Comparison of 2-step laparoscopy-guided abomasopexy versus omentopexy via right flank laparotomy for the treatment of dairy cows with left displacement of the abomasum in on-farm settings

Jean-Philippe Roy, DMV, MS; Denis Harvey, DMV, PhD; Anne-Marie Bélanger, DMV; Sébastien Buczinski, Dr Vet, DACVIM

Objective—To compare characteristics and results of 2-step laparoscopy-guided abomasopexy versus omentopexy via laparotomy in the right paralumbar fossa for the treatment of dairy cows with a left displaced abomasum (LDA).

Design—Prospective clinical trial.

Animals—253 dairy cows with an LDA.

Procedures—All cows that were treated with omentopexy (n = 101) or 2-step laparoscopy-guided abomasopexy (152) from July 2005 through December 2006 were included. Presurgical, perisurgical, and postsurgical information was recorded by attending veterinarians. Producers were interviewed by telephone 7 and 60 days after surgery regarding the response of cows to surgery. Characteristics of and responses to the 2 surgical techniques were compared.

Results—At 7 days after surgery, the 2 groups of cows were not significantly different with respect to appetite, comfort, and milk yield; at 60 days after surgery, groups were similar with respect to milk yield, cull rates, and risk of relapse of LDA. Antimicrobial treatment in response to postsurgical pyrexia was necessary in only 20.4% (31/152) of cows that were treated with 2-step laparoscopy-guided abomasopexy. Mean duration (preparation and surgery) of 2-step laparoscopy-guided abomasopexy was significantly less than that of omentopexy (36 vs 74 minutes, respectively).

Conclusions and Clinical Relevance—Results of 2-step laparoscopy-guided abomasopexy and omentopexy via laparotomy in the right paralumbar fossa were not significantly different. Compared with omentopexy, laparoscopy-guided abomasopexy was performed more quickly and required postsurgical administration of antimicrobials less frequently. Although these factors may be of economic consequence to veterinarians and producers, other aspects must also be considered when choosing between techniques. (J Am Vet Med Assoc 2008;232:1700–1706)

Left displacement of the abomasum is a common pathologic condition in dairy cows. Mean incidence of LDA during lactation ranges from 1% to 5%, but may exceed 13% in some herds.1–5 Treatment may cost up to $500/affected cow, depending on the surgical procedure used.1–6 Several surgical techniques have been developed to reposition the abomasum after LDA develops.5,6,8–10 The standard technique most often used in North America is omentopexy via laparotomy in the right paralumbar fossa.5,6 Other commonly used techniques include abomasopexy via laparotomy in the left paralumbar fossa, abomasopexy via the ventral paramedian approach, and percutaneous fixation by blind-tack suture or toggle-pin.5,7 Percutaneous fixation is the most rapid technique; however, a major disadvantage is that proper attachment of the abomasum is not ensured because the abomasum cannot be viewed.5,7,10 As a result, percutaneous fixation techniques account for the largest proportion of unsuccessful treatments, relapses, and complications associated with surgical correction of LDAs.5

Two-step laparoscopy-guided fixation of the abomasum was introduced in 1998.11 The surgical procedure can be viewed via laparoscopy, yet is minimally invasive; consequently, the 2-step procedure combines an advantage of percutaneous fixation methods (rapidity) with one of traditional surgery (therapeutic safety).12 Another advantage of 2-step laparoscopy-guided abomasopexy is that postsurgical administration of

From the Clinique Ambulatoire Bovine, Faculté de Médecine Vétérinaire, Université de Montréal, St-Hyacint, QC J2S 2M2, Canada. Presented in part at the 24th World Buiatrics Congress, Nice, France, October 2006.

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antimicrobials should not be necessary in most situations. However, little is known about the frequency with which antimicrobials must be administered when 2-step laparoscopy-guided abomasopexy is performed in farm settings. When antimicrobials are not required, costs related to the administration of antimicrobials and to the associated period for withholding milk from sale are eliminated. In addition, problems associated with contamination of bulk-tank milk with antimicrobial residues, such as financial penalties and antimicrobial resistance, are avoided.

In a prospective study conducted in a veterinary hospital of a German university, investigators compared the techniques and outcomes of 2-step laparoscopy-guided abomasopexy and omentopexy in 120 cows with an LDA. Investigators concluded that the success rate for the 2 techniques was the same, but feed intake and milk yield of cows during the first 5 days after surgery was more rapidly and effectively restored in cows treated with the 2-step laparoscopy-guided technique, compared with results after omentopexy. However, no study has been conducted in farm settings or in North America.

The objective of the study reported here was to compare characteristics and results of 2-step laparoscopy-guided abomasopexy versus omentopexy via laparotomy in the right paralumbar fossa for the treatment of dairy cows with an LDA. Specifically, we sought to compare outcomes achieved by use of the 2 techniques as well as advantages and disadvantages of each.

Materials and Methods

Animals—Dairy cows used in this study belonged to clients of the Clinique ambulatoire bovine (Bovine Field Service) of the Université de Montréal. Personnel of the Clinique ambulatoire bovine attend to approximately 100 dairy farms, most of which use tie-stall housing; each farm has 30 to 150 lactating cows (primarily Holsteins). Veterinary students in their final year of clinical rotations typically accompany field service veterinarians on farm visits, assist with surgeries, and participate in the administration of treatments.

All cows in which an LDA was diagnosed by a field service veterinarian from July 2005 through December 2006 were eligible for inclusion in the study. All lactating cows in which an LDA was corrected by 2-step laparoscopy-guided abomasopexy or omentopexy via laparotomy in the right paralumbar fossa were included. Cows with previous LDAs that had been treated surgically were excluded from the study. Cows for which 2 surgical techniques were required during the same surgery to correct the LDA were also excluded. When 2 surgical techniques were required, the first was recorded as a failure and data regarding the second were excluded from the data set. Cows in which 1 or more concurrent diseases had been diagnosed were not excluded from the study, and data regarding these diseases were recorded. Cows were considered ill at the time of surgery when pyrexic (≥ 39.5°C [≥ 103.1°F]) or if diagnosed with 2 or more of the following conditions: metritis, retained fetal membranes, hypocalcemia, mastitis, severe lameness, and pneumonia. Owner consent was obtained by the attending veterinarians prior to performing surgery.

Two-step laparoscopy-guided abomasopexy—Cows treated with 2-step laparoscopy-guided abomasopexy comprised the abomasopexy group. Abomasopexy was performed as described elsewhere, with some modifications. A trocar (internal diameter, 5 mm; length, 12 cm) was used to introduce air into the peritoneal cavity. No containment cage was used; instead, cows were sedated with xylazine (0.05 mg/kg [0.023 mg/lb], IV) administered via the coccygeal vein and guided to dorsal recumbency by use of ropes placed around the trunk and limbs.

As needed, cows were treated with a 50% dextrose solution (500 mL, IV). After surgery, no antimicrobial was administered unless cows had other diseases that required treatment with an antimicrobial. Tolazolineb (0.5 mg/kg, IV) was administered as needed as an antagonist to the effect of xylazine. Cows were subsequently returned to usual management conditions. Rectal temperature was measured by the producers twice a day for the first 3 days after surgery. When the temperature remained > 39.5°C for 24 hours, treatment with antimicrobials was initiated. Producers were instructed to remove sutures 4 weeks after surgery.

Omentopexy via laparotomy in the right paralumbar fossa—Cows treated with omentopexy via laparotomy in the right paralumbar fossa comprised the omentopexy group. Omentopexy with or without pyloropexy was performed as reported elsewhere. As needed, cows were treated with a 50% dextrose solution (500 mL, IV). Procaine penicillin G (22,000 U/kg [10,000 U/lb], IM) was administered immediately prior to surgery. Another antimicrobial may have been administered if the cow developed another disease for which penicillin was not a suitable treatment option. Cows were returned to usual management conditions after surgery. Skin sutures were removed 10 to 14 days after the procedure was performed.

Selection of surgical technique—Choice of surgical technique was assigned systematically to 1 of 2 groups in alternating sequence when the situation permitted. However, because the study was conducted on farms, choice of technique was often influenced by factors such as needs of the producer, availability of laparoscopic instruments, or constraints of the teaching environment.

Data collection—Information on participating cows was collected by veterinarians during farm visits and recorded on data sheets. Collected data included cow identification and medical history (including diseases concurrent with the LDA), results of physical examination (including rectal temperature, heart rate, and respiratory rate), type of surgical technique used to treat the LDA, and treatments administered during the farm visit. Other characteristics of cows were also recorded, including age, body condition score (5-point scale; 1 = thin and 5 = obese), parity, number of days of lactation, lactation number, difficulty of last calving, duration of LDA, previous diseases and treatments since calving, and appetite on the day of surgery (0%, 25%, 50%, 75%, or 100% of usual daily feed intake). All cows were evaluated for acetonaemia by use of a milk sodium nitroprusside test and results were recorded. In addition, certain factors associated with the surgery were recorded for each cow, including perceived ease of surgery (easy, some difficulties, or difficult), presence of...
students during surgery, intraoperative complications, antimicrobial administration, and gross appearance of the required for induction of anesthesia, preparation, and surgery was also recorded.

Producers were interviewed by telephone 7 and 60 days after surgery was performed (day 0) to collect data on the status of cows. Information gathered included appetite (0%, 25%, 50%, 75%, or 100% of usual daily feed intake) and apparent comfort (comfortable or uncomfortable) at days 1, 3, and 7 after surgery; volume of milk yielded (very satisfactory, satisfactory, or unsatisfactory in relation to expected production) at days 1, 3, 7, and 60 after surgery; appearance of surgical wound or site of fixation (typical, swollen, or infected); administration of medications other than those prescribed on the day of surgery; development of another disease after surgery; whether the LDA recurred (relapse or nonrelapse); and whether the cow had been culled (including date and reason for culling). Data on monthly milk yield were recorded when available. Estimated milk yield at 305 days was calculated by use of a minimum of 3 monthly records.

Statistical analysis—Differences between characteristics and results of the 2 surgical techniques were examined by use of statistical software. The Cochran-Mantel-Haenszel test was used for all analyses that involved ordinal variables with >2 categories (ie, appetite or volume of milk produced). For dichotomous variables, the $\chi^2$ test was used. Ordinal data that involved subjective evaluation by producers (eg, very satisfactory, satisfactory, or unsatisfactory) were also reclassified as dichotomous data (satisfactory or unsatisfactory) to minimize potential misclassification bias. Differences between means of continuous variables (eg, age or duration of surgery) were evaluated by use of a t test. A linear regression model was used to estimate milk yield at 305 days. Results of all analyses were considered significant at $P \leq 0.05$.

Results

During the study period, LDA was diagnosed in 305 cows from 79 farms. Of the 305 cows, 23 were treated with a surgical technique other than omentopexy via laparotomy in the right paralumbar fossa or 2-step laparoscopy-guided abomasopexy. Four cows (1 treated with 2-step laparoscopy-guided abomaxopexy and 3 treated with omentopexy) were excluded because they were no longer lactating or were close to the end of the lactation period. Sixteen cows were excluded because they had a relapse of an LDA that had been treated with 2-step laparoscopy-guided abomasopexy (n = 1 cow), toggle-pin fixation (4), or omentopexy (11). Nine cows (6 originally treated with 2-step laparoscopy-guided abomasopexy and 3 originally treated with blind toggle-pin fixation) were excluded because a second technique to reposition the abomasum was required during the same surgical procedure. The remaining 253 cows with an LDA were included in the study. Of the 253 cows, 101 cows were treated with omentopexy via laparotomy in the right paralumbar fossa (the omentopexy group, including 20 with supplemental pyloropexy) and 152 cows were treated with 2-step laparoscopy-guided abomasopexy (the abomaxopexy group).

Prior to surgery, cows in the 2 treatment groups were not significantly different with respect to several characteristics except for the proportion of cows affected by acetonemia (Table 1). In the omentopexy group, 71 of 101 (70.3%) cows had calved unassisted, 25 (24.8%) had calved with the aid of the producer, and 5 (5.0%) had calved with the aid of a veterinarian. In the abomaxopexy group, 114 of 152 (75.0%) cows had calved unassisted, 33 (21.7%) had calved with the aid of a producer, and 5 (3.3%) had calved with the aid of a veterinarian. One of the cows in the omentopexy group was pregnant when treated for an LDA.

Students were involved in 69 of 101 (68.3%) omentopexies and 129 of 152 (84.9%) 2-step laparoscopy-guided abomasopexies. Overall mean duration of surgery was 74.5 minutes for the omentopexy procedure (range, 40.0 to 120.0 minutes) and 36.3 for the abomasopexy procedure (range, 15.0 to 100.0 minutes) and was significantly ($P < 0.0001$) different between procedures. Mean duration of surgery was 60.0 and 76.8 minutes for the omentopexy procedure without or

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Omentopexy</th>
<th>Abomasopexy</th>
<th>$P$ value*</th>
</tr>
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<tbody>
<tr>
<td>Age (y)</td>
<td>3.8 (2–7)</td>
<td>4.1 (2–10)</td>
<td>0.21</td>
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<tr>
<td>Lactation No.</td>
<td>2.3 (1–5)</td>
<td>2.6 (1–8)</td>
<td>0.08</td>
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<tr>
<td>Twin calves (%)</td>
<td>8.9</td>
<td>5.9</td>
<td>0.37</td>
</tr>
<tr>
<td>No. of days of lactation</td>
<td>15.8 (1–244)</td>
<td>14.8 (1–120)</td>
<td>0.74</td>
</tr>
<tr>
<td>Duration of LDA (d)</td>
<td>4.0 (1–15)</td>
<td>3.9 (1–21)</td>
<td>0.78</td>
</tr>
<tr>
<td>Appetite (%)</td>
<td>25.0 (0–75)†</td>
<td>25.0 (0–75)†</td>
<td>0.67</td>
</tr>
<tr>
<td>Body condition score $\S$</td>
<td>3.0 (2.0–5.0)</td>
<td>3.0 (2.6–4.0)</td>
<td>0.80</td>
</tr>
<tr>
<td>Rectal temperature ($^\circ$C)</td>
<td>38.6 (37.0–40.0)</td>
<td>38.6 (37.3–40.2)</td>
<td>0.37</td>
</tr>
<tr>
<td>Acetonemia (%)</td>
<td>53.5</td>
<td>68.4</td>
<td>0.02</td>
</tr>
<tr>
<td>III (%)</td>
<td>25.7</td>
<td>23.0</td>
<td>0.62</td>
</tr>
</tbody>
</table>

*Values reported are mean (range) unless otherwise indicated.
* A value of $P \leq 0.05$ was considered significant. †Appetite was judged by use of a 5-point scale (0%, 25%, 50%, 75%, or 100% of usual daily feed intake). §Body condition was evaluated by use of a 5-point scale (1 = thin and 5 = obese). To convert values to degrees Fahrenheit, multiply the value by 9/5 and add 32.
with students involved, respectively. Mean duration of surgery was 35.1 and 36.5 minutes for the abomasopexy procedure without or with students involved, respectively. Veterinarians rated 84 (83.2%) omentopexies and 110 (72.4%) 2-step laparoscopy-guided abomasopexies as easy to perform. Gross liver abnormalities were detected in 30 of 101 (29.7%) cows in the omentopexy group and 21 of 126 (16.6%) cows in the abomasopexy group. Livers could not be viewed by laparoscopy in 26 cows in the abomasopexy group.

During the omentopexy procedure, a friable omentum was detected in 15 of 101 (14.9%) cows; adhesions were detected in 2 (2.0%). One cow in the omentopexy group was uncooperative. During the abomasopexy procedure, adhesions were detected in 6 (3.9%) cows and severe abomasal dilatation was detected in 3 (2.0%). Six cows in the abomasopexy group were uncooperative. Additional complications related to abomasopexy included difficulty introducing air into the peritoneal cavity (14 [9.2%] cows), location of the toggle pin (10 [6.6%]), and slow release of air from the abomasum (10 [6.6%]).

Prior to surgery, appetite was classified as unsatisfactory in 98% of the cows in both groups. After surgery, the percentage of cows with satisfactory appetite increased rapidly and similarly in the 2 treatment groups (from 25% on day 1 to 88% on day 7 in the omentopexy group and from 18% on day 1 to 84% on day 7 in the abomasopexy group; Figure 1). However, within the abomasopexy group, appetites of cows that received tolazoline after surgery (36 [36.8%] cows) were significantly (P = 0.01) lower at day 3 after surgery than appetites of cows that did not receive tolazoline (96 [63.2%]).

The percentage of cows with satisfactory milk yield increased rapidly in both treatment groups after surgery (from 56% on day 1 to 96% on day 60 in the omentopexy group and from 51% on day 1 to 91% on day 60 in the abomasopexy group; Figure 2). Percentages were not significantly different between treatment groups at any time point. When only data from cows that were not considered ill at the time of surgery were included in the analysis, the difference between treatment groups was not significant. Reclassification of milk yield data from ordinal (very satisfactory, satisfactory, or unsatisfactory) to dichotomous (satisfactory or unsatisfactory) values did not result in detection of a significant association with type of surgery. Associations between duration of LDA and postsurgical milk yield were not significant. Estimated milk yield at 305 days of lactation was not significantly different between the 2 groups (Table 2).

Surgical experience of the attending veterinarian did not have a significant effect on postsurgical milk yield.

**Table 2—Postoperative responses to treatment with omentopexy via laparotomy in the right paralumbar fossa (omentopexy) or 2-step laparoscopy-guided abomasopexy (abomasopexy) in cows with an LDA.**

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Omentopexy</th>
<th>Abomasopexy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. affected</td>
<td>Total No. of cows</td>
</tr>
<tr>
<td>Culled before 60 d of lactation (%)</td>
<td>12</td>
<td>101</td>
</tr>
<tr>
<td>Culled before 100 d of lactation (%)</td>
<td>17</td>
<td>81</td>
</tr>
<tr>
<td>Culled before 1 y after surgery (%)</td>
<td>19</td>
<td>60</td>
</tr>
<tr>
<td>Estimated milk yield at 305 d of lactation (kg)*</td>
<td>—</td>
<td>51</td>
</tr>
</tbody>
</table>

*Values were estimated by use of a linear regression model on the basis of data obtained from 3 monthly reports on milk yield; differences between groups were not significant. †To convert kilograms of milk to pounds of milk, multiply value by 2.2.
— = Not applicable.
yield; however, the veterinarian’s classification of the surgery as easy (vs not easy) was significantly (\(P = 0.03\)) associated with increased postsurgical milk yield within the omentopexy group. On day 7 in the omentopexy group, the percentage of cows with satisfactory milk yield was significantly (\(P = 0.03\)) higher among cows in which surgery was reported as easy (74/84 [88.1%] cows) versus cows in which surgery was not considered easy (11/17 [64.7%]). This effect was no longer evident at day 60, nor was it evident at any time within the abomasopexy group.

Cow comfort after surgery as perceived by producers improved rapidly in the 2 groups (from 79% on day 1 to 96% on day 7 in the omentopexy group and from 78% on day 1 to 95% on day 7 in the abomasopexy group). Post surgical cow comfort was not influenced by the procedure used; however, cows in the omentopexy group that were judged as ill prior to surgery were significantly (\(P = 0.05\)) more uncomfortable at day 3 than cows that were not judged to be ill. One cow appeared to develop severe peritonitis after 2-step laparoscopy-guided abomasopexy was performed, but the cow survived and continued to yield milk through completion of the study.

Antimicrobials were administered IM to all cows in the omentopexy group every 12 hours for 3 days after surgery. Procaine penicillin (22,000 U/kg) was administered to 91 of 101 (90.1%) cows. Of the remaining 10 cows, 1 received cefotiofur hydrochloride (1 mg/kg [0.5 mg/lb]), 3 received oxytetracycline hydrochloride (10 mg/kg [4.5 mg/lb]), and 6 received a combination of trimethoprime (20 mg/kg [9.1 mg/lb]) and sulfadinoxine (100 mg/kg [45.3 mg/lb]). In the abomasopexy group, 31 of 152 (20.4%) cows received antimicrobials for 3 days after surgery. Of the 31 cows, 26 (83.9%) were treated with antimicrobials because they developed a fever of unknown origin (> 39.5°C) after surgery; the other 5 cows received antimicrobials for metritis, mastitis, pneumonia, plebitis, or lameness. Two cows received cefotiofur hydrochloride (1 mg/kg, IM, q 24 h), 24 received procaine penicillin, and 3 received a combination of trimethoprim and sulfadinoxine at the aforementioned dosages. In the abomasopexy group, cows that received antimicrobials had a significantly lower score for appetite at day 7 and yielded significantly (\(P = 0.007\)) less milk at day 7 and significantly (\(P = 0.003\)) less milk at day 60, compared with cows that did not receive antimicrobials.

Surgical sites became swollen or infected in 11 of 101 (10.9%) cows in the omentopexy group and 19 of 152 (12.5%) cows in the abomasopexy group. The main complication that developed after omentopexy via laparatomy in the right paralumbar fossa was surgical site infection, which was reported in 9 (8.9%) cows. The most frequently reported problem after 2-step laparoscopy-guided abomasopexy was swelling at the site of fixation, which was detected in 12 (7.9%) cows.

Risk of being culled was not significantly different between the 2 groups of cows at any point during the follow-up period (Table 2). Illness at the time of surgery was not associated with an increased risk of subsequent culling. Sixteen of the 26 (61.5%) culled cows were culled because they failed to respond to surgery and yielded less milk than expected. The remaining 8 (30.8%) were culled because they developed another health problem (ie, mastitis, teat laceration, pneumonia, or severe lameness; n = 6 cows) or were sold to another producer (2). Proportions of cows culled for the aforementioned reasons were similar between groups.

Initial 2-step laparoscopy-guided abomasopexy was unsuccessful in 6 of 152 (3.9%) cows. In those cows, a second surgical technique was required to correct the LDA and data from this second surgery were excluded from statistical analysis. A different reason for failure was reported for each cow. Reasons included insertion of threads of the toggle-pin into the abomasum; severe dilatation of the abomasum, preventing adequate positioning of the trocar; inability to locate the threads of the toggle-pin in the second step because the cow was uncooperative; excessively rapid deflation of the abomasum when air was introduced into the peritoneal cavity; rupture of the wall of the abomasum and subsequent unfastening of the toggle-pin; or vestige of the umbilical vein obstructing view of the abomasum. In addition, 2-step laparoscopy-guided abomasopexy could not be completed in 6 cows with extensive adhesions in the abdominal cavity. In those cows, a second technique was not attempted because producers decided to cull the cows within a few days. In the omentopexy group, adhesions were detected in 2 cows. One cow had an adhesion that involved the abomasum; the other had an adhesion that involved the liver and the abdominal wall. In both cows, surgery was performed successfully.

No significant associations were detected between responses to surgical techniques and characteristics of the cow at surgery (ie, appearance of the liver, age of cow, number of days of lactation, and body condition score) and duration of the surgical procedure. Among the cows for which follow-up data were available for a period beyond 60 days, only 1 relapse of an LDA was reported for an abomasopexy-treated cow. That relapse developed > 1 year after abomasopexy and after a subsequent calving. No relapses were reported for cows in the omentopexy group.

**Discussion**

To the authors’ knowledge, the study reported here was the first in which investigators compared omentopexy via laparotomy in the right paralumbar fossa with 2-step laparoscopy-guided abomasopexy in dairy cows in farm settings. Although conditions did not allow random assignment of cows to treatment groups, certain general conclusions can be drawn because cows in the 2 treatment groups were similar with respect to presurgical characteristics and because a large number of cows were included in the study.

The 2 surgical procedures resulted in equivalent values of short-term outcomes (milk yield, comfort, and appetite at days 1, 3, and 7) and long-term outcomes (milk yield at 60 days, estimated milk yield at day 305, relapse rate, and risk of culling at 60 days). Thus, the 2-step laparoscopy-guided abomasopexy procedure was as efficacious as the more commonly used procedure (omentopexy via laparotomy in the right paralumbar fossa).
Feed intake and milk yield are reported\textsuperscript{12} to increase more rapidly in cows with an LDA corrected by use of 2-step laparoscopy-guided abomasopexy versus omentopexy. These associations were not detected in the study reported here. One reason for the discrepancy may be that the other study\textsuperscript{12} in which the associations were detected took place in university veterinary hospital conditions and without sedation, whereas our study took place on farms and with sedation. The results of our study may also have been influenced by the subjective nature of the surgical outcomes measured. In our study, producers were asked to judge how well their cows responded to surgery, and their responses may have been influenced by pre-existing attitudes about the procedure used. In addition, in our study, cows were sedated for 2-step laparoscopy-guided abomasopexy, which may have adversely affected short-term postsurgical outcomes. Surprisingly, administration of tolazoline as an antagonist against the effect of xylazine did not improve postsurgical outcomes and appeared to have an adverse effect on appetite 3 days after the procedure.

Mean duration of the procedure (time required for preparation and surgery) was significantly shorter for 2-step laparoscopy-guided abomasopexy (36.3 minutes), compared with omentopexy via laparotomy in the right paralumbar fossa (74.5 minutes). The shorter duration of the 2-step laparoscopy-guided abomasopexy procedure may be of interest to veterinarians who wish to devote more time to other tasks. Duration of either technique would be expected to be even shorter when students are not involved.

Because the risk of contamination during surgery in farm settings is not negligible, postsurgical antimicrobials are routinely prescribed for cows with an LDA that are treated via omentopexy on the farm.\textsuperscript{13} In the study reported here, antimicrobial treatment of all cows that received an omentopexy was justified because surgery was performed on farms and students were involved in the procedures. Compared with the risk of contamination during procedures that involve a surgeon alone, the risk of contamination when students participate should be higher because more people explore the abdomen, more time is needed to perform the surgery, and students are more likely to break aseptic technique than experienced surgeons. Regardless of student participation in our study, administration of antimicrobials was only required in a minority (20.4%) of cows after 2-step laparoscopy-guided abomasopexy.

In the study reported here, some cows with an LDA had other pathologic conditions that may have accounted for the pyrexia detected in some cows after surgery, but fever of unknown origin was often the only abnormality reported by producers. There is also a risk of contamination when students participate should the other study when pyrexia was detected after surgery. The 2-step laparoscopy-guided abomasopexy procedure may be advantageous to producers because less reliance on antimicrobials may result in shorter periods for withholding milk from sale and a reduced risk of contamination of bulk-tank milk with antimicrobial residues. Such benefits were perceived as important by dairy producers involved in our study and were the major factors that convinced several producers to choose 2-step laparoscopy-guided abomasopexy. Dairy producers in our study were quickly and easily convinced that the 2-step laparoscopy-guided abomasopexy is a suitable option for treatment of an LDA, and some of them were convinced that abomasopexy was superior to omentopexy.

Compared with omentopexy via laparotomy in the right paralumbar fossa, 2-step laparoscopy-guided abomasopexy also involves some disadvantages. Because cows must be positioned in dorsal recumbency during the abomasopexy technique, the procedure requires more space than omentopexy and may require sedation of cows and the aid of 2 or 3 additional people. There are also risks associated with dorsal recumbency, but no incidents were reported in this study. The need for sedation and additional assistance can be eliminated by use of a hydraulic containment apparatus similar to that used in several European countries, which allows easy and safe positioning of cows in dorsal recumbency.\textsuperscript{14} The aforementioned disadvantages have prompted interest in a 1-step technique that does not require positioning of cows in dorsal recumbency.\textsuperscript{15,16} The 1-step method is reportedly easier to perform without assistance than the 2-step method, but requires postsurgical treatment with antimicrobials more often.\textsuperscript{17}

Another disadvantage of 2-step laparoscopy-guided abomasopexy is that the procedure cannot be completed when extensive adhesions or, less often, the vestiges of embryonic umbilical structures are encountered. In those circumstances, cows may be culled when the likelihood of success of another procedure is deemed to be low. In the study reported here, abnormalities that precluded completion of the abomasopexy were detected in 6 cows.

Finally, the price of instruments must also be considered when choosing a surgical technique for use on farms. A complete laparoscopic instrument kit is expensive (approx $7,500); however, the instruments are durable. None of the instruments broke during or after the study reported here, so no additional investment was necessary. Laparoscopic instruments can also be used for other purposes, such as diagnosis of various microorganisms were automatically administered to all cows treated with omentopexy but were only administered to cows treated with 2-step laparoscopy-guided abomasopexy when pyrexia was detected after surgery. The 2-step laparoscopy-guided abomasopexy procedure may be advantageous to producers because less reliance on antimicrobials may result in shorter periods for withholding milk from sale and a reduced risk of contamination of bulk-tank milk with antimicrobial residues.
abdominal diseases. In conditions such as those in our study, the cost of the instruments would be recovered after approximately 100 laparoscopy-guided abomasopexy procedures. When instruments are used for these and other purposes, the time interval in which costs could be recovered may be even shorter.

References