the abomasum in an 5-year-old Holstein Friesian cow with RDA imaged from the 12th intercostal space of the right side using a 5.0-MHz linear transducer. The abomasal contents is hypoechogenic and an abomasal fold appears as a sickle-shaped structure. 1 Abdominal wall, 2 Abomasal wall, 3 Hypoechogenic ingesta, 4 Abomasal fold, Ds Dorsal, Vt Ventral

Figure 4: Ultrasonogram of the gas-fluid interface of the abomasum in an 5-year-old Holstein Friesian cow with RDA imaged from the 12th intercostal space of the right side using a 5.0-MHz linear transducer. To the left the abomasal gas cap, to the right the hypoechogenic ingesta is seen. 1 Abdominal wall, 2 Abomasal wall, 3 Dorsal gas cap with reverberation artifacts, 4 Hypoechogenic ingesta, Ds Dorsal, Vt Ventral
Figure 5: A Simmental cow showing where the dorsal and ventral margins of the abomasum occur in right displacement of the abomasum. The lines represent the mean values obtained from 17 cows with RDA.