concentration of testosterone to differentiate geldings from horses with testicular tissue.[117] These wide variations in concentration of testosterone were not observed in another study, which found basal concentrations of testosterone to be accurate in predicting the presence of testicular tissue.[118] That study found an error of only 5%.

A rise in the concentration of testosterone in response to stimulation by administration of hCG increases the accuracy of detecting cryptorchidism.[116,117,120,121] Investigators reported increased concentration of testosterone in cryptorchid stallions at any time between 30 and 120 minutes after intravenous administration of 6000 or 12,000 units of hCG.[116,117] Horses were classified as cryptorchid if the concentration of testosterone both before and after administration of hCG was greater than 100 pg/mL, or as geldings if the concentration in both samples was less than 40 pg/mL. The hCG-stimulation test was 94.6% accurate in predicting the presence of testicular tissue. Response to hCG was poor in horses less than 18 months old and during the winter.[116] Other investigators found that response of bilateral cryptorchid stallions and hemi-castrates to hCG was minimal, but that best results were achieved if poststimulation samples were obtained at 24 hours rather than at 1 hour.[118] Other investigators found that administration of hCG to entire stallions induced an increase in concentration of testosterone that lasted about 10 days, and they suggested that for detection of a retained testis a poststimulation sample should be taken at 2 to 3 days.[119]

In one study, quantification of total, free (i.e., unconjugated) estrogen alone was superior to quantification of total androgens, with or without hCG stimulation, for detecting retained testicular tissue.[121] Although other investigators were unable to confirm superiority of free estrogens for detecting testicular tissue, they found a high correlation between the presence of testicular tissue and the concentration of conjugated estrogen (e.g., estrone sulfate) if cryptorchid horses younger than 3 years and cryptorchid donkeys of any age were excluded from the study.[116,117] The investigators found that young cryptorchid horses and cryptorchid donkeys did not consistently produce enough conjugated estrogens to yield reliable results. Quantification of conjugated estrogen was 96% accurate when these animals were excluded from the study. Although cryptorchid horses produced less estrogen than did entire stallions, the lower threshold of conjugated estrogen for a cryptorchid horse was higher than that of testosterone. Horses with a concentration of estrone sulfate less than 50 pg/mL in plasma or serum were determined to be geldings. A concentration in excess of 400 pg/mL indicated cryptorchidism. Another investigation also revealed a high correlation between the concentration of conjugated estrogens and the presence of testicular tissue in horses older than 3 years.[118] In that investigation, geldings had a concentration of estrone sulfate less than 120 pg/mL, and cryptorchid stallions had a concentration greater than 1000 pg/mL.

Knowing the laboratory's standards for normal hormonal concentrations of geldings and horses with testicular tissue is important when evaluating results of hormonal assays. Comparing test results with values from a known gelding may be necessary, if the laboratory cannot furnish standards. False-positive results from hormonal assays to determine the presence of testicular tissue have not been reported.[122] The clinician can be confident that a horse has testicular tissue if the result of a hormonal assay indicates that testicular tissue is present.

Other Diagnostic Tests

Ultrasonographic examination may delineate abnormalities within the testis and associated structures or assist in determining the location of a cryptorchid testis. To ultrasonographically image an inguinal testis, a 5-MHz, transrectal transducer is placed longitudinally over the superficial inguinal ring.[123] To image an abdominal testis, the transducer is inserted rectally, cranial to the pelvic brim, and the abdomen is scanned in a to-and-fro pattern as the transducer is advanced cranially. Inguinal ultrasonography is ineffective in locating an abdominal testis, and furthermore, abdominal ultrasonography is ineffective in locating an inguinal testis. The echotexture of the cryptorchid testis is less dense than that of a normal descended testis.

Serum concentrations of biochemical markers, such as α-fetoprotein and hCG, are measurable in minute quantities using radioimmunoassay and have been used to monitor the response of humans to treatment for testicular neoplasia.[88] Apparently, no such markers have been used to detect testicular neoplasia of horses or to monitor for the presence of metastatic neoplasms after a neoplastic testis has been removed.

Cytologic examination of peritoneal fluid may be valuable in diagnosing certain diseases of the testes and associated structures, because changes in the fluid within the vaginal cavity may be reflected in the peritoneal fluid. Semen evaluation may be valuable in diagnosing orchitis, epididymitis, or seminal vesiculitis. Thermographic examination of the scrotum may detect a variation in temperature between the testes. A horse with morphologic abnormalities suggestive of intersexuality, such as cryptorchidism accompanied by ambiguous genitalia, can be karyotyped to determine its genetic sexual identity.

SURGICAL PROCEDURES

Castration

Indications

Synonyms for castration include orchidectomy, emasculation, gelding, and cutting. Castration is one of the most common equine surgical procedures and is usually performed to sterilize horses unsuitable for the genetic pool and to eliminate masculine behavior. By removing the primary source of androgens, castration renders the horse more docile and manageable.

Although stallions can be safely castrated at any age, managerial convenience usually governs the age at which a horse is castrated. Typically, a horse is castrated simply because facilities are insufficient to safely contain a stallion. Most horses are castrated when they are 1 to 2 years old, when masculine behavior becomes intolerable to the owner. Sometimes castration is delayed until a masculine feature, such as a crest on the neck, has developed or until it becomes apparent that the horse is unsuitable for breeding.

recumbent castration most easily performed with the horse positioned in left lateral recumbency, and vice versa.

Approach

SCROTAL INCISION

For the standing castration and one technique of recumbent castration, the testes are removed through a scrotal incision. If the horse is anesthetized, and if the testes are small and difficult to grasp, as is often the case with prepubescent stallions, the scrotum can be safely incised by pulling the cranial end of the prepuce craniad and upward to tense the scrotal raphe (Fig. 65-12). Another method of incising the scrotum is to compress the testes against the bottom of the scrotum. Two parallel 8- to 10-cm-long incisions are made 2 cm on either side of the raphe. The incision should be sufficiently long to provide adequate postoperative drainage. To ensure adequate drainage, many surgeons prefer to partially ablate the scrotum, which can be accomplished by connecting the two parallel incisions cranially and caudally and removing the portion of scrotum between the incisions.

Another method of removing the bottom of the scrotum is to grasp the scrotal raphe between the thumb and forefinger, and while applying traction to the bottom of the scrotum, to excise a portion of the tented tissue with a scalpel (Fig. 65-13). When surgery is performed with the horse standing, stab wounds to the horse or surgeon that could result from sudden movement by the horse are avoided by incising with a scalpel blade held between the fingers rather than attached to a handle. A large portion of

Figure 65-12. Incising the scrotum for castration. If the testes are difficult to grasp, the cranial end of the prepuce can be pulled craniad and upward to tense the scrotal raphe.

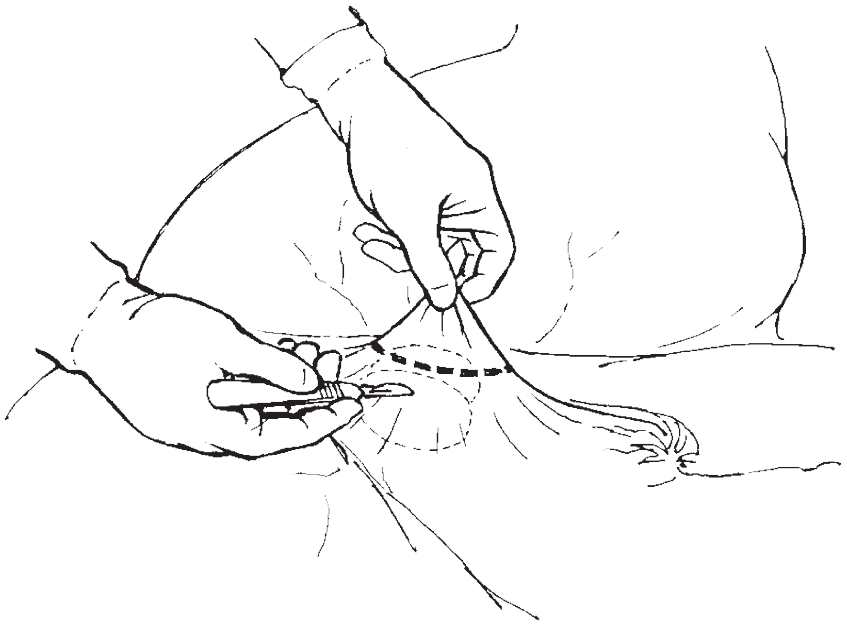

Figure 65-13. The bottom of the scrotum is removed by placing traction on the scrotal raphe with a thumb and forefinger and excising a portion of the tented tissue with a scalpel.

the scrotum should be excised to ensure adequate drainage. To avoid cutting large vessels, the dissection should remain close to the scrotal skin. The testes are then isolated using digital dissection.

INGUINAL INCISION

For the inguinal approach, the horse is anesthetized and positioned in dorsal recumbency. The superficial inguinal ring is exposed through an 8- to 15-cm skin incision (depending on the horse's size) made directly over the superficial inguinal ring.

EMASCULATORS

The emasculator models most commonly used are the improved White's, the Reimer, and the Serra emasculators[129] (Fig. 65-14). The Reimer emasculator crushes the cord, and a separate handle and blade sever the cord distally. Because the cord is severed with a separate handle, there is no danger of cutting the cord before it is satisfactorily crushed. The extra handle on the Reimer emasculator makes the instrument somewhat unwieldy for standing castration. The jaws of the Serra emasculator are curved, so that the cord is evenly crushed, and the grooves on the crushing blades are oriented parallel to the cord, decreasing the chance of accidentally transecting the cord with the crushing portion of the jaws[20] (Fig. 65-15). A type of emasculator used more commonly in Europe than in North American has no cutting component and only crushes the cord (Fig. 65-16). The cord must be severed distal to the crushed segment with a scissors or scalpel blade.

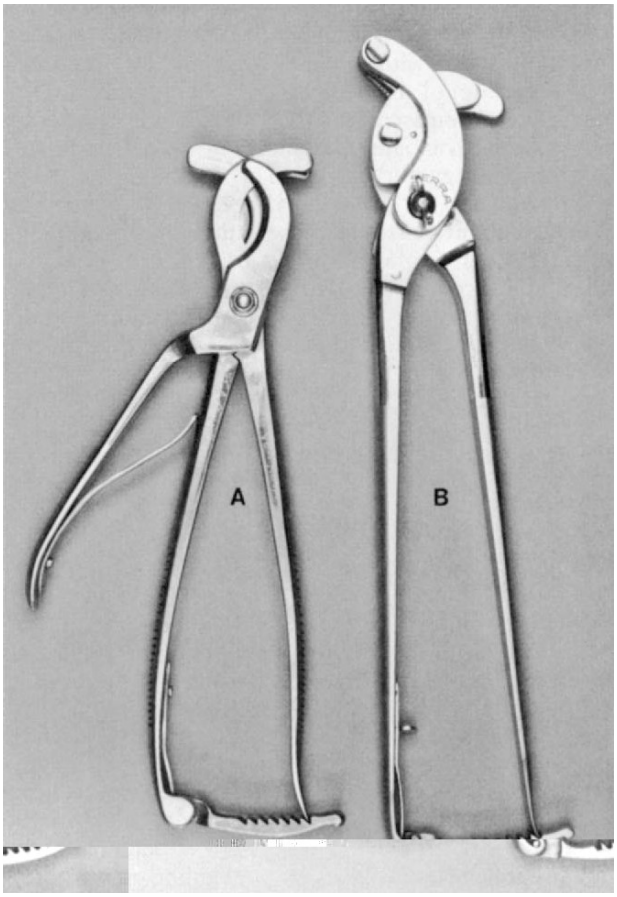

Figure 65-14. Reimer (**A**) and Serra (**B**) emasculators. The Reimer emasculator severs the cord with a blade on a separate handle so that the cord is not accidentally cut before it is satisfactorily crushed.

Surgical Techniques

Techniques of orchidectomy are the open, closed, and half-closed techniques, regardless of whether the horse is castrated while standing or recumbent, or whether the approach is inguinal or scrotal. With the open technique of castration, the parietal (or common vaginal) tunic is retained. With the closed and the half-closed techniques, the portion of the parietal tunic that surrounds the testis and distal portion of the spermatic cord is removed.

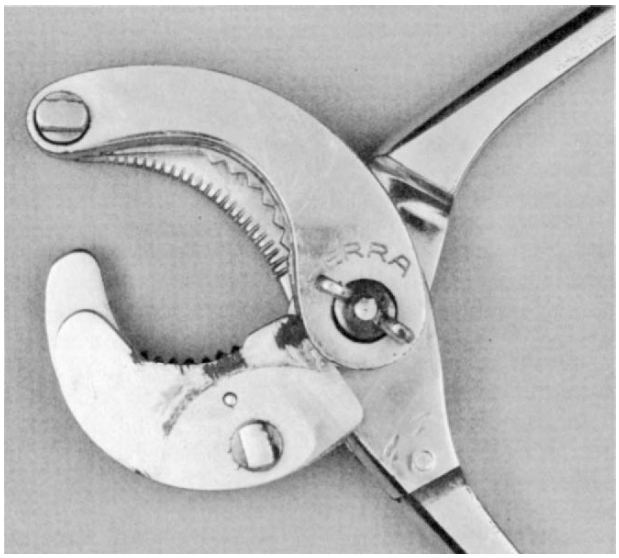

Figure 65-15. Serra emasculator. The grooves of the crushing blade are oriented vertically to prevent the blade from accidentally cutting the cord.

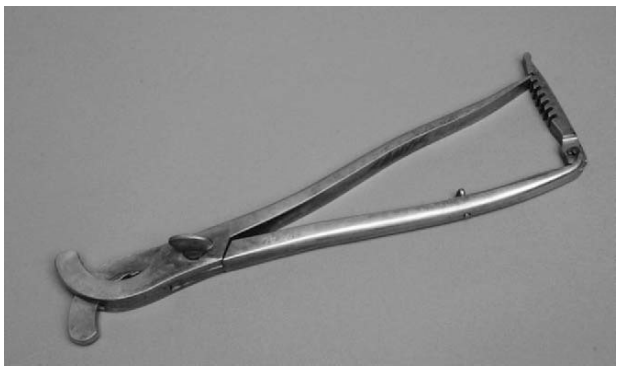

Figure 65-16. An emasculator without a cutting blade. The spermatic cord must be severed distal to the emasculator with a scissors or scalpel blade.

OPEN TECHNIQUE

When performing the open technique of castration, the parietal tunic of 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 severed or bluntly transected. By transecting the fold of the mesorchium and mesofuniculum, the testis, epididymis, and distal portion of the spermatic cord are completely freed from the parietal tunic and removed using an emasculator. The open technique of castration is probably the most commonly used technique.[129]

CLOSED TECHNIQUE THROUGH A SCROTAL APPROACH

With the closed technique, the parietal tunic is not incised, so it also is removed along with the testis and a portion of the cord. Using digital dissection, the parietal tunic surrounding the testis is freed from the scrotal ligament and scrotal fascia, and by placing mild traction on the testis with one hand, the parietal tunic surrounding the cord is separated from fascia surrounding the spermatic cord with the other hand. After the parietal tunic is separated from the surrounding fascia, it and its contents are removed using an emasculator. Care should be taken, when separating the fascia from the spermatic cord, to include the large pudendal vessels that lie within the fascia, so that these vessels are not included in the jaws of the emasculator.

HALF-CLOSED TECHNIQUE

The closed technique just described can be converted to a half-closed technique by making a 2- to 3-cm vertical incision through the exposed parietal tunic at the cranial end of the testis or the distal end of the spermatic cord. A thumb (the left thumb if the operator is right-handed) is inserted through the incision into the vaginal cavity. The testis and a portion of the spermatic vasculature are prolapsed through the incision by applying downward traction on the tunic with the thumb while simultaneously using the fingers of the same hand to push the testis through the incision. The fundus of the parietal tunic inverts and follows the testis through the incision because of its attachment to the testis by the ligament of the tail of the epididymis. Traction is applied to the parietal tunic with the index and middle fingers, which are placed into the sac formed by the inverted fundus. Traction can also be applied to the parietal tunic and the testis by applying a large Carmalt or Allis forceps to the parietal tunic before prolapsing the testis from the vaginal cavity. The half-closed technique should be considered a closed technique because the parietal tunic is removed along with the testis and the distal portion of the spermatic cord.

For each technique, the emasculator is applied at a right angle to the spermatic cord, loosely closed to avoid incorporation of scrotal skin, and slid further proximally. The emasculator is applied so that the crushing component is proximal to the cutting blade. When correctly applied, the wing-nut of the emasculator is oriented distally toward the testis, and the emasculator is said to be positioned "nut to nut." This positioning is not critical when using an emasculator that does not have a cutting blade. The scrotal skin is pushed toward the abdomen with one hand (with the spermatic cord positioned between the index and middle fingers) toward the horse's abdomen, and the jaws of the emasculator are inspected to ensure that they do not contain scrotal skin. The tension on the cord is relieved, and the handles of the emasculator are compressed completely to crush and sever the cord. The time that should elapse before the emasculator is removed from the spermatic cord depends on the size of the cord being severed and the dependability of the emasculator used, but applying the emasculator for about 1 minute is usually sufficient to achieve hemostasis. If the cord is exceptionally large, the emasculator can be applied for a longer time, or the parietal tunic and cremaster muscle can be crushed and severed separately from the testicular vessels and the ductus deferens. The cutting blade of the emasculator should not be so sharp that the cord is completely severed but rather should be slightly dull so that the cord must be torn, although with only slight effort, from the blade. If a noncutting emasculator is used, the cord is severed with a scalpel blade 2 to 3 cm distal to the emasculator. The emasculator should be elevated toward the horse's inguinal area before the cord is released, so that the testicular vessels do not recoil. It is customary, and perhaps prudent, when performing a standing castration to leave the scrotal wound unsutured. Loose scrotal fascia protruding from the scrotal opening is trimmed with scissors.

A technique (i.e., the Zurich technique) frequently used in Europe to ensure adequate scrotal drainage involves suturing a 30-cm-long gauze drain to the stump of one of the cords with heavy catgut suture.[130] The drain that exits the scrotal wound is removed 2 days after castration by rupturing the catgut suture with a sharp tug on the drain.

SELECTION OF TECHNIQUE

An advantage of the closed and half-closed techniques of castration is that removal of the parietal tunic decreases the incidence of postoperative complications, such as septic funiculitis and hydrocele[32,34] (see "Postoperative Complications of Testicular Surgery," p. 802). The half-closed technique permits inspection of the components of the cord and allows a greater portion of the ductus deferens and testicular vasculature to be exteriorized. For horses at risk of having an unapparent inguinal hernia, such as Standardbreds, evisceration can be avoided by using a closed technique and placing a ligature proximal to the proposed site of transection.

The closed technique of castration has no advantage over the open technique in preventing evisceration if a ligature is not applied to the cord proximal to the site of transection. The closed and half-closed techniques are indicated for disease conditions that may involve the parietal tunic, such as neoplasia and orchitis. The closed and half-closed techniques require more dissection than does the open method of castration, and this may be a disadvantage when performing a standing castration on a fractious stallion.

Primary Closure of the Incision

By convention, scrotal incisions are usually left unsutured to heal by secondary intention. Primary closure, however, speeds healing and recovery, eliminates infection, and decreases edema, pain, and muscular stiffness.[131-134] Primary closure may be particularly useful if vigorous exercise cannot be enforced postoperatively. Primary closure decreases

convalescence but is time consuming and requires meticulous hemostasis and strict adherence to aseptic technique. In one study, no complications were encountered when the spermatic cords were simply transected with an emasculator.[133] Hemorrhage from a cord into the sutured scrotum, however, even if only a small amount, risks formation of a hematoma, and therefore, ligation of the cord proximal to the point of division with the emasculator ensures good hemostasis and should be considered an important part of the procedure.

One investigator, pointing out the importance of eliminating dead space, closed the subcutaneous tissue with multiple rows of absorbable suture.[133] Another investigator, however, found multiple-layer closure unnecessary and reported minimal postoperative complications when only the scrotal skin was sutured.[131] The cutaneous incision is best closed with an absorbable 2-0 monofilament suture using a simple-continuous intradermal suture pattern. Because the cutaneous incision is sutured intradermally, removal of cutaneous sutures is not necessary.

The testes can be removed *per primam* through an inguinal incision created over each spermatic cord.[135] This technique is frequently used in Europe when castrating horses 2 years old or older to avoid evisceration, because the vaginal rings of these horses are thought by some surgeons to be wider than those of younger horses. Using this technique, the inguinal fascia is separated digitally to expose the superficial inguinal ring. The fascia must be separated bluntly to avoid lacerating large branches of the external pudendal vessels. Blunt dissection is continued until the spermatic cord is encountered. The parietal tunic surrounding the cord is freed from surrounding fascia and incised longitudinally for 5 cm.

Using an index finger, the testicular vessels and ductus deferens are exteriorized through the incision, and using gentle traction on these structures, the testis is pulled from the vaginal cavity. The ligament of the tail of the epididymis, which attaches the testis to the parietal tunic, is identified and transected. Bleeding vessels are cauterized to prevent hemorrhage into the vaginal cavity. Two transfixing ligatures are applied 1 cm apart, as far proximally as possible, to the testicular vasculature and ductus deferens, using an absorbable, heavy monofilament suture. The vasculature and ductus deferens are severed 2 cm distal to the distal ligature, and the stump is replaced into the vaginal cavity. If this technique of *per primam* castration is performed with the expectation of preventing incarceration of intestine in the inguinal canal, a ligature should be applied to each spermatic cord proximal to the site of transection.[136]

The incision in the parietal tunic and the subcutaneous tissue are each sutured with an absorbable 2-0 monofilament suture using a simple-continuous pattern. The cutaneous incision is closed with the same suture using a simple-continuous intradermal suture pattern.

Aftercare

All horses not previously immunized with tetanus toxoid should receive both tetanus antitoxin and toxoid. The previously immunized horse should receive a booster vaccination if more than a year has passed since its last vaccination.[137] The horse's activity should be restricted for the first 24 hours after castration to avoid hemorrhage from the severed testicular and scrotal vessels. After this period, the horse should be exercised to the degree necessary to prevent excessive preputial and scrotal edema. A large, grass-covered field is an ideal environment for postoperative recuperation, but the owner should be cautioned that turning a horse into a field does not ensure that it will receive adequate exercise.

Antimicrobial treatment is probably unnecessary if clean surroundings are provided, but a survey of practitioners, undertaken to determine the type and frequency of complications that occur after castration, found that horses may be less likely to develop infection at the castration site if they receive perioperative antimicrobial treatment.[129] The operative site can be hosed vigorously, if the horse permits it, to keep the scrotal wound clean, open, and draining, but this same survey found that horses that receive hydrotherapy after castration may be more prone to develop excessive swelling and infection of the scrotum.

Protecting the wound against flies is usually unnecessary, even during fly season, if the horse's tail-hairs are long enough to reach the scrotal area. The horse should be isolated from mares for at least 2 days after castration. Ejaculates are highly unlikely to contain sufficient spermatozoa to cause impregnation after 2 days.[138] The castration wound should be nearly healed by 3 weeks.

Laparoscopic Castration

Ligating and transecting the blood supply and ductus deferens of scrotal testes laparoscopically with the horse standing or anesthetized results in avascular necrosis of the testicular parenchyma with the testes in situ.[139,140]

The standing approach is preferred by most surgeons, when the horse is castrated laparoscopically. To safely insert a laparoscopic sleeve and cannula into the abdomen, the abdomen can be insufflated through a Veress needle, IV catheter, teat cannula, chest drain, or metal uterine catheter introduced into the abdomen through a stab incision created slightly dorsal to the crus of the internal abdominal oblique muscle, midway between the last rib and the tuber coxae. The abdomen can also be insufflated, using the same devices, through a stab incision created on the linea alba. The abdomen is insufflated using a gas, such as carbon dioxide, nitrous oxide, or helium, until the intra-abdominal pressure rises to 8 to10 mm Hg. Care should be taken to avoid insufflating the retroperitoneal space. After the abdomen is inflated, the insufflation device is removed, and a laparoscopic sleeve with a guarded trocar is inserted through an incision in the flank. The laparoscopic sleeve and guarded trocar can also be inserted safely, without insufflating the abdomen, by allowing air to enter the abdomen through a blunt cannula, such as a chest drain, inserted into the abdomen through the flank. Air entering the abdomen causes the viscera to fall away from the body wall, allowing safe introduction of the laparoscopic sleeve and trocar. The trocar is removed, and the laparoscope, which is attached to a fiberoptic light source and a video camera and viewing monitor, is introduced into the abdomen. The laparoscope is directed caudally to view the inguinal areas. A 10-mm-diameter instrument portal is created 8 to 10 cm cranioventral to the laparoscopic portal, and another is created 8 to

10 cm caudoventral to the laparoscopic portal. A third, 5-mm-diameter instrument portal is created 8 to 10 cm caudodorsal to the laparoscopic portal.

The testicular vessels and ductus deferens are identified in the mesorchium as they course toward the vaginal ring. A ligating loop is placed through the 5-mm instrument portal, and a right-angle dissecting forceps is inserted through the cranioventral portal and the ligating loop. The ductus deferens and testicular vessels are grasped with the forceps. Using a bipolar cautery forceps placed through the caudoventral instrument portal, the ductus deferens and testicular vessels are coagulated distal to the forceps. The cautery instrument is removed and replaced with a laparoscopic scissors, which is used to transect the ductus deferens and spermatic vessel immediately distad to the site of coagulation. The ligating loop is now slid over the right-angle forceps onto the coagulated stump of the ductus deferens and testicular vessels, tightened, and tied, and the ends of the ligature are cut. After releasing the forceps, the stump is inspected for hemorrhage.

By elevating the small colon manually per rectum, the contralateral testis can be removed using the same portals and technique. Removing the contralateral testis using portals created on the contralateral side, however, may be faster and easier.

The testes, deprived of their blood supply, swell during the first week and then begin to decrease in size. The atrophied testes can be palpated in the scrotum for at least several months,[140] but by 5 months the remnants are no longer palpable.[139] Within 7 days after the testicular vessels are ligated, the concentration of testosterone falls to that expected of a horse with no functional testicular tissue. The epididymis remains viable, but because it has no contribution to masculine behavior, the horse behaves as a gelding. Swelling and discomfort observed after laparoscopic castration seem to be less severe than is seen after routine castration.[140] A testis whose blood supply has been interrupted can revascularize, however, apparently by peritesticular angiogenesis, before the testis becomes completely necrotic, resulting in preservation of stallion-like behavior.[141] The owner should be warned of this uncommon complication.

Vasectomy

A stallion used for detecting estrous (i.e., a teaser stallion) can be vasectomized to render it incapable of ejaculating spermatozoa and thus from accidentally impregnating mares. A stallion can be vasectomized through an incision created over each spermatic cord or through a single incision created over one testis.[142] To transect a portion of the ductus deferens through a single incision in the scrotal area, the horse is anesthetized, positioned in dorsal or lateral recumbency, and the scrotum is prepared for surgery. A 2-cm, longitudinal, cutaneous incision is made on the medial aspect of one testis, and the incision is extended through the dartos and parietal tunic. The ductus deferens, which is identified as a white, 2- to 3-mm-diameter, cordlike structure, is exteriorized and separated for a length of several centimeters from its mesorchium, using a curved hemostat. Two ligatures of 2-0 absorbable or nonabsorbable suture are placed around the most proximal aspect of the exposed portion of the ductus deferens, and a third ligature is placed around the most distal aspect of the exposed portion of the ductus deferens. The segment of ductus deferens between the two proximal ligatures and the distal ligature is removed. Double-ligating the proximal end minimizes the likelihood of spontaneous reanastomosis and formation of a sperm granuloma.

The incision in the parietal tunic is sutured with an absorbable 2-0 suture using a simple-continuous pattern. The ductus deferens on the medial aspect of the other testis is then palpated through the cutaneous incision and exposed by incising the scrotal septum and overlying parietal tunic. A segment of the ductus deferens is exteriorized, ligated, and transected as described. The incision in the parietal tunic and the subcutaneous tissue are each sutured with an absorbable 2-0 suture using a simple-continuous pattern. The cutaneous incision is closed with the same suture using a simple-continuous intradermal suture pattern.

Immunologic Castration

Immunization against luteinizing hormone–releasing hormone (LHRH), a neuropeptide produced by the hypothalamus, was used in a cryptorchid stallion to decrease serum concentration of testosterone,[143] and immunization against gonadotropin-releasing hormone (GnRH) was used experimentally to suppress testicular function of entire stallions.[144,145] Repeated immunization was necessary to maintain a sufficient binding titer for complete neutralization of LHRH or GnRH and inhibition of the reproductive endocrine axis. Immunization against GnRH caused decreased concentrations of testosterone and estrogen in the serum, diminished sexual behavior, and decreased testicular size, and it had a negative effect on semen quality. Stallions varied in response to immunization, and in one study, libido was not totally suppressed.[144]

If a vaccine against LHRH or GnRH becomes commercially available, unwanted male sexual behavior by cryptorchid or entire stallions can be prevented temporarily. A vaccine against GnRH may enable a stallion to perform at its peak ability at athletic competitions, by decreasing undesirable sexual behavior, until the stallion's genetic potential can be determined, while allowing the stallion to retain its ability to produce progeny. The time required for recovery of libido and semen quality needs to be determined before a vaccine against LHRH or GnRH is used clinically for temporary diminution of male sexual behavior.

Cryptorchid Castration

A retained testis can be removed through an inguinal, parainguinal, suprapubic paramedian, or flank approach. For each of these approaches, except the flank approach, the horse must be anesthetized. The approach is termed noninvasive if the testis can be removed by introducing only one or two fingers into the abdominal cavity, and an approach that requires insertion of a hand into the abdomen is considered invasive. Only the inguinal and parainguinal approaches allow noninvasive removal of a cryptorchid testis.

Inguinal Approach

For the inguinal approach, the horse is anesthetized and positioned in dorsal recumbency. The superficial inguinal ring is exposed through an elliptical, scrotal incision or through an 8- to 15-cm skin incision (depending on the horse's size) made directly over the superficial inguinal ring. A cryptorchid testis and the contralateral scrotal testis (or two cryptorchid testes) can be removed from one incision if the incision is created over the scrotum rather than over the superficial inguinal ring.

The inguinal fascia is separated digitally to expose the superficial inguinal ring. An inguinal testis is readily encountered when the superficial inguinal ring is exposed. The vaginal sac should always be opened and its contents examined to avoid mistaking the descended tail of the epididymis of a partial abdominal cryptorchid for a small, inguinal testis. If the testis has already been removed, the stump of the spermatic cord is encountered as it exits the canal. Finding a stump of a severed ductus deferens, the remnant of spermatic vessels, and a well-developed cremaster muscle indicates that the horse has been castrated.[22,116]

After the superficial inguinal ring has been exposed, an abdominal testis can be retrieved using one of several non-invasive techniques. One noninvasive technique requires locating the rudimentary common vaginal tunic, or vaginal process. This structure contains a portion the epididymis or sometimes a portion of the gubernaculum testis. The body of the epididymis can be exposed through a small incision in the vaginal process and traced to the tail of the epididymis, which is connected to the testis by the proper ligament of the testis. By placing traction on this ligament, the abdominal testis can be exteriorized through the vaginal ring. The key to this technique is locating the vaginal process. The vaginal process of the partial abdominal cryptorchid lies everted within the inguinal canal and is readily encountered during inguinal exploration. The vaginal process of the complete abdominal cryptorchid lies inverted within the abdominal cavity, along with the epididymis and testis, and difficulty may be encountered in locating and everting it into the canal.

An inverted vaginal process can be everted into the inguinal canal by exerting traction on the scrotal ligament, which is also known as the inguinal extension of the gubernaculum testis (IEGT)[12] (Fig. 65-17). This ligament is a remnant of the gubernaculum testis and attaches the vaginal process to the scrotum. The IEGT is located by

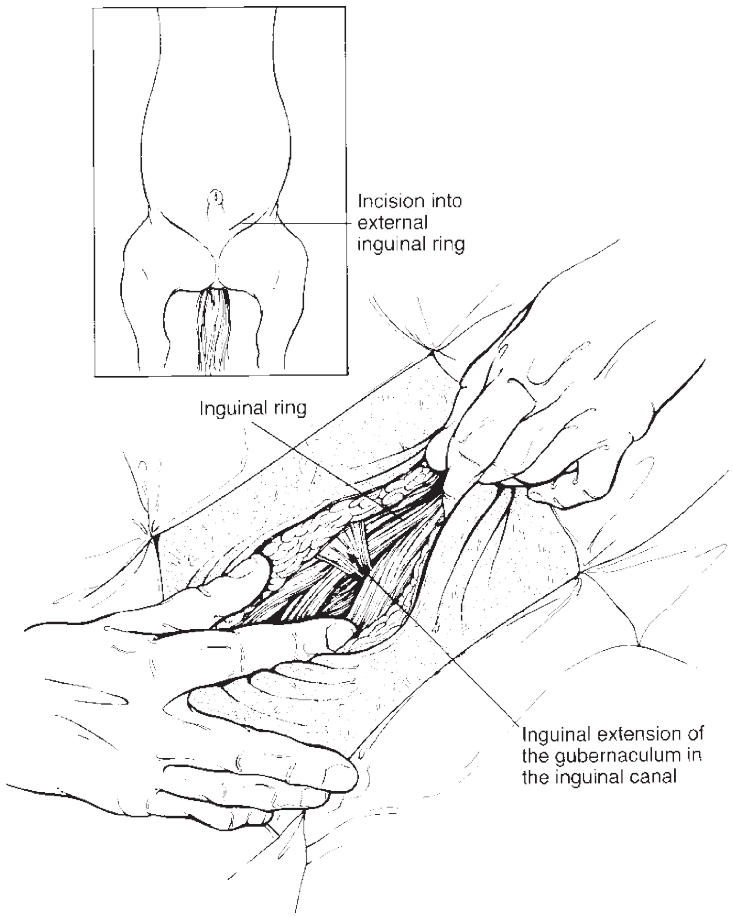

Figure 65-17. An inverted vaginal process can be everted into the inguinal canal by exerting traction on the inguinal extension of the gubernaculum testis. This ligament is a remnant of the gubernaculum and attaches the vaginal process to the scrotum.

carefully examining the margin of the superficial inguinal ring for a fibrous band that descends into the canal. The IEGT can be found on either the medial or lateral aspect of the ring, usually at the junction of the middle and cranial third of the ring. The genitofemoral nerve courses through the canal and can be mistaken for the IEGT. This nerve usually lies further caudally, in the middle or caudal third of the superficial inguinal ring. The IEGT is most easily located by grasping and retracting loose fascia at the junction of the middle and cranial thirds of the ring with the thumb and index finger of one hand and tracing it into the canal with the index finger and thumb of the other hand. The fascia tears if the IEGT is not contained within the fascia, but if the IEGT lies within this fascia, traction causes the inverted vaginal process to evert into the canal, where it and the epididymis or gubernaculum contained within can be seen and palpated. The everted process is a glistening, white structure, usually about the size of a fingertip. A hypoplastic cremaster muscle can be seen attached to the lateral aspect of the vaginal process.

An inverted vaginal process can also be everted using a sponge forceps.[26] A finger is inserted through the vaginal ring into the inverted vaginal process, and a 25-cm, curved sponge forceps is introduced beside the finger. The jaws of the forceps are opened and closed to grasp the apex of the vaginal process. Traction applied on the forceps everts the inverted vaginal process. The difficulty of this technique is locating the vaginal ring. The ring can usually be found beneath the third finger when four fingers are inserted into the inguinal canal.

After the vaginal process is everted and stripped of inguinal fascia, it is incised longitudinally (a no. 12 scalpel blade works best for this) to expose a portion of the epididymis contained within (Fig. 65-18, *A*). The epididymis is grasped with a hemostat and exteriorized until the tail of the epididymis is located (see Fig. 65-18, *B*). The proper ligament of the testis connects the tail of the epididymis to the caudal pole of the testis (Fig. 65-19), and by applying traction to this structure, the testis can be pulled through the vaginal ring and exteriorized for removal (Fig. 65-20). Stretching the vaginal ring to accommodate passage of the testis may not be necessary if the stallion is immature. Usually though, the vaginal ring must be stretched to allow passage of the testis, and this is accomplished by inserting a finger through the incision in the vaginal process and through the vaginal ring. The finger is inserted through the vaginal ring to the level of the second joint, and by flexing the finger, the ring is dilated. The vaginal ring of a mature stallion is usually much more difficult to dilate than that of an immature stallion.

Rarely, the vascular pedicle of the testis is so short that placing an emasculator proximal to the testis and epididymis is impossible. The cord must then be crushed and transected using an écraseur or severed with scissors after occluding the testicular vasculature with one or two ligatures. The contralateral testis is then removed, and the skin incision is sutured or left to heal by secondary intention.

PREVENTING EVISCERATION

The vaginal ring should be re-palpated after the abdominal testis is removed. If the ring accommodates no more than the tips of the index and middle fingers, the horse can be recovered, and unrestricted activity can be safely allowed after several days. If the ring has been dilated beyond this diameter, one of two measures must be taken to prevent evisceration. To avoid evisceration, the inguinal canal can be packed to the level of the vaginal ring with sterile gauze for 24 to 36 hours. The pack is maintained in the canal by partially suturing the skin incision. Evisceration may follow removal of the pack, especially if gauze has been inadvertently inserted through the vaginal ring into the abdomen. Not only does gauze in the abdomen prevent the vaginal ring from contracting but it also becomes adhered to viscera. Evisceration can be avoided by palpating the vaginal ring per rectum after the pack is inserted and before it is removed to ensure that gauze has not entered the abdomen. After the pack is removed, the horse's activity should be restricted to hand-walking for several days before forced exercise is imposed. Jumping, cantering, and galloping should not be allowed for 3 weeks.

Although the deep inguinal ring is inaccessible for suturing, the superficial inguinal ring can be closed with an interrupted or continuous pattern of heavy, absorbable suture to prevent evisceration. A hernia or kidney needle is the needle of choice for suturing the inguinal ring. Not only does suturing the superficial inguinal ring provide better security against evisceration than does packing the canal with gauze but it also allows primary closure of the inguinal fascia and skin. Although viscera can enter the inguinal canal, incarceration of intestine by the vaginal ring has not been reported. Inguinal fascia and skin can be sutured after closure of the superficial inguinal ring or allowed to heal by secondary intention. Activity should be restricted to hand-walking for several days before forced exercise is imposed. Heavy exercise should not be allowed for 3 weeks after surgery.

Parainguinal Approach

If the vaginal process cannot be located using the previously described techniques, the testis can be removed noninvasively by converting the inguinal approach to a parainguinal approach.[146] 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 (Fig. 65-21). The incision is centered over the cranial aspect of the ring. The internal abdominal oblique muscle underlying the aponeurosis is spread in the direction of its fibers, and the peritoneum is penetrated with a sharp thrust of the index and middle fingers. The vaginal ring is palpated caudolateral to the point of entry into the abdomen (Fig. 65-22). The epididymis, ductus deferens, and gubernaculum are situated near the ring, and by sweeping the region with a finger, one of these structures can be grasped between the index and middle fingers and exteriorized. The body of the epididymis is followed to the tail. Traction on the proper ligament of testis pulls the testis through the incision.

If difficulty is encountered in locating the epididymis or associated structures, or if exteriorizing the testis is difficult, the incision can be enlarged to accommodate a hand. After excising the testis, the incision in the aponeurosis of the external abdominal oblique muscle is apposed using heavy absorbable sutures in an interrupted or continuous pattern. The subcutaneous tissue and skin can be sutured or left unapposed to heal by secondary intention. The horse can

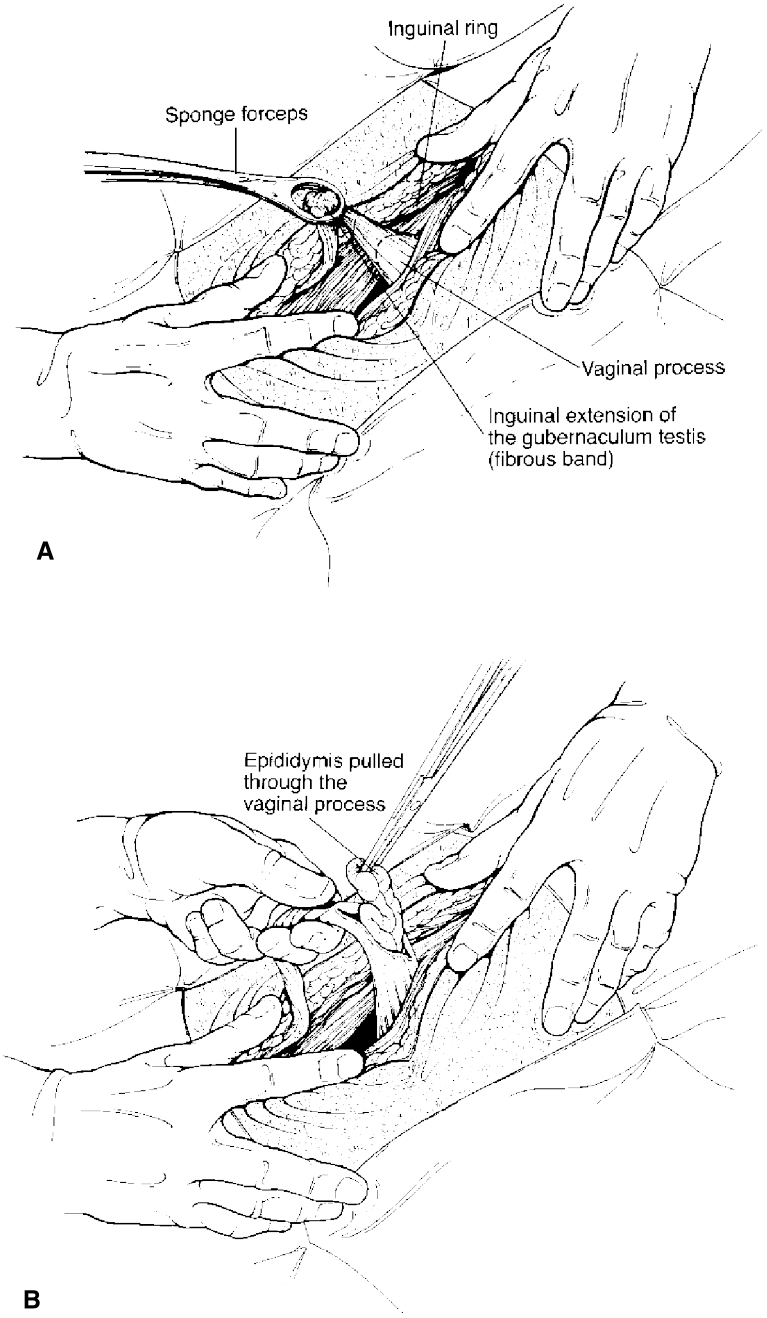

Figure 65-18. A, The everted vaginal process is stripped of inguinal fascia and longitudinally incised. **B,** The epididymis contained within is grasped with a hemostat and exteriorized.

receive exercise after surgery, excluding cantering and galloping, provided that the parainguinal incision was short enough that it could accommodate only several fingers. Unrestricted activity is allowed 3 weeks after surgery.[146]

The parainguinal approach is preferred over the inguinal approach by some surgeons because the vaginal ring is not disrupted.[146] The aponeurosis of the external abdominal oblique muscle is more easily sutured than the superficial inguinal ring.

Suprapubic Paramedian Approach

For the suprapubic paramedian approach, an 8- to 15-cm, longitudinal skin incision is made 5 to 10 cm lateral to the ventral midline.[147-149] The incision begins at the level of the preputial orifice and extends caudally. The large subcutaneous vessels encountered caudally in the incision are ligated. The abdominal tunic and the closely adherent ventral sheath of the rectus abdominis muscle are incised longitudinally, and the underlying fibers of the rectus

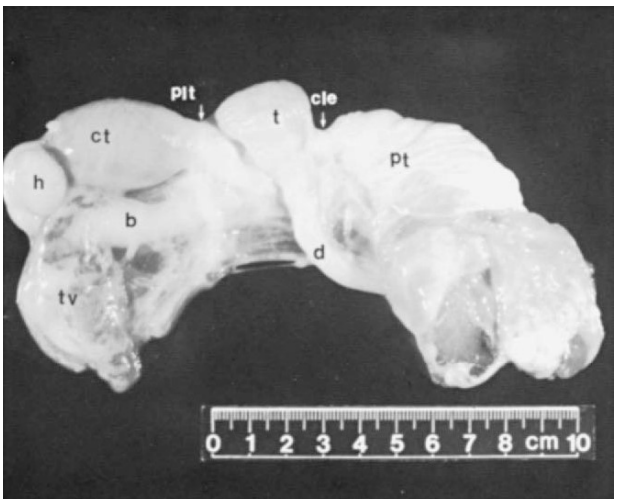

Figure 65-19. Cryptorchid testis. b, body of epididymis; cle, caudal ligament of the epididymis; ct, cryptorchid testis; d, ductus deferens; h, head of epididymis; plt, proper ligament of the testis; pt, parietal tunic; t, tail of epididymis; tv, testicular vessels.

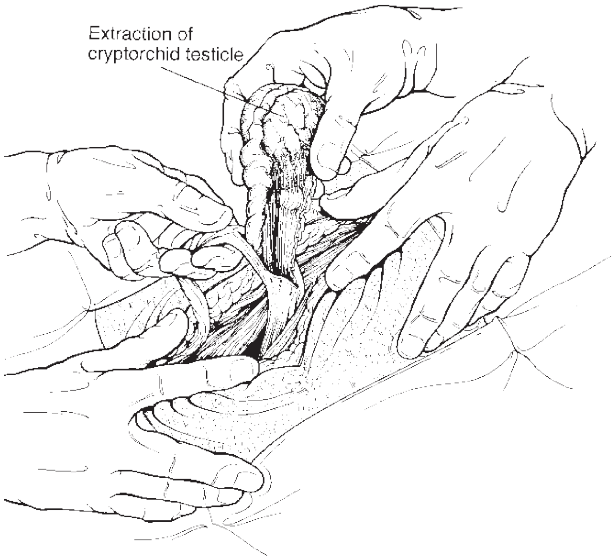

Figure 65-20. With traction on the proper ligament of the testis, the testis is pulled through the vaginal ring.

Figure 65-21. Parainguinal approach to cryptorchidectomy. 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 centered over the cranial aspect of the ring.

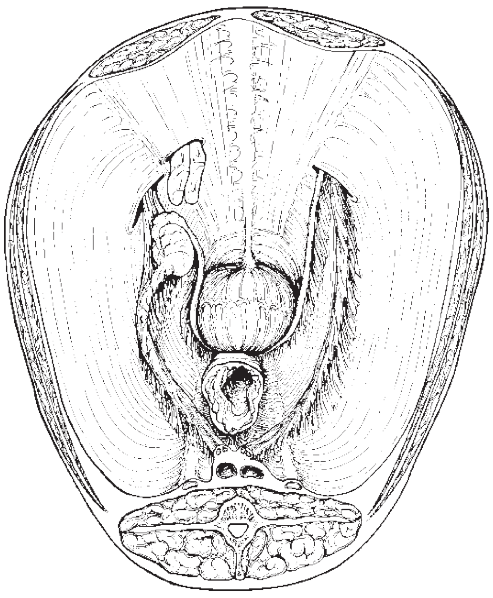

Figure 65-22. Parainguinal approach to cryptorchidectomy. The vaginal ring is palpated caudolateral to the point of entry into the abdomen. Either the epididymis, gubernaculum, or ductus deferens is located at the vaginal ring and exteriorized.

abdominis muscle are bluntly separated in the same direction. The dorsal rectus sheath, retroperitoneal fat, and peritoneum are penetrated with a finger. The perforation is bluntly enlarged, and a hand is introduced into the abdomen.

The testis is usually encountered near the vaginal ring. If the testis cannot be palpated, accessory structures at the vaginal ring can be located and followed to the testis, or the ductus deferens can be found in the genital fold of the bladder and traced to the testis. Both testes of a bilateral cryptorchid can be removed through one incision, but the contralateral testis is difficult to exteriorize, and its cord usually must be transected with an écraseur. After removing the testis, the abdominal tunic, the subcutis, and skin are each closed separately with interrupted or continuous sutures.

Flank Approach

For the flank approach, a 10- to 15-cm incision is made through the skin and subcutis in the paralumbar fossa of the affected side with the horse standing or recumbent.[150] In a standing horse, the incision site must be anesthetized before the surgery. The external abdominal oblique muscle is transected in the direction of the skin incision, and the peritoneum is exposed by splitting the internal abdominal oblique and transversus abdominis muscles in the direction of their fibers. The peritoneum and retroperitoneal fat are perforated with a finger to enter the abdomen. The testis is located and exteriorized as described for the paramedian approach. If the testis cannot be exteriorized, an écraseur is used to transect the testicular vasculature. After the abdominal testis is removed, the internal and external abdominal oblique muscles, subcutis, and skin are each closed separately with interrupted or continuous sutures. Closing the peritoneum and transversus abdominis muscle is difficult and not necessary.

Selection of Approach

The paramedian and flank approaches allow removal of only an abdominal testis, because retraction of an inguinal testis into the abdomen can usually be accomplished only with difficulty. Abdominal testicular retention should be confirmed before either of these approaches is used, but often testicular location cannot be determined reliably. The inguinal approach allows removal of either an abdominal or an inguinal testis. Because an inguinal testis is quickly encountered using an inguinal approach, prior determination of testicular location is not necessary. If the testis is not encountered in the inguinal canal using an inguinal approach, the testis can be removed from the abdomen noninvasively through the vaginal ring or through a small parainguinal incision in the abdominal musculature.

Because the inguinal and parainguinal approaches allow removal of an abdominal testis through a finger-size abdominal perforation, surgery is rapid, and convalescence is short. The lengthy incision required for the suprapubic paramedian and flank approaches prolongs surgery and convalescence. The paramedian approach also increases the risk of postoperative evisceration or herniation. Rarely, an invasive approach is necessary to remove a large, neoplastic, abdominal testis. An abdominal testis can be removed with the horse standing using a flank approach, when general anesthesia is not practical.

Laparoscopic Technique of Cryptorchidectomy

An abdominal testis can be removed laparoscopically with the horse standing or recumbent, but fractious stallions should be anesthetized. Food should be withheld for at least 12 hours before surgery to allow the colon to empty, to decrease the risk of penetrating a viscus when instruments are introduced, and to optimize visualization of intra-abdominal structures.[151-153]

To perform laparoscopic removal of an abdominal testis with the horse standing, the horse is restrained in stocks and sedated.[151-154] The flank region is prepared for surgery, and proposed sites for inserting the laparoscope and grasping forceps are infiltrated subcutaneously and intramuscularly with a local anesthetic agent. The surgical approach is identical to the one described for laparoscopic castration.

The testis is located by inspecting the region surrounding the vaginal ring. The vaginal ring and associated structures are easier to see when the horse is standing than when it is anesthetized and recumbent, because the abdominal contents fall away from the inguinal area. The contralateral vaginal ring can be observed by manipulating the laparoscope under the descending colon, or by passing the laparoscope through a small perforation created in the mesocolon of the descending colon, or by elevating the descending colon, either with an instrument placed through an abdominal portal or with a hand per rectum.[155] The mesorchium, which contains the testicular vasculature, can be seen coursing caudally from the area of the kidney to the area of the deep inguinal ring. An abdominal testis can be observed to lie anywhere between the kidney and the vaginal ring,[140] but most commonly it is located cranioventral to the ring. The testis is attached to the tail of the epididymis by the proper ligament of the testis, and the epididymis is attached to the vaginal ring and sac by the caudal ligament of the epididymis (ligament of the tail of the epididymis).

The testis and mesorchium are desensitized by injecting a local anesthetic agent into the mesorchium or the testis, using a 30-cm-long, 18-gauge needle introduced through the flank.[153,154] Desensitizing the testis and mesorchium may not be necessary, especially if caudal epidural anesthesia, using either a combination of 2% mepivacaine (5 mL) and xylazine (0.18 mg/kg), or xylazine (0.18 mg/kg) diluted to 10 to 15 mL with physiologic saline solution, is administered before surgery.[155]

An instrument portal close to the vaginal ring is created caudal and ventral to the laparoscopic portal.[151-154] The testis is grasped and exteriorized using grasping forceps inserted through this portal. If triangulation is inadequate, a new portal for the laparoscope can be created between the last two ribs using laparoscopic control.[156] The testicular vessels and ductus deferens are ligated and cut, or crushed and transected using an emasculator, and the stump is returned to the abdomen and inspected through the laparoscope for hemorrhage. If the contralateral testis is also located abdominally, the laparoscopic procedure is repeated on the contralateral side. The abdomen is decompressed by opening the cannula. The abdominal fascia and skin are sutured.

The testicular vessels and ductus deferens of an abdominal testis can also be transected intra-abdominally, with the horse standing, before removing the testis.[155] This technique requires the use of a third portal, created close to the other portals, to introduce instruments used to occlude and transect the testicular vasculature and ductus deferens.

The scrotal testis of a unilateral cryptorchid or an inguinal testis is removed through a scrotal incision, or its ductus deferens and vasculature can be ligated and severed intra-abdominally, which causes the testis to atrophy in the scrotum or inguinal canal.[140] Palpable but nonfunctional remnants of the testis may be detectable in the scrotum several months after the testis is destroyed by ligation of the testicular artery and vein. A scrotal testis of a juvenile stallion or an inguinal testis can be retracted into the abdomen for intra-abdominal transection of the ductus deferens and testicular vessels. The testis is retracted into the abdomen by placing traction on the mesorchium, after enlarging the

vaginal ring with scissors. Retracting the testis into the abdomen inverts the vaginal tunic into the abdomen and the exposed ligament of the tail of the epididymis, which attaches the vaginal tunic to the tail of the epididymis, is severed. The incision in the vaginal ring can be closed with staples or left open.[140,157]

To perform laparoscopic removal of an abdominal testis with the horse anesthetized, the horse is positioned in dorsal recumbency.[151-153,157] After preparing the ventral aspect of the abdomen for aseptic surgery, a stab incision is made through the umbilicus, and through this incision the abdomen is insufflated to 10 to 15 mm Hg as described earlier. A laparoscopic sleeve with a guarded trocar is inserted through the incision into the abdominal cavity. The trocar is removed and replaced with a laparoscope. The horse is tipped into Trendelenburg position (i.e., head down approximately 30 degrees) to displace the viscera cranially,[151-153,157] and the laparoscope is directed caudally to view the inguinal areas. Because the hindquarters are elevated, positive-pressure ventilation is necessary. If the testis is not readily visible, it can be located by following the ductus deferens cranially over the lateral ligament of the bladder to the inguinal ring. Traction on the ductus deferens elevates the testis into view.

The testis can be removed prior to occluding and transecting the testicular vessels and ductus deferens,[151-153] or the testicular vessels and ductus deferens can be occluded and transected intra-abdominally before the testis is removed.[151-153,157] If the testis is to be exteriorized prior to transecting the testicular vessels and ductus deferens, the instrument portal is created 4 cm cranial and axial to the superficial inguinal ring, on the side of testicular retention. The testis is exteriorized using a grasping forceps introduced into the abdomen through this incision.[151-153] The exteriorized testicular vessels and ductus deferens are ligated and cut, or crushed and transected using an emasculator, and the stump is returned to the abdomen. Both testes of a horse with bilateral, abdominal, testicular retention can be viewed from one portal, but a portal must be created cranial and axial to each inguinal ring to remove each testis. The abdomen is deflated through the laparoscopic cannula, and the portals are closed by suturing the external lamina of the rectus abdominis muscle, the subcutaneous tissue, and skin.

To occlude and transect the testicular vessels and ductus deferens intra-abdominally with the horse anesthetized and positioned in dorsal recumbency, a grasping forceps for manipulating the testis is introduced through a cannula inserted 8 to 10 cm axial and cranial to the superficial inguinal ring.[157] A third instrument portal is created at the cranial, abaxial edge of the sheath to introduce instruments used to occlude and transect the testicular vasculature and ductus deferens. The testicular vessels and ductus deferens can be occluded using an endoscopic clip or an endoscopic ligating loop and transected using an endoscopic scissor or monopolar or bipolar electrocoagulation or a harmonic scalpel, or they can be occluded and transected using an endo-GIA stapler (Endo-GIA 30, United States Surgical Co., Norwalk, Ct).[157] Severing the mesorchium and ductus deferens with monopolar or bipolar electrocoagulation alone provides adequate control of hemostasis.[158] The risk of accidental thermal injury to adjacent viscera is far greater when using monopolar electrocoagulation than when using bipolar electrocoagulation. The testis is removed from the abdomen by expanding the skin incision over the portal through which the grasping forceps was introduced. Placing the testis in a retrieval bag facilitates exteriorization of the testis and eliminates the risk of dropping it into the abdomen.[158]

An advantage of intra-abdominal transection over extra-abdominal transection is that with intra-abdominal transection, the severed stump of the vasculature can be inspected before the testis is removed from the abdomen. Exteriorizing a testis causes loss of insufflation, which impairs visibility. A hemorrhaging stump is more easily noted and ligated when the abdomen is still inflated. Insufflation of the abdomen can be preserved during bilateral cryptorchidectomy by occluding and transecting the ductus deferens and vessels of each testis before either testis is removed from the abdomen.

Laparoscopic cryptorchidectomy simplifies locating the cryptorchid testis, avoids disruption of the vaginal ring, which minimizes the likelihood of evisceration, and permits early return to exercise because the incisions are small.[151-153,159] Laparoscopy may be particularly useful in evaluating a horse that displays stallion-like behavior but has the appearance of a gelding, especially when the presence or absence of testicular tissue cannot be determined conclusively by hormonal assay.[152] Laparoscopy is also useful for removing an abdominal testis when the side of the testicular retention is not known.

A disadvantage of laparoscopic cryptorchidectomy is the expense of the equipment.[151-153] A viscus, a large vessel, or the spleen can be penetrated inadvertently if the instruments are not inserted carefully into the abdomen.[160,161] Improper use of electrosurgical coagulation during the procedure may also result in perforation of a viscus.[157] If the procedure is performed with the horse anesthetized, the hindquarters must be elevated to displace the viscera cranially, making positive-pressure ventilation necessary. Familiarity with laparoscopic equipment and experience in laparoscopic techniques are required.

Repair of Inguinal Hernias and Ruptures

Nonsurgical Management

The majority of inguinal hernias are congenital, cause no distress, and spontaneously reduce by the time the foal is 3 to 6 months old.[52,162] Repeated manual reduction may encourage spontaneous reduction, and applying a truss after manually reducing the hernia may speed resolution.[75] To apply a truss, the foal is sedated and positioned in dorsal recumbency. The hernia is reduced, and the superficial inguinal ring is packed with rolled cotton. The cotton is maintained within the ring with elastic gauze and tape wrapped over the back and over both inguinal rings in a figure-eight (Fig. 65-23). The bandage can be left in place for up to a week. Surgical reduction of a congenital inguinal hernia is not necessary unless contents of the hernia become incarcerated or unless the hernia fails to regress.

Horses with an acquired inguinal hernia or an inguinal rupture usually require immediate treatment, because the intestine that has escaped through the vaginal ring or hole in the peritoneum is likely to become strangulated. Nonsurgical reduction of inguinal hernias by external