

Review Article

Equine castration: A review of techniques, complications and their management

I. Kilcoyne

The William R. Pritchard Veterinary Medical Teaching Hospital, School of Veterinary Medicine, University of California-Davis, California, USA.

Corresponding author email: isabellekilcoyne@hotmail.com

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Summary

Complications associated with castration occur commonly and, although the majority are mild and resolve easily, potentially life-threatening complications can occur. The preoperative identification of risk factors for these complications can help the veterinarian to take the appropriate measures to reduce these risks. However, even with proper surgical technique, complications can occur. Therefore prompt recognition and initiation of appropriate therapy are essential to prevent further morbidity, death or lawsuits.

Introduction

Castration is one of the most common surgical procedures performed in equine practice. Potential reasons for performing this procedure include a desire to reduce or prevent masculine or aggressive behaviour in animals unsuitable for breeding, testicular trauma or neoplasia, or inguinal herniation (Shoemaker *et al.* 2004). Open, closed, and semiclosed techniques are used for castration of horses and the procedure may be performed in a standing, sedated animal or in a recumbent animal under general anaesthesia (Schumacher 1996, 2012; Searle *et al.* 1999).

Although the procedure is considered to be routine, complications can occur and remain a common cause of malpractice claims against equine practitioners (Wilson and Quist 1992). The majority of complications encountered after castration tend to be mild and resolve with minimal treatment, but more serious or life-threatening complications, such as eventration, peritonitis and haemorrhage can also occur. A thorough knowledge of male reproductive anatomy and physiology combined with a good surgical technique help to reduce the rate of complications associated with the procedure (Schumacher 1996; Searle *et al.* 1999).

Preoperative considerations

All horses to be castrated should undergo a full physical examination prior to surgery including palpation of the testicles. All animals should be examined for the presence of concurrent scrotal herniation or cryptorchidism. Older horses have previously been reported to be at higher risk for the development of complications post operatively (May and Moll 2002) probably due to the larger scrotal size and larger testicular vessel size; however, another study (Kilcoyne *et al.* 2013) did not reveal any significant association between age of the horse and the development of a complication.

All horses undergoing any surgical procedure should be current on tetanus prophylaxis. If the horse has not been

vaccinated in the previous 6 months, a tetanus toxoid booster should be administered preoperatively. If the vaccination status is not known then tetanus antitoxin should be administered in addition to a tetanus toxoid.

Some veterinarians choose to administer one dose of procaine penicillin (22,000 u/kg bwt) prior to surgery. The use of antibiotics to prevent post operative infections is debatable and generally based on clinician preference. The presence of adverse weather conditions (hot weather with associated flies or cold and wet weather leading to inadequate turnout), less than ideal surroundings (muddy area, unhygienic surgical field) and contamination at time of surgery may warrant the use of antibiotics.

Preoperative use of nonsteroidal anti-inflammatories (phenylbutazone 2.2–4.4 mg/kg bwt; flunixin meglumine 1.1 mg/kg bwt) is recommended by some clinicians. Results of a 2005 survey (Price *et al.* 2005) in the UK indicated that 45.4% of veterinarians did not provide additional analgesic drugs (post operative administration of nonsteroidal anti-inflammatory drugs [NSAIDs]) following castration, 17.7% administered them occasionally, and 36.9% administered them routinely. In one study (Sanz *et al.* 2009), administration of butorphanol (0.05 mg/kg bwt i.m. prior to surgery and then every 4 h for 24 h) had the same apparent analgesic effect as phenylbutazone (4.4 mg/kg bwt i.v. prior to surgery and then 2.2 mg/kg bwt per os every 12 h for 3 days) treatment in young colts being castrated under general anaesthesia (with intratesticular lidocaine injection). Also, combined treatment with butorphanol and phenylbutazone was not apparently superior to either drug used alone.

Methods of sedation and anaesthesia

To facilitate castration under injectable general anaesthesia, an i.v. catheter may be placed via aseptic technique prior to surgery. In the author's practice (an ambulatory practice) horses castrated under injectable general anaesthesia typically receive butorphanol tartrate (0.01 mg/kg bwt, i.v.) as part of the sedation protocol (typically 0.5 mg/kg bwt xylazine hydrochloride) for catheter placement and palpation of the testicles prior to surgery, as do all horses to be castrated standing. Horses to be castrated under general anaesthesia are generally premedicated with an α_2 agonist such as xylazine hydrochloride (1.1 mg/kg bwt, i.v.). This dose is given in addition to the sedation provided to facilitate palpation and i.v. catheter placement. When sedation is deemed adequate, anaesthesia is induced with ketamine hydrochloride (2.2 mg/kg bwt i.v.) and diazepam (0.05 mg/kg bwt, i.v.). The horse should be placed in lateral or dorsal recumbency (depending on clinician preference) with the hindlimbs

restrained to facilitate surgery. Anaesthetic depth is monitored on the basis of heart rate, respiratory rate, movement, palpebral reflex, and presence of nystagmus. When an additional dose of anaesthetic agent is deemed necessary to maintain an adequate plane of anaesthesia (i.e. if anaesthetic depth was determined to be too light), ketamine (1.1 mg/kg bwt, i.v.) is typically administered in combination with xylazine hydrochloride (0.5 mg/kg bwt i.v.).

The scrotal area should be routinely prepared for surgery with dilute povidone-iodine or chlorhexidine followed by intratesticular injection of 2% lidocaine hydrochloride, the dose of which may vary according to size of horse (typically 10–20 ml/testis).

For horses castrated under standing sedation, chemical restraint can be achieved using a combination of detomidine (0.01 mg/kg bwt, i.v.) and butorphanol (0.01 mg/kg bwt, i.v.). A twitch may also be applied to facilitate restraint. Typically, horses are only castrated under standing sedation if they are deemed to have an amenable temperament (lacking anxious or aggressive behaviour) and are of sufficient height to perform the surgery safely for the veterinarian. The scrotal area is prepared for surgery as described for horses castrated under general anaesthesia. Lidocaine should always be injected intratesticularly and locally along the planned incision sites on each side of the median raphe. In one study (Portier *et al.* 2009) incisional, intrafunicular and intratesticular lidocaine administration resulted in a significant decrease in the number of additional incremental i.v. boluses of anaesthetic agent required during castration of horses under total i.v. anaesthesia. Investigators in that study found that lidocaine did not result in increased haemorrhage or complications after surgery and also appeared to improve the quality of anaesthesia. Another technique for local anaesthesia involves the direct injection of anaesthetic agent into the spermatic cord. This technique provides good anaesthesia of the cord but occasionally may lead to haematoma formation within the spermatic cord, thus interfering with proper emasculation (Schumacher 2012).

In one study (Kilcoyne *et al.* 2013) 31 horses were castrated while standing, of which 5 (16%) developed complications, compared with 28 of 293 (9.6%) castrated under general anaesthesia; however, the odds of developing a complication did not differ between these 2 categories (odds ratio = 1.81, 95% confidence interval = 0.5–5.34, $P = 0.39$). These findings are similar to those in a previous study (Mason *et al.* 2005) in which horses castrated while standing had a complication rate of 22%, compared with a complication rate of 6% for those in which castration was performed under general anaesthesia with primary closure of the scrotal incisions. Castration in standing horses minimises the risk of death associated with general anaesthesia and traumatic injury during recovery and it tends to be less expensive than surgery with general anaesthesia (Mason *et al.* 2005).

Surgical techniques

After routine preparation of the surgical site as described above, the procedure for horses castrated with the closed technique involves an incision made through the scrotal skin, *tunica dartos* and scrotal fascia until the parietal tunic is encountered. The testis, still encapsulated by the parietal tunic, is grasped, and the scrotal fascia is 'stripped' (separated using a sterile gauze) from the parietal tunic until the cremaster muscle and tunic are fully exposed (Fig 1). The emasculators



Fig 1: 'Stripping' of the testis enclosed within the parietal tunic using a sterile gauze during a closed castration.



Fig 2: Opening of the parietal tunic during a semi-closed castration allowing direct visualisation of the testis, epididymis, the spermatic vasculature and the ductus deferens. This technique also allows the surgeon to check for the absence of herniated intestine.

are then applied to the entire spermatic cord (Schumacher 2012). In some horses that have a large spermatic cord, the cremaster muscle can be bluntly dissected from the spermatic cord and the emasculators applied separately prior to crushing and severing the entire spermatic cord within the parietal tunic with emasculators.

The approach for those castrated with the semi-closed technique is similar; however, after the parietal tunic and cremaster muscle are exposed, a 2–3 cm incision is made in the parietal tunic just proximal to the testis. The contents of the parietal tunic can then be inspected to ensure there is no evidence of herniated intestine (Fig 2), and emasculators are then applied to the entire spermatic cord (including the parietal tunic) proximal to the testis. Alternatively, for some horses in which a large spermatic cord is encountered, the spermatic vasculature can be exteriorised from the tunic and the emasculators applied to these separately before crushing and severing the entire spermatic cord within the parietal tunic



Fig 3: Routine castration pack including Reimer emasculator. Also included are a No. 20 scalpel blade, Ochsner forceps, Mayo scissors and sterile gauze.

(Searle *et al.* 1999; Schumacher 2012). The semiclosed technique should be considered a closed technique as the parietal tunic is removed along with the testis and distal portion of the spermatic cord.

For the open technique, the parietal tunic of the testis is incised. The ligament of the tail of the epididymis (caudal ligament of the epididymis), which attaches the parietal tunic to the epididymis, is cut or bluntly transected. The testis, epididymis and distal portion of the spermatic cord are completely freed from the parietal tunic by transecting the fold of mesorchium and mesofuniculum and removed using an emasculator. The open technique requires less dissection than does the closed technique and is therefore preferred by some veterinarians (Schumacher 1996).

In one study (Kilcoyne *et al.* 2013), a higher proportion of horses that underwent semiclosed castration (18/77; 23.4%) went on to develop complications, compared with those that underwent closed castration (15/247; 6.1%). Investigators in another retrospective study (Moll *et al.* 1995) found that use of a semiclosed technique resulted in a higher occurrence of infection, oedema, and excessive haemorrhage, compared with open or closed techniques. Potential reasons for an increased complication rate associated with the semiclosed technique may include increased tissue handling, increased contamination, or longer duration of surgery, compared with the closed or open techniques.

The most commonly used emasculators include Reimer, Serra and improved White's emasculators. The Reimer (**Fig 3**) emasculator crushes the spermatic cord and a blade operated on a separate handle cuts the cord distally. The improved White's and Serra emasculators simultaneously crush and cut the spermatic tissue (May and Moll 2002; Schumacher 2012). One study (Moll *et al.* 1995) demonstrated a significantly higher rate of haemorrhage associated with the use of the Reimer emasculator compared with the Serra emasculator; however, to the author's knowledge no prospective study directly comparing the use of instruments has been performed. The importance of properly maintained surgical instrumentation, regardless of which emasculator is used, should be emphasised. Thorough cleaning following use and regular maintenance can help improve longevity and functionality (May and Moll 2002). The Henderson Equine Castrating Instrument is another available instrument to facilitate castration. When using this instrument, one hand



Fig 4: Application of the Henderson castration unit for a routine closed castration.



Fig 5: The testis, which is grasped within the instrument, is rotated slowly for about 5 turns and then the speed of the rotation is increased gradually while keeping tension on the cord which leads to separation proximal to the instrument.

grasps the testis and the instrument is clamped across the entire cord proximal to the testis such that a closed castration is performed. Slight tension is placed on the drill and the instrument is held parallel to the cord (**Fig 4**). The testis, which is grasped within the instrument, is rotated slowly for about 5 turns and then the speed of the rotation is increased gradually while keeping tension on the cord. After approximately 20–25 rotations, the cord separates about 8–10 cm proximal to the instrument (**Fig 5**). The twisting action of the spermatic cord effectively seals the severed vessels (Schumacher 2012).

Some veterinarians will use ligatures around the vasculature of the spermatic cord in order to reduce the incidence of post operative haemorrhage and to help prevent inguinal eventration. It has previously been recommended that all donkeys have ligatures with absorbable suture placed as part of the procedure as a

preventative measure against any possible haemorrhage, because blood vessels of the spermatic cord are typically larger in donkeys than in horses (Sprayson and Thielmann 2007). Investigators of a previous study (Carmalt *et al.* 2008) did not find that placement of ligatures during castration of draught colts under field conditions helped prevent omental herniation and intestinal eventration significantly reduced the incidence of post operative haemorrhage (2.3%), compared with a reported rate of 2.44% without ligatures (Moll *et al.* 1995). However due to the varied population of horses castrated under variable conditions in the latter study it is difficult to make a direct comparison. The presence of foreign material at the castration site has been reported to result in an increased incidence of post operative infection (Moll *et al.* 1995; Schumacher 1996); however, the infection rate in a study (Carmalt *et al.* 2008) of draught horse colts that underwent castration under field conditions with ligatures placed was low (0.76%). In a recent study (Kilcoyne *et al.* 2013) only 17 (5.2%) cases of a total of 324 had ligatures placed as part of the procedure. The overall rate of haemorrhage as a complication in this study was 6/324 (1.8%) indicating that the use of ligatures may not be necessary to prevent post operative haemorrhage.

Scrotal incisions are generally allowed to heal by second intention and left unsutured. Primary closure may also be performed, but this is not typically performed in the field. One study (Mason *et al.* 2005) showed the complication rate of horses castrated standing and nonsutured to be 22% vs. a 6% complication rate in those castrated using a primary closure under general anaesthesia in aseptic hospital conditions. However, the same study found the cost of the standing nonsutured horses to be one-third of the cost of the horses castrated under general anaesthesia with a primary closure.

Complications

Complications that result from castration, including scrotal swelling, oedema, haemorrhage, omental herniation, eventration, penile trauma, bacterial infection of the spermatic cord (also called scirrhus cord formation), incisional infections, hydrocele formation, and peritonitis have been reported (Nickels 1988; Thomas *et al.* 1998; Shoemaker *et al.* 2004). Most post operative complications are mild and not considered life-threatening, but eventration, haemorrhage, penile trauma and peritonitis may be fatal. A recent study (Kilcoyne *et al.* 2013) reported the overall complication rate of routine castrations in 324 equids to be 10.2% with only a 0.3% mortality rate.

Post operative swelling and seroma formation

Post operative swelling affecting the preputial and scrotal regions is common following castration and is usually greatest 4–5 days after surgery has been performed (Hunt 1991). In previous studies (Moll *et al.* 1995; Carmalt *et al.* 2008; Kummer *et al.* 2009), the incidence of swelling and seroma formation was 27.6%, 3.8% and 24.3%. Excessive swelling may be attributed to inadequate drainage, inadequate exercise following surgery, excessive tissue trauma at the time of surgery, or infection (Hunt 1991). Older horses have also been reported to be more prone to development of excessive oedema following castration, compared with younger horses (May and Moll 2002). Following castration, exercise, cold-water treatment of the area and administration of NSAIDs can

help to minimise swelling (Schumacher 2012). Excessive post operative swelling can be painful and may result in an unwillingness to exercise, causing premature closure of the surgical wound, further compounding the problem (Hunt 1991; Schumacher 1996). Adequate post operative exercise consisting of handwalking or trotting daily for 10–14 days can help prevent premature closure of the surgical wound and seroma formation. Treatment involves administration of NSAIDs to reduce swelling and increase the tolerance of the animal to exercise and move around. Where seroma formation has occurred it may be beneficial to re-open the scrotal wounds digitally in a sterile manner to facilitate drainage. Therapy with systemic antibiotics is indicated where signs of infection are present such as purulent discharge. They are usually administered prophylactically in cases of seroma formation to prevent the development of an infection (Schumacher 1996; May and Moll 2002).

Infection

Infection is a commonly reported complication of castration (Moll *et al.* 1995; Mason *et al.* 2005). Infection may not be evident until days after the surgery was performed. Clinical signs may include fever, swelling, lameness or discomfort when exercising and drainage from the incisions. Infection may also follow formation of a seroma allowing the development of a 'septic seroma'. The use of ligatures has been implicated as a cause for post operative infection potentially acting as a nidus (Moll *et al.* 1995; May and Moll 2002). Treatment involves opening of the scrotal incisions to facilitate drainage, similar to that performed for a seroma. Exercise to help prevent premature closure of the incisions and promote drainage should also be started. Administration of broad-spectrum systemic antibiotics should be instituted. A sample taken from deep within the scrotal incisions may be taken and submitted for culture and sensitivity to help direct antimicrobial therapy. Infections that do not resolve with initial medical therapy should be referred to a surgical facility as surgical resection of infected tissue may be warranted to resolve the issue completely (Searle *et al.* 1999; Getman 2009). Scirrhus cord, which may also be referred to as funiculitis, refers to the chronic infection of the spermatic cord stump where the scrotal incisions heal but the stump continues to be infected or abscess eventually forming a draining tract. It may develop as an extension of a scrotal infection or from a contaminated emasculator or ligature. This is generally caused by a *Staphylococcus* sp. It is usually palpable as a firm mass in the inguinal region and may not be evident for months to years. In the early stages treatment with appropriate antimicrobials may be sufficient but occasionally treatment involves surgical resection of the infected stump (Searle *et al.* 1999; Schumacher 2012). Removal of an infected cord within a few weeks after castration is generally much easier than removal of a chronically infected cord due to the presence of fibrous adhesions to the parietal tunic and their associated blood supply (Schumacher 2012). *Champignon* is a term used to describe a type of infection of the spermatic cord caused by *Streptococcus* (Schumacher 2012). It is characterised by a mushroom shaped nodule of granulation tissue that protrudes from the scrotal incisions with an associated purulent discharge. This was a more common complication before the advent of emasculators to help control haemorrhage but is now rarely seen (Schumacher 2012).

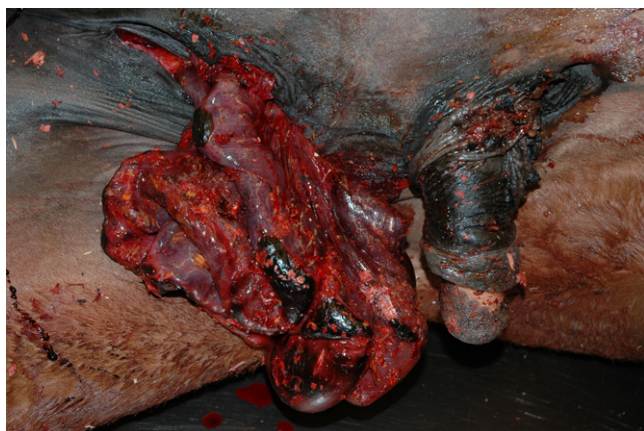


Fig 6: Eventration of part of the jejunum through the scrotal incisions following castration.

Clostridial infections of the surgical sites can be particularly severe as a result of the severe tissue necrosis and toxæmia produced by clostridial organisms and may result in death within a few days. Tetanus and botulism can occur in unvaccinated horses (Schumacher 2012). Wound infections with other clostridial species may result in myositis, necrotising cellulitis and systemic endotoxaemia. Treatment includes administration of high doses of penicillin, systemic NSAIDs, supportive care along with debridement of any necrotic tissue to allow drainage. Generally, these cases necessitate referral (Getman 2009).

Haemorrhage

Some haemorrhage is normal following castration in the immediate post operative period when the horse stands up from anaesthesia or immediately after the emasculators have been removed. When bleeding occurs in the form of a steady drip (>one drop/s) or stream for an excessive period of time (>15 min) it should be addressed (Searle *et al.* 1999). The most common source of severe bleeding post operatively is the testicular artery. Initial therapy should be aimed at identifying and eliminating the source of haemorrhage. The stump of the spermatic cord can be identified and the individual bleeding vessel isolated and ligated or if enough of the cord can be exteriorised the entire cord can be emasculated again. This, however, can be difficult in the standing animal and may necessitate general anaesthesia. If the source of the bleeding cannot be identified the scrotal incision can be packed with sterile gauze, which can be left in place for 24–48 h by suturing the incisions closed. In general these horses should be placed on oral systemic antibiotics as a precautionary measure to reduce the incidence of infection. Other therapies reported as adjunctive treatments include use of aminocaproic acid, that acts to decrease fibrinolysis, given at a dose of 20–100 mg/kg bwt i.v. (Getman 2009; Kilcoyne *et al.* 2013). Other treatments reported include the use of diluted formalin (0.5–1.0%) i.v. to decrease haemorrhage post operatively (Schumacher 1996). Referral should be considered where substantial blood loss has occurred or signs of hypovolaemic shock are evident.

Eventration

Eventration is an uncommon complication of castration that occurs when a portion of intestine prolapses through the



Fig 7: Prolapse of omentum through the scrotal incisions following routine castration.

inguinal canal and out of the scrotal incision (**Fig 6**). It typically occurs within 4–6 h after castration (Hunt 1991) but has been reported to occur up to 12 days following surgery (Boussauw and Wilderjans 1996). Risk factors include breed with Standardbreds and draught horses being over-represented, pre-existing inguinal hernias, presence of an inguinal herniation as a foal and large inguinal rings (Shoemaker *et al.* 2004; Getman 2009; Schumacher 2012). Results of one study (Shoemaker *et al.* 2004) indicated a 4.8% incidence of eventration in horses, with no significant difference between open and closed castration techniques with regard to this variable. One possible reason for the high rate of eventration in that study (Shoemaker *et al.* 2004) was that the population of horses examined consisted of draught horse colts, a breed that have been reported as having a higher incidence of eventration after castration, compared with other breeds (Moll *et al.* 1995; Schumacher 1996). Investigators in other studies (Hutchins and Rawlinson 1972; van der Velden and Rutgers 1990; Moll *et al.* 1995) found the incidence of eventration to be 2.96%, 0.4% and 0.2%. In another study (Kilcoyne *et al.* 2013), eventration occurred in only one of 324 (0.3%) horses. In that study, the incidence of eventration was low, despite the lack of use of ligatures as part of the routine procedure in most horses. This suggests that further investigation may be needed to determine whether ligatures provide an advantage when castrating horses of breeds other than those reported to be at an increased risk of eventration. Eventration has been hypothesised to result from increased abdominal pressure, presence of a large inguinal ring, leg position during recovery from general anaesthesia, and possibly excessive exercise (Shoemaker *et al.* 2004). One study (Carmalt *et al.* 2008) found that common vaginal (parietal) tunic ligation significantly reduced the incidence of omental herniation and eventration, with only one of 131 (0.8%) evaluated horses developing eventration. Protrusion of omental tissue through the inguinal rings can also occur following castration (**Fig 7**). A thorough examination in a well sedated horse should be performed to assess the type of tissue protruding as occasionally subcutaneous tissue may be found protruding through the scrotal incision. In most cases of minor omental prolapse emasculating of the tissue can be performed. The animal should be confined to a stall for 24–48 h

to prevent more tissue prolapsing and systemic antimicrobial therapy should be instituted to prevent an ascending infection or peritonitis. Where severe herniation of omentum has occurred surgery under general anaesthesia may be necessary to facilitate ligation and transection of the tissue. It is also advisable to perform a rectal examination to allow examination of the inguinal rings and ensure there is no intestinal prolapse through the rings (May and Moll 2002; Getman 2009).

Peritonitis

The vaginal tunic derived from the peritoneum continues through the inguinal canal to line the interior of the scrotum. It is composed of 2 layers, the visceral tunic which attaches firmly to the *tunica albuginea* around the testis and the parietal tunic, which is continuous with the parietal peritoneum of the abdomen (Schumacher 2012). As a result of this communication many horses exhibit a nonseptic peritonitis, characterised by elevated cell counts $>100 \times 10^9/l$, for up to 5 or more days following castration (Schumacher 1996; May and Moll 2002). Although peritoneal inflammation is common post castration, bacterial peritonitis is a rare complication where an elevated nucleated cell count with presence of degenerative neutrophils ($>90\%$) and intracellular bacteria on abdominocentesis confirms the diagnosis. Clinical signs may include fever, depression, inappetence or mild signs of colic. Culture of peritoneal fluid is recommended if possible (Searle *et al.* 1999). Treatment should involve administration of systemic antimicrobials and anti-inflammatories, i.v. fluid therapy and peritoneal lavage through the use of an indwelling abdominal drain if indicated (Schumacher 1996; Getman 2009).

Hydrocele formation

A hydrocele, which may also be referred to as a vaginocoele, is a painless accumulation of fluid within the vaginal cavity in stallions; however, it may also be seen in geldings up to months or years following castration (Schumacher 1996, 2012; May and Moll 2002). They occur uncommonly after castration and are reportedly more likely to occur in mules (Schumacher 1996). They are more likely to form after castration is performed using the open method as the parietal tunic is not removed using this technique (Schumacher 1996). The swelling that develops may resemble a scrotal testis or hernia and on aspiration a clear, amber coloured fluid will be obtained. On palpation the swelling may be reduced by squeezing the fluid into the abdominal cavity (Searle *et al.* 1999). Drainage of the fluid will only temporarily relieve the condition. Treatment involves the removal of the parietal tunic under general anaesthesia with the horse placed in dorsal recumbency. However, this is only usually necessary when the swelling interferes with functionality of the animal or for cosmetic purposes (Searle *et al.* 1999).

Penile damage

Penile damage during castration is almost exclusively iatrogenic and usually occurs when the penile shaft is mistaken for a testis. If the penis is transected the horse should be referred immediately to a surgical facility for surgical repair or phallectomy (Searle *et al.* 1999; Getman 2009).

Continued stallion-like behaviour

Serum concentrations of testosterone and oestrogen decline within 6 h after castration; however, castration may not always

be successful in eliminating masculine or stallion-like behaviour. These geldings are often referred to as 'false rigs' (Schumacher 1996). While causes such as retention of epididymal tissue, adrenal cortex production of testosterone and heterotopic testicular tissue have been implicated, it is more likely that this persistent behaviour is innate and represents normal social interaction among horses (Searle *et al.* 1999). In cases where the continued masculine behaviour is excessive or there is little information pertaining to the actual castration itself, hormonal testing can be performed to establish if there is residual testicular tissue present. Hormonal assays that may be useful include basal plasma or serum testosterone concentrations, basal oestrone sulfate concentrations or testosterone concentrations following human chorionic gonadotropin stimulation (Searle *et al.* 1999). In general, males should be isolated from mares for 2 days following castration under routine circumstances. After 2 days, ejaculates are highly unlikely to contain sufficient numbers of spermatozoa to cause pregnancy (Shideler *et al.* 1981).

Conclusions

Overall, the incidence of complications associated with castration is considered low and the mortality rate associated with the procedure very low with few fatalities reported with only 1/324 (0.3%) cases suffering mortality due to eventration in one study (Kilcoyne *et al.* 2013). However, prompt recognition and management of any complications encountered should be instituted to prevent further morbidity, death or malpractice claims. While most complications encountered are mild and can be resolved relatively quickly with appropriate therapy, eventration, haemorrhage or signs of peritoneal infection should be considered emergencies and strong candidates for referral.

Author's declaration of interests

No competing interests have been declared.

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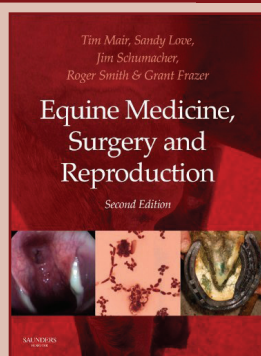
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