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Clinical and surgical approach to umbilical disorders in calves - literature review

Abordagem clínica e cirúrgica das afecções umbilicais em bezerros - revisão de literatura

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Highlights

Demonstration of umbilical components of bovine fetuses.
Possibility of using laparoscopy in the diagnostic umbilical disorders in calves.
Possibility of using laparoscopy in the surgical treatment of omphalopathy.
Correct diagnosis of umbilical disorders allows for a good surgical plan.

Abstract

Umbilical disorders, which frequently occur in calves, are among the major causes of economic losses in herds. Antibiotic therapy alone is effective for some infectious cases, but surgical intervention is often indicated. This review aims to provide an overview of the clinical and surgical perspectives of the principal umbilical disorders in calves. The umbilicus may be affected by infectious or non-infectious conditions, including hernia, persistent urachus, omphalitis, urachitis, omphalophlebitis, and omphaloarteritis. Infectious varieties can culminate in sepsis and sometimes even involve other organs. Under these conditions, the chief complaint of calves tends to be apathy and visible swelling in the umbilical region. When surgery is indicated, the veterinary surgeon needs to have a thorough understanding of umbilical disorders, which coupled with careful clinical examination, will enable the formulation of an effective surgical plan. Surgical principles linked to pre-, trans-, and post-operative care must be considered, as recovery depends upon the surgery performed, pathological factors, and the patient's individual response. Some of the most common surgeries performed include herniorrhaphy, urachus, and umbilical vein resection. Several technological

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resources, such as ultrasonography and laparoscopy, are new tools that can help improve the performance of these procedures.
Key words: Calves. Omphalopathy. Persistent urachus. Surgical treatment. Umbilical hernia.

Resumo

As afecções umbilicais são frequentes em bezerros e causam prejuízos econômicos e produtivos nos rebanhos. Apesar da antibioticoterapia ser eficaz em muitos casos infecciosos, o tratamento cirúrgico pode ser indicado. Pela incipiência de revisão relacionada a temática, objetivou-se produzir uma revisão sobre a abordagem clínica e cirúrgica das principais afecções umbilicais de bezerros. O umbigo pode apresentar infecções, como onfalite, uraquite, onfaloflebite, onfaloarterite, paratopias cirúrgicas e persistência de úraco. As infecções podem progredir para quadros septicêmicos com acometimentos de outros órgãos. A queixa principal dessas afecções consiste na protrusão da região umbilical e apatia dos bezerros. Quando a indicação terapêutica for cirúrgica, uma adequada compreensão das afecções umbilicais aliada a um bom exame clínico possibilitará ao cirurgião veterinário estabelecer um bom plano cirúrgico. Princípios cirúrgicos relacionados ao pré, trans e pós-operatório devem ser levados em consideração, pois a recuperação do paciente está diretamente relacionada à tratamento cirúrgico executada, fatores patológicos e resposta individual do paciente. Dentre as cirurgias mais comuns realizadas estão as herniorrafias, cirurgias de úraco e de veias umbilicais. Vários recursos tecnológicos trazem novidades nesses procedimentos, como a ultrassonografia, com destaque para videocirurgia.
Palavras-chave: Bezerros recém-nascidos. Onfalopatia. Úraco persistente. Tratamento cirúrgico. Hérnia umbilical.

Introduction

Umbilical disorders are the third leading cause of disease in calves and can cause economic, productive, and sanitary losses to the production system (Mõtus et al., 2017; Van Camp et al., 2022). While infectious or non-infectious conditions may cause umbilical disorders, the principal clinical signs include increased volume in the umbilical region, as well as evidence of edema, abscesses and/or infection that has spread to the peritoneum, vein, and umbilical arteries, urachus, or other organs within the abdominal cavity (Bozukluhan et al., 2018; Steerforth & Van Winder, 2018).

In chronic infections, there is a high chance of infection passing through the umbilical vessels and urachus, which may contaminate related structures and organs, such as the liver and bladder, causing sepsis (Abdullah et al., 2015; Dogan et al., 2016). Surgical intervention is often indicated because drug therapy alone is inadequate (Marchionatti et al., 2016; Reig Cordina et al., 2018). In particular, surgery is indicated as treatment in non-infectious umbilical disorders, such as umbilical hernias and patent urachus (Farman et al., 2017).

To develop an effective surgical plan, surgeons need to have pathophysiological knowledge of umbilical disorders and the anatomical structures of the umbilical region and conduct a meticulous clinical examination of affected patients (Baird, 2016; Guerri et al., 2020). Few literature reviews have been

conducted on the performance of umbilical surgery in calves. Therefore, this review aims to provide an overview of the clinical and surgical approaches to the main umbilical disorders seen in calves, the anatomy and physiology of the umbilical structures, and the pathogenesis of umbilical disorders.

Search strategy

This literature review is based on two years of research using Academic Google (https://scholar.google.com.br/) and complemented with searches at the National Center for Biotechnology Information - NCBI (https://www.ncbi.nlm.nih.gov/) and National Library of Medicine – PubMed.gov (https://pubmed.ncbi.nlm.nih.gov/), using the following sets of words: 'umbilical disorders in calves', 'surgical management in calves', 'omphalitis in calves', 'laparoscopic structure umbilical', 'laparoscopic in veterinary', 'urachal abscess', 'hernia in cattle', 'calf mortality', 'ultrasonographic umbilical', 'mortality in dairy farms', 'infection umbilical in calves', 'persistent urachus in calves', 'diagnostic structure umbilical in calf', 'septic arthritis in calves', and 'laparoscopic portal'. In this study, the period of publication of the manuscripts was specified (2014-2021), and only works published in indexed journals were selected, including one case report. The articles were screened, and only those that examined umbilical disorders in calves and diagnostic/therapeutic methods associated with these conditions were included. Some studies prior to 2014 have also been included, as they are considered classics and, therefore, indispensable to research.

Anatomy and physiology of umbilical structures and pathogenesis of their disorders

Sound knowledge of the umbilical anatomy of calves is crucial for a good understanding of umbilical disorders and can ensure assertive surgical intervention (Baird, 2016). The umbilical arteries and veins, as well as the urachus, pass through the umbilical hiatus (Figures 1A, 1B, and C). The arteries run parallel to the fetal bladder and enter the internal iliac artery (Figure 1E). The veins then unite to form a single vessel that enters the liver in the portal vein (Figure 1D). The urachus then proceeds to the anterior portion of the bladder (Figure 1E). In the abdomen, the arteries and urachus lie caudal to the umbilicus, whereas the vein lies cranial (Seino et al., 2016; Bombardelli et al., 2018).

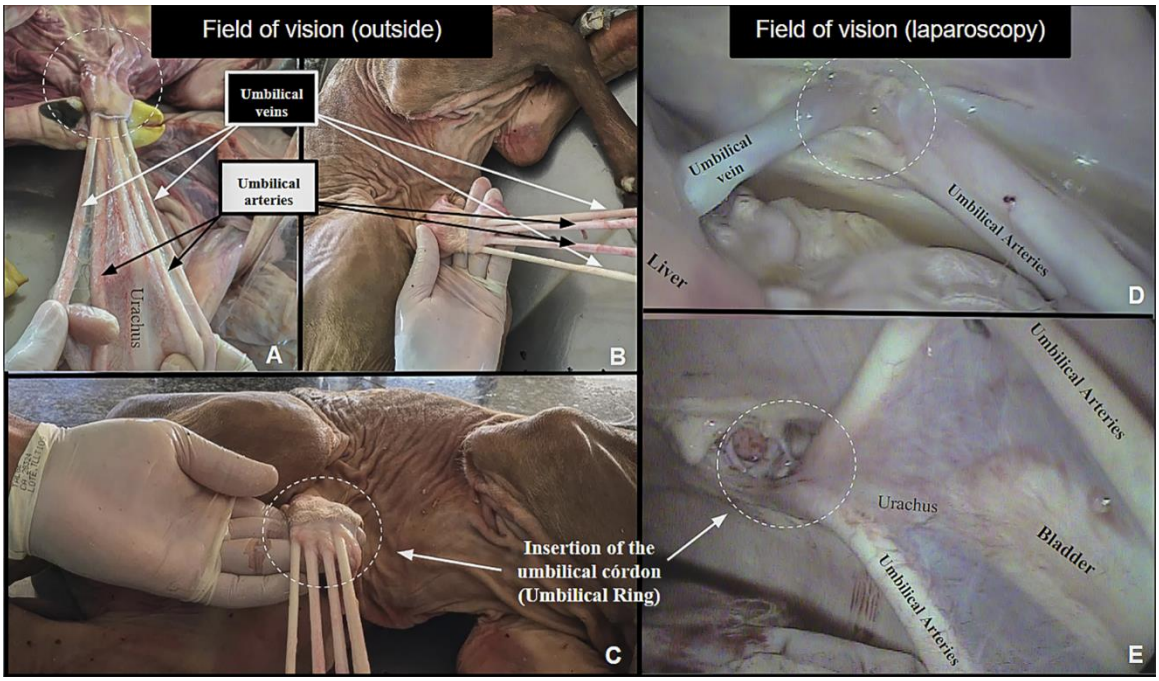

Figure 1. Anatomy of the bovine umbilical cord. **A** Besides the umbilical veins and arteries, the urachus is also visible (external view). **B** The two veins and two umbilical arteries are shown separately (external view). **C** Insertion of the umbilical cord into the abdomen, umbilical region (external view). **D** Umbilical ring, a single umbilical vein and its entry into the liver (intrabdominal-laparoscopic view). **E** Umbilical ring, umbilical arteries, urachus, and bladder (intrabdominal-laparoscopic view).

After delivery, when the umbilical cord is cut, the umbilical vessels and the urachus are retracted into the abdomen. This can be observed using ultrasound during the physiological involution process (Seino et al., 2016; Bombardelli et al., 2018). While umbilical remnants decrease within three to four days, physiological involution may take three to four weeks. In contrast, in the abdominal cavity, the umbilical arteries form the lateral ligaments of the bladder, and the umbilical vein forms the round ligament of the liver (Bombardelli et al., 2018; Guerri et al., 2020). The healing time of the umbilicus and total involution of the umbilical remnants are important for the adoption of curative measures, as treatment should be continued until complete healing of the umbilicus.

When the physiological involution of the umbilicus is well understood, effective preventive measures for umbilical disorders can be implemented (Wieland et al., 2016). Iodine tincture 7%, and chlorhexidine gluconate 2% and 4% have been successfully used to prevent umbilical infections in calves (Robinson et al., 2015; Wieland et al., 2016).

Some calves display a predisposition to umbilical disorders, which may arise from genetic factors or failure to transfer passive immunity; unhygienic conditions may be another possible reason (Rodrigues et al., 2018). Conception methods may be correlated with the occurrence of omphalopathies: animals from in vitro fertilization had a higher frequency of urachus persistence (66.7%),

and those conceived by artificial insemination had a higher frequency of umbilical hernia (58.4%) (Rodrigues et al. 2010). The principal non-infectious conditions include umbilical hernias and persistent urachus (Beasley, 2017; Yasin et al., 2017). Omphalophlebitis, omphaloarteritis, and omphalourachitis are of infectious origin but may appear as associated conditions (Rassel & Rahman, 2020).

Immediately after birth, neonatal umbilical structures are exposed and are highly prone to umbilical infections (Rassel & Rahman, 2020). As the blood in the umbilical vessels is clotted, bacterial proliferation can occur, which can cause an acute infection that can be treated with antibiotic therapy (Rassel & Rahman, 2020; Silva et al., 2021). The microorganisms predominantly related to omphalitis include Actinomyces pyogenes, Fusobacterium necrophorum, Pasteurella spp., Streptococcus spp., Staphylococcus spp., Proteus bacteroides, Escherichia coli, Clostridium tetani and Citrobacter koseri (Komine et al., 2014; Silva et al., 2021).

Infections of the urachus occur more frequently, with umbilical veins showing higher susceptibility than arteries because of their larger lumen and thinner walls. In fact, their lesser musculature and elastic tissue increase their vulnerability to infection (Figure 2D), which can spread to the liver and bladder, resulting in liver abscesses and cystitis, respectively (Silva et al., 2021).

Figure 2. Calf with omphalophlebitis and polyarthritis. **A** Calf in sternum-lateral recumbency with polyarthritis, showing the left forelimb and left pelvic limb to be rigid. **B** Calf with polyarthritis standing, revealing ataxia with stiff limbs. **C** Arthritis in the left scapulohumeral joint. **D** Enlarged umbilical vein characteristic of omphalophlebitis.

When umbilical infections progress, they can result in diffuse peritonitis, arthritis (Figures 2A, 2B, and 2C), meningitis, endocarditis, pneumonia, hepatitis, cystitis, enteritis, and other systemic infections (Abdullah et al., 2015). These infections can cause weakening of the abdominal wall, and thus the patient is predisposed to umbilical hernia, which is easily identifiable by palpation during physical examination (Hopker, 2014).

Umbilical disorders are observed when the umbilicus increases in size and is accompanied by urinary or mucopurulent secretions, showing changes such as hyperemia and edema in the inflammatory process (Figure 3). Thus, a correct diagnostic approach to such changes can promote a good treatment plan to be developed (Hopker, 2014; Baird, 2016).

Figure 3. Skinny calf with bristly and opaque hair and swelling in the umbilical region.

Diagnostic exploration of the umbilical structures

A general clinical examination should be sufficient to exclude ventral edema from other causes, such as liver or cardiac dysfunction and other diseases unrelated at the umbilicus (Hopker, 2014; Baird, 2016). In some cases, the animal does not present external umbilical alterations. In these cases, ultrasound is required to diagnose omphalopathies, as the morphological changes are restricted to the intrabdominal regions of the umbilical veins and arteries, as well as liver abscesses and cystitis.

Anamnesis and physical examination of the umbilical region and paralumbar fossa may indicate umbilical disorders due to the presence of pain, hernia rings, and enlargement of the urachus and umbilical vein (Baird, 2016; Sato et al., 2019). As physical examination alone has limitations in identifying intra-abdominal changes in umbilical structures, more sophisticated techniques such as ultrasound and exploratory laparoscopy should be conducted (Robert et al., 2016; Guerri et al., 2020).

Ultrasonography at the navel

Ultrasonography facilitates the identification of intra-abdominal changes in the umbilical vessels, urachus, liver, and bladder (Guerri et al., 2020; Bombardelli et al., 2018). These changes are usually strongly correlated with the data obtained during clinical examinations (Baird, 2016; Seino et al., 2016). The ultrasound probe must be positioned in the ventral part of the flank or abdomen at approximately the navel, and an appropriate gel must be used to improve the probe contact and transmission of ultrasonic waves for imaging, as shown in Figure 4. A systematized and standardized method can improve the ultrasound examination and enhance the images captured, thus ensuring better analysis to identify the pathologies associated with the umbilical structures, namely, the liver and bladder (Baird, 2016; Guerri et al., 2020).

For ultrasound examination of the umbilical stump and remnants, the hair must be trimmed over the skin of the ventral surface of the abdomen, between the inguinal region and xiphoid. An adequate amount of coupling gel must be used to obtain accurate structural images. A multifrequency linear probe from 7 to 10 MHz can be used. The examination should be performed with the calf in the left lateral decubitus position with manual restraint. The examination may begin with the evaluation of the two umbilical arteries and the urachus, followed by the extra-abdominal umbilical structures and umbilical vein. The umbilical arteries can be evaluated with a probe positioned at the midpoint of the urinary bladder, in the transverse plane, to the left and right of the bladder. The umbilical arteries are not perfectly circular in cross-section. Extra-abdominal umbilical structures can be evaluated with a probe positioned at the cranial edge of the umbilical stump, transverse to the long axis of the cord. The umbilical vein is not perfectly circular in cross-section.

Figure 4. Transverse image of the umbilical vein in a calf affected by omphalophlebitis (Mindray Z5 Vet). * Presence of purulent material inside the umbilical vein (hyperechoic). Abdominal wall (white arrow).

Laparoscopy in navel diagnosis and surgical treatment

As a complementary examination of the physical and ultrasonographic examinations, laparoscopy enables visualization and inspection of the umbilical structures, liver, and bladder (Figures 5A, 5A-1, and 5A-2), facilitating the accurate recognition of macroscopic changes, including multifocal abscesses in the liver, disorders in inaccessible regions, focal thickening, and adhesions (Robert et al., 2016).

The surgeon must position the patient according to the laparoscopic approach chosen so that laparoscopic portals can be established. These can be placed in the ventral part of the abdomen or paralumbar fossa with two or three suitably triangulated access portals (Figure 5A) (Milovancev & Townsend, 2015; Monteiro et al., 2021). At the discretion of the surgical team, pneumoperitoneum can be created using a Veress needle, either prior to the insertion of the first trocar or just after the trocar is directly inserted (George et al., 2019; Abass et al., 2020). This direct trocar insertion procedure is similar to that of Kaistha et al. (2019). As this procedure is quick and safe, we believe it should be employed more often by veterinary surgeons. In the flank (Figure 5B), the first laparoscopic portal can then be established through the blind insertion of the trocar, with pneumoperitoneum subsequently at 8 mmHg (Figure 5D). In contrast, the second and third portals (Figures 5A and 5E) should be performed with video assistance to ensure greater safety during trocar insertion (Monteiro et al., 2021).

Figure 5. Laparoscopy performed through the right flank to access umbilical structures in a calf. **A** Position of the surgeon and three access portals to the umbilical structures from the right flank, paralumbar fossa (A-1 Intra-abdominal view of the umbilical structures during laparoscopy. A-2 Manipulation of the intra-abdominal umbilical structure via laparoscopy). **B** Calf in left lateral recumbency with a wide trichotomy of the right flank (Cl: Caudal and Cr: Cranial). **C** Flank pre-surgical care (trichotomy, antisepsis, and field cloth). **D** Insertion of the first trocar to establish the first access port (laparoscopic). E First laparoscopic access port and second instrument access port.

Open surgical treatment of umbilical disorders

Pre-surgical considerations

Surgical intervention is mandatory for cases of umbilical hernia, persistent urachus, and chronic infections (with or without abscesses) (Williams et al., 2014; Sato et al., 2019). For chronic infections, decreasing the bacterial load by resectioning the infected structures helps improve the patient's prognosis due to the removal of the infected structures with low antimicrobial penetration (Williams et al., 2014; Boscarato et al., 2021). Thus, the surgical plan should consider the severity and complications that can arise from the propagation of infection (Robert et al., 2016).

In sick calves, factors such as concurrent diseases that affect the lungs, immune status, pH, and electrolyte imbalance should be noted before surgery. Complementary laboratory examinations of the patient, with fasting, should be performed prior to the performance of any surgical procedure (Marchionatti et al., 2016; Baird, 2016).

Umbilical surgery can be performed under sedation with local or general anesthesia alone. The anesthetic protocol selected is at the discretion of the surgeon and anesthesiologist and is usually based on the size and temperament of the patient, the anticipated degree of difficulty of the procedure, the method of restraint, and the precise surgical plan.

Surgery can be performed in the field or within a pertinent surgical environment; however, in cases that require herniorrhaphy using a prosthetic mesh, field surgery is not recommended, as this involves a technically more demanding procedure and longer surgical time, with the possibility of more complications than other umbilical surgeries (Williams et al., 2014). When sedation and local anesthesia do not warrant patient restraint, physical restraints are advised (Marchionatti et al., 2016; Baird, 2016).

Preoperative management

During umbilical surgery, the patient's vital signs must be continuously monitored, with verification of the respiratory rate, heart rate, rectal temperature, mucous membrane color, and pulse oximetry (Marchionatti et al., 2016; Baird, 2016).

Surgical approaches for the treatment of umbilical disorders

Based on the indicated therapy, the site and shape of the surgical incision in the umbilical region are determined based on the physical and complementary examination results, including ultrasonography (Steerforth & Van Winder, 2018; Guerri et al., 2020). An incision is made to facilitate easy access to the affected structures and hernia sac for correction of the disorders (Guerri et al., 2020; Beasley, 2017). During umbilical celiotomy, to ensure better access to the urachus and umbilical vessels, the incision can be performed in an ethylene line in the mid-line, supra-umbilical, and infra-umbilical regions. Another alternative is to make an elliptical incision in the peri-umbilical region, just around the umbilical stump (Figure 6A), and over the hernia and tumor/umbilical abscess to ensure ease of access to the umbilical vessels and urachus, and the hernia

ring or swollen area (Baird, 2016; Beasley, 2017). During laparoscopy, incisions can be made in the ventral region of the abdomen or the right paralumbar fossa (Robert et al., 2016; Monteiro et al., 2022).

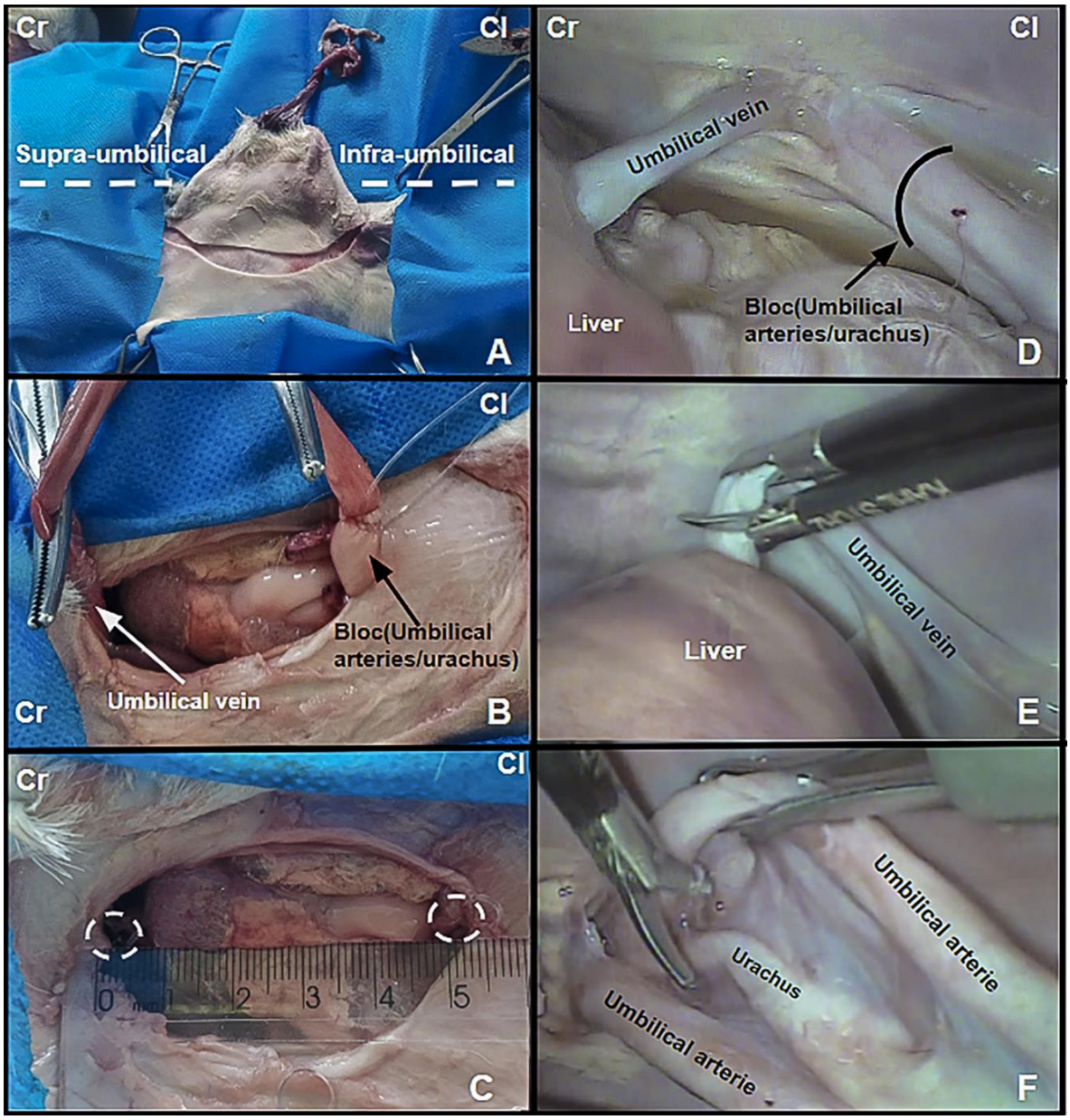

Figure 6. Approaches by celiotomy and laparoscopy in the umbilical structures of bovine fetuses. **A** Elliptical incision around the umbilicus (Cr: cranial, Cl: caudal). **B** Access via celiotomy to the umbilical structures and ligation with Miller's Knot of the umbilical vein and block (umbilical arteries and urachus) (Cr: cranial, Cl: caudal). **C** Celiotomy with resected umbilical structures (Cr: cranial, Cl: caudal). **D** Laparoscopic inspection of the umbilical structures (Cr: cranial, Cl: caudal). **E** Simulation of laparoscopic umbilical vein resection near its insertion into the liver. **F** Simulation of laparoscopic urachal resection.

Incisions can be made for both celiotomy and laparoscopy by maintaining the patient in a supine position and keeping the hind limbs extended and abducted to clearly expose the umbilical region (Baird, 2016; Beasley, 2017). The lateral recumbency position has been found to be feasible for laparoscopic surgical interventions in the umbilical structures of bovine fetuses (Monteiro et al., 2021). The most common method for celiotomy is to make an elliptical or fusiform incision around the umbilicus (Figure 5A), with a deviation of the incision to the foreskin in male calves. Then, the subcutaneous and rectus abdominis are dissected up to the peritoneum, which is then cut open to facilitate access to the umbilical structures (Figure 6B) (Marchionatti et al., 2016; Monteiro et al., 2021). The opening can be extended using Mayo scissors to ensure better visualization and access to the structures that can be resected individually or in blocks (Figure 6C) (Baird, 2016). Resection of the pathologically affected structures must be carefully performed, with attention paid to hemostasis and avoiding contamination (Figure 6B) with the use of ligatures or hemostatic clamps (Figure 6C) (Marchionatti et al., 2016; Baird, 2016; Monteiro et al., 2022).

Umbilical vein resection

In the case of omphalophlebitis, to facilitate direct access to the umbilical vein up to its hepatic insertion, the incision can also start at the level of the umbilicus and extend cranially. The use of double ligation or double clipping with the interspersed section of the umbilical vein in the area nearest to the liver is adequate to warrant safe resection of this structure. To prevent contamination of the abdominal cavity, excision of the infected parts should be conducted meticulously, with the area covered with a surgical glove or compression employed (Figures 6B and 6C). In cases where umbilical vein infection reaches the liver parenchyma and forms an abscess, vein marsupialization is recommended (Marchionatti et al., 2016; Canola et al., 2020).

Marsupialization of the umbilical vein

During umbilical vein marsupialization, the end of the vein in the umbilical hiatus is fixed after being sectioned with a double ligature and intercalated incision in the abdominal wall at the cranial end or another separate surgical opening. Vein suturing to the abdominal wall is performed in three layers using little tension, with the rectus abdominis sheath and subcutaneous tissue sutured to the vein wall in two layers, using 2-0 absorbable sutures. However, the skin is sutured to the vein wall using a nonabsorbable 2-0 suture and the simple interrupted pattern technique (Marchionatti et al., 2016; Canola et al., 2020).

To stimulate drainage of the exudate, the lumen of the marsupialized vein requires washing every day using a 20 mL syringe with saline or iodinated solution. Systemic antibiotics must be administered, and the patient's owner must be informed that a second surgery may be necessary to resect the vein and close the marsupium (Marchionatti et al., 2016; Canola et al., 2020).

Surgical approach to the urachus

In the event of urachal disorders, namely urachal abscesses, cysts, and persistent urachus, ultrasonography is a proven and useful technique that enables the surgeon to select the best surgical treatment option (Sato et al., 2019). Incisions made in the umbilicus and peri-umbilical regions, which are extended caudally, facilitate access to the urachus to the point of insertion into the bladder, enabling the surgeon to explore and correct this structure (Figures 6B and 6C) (Canola et al., 2020). For surgical intervention of the urachus, the bladder must be fully empty and maintained to prevent the surgical field from being contaminated with urine. When the bladder apex requires suturing, the mucosa must be sutured first using a 0- or 2-0 absorbable suture using the simple continuous stitch technique and then the seromuscular, using the same absorbable suture but with an inversion pattern (either the Cushing or the Lembert pattern). Bladder closure must ensure sealing without urine leakage (Baird, 2016).

Surgical approach to umbilical arteries

An incision is started in the umbilicus, extended caudally, and in the peri-umbilical regions, and extended caudally, which permits good access into the umbilical arteries via celiotomy and enables free and accurate intervention by the surgeon to either resect the affected structures or perform individual or block-type resection (Figures 6B and 6C). After ascertaining that the artery is dissected from the bladder and/or any adhered tissue, it can be ligated and resected (Marchionatti et al., 2016; Baird, 2016).

Herniorrhaphy (access to the hernia ring): open and closed

Hernias are recognized as the most common umbilical disorder observed in calves (Figure 7A). They occur due to the delayed closure of the umbilical ring, which forms a hernial sac with the abdominal viscera. Although hernias are often associated with infections of the umbilical vessels or urachus, they are usually caused by a congenital defect (Hopker, 2014; Beasley, 2017). Hernias are easy to diagnose by simple palpation because the herniated contents slide effortlessly into the abdomen. The hernia ring size can also be assessed by palpation (Baird, 2016; Beasley, 2017).

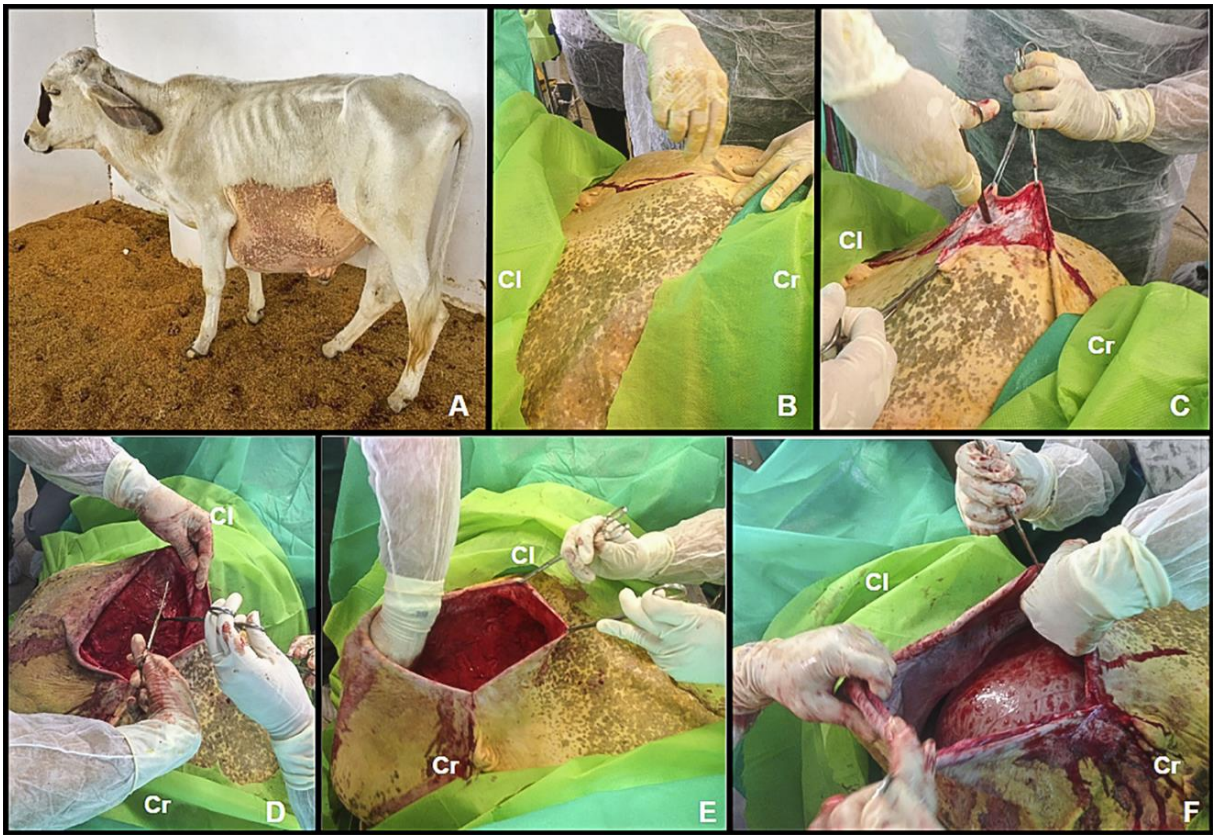

Figure 7. Herniorrhaphy in a young bovine with an umbilical hernia. **A** Cow with an umbilical hernia. **B** Skin incision over the hernia (Cr: cranial, Cl: caudal). **C** Divulsion of the subcutaneous tissue (Cr: cranial, Cl: caudal). **D** Superficial muscle incision (Cr: cranial, Cl: caudal). **E** Deep muscle release. **F** Access to the hernia sac (Cr: cranial, Cl: caudal).

Umbilical hernias can be repaired using an open or closed surgical approach (Figures 7B–7F). In the open method, the main features include an incision of the peritoneum, hernial sac, and access to the abdominal cavity. The peritoneum is not incised in the closed method. Closed herniorrhaphy is practical only in the absence of infected umbilical structures or adhered viscera and is a good choice for the correction of small hernias (Maruthi et al., 2017).

In the case of closed herniorrhaphy, an elliptical incision is made in the skin just over the umbilical hernia (Figure 7B), and the subcutaneous tissue around the hernia sac is dissected (Figures 7C to 7E), up to the ring (Figure 7F). Then the hernia sac is introduced into the abdominal cavity. In the case of open herniorrhaphy, after the hernia sac and peritoneum are incised, the viscera is introduced into the abdominal cavity, and abdominorrhaphy is subsequently performed (Beasley, 2017).

The performance of closed herniorrhaphy helps to prevent peritoneal contamination as it requires a shorter surgical time and is associated with a lower rate of complications. When the hernias exceed 5 cm in diameter or prior treatment has proven unsuccessful, a prosthetic mesh can be

applied to the muscle layer along the edges of the hernia ring or as an adhesive over the ring closure via the subcutaneous layer (Beasley, 2017). However, the application of mesh raises the procedure costs and increases the likelihood of post-operative infection, thus exacerbating the prevalence of post-surgical complications; application in the field is not indicated (Baird, 2016; Beasley, 2017).

Abdominorrhaphy

Upon completion of the removal of the umbilical structures, correction of the disorder, and introduction of the hernial sac or herniated content into the abdominal cavity, abdominorrhaphy can be performed (Figure 8). The peritoneum and muscle are sutured using absorbable suture thread 2-0, adopting the interrupted pattern technique that supports high tension or an overlapping suture pattern overlapping the edges of the hernia ring or surgical wound (Figures 8A, 8B, and 8C) (Beasley, 2017; Monteiro et al., 2021). Subcutaneous tissue with 2-0 absorbable thread and a simple continuous pattern can be anchored in the musculature to minimize dead space (Figure 7D). Dermorrhaphy is performed using a 0 nonabsorbable suture with an interrupted cross pattern; usually, one or two stitches are required when laparoscopic surgery is performed (Robert et al., 2016; Beasley, 2017).

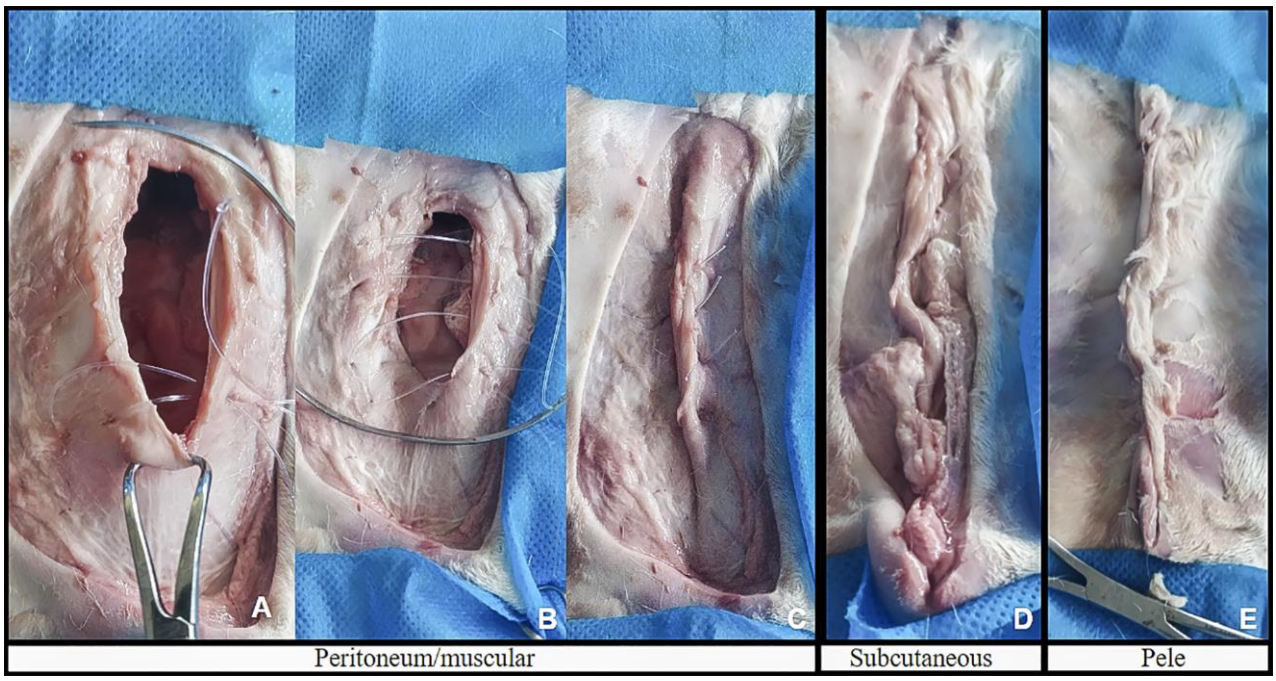

Figure 8. Umbilical abdominorrhaphy in bovine fetuses, experimental surgery (cadaveric study). A, B, and C Peritoneum/muscle suture with overlapping edges, overlapping suture pattern type, an indication of absorbable suture n. 0. D Subcutaneous suture showing muscle anchorage for the reduction of dead space, continuous pattern, an indication of an absorbable suture. E Demorrhaphy with interrupted suture pattern. Observation: In the figure, nylon was used in all suture layers during abdominorrhaphy because it was an experimental study performed on cadavers.

Post-operative care

Daily dressing of the surgical wound with protective bandaging is mandatory to avoid infection and myiasis until complete wound healing is achieved. The patient must be isolated in a clean paddock, separate from other animals, and food provided only after ensuring full anesthetic recovery (Baird, 2016; Marchionatti et al., 2016).

In patients receiving umbilical vein marsupialization, greater care of the marsupialized vein is required. The vein lumen must be washed daily under controlled pressure with a physiological solution to stimulate the release of the purulent secretions present in diffuse and liver abscesses until they are eliminated and the abscesses fully healed. These patients require a second surgery to remove the marsupialized vein and close the marsupium (Baird, 2016; Marchionatti et al., 2016).

The administration of antibiotics and anti-inflammatories is necessary for a minimum of five days, depending on the clinical state of the patient; however, in instances where the patient develops septicemia, with other organs being involved, antibiotics may be used until full recovery is assured. For umbilical surgeries, anti-inflammatory drugs are administered with Flunixin meglumine (1 mg/kg IV SID for three days) and Meloxicam (0.5 mg/kg IV/SC every 48 h for three days); the antibiotics commonly used include ampicillin sodium (10 mg/kg IV every 8 hours), ceftiofur sodium (2.2 mg/kg IV BID), penicillin G procaine (22,000 IU/kg IM SID) and Enrofloxacin (10 mg/kg IV SID) (Beasley, 2017; Baird, 2016; Marchionatti et al., 2016).

Final considerations

Umbilical disorders are one of the main health issues identified in calves. Although they cause damage to the production system, they do not always require surgical intervention. Correct diagnosis of the umbilical disorder can enable veterinary surgeons to select an appropriate intervention and formulate an effective surgical plan. The recovery of the patient depends upon the surgery performed, pathological factors, post-operative management, and the patient's individual response

Competing interests

The authors declare that they have no conflicts of interest. The authors are responsible for the content and writing of this manuscript.

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