Castration is one of the most common surgical procedures performed in equine practice. The reasons for performing this procedure include a desire to reduce or prevent masculine or aggressive behavior in animals unsuitable for breeding, testicular trauma or neoplasia, or inguinal herniation. 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 anesthesia. Complications that result from castration, including scrotal swelling, edema, hemorrhage, omental herniation, eventration, penile trauma, bacterial infection of the spermatic cord (also called schirrous cord formation), incisional infections, hydrocele formation, and peritonitis, have been reported. Most postoperative complications are mild and not considered life threatening, but eventration, hemorrhage, and peritonitis may be fatal.

The objective of the retrospective study reported here was to determine the complication rate and identify risk factors associated with complications following routine castration in equids (including horses, mules, and donkeys) in an equine ambulatory practice. A complete understanding of these factors can help veterinarians minimize the development of these complications and treat them more effectively when they do occur.

Materials and Methods

Criteria for selection of cases and medical records

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management and outcome) were recorded if these developed. Time from surgery to development of a complication was defined as when the complication was first observed by the owner. Cases were excluded from the study if the available medical record was incomplete or lacked information regarding the anesthetic protocol or method of castration.

**Anesthesia and castration procedures—**All equids underwent a full physical examination prior to surgery. Equids castrated under injectable general anesthesia had an IV catheter placed in a jugular vein via aseptic technique prior to surgery. To facilitate catheter placement and palpation of the testicles prior to castration, animals were generally administered a combination of xylazine hydrochloride (0.5 mg/kg [0.23 mg/lb]) and butorphanol tartrate (0.01 mg/kg [0.005 mg/lb]) IV for sedation. Perioperative antimicrobial treatment was administered at the attending surgeon’s discretion. Equids were premedicated with xylazine hydrochloride (1.1 mg/kg [0.50 mg/lb], IV), and when sedation was deemed adequate, anesthesia was induced with ketamine hydrochloride (2.2 mg/kg [1.0 mg/lb], IV) and diazepam (0.05 mg/kg [0.02 mg/lb], IV). Animals were placed in lateral recumbency with the hind limbs restrained to facilitate surgery. Anesthetic depth was monitored on the basis of heart rate, respiratory rate, movement, palpebral reflex, and presence of nystagmus. When an additional dose of anesthetic agent was deemed necessary to maintain an adequate plane of anesthesia, ketamine (1.1 mg/kg, IV) was typically administered. The scrotal area was routinely prepared for surgery with dilute povidone-iodine followed by an intratesticular injection of 2% lidocaine hydrochloride (when used), the dose of which varied according to size (typically 10 to 15 mL/testicle).

Equids that underwent castration while standing were sedated with detomidine (0.01 mg/kg, IV) and butorphanol (0.01 mg/kg, IV). Animals were selected for castration while standing if they were deemed to have an amenable temperament (lacking anxious or aggressive behavior) and were of sufficient height to perform the surgery. The scrotal area was prepared for surgery as described. Lidocaine was injected intratesticularly and locally along the planned incision sites on each side of the median raphe.

After routine preparation of the surgical site, the procedure for equids castrated with the closed technique involved an incision made through the scrotal skin, tunica dartos, and scrotal fascia until the parietal tunic was encountered. The testicle, still encapsulated by the parietal tunic, was grasped, and the scrotal fascia was stripped from the parietal tunic until the cremaster muscle was exposed, a 2- to 3-cm incision was made in the parietal tunic just proximal to the testicle. The inside of the parietal tunic was inspected to ensure there was no evidence of herniated intestine, and emasculators were applied to the entire spermatic cord proximally. Alternatively, for some equids in which a large spermatic cord was encountered, the blood vessels were exteriorized from the tunic, and the emasculators were applied to these separately before crushing and severing the entire spermatic cord within the parietal tunic.

All castrations were performed by fourth-year veterinary students under the direct supervision of an experienced veterinarian. All surgeons wore sterile gloves to perform surgery. Castrations were performed with riemer and serra emasculators; generally, riemer emasculators were used in small equids with smaller spermatic cords, and serra emasculators were used for those with larger spermatic cords. All emasculators were left in place for 1 to 2 minutes. All incisions were allowed to heal by second intention. If ligatures were placed intraperitoneally, size 0 polyglactin 910 was typically used to place a single transfixing ligature as far proximal on the cord as possible. All animals were administered tetanus prophylaxis if vaccination was not current.

**Complications and follow-up data—**For each case in which a postoperative complication was recorded, a grade was assigned on the basis of severity as follows: grade 1, complication developed > 24 hours after surgery and did not require emergency treatment; grade 2, complication required more intensive management (eg, systemic medications or interventional treatment to mitigate bleeding or treat prolapsed tissue) or was treated on an emergency basis ≤ 24 hours after surgery; and grade 3, complication resulted in natural death or euthanasia of the horse. If any horse included had > 1 complication, the most severe complication was used in the analysis. Follow-up information was obtained for all equids by use of medical records or via telephone conversation with the owners.

**Statistical analysis—**Factors were evaluated via univariate analysis, and those that appeared to influence whether the horse developed a complication were examined via a multivariate logistic regression model with a commercially available statistical program. Statistical results are reported as ORs and 95% CIs. Associations between additional doses of anesthetic agents and the development of complications were analyzed with a Jonckheere-Terpstra test. For all analysis, values of P ≤ 0.05 were accepted as significant.

**Results**

Medical records of 324 equids that met the study criteria were identified. Although many breeds were included, American Quarter Horses were the most highly represented (n = 112 [34.6%]), followed by Thoroughbreds (63 [19.4%]), American Paint Horses (34 [10.3%]), Arabians (22 [6.8%]), warmblood types (18 [5.6%]), Morgans (12 [3.7%]), gaited horses (11 [3.4%]), mules (10 [3.1%]), Appaloosas (10 [3.1%]), American Miniature Horses (9 [2.8%]), draft horse breeds (9 [2.8%]), and Mustangs (4 [1.2%]). Donkeys (n = 3), pony breeds (3), Andalusians (1), Standardbreds (1), and unknown breeds (2) each comprised < 1% of horses in the study. No significant association be-
Between breed and development of a complication after castration was found.

The age of the equids at castration ranged from 1 to 228 months (mean, 25.3 months; median, 12 months). Age at castration was not associated with development of complications. Only 3 of 324 (0.9%) animals were described as having umbilical hernias on physical examination at the time of castration.

Thirty-three of 324 (10.2%) equids developed a complication after surgery. This included 8 Thoroughbreds, 7 American Quarter Horses, 6 American Paint Horses, 5 Morgans, 2 Arabians, 2 donkeys, 2 warmbloods, and 1 Andalusian. Of these 33, 25 (75.8%) developed grade 1 complications. This group included equids with mild swelling (n = 5), seroma (11), infection or abscess at site of surgery (7), and fever (rectal temperature > 38.6°C [101.5°F]) with respiratory signs (increased respiratory rate or increased bronchovesicular lungs sounds on auscultation; 2). Seven of 33 (21.2%) equids developed grade 2 complications. This group included equids with hemorrhage (n = 6) and protruding tissue from the incision (1). One (3.0%) horse, a 3-year-old Thoroughbred, developed eversion of the small intestine (grade 3 complication) following castration via the semiclosed technique under general anesthesia and was euthanized because of poor prognosis and the owner's financial constraints.

The time from surgery to the development of complications ranged from 2 to 8 days (mean, 5.6 days; median, 6 days) for swelling, from 2 to 15 days (mean, 6.6 days; median, 4 days) for seroma, and from 3 to 21 days (mean, 12 days; median, 12 days) for infection or abscess at the surgical site. Fever and mild respiratory signs developed 1 day after surgery in 2 affected horses, and hemorrhage was detected in 2 equids at each of the following time points: after surgery but prior to recovery, immediately after recovery, and 3 to 4 hours after surgery and recovery. Protrusion of tissue through the incision was detected 1 day after surgery (1 horse), and eversion was detected 1 to 2 hours after castration (1 horse).

All equids that developed seromas were treated by digitally reopening the scrotal incision to facilitate drainage, together with cold hydrotherapy (applied by means of a hose) and exercise (either hand walking or trotting exercise as deemed appropriate by the clinician). These equids received anti-inflammatory (phenylbutazone [2.2 mg/kg, PO, q 12 h] or flunixin meglumine [1.1 mg/kg, PO, q 12 h]) and antimicrobial (typically trimethoprim-sulfamethoxazole at a dose of 30 mg/kg [13.6 mg/lb], PO, q 12 h) drugs for 5 to 7 days. Those with mild swelling were treated similarly, although their incisions were not reopened, and 4 of 5 of received trimethoprim-sulfamethoxazole as described.

Four of the 6 equids with postoperative hemorrhage were treated by packing with sterile laparotomy sponges, which were kept in place with either sutures or towel clamps, into the scrotal incisions; systemic antimicrobials were administered, and the sponges were removed after 24 to 48 hours. One horse, in which bleeding was considered to be a substantial amount and of immediate clinical concern, also received aminocaproic acid (20 mg/kg [9.1 mg/lb], IV, once). One donkey, in which bleeding was not sufficient to require packing, was sedated and confined to a stall to be monitored for 24 to 48 hours. Of the 2 horses that had fevers and mild respiratory signs after surgery, one received 1 dose of flunixin meglumine (1.1 mg/kg, PO) and the other was administered trimethoprim-sulfamethoxazole (30 mg/kg, PO, q 12 h) and phenylbutazone (2.2 mg/kg, PO, q 12 h) for 5 days. The horse that had tissue prolapsed through the scrotal incision was sedated to facilitate examination and then treated by means of sharp dissection of the fatty tissue after identification of the structures, followed by administration of trimethoprim-sulfamethoxazole (30 mg/kg, PO, q 12 h) for 7 days.

Two hundred forty-seven of 324 (76.2%) equids underwent castration with the closed technique, including 2 donkeys and 8 mules. The mean age of equids undergoing closed castration was 18.6 months (median, 12.0 months). Fifteen of these 247 (6.1%) animals developed a complication. Seventy-seven (23.8%) equids underwent castration with a semiclosed technique, including 1 donkey and 2 mules. The mean age of equids that underwent semiclosed castration was 46.6 months (median, 36 months). Of these 77 animals, 18 (23.4%) developed a complication. Equids that underwent castration with the semiclosed technique had significantly (P < 0.001) higher odds of developing a complication after surgery (OR, 4.69; 95% CI, 2.09 to 10.6), compared with those in which the closed castration procedure was performed.

Of 324 equids, 293 (90.4%) were castrated under general anesthesia, and 31 (9.6%) had the procedure performed under sedation and local anesthesia while standing. No donkeys or mules were castrated while standing. All horses that underwent castration while standing were > 1 year of age (mean, 66 months; median, 48 months). Of the 293 equids castrated under general anesthesia, 28 (9.6%) developed a complication, whereas 5 of 31 (16.1%) that had the procedure performed while standing developed a complication. However, the odds of developing a complication were not significantly (P = 0.39) different between equids that underwent castration with these 2 methods of anesthesia (OR, 1.81; 95% CI, 0.5 to 5.34). Of the 31 horses castrated under standing sedation, 23 (74.2%) had the procedure performed using the semiclosed technique, and 8 (25.8%) had the procedure performed using the closed technique. Complications that developed following castration under standing sedation were classified as grade 1 in all 5 horses, including 4 that developed a seroma and 1 that had a mild fever.

Sixty-eight of 324 (21.0%) equids received preemptive antimicrobial treatment with penicillin G procaine (22,000 U/kg [10,000 U/lb], IM, once) at the time of surgery. Of the 33 equids that developed a complication, 8 (24.2%) had received this antimicrobial treatment. Preemptive antimicrobial treatment during the procedure was not significantly (P = 0.771) associated with development of complications (OR, 1.23; 95% CI, 0.46 to 3.00). Eighteen of 324 (5.6%) equids, deemed to be at risk for development of complications, received oral antimicrobial treatment after surgery, including 4 animals that had ligatures placed intraoperatively, 2
that were noted to have a concurrent wound at the time of surgery, 3 with abnormal lung sounds on auscultation before surgery, 3 that underwent semiclosed castration with extensive tissue handling intraoperatively, and 6 that were castrated during warm weather, with many flies in the environment. None of these 18 equids developed a complication.

Of 293 equids castrated under general anesthesia, 201 (68.6%) received additional anesthetic during the procedure to maintain adequate anesthesia. This included 157 of 239 (65.7%) equids that were castrated via the closed technique and 44 of 54 (81.5%) that were castrated via the semiclosed technique. Equids that received an additional dose of anesthetic agent during surgery had a significantly (P = 0.049) higher frequency of complications, compared with those that did not receive this treatment.

Lidocaine was administered intratesticularly for local anesthesia-analgesia in 106 of 324 (32.7%) equids. No association between use of lidocaine and development of a complication was found (OR, 0.63; 95% CI, 0.35 to 1.13; P = 0.130). Of 75 equids that received lidocaine perioperatively (excluding 31 horses that had intratesticular injection of lidocaine for castration while standing), 30 (40.0%) did not require an additional dose of anesthetic agent to maintain adequate general anesthesia.

Seventeen of 324 (5.2%) equids (including all 3 donkeys) had ligatures placed with absorbable suture during castration. Two of these equids underwent castration while standing, and 15 had the procedure performed under general anesthesia. Two of these 17 (both adult donkeys) developed complications. Four of the remaining 15 animals (1 donkey, 2 mules, and 1 Thoroughbred) had transfixing ligatures placed on both spermatic cords as part of the routine procedure, and 11 had ligatures placed to stop intraoperative hemorrhage; none of these developed complications. Use of ligatures was not significantly (P = 1.000) associated with development of a complication (OR, 1.19; 95% CI, 0.63 to 2.23). Of the 17 animals in which ligatures were placed, 14 had 1 dose of penicillin G procaine administered IM perioperatively, 6 were administered trimethoprim-sulfamethoxazole (30 mg/kg, PO, q 12 h) for 5 to 7 days after surgery, and 2 did not receive any antimicrobial treatment.

Anti-inflammatory drugs were administered to 29 of 324 (9.0%) equids perioperatively. Six received 1 dose of phenylbutazone (2.2 mg/kg, IV), and 23 received 1 dose of flunixin meglumine (1.1 mg/kg, IV). This variable was not significantly (P = 0.068) associated with development of a complication (OR, 1.47; 95% CI, 0.35 to 4.68).

Discussion

Castration of equids is one of the most commonly performed surgical procedures in equine practice. Although the procedure is considered to be routine, complications can occur and remain the most common cause of malpractice claims against equine practitioners in North America. Most complications following castration are mild and resolve easily with treatment, but more serious or life-threatening complications, such as evagination, peritonitis, and hemorrhage, can occur. Thorough knowledge of male reproductive anatomy and physiology combined with a good surgical technique helps to reduce the rate of complications associated with the procedure.

In the present study, complications were scored on the basis of severity (grade 1, complication developed > 24 hours after surgery and did not require emergency treatment; grade 2, complication was more serious and required more intensive treatment or was treated on an emergency basis within 24 hours after surgery; and grade 3, complication resulted in natural death or euthanasia of the horse). Most complications were grade 1 and typically consisted of mild swelling or seroma formation, all of which resolved with treatment (16/324 [4.9%]). In other studies, the incidence of swelling and seroma formation was 3.8%, 27.6%, and 24.3%. Excessive swelling is a common complication, usually detected 3 to 5 days after surgery, and may be attributed to inadequate drainage, inadequate exercise following surgery, excessive tissue trauma at the time of surgery, or infection; older horses have also been reported to be more prone to development of excessive edema following castration, compared with younger horses.

Following castration, exercise, cold-water treatment of the area, and administration of NSAIDs can help to minimize swelling. Excessive postoperative swelling can be painful and may result in an unwillingness to exercise, causing premature closure of the surgical wound, further compounding the problem. Adequate postoperative exercise consisting of hand walking or trotting daily for 10 to 14 days can help prevent premature closure of the surgical wound and seroma formation.

Evagination is an uncommon complication of castration that occurs when a portion of intestine prolapses through the inguinal canal and out of the scrotal incision. It typically occurs within 4 to 6 hours after castration but has been reported to occur up to 12 days following surgery. Results of 1 study indicated a 4.8% incidence of evagination in horses, with no significant difference between open and closed castration techniques with regard to this variable. One possible reason for the rate of evagination in that study was that the population of horses examined consisting of draft horse colts, which have been reported as having a higher incidence of evagination after castration, compared with other breeds. Investigators in other studies found the incidence of evagination to be 2.96%, 0.4%, and 0.2%. In the present study, evagination occurred in only 1 of 324 (0.3%) horses. This was a 3-year-old Thoroughbred that underwent castration via the semiclosed method under general anesthesia. On postmortem examination, 2 m of jejunum was found herniated through the left inguinal ring. The inguinal ring itself was normal, and increased straining due to colic resulting from an adverse drug reaction was suspected as a possible cause. Evagination has been hypothesized to result from increased abdominal pressure, presence of a large inguinal ring, leg position during recovery from...
general anesthesia, and possibly excessive exercise. One study found that common vaginal (parietal) tunic ligation significantly reduced the incidence of omental herniation and eventration, with only 1 of 131 (0.8%) evaluated horses developing eventration. That study focused on the castration of young draft horses, a breed type reported to be at increased risk of eventration after castration. In the present 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 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.

Some breeds, such as draft horse breeds and Standardbreds, have been reported to have a higher incidence of complications following castration; however, no association between breed and development of a complication was detected in the study reported here. Although we also found no association between age and development of a complication, horses that were castrated via the semiclosed technique were typically older (mean age, 46.6 months [median, 36 months]) than those castrated via the closed method (mean age, 18.6 months [median, 12 months]). Horses castrated via the semiclosed technique had significantly (P < 0.001) higher odds of developing a complication than did those castrated via the closed technique, and this may have been confounded by age.

All of the castrations included in this study were performed with 1 of 2 techniques (closed or semiclosed). The closed technique involves freeing the parietal tunica of each testis from the surrounding fascia and excising the testis and the parietal tunica that surrounds it, thus removing a portion of the parietal tunica and cremaster muscle with the testis. With the semiclosed technique, the parietal tunica is incised to allow exteriorization of the testis, its vasculature, the epididymis, and the ductus deferens. In the present study, a higher proportion of horses that underwent semiclosed castration (18/77) went on to develop complications, compared with those that underwent closed castration (13/247). To our knowledge, no controlled study has been performed to investigate the superiority of either technique. Investigators in a retrospective study found that use of a semiclosed technique resulted in a higher occurrence of infection, edema, and excessive hemorrhage, 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 closed or open techniques.

Because of the retrospective nature of the present study, duration of surgery was not accounted for; however, animals that received additional doses of anesthetic agent to maintain an adequate plane of general anesthesia had a significantly (P = 0.04) higher frequency of complications than did those that did not receive this additional treatment. A large proportion (201/293 [68.6%]) of equids castrated under general anesthesia required an additional dose of the anesthetic agent to maintain an adequate surgical plane of anesthesia, and it is possible that this may have reflected longer surgical times because castrations were all performed in a teaching facility by fourth-year veterinary students under the direct supervision of experienced veterinarians. A greater proportion of equids required additional anesthetic administration during semiclosed castration (44/54 [81.5%]) than during closed castration (157/239 [65.7%]). Although not evaluated statistically, this apparent difference may have been attributable to the fact that castration via the semiclosed technique is more technically demanding, requiring more dissection and time to complete than castration with the closed technique.

Of the 75 equids that received lidocaine perioperatively for castration under general anesthesia, 30 (40.0%) did not require an additional dose of anesthetic agent to maintain adequate surgical anesthesia. Lidocaine is commonly used for local anesthesia in equids. In 1 study, incisional, intrafunicular, and intratesticular lidocaine administration resulted in a significant decrease in the number of additional incremental IV boluses of anesthetic agent required during castration of horses under total IV anesthesia. Investigators in that study found that lidocaine did not result in increased hemorrhage or complications after surgery and also appeared to improve the quality of anesthesia. Results of another study performed to investigate the distribution of radiolabeled lidocaine after intratesticular injection revealed diffuse distribution to and within the spermatic cord but poor distribution to the testicular parenchyma and cremaster muscle. Another technique for local anesthesia involves the direct injection of anesthetic agent into the spermatic cord. This technique provides good anesthesia of the cord but occasionally may lead to hematoma formation within the spermatic cord, thus interfering with proper emasculature.

All of the donkeys included in the study had ligatures with absorbable suture placed as part of the procedure. This was done as a preventative measure against any possible hemorrhage because blood vessels of the spermatic cord are typically larger in donkeys than in horses. Two mules and 1 Thoroughbred also had ligatures placed as part of the routine procedure. The other 11 of 17 equids had absorbable ligatures placed to stop intraoperative hemorrhage. The low overall complication rate in our study population suggests that placement of ligatures on the spermatic cords is not required in most routine castrations. Investigators of a previous study did not find that placement of ligatures significantly reduced the incidence of postoperative hemorrhage (2.3%), compared with a reported rate of 2.44% without ligatures. The presence of foreign material at the castration site has been reported to result in an increased incidence of postoperative infection; however, the infection rate in a study of draft horse colts that underwent castration under field conditions with ligatures placed was low (0.76%).

Thirty-one horses were castrated while standing, of which 5 (16.1%) developed complications, compared with 28 of 293 (9.6%) castrated under general anesthesia; however, the odds of developing a complication did not differ between these 2 categories. These findings are similar to those in a previous study 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 anesthesia with primary closure of the scrotal incisions. Castration in standing horses minimizes the risk of death associated with general anesthesia and traumatic injury during recovery; it is also less expensive than surgery with general anesthesia and can be performed in the field. In general, the horses castrated while standing in this study were young adults (mean age, 66 months [median, 48 months]) with a good temperament or of a large breed. The majority of complications that developed after castration while standing (4/5) were grade 1 on the 1 to 3 scale and associated with mild swelling and seroma formation at the surgical site, which resolved promptly with treatment.

Only 29 of 324 (9.0%) equids in the present study received NSAIDs perioperatively. Results of a 2003 survey in the United Kingdom indicated that 43.4% of veterinarians did not provide additional analgesic drugs following castration, 17.7% administered them occasionally, and 36.9% administered them routinely. In the study reported here, equids castrated under injectable general anesthesia typically received butorphanol tartrate (0.01 mg/kg, IV) as part of the sedation protocol for catheter placement and palpation of the testicles prior to surgery, as did all horses castrated while standing. In another study,13 administration of butorphanol had the same apparent analgesic effect as phenylbutazone treatment in young colts being castrated under general anesthesia (with intratesticular lidocaine injection). Also, combined treatment with butorphanol and phenylbutazone was not apparently superior to either drug used alone. Although only 106 of 324 (32.7%) equids in the present study were known to receive lidocaine intratesticularly, this number may have been underestimated because the study was retrospective and administration of lidocaine may not have been recorded in some medical records. Recently, all horses undergoing castration in our practice have received this treatment.

Overall, the incidence of complication associated with castration (33/324 [10.2%]) was considered low in the present study, and the mortality rate (1/324 [0.3%]) was very low. The findings suggested that most of the evaluated variables were not associated with development of complications, and choice of surgical technique (closed vs semiclosed) is an important factor to consider in this regard. Further studies should evaluate associations between duration of surgery and development of complications.

References