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NOTE

Surgery

Retrospective study on the outcomes and risk factors of right paramedian abomasopexy for right abomasal disorders in 47 dairy cows

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ABSTRACT. Very few epidemiologic studies have verified the utility of the right paramedian abomasopexy (RPA) technique in cows with right abomasal disorders. This study aimed to investigate the outcomes and risk factors for non-survival in the herd within 30 days of surgery in cows with right abomasal disorders who underwent the RPA technique. Forty-seven Holstein cows with right abomasal disorders (25 with right abomasal displacement [RDA] and 22 with right abomasal volvulus [RAV]) were included. Twenty-two cows with RDA (22/25, 88.0%) and 10 cows with RAV (10/22, 45.5%) survived at 30 days post-surgery. Multivariate logistic regression analysis indicated that hyponatremia, hypokalemia, and the presence of abomasal volvulus were the major risk factors associated with non-survival.

KEY WORDS: cow, mortality, right abomasal displacement, right abomasal volvulus, right paramedian abomasopexy

Since the first report of displacement of the abomasum (DA) in 1950 [3], this disorder has become more common in dairy cows. A DA is an abnormal positioning of the abomasum within the abdominal cavity and is classified into three broad categories: left abomasal displacement (LDA), right abomasal displacement (RDA), and right abomasal volvulus (RAV) [21]. In general, cows with simple displacements have good prognosis for returning to a productive life after surgical replacement [2, 13, 20, 23, 24]. However, since RAV is an emergency condition with severe hemodynamic compromise [6, 14], cows with RAV have poorer prognosis than cows with simple displacement [20]. The goals of treatment for DA are to return the abomasum to its normal position and to prevent the recurrence of displacement.

Surgery is known to be the only correction method that ensures satisfactory replacement and prevents recurrence [19]. Many surgical techniques have been employed, including right paralumbar fossa omentopexy (RPFO) [15], left paralumbar fossa abomasopexy [16], left paralumbar fossa omentopexy [25], right paramedian abomasopexy (RPA) [13], toggle pin (bar) suture [17], and 1-step [1] or 2-step [11] laparoscopic abomasopexy. In Japan, RPFO and RPA are the most widely used surgical techniques for cows with DA. Although there are specific indications for RPFO and RPA, which procedure is more advantageous remains controversial. It is well known that in cows with LDA, there is no association between the surgical procedure and longevity [21]. For instance, Fubini *et al.* [13] demonstrated that there was no difference between RPFO and RPA in the rate of a negative outcome within 30 days in cows with LDA. However, the RPA technique is not recommended as the first option for right abomasal disorders [12], because of the difficulty in identifying and manipulating the viscera caused by position in dorsal recumbency. Notably, the relationship of structures is less familiar to most veterinarians using this approach [12]. Indeed, few reports have revealed surgical outcomes with the RPA technique in cows with right abomasal disorders. However, as abomasopexy enables long-lasting correction of displacement [19], the RPA technique has an advantage from the perspective of DA recurrence. Furthermore, the proximity of the abomasum to the incision makes this approach possible for the smallest surgeon and the largest cow [12]. Thus, the usefulness of the RPA technique in cows with right abomasal disorders should be considered.

To the best of our knowledge, there is very little epidemiologic research to verify the utility of the RPA technique in cows with right abomasal disorders. Thus, the aim of the present study was to investigate the outcomes and identify risk factors for

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non-survival in cows with right abomasal disorders who underwent the RPA technique. Our results may be useful for veterinary practitioners when selecting surgical techniques for right abomasal disorders.

A retrospective study was conducted using medical records of Holstein cows that underwent surgical treatment for right abomasal disorders at the Minami Hokkaido Agricultural Mutual Aid Association located in northern Japan (140°E, 42°N) between December 2014 and December 2020. The criteria for selection were as follows: 1) surgical treatment was performed to correct RDA or RAV with the RPA technique on the day of diagnosis; 2) blood analysis results for the day of surgery were available; and 3) the cows had no history of surgical correction of abomasal disorders. Cows presenting with astasia were excluded. Consequently, 47 cases of right abomasal disorders (25 cases of RDA and 22 cases of RAV) were identified. The medical records of these cases were derived from a specific veterinary practice that was equipped with an operating table facility to retain the cow in a dorsal position. In this veterinary practice, surgical correction of DA was performed using the RPA technique in all cases; therefore, surgeons in the veterinary practice were accustomed to this approach. From medical records, data on supportive medical treatments during the operative period, clinical experience of surgeons, and presence or absence of complications were obtained. Furthermore, we investigated the prognosis of cows with right abomasal disorders that underwent the RPA technique; cows were defined as non-surviving if they died or were culled within 30 days of surgery.

All cows underwent a blood analysis immediately before surgery, including blood sodium (Na), potassium (K), chloride (Cl), hemoglobin (Hb), hematocrit (Ht), and anion gap (AG) values, using an automatic gas analyzer (i-STAT 1, Abbott Lab, Princeton, IL, USA) and i-STAT cartridge (i-STAT CHEM8+ Cartridge, Abbott Lab).

The RPA technique used in this study was as follows. The cows were placed in dorsal recumbence on an operating table. All cows were injected with 50 ml of 2% lidocaine hydrochloride (lidocaine injection 2%, Pfizer Co., Ltd., Tokyo, Japan) at the incision area as a local anesthetic. The skin was incised 10 cm caudal to the sternum and 10 cm to the right of the midline. The surgical incision was 15 cm in length. The abomasum was decompressed if necessary and placed in the correct anatomical position. If correction is not obtained with gas decompression alone owing to volvulus and/or large abomasal fluid volume, the cow's position was changed from dorsal to left lateral recumbency and the pylorus was then pulled out from the incision to expose the body of the abomasum. Abomasotomy was performed in cases with a large amount of fluid in the abomasum. A 6-cm portion of the greater curvature of the abomasum (approximately 10 cm from the reticulo-abomasal junction and 4 cm from the attachment of the greater omentum) was incorporated into the closure of the USP 5 silk sutures (Zyuuiyou Surgical Silk, Kawasaki-Seibutu Kagakukenkyusho Co., Ltd., Tokyo, Japan) in a simple continuous pattern. Care was taken to avoid penetrating the abomasum mucosa. The peritoneum and rectus muscle were closed with 0.6-mm braided absorbable sutures (Polysorb^{TM}, Covidien Japan Co., Ltd., Tokyo, Japan) in a simple continuous pattern, and the subcutaneous tissues were closed with the same 0.6-mm braided absorbable sutures in a Ford interlocking pattern. The skin was also closed with the same 0.6-mm braided absorbable sutures in an intradermal suture pattern.

Statistical analysis was performed using Excel Toukei 2010 (SSRI, Osaka, Japan). Normally distributed data are reported as the mean ± standard deviation (SD), and non-normally distributed data are expressed as the median (minimum–maximum). Cows were divided into two groups based on the survival period (up to 30 days) from the surgical treatment (survival group or non-survival group). Student's *t*-test or Mann-Whitney *U*-test after the *F*-test was used for comparisons of blood data between groups. If there were significant differences in blood analysis values between groups, those values were categorized for multivariate logistic regression analysis based on the reference values: Na (133–139 mM [8]), K (3.6–4.4 mM [8]), Cl (94.7–103.3 mM [8]), Hb (8.3–10.5 g/dl [22]), Ht (26.1–33.5% [22]) and AG (14–20 mM [7]). Thereafter, the multivariate association between categorized variables (blood analysis values with differences between groups (if any), presence of abomasal volvulus, clinical experience of surgeons [23], and presence of complications) and outcomes of therapy were evaluated by logistic regression analysis with the calculation of odds ratios (ORs) and associated 95% confidence intervals (95% CI). In addition, the overall survival time (OST) was calculated as the time between surgical treatment and non-survival. The OST curves were estimated using Kaplan-Meier statistics for the different groups with or without risk factors for non-survival. The OST was compared between groups using the log-rank test. The significance level was set at $P<0.05$.

The age, parity, and days postpartum in cows enrolled in this survey were 4 (2–11) years, 3 (1–9), and 34 (2–337) days, respectively. Diagnosis and surgical corrections were performed by 14 different surgeons, who had 5 (2–33) years of clinical experience. The median number of cases operated per surgeon was 3 (1–9). Abomasotomy was performed to excrete the fluid of the abomasum in 1 cow in the survival group and in 4 cows in the non-survival group. Supportive medical treatments mostly consist of antimicrobial and intravenous fluid therapies. During the operative period, antibiotics were administered to all cows. Although the total intravenous fluid volume was significantly higher in the non-survival group than in the survival group (survival vs. non-survival: 6.3 [0.0–16.5] vs. 8.0 [2.0–18.0] l, $P=0.003$), there were no significant differences in the volume of hypertonic saline solution, an intravenous fluid solution used to correct severe electrolyte imbalances and dehydration in cows, during the operative period (survival vs. non-survival: 0.5 [0.0–3.0] vs. 2.0 [0.0–3.0] l, $P=0.717$). In this survey, 17 of 47 (36.2%) cases had complications: ketosis (n=8, 17.0%), milk fever (n=5, 10.6%), mastitis (n=3, 6.4%), and uterine disease (n=1, 2.1%). Therefore, the veterinary practitioner also treated complications before and after repositioning surgery until the cows were discharged in a healthy state.

In this survey, 22 cows with RDA (22/25, 88.0%) and 10 cows with RAV (10/22, 45.5%) survived at 30 days from the day of surgical treatment. Therefore, the survival rate of the 47 patients in this survey was 68.1% (32/47). In our survey, 93.3% (14/15) of cows in the non-survival group died within 21 days without recovery after surgery, and the remaining cows were culled 24 days after surgery because the producer was not satisfied with her performance. Previous studies reported a survival rate for right flank

laparotomy, such as RPFO and right paralumbar fossa pyloropexy, in cows with RDA and RAV ranging from 85.0% to 95.5% and from 35.0% to 60.0%, respectively, within 30 days following surgery [4, 5, 10]. In this survey, the survival rate within 30 days in cows who underwent the RPA technique was 88.0% for RDA and 45.5% for RAV, which were in good agreement with those of right flank laparotomy. Therefore, the present survey indicated that RPA techniques are not inferior to right flank laparotomy based on the survival rate in the surgical correction of right abomasal disorders.

We also investigated the major risk factors associated with non-survival in cows with right abomasal disorders that underwent the RPA technique. The blood Na (survival vs. non-survival: 137.2 ± 3.9 vs. 132.4 ± 6.3 mM, P=0.003), K (survival vs. non-survival: 3.5 ± 0.6 vs. 3.0 ± 0.6 mM, P=0.005) and Cl (survival vs. non-survival: 93.8 ± 9.7 vs. 83.9 ± 9.0 mM, P=0.002) concentrations were significantly lower in the non-survival group than in the survival group. The blood AG value was significantly higher in the non-survival group than in the survival group (survival vs. non-survival: 16.1 ± 2.4 vs. 17.9 ± 2.8 mM, P=0.032). Although a significant difference was observed in AG values between the groups (P=0.032), these values remained within the normal range. There were no significant difference in Hb concentration (survival vs. non-survival: 10.7 ± 1.7 vs. 11.8 ± 2.5 g/dl, P=0.149) and Ht (survival vs. non-survival: 31.7 ± 4.5% vs. 34.5 ± 7.4%, P=0.162) between the groups. The blood Na, K, and Cl concentrations, abomasal volvulus, clinical experience of surgeons, and complications were categorized using multivariate logistic regression analysis (Table 1). Multivariate logistic regression analysis indicated that hyponatremia (<133.0 mM, OR 38.20; 95%CI 1.66–879.00; P=0.022), hypokalemia (<3.6 mM, OR 40.60; 95% CI 1.31–1,260.00; P=0.034), and presence of abomasal volvulus (OR 10.60; 95% CI 1.05–107.00; P=0.045) were the major risk factors associated with non-survival in cows with right abomasal disorders. However, no differences were found between groups in blood Cl concentrations, clinical experience of surgeons, and the presence of complications.

Figure 1 shows the OST from the day of surgical treatment for cows with right abomasal disorders with or without risk factors for non-survival. At the end of the survey, at 30 days from the day of surgical treatment, all cows (n=13, 100%) without risk factors survived. However, at the end of the survey, 17 of 34 (55.9%) cases indicated that hyponatremia, hypokalemia, and the presence of

Table 1. Risk factors for non-survival in the surgical correction of right abomasal disorders with right paramedian abomasopexy

Variable	Variable category	n	Odds ratio	95% confidence interval	P value
Sodium concentration	≥133.0 mM	36	1.00	-	-
	<133.0 mM	11	38.20	1.66, 879.00	0.022
Potassium concentration	≥3.6 mM	19	1.00	-	-
	<3.6 mM	28	40.60	1.31, 1,260.00	0.034
Chloride concentration	≥94.7 mM	22	1.00	-	-
	<94.7 mM	25	1.89	0.23, 15.80	0.556
Abomasal volvulus	No	25	1.00	-	-
	Yes	22	10.60	1.05, 107.00	0.045
Clinical experience of the surgeon	More than 5 years	26	1.00	-	-
	Under 5 years	21	0.21	0.03, 1.69	0.143
Complications	No	30	1.00	-	-
	Yes	17	0.11	0.01, 1.31	0.081

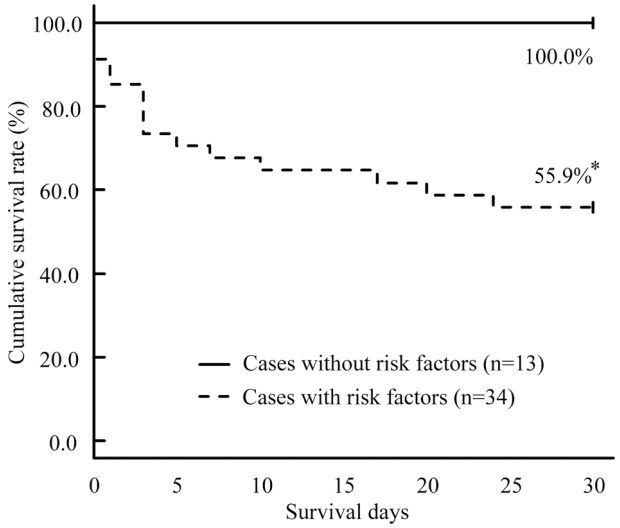

Fig. 1. Graphs depicting the overall survival time (OST) from the initiation of surgical treatment in cases with or without risk factors associated with non-survival by Kaplan-Meyer analysis. The OST between groups was compared using the log-rank test. *; P=0.006, vs. cases without risk factors.

abomasal volvulus were the major risk factors for mortality. Therefore, based on the survival estimated by Kaplan-Meier analysis, cows with hyponatremia, hypokalemia, and/or abomasal volvulus had a significantly shorter survival (P=0.006) than those without.

It is well known that since RAV is an emergency condition with severe hemodynamic compromise; cows with RAV have poor prognosis [6, 14]. Indeed, in this survey, the total intravenous fluid volume, which was determined by the degree of dehydration, was significantly higher in the non-survival group than in the survival group during the operative period, indicating that the non-survival group had more severe hemodynamic compromise. Previous studies have revealed that hyponatremia [10, 14], hypokalemia [20], and abomasal volvulus [4, 5, 10] were observed in cows with right abomasal disorders that underwent non-RPA techniques including RPFO [10] with non-survival. Our results indicated that the surgical outcome of the RPA technique was affected by preoperative conditions, such as severe hemodynamic compromise and electrolyte abnormality, similar to that of non-RPA techniques [4, 5, 10, 14, 20].

Generally, because it is believed that the surgical outcome depends on the skill of the surgeon, the clinical experience of the surgeon is a factor that requires consideration. In this survey, surgical corrections were made by 14 different surgeons, who had 5 (2–33) years of clinical experience; however, all surgeons were accustomed to the RPA approach, which is less familiar to most veterinarians [12]. There was no association between the experience of surgeons and longevity in the herd. Therefore, the effects of surgeon skill on the surgical outcomes examined in the present survey were minimal.

Kalaitzakis *et al*. [18] reported that the non-survival of cows with LDA who underwent repositioning surgery was related to fatty liver disease. Moreover, ketosis and retained placenta have been reported to be risk factors for herds with a high prevalence of postpartum culling [9]. Since previous studies indicated that concurrent postpartum disorders affect prognosis after LDA surgery, the presence of complications was forced into the logistic regression analysis model in this survey. However, our survey revealed that the presence of complications was not involved in the prognosis of cows with right abomasal disorders that underwent the RPA technique.

Since the survival rate and risk factors in the RPA technique are similar to those of the non-RPA technique reported previously, we concluded that RPA techniques are not inferior to non-RPA techniques that are popular among most veterinarians for surgical correction of right abomasal disorders. Our survey showed the usefulness of the RPA technique in cows with right abomasal disorders. Therefore, veterinarian practitioners can select the RPA technique depending on the preference of surgeons or the condition of cows with right abomasal disorders.

CONFLICTS OF INTEREST. The authors have no conflicts of interest directly relevant to the content of this article.

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