Review Report

Common swine field reproductive surgeries

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Abstract

Reproductive surgery in commercial swine is limited by the relative limited financial value of animals with limited market value. In herds containing animals with high genetic value, biosecurity concerns often preclude the movement of animals to a hospital facility. Performing some procedures on the farm may be economically feasible and reduce culling rates. Growing concerns for animal welfare and the increasing popularity of pigs as pets dictates a larger involvement of veterinarians in surgical procedures in swine.[1] This manuscript describes common reproductive surgeries for male swine, practical anesthetic protocols, and the post-operative treatments that a veterinary practitioner should be able to perform. The most frequently requested surgery in boars is castration, which is usually performed by management during the first week of age as a portion of on-farm processing. In adult boars, castration is occasionally requested to improve the quality of the meat and reduce the boar taint in animals destined for slaughter. Orchiectomy of adult boars is increasingly requested for pot-bellied pigs, and other breeds maintained as pets and rescued by "sanctuaries" to avoid unwanted breedings and reduce aggressive behavior. Inguinal herniation, a common disorder in intact boars, often requires surgical correction in both production settings and pet pigs. Because of the presumed heritable basis, surgery in animals intended for breeding should be discouraged. Swine have one of the highest incidences of cryptorchidism among common livestock species.[2] Surgical correction of cryptorchidism in breeding animals is strongly discouraged due to the likelihood of a heritable basis for the failure of testicular descent. Cryptorchidectomy as a portion of bilateral castration is often requested for animals being shown in livestock exhibitions and occasionally in commercial facilities for animals intended for slaughter.

Keywords: Porcine, castration, anesthesia, inguinal hernia, cryptorchidism

Field anesthesia for swine

Field anesthesia of pigs is complicated by factors uncommon to other species: swine are easily stressed by handling and restraint, increasing the metabolic clearance of many medications, including sedatives and anesthetics; obtaining accurate body weights is often very difficult on farm: venous access is limited, and swine can be difficult to restrain sufficiently to appropriately administer anesthetic agents.

To facilitate anesthetic administration, it is important to isolate the pig in a quiet area before administering premedication. For adult animals, it can be useful to restrain the patient in a calf chute to limit motion and, at the same time, obtain an accurate weight. Younger pigs can be held in dorsal or lateral recumbency.[3] Swine have thick skin and, like humans, are fixed-skin animals with too little subcutaneous space to accept large-volume injections. Few peripheral vessels are accessible, and swine are prone to vasospasm during phlebotomy. The most common site for intravenous (IV) injections are the lateral or medial auricular veins (Figure 1) which can be accessed with small-diameter intravenous catheters by an experienced phlebotomist if the animal is sufficiently restrained. Sedation before attempting auricular vein catheterization for induction of anesthesia is advised.[4] The muscles of the dorsolateral neck are a good site for small-volume intramuscular (IM) injections. For larger volume IM injections, either semimembranosus or semitendinosus muscles just above the hock or the caudal portion of the biceps femoris muscle using an inch-and-a-half long needle are suggested.[5] In swine intended for food, intramuscular injection into the gluteal (ham) muscles is discouraged because of the potential for muscle inflammation and fibrosis in a high-value carcass area.[6] In the author's experience, the easiest way to administer intramuscular injections for sedatives to a pig is the use of an extension tube connected to an 18 G 1-inch and half needle. This can be

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Figure 1. Catheterization of an ear vein for intravenous drug administration.

Figure 2. Intramuscular administration of sedatives via an extension tube to an unrestrained pig.

done by only one operator, with the pig only minimally restrained (Figure 2).

To reduce the risk of regurgitation or aspiration, healthy swine should be fasted for at least 12 hours, and access to the water should be eliminated 6 hours before general anesthesia. Longer fasting is not necessary because swine are monogastrics, and fasting longer than 24 hours may contribute to gastritis and post operative vomiting.

Swine benefit from other pre-anesthetic agents prior to anesthetic induction.[7] Anticholinergic agents like atropine or glycopyrrolate administered preoperatively will dry the upper

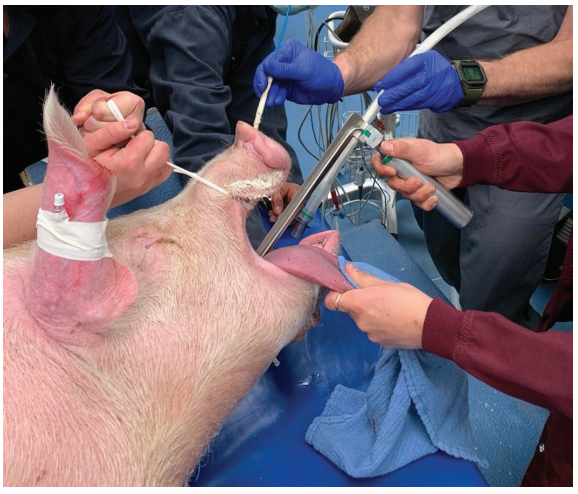

Figure 3. Endotracheal intubation of an adult pig utilizing a laryngoscope.

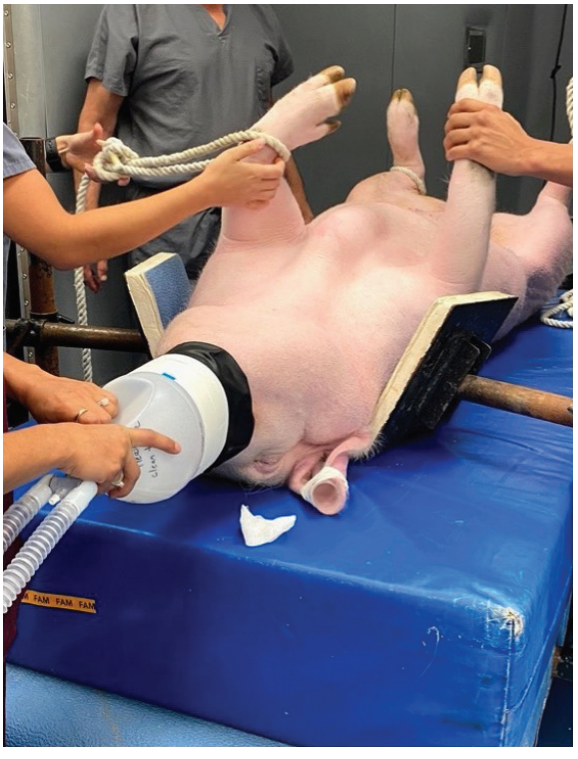

Figure 4. Administration of inhalation anesthesia using a homemade mask.

respiratory tract, reduce oral secretions, and counter the bradycardia associated with general anesthesia.

A variety of sedative agents have been used as premedications. Acepromazine (0.11 – 1.1 mg/kg IM, IV, SC) is commonly used but may cause alpha-adrenergic blockade at high doses. Benzodiazepines are often advocated. Diazepam (0.5–10 mg/kg SQ; 0.44–2 mg/kg IV administered slowly) or midazolam (0.1–0.5 mg/kg IM, SQ, or IV) have frequently been employed as pre-anesthetic tranquilizers. Midazolam is preferred over diazepam for IM use because it has more consistent absorption from muscles.

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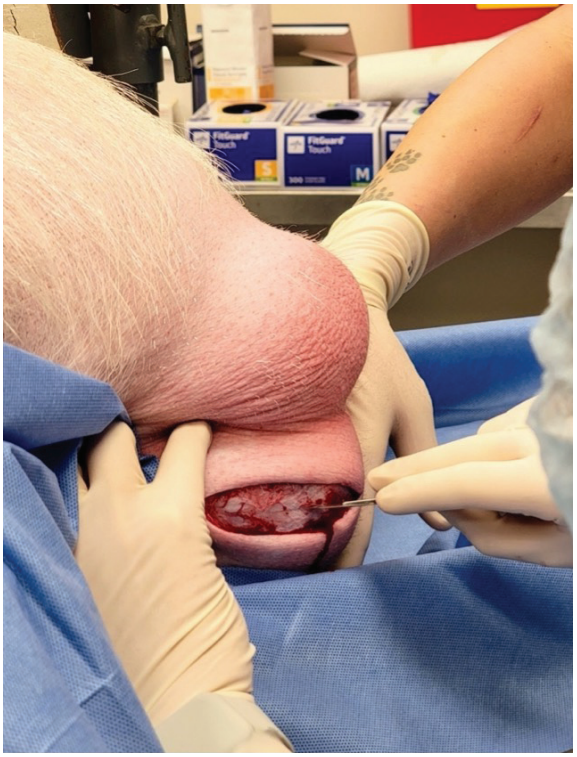

Figure 5. Castration of an adult boar. Scrotal technique. One incision is made over each testis in the ventral aspect of the scrotum.

Figure 6. Open castration technique. The skin, scrotal fascia, and parietal visceral tunic are incised to allow visualization of the albuginea of the testis. Visualization and identification of the spermatic cord facilitate ligation and emasculation.

Figure 7. Pre-scrotal technique. The testes are pushed cranially and to the midline of the pig.

Figure 8. Pre-scrotal castration. The incision is made on the midline and extended cranially.

Figure 9. Pre-scrotal castration. With the help of an assistant, tension is applied to the testis while increasing the incision length.

Figure 10. Pre-scrotal castration. Ligation of the spermatic cord with A Miller's knot.

Benzodiazepines likely increase the length of the anesthetic recovery period, especially if used intraoperatively.

For the induction of anesthesia, the authors prefer the combination of ketamine (5–10 mg/kg) and xylazine (2.5 mg/kg). Ketamine is a dissociative anesthetic agent that produces rapid immobilization with minimal cardiovascular depression but does not provide good visceral analgesia and provides very little muscle relaxation. A combination of ketamine with xylazine improves performance in those areas.

Following induction, the endotracheal tube is placed utilizing a laryngoscope, as shown in Figure 3, and inhalation anesthesia is used for maintenance. In some instances, endotracheal intubation of adult animals may be difficult or impossible due to the presence of the pharyngeal diverticulum, and a mask

Figure 11. Pre-scrotal castration. Excision of the spermatic cord following ligation.

Figure 12. Pre-scrotal technique. A 5-mm SCUD may be used to seal and cut the vessels of the spermatic cord.

may be used to deliver anesthetic gases and maintain oxygenation (Figure 4). Either isoflurane or sevoflurane may be utilized safely in pigs. Isoflurane has a low blood gas solubility resulting in rapid anesthetic recoveries and allowing rapid alteration of the depth of anesthesia. Although isoflurane produces a dose-dependent depression of the cardiovascular system, it has the greatest margin of safety of inhalation anesthetics currently in use and is considered the inhalation agent of choice in swine. Sevoflurane has similar physiologic effects and may be used instead of isoflurane.

The author performs castration of adult boars under general anesthesia. The animal is sedated with a combination of xylazine (2.5 mg/kg) and ketamine (5–10 mg/kg) intramuscularly in the neck behind the ear. When the animal is sufficiently sedated and immobilized, an intravenous catheter (22 G) is placed in one of the ear veins, and an additional

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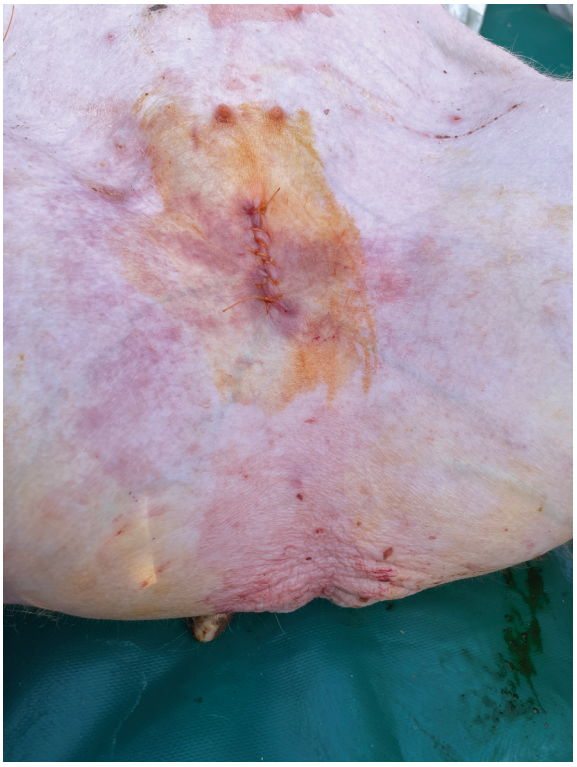

Figure 13. Pre-scrotal technique. Closure of the skin with a simple continuous pattern using absorbable suture material.

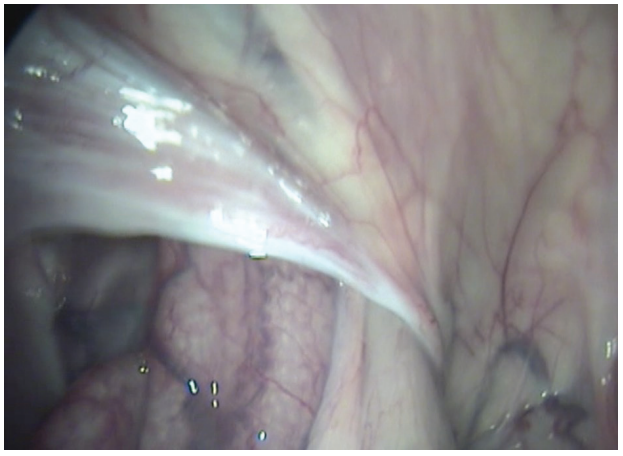

Figure 14. Laparoscopic view of an inguinal hernia with intestines passing through the internal inguinal ring.

dose of ketamine (1–2 mg/kg) is given IV. When the animal is deeply sedated, it is moved to the surgery table and intubated. Lidocaine (20 mg/mL) is injected directly into the testicular parenchyma (4–10 mL depending on the size of the testes) or into the spermatic cord (2–3 mL) of both testes. It is important to remember that the toxic dose for lidocaine in swine is 5mg/kg, and care is taken not to exceed that amount.[2]

Castration of adult boars

In this chapter, we will describe only options to neuter weaned pigs and adult boars. Commercial pigs are normally castrated during their first week of life without the use of sedatives or anti-inflammatories. Increasing attention to animal welfare

Figure 15. Oblique incision over the affected inguinal ring in a piglet with an indirect inguinal hernia.

Figure 16. Twisting the spermatic cord to reduce the herniated organs through the inguinal canal. Note that the parietal vaginal tunic is intact and the intestines never leave the peritoneal cavity.

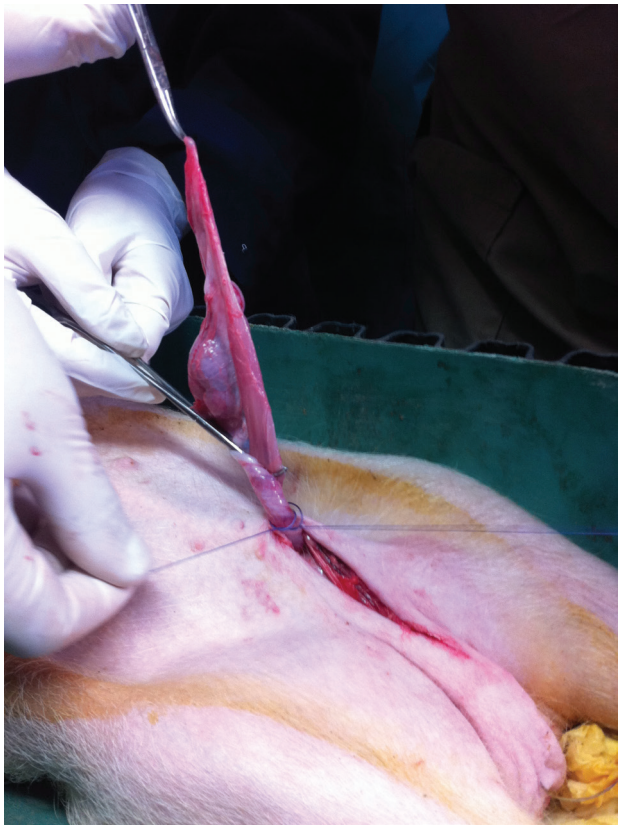

Figure 17. Miller's knot placed on the spermatic cord following reduction of the hernial contents.

has led to recommendations for sedation or general anesthesia for pigs older than one month of age. In Europe, using sedatives and analgesics during castration of all pigs is mandatory, regardless of age.[8]

Castration is often delayed in pot-bellied pigs, and other pigs maintained as pets. In these cases, the surgery is primarily done to render the animal sterile and reduce male behavior. Pot-bellied pigs that live in the household should be castrated before 12 weeks of age to reduce the development of the preputial diverticulum,[5] which results in less accumulation of malodorous smegma.

Castration of adult boars in commercial herds is not common. Still, mastery of the technique and the knowledge of possible challenges are important in those occasional cases and increasingly frequent requests for the castration of mature pet pigs, rescued animals, or research animals.

The size of the spermatic cord and associated vasculature is the major challenge in castrating adult boars. In neonatal piglets, the spermatic cord is very thin, and the testicles can be pulled away from the scrotum with minimal hemorrhage. In the post-pubertal boars, the pampiniform plexus is extremely large, and failure to ligate or emasculate could lead to death from blood loss. In heavy mature boars, appropriate surgical positioning during surgery and anesthesia is critical to avoid compressive myopathy. Boars must be maintained on a soft surface when positioned in dorsal or lateral recumbency.

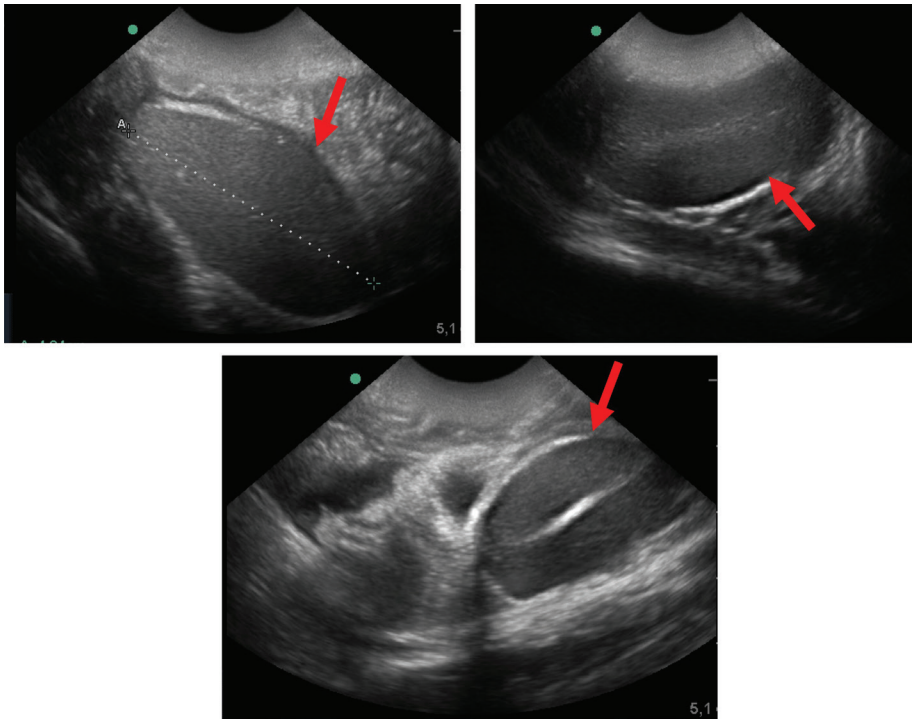

Figure 18. Ultrasonographic images of pig cryptorchid testes. (Arrows)

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Figure 19. Laparoscopic-assisted technique. Placement of the first trocar at the level of the umbilical scar.

Figure 20. Laparoscopic-assisted technique. The second port is placed to allow the introduction of Babcock forceps to grasp the retained testis.

Preparation

Castration of the older boar is best performed under deep sedation or general anesthesia. The pig may be placed in lateral or dorsal recumbency, and the surgical site prepped sterilely.

Scrotal technique

A 5–10 cm incision is made through the skin at the caudo-ventral aspect of the scrotum while tensing the scrotal skin over the testis (Figure 5). Either an open or closed castration can be performed. The open castration provides better visualization of the spermatic cord and facilitates the placement of ligatures on the vessels for hemostasis (Figure 6). An open castration is more time-consuming and may require resectioning a portion of the vaginal tunic with the closure of the tunics to minimize the chance of evisceration.

Following the skin incision, in an open castration, the common vaginal tunic is incised, and the testicular tunica albuginea is exposed. The testis is exteriorized, and the ligament of the tail of the epididymis identified; the fascia surrounding the spermatic cord is stripped using dry gauzes to allow direct visualization of the pampiniform plexus and deferent duct. Depending on the size of the spermatic cord, simple ligation plus or minus emasculation can be performed to provide hemostasis. The authors prefer to place two ligations as close as possible to the inguinal region and then emasculate the spermatic vessels distal to the sutures. A Miller's knot and a transfixing suture or two transfixing ligatures using absorbable suture material size #0 or 1 are recommended.

Attaching a hemostat to the suture leads before emasculation or transection of the spermatic cord is useful to allow retrieval of the spermatic cord stump to check for hemorrhage. Following the removal of the first gonad, the procedure is repeated on the opposite side.

Closure of the skin is seldom done when using the scrotal approach; leaving the surgical wound open promotes drainage.

Pre-scrotal technique

Following induction of anesthesia, the boar is positioned in dorsal recumbency, and the inguinal area is prepped for sterile surgery. Pressure through the scrotal skin is applied to one testis, and the gonad is pushed cranially into a position on the midline just cranial to the scrotum (Figure 7). With one testis held in this position, a skin incision is made through the skin over the testis and continued for 3–8 cm cranially, depending on the pig's size and age. The incision must be sufficient to allow the testicles to be exteriorized (Figures 8 and 9). With this approach, a closed castration is more commonly chosen, and the parietal tunic is left intact.

The first testicle is delivered through the prescrotal incision following dissection of the subcutaneous connective tissues, and the fascia is stripped away from the testis and spermatic cord to allow exteriorization. Two curved Kelly hemostats or similar instruments are placed across the spermatic cord proximal to the testis and used to crush the tissues of the spermatic cord. The spermatic cord is ligated with one transfixing suture above the hemostats and a second ligature with a Miller's knot

Figure 21. Laparoscopic-assisted technique. Exteriorization of the cryptorchid testis visualized by laparoscopy.

Figure 22. Open cryptorchidectomy. Local block of the skin using 2% lidocaine.

between the transfixion ligature and the testis (Figure 10). The spermatic cord is sharply excised (Figure 11), the hemostats removed, and the spermatic cord checked for evidence of hemorrhage. Alternatively, a Sonicision™, a Cordless Ultrasonic Dissector (SCUD), can be used for emasculation to produce coagulation and transection of vessels (Figure 12). The remainder of the spermatic cord is placed back into the incision after ensuring adequate hemostasis. The procedure is repeated, with the second testis being manipulated through the same skin incision. The skin incision is closed with the surgeon's preferred pattern using absorbable suture material (Figure 13).

Medications

Systemic antibiotic coverage should be provided for 2–3 days before the surgery and continuing for 2–3 days post-surgery. Anti-inflammatories and analgesics such as flunixin meglumine can be administered intraoperatively to decrease inflammation and pain post-operatively. Fly spray is applied to the wound. The animal should be kept in a clean, dry stall for at least a week.

Complications

The most common complications are hemorrhage, abscess formation, evisceration through an undetected inguinal hernia, and seroma formation. Applying ice packs to the scrotum as the boar recovers from anesthesia helps decrease the swelling. Anti-inflammatories such as meloxicam (0.4 mg/kg) per os may be administered to decrease inflammation and pain. A dose of ceftiofur crystalline free acid (6.6 mg/kg SQ) may be indicated in cases of likely post-operative infections when daily therapy is difficult.

Post-op

It is common to observe an enlarged scrotum post-surgery for a week following surgery; Care during the surgical approach to locate the incisions very ventrally will allow good drainage and minimize post operative edema. The boar should not be allowed to be with females for at least ten days post-surgery, as unwanted pregnancies could theoretically occur from the sperm left in the ampullae and ductus deferens.

Inguinal hernia repair

Inguinal hernias occur when abdominal organs, most commonly intestines, pass through a defect of the abdominal wall adjacent to the inguinal ring or pass through the inguinal canal.[9] In domestic swine, herniation through a congenitally enlarged inguinal ring is a common developmental defect and is thought to have a heritable basis.[10] Pigs with inguinal herniation may sometimes become anorexic if intestinal strangulation occurs but more commonly have few signs other than scrotal enlargement and perhaps retarded growth rates, which contribute to economic losses for the producers and unwanted pain and stress for the animals.[9–11] Routine castration of animals with an undetected inguinal hernia will often be followed by evisceration.

There are two classifications of inguinal hernia, direct and indirect. Direct herniation occurs when abdominal organs pass through acquired defects of the posterior wall of the inguinal canal and do not communicate with the vaginal cavity. Indirect herniation occurs when the intestines or omentum pass through the inguinal canal and into the space between the common and parietal vaginal tunics. Contents of an inguinal hernia may become 'scrotal' when the organs descend completely into the scrotal portion of the vaginal cavity between the two portions of the vaginal tunics (Figure 14).

Indirect inguinal hernias in swine appear to have a genetic link, and boars affected by this disorder should not be considered for use as breeding stock. The frequency of the defect in commercial pigs varies from 1.7% to 6.7%, depending on the breed, line, and management practices.[12]

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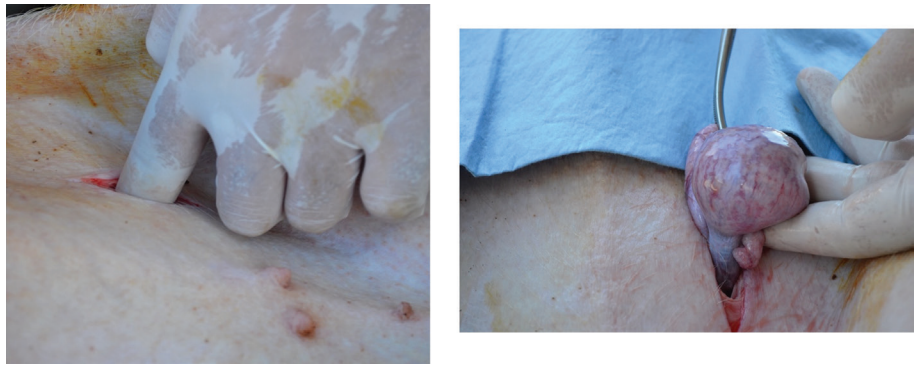

Figure 23. Open cryptorchidectomy. Digital palpation of the abdominal testis based on ultrasonographic identification and exteriorization.

Figure 24. Open cryptorchidectomy. Ligation of the spermatic cord and excision of the testis.

Palpation of the inguinal area and scrotal contents aids the evaluation of animals with an enlarged scrotum and coupled with an ultrasonographic evaluation, it helps in differentiating inguinal herniation from hydrocele, scirrhous cord, testicular hematoma, and other causes of scrotal enlargement. Potential consequences of a chronic inguinal hernia include intestinal incarceration and strangulation which are more likely in cases of direct herniation.

Inguinal herniorrhaphy

Surgical repair of indirect inguinal hernias is best accomplished before the pig is castrated, and the procedure is generally performed on young animals. The patient is positioned in dorsal recumbency with its rear legs slightly elevated. In most uncomplicated cases, injectable agents supplemented with local infiltration of the surgical site with lidocaine are appropriate. In older animals, inhalation anesthesia might be justified. The inguinal area is prepped for sterile surgery, and an oblique incision is made over the affected inguinal ring (Figure 15). If possible, the hernia contents should be reduced or partially reduced before making the skin incision. Like a closed castration, subcutaneous tissue is bluntly dissected until the parietal vaginal tunic is encountered. Maintaining the integrity of the parietal vaginal tunic prevents intestinal exteriorization and facilitates replacement into the abdominal cavity. The attachment of the ligament of to the tail of the epididymis is manually disrupted, and the testis and spermatic cord are isolated.

The intact tunic containing the testis and herniated organs is gently twisted to force the intestines through the inguinal canal and into the abdomen (Figure 16). A transfixing suture and a Miller's knot are then placed on the spermatic cord as close to the inguinal ring as possible (Figure 17) to ligate the testicular vessels and close the peritoneal cavity. The spermatic cord is transected, and the testis removed. The inguinal ring is closed with additional interrupted absorbable sutures. To assess for complete strong closure of the inguinal ring, manual pressure is applied to the abdominal wall. Additional sutures may be placed in the subcutaneous tissues. The skin is closed with an absorbable suture using an intradermal pattern. The contralateral testis is then removed routinely. It is important to evaluate the contralateral inguinal ring and rule out bilateral inguinal herniation before the completion of the castration.

In cases of chronic herniation, post-operative severe scrotal serum accumulation can occur. For this reason it is suggested to make the incision as ventral as possible to improve post surgical drainage.

In long standing inguinal hernias, adhesions may have formed between the intestines and the walls of the vaginal cavity. In this situation, the parietal vaginal tunic will need to be carefully incised, the intestinal adhesions broken down and the herniated intestines reduced into in the abdomen prior to closing the inguinal canal.

Cryptochidectomy

Cryptorchidism is a congenital abnormality in which one or both testicles fail to descend into the scrotum. In most livestock species, the testes descended before birth. Cryptorchid testes may be located in the abdomen, usually caudal to the ipsilateral kidney, in the inguinal canal, taking the shape of a cigar due to the narrow space, or subcutaneously in the inguinal region.

Cryptorchidism is common in pigs, with a reported prevalence of 2.2%[13] in older literature, with no recent estimates available. Like most other species, unilateral cryptorchidism is more common than bilateral in pigs. Either testis may be retained, but the right testis is the most commonly affected. Failure of testicular descent is believed to be a heritable homozygous recessive trait in some breeds of pigs,[14] but there are no recent breeding studies to confirm this. Inbreeding likely increases the incidence of cryptrchididm.[2]

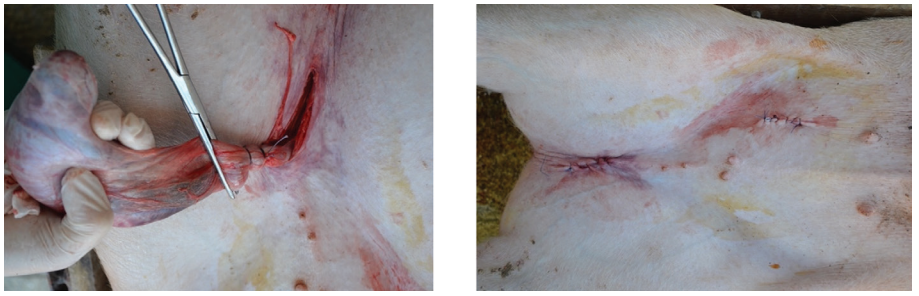

Figure 25. Open cryptorchidectomy. Castration of the descended testis and suture of the skin incisions.

For spermatogenesis to occur, the testes must be at a temperature lower than the body. In cryptorchid testes, due to the higher temperatures, the parenchyma degenerates leading to seminiferous tubules containing almost exclusively spermatogonia and Sertoli cells. Insufficient proliferation, excessive apoptosis, and autophagy were found to be the major factors involved in the regulation of the decrease in spermatogonia in cryptorchid boar testes.[15] For this reason, the cryptorchid boar fertility is compromised. Even if there is enough sperm production from the descended testis, the unilateral cryptorchid pigs should be castrated to avoid perpetuating this genetic trait in the progeny.

The most common presentation is young boars with unilateral cryptorchidism that need to be castrated before puberty to avoid the undesirable effects of "boar taint" on meat quality. Alternatively, boars thought to be castrated are presented to the veterinarian because they exhibit male traits. Cryptorchidism is often seen in miniature and pet pigs.[16] When one scrotal testis is present, scrotal palpation helps identify which of the testes is retained. If the animal has been hemicastrated, and the surgical wound has healed, it may be difficult to define if the retained gonad is the left or right. Ultrasonographic evaluation is useful for the identification of the retained testicle and to determine if it is located abdominally or inguinally, guiding the selection of the surgical approach and reducing the duration of anesthesia. Ultrasonographic evaluation is better performed when the boar is under general anesthesia. A linear or convex transducer can be used. The exam should start from the inguinal ring and continue toward the cranial abdomen. Abdominal testes are found between the ipsilateral kidney and the inguinal ring, lateral to the bladder. After the testicle is visualized (Figure 18), the location can be marked on the skin with a surgical pen. We will describe two surgical techniques to remove the ectopic testicles, a laparoscopic-assisted and cryptorchidectomy via laparotomy.

Laparoscopic-assisted cryptorchidectomy

The pig is placed under general anesthesia and positioned in dorsal recumbency. The abdomen is prepped for sterile surgery. Following a local block with 2% lidocaine at the site of the umbilical scar, a 1.5 cm skin incision is made cranial to the external preputial orifice. A laparoscopic cannula and trocar are tunnelled caudally subcutaneously for 2 cm and then used to penetrate the abdominal wall and peritoneum to enter the abdominal cavity, taking care to avoid penetrating any underlying viscera (Figure 19). The trocar is then removed from the cannula, and a CO2 line is attached to it. The abdomen is distended with CO2 to 12 mm/Hg pressure to facilitate visualization of abdominal organs. The surgical table is tilted to elevate the hindquarters and place the boar in the Trendelenburg position, displacing the abdominal viscera cranially and facilitating identification of the retained testis. A 10 mm, 0° operative scope is inserted through the cannula, and the abdomen is searched to locate the retained testis. Following the application of a lidocaine block, a second laparoscopic port is created by inserting a cannula and trocar into the abdomen in the area overlying the testis. When the trocar is removed, and Babcock forceps are introduced to grasp the testis and elevate it to the body wall (Figure 20). The incision at the site of the second port is extended, and the testis is exteriorized (Figure 21). The spermatic cord is ligated as previously described for open castration. Alternatively, a radiofrequency-driven bipolar electrosurgical device (Ligasure™) may be used intra-abdominally to transect the spermatic cord and seal the associated vessels before removal. The portal sites are closed with cruciate or simple continuous sutures using appropriate absorbable suture material.

Cryptorchidectomy via laparotomy

Following induction of general anesthesia, the boar is placed in dorsal recumbency, and the abdomen is prepped for sterile surgery. The abdomen is prepped sterilely, and a local block with 2% lidocaine is placed subcutaneously over the area of the proposed inguinal incision (Figure 22).

When the retained testis is in the inguinal canal, an incision is made on the skin overlying the external inguinal ring, and blunt dissection of the underlying connective tissue is pursued until the vaginal process of the peritoneum is identified. A small incision of the vaginal process allows for exploration to identify the ligament of the tail of the epididymis. When traction is applied to the ligament, the testis can be exteriorized.

If the retained testis is abdominal, a paramedian incision is made lateral to and parallel to the prepuce. The underlying muscle is dissected bluntly to expose the peritoneum. The peritoneum is then elevated with thumb forceps and incised to gain access to the abdominal cavity. Inclining the surgical table to position the head lower than the hind legs will displace abdominal viscera cranially, helping find the retained testis. Introducing a finger in the incision is often sufficient to allow exploration and identification of the retained testis or ductus deferens and exteriorization of the retained gonad (Figure 23). Occasionally location of the gonadal structures is more difficult, and the abdominal incision may need to be enlarged to permit a more thorough search.

Once the testis is located and brought out of the incision, the spermatic cord is isolated and ligated using a transfixing suture

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and Miller's knot. Following secure placement of the ligatures, the spermatic cord is transected distal to the sutures, and the testis removed. The pedicle is inspected, and if the hemorrhage is controlled replaced in the abdomen (Figure 24). The abdominal incision and skin are sutured routinely, and the scrotal testis is removed through a separate incision (Figure 25).

Complications

Exteriorization of the retained testis can be difficult if the spermatic cord and pampiniform plexus are very short or closely adhered to the inguinal canal. It is important not to apply too much force to induce rupture of the vessels; in those situations, enlarging the incision site sufficiently to allow intra-abdominal ligation of the spermatic cords is required to avoid hemorrhage.

Post-op

Anti-inflammatories and antibiotics are administered as described for the other procedures above.

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