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Equine castration: review of anatomy, approaches, techniques and complications in normal, cryptorchid and monorchid horses

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Complications associated with equine castration are the most common cause of malpractice claims against equine practitioners in North America. An understanding of the embryological development and surgical anatomy is essential to differentiate abnormal from normal structures and to minimise complications. Castration of the normal horse can be performed using sedation and regional anaesthesia while the horse is standing, or under general anaesthesia when it is recumbent.Castration of cryptorchid horses is best performed under general anaesthesia at a surgical facility. Techniques for castration include open, closed and half-closed techniques. Failure of left and right testicles to descend occurs with nearly equal frequency, however, the left testicle is found in the abdomen in 75% of cryptorchid horses compared to 42% of right testicles. Bilateral cryptorchid and monorchid horses are uncommon. Surgical approaches described for the castration of cryptorchid horses include an inguinal approach with or without retrieval of the scrotal ligament, a parainguinal approach, or less commonly a suprapubic paramedian or flank approach. Laparoscopic castration of cryptorchid horses has recently been described but the technique has limited application in practice at this time. A definitive diagnosis of monorchidism can only be made after surgical exploration of the abdomen, removal of the normal testis and hormonal testing. Hormonal assays reported to be useful include analysis of basal plasma or serum testosterone or oestrone sulphate concentrations, testosterone concentrations following hCG stimulation, and faecal oestrone sulphate concentrations. Reported complications of castration include postoperative swelling, excessive haemorrhage, eventration, funiculitis, peritonitis, hydrocele, penile damage and continued stallion-like behaviour.

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Castration is one of the most common surgical procedures performed in equine practice.[1,2] Although the procedure is considered routine, surgical complications constitute the most common cause of malpractice claims against equine practitioners in North America.[3] A complete understanding of male reproductive anatomy and physiology and good surgical technique will reduce the rate of surgical complications. Presurgical evaluation and surgical approach to cryptorchid and monorchid horses are a more complex diagnostic and surgical challenge. This article provides practitioners with a review of relevant information on the embryological development and anatomical features of the male equine reproductive tract, the approaches to castration of the normal, cryptorchid, and monorchid horse, and the diagnosis and management of surgical complications.

IM	Intramuscularly
IV	Intravenously

Embryonic development and surgical anatomy of the equine testis

The embryonic gonad differentiates into a testis at approximately 5½ weeks of gestation, at which time it lies on the ventral aspect of the mesonephric kidney.[4,5] A retroperitoneal cord of mesenchyme coursing across the abdominal cavity from the caudal pole of the testis to an extraperitoneal position at the site of the future scrotum forms the gubernaculum.[5] The gubernaculum is divided into two parts by the mesonephric duct which ultimately

differentiates into the epididymis.[4] At day 45 a peritoneal outpouching at the site of the future internal inguinal ring invades the extraperitoneal segment of the gubernaculum forming the vaginal process.[5] Ultimately, when it is completely differentiated, the gubernaculum can be divided into the three different segments identified in the adult horse: the proper ligament of the testis lies between the caudal pole of the mature testis and the tail of the epididymis, the ligament of the tail of the epididymis lies between the tail of the epididymis and the parietal tunic of the vaginal process, and the scrotal ligament lies between the parietal tunic of the vaginal process and the scrotum (Figure 1).[5]

At approximately 6 weeks gestation, the interstitial cells of the testis begin to multiply. By 5 months the embryonic testicle approaches the size of that of a mature stallion and lies in contact with the kidney and the internal inguinal ring.[4,5] Between 7 and 10 months of gestation the testicle atrophies to approximately one tenth of its former size as the gubernaculum shortens.[4,5] The epididymis and the ligament of the tail of the epididymis expand to dilate the vaginal ring and inguinal canal.[5] Ultimately, at 9 and 10 months of gestation dilation of the inguinal ring, contraction of the gubernaculum and increase in intra-abdominal pressure combine to force the small, flaccid testicle into the inguinal ring.[5] The volume of extra-abdominal gubernaculum prevents the testicle from descending completely into the scrotum, so at birth the testicles usually lie within the inguinal rings.[4,5] The mass of gubernaculum is quite large at birth and may be mistaken for a testicle.[5] During the first few weeks of life vaginal rings contract to approximately 1 cm in diameter and gubernacular tissues reduce in size, allowing the testicle to assume a scrotal position.[4,5]

The testicular tissue is encased in the tunica albuginea.[2,5] In the horse the left testicle is usually larger than the right and is suspended more ventrally and situated more caudally.[5] The head of the epididymis is found cranially continuing as the body and tail to become the ductus deferens caudally.[5] The testicles lie within an outpocket of abdominal peritoneum known as the tunica vaginalis.[2,5] The tunica vaginalis consists of visceral and parietal tunics. The visceral tunic is tightly adhered to the testicle, ducts and vessels, and the parietal tunic is continuous with the parietal peritoneum (Figure 1).[5] The cremaster muscle is a caudolateral extension of the internal abdominal oblique muscle and is continuous with the parietal layer of the tunica vaginalis inserting at the caudal pole of the testicle (Figure 2).[5] The parietal tunic is intimately adherent to the scrotal skin through the scrotal fascia and tunica dartos muscle.[2,5] The tunica dartos sends a sagittal septum into the scrotal sac dividing it into left and right pouches.[5] The spermatic cord courses from abdomen to scrotum through the inguinal canal which is bounded by deep and superficial inguinal rings. The deep inguinal ring is a dilatable opening between internal abdominal oblique muscle, rectus abdominus muscle, prepubic tendon and inguinal ligament. The superficial inguinal ring is formed by a small opening in the external abdominal oblique muscle.

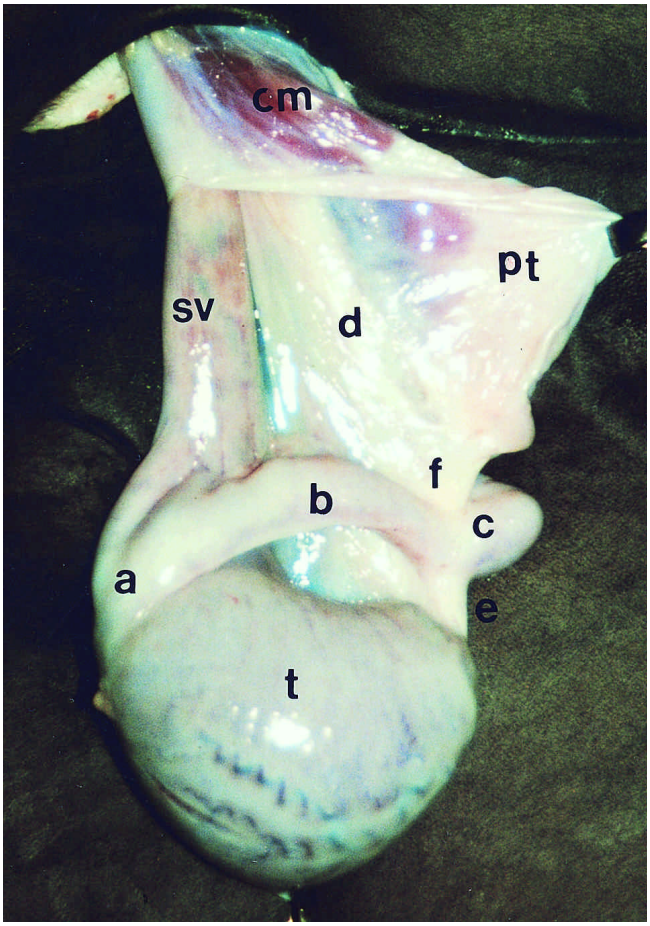

Figure 1.The testicular structures seen during castration of the mature male horse using an open castration technique. The testicle (t) is tightly enclosed in the tunica albuginea.The head of the epididymis (a) continues as the body (b) and the tail (c) the latter continues as the vas deferens (d).The tail of the epididymis is attached to the caudal pole of the testis by the proper ligament of the testis (e).This continues as the ligament of the tail of the epididymis (f) between the tail of the epididymis and the parietal tunic (pt).The visceral tunic covers the visceral surface of the testicle, epididymis, spermatic vessels (sv), and vas deferens. The parietal tunic and cremaster muscle (cm) have been incised and are partially retracted.

Preoperative considerations

Before castration all horses should undergo physical examination including external examination of the reproductive tract.[5] Sedation may be required to palpate the scrotum and the inguinal canals for the presence of two testicles and absence of an inguinal hernia. Tetanus prophylaxis should be current. Some practitioners choose to give procaine penicillin (20 mg/kg IM) prophylactically prior to surgery. The efficacy of this in reducing postoperative complications in castration of normal horses is questionable. The use of antimicrobials for horses undergoing cryptorchid or monorchid castration should be considered on a case-by-case basis but cannot be a substitute for aseptic technique. Preoperative adminis-

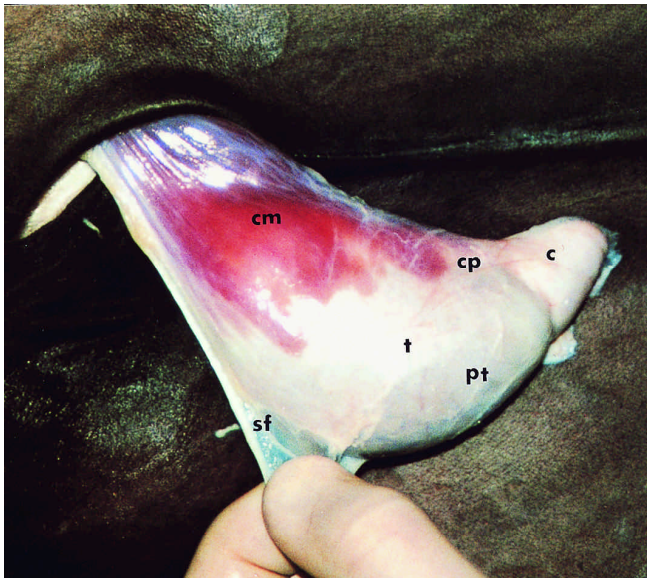

Figure 2.The testicular structures seen during castration of the adult male horse using a closed technique.The testicle (t) and the tail of the epididymis (c) are outlined within the parietal tunic (pt).The cremaster muscle (cm) can be seen fanning out to insert towards the caudal pole of the testis (cp).The scrotal fascia (sf) remaining after the testicle and cord have been stripped can still be seen.

tration of a nonsteroidal anti-inflammatory drug (phenylbutazone 2.2 to 4.4 mg/kg or flunixin meglumine 1 mg/kg), and postoperative administration as required, may help control postoperative pain and swelling.

Castration can be performed in the standing sedated horse using regional anaesthesia or with the horse under general anaesthesia. The choice is largely based on the surgeon's preference and experience. Docile colts whose genitals can be palpated readily without sedation are usually the safest candidates for standing castration.[5]

Sedation and anaesthesia for cas - tration

Standing castration

A combination of physical and chemical restraint and regional anaesthesia is generally recommended.[2] Drugs used commonly, alone or in combination, include acepromazine, xylazine hydrochloride, romifidine, detomidine hydrochloride and butorphanol tartrate. A combination of detomidine hydrochloride (20 to 40 µg/kg) or xylazine hydrochloride (0.3 to 0.5 mg/kg) and butorphanol tartrate (0.01 to 0.05 mg/kg) provides reliable sedation and analgesia.[6]

Various regional anaesthetic techniques have been described for castration of the standing horse.[2,5,6] Local anaes-thetic can be injected into the spermatic cord, testicular parenchyma, or both. The testicular nerves may be anaesthetised by directly injecting 15 to 30 mL of local anaesthetic into the spermatic cord using a 21-gauge 1.5 inch needle. This can be achieved by placing gentle traction on the testicle allowing access to the spermatic cord or by depositing the local anaesthetic at the level of the superficial inguinal ring.[2] Infiltration of the spermatic cord may occasionally cause a haematoma which can interfere with application of the emasculator.[5] When injecting into the testicular parenchyma, the testis is tensed in the fundus of the scrotum and 15 to 25 mL of local anaesthetic is injected into the parenchyma of each testis using a 18-gauge 1.5 inch needle. Given sufficient time the local anaesthetic is proposed to diffuse from the pampiniform plexus to anaesthetise the cord.[2] When combining both techniques, infiltration of the testicle first can facilitate access to the cord in anxious horses. In our hands this combination provides reliable anaesthesia for most horses. Using either technique, 5 to 10 mL of local anaesthetic should be deposited under the scrotal skin either side of the median raphe along the proposed incision line.[2]

Recumbent castration

We prefer to use general anaesthesia because surgical exposure is improved and it carries less risk for surgeon and patient. Various drugs and drug combinations have been recommended for this procedure.[2,5] The placement of a jugular catheter is warranted for drug administration. Thiobarbiturates (thiopentone sodium 4 to 8 mg/kg IV to effect) administered following sedation with xylazine hydrochloride (0.3 to 0.5 mg/kg IV) or acepromazine (0.03 to 0.05 mg/kg IV), or given with or after muscle relaxants such as guaifenesin (100 mg/kg IV to effect) have been recommended for short anaesthetic procedures.[2] While these combinations provide excellent muscle relaxation and analgesia, anaesthetic recovery may be considered less than satisfactory if repeated administration of the barbiturate is required.[2,5]

Xylazine hydrochloride (1.1 mg/kg IV) followed by ketamine hydrochloride (2.2 mg/kg IV) combined with diazepam (0.05 to 0.1mg/kg IV) is an effective combination.[2,5] Diazepam provides muscle relaxation and appears to improve the quality of anaesthetic induction and recovery. The addition of butorphanol tartrate (0.02 to 0.03 mg/kg IV) will provide additional analgesia and may improve anaesthetic recovery. This combination generally allows at least 12 to 15 min of surgical time. Additional doses of xylazine (0.25 mg/kg IV) and ketamine (0.5 mg/kg IV) can be used safely to extend surgical anaesthesia.

Cryptorchid castration

Unless the position of the non-descended testicle can be accurately determined and is easily accessible, this surgery is best performed at a surgical centre under gaseous anaesthesia.[3,5]

Surgical techniques for castration of normal horses

Surgical removal of the descended testis can be performed using an open or closed technique. There is also a variation on the closed technique referred to as half-closed or semi-closed castration.[2,5] There are several modifications of each technique but, regardless of whether the horse is sedated and standing or recumbent and anaesthetised, the surgical principles for castration remain the same.[2,5] Traditionally, castration techniques allow for second intention healing of scrotal wounds, however some have advocated primary closure.[7,8] Primary closure is rarely suited for castrations performed in the field but may be of benefit in select cases where castration is

performed aseptically in a surgical facility. Reported advantages of primary closure include early return to work, minimal postoperative management and a more favourable and early cosmetic outcome with no possibility of eventration.[7]

Open technique

Two incisions are made through the scrotal skin, tunica dartos, scrotal fascia and parietal tunic parallel to the median raphe, approximately 2 cm apart and 8 to 10 cm long. The testis is prolapsed out of the tunic but remains attached to the parietal tunic by the ligament of the epididymis (Figure 1). This ligament can be transected to release the parietal tunic and cremaster muscle and expose the vessels and ductus deferens which can then be emasculated. To reduce the occurrence of postoperative complications such as scirrhous cord and hydrocele, it is desirable to digitally strip the fascia around the parietal tunic as far proximal as possible so it may be emasculated and removed.[2,5] This is easily achieved if the parietal tunic alone (not the parietal tunic and testicle together) is pulled distally with Carmalt forceps while the fascia is stripped proximally using gauze swabs. Alternatively the parietal tunic, the cremaster muscle, the vessels and the ductus deferens can all be emasculated together.

Closed technique

Incisions similar to those for the open technique are made down to but not through the parietal tunic (Figure 2). The testicle, still encapsulated by the tunic, is grasped and the scrotal fascia is stripped from the parietal tunic using a dry swab, until the cremaster muscle and the parietal tunic are clearly exposed. The entire spermatic cord is then emasculated.[2,5]

Half-closed technique

The approach is similar to the closed technique, however after the parietal tunic and the cremaster muscle are exposed a 2 to 3 cm vertical incision is made through the parietal tunic just proximal to the testicle. The inside of the parietal tunic is inspected to ensure there is no evidence of herniated intestine and the entire spermatic cord is emasculated proximally. Alternatively the vessels and ductus can be exteriorised from the parietal tunic and emasculated before emasculating the parietal tunic and cremaster muscle. In another modification the surgeon's thumb can be placed through the incision made in the parietal tunic and the fingers used to prolapse the testicle, vessels and ductus deferens through the incision. This provides the surgeon with a secure grip on the parietal tunic. The vessels and ductus deferens can then be emasculated separately prior to emasculation of the parietal tunic and cremaster muscle or the cord can be emasculated in one.[5]

Cryptorchid castration

The failure of the right and left testicle to descend occurs with nearly equal frequency.[9,10] Of left testicles that fail to descend 75% are found within the abdomen compared to 42% of right testicles.[10] Failure of both testicles to descend is uncommon, affecting 9 to 14% of cryptorchid horses.[5,10]

An accurate castration history is helpful in determining the surgical approach to the cryptorchid horse.[5,11] Palpation of the scrotum and inguinal rings for presence of testicular structures may require sedation in younger or more anxious colts.[5] Transrectal examination generally contributes little to differentiating the type of cryptorchid and carries inherent risks in younger or more fractious animals.[5,11]

Surgical options include inguinal, parainguinal, suprapubic paramedian and flank approaches.[2,5] More recently, standing and recumbent cryptorchidectomy using a laparoscopic technique have been described.[12,13]

Inguinal approach

Two approaches are described for inguinal exploration.[5,11] A 10 cm incision is made through the scrotal skin where the testicle should be and digital dissection is continued towards the superficial inguinal ring.[5] Alternatively, a 8 to 15 cm incision can be made directly over the superficial inguinal ring.[11] A scrotal incision results in less skin haemorrhage and precludes the need to displace inguinal fat to locate the superficial inguinal ring.[11] Recognition of anato-mical features is improved if haemorrhage is controlled. During dissection down to the inguinal ring the smooth, white parietal tunic of the vaginal process is sought. If no structures are identified the inguinal extension of the gubernaculum testis (scrotal ligament) can often be identified exiting from the superficial inguinal ring. It is a thin, flat, fibrous band that courses from the vaginal process to the scrotum. It can be located by carefully inspecting the lateral or medial margins of the cranial third of the superficial inguinal ring.[14] Gentle traction on this ligament using sponge forceps will evert the vaginal process from the superficial inguinal ring and it can be opened longitudinally using scissors. Commonly the tail of the epididymis is the first structure identified and gentle traction on the epididymis will expose the ductus deferens, the proper ligament of the testis, and finally the testis.

If the vaginal ring can accommodate more than the tips of the index and middle fingers then the inguinal canal should be packed with sterile gauze for 24 to 36 h or closed with sutures to reduce the risk of intestinal prolapse through the canal. A sterile gauze bandage can be used as packing to obliterate the inguinal canal and the distal end is left hanging freely from the scrotal wound. The pack is maintained in the inguinal ring by loosely suturing skin edges. Alternatively the superficial ring can be sutured closed using simple interrupted sutures of heavy absorbable suture material.

Surgical approaches for cryptorchid horses

- Inguinal
- Parainguinal
- Suprapubic paramedian
- Flank
- Laparoscopic

Parainguinal approach

Where the testis cannot be exteriorised from the inguinal canal using noninvasive inguinal approaches,[10] several more invasive techniques have been described to explore the inguinal canal.[5,11] These have been used commonly but it has been suggested that they increase the risk of evisceration.[10,11] The parainguinal approach provides a convenient alternative where the noninvasive inguinal approaches

have been unsuccessful.[15] A 4 cm incision is made in the aponeurosis of the external abdominal oblique muscle 1 to 2 cm medial and parallel to the superficial inguinal ring. The incision is centred over the cranial aspect of the ring. The internal abdominal oblique muscle underlying the aponeurosis is bluntly separated along its muscle fibres to expose the peritoneum which is then penetrated to enter the abdominal cavity. The internal inguinal ring can be identified caudolaterally and, with a sweeping action, the fingers should pick up any testicular structures. These can be exteriorised and emasculated. If difficulty is encountered in locating the epididymis or associated structures the incision can be enlarged to allow the surgeon's hand to enter the abdominal cavity for exploration of the urogenital tract. The incision in the aponeurosis is closed using heavy absorbable sutures and the subcutaneous tissue and skin can be closed or left open to heal by second intention.[15]

Suprapubic paramedian approach

An incision of 8 to 15 cm is made cranially from the level of the preputial orifice approximately 5 to 10 cm lateral to the ventral midline.[5,16] The abdominal tunic, which is closely adherent to the ventral sheath of the rectus abdominis muscle, is incised longitudinally and the underlying fibres of the rectus abdominis muscle are bluntly separated in the same direction. Blunt dissection is used to penetrate through the dorsal rectus sheath, retroperitoneal fat and peritoneum. The testicle is usually found near the deep inguinal ring and is easily exteriorised. After emasculation, the abdominal tunic, the subcutis and skin are each closed separately with interrupted or continuous sutures. This procedure has largely been superseded by the parainguinal approach, however it is proposed to allow access to both testicles in the case of a bilateral cryptorchid.[5]

Flank approach

A standard flank approach can be used in standing or recumbent horses.[17] The testicle is located and removed using a similar technique to the paramedian approach. This technique is less acceptable cosmetically than the other approaches and is now generally reserved for removal of large neoplastic testicles.[5]

Laparoscopy

Laparoscopic techniques for castration of cryptorchid horses have recently been described.[12,13] Laparoscopy requires special instruments not readily available in general practice[5] and further refinements are needed in the method.[13] At present this technique has limited application in general practice but it may be more feasible in the future.[5]

Monorchidism

Monorchidism is the complete absence of one testicle and is rare in the horse.[5] A definitive diagnosis can only be made after surgical exploration of the abdomen, removal of the other testis and hormonal testing.[18,19] Useful hormonal assays include basal plasma or serum testosterone and oestrone sulphate concentrations, testosterone concentrations following hCG stimulation, and faecal oestrone sulphate concentration.[5,18,19] The hCG stimulation test in horses older than 18 months, basal oestrone sulphate assay in horses older than 3 years or a combination of both tests appear to be most reliable.[5,11,18,19] The hCG stimulation test measures plasma or serum testosterone concentrations, before and 1 and 24 h after intravenous administration of 6000 to 10,000 IU of hCG.[18,19] There should be no increase above basal testosterone concentrations in horses with no testicular tissue. The response in horses with testicular tissue may be poor during winter or if testicular tissue is abdominal. Both tests should be performed if either test is inconclusive. Samples should be submitted to laboratories that routinely assay equine testosterone and oestrone sulphate concentrations so that reliable reference values are available.[14,19]

Hormonal assays detecting testicular tissue

Hormone detected	*Sample*
Basal testosterone	Serum or plasma
Basal oestrone sulphate	Serum, plasma or faeces
Testosterone following hCG stimulation	Serum or plasma

Complications of castration

Postoperative swelling

Some preputial and scrotal oedema is normal, usually greatest 3 to 6 days after surgery and subsiding by 9 days.[20] Excessive swelling is a common complication and typically occurs with inadequate wound drainage, inadequate postoperative exercise, poor lymphatic drainage, excessive surgical trauma or infection.[1,20]

Postoperative swelling can be reduced by creating a large scrotal incision, avoiding excessive tissue trauma, removing as much tunica vaginalis as possible, manually stretching the surgical incision and removing the median raphe during surgery.[5,20] Following castration, exercise, hosing the wound, and the use of nonsteroidal anti-inflammatory drugs can reduce swelling.[1,5,20] The owner may start riding the horse 24 to 48 h after surgery.[20]

Excessive postoperative swelling is painful and reduces willingness to exercise, causing the wound to seal prematurely and compounding the problem. Treatment involves nonsteroidal anti-inflammatory drugs to decrease pain and inflammation and increase tolerance to exercise.[1,5,20] If scrotal wounds have closed, it may be beneficial to sedate the horse and reopen the wounds manually wearing a sterile glove.[1,5,20] This may need to be repeated on consecutive days until the swelling reduces. Antimicrobial drug treatment may be indicated where the discharge is purulent. Secondary problems associated with severe swelling include phimosis, paraphimosis, cellulitis, wound infection and dysuria.[20]

Excessive haemorrhage

Haemorrhage may occur during, immediately after or several days after surgery.[20] Some bleeding from scrotal wounds after castration is normal but if profuse bleeding continues unabated for more than 15 min haemorrhage should be considered excessive.[1,5,20] Excessive haemorrhage generally occurs from the testicular artery, but may originate from traumatic rupture or laceration of branches of the external pudendal vein.[1,20] Arterial haemorrhage is generally a result of inadequate crushing by the emasculators. The emasculators should be applied perpendicular to, and without tension on, the spermatic cord with the cutting blade closest to the testes.[1,5,20]

Precise guidelines for when to intervene surgically are not established but treatment of postoperative haemorrhage is best performed under general anaes-

Complications of castration

- Postoperative swelling
- Excessive haemorrhage
- Eventration
- Funiculitis
- Hydrocele
- Penile damage
- Continued masculine behaviour

thesia.[1,5,20] Before anaesthesia the patient should be assessed carefully, paying particular attention to cardiovascular status. The site of haemorrhage should be identified. The spermatic cord may be grasped with long forceps passed into the inguinal canal and the testicular artery occluded. The cord can then be emasculated proximally or ligated. If the cord cannot be ligated or emasculated, the forceps can be left in place for 12 to 24 h to allow thrombosis to occur. Where the end of the cord cannot be grasped, haemorrhage can usually be controlled by packing the scrotum with gauze. If the haemorrhage is occurring from a large superficial vein in the scrotal or inguinal area, ligation of the vessel is the treatment of choice.

Eventration

Eventration through the vaginal ring and open scrotal incision is uncommon, generally occurring within 4 h but may occur up to 6 days after surgery.[21] Eventration of the small intestine makes up 67% of cases while omental prolapse comprises the remainder.[22] A survival rate of 85 to 100% can be expected where appropriate treatment is instituted.[22] Suggested predisposing factors include a pre-existing undetected inguinal hernia, presence of visceral structures adjacent to the internal inguinal ring, and increased abdominal pressure following surgery.[22] Palpation of the scrotum and inguinal regions for hernias prior to castration is recommended in foals. Standardbred horses are believed to be predisposed to congenital inguinal herniation.[5]

If evisceration occurs the main objective is to clean and protect the intestine and return it to the abdomen before it is excessively traumatised or contaminated.[21] The intestine should be protected by a moistened towel shaped into a sling and the horse anaesthetised and positioned in dorsal recumbency.[21] In the field the intestine should be lavaged and where possible placed back within the scrotum which is sutured.[21] Broadspectrum antimicrobial therapy should be initiated, an analgesic dose of flunixin meglumine administered and the horse immediately referred to a surgical facility. To replace the intestines into the abdomen, dilation of the vaginal ring and traction on the intestines through ventral midline or parainguinal celiotomy are usually necessary.[5,21] The tunic should be ligated and emasculated as far proximally as possible and the superficial inguinal ring closed with large-diameter, absorbable suture material.[1,5,20] Alternatively, the inguinal canal can be packed with gauze for 24 to 48 h, however intestine may still eventrate around the packing.[1,5,21] Prolapse of the omentum through the inguinal ring can usually be managed using sedation and transecting the prolapsed omentum as far proximally as possible. After recovery from anaesthesia the horse should be kept quiet in a stall for 24 to 48 h.[5,21]

Evisceration of omentum from the scrotal wound is much less serious and is best treated with transection of the omentum which can be performed with the horse standing.[5]

Funiculitis

Funiculitis refers to inflammation of the spermatic cord.[1,5,21] It is usually a septic process developing as an extension of a scrotal infection or from a contaminated emasculator or ligature.[5] Failure to remove the tunica vaginalis and external cremaster muscle during open castrations predisposes horses to septic funiculitis.[23] Signs vary with pyrexia, lameness, inguinal and scrotal swelling and chronic discharge often noted.[1,5] These may not develop for months or years after castration.[5,21]

In the early stages, funiculitis often resolves with antimicrobial therapy and the establishment of drainage, but occasionally surgical removal of the infected stump is required.[5,21] A chronic infection with pyogenic bacteria is commonly referred to as scirrhous cord, however the term 'champignon' and 'botriomycosis' have been used historically to describe infection with *Streptococcus* spp and *Staphylococcus* spp, respectively.[5,21] Extension of the septic process through the inguinal ring and into the peritoneal cavity is possible but uncommon.[5] Treatment of scirrhous cord requires surgical resection and antimicrobial therapy.[1,5,20] The horse should be anaesthetised and positioned in dorsal recumbency. The infected stump is then isolated from healthy tissue using blunt dissection. The cord is emasculated proximal to the infected stump and the wound is left to heal by second intention.[5]

Peritonitis

The vaginal and peritoneal cavities communicate and nonseptic peritonitis is common following castration.[1,5,21] Haemoperitoneum and secondary inflammation can increase peritoneal total nucleated cell counts to more than 10 x 10^9 cells/L for at least 5 days with counts greater than 100 x 10^9 cells/L not uncommon.[23] Septic peritonitis is rare,[1] but should be considered where signs include abdominal pain, pyrexia, tachycardia, diarrhoea, weight loss and reluctance to move.[1,5,21] Toxic or degenerate neutrophils and intracellular bacteria found on abdominocentesis confirm the diagnosis.[1,5,21] Culture of a peritoneal fluid sample is suggested where possible. Treatment consists of appropriate antimicrobial and nonsteroidal anti-inflammatory therapy, and providing analgesia, peritoneal drainage and lavage, and adequate drainage through the scrotum.[5] Until culture results become available, procaine penicillin (20 mg/kg IM twice daily) and gentamicin sulphate (6.6 mg/kg, IV or IM once daily) should be considered.

Hydrocele

A hydrocele is an accumulation of sterile amber-coloured fluid within the vaginal tunic. It can appear months to years following castration.[1,5,21] It is believed to result from failure to resect the vaginal tunic adequately during castration and is reported to occur most commonly in mules.[1,5] It appears as a fluid-filled enlargement of the scrotum that can often be reduced by squeezing the fluid into the abdominal cavity. Treatment is only necessary where the swelling is unsightly or interferes with function. The skin is incised over the sac and the vaginal tunic is isolated proximally to the inguinal ring and emasculated.[1,5]

Penile damage

Complications involving the penis are rare and generally associated with iatrogenic trauma to the penile shaft. Penile prolapse can occur secondary to excessive swelling, and priapism and penile paralysis has been reported following administration of phenothiazine-derivative tranquillizers.[1,5,21]

Continued masculine behaviour

Castration does not always result in elimination of objectionable stallion-like behaviour. This has been attributed to incomplete removal of epididymal tissue, presence of heterotopic testicular tissue, production of high concentrations of androgens from the adrenal gland, incomplete cryptorchid castration and psychological reasons.[1,5] Androgens are not produced by the epididymis and therefore the presence or absence of epididymal tissue cannot influence masculine behaviour. Amputating the spermatic cords was reported to abolish objectionable masculine behaviour in 75% of castrated horses, but no satisfactory explanation was offered for this response.[24] Heterotopic testicular tissue and production of adrenal androgens have never been established in horses and are unlikely to be the cause of continued stallion-like behaviour.[1,5] About 20 to 30% of horses display some masculine behaviour following castration.[3,26] It is likely that this is psychological in origin and represents normal social interaction between horses. Where this behaviour is excessive or the castration history is obscure, hormonal testing (see monorchidism) can be used to establish whether testicular tissue is present.

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Erysipelas in malleefowl

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The malleefowl *(Leipoa ocellata)* is a ground-dwelling Australian native bird originally found in a range of habitats. It belongs to the mound-building family of birds, the Megapodiidae, which are confined almost entirely to the Australian region. Members of this family vary greatly in colour and form. However, they all have in common the fact that they do not build a nest and brood their eggs, but bury them in the ground, or in a mound, or in heaps of fermenting vegetable material built up for this purpose (Figure 1). The incubation process utilises external sources of heat such as decomposing vegetation or incident solar radiation. The adults keep the eggs at a constant temperature by constantly remodeling the mound, adding or removing dirt and leaves. The eggs hatch in the mound and the chicks are left to look after themselves.[1] Numbers of malleefowl have declined appreciably since European settlement.[2] Factors influencing this decline include land clearance for cropping and pastoralism, predation by the European fox *(Vulpes vulpes)*, changes in fire frequency, grazing of malleefowl communities by domestic stock, and the presence of introduced mammalian pests, particularly goats *(Capra hircus)* and rabbits *(Oryctolagus cuniculus)*.[3] No reports of disease as a factor in the decline of the malleefowl are available