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NOTE

Surgery

Lateral abdominal hernia associated with thin abdominal musculature in a calf

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ABSTRACT. This study aimed to evaluate the clinical utility of ultrasonography in the diagnosis of a newborn calf presenting with extended swelling within its right flank, in addition to its therapeutic planning. Ultrasonograms of the bilateral flanks identified thinning of the external and internal oblique abdominal muscles in whole areas of the abdominal walls. A right lateral abdominal hernia associated with thin abdominal muscular structures was diagnosed ultrasonographically. The right flank abdominal hernia was successfully reconstructed through a modified Mayo mattress suture. This allowed the overlapping of the two very thin structures of the abdominal walls, resulting in the creation of a thicker structure of the right lateral abdominal walls. Reconstruction of the abdominal walls using this method could prevent re-protrusion of the viscera during calf growth.

KEYWORDS: calf, lateral abdominal hernia, Mayo mattress suture, thin abdominal muscle, ultrasonography

Hernias are one of the common abdominal diseases in newborn calves, typically found within the umbilical cord and inguinal region, but rarely within the ventral and lateral abdominal walls [1, 8, 10, 11, 13]. Ventral and lateral abdominal herniation is commonly caused by acquired factors, such as external force and trauma to the affected regions or weakened abdominal musculature [10]. Alternatively, congenital or inherited factors that induce muscular deformity during the developmental stage are also identified as rare etiological causes of herniation [1, 8, 11]. In bovines, hypoplasia of the abdominal walls has also been diagnosed based on histopathological evidence that hypoplastic changes to the muscular fibers were predominant [1]. This condition was an etiological cause of abdominal herniation in three previous bovine cases, which presented whole abdominal distension in their flank areas [1, 11].

Abdominal hernias can be easily diagnosed by palpation to the swollen, affected regions, allowing evaluation of the location and size of the hernia rings, as well as the susception or incarceration of abscessation [13]. Ultrasonography is an effective diagnostic option that is superior to palpation, in terms of identifying the contents entering the hernia sacs and any intra-abdominal involvements [13]. Additionally, hypoplasia of the abdominal muscles, as a minor cause of abdominal hernias [8], can be identified ultrasonographically [11].

The appropriate surgical option for abdominal hernias can be chosen based on hernia ring size [8]. Small abdominal hernias, for example, can be reconstructed by herniorrhaphy using single interrupted or Mayo mattress ('vest-over-pants') suturing techniques [8]. Hernioplasty using various types of mesh materials is recommended for the reconstruction of large hernias [8]. However, there was no previous bovine report describing the surgical technique for hypoplastic-wall-associated hernias within the flanks [1, 11].

The present report concerns a calf presenting abdominal distention within the right flank, with clinical signs resembling those of previous bovine cases [1, 11]. This study aimed to show the clinical utilization of ultrasonography for the diagnosis of this disease, based on observation of the echotexture and thickness of the abdominal musculatures. The study also aims to discuss the modified Mayo mattress suturing procedure used to thicken the very thin right lateral abdominal musculatures.

A newborn crossbreed (Japanese black and Holstein breeds) male calf presented with abdominal distention of its whole right flank area, which had extended gradually following a normal birth. No abnormal behavior, e.g., activity, appetite, or drinking performance, was evident during the development of the abdominal distention. The feces were normal and discharged daily, without diarrhea. Hematologic examination revealed slight anemia based on decreased levels of hematocrit (28.9%, reference normal value: 34.3 ± 6.3%) and hemoglobin (9.0 g/dl, reference normal value: 10.6 ± 1.5 g/dl) [9, 14]. No leukocytosis was evident (white blood cell count: 9,200/µl, reference normal value: 10,081.3 ± 4,136.6/µl) [9, 14]. Values in the calf's biochemistry

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were normal, i.e., its levels of urea nitrogen (12.3 mg/dl, reference normal value: 12.0 ± 5.9 mg/dl) or creatinine (0.5 mg/dl, reference normal value: 0.90 ± 0.19 mg/dl) [9, 14]. At 39 days postpartum, the swelling in the extended right flank was seen to be more rounded in the ventral surface compared with the dorsal surface (Fig. 1A). In the dorsal-ventral view of the right flank, the swelling protruded from the neighboring right abdominal walls by over 10 cm (Fig. 1B). No swelling was macroscopically evident in the left flank. Palpation in the right flank revealed the penetration of the viscera into the very soft, swollen area. When pushed by hand, a fist could access the overall dented space of the swollen area. No structure of the hernia ring was palpable within the rounded, swollen area of the right flank. The present case did not exhibit cryptorchidism.

Abdominal ultrasonography was carried out using a portable ultrasound machine (MyLabOne VET, Esaote Co., Genova, Italy), with a probe accuracy measurement of 0.1 mm. A 10.0 MHz linear transducer was applied longitudinally to the non-shaved skin between the dorsal and ventral areas of both flanks. The flanks had been sprayed with alcohol and the transducer was applied with ultrasound gel, with the non-sedated calf in a standing position. The full thicknesses of the abdominal muscular structures—consisting of the internal and external oblique muscles of the abdomen—were measured ultrasonographically in three regions of the flanks: the dorsal region below the transverse process of the lumbar vertebrae; the middle region at a height level with the stifle; and the ventral region close to the ventral corner, in a triangular shape on the flank. In this study, normal measurements were also obtained by the same scanning procedure in eight healthy calves (five males; three females; all aged 36–59 days), in which half were bred at the same farm rearing the present case and half were bred at the Tottori University farm. In the calf with the swelling, when scanning to the middle area of the right flank, the abdominal musculatures were visible as a two-layered structure comprising of the internal and external oblique muscles of the abdomen, in the deeper areas of the hyperechoic skin and hypoechoic subcutaneous fat tissues (Fig. 2A). The structures of the internal and external oblique muscles of the abdomen were slightly hypoechoic compared with the echogenicity of the abdominal musculatures as seen on the ultrasonograms of the assessed healthy calves; in the healthy calves, the internal and external oblique muscles of the abdomen were seen to be separated by the hyperechoic muscular fascia (Fig. 2C). In the calf with the swelling, the thicknesses of the abdominal musculatures in the dorsal, middle, and ventral areas of the right flank were 3.5 mm, 3.6 mm, and 3.7 mm, respectively (Table 1). The values in these three regions were smaller than the values (average ± standard deviation) in the corresponding regions in the eight healthy animals (6.86 ± 1.48, 8.20 ± 2.11, and 6.11 ± 0.82 mm, respectively). In the most swollen area of the right flank, the multilayered, normal structures of the small intestine were visible, together with the deep hyperechoic intra-abdominal fat tissues adjacent to the thin abdominal musculatures. However, when scanning more caudally to the swollen area, near the level of the stifle, the abdominal musculatures thickened to approximately 1 cm. The structure of the kidney was seen to have normal size and echotexture, adjacent to thin abdominal musculatures in the dorsal area of the right flank. Additionally, intra-costal scanning of the right abdomen found the hepatic structure had normal size and echotexture, without the formation of a cystic mass. Ultrasonography of the herniated calf's left flank revealed thinning of the abdominal musculatures, in which the hyperechoic muscular fascia was relatively thick compared with the very thin internal and external oblique muscles of the abdomen (Fig. 2D). The thicknesses of the abdominal musculatures were 3.4 and 3.0 mm in the middle and ventral areas of the left flank, respectively (Table 1). These values were thinner than those of the layered abdominal musculatures in the same area of the eight healthy animals (8.77 ± 1.73 and 6.74 ± 1.25 mm, respectively) (Fig. 2E). Based on ultrasonographic evaluation, the present case could be diagnosed with a lateral abdominal hernia associated with thin abdominal musculatures. Thus, the therapeutic goal in the present case was to create thicker, massive abdominal musculatures in the right flank. With that in mind, the modified Mayo mattress suture was chosen as the surgical option.

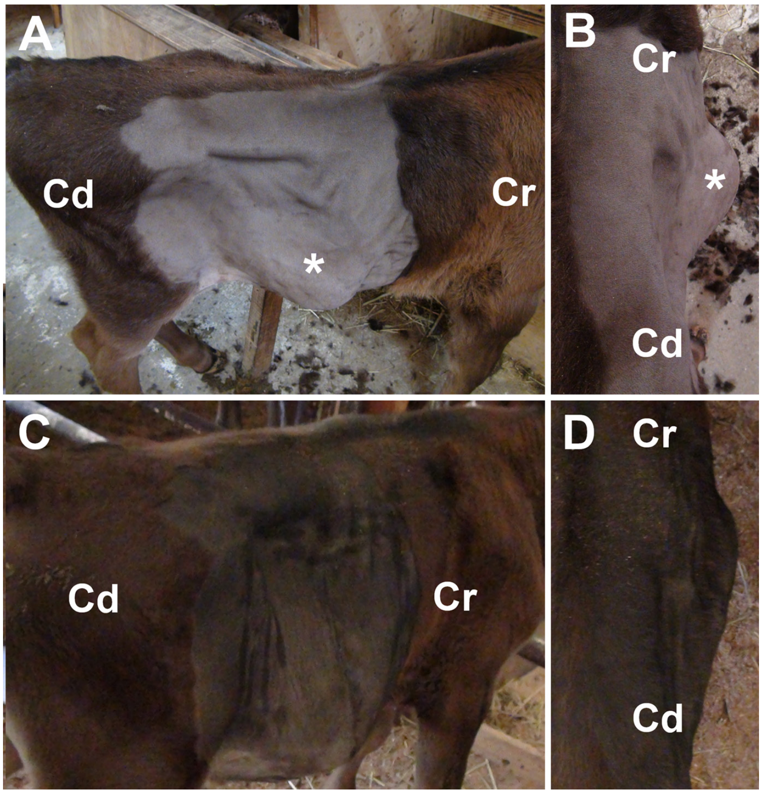

Fig. 1. Lateral and dorsoventral macroscopic views of the right abdomen taken before surgery (**A** and **B**), and at 42 days after surgery (**C** and **D**). Cr: cranial; Cd: caudal.

The animal was positioned in left lateral recumbency, while anesthetized with an intravenous injection of xylazine hydrochloride (0.2 mg/kg, IV; Selactar 2%, Bayer Yakuhin Ltd., Osaka, Japan). The area of operation of the right flank was shaved, disinfected, and anesthetized locally with a subcutaneous injection of lidocaine hydrochloride (10 ml; Xylocaine injection 2%; AstraZeneca K. K., Osaka, Japan). A 25-cm incision was made longitudinally between the dorsal and ventral areas of the right flank. On the macroscopic view of the abdominal muscular structures through the incision, the color was pale red, while the longitudinal running of the muscle fibers was unclear. When palpated, the muscular structure showed poor elasticity. No hernia ring structure was evident macroscopically. A 20-cm incision (dorsal-ventral direction) was made in the central area of the abdominal muscular structure and peritoneum, passing through the most swollen region. The cut surface of the muscular structure was membranous, very thin, and could not be identified as a layered structure (Fig. 3A). In the intra-abdominal cavity around the incision, no complicated lesion, such as abscessation, accumulation of ascites, or adhesion to the viscera, was evident. The reconstruction of the thin abdominal musculature could be achieved by a two-step suturing procedure. Firstly, the incised muscular structures were sutured using Mayo mattress suture to achieve both the closure of the abdomen and the creation of the muscular flaps used in the second step. The spinal of a nonabsorbable, braided suture (ETHIBOND EXCEL USP1; Ethicon Inc., Somerville, NJ, USA) was first introduced near-to-far on the caudal side of the abdominal muscular structures, which was close to the cranial area of the stifle; the location was approximately 10-cm caudally apart from the cut surface of the abdominal muscular structures (Fig. 3B). A subsequent suture was placed in a near-far-far-near pattern on the cranial side of the abdominal muscular structures, placed with a 1–2-cm margin from the cut surface. Finally, a far-to-near suture was made on the caudal side of the abdominal muscular structures at the same level as the first placing part. Four Mayo mattress sutures were applied. Gentle ties of four sutures enabled the cranial edge of the cut surface to be secured to the caudal areas of the abdominal muscular structures. This technique aided the creation of an approximately 10-cm muscular flap, derived from the caudal side of the abdominal muscular structures (Fig. 3C). In the second step, the muscular flap was secured to the cranial area of the abdominal walls, close to the thirteenth rib bone, by simple suturing, overlapping the overall cranial area of the abdominal muscular structures (Fig. 3D, 3E). The overlapped two layers of the abdominal muscular structures were then sutured randomly for closure of the dead space between them. Good elasticity could be palpated in the reconstructed abdominal muscular structures when pressed by the finger of a surgeon through the surgical opening. Single sutures were made between the cranial and caudal areas of the subcutaneous tissues using an absorbable suture material (MAXON; Davis & Geck Inc., Brooklyn, NY, USA), followed by the skin's closure using a nylon suture material (Suprylon USP0, Vömel, Gronberg, Germany).

Postoperative care consisted of four-day, intramuscular administration of a combined penicillin and streptomycin solution (Mycillin, Meiji Seika Pharma Co., Ltd., Tokyo, Japan) and one-day subcutaneous administration of meloxicam solution (Metacam

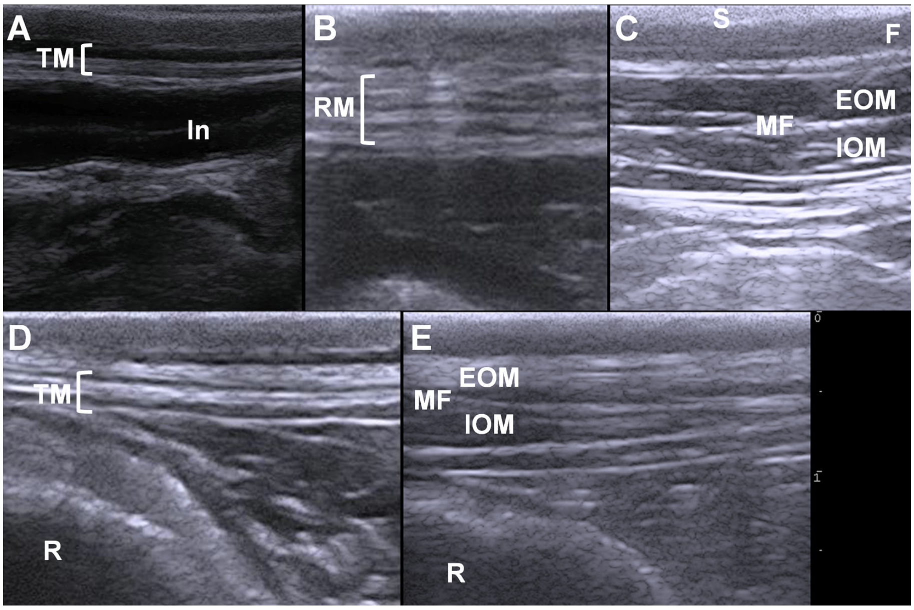

Fig. 2. Ultrasonograms of the middle areas of the right flank when scanned preoperatively (A) and at 42 days after surgery in the present case (B), and in an age-matched calf (C). Ultrasonograms of the ventral areas of the left flank in the present case and an age-matched calf (D and E). (**A**) The thin abdominal musculature (TM) is seen as a two-layered structure comprising of the internal and external oblique muscles of the abdomen. In: small intestine. (**B**) Reconstructed musculature (RM) is seen as an irregular, multilayered structure. (**C**) The lateral abdominal wall is characterized by a two-layered structure, in which the hyperechoic line of the muscular fascia (MF) runs across the space between the internal oblique muscles (IOM) and the external oblique muscles of the abdomen (EOM). F: subcutaneous fat tissues; S: skin. (**D**) The thin abdominal musculature (TM) has a layered echotexture at the level of the left flank, in which the caudo-ventral margin of the rumen (R) is visible. (**E**) At the same level of the left flank, the abdominal wall is normally comprised of the internal oblique muscles (IOM) and external oblique muscles of the abdomen (EOM), separated by muscular fascia (MF). R: rumen.

Table 1. Thickness of the abdominal musculatures measured ultrasonographically in the flanks of the present case

	Dorsal	Middle	Ventral
Left flank			
The present case	NE	3.4	3.0
Healthy calves (n=8)	6.32 ± 1.01	8.77 ± 1.73	6.74 ± 1.25
Right flank			
The present case, preoperative	3.5	3.6	3.7
The present case, postoperative	NE	8.0	NE
Healthy calves (n=8)	6.86 ± 1.48	8.20 ± 2.11	6.11 ± 0.82

NE, not examined.

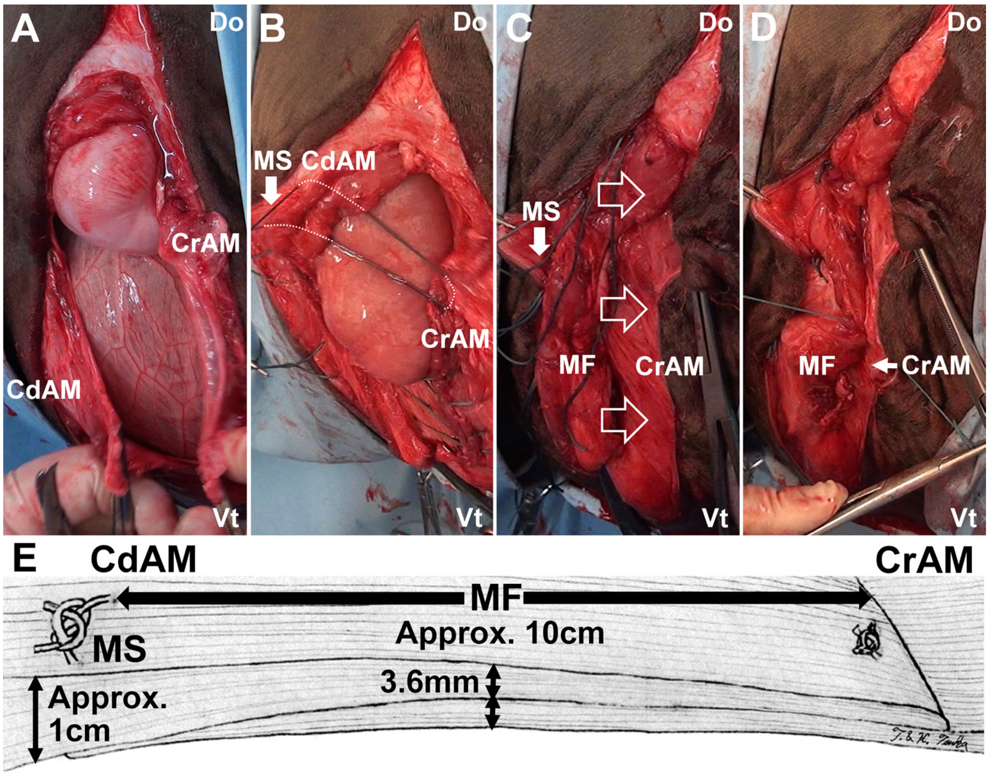

Fig. 3. Intraoperative photos (A–D) and schematic diagram (E) in the reconstruction of the abdominal muscular structures in the right flank. (**A**) The viscera is seen via the longitudinal incision of the abdominal muscular structures, between the dorsal and ventral areas of the right flank (upper and lower sides of the photos, respectively). The cut surfaces of the cranial and caudal abdominal muscular structures (CrAM and CdAM, respectively) are very thin. Do: dorsal; Vt: ventral. (**B**) Mayo mattress suture (MS) is applied between the margin of CrAM and the caudal side of CdAM. Do: dorsal; Vt: ventral. (**C**) The muscular flap (MF), derived from CdAM, is created by a gentle tie of four sutures of MS placed between CrAM and CdAM. The MF is extended forward (arrows), allowing it to lie on top of the entire area of CrAM. Do: dorsal; Vt: ventral. (**D**) The MF is secured to the CrAM at a level close to the thirteenth rib bone, by simple suturing. Do: dorsal; Vt: ventral. (**E**) The CrAM are overlapped by approximately 10-cm MF, created using MS applied in the thicker area of CdAM (approximately 1 cm thickness).

2%, ZENOAQ, Fukushima, Japan). This was followed by the removal of the skin suture at seven postoperative days. The calf had no postoperative complications, such as drug-induced side effects, abscessation or recurrence of the lateral abdominal swelling due to re-rupture of the reconstructed area, despite a slight, firm swelling due to the adhesive reaction (Fig. 1C, 1D). Ultrasonography of the right flank at 42 postoperative days found the reconstructed area of the abdominal musculatures could be visualized as irregular layered structures, in which thin, hypoechoic lines ran across the heterogeneous echogenic fibrous structures (Fig. 2B). The thickness of the reconstructed abdominal musculatures measured 8.0 mm, close to normal levels (Table 1). Additionally, no wrinkling change was evident macroscopically in the left flank, and the animal was growing normally.

In the present case, thinning in the abdominal musculatures, identified as the cause of the lateral abdominal hernia, could be reconstructed by a modified Mayo mattress suturing procedure after diagnosis through ultrasonographic evaluation of the echotexture and thickness. The lateral abdominal hernia associated with thin abdominal musculatures greatly resembled the clinical characteristics found in previous bovine cases involving degeneration or hypoplasia of the abdominal musculatures in their flanks [1, 11], although histopathological identification could not have been conducted in the present case. The previous bovine case reports indicated the clinical similarity between these lateral herniations in bovines and prune belly syndrome in humans [1, 11], based on the previous experimental reproduction of this abnormality in a caprine model [6]. Prune belly syndrome—named after the wrinkled macroscopic appearance associated with congenital hypoplasia of the abdominal musculatures—is classified into mild, moderate, and severe types based on the clinical signs associated with concurrent involvements such as undescended, intra-abdominal testicles; urethral obstruction followed by distention of the bladder; accumulation of urinary ascites; and hydroureter [4, 5, 7]. In terms of surgical intervention for this disease, surgery is commonly only recommended for the mild type [7]. If applying the criteria of severity, the abnormalities found in the three aforementioned previous bovine cases would seem to be categorized into moderate and severe types, due to the involvement of hepatic fibrosis and cyst formation, abdominal effusion, and renal disturbances [1, 11]. Surgical interventions in these animals' cases may be considered meaningless due to their critical conditions [1, 11]. The present case may be classified as mild, given the clinical sign consisted of a single appearance of thin abdominal musculatures, without concurrent disease.

In the common Mayo mattress suture technique, suturing is applied between the muscular layers near the edges of the cut surfaces [12]. In our method, the edge of the cut surface in the cranial part of the muscular structures was sutured to the most caudal, thick area of the caudal part, allowing the creation of the large muscular flap. In human patients, abdominoplasty consisting of plication with the complete overlap of the fascia can contribute to the reconstruction of completely or partially absent abdominal musculatures [5]. Mayo mattress suturing can allow the creation of a double layer of fascia to reinforce the abdominal walls in human patients [4, 7]. This technique's use in human patients seems identical to that of our bovine technique [4, 7]. Hernioplasty using mesh materials might have been chosen for the present case. However, it could not have contributed to the complete repair—by partial reinforcement with mesh materials in the thin abdominal musculatures, over the entire area of the right flank—without improving its elasticity. In addition, in terms of placing the mesh materials, it might have been difficult to determine an adequate location in the extended affected lesion, given the complete lack of a hernia ring. Although identified ultrasonographically, the thin abdominal musculature was not reconstructed in the left flank of the present case, in which severe outstretch was not evident macroscopically. This finding could be associated with the presence of the rumen, occupied entirely within the left intra-abdominal cavity, resulting in the prevention of eventration of other viscera. The occurrence of left lateral herniation is possible, and as such careful, continual monitoring is recommended; eventration of viscera such as the rumen can be promoted by the intensive distribution of abdominal pressure toward the weak, thin abdominal musculature in the left flank—associated with the reinforcement of the right flank—as the main postoperative abdominal pressure point.

Ultrasonography is a convenient imaging modality used routinely without sedation for the observation of various organs in bovine practice [9, 14]. Abdominal musculatures have also been examined ultrasonographically as this allows clear visualization of the specific findings; musculature can normally be identified by the individual layers of the hypoechoic muscular structures, comprising of the internal and external abdominal oblique and transverse muscles, due to the clear border of the hyperechoic fascia [2, 3]. In the two previous cases with suspected prune belly syndrome, ultrasonography was successfully utilized to identify the lack of abdominal musculatures at the deeper sites of the skin and the underlying connective structures [11]. On the ultrasonogram in the present case, the abdominal musculatures were observed to have a normal layered structure but were very thin. Ultrasonography could then allow quantitative evaluation of the thickness of the abdominal musculatures, helping to identify the cause of the lateral abdominal hernia. The diagnosis of this disease was supported by comparing the normal measurements of the abdominal musculatures (comprising of the external and internal abdominal oblique muscles) in both flanks of eight healthy calves. In addition, the postoperative use of ultrasonography was helpful for quantitative evaluation of our surgical technique's ability to create nearly normal thickness in the present case, despite its previous utilization being to clarify postoperative complications [2, 3]. Based on the difference between the present calf's values around 1 cm and the previous values around 2 cm in adult cows [2, 3], age-matched reference values can be created in terms of the thickness of the abdominal musculatures.

POTENTIAL CONFLICTS OF INTEREST. The authors have no conflicts of interest to disclose.

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