NOTE *Surgery*

Laparoscopic cryptorchidectomy in standing bulls

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ABSTRACT. Laparoscopic cryptorchidectomy without insufflation was applied in 10 standing bulls aged 3 to 15 months. Nine bulls were preoperatively pointed out intra-abdominal testes by computed tomography. Preoperative fasting for a minimum of 24 hr provided laparoscopic visualization of intra-abdominal area from the kidney to the inguinal region. Surgical procedure was interrupted by intra-abdominal fat and testis size. It took 0.6 to 1.5 hr in 4 animals weighing 98 to 139 kg, 0.8 to 2.8 hr in 4 animals weighing 170 to 187 kg, and 3 and 4 hr in 2 animals weighing 244 and 300 kg to complete the cryptorchidectomy. In conclusion, standing gasless laparoscopic cryptorchidectomy seems to be most suitable for bulls weighing from 100 to 180 kg.
KEY WORDS: bull, cryptorchidism, gasless, laparoscopy, standing

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Cryptorchidism is a congenital condition of the male reproductive system in which one or both of the testicles fail to descend into the scrotum and remain in the abdominal cavity or in the inguinal area [12]. The undescended testicle may be found in the abdominal cavity or beneath the skin in the abdominal or scrotal region away from the normal path of testicular descent. Spermatogenesis is often inhibited due to exposure to a higher temperature, but hormone synthesis occurs normally [11]. If left intact, cryptorchid bulls may develop heavy musculature and aggressive male behavior later in the fattening phase, posing a challenge to the producers in terms of both meat quality and husbandry management [20]. In addition, cryptorchid testes are associated with an increased risk of tumor, and development of a tumor within a cryptorchid testis has also been reported in Japanese Black cattle [16]. Thus, early castration is strongly recommended for affected animals.

In cattle, cryptorchidectomy via paramedian incision in the supine position [21] and flank incision in the standing position [19] has been reported. With these approaches, however, the abdominal testis has to be located by palpation, and localization of the testis is not always possible. For this reason, the use of laparoscopy has been suggested as an alternative [19, 21]. The usefulness of laparoscopic cryptorchidectomy has been studied in standing horses [6, 7, 10], but the authors are unaware of any reports of laparoscopy-assisted cryptorchidectomy in standing bulls, although standing laparoscopic approach has been used for abomasal displacement [1, 5], ovariectomy [2], and liver and kidney biopsy in cattle [4]. These articles report the advantages of performing a minimally invasive technique, while allowing detailed intra-abdominal examination. Meanwhile, gas insufflation of the abdominal cavity is routinely used in laparoscopic surgery in large animals [3, 8, 9, 15, 22] to improve visualization and to facilitate instrumental and visceral manipulation [14]. However, gas insufflation in standing cattle may cause discomfort, restlessness and even collapse, if the procedure is prolonged [18, 22]. In the present study, we performed gasless laparoscopic surgery of abdominal cryptorchid testes in standing bulls without general anesthesia to examine its possibility as a new approach to bovine cryptorchidectomy. In addition to laparoscopy, we also used computed tomography (CT) imaging to assist localization of the abdominal testis.

Ten bulls suspected to have an abdominal testis between January 2011 and July 2013 in Miyazaki Prefecture, Japan, were used in the study. These bulls belonged to private farms in Miyazaki prefecture, Japan. Subcutaneous cryptorchidism was ruled out on palpation before the procedure. There was 1 case of bilateral cryptorchidism, 2 cases of right-sided unilateral cryptorchidism and 7 cases of left-sided unilateral cryptorchidism (Table 1). To locate the abdominal testis, abdominal palpation was performed in all cases and rectal palpation in Cases 5 to 10, which had larger body sizes. Cases 1 to 9 were also evaluated by CT after 12 to 24 hr of

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Table 1. Summary of laparoscopic cryptorchidectomy in standing bulls

No.	Breed	Age in month	Body weight (kg)	Side of cryptorchidism	Surgical site	Intra-abdominal spermatic cord procedure	Collapse on the floor	Surgical time (hr)	Incision size (cm)
1	Crossbred	3	98	Left	Right	Successful	-	1	3.5
2	Crossbred	3	98	Bilateral	Right	Successful	-	1	2.5
3	Holstein-Friesian	4	130	Right	Right	Successful	-	0.6	3.5
4	Holstein-Friesian	4	139	Right	Right	Successful	-	1.5	3
5	Japanese Black	5	170	Left	Left	Successful	-	0.8	3
6	Japanese Black	6	175	Left	Left	Successful	-	2.8	3
7	Japanese Black	5	180	Left	Left	Successful	Temporary	1	3
8	Japanese Black	7	187	Left	Right	Successful	Temporary	1.8	4
9	Japanese Black	9	244	Left	Right → Left	Incomplete	Temporary	3	4
10	Japanese Black	15	300	Left	Left	Incomplete	Temporary	4	16

fasting, which was followed by 24 hr of fasting and standing laparoscopic procedure.

We used CT imaging to rule out the presence of subcutaneous cryptorchidism and assist localization of the abdominal testis. CT images were obtained using a CT scan (Aquilion, Toshiba Medical Systems, Otawara, Japan) with the animals in the lateral recumbent position with affected side up and under general anesthesia. The technical parameters included image acquisition with 4-mm slice thickness, 120 kV and 85 mAs. Case 2, which was suspected to have bilateral cryptorchidism, was positioned in right lateral recumbency. The bulls deeply sedated with 0.2 mg/kg IV xylazine and anesthetized with inhalant isoflurane through the endotracheal tube.

Laparoscopic examination and surgery were performed using a TRICAM SL camera system and a XENON NOVA cold light fountain (KARL STORZ GmbH & Co. KG, Tuttlingen, Germany). After 24 hr of fasting, the animals were restrained to a stall, shaved and locally anesthetized with 2% lidocaine (Xylocaine® injection 2%, AstraZeneca K.K., Osaka, Japan) SC and IM (20–30 m*l*/head) in the flank. In addition to local anesthesia, Cases 3, 5 and 6 also received epidural anesthesia with 2% lidocaine (4 m*l*/head between the first and second lumbar vertebrae). Laparoscopy was performed via the right or left flank approach. After the operative field was disinfected with chlorhexidine and 70% alcohol and draped, a 2-cm incision was made through the skin, and blunt dissection was made through the subcutaneous tissue and muscles to expose the peritoneum. The peritoneum was grasped with Pean forceps, and after incision of the peritoneum, nylon stay sutures were placed through the skin and the peritoneum. A trocar cannula (11 mm in diameter and 20 cm in length; KARL STORZ GmbH & Co. KG) was then inserted. The port site was determined based on the findings during rectal palpation or based on the CT results. Through this port, a 0˚ laparoscope (10 mm in diameter and 65 cm in length; KARL STORZ GmbH & Co. KG) was inserted to examine the abdominal cavity. Then, a trocar cannula (11 mm in diameter and 15 cm in length; Olympus Corporation, Tokyo, Japan) was inserted as the second portal for forceps (Fig. 1A and 1B). Up to 4 portals were established as necessary using trocar cannulae (5 mm in diameter and 25 cm in length; KARL STORZ GmbH & Co. KG). Laparoscopic evaluation was started from the right or left kidney and then advanced caudally within the cavity to locate the cryptorchid testis. When the testis was located, any fat tissue surrounding the spermatic cord was removed, and the spermatic cord was dissected and coagulated using an ultrasonic cutting/coagulation system (SonoSurg, Olympus Corporation) without grasping the testis whenever possible. The dissected testis was grasped with forceps (Fig. 1C) and externalized, and the port sites were closed by the standard suture technique. We difined the operation as a success, in cases where the spermatic cord could be dissected by laparoscopic procedure, and the cryptorchid testis could be externalized.

A summary of laparoscopic cryptorchidectomy is shown in Table 1. In all of the cases examined, the cryptorchid testes were detected on CT (Fig. 2) and by laparoscopy. In Cases 1 to 5, intra-abdominal testis resection was successful, and the mean surgical time was approximately or about 1 hr. In Case 6, the spermatic cord was resected successfully within the abdomen, but during retraction of the testis, the epididymis was separated and left behind within the abdominal cavity. The epididymis was localized using the laparoscope and removed. The total surgical time was 2 hr and 45 min. In Cases 7 and 8, the bulls collapsed when the testis was grasped with the forceps during manipulation. In Case 7, the spermatic cord resection could be completed laparoscopically. The animal was kept in a recumbent position, while the trocar cannula was removed and Babcock forceps were inserted through the port to grasp and retract the testis. In Case 8, the standing laparoscopic procedure was continued, because the animal recovered and stood up immediately after collapse. Similarly to Case 6, the epididymis was left within the abdominal cavity, but was located immediately. The surgical time was approximately 1 hr in Case 7 and 1 hr and 45 min in Case 8. Cases 9 and 10 collapsed during laparoscopic hemostasis when the testis was grasped and became recumbent. In Case 9, the testis was externalized through the port, and the spermatic cord and vessels were ligated with absorbable sutures (VICRYL sizes 1, Ethicon, Johnson and Johnson, New Brunswick, NJ, U.S.A.) and resected by Metzenbaum scissors. The surgical time was approximately 3 hr. In Case 10, all the trocar cannulae were removed. After

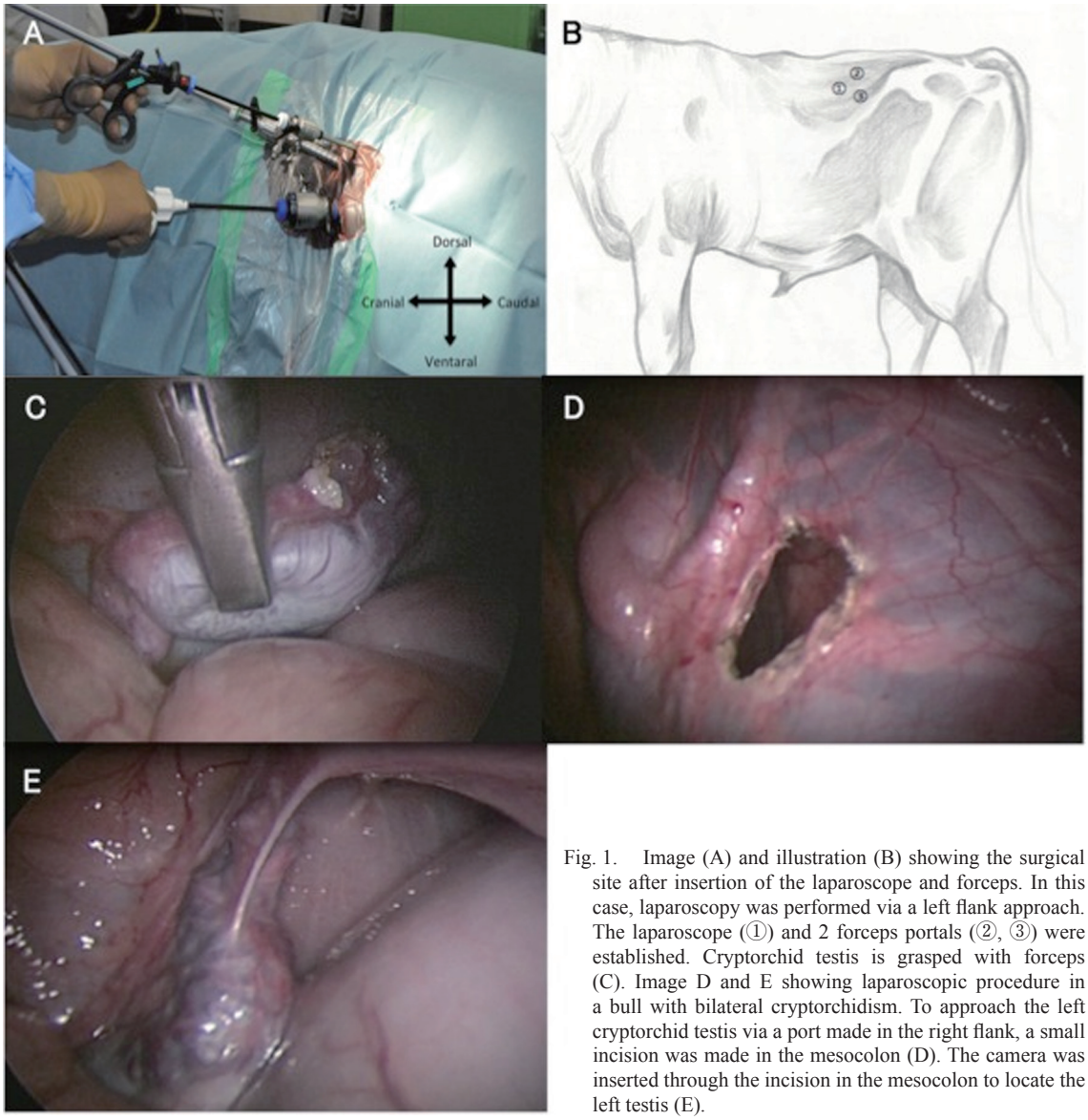

Fig. 1. Image (A) and illustration (B) showing the surgical site after insertion of the laparoscope and forceps. In this case, laparoscopy was performed via a left flank approach. The laparoscope (①) and 2 forceps portals (②, ③) were established. Cryptorchid testis is grasped with forceps (C). Image D and E showing laparoscopic procedure in a bull with bilateral cryptorchidism. To approach the left cryptorchid testis via a port made in the right flank, a small incision was made in the mesocolon (D). The camera was inserted through the incision in the mesocolon to locate the left testis (E).

the incision was extended, the left testis was externalized by hand and resected by the standard technique. The surgical time was approximately 4 hr.

Laparoscopy was performed through the right flank incision in Cases 1 to 4 and 8. In Case 9 with left-sided cryptorchidism, laparoscopy was initiated from the right flank, but switched to the left side, because the testis could not be reached with forceps. In Cases 5 to 7 and 10, a left-side approach was used. The incision size was less than 4 cm in all cases except for Case 10, in which the incision was extended to about 16 cm for manual retrieval of the testis.

This seems to be the first report of laparoscopic removal of abdominal cryptorchid testes in standing bulls. The cryptorchid testis was localized in all of the 9 cases examined by CT and all of the 10 cases examined by laparoscopy. We had previously experienced 2 cases of subcutaneous cryptorchidism in which the undescended testis was not palpable despite its subcutaneous location (unpublished data). By using CT, we were able to detect the testis and avoid an unnecessary laparoscopic procedure. This is why we believe that performing CT is important in order to locate a cryptorchid testis accurately. However, it is hard to use CT in routine diagnostic procedure due to its cost and the limitation of use. In this study, the surgeries were conducted with a combined use of CT and laparoscopy. In all cases, use of laparoscope was enough to find abdominal testis, and thus, it may be able to conduct a surgery using only laparoscope. In cases where it is unable to find cryptorchid testis using a laparoscope, though, it may be necessary to examine using CT scan.

Since the laparoscope allowed direct visualization of the cryptorchid testis, blind manual search was no longer necessary. The rumen volume was reduced by preoperative

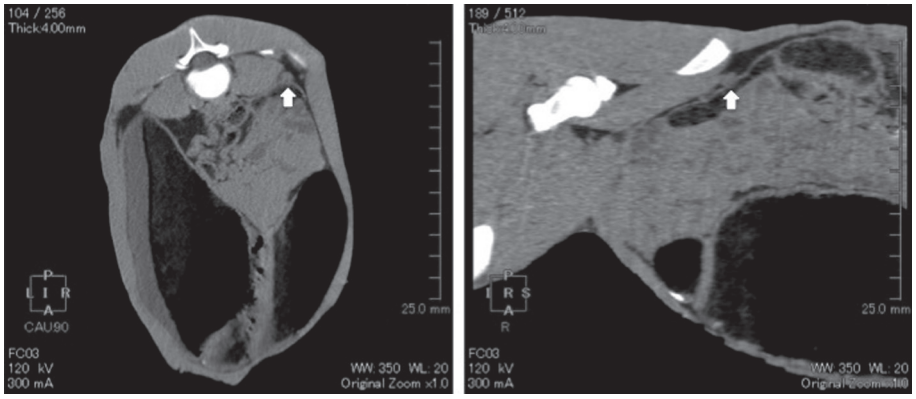

Fig. 2. Computed tomography images of Case 3 in axial (left) and sagittal (right) planes. Arrow indicates the cryptorchid testis.

fasting, and we were able to examine the abdominal cavity around the kidney and to the inguinal region without insufflation with carbon dioxide. Abdominal testes are sometimes difficult to locate due to adhesions to the surrounding tissue of the kidney or the serous membrane beneath the lumbar vertebrae [13, 17]. For such cases, the standing laparoscopic approach may also be useful, as it allowed clear visualization of the kidney in the present study. The use of an ultrasonic cutting/coagulation system was also useful, as it ensured rapid hemostasis and dissection of the surrounding fat tissue and the spermatic cord thus reducing the risk of hemorrhage during cryptorchidectomy. There was practically no risk of ligature failure, which is associated with the conventional technique. Thus, standing laparoscopic cryptorchidectomy with an ultrasonic surgical system provided a minimally invasive alternative to open laparotomy for removal of a cryptorchid testis in cattle.

For the port site, the left flank is generally recommended for laparoscopy in standing cattle, because the right flank approach is associated with perforation of the digestive tract and compromised intra-abdominal visibility due to the presence of the greater omentum [2, 23]. In the present study, however, we employed the right flank approach wherever possible to avoid the risk of rumen injury, and this approach was successful even for left-sided cryptorchid testes (Cases 1, 2 and 8). When the animals had smaller body sizes (Cases 1 and 2), we were able to visualize and remove the left abdominal testis via the right-side port by making a small incision in the mesocolon (Fig. 1D and 1E). In Case 8 with a heavier weight (187 kg), the left abdominal testis was visible by the right flank approach, but the surgery was more complicated due to increased intra-abdominal fat and thicker mesocolon. In an even heavier bull (Case 9; 244 kg), it was impossible to reach the left cryptorchid testis from the right-sided port. Therefore, we recommend a right flank approach for bulls, weighing approximately 100 kg, regardless of the side of cryptorchidism in order to avoid damaging the rumen, whereas in larger bulls, the approach should be made carefully from the affected side. In our cases, visualization was not compromised by the greater omentum unlike the previous reports in which gas insufflation was performed [2, 23]. From our previous experience with small animal laparoscopy, visualization is greatly compromised when the gas enters under the great omentum during insufflation. This might be the case in the above-mentioned reports in cattle. In our study, laparoscopy was performed gasless, but a small skin incision allowed the natural flow of air into the abdomen, and the digestive tract moved downward under its own weight, thus naturally creating a space between the digestive tract and the caudal organs. Improved visualization in turn should help reduce the risk of perforation of the digestive tract.

In the younger and lighter animals (Cases 1 to 4; 100 to 140 kg), the procedure was completed in about 1 hr, as they had less intra-abdominal fat and vessel coagulation was easier. The surgical time was greatly different for the animals with bodyweight ranging between 170 and 190 kg (Cases 5 to 7), since they had varying amounts of fat with varying sizes of abdominal testes. While the intra-abdominal procedures were successful in Cases 5 and 6, the epididymis was separated from the testis during testis retraction in Case 6. This was likely because the length of incision was not sufficient for the size of the testis. In Cases 7 and 8, the bulls collapsed temporarily after coagulation of the pampiniform venous plexus and when the testis was grasped during manipulation. In the heaviest bulls (Cases 9 and 10), testis and vessel manipulation was even harder, because they had increased amounts of intra-abdominal fat. They also collapsed when the testis was grasped. Pain may have triggered the collapse, as all cases of collapse occurred when the testis was grasped with forceps. In fact, collapse did not occur in the bulls that received epidural lidocaine, i.e. Cases 3, 5 and 6. It is also interesting to note that collapse occurred only in Japanese Black bulls. This breed may have higher sensitivity for pain. Further studies are necessary to examine the effect of anesthetic technique and other factors.

In conclusion, the results of our study suggest that standing gasless laparoscopic cryptorchidectomy seems to be most suitable for bulls, weighing from 100 to 180 kg, based on the amount of intra-abdominal fat.

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