# Comparison of laparoscopic-guided abomasopexy versus omentopexy via right flank laparotomy for the treatment of left abomasal displacement in dairy cows

Torsten Seeger, Dr Med Vet; Harald Kümper, Dr Med Vet; Klaus Failing, Dr Rer Nat; Klaus Doll, Dr Med Vet Habil

**Objective**—To compare results obtained by use of laparoscopy-assisted abomasopexy versus omentopexy via right flank laparotomy for the treatment of dairy cows with left displaced abomasum (LDA).

**Animals**—120 dairy cows with an LDA.

**Procedure**—In a prospective clinical trial, cows were randomly allocated to the abomasopexy group (laparoscopy-assisted abomasopexy) or to the control group (omentopexy via right flank). Data were obtained during the first 5 days after surgery and 6 weeks and 6 months after surgery.

**Results**—59 of 60 cows in the abomasopexy group and all 60 cows in the control group were treated successfully. Median duration was shorter for the laparoscopic procedure (27.5 minutes), compared with that for the control group (38 minutes). Five cows in the abomasopexy group had wound complications and 2 had LDA relapses, compared with 2 wound complications and no relapses in the control group. During the 5 days after surgery, the abomasopexy group had a significantly higher increase in rate of energy intake and milk yield and a more rapid return to reference range for serum glutamic dehydrogenase activity and total bilirubin concentration, compared with results for the control group.

**Conclusions and Clinical Relevance**—Success rates were almost equal for both methods. Advantages of the laparoscopic abomasopexy procedure include practicality, low risk of complications, and rapid postoperative recovery. Contraindications are cardiopulmonary diseases. Other disadvantages include the cost of the instruments and inability to perform the procedure in cows with abomasal adhesions. (*Am J Vet Res* 2006;67:472–478)

The first account of an LDA was in the 1950s.[1] This disorder has continuously increased in importance.[2] Dairy cattle, such as Holstein-Friesians or Guernseys, are the most commonly affected.[3] The mean lactation incidence is approximately 1% to 5% but is > 10% in some herds.[3–7] Various surgical procedures have been used, all of which have specific advantages and disadvantages. Open surgical techniques include abomasopexy via the ventral paramedian approach[8]; laparotomy via the left paralumbar fossa for omentopexy[9] and abomasopexy,[10] respectively; and omentopexy via laparotomy in the right paralumbar fossa.[11] Omentopexy via laparotomy in the right paralumbar fossa is considered the standard procedure for the treatment of cattle with an LDA in Germany. Because of financial and time constraints, percutaneous fixation techniques, such as the blind-tack suture procedure[12] or toggle-pin method,[13] have become more commonly used by practitioners, even though success rates are lower and the risk of complications is increased.[2,a]

In 1998, a minimally invasive laparoscopic procedure for the treatment of LDAs was introduced.[14] This method combines the advantages of conventional open surgery methods, namely high therapeutic safety and success rates of laparotomy, with the practicality of percutaneous abomasopexy. That laparoscopic technique is divided into 2 stages. The first stage is performed with the animal standing, and the second is conducted after the animal has been positioned in dorsal recumbency. In 2004 and 2005, other laparoscopy-assisted procedures for treatment of abomasal displacement were described.[15–17,b] These 1-stage procedures are performed via the left paralumbar fossa with the animal standing or via the ventral abdominal wall with the animal positioned in dorsal recumbency.[15–17] To our knowledge, data published for these methods have been based solely on anecdotal evidence.[14–17,b,c] The objective of the study reported here was to compare results achieved by use of the 2-stage laparoscopy-assisted abomasopexy and omentopexy via laparotomy in the right paralumbar fossa.

## Materials and Methods

**Animals**—The study was performed on cattle with an LDA admitted to the Clinic for Ruminants and Swine,

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| LDA | Left displaced abomasum |
| Q1 | First quartile |
| Q3 | Third quartile |
| USP | United States Pharmacopeia |
| NEL | Net energy for lactation |
| RM | Repeated measures |
| GDH | Glutamic dehydrogenase |

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From the Clinic for Ruminants and Swine (Seeger, Kümper, Doll) and Department of Biomathematics and Data Processing, Institute of Veterinary Physiology (Failing), University of Giessen, 35392 Giessen, Germany.
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Address correspondence to Dr. Doll.

University of Giessen, between January 2000 and August 2002. Inclusion criteria were cows with an LDA, independent of the degree of displacement, and informed consent provided by the owners. Exclusion criteria included cows that were pregnant (gestation > 3 months) and cows that had other diseases, except acetonemia (as determined on the basis of results for a urine test strip[d]), mild hepatic dysfunction without icterus, mild endometritis or mild mastitis without fever, and mild lameness (score of 2 on a scale of 1 to 5)[18] affecting only 1 limb.

After confirmation of eligibility, 120 cows with an LDA were included in the study. Cows (60 cows/group) were assigned by use of a randomization list to surgical treatment by use of a laparoscopy-assisted abomasopexy[14] or omentopexy via laparotomy in the right paralumbar fossa[11] (control group). The randomization list was generated by use of a validated program[e] in accordance with a nonblock design. Sealed envelopes numbered 1 through 120 were prepared that assigned each cow to the laparoscopy-assisted abomasopexy or control group. These envelopes were opened only after confirmation of eligibility and immediately before surgery. Day of surgery was designated as day 0.

All cattle were Holsteins, except for 2 Fleckvieh cows (1 in each group). Although we did not consider parity, lactation status, and duration of clinical signs when assigning cows to the treatment groups, both groups were almost identical with regard to these variables. In most cows of the laparoscopy-assisted abomasopexy and control groups, the LDA was detected shortly after the second parturition. For both groups, median parity was 2, with parity of 1 and 4 for Q1 and Q3, respectively. Parity ranged from 1 to 7 for the abomasopexy group and 1 to 9 for the control group. Number of days in milk was also similar between the abomasopexy group (median, 13.5 days; Q1, 7.8 days; Q3, 21.3 days; range, 2 to 89 days) and control group (median, 15.0 days; Q1, 9.8 days; Q3, 25.0 days; range, 2 to 82 days). Duration of clinical signs also was similar for the abomasopexy group (median, 4.5 days; Q1, 2 days; Q3, 7 days; range, 1 to 21 days) and control group (median, 5.5 days; Q1, 2 days; Q3, 10 days; range, 1 to 22 days).

**Laparoscopy-assisted abomasopexy—**For laparoscopy-assisted abomasopexy, the original surgical instruments[f] developed for this method and a 180° hydraulic tiltable surgery table[g] were used. In general, cows were not sedated and only physically restrained so that they were able to stand safely after surgery. Only 2 extremely restless cows were administered detomidine[h] (20 µg/kg, IM.). Each cow was positioned with its right flank against the tiltable table, and the head of each cow was then secured.

Two small areas, one in the cranial aspect of the left paralumbar fossa (position 1) and the other 10 cm ventral to the transverse processes of the lumbar vertebrae in the left 11th intercostal space (position 2), were clipped and prepared for aseptic surgery. Each site was infiltrated with 20 mL of a 2% solution of procaine, which was followed by a stab incision with a scalpel in the center of each area.[14] For position 1, a Verres needle connected to a halogen cold light source with an integrated insufflator was inserted into the abdomen. The intra-abdominal pressure was passively equalized with the outside pressure, and 42 L of filtered air was then insufflated (3.5 L/min) to create pneumoperitoneum. In cows, this volume leads to an overpressure of 5 to 10 mm Hg.[19] A magnetic valve trocar (length, 12 cm; internal diameter, 8 mm) was inserted via position 1 such that a rigid 0° laparoscope (length, 40 cm; diameter, 8 mm) could be introduced into the abdominal cavity. The abomasum, rumen, spleen, and left abdominal wall were visually inspected. Laparoscopic guidance was used to insert a second trocar (length, 35 cm; internal diameter, 5 mm) at position 2 into the abdomen and then the dorsocranial aspect of the LDA (ie, greater curvature of the abomasum). The stylet was removed from the trocar, and a modified toggle[i] was inserted through the trocar sleeve into the abomasum. The abomasum was then deflated, which resulted in retraction to a ventral position. The trocar sleeve exited the abomasum during retraction, and the toggle suture was pulled into the abdominal cavity. At this point, all instruments were removed and the entry points were treated with a spray containing aluminum powder.[14]

Each cow was restrained to the tiltable table by use of 2 belts (1 placed around the thorax and 1 placed around the abdomen). The table was tilted to position the cow in right lateral recumbency, and the forelimbs and hind limbs were secured to the table by tying them to the adjustable foot supports by use of soft nylon bands placed approximately 10 cm proximal to the metacarpophalangeal or metatarsophalangeal joints. The table was then tilted further such that the cow was ultimately positioned in dorsal recumbency.

Two more entry sites, each of which was 10 cm cranial to the umbilicus, were clipped, aseptically prepared, and infiltrated with procaine solution, followed by a stab incision. A magnetic valve trocar (length, 12 cm; internal diameter, 8 mm) was inserted into the abdomen at a point 5 cm to the left of the midline (position 3) and served as a portal for the laparoscope. A second trocar (length, 12 cm; internal diameter, 5.5 mm) was inserted into the abdomen at a point 5 cm to the right of the midline (position 4) and served as an instrument portal for a forceps (length of forceps, 60 cm). The toggle sutures were located by use of the laparoscope, grasped with the forceps, and exteriorized. The trocar sleeve at position 4 was removed, and the ends of the sutures were clamped with a hemostat to prevent them from gliding back into the abdominal cavity. The laparoscope was removed and excess air was expressed from the abdomen via the trocar sleeve at position 3.

The tiltable table was repositioned such that each cow was returned to right lateral recumbency. Tension was placed on the toggle sutures to position the abomasum against the abdominal wall. In cows with incisional swelling, tension on the toggle sutures may lead to formation of an abomasal fistula. Therefore, both sutures were threaded through a gauze bandage and tied into a knot that left a gap of 5 cm between the toggle and gauze bandage. The entry points of the trocars were sprayed with the aluminum powder. In accordance with the original description of the surgical technique,[14] antimicrobials were not routinely administered after surgery. Sutures were allowed to remain in place until 4 weeks after surgery to ensure stable adhesion of the abomasum to the abdominal wall.[14]

**Omentopexy via laparotomy in the right paralumbar fossa—**Omentopexy was performed on cows of the control group. Local anesthesia was achieved by infiltration with a 2% solution of procaine in an inverted-L block. Omentopexy was performed as described elsewhere.[11] After an incision was made in the right paralumbar fossa, the displaced abomasum was identified. Gas was expelled from the abomasum by inserting a large-gauge needle attached to a piece of tubing. The abomasum was then repositioned to its typical position. The greater omentum was affixed by use of polyamide suture (USP 6 [metric 8]) to the abdominal wall at a point 10 cm from the pylorus, approximately 10 cm caudal to the ventral aspect of the incision in the right paralumbar fossa, and approximately 20 cm dorsal to the flank fold. The suture was passed through an oval disk (5.5 × 2.2 cm) consisting of synthetic polyamide fibers[j]; the disk was attached to the visceral portion of the omentum in an attempt to minimize the risk that there would be too much tension on the suture and it would abrade into the omentum. The laparotomy incision was closed by use of silk suture (USP 8 [metric 10]). In

accordance with the original description of the surgical technique,[11] all cows in the control group were treated by intra-abdominal administration of an antimicrobial solution[k] containing 1.5 g of ampicillin and 1.5 g of cloxacillin immediately before the laparotomy site was closed.

**Evaluation of clinical progress and additional treatments**—Cows were housed separately in stalls in our clinic for 5 days after surgery to enable postsurgical surveillance. Cows were fed grass hay and concentrate with minerals 3 times daily. Amount of feed provided at each feeding was weighed by use of a calibrated scale. Uneaten feed was retrieved and weighed immediately before the subsequent feeding. The NEL was calculated on the basis of feed intake for each of the feedstuffs. For the concentrate,[l] manufacturer information indicated it contained 6.35 MJ/NEL. For the grass hay, textbook values[20] were used.

Cows were milked twice each day. Milk yield was recorded electronically by use of a flow-measuring device.[m] Precision of these measurements was ± 7%.

Physical examination was performed twice daily. Concentrations of ketone bodies were measured semiquantitatively in the urine by use of commercially available test strips[c] and scored on a scale of 0 to 3 (0, negative results; 1, mild acetonemia; 2, moderate acetonemia; and 3, severe acetonemia). When urinalysis by use of the commercial test strip revealed mild or moderate acetonemia, the cow was administered propylene glycol (200 mL, PO, q 12 h). When severe acetonemia was detected, the cow was administered propylene glycol and a 10% glucose solution (10 L/24 h, IV). Parental antimicrobial treatment was initiated when body temperature of a cow exceeded 39.5°C.

Blood samples were collected from a jugular vein before and on the fifth day after surgery. Blood samples were placed in tubes containing potassium EDTA, heparin, or no anticoagulant. Samples were used for determination of a CBC count; measurement of concentrations of glucose, urea, total bilirubin, calcium, magnesium, inorganic phosphate, sodium, potassium, and chloride; measurement of GDH activity; and evaluation of blood gases.

Cows were discharged to their respective owners on day 6 after surgery. Six weeks and 6 months after surgery, the outcome, condition, and milk yield for each cow were determined at their farm of origin.

**Statistical analysis**—Five primary response variables were chosen to compare results for the minimally invasive procedure and control treatment. Response variables were success rate (defined as successful repositioning and fixation of the LDA during surgery), incidence of complications (including relapse) after surgery, daily energy intake, daily milk yield, and ketone body concentration in the urine. Various secondary response variables were also analyzed, such as duration of the procedure, additional results of physical examination and laboratory analyses, and data collected at the farms of origin.

Results were compared by the use of an RM ANOVA with 2 factors (time and group), the Friedman 2-way blocked ANOVA, the Wilcoxon Mann-Whitney *U* test, or the Fisher exact test (2-sided),[21,n] depending on the type and distribution of the data and number of observations. The $\alpha$ values were always for 2-sided tests. A Bonferroni correction (ie, $\alpha/5$) was performed for the significance value to control for the risk of false-positive results within the primary response variables. Accordingly, test results were considered significant for values of $P < 0.01$.

No correction was performed for the secondary response variables because they were not used to evaluate the results. Secondary response variables were determined only for exploratory purposes to detect potential differences between the groups.

## Results

**Primary response variables**—The success rate did not differ significantly ($P = 1.0$; Fisher exact test [2-sided]) between the surgical procedures. The surgical procedure was successfully completed in 59 of 60 (98.3%) cows in the laparoscopy-assisted abomasopexy group and 60 of 60 (100%) cows in the omentopexy (control) group. In the 1 cow in which we were not able to successfully complete the surgical procedure, extensive adhesion of the abomasum to the left ventral abdominal wall resulted from a perforating ulcer, and repositioning was therefore not possible. That cow was euthanatized and the diagnosis confirmed during necropsy. Thus, data for that cow were excluded from further evaluation.

Postsurgical complications were observed in 7 (11.6%) cows of the abomasopexy group, which did not differ significantly ($P = 0.163$; Fisher exact test [2-sided]) from the number of cows with postsurgical complications (2 [3.3%]) in the control group. Two cows in the abomasopexy group developed moderate localized peritonitis that was more severe than expected after the surgical procedure. Peritonitis was diagnosed on the basis of clinical signs (fever, tenseness of the abdominal wall, and moderate decrease in general condition) and results of transabdominal ultrasonography. Furthermore, 3 cows developed cellulitis at the abomasopexy site, which was recognizable as a phlegmonous swelling of the abdominal wall, and 2 cows had a relapse of the LDA after they had kicked the gauze bandage off. For both cows with relapse, a second laparoscopy-assisted abomasopexy was successfully performed. None of the cows in the control group had relapse of the LDA, but 2 cows developed a purulent infection at the omentopexy site. All wound infections (3 cows with cellulitis in the abomasopexy group and 2 cows with purulent infection in the control group) resolved after parenteral administration of an antimicrobial for several days.

Daily energy intake increased significantly ($P < 0.001$; RM ANOVA) after surgery in each group. However, the increase was significantly ($P < 0.001$; RM ANOVA) more rapid for the abomasopexy group. On the day of surgery (day 0), median energy intake was 21.4 MJ of NEL (Q1, 16.8 MJ of NEL; Q3, 25.3 MJ of NEL; range, 6.8 to 34.6 MJ of NEL) for the abomasopexy group and 12.2 MJ of NEL (Q1, 9.1 MJ of NEL; Q3, 15.2 MJ of NEL; range, 5.1 to 21.9 MJ of NEL) for the control group. By day 4 after surgery, median energy intake increased to 86.1 MJ of NEL (Q1, 77.2 MJ of NEL; Q3, 99.7 MJ of NEL; range, 42.7 to 124.7 MJ of NEL) for the abomasopexy group and 71.9 MJ of NEL (Q1, 59.2 MJ of NEL; Q3, 89.6; range, 11.9 to 120.7 MJ NEL) for the control group (**Figure 1**).

Results for milk yield had the same pattern as that for daily energy intake. Daily milk yield increased significantly ($P < 0.01$; RM ANOVA) after surgery in each group. For the abomasopexy group, median milk yield documented for the afternoon milking after surgery was 2.9 kg (Q1, 1.0 kg; Q3, 4.4 kg; range, 0.3 to 11.9 kg), whereas corresponding median milk yield was 1.9 kg (Q1, 0.6 kg; Q3, 3.9 kg; range, 0.2 to 8 kg) for the control group. On day 4 after surgery, median daily milk

yield reached 17.9 kg (Q1, 15.1 kg; Q3, 21.6 kg; range, 9 to 34.5 kg) for the abomasopexy group and 15.8 kg (Q1, 12.3 kg; Q3, 19.4 kg; range, 4.5 to 36.8 kg) for the control group (**Figure 2**). Analysis of daily milk yield on each of the 5 days after surgery revealed a significantly ($P$ = 0.003; RM ANOVA) higher rate for the abomasopexy group, compared with that for the control group.

During initial examination at our clinical facility, all cows had mild to severe acetonemia, which decreased significantly ($P$ < 0.001; Friedman 2-way blocked ANOVA) after surgery. On the day of surgery, median score for ketone body concentration in the urine was 2 (Q1, 0.3; Q3, 3; range, 0 to 3) for the abomasopexy group and 1 (Q1, 0; Q3, 2; range, 0 to 3) for the control group. On day 4, values were the same for both groups (median, 0; Q1, 0; Q3, 0; range, 0 to 2). Values did not differ significantly ($P$ = 0.162 to 0.926; Wilcoxon Mann-Whitney $U$ test) between the 2 groups on any of the study days.

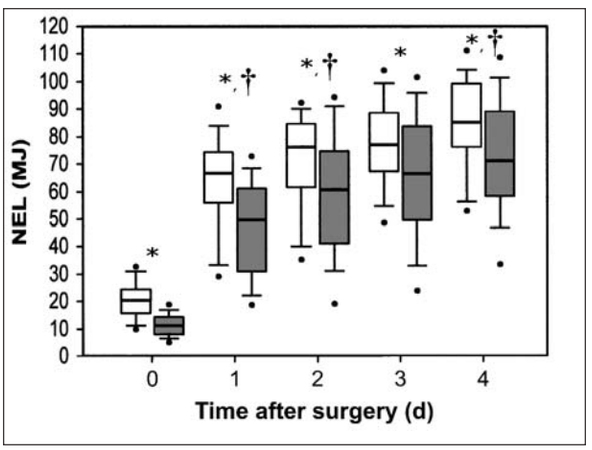


Figure 1—Box-and-whisker plots of energy intake for dairy cows during the first 5 days after laparoscopic-assisted abomasopexy (white boxes) or omentopexy via laparotomy in the right paramedian fossa (gray boxes) to correct an LDA. Day 0 is the day of the surgical procedure; data for day 0 represent energy intake after the procedure was completed. The boxes represent the 25th to 75th percentiles, whiskers represent the 10th to 90th percentiles, and dots represent 5th to 95th percentiles. The horizontal bar in each box represents the median value. *Within a time point, the median value differs significantly ($P$ < 0.001) between the surgery groups. †Within a time period, the median value for both surgery groups increased significantly ($P$ < 0.001), compared with the value for the preceding time period.

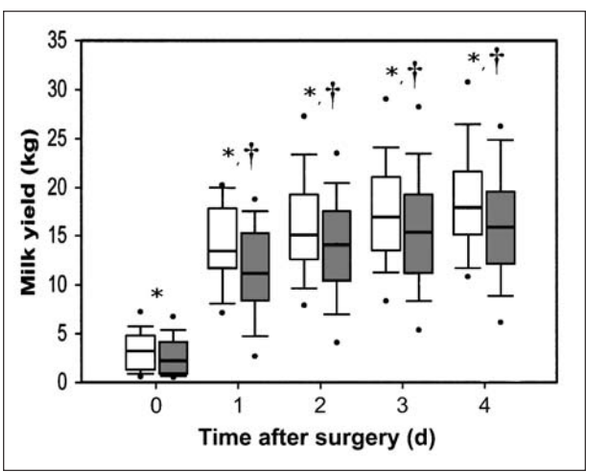


Figure 2—Box-and-whisker plots of milk yield for dairy cows during the first 5 days after laparoscopic-assisted abomasopexy (white boxes) or omentopexy via laparotomy in the right paramedian fossa (gray boxes) to correct an LDA. Day 0 is the day of the surgical procedure; data for day 0 represent milk yield after the procedure was completed. *Within a time point, the median value differs significantly ($P$ = 0.003) between the surgery groups. *See* Figure 1 for remainder of key.

**Secondary response variables**—Duration of the surgical procedures was defined as the interval between the first skin incision and end of the surgery. Median duration of the procedure was 27.5 minutes (Q1, 24 minutes; Q3, 31.3 minutes; range, 20 to 46 minutes) for the abomasopexy group, which was significantly ($P$ < 0.01; Wilcoxon Mann-Whitney $U$ test) less than for the control group (median, 38 minutes; Q1, 35 minutes; Q3, 45 minutes; range, 22 to 60 minutes).

Values for variables monitored by use of physical examinations during the postoperative period did not differ significantly between the 2 groups of cows. These variables included body temperature, heart rate, respiratory rate, and results for auscultation of the lungs.

Analysis of laboratory data revealed minor differences between the 2 groups regarding serum total bilirubin concentration and GDH activity. Values for these variables returned to within the respective reference ranges but at a significantly ($P$ < 0.01; RM ANOVA) faster rate for the abomasopexy group, compared with the rate for the control group. Median bilirubin concentration before surgery was 13.8 µmol/L (Q1, 9.9 µmol/L; Q3, 19.1 µmol/L; range, 6.8 to 36.8 µmol/L) for the abomasopexy group, which decreased to 7.1 µmol/L (Q1, 5.2 µmol/L; Q1, 11.3 µmol/L; range, 3.1 to 19.1 µmol/L) on day 4. Median bilirubin concentration for the control group before surgery was 13.5 µmol/L (Q1, 7.7 µmol/L; Q3, 18.2 µmol/L; range, 1.6 to 31 µmol/L), which decreased on day 4 to 7.5 µmol/L (Q1, 5.5 µmol/L; Q3, 13.7 µmol/L; range, 2.5 to 29.6 µmol/L). Before surgery, median GDH activity for the abomasopexy group was 17.5 U/L (Q1, 9.0 U/L; Q3, 35.5 U/L; range, 2 to 283 U/L) and 22.5.1 U/L (Q1, 15.0 U/L; Q3, 34.3 U/L; range, 2 to 229 U/L) for the control group. There was a further decrease in GDH activity until day 4 for the abomasopexy group (median, 9.0 U/L; Q1, 5.0 U/L; Q3, 12.8 U/L; range, 2 to 51 U/L), compared with values for the control group (median, 10.8 U/L; Q1, 10.8 U/L; Q3, 30.0 U/L; range, 2 to 101 U/L).

After 5 days of monitoring in our clinical facility, 58 of 60 (96.7%) cows in the abomasopexy group had recovered completely and were discharged to their respective farm of origin. In addition to the 1 cow with a perforated abomasal ulcer and adhesions, another cow was euthanatized because of a pelvic fracture sustained during a sudden fall in the clinic. For the control group, 59 of 60 (98.3%) cows were discharged after successful treatment of an LDA. One cow was euthanatized because of liver failure caused by severe hepatic degeneration and lipidosis, which were confirmed during necropsy.

Six weeks after surgery, all cows discharged to their owners were in typical dairy production. Relapses or complications attributable to the surgical procedure were not reported. Median daily milk yield for the abomasopexy group was 28.8 kg (Q1, 25.2 kg; Q3, 32.1 kg; range, 15.8 to 51.3 kg), which was significantly ($P < 0.01$; Wilcoxon Mann-Whitney $U$ test) higher than for the control group (median, 26.3 kg; Q1, 22.2 kg; Q3, 30.2 kg; range, 13.6 to 39.2 kg).

Six months after surgery, most of the cows in both groups had progressed satisfactorily, were pregnant, and were maintained in their herds of origin for a subsequent lactation. Five cows in each group were sent to slaughter because of infertility, chronic mastitis, or lameness. At 6 months after surgery, recovery rates were almost equal in both groups (88.3% and 90.0% for the abomasopexy and control groups, respectively); recovery rates did not differ significantly ($P = 0.88$; Fisher exact test [2-sided]) between groups. In addition, milk yields were similar between groups.

## Discussion

Success rates for the treatment of cattle with an LDA cited in the literature are not comparable for many reasons, such as the varying number and selection of patients, differing criteria applied to evaluate therapeutic success, and the varying period during which animals were monitored. Only a few controlled clinical studies[22,23,a] have compared various treatment methods. There is a high success rate for omentopexy via laparotomy in the right paralumbar fossa,[11,23–26,a] which was confirmed by the study reported here. The laparoscopic procedure was equally successful in the treatment of cows with an LDA. The 1 cow with a perforating ulcer did not recover even though laparotomy was performed immediately after the attempted laparoscopic method had failed. Similarly, high success rates for this laparoscopic procedure have also been described by other authors.[14,c] Analysis of results obtained for the study reported here revealed that the minimally invasive laparoscopic method is a safe alternative method of treatment, independent of the degree of abomasal displacement and amount of rumen contents. These advantages cannot be unconditionally applied to the traditional blind-tack method and toggle-pin technique.[27,a] Adhesions can limit manipulation during laparoscopy, and laparotomy is considered the method of choice in cows in which adhesions are suspected.

Significantly higher feed intake during the first 24 hours after surgery in cows treated by use of the laparoscopic abomasopexy procedure may indicate that the minimally invasive technique was associated with less postoperative pain than the standard surgical approach via the right paralumbar fossa. This advantage also partially applies to other percutaneous methods of abomasopexy.[a] In the experience of one of the authors, cows with an LDA treated by use of the laparoscopic method had a lower peak and an accelerated decrease of serum cortisol concentrations after surgery, compared with results for cows treated by use of right-sided laparotomy. These results and conclusions could explain the more rapid return to typical feed intake and a more rapid increase in milk yield in our study, which confirmed observations made in practice settings.[14,c]

Several investigations[28,29] have revealed that positioning cows in dorsal recumbency results in considerable cardiopulmonary effects, even when the cows are not sedated. In the study reported here, we did not measure these effects. However, none of the cows from the abomasopexy group had any clinical signs of cardiopulmonary disturbance after the procedure, and most cows began eating soon after they were returned to their stalls. This indicates that these effects are not sufficiently severe to negatively influence the postoperative period, although the period of dorsal recumbency should be kept as short as possible to minimize cardiopulmonary compromise. Furthermore, cows should not be routinely sedated when a hydraulic surgery table is used because intraoperative deaths of cows as a result of cardiovascular collapse following sedation with xylazine have been reported.[14]

Investigators have reported[30,31] an association of LDA with liver function disorders and their influence on the postoperative convalescence of cattle. Successful treatment of an LDA in the abomasopexy and control groups resulted in an improved metabolic status, including variables for liver function, which indicated that, in general, these abnormalities are secondary and also reversible when liver function disorder is not severe and the LDA is diagnosed and the cow treated in a timely manner.[31,a] Typically, it required a longer period for acetonemia to resolve in the abomasopexy group, even though feed intake was higher for that group than for the control group. This finding can be explained by the significantly faster increase in milk yield for the abomasopexy group, compared with results for the control group.

Both surgical techniques harbor specific risks regarding complications at the surgical site. Such events were rare. When an omentopexy[11] is performed, the disk implanted in the subcutaneous tissues poses a risk factor for infections at the surgical site, although this risk is considered minimal when the disk is placed correctly.[11,24,a] Alternatively, another method of omentopexy can be used that does not involve the use of synthetic discs.[2,25] All methods of percutaneous abomasopexy, including the minimally invasive laparoscopic technique, bear a risk of extensive complications at the abomasopexy site.[32–34,a] In the abomasopexy group in the study reported here, all cows had edematous swelling (approx 8 cm in diameter) without signs of pain or heat; this swelling was considered to be a typical postsurgical reaction. This was accounted for during surgery (ie, we left a space of 5 cm between the toggle and gauze bandage). In this study, a mark was placed on the toggle sutures specifically for this purpose. In the 3 cows with extensive cellulitis at the abomasopexy site, the space left between the toggle and gauze bandage was sufficient to avoid pressure necrosis and development of an abomasal fistula, which are complications that may follow percutaneous abomasopexy.[32,33,35]

In general, there are no clinical signs of peritonitis, and extensive postoperative peritonitis is rare.[14,33,34,c]

Adhesions between the abomasum and abdominal wall at the abomasopexy site, caused by a local circumscribed peritonitis, are essential for the avoidance of relapses.

The risk of peritonitis following a laparoscopic procedure in cows is minimal.[19,36] Routine administration of antimicrobials does not appear to be necessary because of the rarity of complications. Consequently, the withdrawal period for withholding of milk is minimal. However, regular monitoring of the abomasopexy site and body temperature is important to detect potential complications at an early stage.

We did not detect any relapses of an LDA in the control group, even though removal of the synthetic disc placed in the subcutaneous tissues was necessary in 2 cows because of a purulent infection at the omentopexy site. Similar results have been cited in the literature.[11,24,25,a]

In percutaneous abomasopexy procedures, fixation of the abomasum is achieved by fibrinous adhesions that develop between the ventral abdominal wall and wall of the abomasum. Premature pull out of the toggle suture, as happened here because 2 cows kicked off the gauze bandage, or because of breakage of the toggle, would predispose cows to relapse.[14,32] In these cases, it is possible to perform a second laparoscopic abomasopexy.[14,c]

Relapse was not detected during the subsequent lactation period in any of the remaining cows in the abomasopexy group. Two years after completion of the study, only 2 cows in the abomasopexy group had a relapse (13 and 27 months after laparoscopic surgery, respectively). This comparatively low rate of relapse corresponds to the data reported in practice settings.[14,c]

The controlled study reported here revealed that the minimally invasive laparoscopic procedure is a quick and safe technique for use in the treatment of cows with an LDA. Advantages include a high success rate for surgery, rapid postoperative recovery, and a low incidence of relapse during subsequent lactations. In certain cases, such as cows suspected of having intra-abdominal adhesions, laparotomy would be preferred to the laparoscopic technique for treatment of a cow with an LDA. Furthermore, cows with cardiopulmonary disorders should also be treated by a method other than the laparoscopic procedure described here to avoid the additional strain caused by being positioned in dorsal recumbency. Another disadvantage of the laparoscopic procedure is the fairly high costs for the necessary surgical instruments and for the hydraulic surgery table. Although performing this procedure is greatly facilitated by the surgery table, the use of a hydraulic table is not essential.[14] Laparoscopic replacement of an LDA is comparatively easy to learn; on the basis of our experiences, assisting on approximately 10 to 15 surgeries should provide a sufficient learning period.

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d. Ketur-Test, Roche Diagnostics GmbH, Mannheim, Germany.
e. Rancode, release 3.6, IDV, Gauting, Germany.
f. Set for laparoscopic repositioning and fixation of abomasal displacement in cattle, Dr. Fritz GmbH, Tuttlingen, Germany.
g. Mobile hydraulic operation table, Fa. Bartmann, Lübbecke, Germany.
h. Domosedan, Fa. Pfizer GmbH, Karlsruhe, Germany.
i. Safety toggle pin for laparoscopic abomasal fixation, Dr. Fritz GmbH, Tuttlingen, Germany.
j. Perlon discs for omentopexy, Heiland Vet GmbH, Hamburg, Germany.
k. Mastipent, Merial GmbH, Hallbergmoos, Germany.
l. RWZ Kraft 202 Press, Raiffeisen Warenzentrale Rhein-Main, Wiesbaden, Germany.
m. Tru-flow, Tru-Test Ltd, Auckland, New Zealand.
n. BMDP/Dynamic, release 7.0, BMDP Statistical Software Inc, Los Angeles, Calif.

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