CHAPTER 66

Penis and Prepuce

James Schumacher

ANATOMY AND PHYSIOLOGY

Penis

The penis is the male organ of copulation and is composed of erectile tissue that encases the extrapelvic portion of the urethra[1-4] (Fig. 66-1). The penis of the horse is musculocavernous and can be divided into three parts: the root, the body or shaft, and the glans penis. The penis originates caudally at the root, which is fixed to the lateral aspects of the ischial arch by two crura (leg-like parts) that converge to form the shaft of the penis. The shaft constitutes the major portion of the penis and begins at the junction of the crura. It is attached caudally to the symphysis ischii of the pelvis by two short suspensory ligaments that merge with the origin of the gracilis muscles (Fig. 66-2). The glans penis is the conical enlargement that caps the shaft. The urethra passes over the ischial arch between the crura and curves cranioventrally to become incorporated within erectile tissue of the penis.

The mobile shaft and glans penis extend cranioventrally to the umbilical region of the abdominal wall.[3] The body is cylindrical but compressed laterally. When quiescent, the penis is soft, compressible, and about 50 cm long.[4] Fifteen to 20 cm lie free in the prepuce. When maximally erect, the penis is up to three times longer than when it is in a quiescent state.[5]

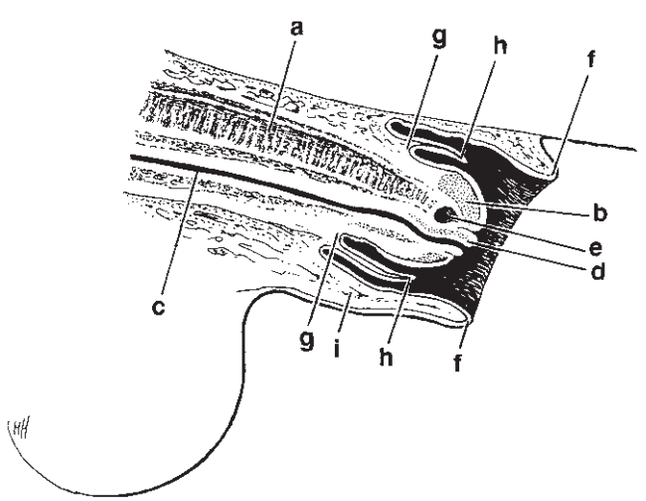

Figure 66-1. The cranial end of the penis in median section in situ in the horse, medial aspect. a, corpus cavernosum penis; b, corpus spongiosum glandis; c, urethra; d, urethral process; e, fossa glandis; f, external preputial orifice; g, preputial cavity (internal); h, plica preputialis; i, prepuce.

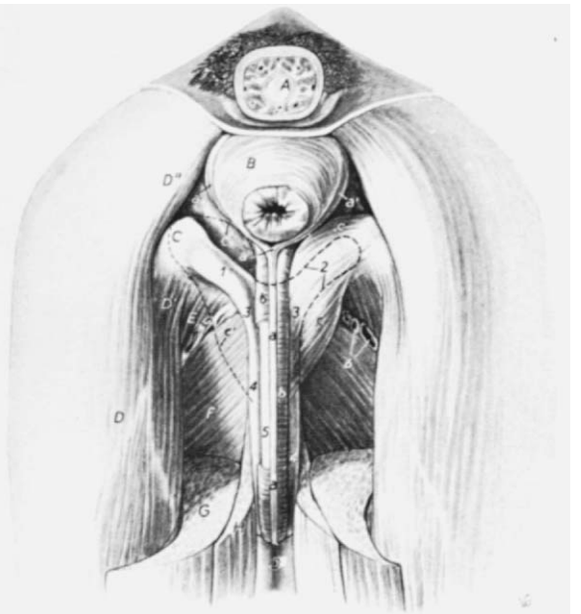

Figure 66-2. Perineum of stallion, deep dissection, caudal aspect. A, cross-section through root of tail; B, external anal sphincter; C, tuber ischiadicum; D, semitendinosus; D′, short head from tuber ischiadicum; D″, vertebral head; E, obturator externus; F, adductor; G, ventral stump of semimembranosus (the dorsal part of the muscle has been removed); H, gracilis; J, caudal wall of scrotum; a, penile part of retractor penis; a′, a″, rectal part of retractor penis; b, bulbospongiosus, partly removed on the left side to expose the urethra; c, right ischiocavernosus, covering right crus penis *(broken line);* c′, outline of left ischiocavernosus, which has been removed to expose left crus penis; 1, left crus penis; 2, outline of right crus penis under cover of ischiocavernosus; 3, union of crura penis; 4, corpus cavernosum penis; 5, urethra, surrounded by corpus spongiosum; 6, muscular branches of obturator vessels. (From Nickel R, Schummer A, Seiferle E, Sack WO: The Viscera of the Domestic Mammals, Oxford, UK, 1973, Blackwell.)

Erectile Bodies

Two cavernous spaces make up the majority of the penile shaft: the dorsally located corpus cavernosum penis (CCP), which is responsible for erection, and the ventrally located corpus spongiosum penis (CSP), formerly termed the corpus cavernosum urethrae[3,4] (Fig. 66-3). The CCP originates below the ischial arch at the union of the crura, which attach to the ischial arch, and makes up the bulk of the shaft.[2,3] It ends distally in one long central and two blunt ventrolateral projections[3] (Fig. 66-4). Along the ventral surface of the CCP runs the urethral groove or urethral sulcus.

The CSP lies in the urethral groove of the CCP and surrounds the urethra[2-4] (see Fig. 66-3). The bulb of the penis is the proximal enlargement of the CSP. At its distal termination, the CSP expands into the glans penis, which caps the central projection of the CCP (see Fig. 66-4). The tunica albuginea of the glans is thinner than that of the rest of the penis, making it softer in the erect state than the CCP.[5] A long dorsal process of the glans penis extends 10 cm proximally on the dorsum of the CCP. The circular edge of the glans penis is termed the corona glandis, and the collum glandis represents the constriction behind it. The convex, cranial surface of the glans contains a deep

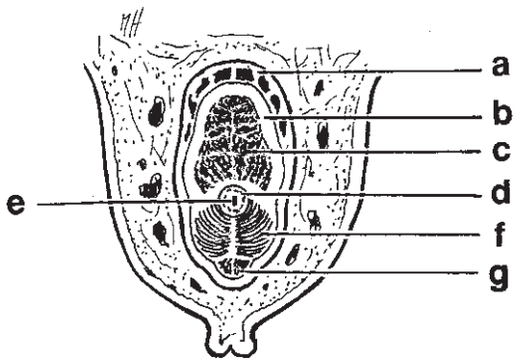

Figure 66-3. Cross-section of the penis. a, dorsal veins of penis; b, tunica albuginea; c, corpus cavernosum penis with dividing trabeculae; d, corpus spongiosum; e, urethra; f, bulbospongiosus; g, retractor penis muscle.

depression, the fossa glandis, into which the urethra protrudes 1.5 to 3.0 cm as a free tube surrounded only by thin integument[1,3,4,6] (Fig. 66-5). This tubular protrusion of the urethra is termed the urethral process. A dorsal diverticulum of the fossa glandis, the urethral sinus, is often filled with smegma, a caseous mass of sebaceous matter and epithelial debris. A collection of hardened smegma in the urethral sinus is termed a bean. Large beans have been purported to interfere with urination. Two ventrolateral recesses also project from the fossa glandis.[4] The fossa glandis and its recesses can harbor bacteria capable of producing venereal disease.[7]

The erectile bodies are surrounded by the thick, fibroelastic tunica albuginea, which sends fibrous trabeculae inward to form the supporting framework of the cavernous spaces.[1,2,6] The CSP has thinner trabeculae with larger,

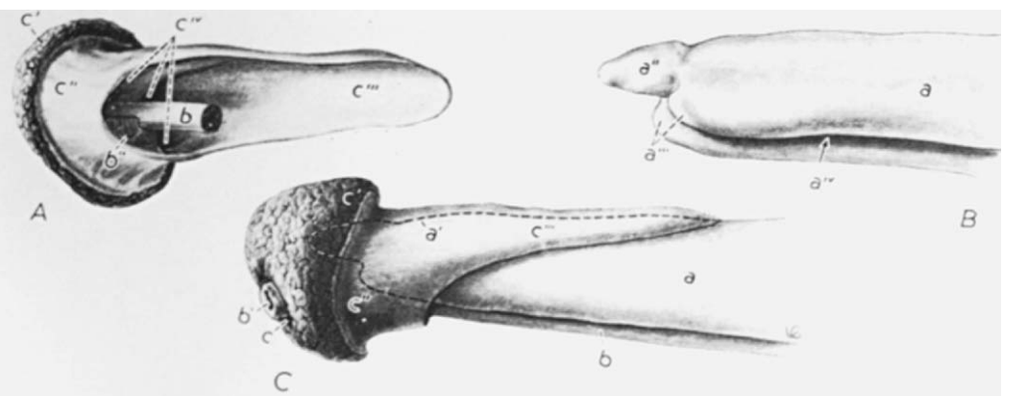

Figure 66-4. Distal end of the penis of the horse. A, caudoventral aspect of the glans, and of the terminal part of the urethra with corpus spongiosum; B, ventrolateral aspect of corpus cavernosum; C, lateral aspect of tip of the penis (the skin of the penis has been removed proximal to the corona glandis); a, a′, corpus cavernosum; a″, dorsomedian process of corpus cavernosum; a‴, ventrolateral processes of corpus cavernosum; a^{iv}, urethral groove; b, urethra, surrounded by corpus spongiosum; b′, urethral process and external urethral orifice; b″, stump of bulbospongiosus; c, fossa glandis; c′, corona glandis; c″, collum glandis; c‴, dorsal process of glans; c^{iv}, recesses on the interior of the glans for the three processes (a″, a‴) of the corpus cavernosum. (From Nickel R, Schummer A, Seiferle E, Sack WO: The Viscera of the Domestic Mammals, Oxford, UK, 1973, Blackwell.)

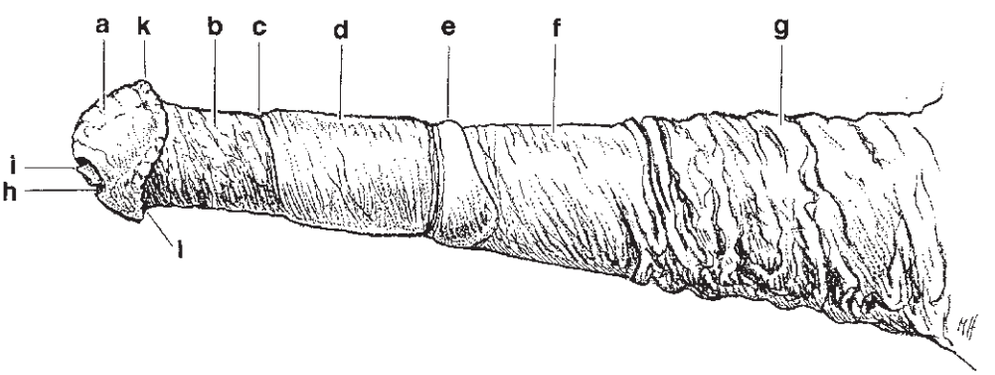

Figure 66-5. Extended penis of a stallion (protruded from the prepuce), left lateral aspect. a, glans penis; b, free part of the penis; c, attachment of the inner lamina of the preputial fold to penis; d, inner lamina of the preputial fold; e, preputial ring; f, outer lamina of the preputial fold; g, internal lamina of the external fold of the prepuce; h, fossa glandis; i, urethral process; k, corona glandis; l, collum glandis.

veinlike cavernous spaces than seen in the CCP. The tunica albuginea of the CSP is thin and elastic and merges distally with the integument of the glans.[4] The cavernous spaces are lined with endothelial cells and longitudinally oriented bundles of smooth muscle. Tonus of these muscular trabeculae and the retractor penis muscles maintains the nonerect penis within the prepuce. Decrease in tonus, as during micturition, causes the nonerect penis to protrude from the prepuce.

Mechanism of Erection

Penile erection is a neurovascular phenomenon, and the primary hemodynamic event leading to erection is increased arterial flow to the cavernous spaces.[4] Sexual excitement stimulates parasympathetic outflow from the sacral portion of the spinal cord and results in dilation and straightening of the helicine arteries (coiled branches of the deep artery of the penis) and relaxation of the sinusoidal smooth muscles, enabling blood to pass into the sinusoidal spaces.[4,8] Engorgement of the cavernous spaces, which is controlled and finally stopped by the unyielding tunica albuginea and trabeculae, lengthens and stiffens the penis.

Obstruction of venous return from the CCP appears to be important during erection in the stallion.[9,10] Circulation to and from the CCP passes between the ischium and the ischiocavernosus muscles. Contraction of the ischiocavernosus muscles from stimulation of the pudendal nerves occludes arterial and venous flow against the ischium, making the CCP a closed system during peak erection. Compression of the crura by the ischiocavernosus muscles forces blood into the CCP to produce high pressures. In one study, the mean pressure within the quiescent CCP measured 13 mm Hg, but it rose to 107 mm Hg during sexual arousal, and finally to 6530 mm Hg during coitus.[10] Anesthesia of the ischiocavernosus muscles caused diminution of erection by reducing the peak pressure in the CCP to a value close to that of the systemic blood pressure.

During coitus, increased arterial blood flow into the CSP and contraction of the bulbospongiosus muscles lead to increased pressure within the CSP and considerable distention of the glans penis.[11] The glans penis is greatly distensible and may become so large before coitus that the stallion is unable to accomplish intromission. In one study, mean pressure within the CSP was 17 mm Hg during the quiescent state, 76 mm Hg on arousal, and finally, 994 mm Hg during coitus.[11] Contractions of the bulbospongiosus muscles were likely responsible for the high pressure, because anesthesia of these muscles greatly reduced pressure in the CSP during coitus. The CSP remains an open system during erection because vessels entering the bulb of the penis do not pass between an osseous structure and the bulbospongiosus muscles.[11] Blood passes down the CSP to the glans penis and out through the dorsal veins.

Detumescence occurs after ejaculation because parasympathetic impulses diminish, and because sympathetic impulses that facilitate emission of semen also cause the helicine arteries to return to their coiled state, thus restricting inflow of arterial blood. Sympathetic impulses also decrease venous compression and allow emissary veins to open, thereby increasing venous outflow.[4,8,12,13]

Muscles

The short, paired, ischiocavernosus muscles that arise from the tuber ischii and the adjacent part of the sacrotuberous ligament attach to the crura and adjacent parts of the body of the penis[3,4] (see Fig. 66-2). Contraction of these muscles elevates the erect penis, bringing it into position for intromission. By compressing the penis against the ischium, the ischiocavernosus muscles assist in producing and maintaining erection by impeding venous return from the CCP.

The urethralis muscle surrounds the pelvic urethra and the bulbourethral glands and, by its contractions, forces release of seminal fluid during ejaculation as well as emptying of the last of the urine during urination.[3] The bulbospongiosus muscle, formerly termed the bulbocavernosus muscle, covers the CSP ventrally and extends nearly the entire length of the penis[4] (see Fig. 66-2). It originates near the bulbourethral glands, where it is continuous with the urethralis muscle, and ends at the free part of the penis near the glans penis. It sends transversely directed fibers from the edges of the urethral groove to meet at a median septum. Rhythmic contractions of the bulbospongiosus muscle during ejaculation force blood from the bulb, causing a pressure wave to be sent down the CSP to forcefully expel semen from the urethra.[3,11]

The ischiourethral muscles extend from the ventral surface of the ischium and crura, pass around the ischial arch into the pelvic cavity, and end at the ventral layer of the urethralis muscle.[3,4] They may assist erection by compressing the dorsal veins of the penis. The paired, longitudinal retractor penis muscles arise on the ventral surface of the first few coccygeal vertebrae and pass ventrally on each side of the rectum to form a loop beneath the terminal end of the rectum and anus[3,4] (see Fig. 66-2). From the loop, the muscles pass distally along the bulbospongiosus muscle and end at the glans penis. They retract the penis into the prepuce after erection or protrusion.

Blood Vessels, Nerves, and Lymphatics

Arteries supplying the penis include the terminal branches of the internal pudendal, obturator, and external pudendal arteries.[1-3] The external pudendal artery supplies the cranial artery of the penis, a major source of blood for erectile tissue.[2] It supplies a branch to the scrotum and continues as the caudal superficial epigastric artery, which provides branches to the prepuce.[2,4] The deep arteries of the penis originate from the obturator arteries and supply the CCP.[9] The internal pudendal artery supplies the pelvic portion of the urethra and terminates in the CSP as the artery of the bulb of the penis, which supplies the CSP.[2,4] Blood flows from the penis through a venous plexus on the dorsum and sides of the penis.[2,3] The venous plexus is emptied by the external pudendal and obturator veins; blood is carried from the root by the internal pudendal veins.[3]

Nervous supply to the penis is primarily via the pudendal nerves and the pelvic plexus of the sympathetic nervous system.[3] The pudendal nerves branch into the dorsal nerves of the penis, and the sympathetic fibers supply the smooth muscle of the vessels and the erectile tissue. The deep perineal and caudal rectal nerves supply the bulbospongiosus,

ischiocavernosus, and retractor penis muscles.[4] Efferent lymphatics of the penis carry lymph to the superficial and deep inguinal lymph nodes.

Accessory Genital Glands

The accessory genital glands of the horse are the paired seminal vesicles, the prostate, the paired bulbourethral glands, and the paired ampullae of the ductus deferens[3,4,14] (Fig. 66-6). The accessory genital glands are fully developed in the sexually mature stallion but resume their juvenile size in the gelding.[5] The ducts of these glands empty into the pelvic urethra and provide the major portion of the ejaculate and serve to transport, nourish, and buffer spermatozoa.[8]

The distal 10 to 15 cm of each deferent duct widens to form an ampulla, the wall of which is thickened with secretory glands.[5,15] Each ampulla is evident as an enlargement near the midline of the pelvic floor. The seminal vesicles are two hollow, pear-shaped glands that lie on the dorsal surface of the neck of the bladder lateral to the ampullae.[3,4] They are often difficult to palpate per rectum, but identification can be enhanced if the stallion is sexually aroused prior to palpation.[14] Each vesicle of the stallion is 10 to 15 cm long and 3 to 6 cm wide, but those of geldings are much smaller. The seminal vesicles narrow as they converge toward the midline, and each forms a single excretory duct, which travels beneath the prostate and opens together with or beside the ipsilateral ampulla on the colliculus seminalis. The combined terminal portion of the ampulla and excretory duct of the seminal vesicle is termed the ejaculatory duct. The seminal vesicles are true glandular structures and not just reservoirs for the storage of spermatozoa, as was once thought.[8] The secretions of the seminal vesicles are viscous and contribute the major portion of the volume of ejaculate.[3,4,8] Secretions from the seminal vesicles are the last to enter the urethra.[5] Seminal vesiculitis, a rare but important problem in stallions, may be associated with infertility. Surgical removal of chronically infected vesicles has been described.[16]

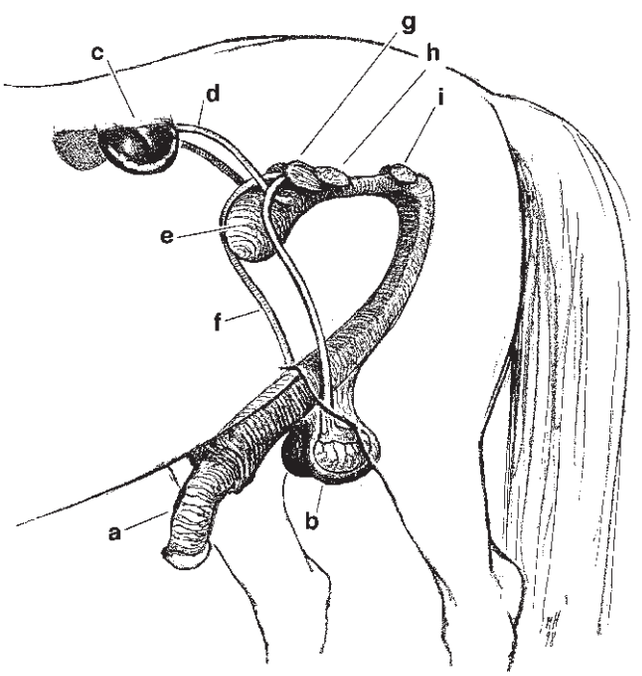

Figure 66-6. Graphic representation of the urogenital tract of the stallion. a, penis; b, testes; c, kidneys; d, ureters; e, urinary bladder; f, ductus deferens; g, seminal vesicles; h, prostate gland; i, bulbourethral glands.

The prostate is a nodular, bilobed gland that lies dorsal to the neck of the bladder.[3,4] The prostate of a stallion can, with some difficulty, be palpated per rectum, especially if the horse is sexually aroused. Each lobe is 5 to 9 cm long, 3 to 6 cm wide, and about 1 cm thick; the lobes are connected across the midline by a 3-cm-long isthmus. Prostatic secretion from each lobe is carried through 15 to 20 prostatic ducts, which open into the urethra through small, slit-like openings located lateral to the colliculus seminalis. The prostate produces a watery, alkaline secretion that neutralizes the acidity of fluid entering the urethra from the ductus deferens.[8]

The two bulbourethral (or Cowper's) glands are situated on the dorsolateral surface of the urethra at the ischial arch, 2 to 3 cm caudal to the prostate.[1-5] Each is covered by a bulboglandularis muscle. The bulbourethral glands of the stallion are 4 to 5 cm long and 2.5 cm wide and are difficult to palpate per rectum. Six to eight excretory ducts from each gland open in two longitudinal rows of small papillae on the dorsal surface of the pelvic urethra caudal to the openings of the prostatic ducts. The bulbourethral glands produce an alkaline, mucinous secretion that clears the urethra of urine prior to ejaculation and lubricates the urethra for the passage of seminal fluid.[8]

Prepuce

The prepuce, or sheath, is a voluminous, folded "sleeve" of integument covering the mobile portion of the quiescent penis.[3] The prepuce consists of the haired external lamina, which is continuous with the skin of the abdominal wall, and an internal lamina, which is in contact with the penis[3,4,6] (see Fig. 66-5). The external lamina extends cranially from the scrotum to within 5 to 8 cm of the umbilicus and is continuous with the internal lamina at the opening of the prepuce, the preputial orifice[3] (see Fig. 66-1). Close to the cranial extent of the external lamina are two rudimentary teats. The preputial raphe, a cranial continuation of the scrotal raphe, divides the external lamina sagittally on its ventral midline. The prepuce is supported by an elastic suspensory ligament that lies within the external lamina and is derived from the abdominal tunic.[17] When the horse trots or canters, movement of the penis within the prepuce often creates a sucking noise.

The prepuce of the horse differs from that of other species in that it is formed by a double fold of preputial skin, one inside the other.[2-4,6] When the penis is retracted, the internal lamina doubles on itself to form a cylindrical internal fold, the plica preputialis or preputial fold. The preputial cavity is thus divided into external and internal cavities, of which the external is the more spacious.[4] The opening of the plica preputialis is termed the preputial ring. When the plica preputialis unfolds during erection, the preputial ring can be recognized as a thickened band on the extended penis.[1,2]

The penis is not free in the preputial cavity at birth, because epithelium of the internal lamina of the prepuce and epithelium of the free part of the penis are fused into a

single lamina. The lamina is split into external and internal laminae by a cytolytic process that forms vesicles that coalesce to form the preputial cavity.[18,19] Separation of the internal and external laminae occurs in the first month after birth and is controlled by androgens.

DIAGNOSTIC PROCEDURES

History

Most preputial and penile abnormalities are easily diagnosed from the horse's history and during physical examination, and further studies are not required. History pertaining to problems of the penis and prepuce may include such information as copulatory performance, drug therapy, behavioral changes, conception rates, duration of disability, and previous injuries, illnesses, or urogenital surgery.

Clinical Examination

Urination

Physical examination of a horse with a penile or preputial disorder should include observation of urination. The horse can sometimes be stimulated to urinate by placing it in a freshly bedded stall; shaking the bedding while whistling may increase the horse's urge to urinate. If this technique fails, intravenously administered furosemide generally results in urination within 15 minutes. If the horse makes painful and unsuccessful attempts to urinate, urethral obstruction should be suspected, and the bladder should be palpated per rectum. If the bladder is distended, it should be catheterized to relieve its distention and to determine the location of urethral obstruction. A large accumulation of hardened smegma within the fossa glandis can produce stranguria by distorting the urethral process, but this accumulation is readily identified and easily removed.

Erection and Ejaculation

A breeding stallion that is experiencing difficulty with erection or ejaculation should be observed servicing a mare. Inability of a sexually excited stallion to achieve erection could be caused by a vascular shunt from the CCP to a vessel outside the tunica albuginea, or by fibrosis of cavernous tissue from an unresolved episode of priapism. Shunts between the CCP and one or more dorsal veins of the penis could result from a congenital anomaly or from laceration or rupture of the tunica albuginea. Damage to the CCP caused by priapism (persistent erection without sexual excitement) can be assessed by palpating the cavernous tissue. Fibrous, noncompliant cavernous tissue indicates that the CCP has been permanently damaged. A stallion that is reluctant to ejaculate or displays pain during ejaculation may suffer from urethritis or seminal vesiculitis. If so, semen should be examined for the presence of blood, and the urethra should be endoscopically inspected for evidence of seminal vesiculitis or a urethral abnormality.

Palpation

The penis can be palpated as it lies retracted in the prepuce by inserting a gloved and lubricated hand through the preputial orifice and preputial ring. This may be the only method of physically evaluating the penis and internal preputial lamina of a horse with phimosis (an inability to protrude the penis from the prepuce because of a stricture of the preputial orifice or preputial ring). The external and internal preputial cavities, preputial ring, and free part of the penis, including the urethral sinus and process, can be evaluated by palpation. Beans within the urethral sinus can usually be palpated by compressing the tip of the penis. Dense, brown-black, greasy smegma is normally encountered at the preputial fornix.

Visual Inspection

To ascertain the exact nature and extent of penile or preputial abnormalities, visual inspection of the horse's penis and internal preputial lamina is usually necessary. The stallion's penis can be protruded by administering xylazine HCl or preferably by stimulating sexual arousal. Administration of phenothiazine-derivative tranquilizers to stallions should be avoided because of association of these tranquilizers with penile paralysis and priapism. The gelding's penis can be protruded by administering a tranquilizer or sedative or by placing a loop of gauze behind the corona glandis and with steady traction overcoming the pull of the retractor penis muscles. Producing penile protrusion by chemical means is preferable to pulling the penis from the prepuce, because traction on the penis is resented by the horse and could damage the penis.

The penis can be desensitized and extruded by anesthetizing the pudendal nerves at the level of the ischial arch.[2,20] The point of injection is 2 cm dorsal to the ischial arch and an equal distance lateral to the anus. The needle is inserted at an angle until its point contacts the ischial arch on the midline where the pudendal nerves course around the ischium. The penis usually protrudes within 5 minutes after deposition of 3 to 5 mL of a local anesthetic agent adjacent to each nerve. Unless prolonged penile desensitization is required, a short-acting local anesthetic, such as lidocaine HCl, should be used to avoid prolonged penile protrusion. Desensitization and extrusion of the penis and internal lamina of the prepuce by anesthetizing the right and left pudendal nerves where they are embedded in the sacrotuberous ligament is described, but this pudendal nerve block is difficult.[21]

The urethral process and fossa glandis should be inspected for lesions of cutaneous habronemiasis. With the penis extended, the entire internal preputial lamina is visible and can be evaluated for wounds, scars, hematomas, neoplasia, and granulomas. Penile and preputial wounds should be closely examined to determine if they penetrate the tunica albuginea or invade the urethra. Leakage of urine from a traumatized area may be noted, especially when the horse urinates. A hematoma should be differentiated from an abscess. Physical findings of hematoma include penile swelling and ecchymosis, particularly noticeable in nonpigmented areas. Aspiration of a hematoma confirms the diagnosis. Examination of a horse with paraphimosis (an inability to retract the protruded penis into the prepuce) should include an evaluation of penile sensory innervation, because protrusion accompanied by penile paralysis may be permanent.

If preputial or penile neoplasia is suspected, the entire external genitalia should be examined meticulously for other primary lesions, and the inguinal regions should be palpated to detect enlarged lymph nodes. Superficial inguinal lymph nodes may enlarge initially from inflammation but later from malignant infiltration. Lymph nodes adhered to overlying skin or with fistulous tracts have most likely been infiltrated by malignant emboli. Metastases to internal lymph nodes may be detected by palpation per rectum. Recognition of carcinoma of the external genitalia should lead to examination of other structures commonly affected by carcinoma, such as the third eyelids and the perineum.

Other Diagnostic Procedures

Endoscopy

Endoscopy may be useful for identifying the source of hemorrhage noted to occur during urination or ejaculation. Endoscopy of the urethra and bladder is performed with the horse standing and sedated using a sterile, 100-cm (or longer), flexible endoscope with a diameter no larger than 12 mm. The vasculature and cavernosal spaces surrounding the urethra are prominent, especially in the proximal portion of the urethra, and should not be mistakenly interpreted as inflammation. The lumen of the seminal vesicles can be examined for evidence of infection by passing the insertion tube of a small-diameter endoscope into the ducts at the colliculus seminalis.[22]

Ultrasonography

Ultrasonography can be used to assess the physical status of cavernous tissue and to identify urethral lesions, such as calculi or stenosing scars. Ultrasonographic examination of a penile hematoma may identify a rupture of the tunica albuginea. Abnormality of an accessory sex gland can sometimes be detected using transrectal ultrasonography.[14] The glands can be more readily identified if the stallion has been sexually aroused before ultrasonographic examination.

Cavernosography

Cavernosography may be useful for determining the cause of persistent impotence. Contrast medium (100 to 200 mL of iohexol, a 24% water-soluble, organic iodine radiographic contrast medium) is injected into the CCP, and serial radiographs of the penis are obtained. If shunts are present, contrast medium appears in the nutrient vessels of the penis and prepuce. If trabeculae are damaged, the sinusoidal spaces fill incompletely with contrast medium. Cavernosography also may be useful in identifying a rupture or laceration of the tunica albuginea of the CCP.

Miscellaneous Diagnostic Procedures

Urethral and ureteral catheterization may be useful for determining the source of hemorrhage observed to occur during urination or ejaculation or to obtain fluid expressed from the seminal vesicles for cytologic examination and culture.[22] Cytologic or histologic evaluation of penile and preputial lesions may be necessary to distinguish between various diseases, such as cutaneous habronemiasis and squamous cell carcinoma.

PENILE AND PREPUTIAL DISORDERS

Penile and Preputial Injuries

Etiology

Horses can lacerate their penis while jumping barriers or attempting to breed a mare over a fence, by falling on sharp objects, or during coitus from the mare's tail hairs or a loosely tied "breeding stitch." Stallion rings that are too small or improperly cleaned may cause erosions of the shaft.[23] Penile hematomas are usually caused by trauma to the erect penis and can occur when stallions are pastured with other horses or permitted to breed improperly restrained mares. Severe bending of the penile shaft during coitus or semen collection may cause tearing of a corporeal body or subfascial vessels on the surface of the penis.

Penile lacerations or erosions are usually superficial, but lacerations into the cavernous tissue and urethra have been reported.[24-28] A tear in the urethral sinus leading directly into the CSP caused severe penile hemorrhage in a stallion during coitus,[25] and improper castration of two horses caused urethral damage and necrosis of tissue at the scrotum from escape of urine.[26,27]

Hematomas usually arise from rupture of the extensive vascular plexus located subfascially on the surface of the penis,[29] but occasionally, a hematoma may originate from a torn corporeal body.[30] Rupture of the CCP is sometimes referred to as fracture of the penis. Rupture of the bulb of the penis, presumably from a blow, eventually led to the death of a stallion by causing urethral stenosis and subsequent rupture of the bladder.[31] A hematoma confined within the intact tunica albuginea of the CCP, apparently caused by a breeding accident, resulted in deviation of a stallion's penis during erection, presumably from disruption of blood flow through the cavernous structure.[32] Aspiration of the hematoma, using ultrasonographic guidance, resulted in straightening of the penis.

Pathophysiology

Unsutured preputial lacerations inevitably become infected, and migration of infection through the loose preputial connective tissue results in cellulitis and generalized swelling. If cellulitis and swelling become severe, the penis and internal lamina of the prepuce protrude through the preputial orifice. Superficial wounds, if properly treated, heal without complication, but large unattended wounds that heal by cicatrization may restrict action of the prepuce. An unsutured wound into cavernous tissue may lead to impotence caused by creation of a shunt between the cavernous tissue and the superficial penile vasculature. Although longitudinal urethral lacerations generally heal without stricture when left to heal by secondary intention, unsutured, transecting urethral lacerations usually heal with obstructing stenosis. An improperly attended urethral injury could result in a cutaneous-urethral or cavernosourethral fistula.

Rupture of superficial penile vessels or corporeal bodies causes extravasation of blood into the loose preputial fascia. Extreme preputial swelling may occur within minutes of

injury and may prevent the horse from retracting its penis into the preputial cavity. The penis may rapidly enlarge to several times its normal size. The hematoma may interfere with venous and lymphatic drainage by impinging on undamaged veins and lymphatic vessels, thus exacerbating the swelling,[23] or the hematoma may interfere with urination by impinging on the urethra.[31]

Treatment

OPEN WOUNDS

To avoid infection, fresh penile and preputial wounds should be débrided and sutured. Sutures can be either absorbable or nonabsorbable but should be soft and nonirritating. Infected wounds should be frequently cleansed with a mild antiseptic solution several times daily and covered with an antimicrobial ointment. If the urethra is completely disrupted, it should be reapposed with absorbable suture; stenting the urethral lumen with a male urinary catheter during surgery simplifies the anastomosis. Stenosis of the urethra caused by cicatrix formation after injury can sometimes be relieved by transendoscopic laser ablation.[33] Often, penile amputation is the most expedient means of treating complete urethral disruption accompanied by severe trauma of surrounding tissue, especially if the injured horse is a gelding.[28]

HEMATOMAS

Treatment of a horse with a penile hematoma should be instituted immediately after injury and aimed at decreasing hemorrhage. Compressing the penis and internal lamina of the prepuce with a pneumatic bandage or tight wrap may relieve edema and minimize hemorrhage. To compress the penis and prepuce, the horse is anesthetized, and starting at the distal end of the penis, the penis and internal lamina of the prepuce are wrapped snugly from the glans to the preputial orifice with an elastic bandage.[34] The wrapped penis and prepuce and the preputial orifice are massaged until the wrap loosens from the decrease in size of the penis and prepuce. The process is repeated until maximal decrease in size is achieved. The penis and internal lamina of the prepuce should then be supported against the abdomen or within the external prepuce to diminish hemorrhage and edema. Hydrotherapy with cold water may hasten vasoconstriction. If the hematoma continues to expand despite treatment, the area of the hematoma should be examined ultrasonographically for evidence of a rent in the tunica albuginea, or surgically explored. Failure to repair a rupture of the tunica albuginea could result in formation of a shunt between the damaged erectile body and the dorsal veins of the penis.

Aftercare

To avoid erection and more hemorrhage, a horse with a penile or preputial injury should not be subjected to sexual stimuli. Because exercise may exacerbate hemorrhage, the horse should initially be closely confined. After 5 or 6 days, when hemostasis is ensured, the horse should be lightly exercised to decrease the edema. Hot packs applied to the penis at this time stimulate vasodilatation and thus resorption of the hematoma.

Paraphimosis

Etiology

Paraphimosis, or the inability of the horse to retract its protruded penis into the prepuce, occurs most frequently from preputial edema caused by genital trauma, such as preputial laceration, penile hematoma, or castration. Paraphimosis may be a manifestation of disease characterized by extensive edema, such as dourine and purpura hemorrhagica,[23,35] or it may be caused by damage to penile innervation. Penile denervation has been associated with spinal disease, trauma, and infectious diseases, such as equine herpes virus I and rabies.[23,36] Paralysis associated with priapism and debilitation has been reported[37,38] (Fig. 66-7). Penile paralysis has followed administration of

Figure 66-7. Paraphimosis caused by severe debilitation. The preputial ring has become a constricting cuff.

phenothiazine-derivative tranquilizers, most notably propiomazine (formerly termed propiopromazine).[39,40]

Pathophysiology

Tonus of the retractor penis muscles and the smooth muscle of the cavernous spaces normally maintains the penis within the prepuce.[37] With penile or preputial injury, edema develops in loose connective tissue between the penis and the internal lamina of the prepuce, and the weight of edema causes muscular fatigue, followed by protrusion of the penis and internal preputial lamina from the preputial cavity. The relationship between debilitation and penile paralysis is obscure, but general debilitation may cause loss of muscular tonus, allowing the penis to protrude and the pudendal nerves to become contused or stretched at the ischial arch.[37,41,42] Penile paralysis occurring after administration of a phenothiazine-derivative tranquilizer may likewise be caused by mechanical damage to the pudendal nerves from prolonged penile protrusion and not from direct damage to penile innervation by the tranquilizer, as suggested by one investigator.[39] Motor innervation of the retractor penis muscles is probably supplied solely by α-adrenergic fibers, and phenothiazine-derivative tranquilizers block these α-adrenergic fibers.[1] The retractor penis muscles can, however, be transected without causing the penis to protrude. Tranquilization may also block sympathetic impulses to the smooth muscle of the cavernous tissue, allowing the sinusoidal spaces to fill with blood and the penis to drop from the preputial cavity.[36]

Prolonged protrusion itself produces edema of the penis and prepuce by impairing venous and lymphatic drainage. As the penis and internal preputial lamina swell from edema, the preputial ring becomes a constricting cuff that compounds swelling distally. After several days, fluid begins to seep diffusely through the penile and preputial epithelium. Edema increases fragility of tissues, and because the exposed penis is subjected to trauma and effects of temperature, the penile and preputial epithelia soon become extensively excoriated.

Bacterial invasion of excoriated epithelium causes inflammation of the penis and prepuce, or balanoposthitis, and bacterial migration through the loose preputial connective tissue causes cellulitis. Eventual invasion of edematous and inflamed tissue by fibroblasts results in fibrosis of the penile integument and fascia, causing permanent impairment of the normal telescoping action of the prepuce.[37] The pendulous weight of the penis may eventually damage the pudendal nerves.[40,41]

The protruded penis becomes curved with the glans penis pointing caudoventrally. Urination is usually unimpeded.[40] Paralysis is usually accompanied by loss of erectile function, but ejaculatory capability is often still preserved.[23]

Treatment

Treatment of a horse affected with paraphimosis should be directed toward controlling edema and preventing further trauma. To preserve normal venous and lymphatic drainage and to protect against injury, the penis should be retained within the external preputial lamina. The penis can be temporarily retained with sutures or towel clamps placed across either the preputial orifice or preputial ring, but these devices should not be relied on for more than several days, because they damage the prepuce. Prolonged, atraumatic support can be provided by a nylon net or hosiery suspended at the preputial orifice by a crupper and surcingle made of rubber tubing (Fig. 66-8).

If the protruded penis is too edematous to be replaced within the external preputial lamina, it should be compressed against the abdomen with a bandage until edema subsides. A pneumatic bandage or a tight bandage applied directly to the penis may also be effective in reducing edema. Applying a nonirritating, hydrophilic agent, such as glycerin, or sulfa-urea to the penis may increase the effectiveness of the compressive bandage. Massaging the penis between bandage changes is helpful for dissipating edema. Applying an antimicrobial ointment to the penis prevents epithelial maceration and infection, and a systemically administered nonsteroidal anti-inflammatory drug reduces inflammation. The horse should be lightly exercised to reduce edema.

If the relatively inelastic preputial ring prevents penile retraction or impedes venous and lymphatic drainage, a

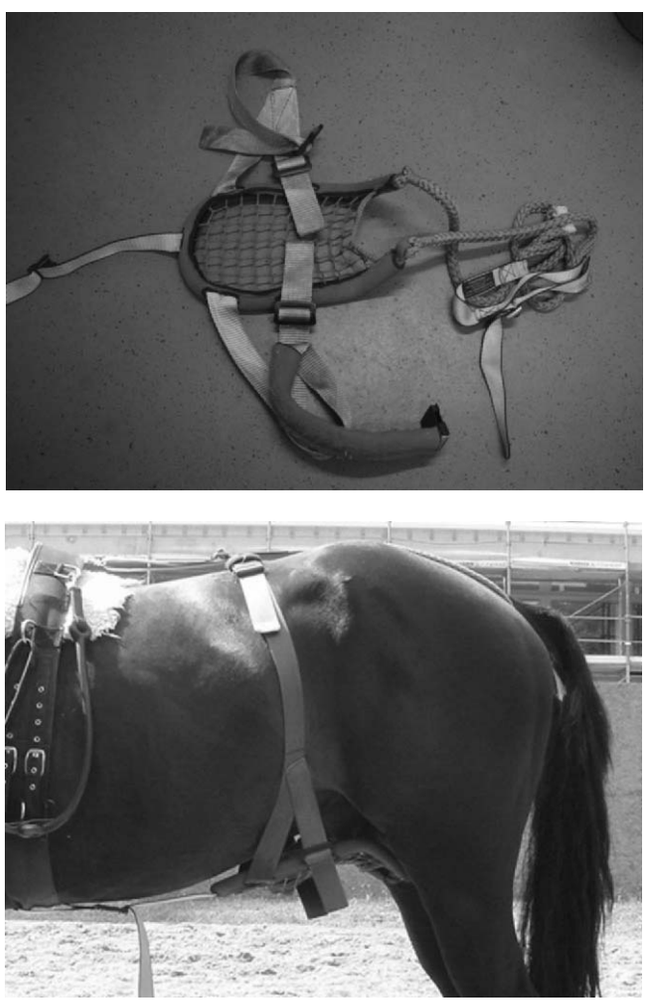

Figure 66-8. A, Suspensory device manufactured from a lightweight aluminum tube and nylon net. **B,** The device mounted on a horse. (Courtesy A. Fürst and R. Keller, University of Zurich.)

preputiotomy can be performed. The preputial ring is severed with a longitudinal incision after administration of local or general anesthesia, and the incision is allowed to heal by secondary intention.[36]

With prompt treatment, paraphimosis resulting from acute trauma usually resolves within several days. Even after initial swelling and inflammation subside, preputial cicatrization may restrict normal telescoping action of the prepuce. Excision of restrictive cicatricial tissue by segmental posthetomy (reefing) may be necessary to restore normal preputial function (see "General Surgical Procedures," p. 827). Horses with chronic paraphimosis accompanied by penile paralysis or generalized preputial fibrosis are unlikely to regain the ability to retract the penis. Stallions with penile paralysis generally retain their libido but are unable to achieve erection.[23,39] For some stallions, however, ejaculation may still be possible. Penile paralysis need not necessarily end a stallion's breeding career, if the stallion can be trained to ejaculate into an artificial vagina (provided that the horse's breed registry permits artificial insemination). The horse can be salvaged for purposes other than breeding by permanently retracting its penis into the preputial cavity or by amputating its penis (see "General Surgical Procedures," p. 827).

Phimosis

Etiology

Phimosis refers to the inability of the horse to protrude its penis from the prepuce because of a congenital or acquired stricture of the preputial orifice or preputial ring. Discounting the normal fusion of the internal lamina of the prepuce to the free part of the penis present during the first month after birth, congenital phimosis rarely, if ever, occurs in horses.

Acquired phimosis can result from tumors or cicatrizing lesions at the preputial orifice or preputial ring (Fig. 66-9) or from impairment of the normal telescoping action of the prepuce. When the horse cannot protrude its penis, urine enters the preputial cavity and produces mucosal inflammation that may eventually lead to more cicatrization and occlusion of the preputial orifice or preputial ring. An unusual cause of phimosis occurred when a gelding's penis became entrapped in a rent in the suspensory ligament of the prepuce. The ligament had apparently been torn when the horse was castrated.[17]

Figure 66-9. Phimosis in a horse caused by a cicatrix at the preputial ring.

Treatment

If phimosis is caused by constriction of the preputial orifice, a wedge of external preputial lamina based toward the preputial orifice is removed.[43] The internal and external preputial laminae are joined with a row of closely spaced, interrupted sutures. If phimosis is caused by constriction of the preputial ring, a similar wedge can be removed from the internal preputial fold, and after the penis is exposed, the constricting cicatrix can be removed by segmental posthetomy (reefing) (see "General Surgical Procedures," later). Phimosis caused by rupture of the suspensory ligament of the prepuce is corrected by suturing the torn ligament.[17]

Priapism

Priapism, or persistent erection without sexual excitement, occurs when the erect penis fails to detumesce.[44] The condition derives its name from the Greek god Priapus, symbol of fertility, but a frequent outcome of the condition in all species in which it occurs is infertility resulting from impotency.

Etiologic Factors

Etiologic factors in the development of priapism in men include hematologic diseases that cause vascular sludging, such as sickle cell anemia and leukemia; administration of antihypertensive or antidepressant drugs, especially when combined with alcohol; perineal trauma; spinal cord injury; and inflammatory disorders of the urogenital tract.[44] The cause of priapism in about half of all affected men is idiopathic.[45] Priapism of horses usually occurs after administration of a phenothiazine-derivative tranquilizer, usually acetylpromazine.[46] Phenothiazine-derivative tranquilizers may cause failure of detumescence by blocking α-adrenergic impulses that mediate detumescence.[47] Other, less commonly reported causes of priapism of horses include general anesthesia,[48] nematodiasis of the spinal cord,[49] and neoplasia of the pelvic canal.[50] Priapism occurs in both stallions and geldings, but stallions are more commonly affected, perhaps because of a direct influence of androgens on development of the condition, or perhaps because stallions develop erections more frequently.[50,51]

Pathophysiology

During normal erection, the rate of flow of blood into the CCP equals the rate of flow of blood from the structure. The precise mechanisms by which priapism occurs are unknown, but basically, priapism is a result of a disturbance of either the arterial inflow or the venous outflow to the CCP, causing the erect penis to fail to detumesce.[44] Priapism

in men is classified as being either high flow or low flow. High-flow priapism occurs when arterial blood flow to the cavernosal tissue is increased, usually as a result of a traumatically induced arteriocavernosal shunt, and venous drainage cannot compensate for this increase.[52] Low-flow priapism occurs when the neural impulses that mediate detumescence are altered or when vascular or hematologic alterations mechanically interfere with venous drainage. High-flow priapism of men almost always results from trauma to the perineum or penis.[52] Low-flow priapism occurs in men much more commonly than does high-flow priapism, and it is the only type of priapism reported to occur in horses.

Low-flow priapism, regardless of its etiology, is characterized by stasis of blood within the CCP (Fig. 66-10). Blood aspirated from the CCP of men affected with low-flow priapism has a low pH (typically, less than 7.25), a low partial pressure of O_2 (typically, less than 30 mm Hg), and a high partial pressure of CO_2 (typically, greater than 60 mm Hg).[53] High partial pressure of CO_2, caused by vascular stasis, causes erythrocytes to sickle and causes endothelial damage to the vessels and trabeculae in the CCP. The sickled erythrocytes occlude the venous outflow from the CCP, eventually irreversibly.[54] Endothelial damage and occlusion cause trabecular edema, which eventually progresses to fibrosis, thereby decreasing the size of the sinusoidal spaces in the CCP and the capacity of the CCP to expand during erection. Arterial flow to the CCP remains patent during early stages of priapism, but ultimately, it too becomes occluded permanently by clots, edema, or fibrosis.[54] Protracted erection in the horse may also damage the pudendal nerves, presumably from tension on the nerves or from compression of the nerves against the ischium, causing paralysis of the penis.[50] The end result of unresolved priapism in the horse is impotence caused by loss of both erectile function and sensitivity of the glans and shaft of the penis.

Clinical Signs

A horse suffering from priapism may not have a full erection, causing the penis to appear to be paralyzed or merely protruded rather than erect. Turgidity of the CCP can be detected when the penis is palpated, however, and the engorged penis cannot be reduced manually into the prepuce. Unless properly cared for, the penis and the internal lamina of the prepuce become edematous soon after the onset of priapism.[51] Although uncommon, dysuria may be a feature of the condition. The CCP of a horse chronically affected by priapism feels fibrous, and during ultrasonographic examination, it appears to be densely echogenic. A chronically affected horse may not respond when a noxious stimulus is applied to the distal portion of the penis or internal lamina of the prepuce.[50]

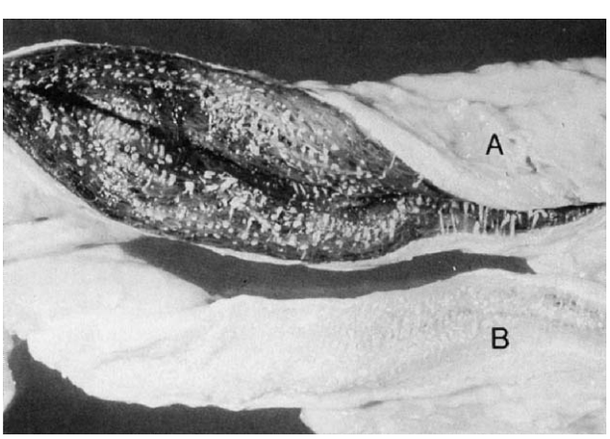

Figure 66-10. A, Longitudinal section of corpus cavernosum penis (CCP) of a stallion with longstanding priapism. The CCP is hemorrhagic and edematous. B, Longitudinal section of the CCP of a normal gelding.

Treatment

MEDICAL

Horses with priapism have been treated by massaging the penis, by applying an emollient dressing to the penis, and by compressing the penis against the body wall with a sling.[51] These treatments, although important in preventing preputial edema and damage to the penile and preputial integument, have no effect on re-establishing normal circulation in the erectile tissue of the CCP. To re-establish normal venous drainage impaired by drugs that cause α-adrenergic blockade, such as acetylpromazine, affected horses have been treated by administration of benztropine mesylate.[44,48,55-57] Benztropine mesylate is a synthetic drug created by combining the active portions of atropine and diphenhydramine.[48] This drug is most successful in resolving priapism if treatment is initiated soon after the onset of priapism.[48,55] The effects of the drug on horses affected with priapism are attributed to its anticholinergic effects.[48] The usual dose for a horse of average size is 8 mg, administered by slow intravenous injection. Side effects seen at higher dosages could include paralytic ileus, impaction, dysuria, and muscular weakness.

Alpha-adrenergic agents, such as adrenalin and phenylephrine, are often injected into the CCP of men in the early stages of priapism to achieve detumescence by promoting contractility of cavernous and arterial smooth muscle.[12,44,53,56] Instillation of 10 mg of phenylephrine diluted in 10 mL physiologic saline solution directly into the erect CCP is sometimes effective in resolving priapism of horses, provided that treatment is initiated soon after onset of priapism.[58] Phenylephrine can be injected safely into the cavernous tissue of men every 15 minutes until detumescence occurs,[12] and the same is probably true for horses. Horses chronically affected by priapism experience only temporary detumescence after this treatment.

IRRIGATION OF THE CORPUS CAVERNOSUM PENIS

A horse that does not respond within a few hours to cholinergic blockage or to three or more intracavernosal injections of an α-adrenergic agent, such as phenylephrine, should be treated by irrigation of its CCP with heparinized, physiologic saline solution (PSS).[38] Irrigation of the CCP not only removes sickled erythrocytes, it also improves the acidotic environment within the CCP. The CCP can be irrigated with the horse standing, but the procedure is most easily accomplished with the horse anesthetized and in dorsal recumbency. After preparing the penis and perineal area for aseptic surgery, PSS containing 10 IU heparin/mL is introduced into the CCP under pressure through a large-bore needle (e.g., a

12-gauge needle) inserted into the turgid CCP just proximal to the glans penis. The PSS, along with the stagnant blood, is exited 10 to 15 cm caudal to the scrotum, either through one or two large-bore needles inserted into the CCP or through a stab incision into the CCP. The CCP is irrigated until fresh blood appears in the efflux. Failure of arterial blood to appear in the efflux after stagnant blood has been evacuated indicates that the arteriolar supply to the CCP is permanently damaged and that the horse is likely to be impotent. The stab incision in the tunica albuginea of the CCP is sutured after irrigation is complete.

CREATION OF A SHUNT

Erection recurs after irrigation if venous outflow remains occluded, provided that arteriolar inflow vessels remain patent. If erection fails to resolve after several irrigations of the CCP, blood trapped in the CCP should be removed by creating a shunt between the CCP and the corpus spongiosum penis (CSP). The CSP offers a convenient exit for blood trapped in the CCP, because in contrast to the CCP, the CSP does not act as a closed system during erection.[44,45] Shunting should be performed before the cavernous tissue or the pudendal nerves become irreversibly damaged, but the time at which damage to the cavernosal tissue becomes irreversible after the onset of priapism has not been determined for horses.

The shunt is probably best performed in the perineal region of the horse. It could be created further distally, but creating it in the perineal region allows a more thorough evacuation of the stagnant blood by irrigation and provides drainage of blood from a greater length of the CCP. Because the CSP is thickest in the perineal region, the urethra is less likely to be perforated during the procedure. To create the shunt, the horse is anesthetized and positioned in dorsal recumbency. The penis and inguinal and perineal regions are prepared for aseptic surgery, and a stallion catheter is inserted into the urethra. A 15-cm incision is created along the perineal raphe, about 4 to 8 cm caudal to the base of the scrotum to expose the penis, and the retractor penis muscle is retracted to expose the bulbospongiosus muscle, which covers the ventral aspect of the CSP. The right or left edge of the bulbospongiosus muscle is elevated from the edge of the urethral groove to expose 4 to 5 cm of the underlying tunica albuginea of the CSP. A 3-cm longitudinal incision is made through the tunica albuginea of the CCP adjacent to the CSP to expose the sinusoidal spaces of the CCP, and stagnant blood is evacuated from the cavernous spaces of the CCP through this incision using irrigation as described earlier (Fig. 66-11).

A matching 3-cm longitudinal incision through the tunica albuginea of the CSP is created adjacent to the 3-cm incision into the CCP. The urethral catheter compresses the sinusoidal spaces of the encircling CSP, so the CSP must be incised carefully to avoid extending this incision into the lumen of the urethra. Bright red blood hemorrhages from the incised CSP, and at this point in the procedure, suction is usually required to maintain visibility. The medial edge of the incision in the tunica albuginea of the CCP is sutured to the lateral edge of the incision in the tunica albuginea of the CSP with 3-0 or 2-0 absorbable suture using a simple-continuous suture pattern. To complete the shunt, the lateral edge of the incision into the CCP is sutured to the medial edge of the incision into the CSP using a simple-continuous suture pattern. The bulbospongiosus muscle is sutured to its origin on the tunica albuginea of the CCP at the edge of the urethral groove, and the subcutaneous tissue and skin are apposed. Horses appear to suffer no discomfort after the surgery, and swelling is minimal.[57] The stallion should receive no sexual stimulation for at least a month after surgery.

Complications of the cavernosal shunt in men include urethrocavernous or urethrocutaneous fistula, penile gangrene, infection, and a painful CSP during erection.[45] Men receiving a shunt for treatment for priapism may become impotent from failure to achieve or maintain pressure in the CCP required for intromission,[44,45] and this failure can be the result of damaged cavernous tissue or from the shunt itself.[45] The shunt may close as normal blood outflow in the CCP resumes, but whether closure is essential for return of potency is not known. Bulls may become impotent after developing a trauma-induced shunt between the CCP and CSP,[36,59] but a shunt created surgically between the CCP and

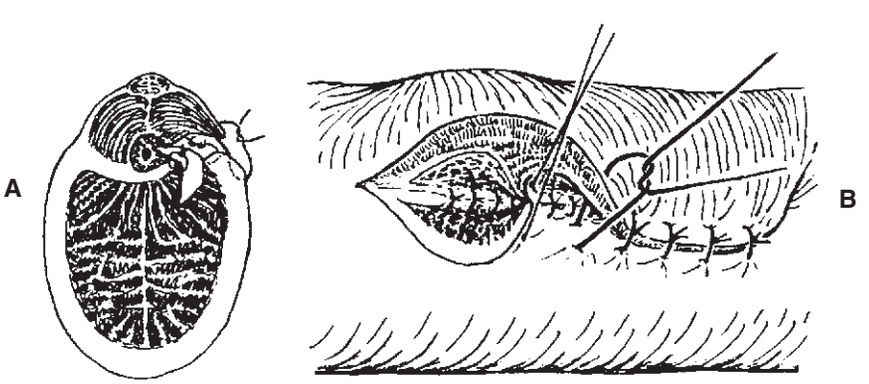

Figure 66-11. Cross-sectional view (**A**) and three-dimensional view (**B**) showing creation of a vascular shunt between the corpus cavernosum penis (CCP) and corpus spongiosum penis (CSP). 1, retractor penis muscle (not shown in B); 2, bulbospongiosus muscle; 3, CSP surrounding the urethra; CCP; 5, tunica albuginea of CSP; 6, tunica albuginea of CCP. The medial portion of the incision through the tunica albuginea of the CCP is sutured to the lateral portion of the incision through the tunica albuginea of the CSP. The medial portion of the incision through the tunica albuginea of the CSP is sutured to the lateral portion of the incision through the tunica albuginea of the CCP. The bulbospongiosus muscle is sutured to the tunica albuginea of the CCP.

the CSP of normal stallions does not seem to interfere with subsequent erection and ejaculation, even if the shunt does not close.[57] In one report, a stallion that developed penile paralysis after suffering from priapism for several days regained normal erectile and ejaculatory function within 1 year after resolution of priapism, even though the horse had received two shunts between the CCP and the CSP.[60] Failure of a stallion affected by priapism to develop a normal erection after creation of a shunt between the CCP and the CSP is most likely the result of damage to erectile tissue caused by protracted priapism, rather than by the shunt.

Erectile function in men with cavernosal tissue damaged by protracted priapism has been enhanced by injecting a vasoactive drug, such as papaverine, phenoxybenzamine, or phentolamine, into the cavernosal tissue.[44,61] Administering a vasoactive drug into the cavernous tissue may likewise be useful for enhancing erectile function of horses with damaged erectile tissue. Some stallions with damaged erectile tissue may regain the ability to achieve intromission if they are assisted in placing their penis into the vagina of the mare, and some may be trained to ejaculate into an artificial vagina. If a stallion has decreased penile sensitivity resulting from damage to the pudendal nerves caused by priapism, an antidepressive drug, imipramine, can be administered before breeding to lower the stallion's ejaculatory threshold.[62]

PHALLECTOMY

Phallectomy may be necessary if all other treatments to relieve priapism fail[51,63] (see "General Surgical Procedures," p. 829). Hemorrhage during or after phallectomy may be no worse than that expected during and after amputation of the penis of a horse not affected by priapism.

Intersex

Clinical Features

Anomalous development of the external genitalia of intersexes confuses their sexual identification. The most common intersex, the male pseudohermaphrodite, usually has a rudimentary penis, which resembles an enlarged clitoris, and prepuce, which resembles a vulva, situated on the midline somewhere between the ischial arch and the normal, ventral abdominal location of the preputial orifice (see Fig. 65-10).[43,64-66] Its testes are usually located within the abdomen or inguinal canals or hidden subcutaneously beneath a moderately developed udder (see Chapter 65). Despite its deceptive feminine appearance, the intact male pseudohermaphrodite displays masculine behavior and is even capable of achieving an erection of the rudimentary penis.

Treatment

If the genitalia are located close to the ischium, the pseudohermaphrodite's appearance can be altered to more closely resemble that of a female by amputating the rudimentary penis and constructing a vulva using the prepuce.[43] Alternatively, if the genitalia are less than 15 cm caudal to the inguinal area, the male pseudohermaphrodite's appearance can be altered to more closely resemble that of a male by cranially rotating the genitalia to a more normal position caudal to the umbilicus.[64] The horse should be castrated 4 to 6 weeks before surgery.

Neoplasia

Incidence and Etiology

The incidence of neoplasia of the external genitalia is second only to that of the skin.[67] Neoplasms of the penis and prepuce include squamous papillomas, squamous cell carcinomas, sarcoids, melanomas, mastocytomas, and hemangiomas.[68-71] Melanomas are occasionally found on the prepuce of old gray horses,[23] and squamous papillomas, the benign counterparts of squamous cell carcinoma, are often found on the external genitalia of young horses[72] or adjacent to penile or preputial carcinomas of old horses.[73] Squamous cell carcinoma is by far the most common penile and preputial neoplasm.[68,73] Genital squamous cell carcinoma may arise de novo or from malignant transformation of a squamous papilloma.[72,73] Any papillomatous lesion present on the penis or prepuce of a horse should be considered to be premalignant.

Squamous cell carcinoma is usually found on old horses, especially those of breeds with nonpigmented genitalia, such as Appaloosas and American Paint horses.[36,69,74] Lack of preputial or penile pigmentation seems to predispose to carcinoma, even though the external genitalia are not exposed to direct sunlight.[75] One study performed on mice showed that squamous cell carcinoma may be caused by unidentified carcinogenic agents in smegma,[76] but another study, also performed on mice, which used human smegma, was not able to substantiate this finding.[77] Regardless of whether smegma contains a carcinogenic agent, it may stimulate neoplastic changes in penile and preputial integument by causing chronic irritation. Geldings and old horses, therefore, may be predisposed to development of genital squamous cell carcinoma, because they produce a greater amount of smegma than do young horses and stallions.[75,76]

Squamous cell carcinoma occurs most commonly on the glans and internal lamina of the prepuce.[73,74] Penile and preputial squamous cell carcinomas are locally invasive but have a low grade of malignancy and grow surprisingly slowly for carcinomas.[69,73,74] Metastasis to the superficial and deep inguinal lymph nodes occurs late in the disease. In one study, 12% of 48 horses affected with penile or preputial squamous cell carcinoma had metastatic involvement of the inguinal lymph nodes.[73]

Diagnosis

Most affected horses are presented for examination when the owner observes the lesion, but some may be presented because of a malodorous, purulent, blood-stained, preputial discharge.[73,74] The duration of disease is usually unknown but lengthy, because most owners inspect their horse's penis infrequently.[74] Precancerous lesions may appear as a small, heavily keratinized plaque, and cancerous lesions may first appear as a shallow, flat ulceration with an indurated base.[69,74,78] Longstanding carcinomas may attain a cauliflower-like excrescence, containing areas of necrosis, ulceration, and hemorrhage, that can interfere with coitus or normal protrusion and retraction of the penis[79] (Fig. 66-12). The

Figure 66-12. Squamous cell carcinoma of the inner lamina of the preputial fold.

tumor can cause dysuria by impinging on the urethra. Most affected horses are also affected by balanoposthitis.[71,74]

Metastatic spread of penile and preputial squamous cell carcinoma can sometimes be palpated as an enlargement of the inguinal lymph nodes, but mild, metastatic enlargement of the inguinal lymph nodes may be difficult to differentiate from lymphadenopathy secondary to balanoposthitis.[73] Penile or preputial squamous cell carcinoma can metastasize to internal organs without causing gross enlargement of the inguinal lymph nodes.[80]

Treatment

A variety of treatments for horses affected with squamous cell carcinoma of the penis or prepuce have been described, including surgical excision, cryosurgery, chemotherapy, and hypothermia.

SURGICAL EXCISION

A small lesion on the prepuce can be excised and the wound sutured. Using a carbon dioxide laser to locally excise squamous cell carcinoma from the external genitalia may decrease the incidence of recurrence of the neoplasm.[81] Using a laser to excise a neoplasm not only decreases postoperative swelling by sealing lymphatic vessels but also has a thermal, killing effect on marginal tumor cells.[82] Horses with extensive neoplastic lesions of the external genitalia require preputial reefing or phallectomy (see "General Surgical Procedures," p. 827). Occasionally, neoplasms become so extensive that prescrotal urethrostomy combined with en bloc resection of the penis, prepuce, and inguinal lymph nodes becomes necessary.[83]

CRYOTHERAPY

Cryotherapy is a useful treatment of horses with early lesions of squamous cell carcinoma. Cryotherapy can be performed using liquid nitrogen administered as a spray or through a cryoprobe, or using CO_2 administered through a cryoprobe. Thermocouple needles and a pyrometer (i.e., tissue temperature indicator) are used to monitor the depth and degree of freezing. A double, fast-freeze–slow-thaw cycle gives the best results.[84] More information on cryosurgery is found in Chapter 15.

CHEMOTHERAPY

Horses with small genital lesions of squamous cell carcinoma have been treated successfully by applying 5% 5-fluorouracil to the lesions at 14-day intervals.[85] Lesions need not be debulked, provided that the lesion is raised no more than to 2 to 3 mm above the surrounding integument. Up to seven treatments may be required to effect resolution of lesions. The drug is also effective in causing regression of preneoplastic lesions to which it is applied.

Horses with squamous carcinoma of the external genitalia have been treated by intratumoral injection of cisplatin in sesame oil.[86,87] The drug is administered at a dosage of 1 mg/cm^3 tissue every 2 weeks, usually until the tumor has been injected four times. Intratumoral chemotherapy with cisplatin can be used alone for treatment of horses with small tumors or in combination with surgery for treatment of horses with large tumors. Tumor cells still present after the tumor has been excised or debulked are stimulated into active proliferation and hence are more susceptible to cisplatin. Administration of cisplatin treatments intra-operatively and at 2-week intervals appears to result in a better outcome, at least for horses with tumors that have a high proliferation index, than does delaying chemotherapy until the wound has healed.[87] Injecting the tumor bed and a margin of normal tissue with cisplatin at the time of surgery and during all phases of wound healing does not have clinically apparent detrimental effects on healing of wounds closed primarily or wounds left open to heal by secondary intention.[86,87] (For more information on skin tumor treatments, and chemotherapy in general, see Chapter 29.) Topical or intratumoral chemotherapy is impractical for treatment of horses affected with squamous cell carcinoma that has metastasized to internal organs. Horses affected with metastatic squamous cell carcinoma can be treated with a systemically administered chemotherapeutic agent, such as doxorubicin or piroxicam,[88] but little information is available on the efficacy of systemically administered chemotherapy to treat horses for neoplasia.

HYPOTHERMIA

Radiofrequency-induced hyperthermia has been used to treat horses with sarcoids and cattle and horses suffering from ocular neoplasia.[89,90] Although its use to treat horses with genital neoplasia has not been reported, radiofrequency-induced hyperthermia could be useful for treatment of horses with genital neoplasia. Intratumoral hyperthermia is induced by a radiofrequency current of 2 MHz. Using this treatment, the tumor is heated to approximately 50° C for 30 seconds. Large tumors are heated in sections. Multiple

treatments are required, but the length of the interval between treatments is determined subjectively.

Prognosis

In one study of 48 male horses with genital carcinoma, 64.5% of horses were alive 18 months after surgical therapy.[73] In another study, about 81% of 45 affected horses survived at least 1 year after surgical therapy with no evidence of recurrence of the disease.[74] Both studies found that prognosis for survival was poor if squamous cell carcinoma had metastasized to the inguinal lymph nodes.[73]

Invasion of the cavernous tissue by squamous cell carcinoma is a pejorative prognostic factor for survival in men[91] and is likely to be so in horses as well, because neoplastic invasion into a corporeal body may be more likely to result in hematogenous spread of the neoplasm. In one study, three of four horses that had metastases of penile carcinoma to the abdomen had gross or histologic evidence that the neoplasm had invaded the cavernous tissue.[74] Horses that have corporeal invasion by a carcinoma seem to have a high likelihood of abdominal metastases, and therefore, laparoscopic examination of the abdomen of a horse that has neoplastic invasion of a corporeal body may be prudent. Because lesions of squamous cell carcinoma sometimes recur, horses should be monitored periodically for recurrence of disease after apparently successful treatment.

Habronemiasis

Etiology

Cutaneous habronemiasis, also known as "summer sore" or granular dermatitis, is a granulomatous, mildly pruritic disease caused by cutaneous migration and encystment of the larvae of the equine stomach worm *Habronema*.[78,92] Larvae passed in the feces are ingested by fly maggots, and after the maggot pupates, the larvae are deposited on wounds from the feeding fly. The disease appears in spring and summer, when flies are prevalent, and usually disappears with onset of cold weather. The penis and prepuce are common sites of infestation by these larvae because moisture on these structures attracts flies. Horses that tend to extend their penis while resting and horses that receive anthelmintic drugs infrequently may be more prone to developing genital habronemiasis.[92]

Pathophysiology

Infestation stimulates an acute granulomatous reaction characterized by exuberant granulation tissue that contains numerous small, yellow, hard, caseous granules composed of eosinophils, nuclear remnants, and larvae. The larvae may excrete a substance lytic to the host's tissue,[78] but a local hypersensitivity reaction to the larvae resulting from repeated reinfestation is probably responsible for the extreme granulomatous response.[92] The presence of mature *Habronema* in the stomach may induce a state of general hypersensitivity, because horses affected by cutaneous habronemiasis are almost always heavily parasitized by adult worms. Some horses appear to be more susceptible and are plagued by yearly recurrence of lesions.

Clinical Signs

The preputial ring and urethral process are the genital sites of predilection. Preputial lesions may appear as ulcerated, red areas demarcated by edges of depigmentation.[78] Lesions may be granulomatous and extensive (Fig. 66-13). The infested urethral process may be enlarged from periurethral fibrosis, and hyperemic prolapsed mucous membrane may protrude from the urethral orifice.[93] Preputial lesions may mechanically impede the telescoping action of the preputial laminae, and lesions of the urethral process may cause partial obstruction to the flow of urine.[93] A horse with a distorted urethral process may spray itself or show signs of discomfort during urination. Erosions into the CSP may result in hemorrhage at the end of urination or ejaculation.[94] Horses with a genital lesion of cutaneous habronemiasis may have lesions of cutaneous habronemiasis elsewhere on the body.

Diagnosis

Cutaneous habronemiasis of the external genitalia is usually diagnosed by its typical appearance, but lesions can be confused with squamous cell carcinoma, exuberant granulation tissue, or phycomycosis.[92] A nonhealing, granulating wound accompanied by marked circulating eosinophilia is suggestive of the disease. Squeezing the lesion may cause granules to extrude, and occasionally a larva may be found if exudate is squeezed onto a slide and examined microscopically. Eosinophils, multinucleated giant cells, granules, and, sometimes, cross-sections of larvae can be seen by examining affected tissue histologically.[93,95]

Treatment

NONSURGICAL TREATMENT

Lesions are resolved by eliminating the larvae or by reducing the horse's hypersensitivity to them.[92] Ivermectin, administered orally at 200 µg/kg, or organophosphates administered topically, orally, or intravenously have been effective in destroying the larvae.[96] Prednisolone, administered orally at 1.5 mg/kg once a day for 10 to 14 days, or diethylcarbamazine, administered orally at 1.5 mg/kg twice a day for

Figure 66-13. Massive granuloma on the internal preputial lamina caused by cutaneous habronemiasis. This mass was removed by segmental posthetomy.

7 to 14 days, has brought about resolution of lesions by diminishing the body's response to the larvae. Daily topical application of a cream containing an organophosphate, such as trichlorfon, and a corticosteroid, such as dexamethasone, may bring about resolution of small granulomatous lesions caused by cutaneous habronemiasis.

SURGICAL TREATMENT

Elliptical or circumferential resection of fibrotic areas of the internal lamina of the prepuce caused by chronic infestation may be required to restore normal preputial function, and amputation of an affected urethral process may be required to restore normal urination or to prevent hemospermia.[93]

Hemospermia

Etiology

Hemospermia, or blood in the ejaculate, is an important cause of infertility of stallions and has been attributed to bacterial urethritis occurring usually at the area of the ejaculatory ducts; habronemiasis or neoplasia of the urethral process; improperly fitted stallion rings; seminal vesiculitis; and trauma to the urethral process or glans penis.[25,97,98] Viral urethritis has been suspected, but not proven, to cause hemospermia.[99] Hemospermia has been reported to occur from urethral rents, the etiology of which is unknown.[100] The source of voluminous hemorrhage in the ejaculate is usually the CSP. Hemorrhage from the CSP typically occurs at the end of ejaculation when contraction of the bulbospongiosus muscle causes pressure within the CSP to increase from 17 to nearly 1000 mm Hg.[11]

Red blood cells in the ejaculate are associated with reduced fertility, even though seminal quality appears otherwise unaffected, because red blood cells are spermicidal.[98] The condition may be more common in Quarter Horses,[101] and frequently bred stallions are more often affected.[98]

Diagnosis

Stallions affected by hemospermia may require several mounts to ejaculate and sometimes exhibit pain during erection or ejaculation.[101] Blood in the semen is most easily identified by collecting the stallion's ejaculate with an artificial vagina. Semen of affected horses is usually pink to red, but because blood in amounts too minute to be detected grossly can cause infertility, microscopic examination of the semen may be necessary to detect the condition.[22] Microscopic examination of semen may also reveal a large number of white blood cells if septic seminal vesiculitis is the cause of hemospermia.

Septic seminal vesiculitis, an occasional cause of hemospermia, may be detected by identifying numerous clumps of purulent material in the semen and by finding blood in the gel fraction of the ejaculate.[102] A thickened vesicle filled with echogenic fluid may be seen during transrectal ultrasonographic examination of a septic seminal vesicle. The causative organism of septic, seminal vesiculitis can be cultured from fluid obtained directly from the infected seminal vesicle.

Rents in the urethra, a common cause of hemospermia, can be detected by examining the urethra with a sterilized, flexible endoscope that is at least 100 cm long. A urethral tear into the CSP appears endoscopically as a 5- to 10-mm-long, linear defect on the convex surface of the urethra, distal to the openings of the bulbourethral glands, near the level of the ischial arch.[100] The shaft of a hypodermic needle can be introduced percutaneously into the lumen of the urethra at the level of the ischial arch during endoscopic examination to confirm the location of the defect (Fig. 66-14). By endoscopically examining the urethra of a horse affected with hemospermia immediately after ejaculation, the examiner may be able to observe blood emanating from an otherwise undetectable rent.[22]

Urethrography to diagnose urethral lesions has been described.[98,99] The penis is radiographed after injecting 180 mL of barium suspension into the urethra. The barium is allowed to drain, 180 mL of air is injected to provide double contrast, and the penis is again radiographed. Bacterial and viral cultures and biopsy and histologic examination of urethral lesions may establish the cause of urethritis.

Treatment

NONSURGICAL TREATMENT

Sexual abstinence seems to be important in the treatment of stallions affected with hemospermia, regardless of the origin, because erection and contractions of the bulbospongiosus muscle during ejaculation dilate and further traumatize the urethra.[98,101] Medical treatment of affected horses has included intravenous administration of formaldehyde solution, oral administration of methenamine, and systemic administration of antimicrobial drugs.[99]

Horses affected with hemospermia caused by septic seminal vesiculitis should receive antimicrobial therapy that is effective against the causative organism. Systemic

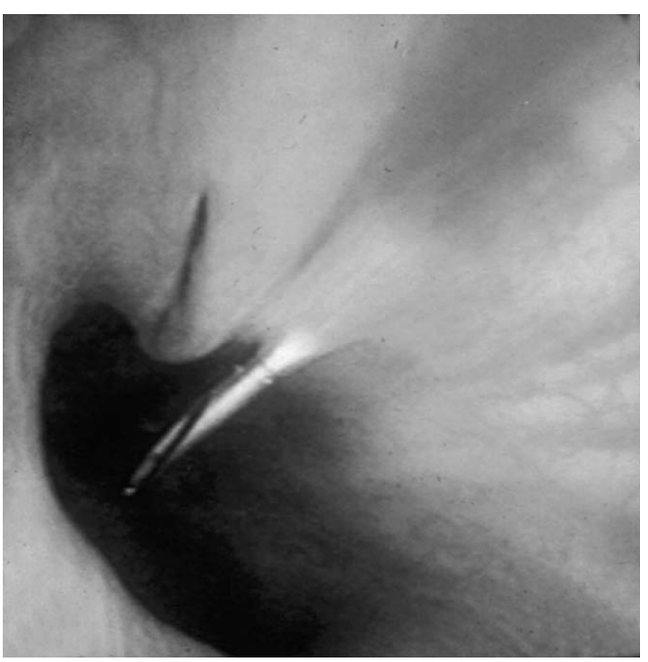

Figure 66-14. Endoscopic view of a urethral rent. The shaft of a hypodermic needle has been inserted percutaneously into the lumen of the urethra at the level of the ischium to pinpoint the location of the defect.

administration of antimicrobial drugs to stallions affected with septic seminal vesiculitis is often ineffective because antimicrobial drugs diffuse poorly into the gland. Infusing the appropriate antimicrobial drug directly into the seminal vesicles after the vesicles have been lavaged may be a more effective treatment.[102] Horses with low-grade hemospermia can sometimes be managed by adding an extender to the semen to dilute the effect of the red blood cells on the spermatozoa.[97,103]

SURGICAL TREATMENT

Temporary perineal urethrostomy combined with sexual rest has been effective in eliminating hemospermia caused by a urethral lesion.[99-101] Eleven of 15 affected horses were successfully treated by temporary subischial urethrostomy and daily installation of suppositories of nitrofurazone and hydrocortisone into the urethra, although two stallions developed a urethral fistula.[101] These investigators offered no sound rationale for the relatively high incidence of success of temporary urethrostomy, but other investigators implied that topical application of antimicrobial drugs to lesions of bacterial urethritis is responsible for resolution of hemospermia.[98] More likely, success of temporary subischial urethrostomy in eliminating hemospermia should be attributed to decreased pressure in the CSP and diversion of blood flow from the urethral lesion. When the bladder has been emptied, the bulbospongiosus muscle contracts to expel urine that remains in the urethra. Incising the CSP at the ischium decreases cavernosal pressure at the end of urination and diverts blood flow from the urethral lesion to the temporary urethrostomy, thus permitting healing of the urethral mucosa and underlying tunica albuginea of the CSP. Simply incising the convex surface of the tunica albuginea of the CSP at the ischium, without exposing the lumen of the urethra, may be as effective as temporary urethrostomy for eliminating hemospermia, and the risk of the stallion's developing a urethral fistula is eliminated. This theory, however, has not been clinically evaluated.

Hematuria

Etiology

Hematuria can originate from the kidney, ureter, bladder, urethra, or reproductive organs.[94,97] Causes of hematuria include renal, ureteral, vesicular, or urethral calculi; renal, and vesicular neoplasia; and pyelonephritis. Terminal hematuria (i.e., hematuria that occurs at the end of urination) is associated with a lesion located at the proximal portion of the urethra and the trigone of the bladder. Hematuria associated with a rent of unknown cause at the proximal portion of the urethra has been observed in geldings.[100] The urethral rent appears to be identical to that often seen in stallions with hemospermia (see "Hemospermia," earlier).

The cause of urethral rents is idiopathic, but the reason why the rent occurs invariably at the level of the ischial arch may be explained by the anatomy of the urethra. The diameter of the urethral lumen is approximately 1 to 1.5 cm at the origin of the urethra.[3] The lumen dilates to 3.5 to 5 cm in the pelvic portion of the urethra (i.e., at the pars pelvina) and decreases dramatically in diameter to 1 to 1.5 cm where the urethra bends sharply as it crosses the ischial arch. The sharp turn and the narrowing of the urethral lumen in the area of the ischial arch may expose the convex surface of the urethra at the level of the ischial arch to hydrodynamic forces not encountered by other portions of the urethra.

Pathophysiology

Because urethral rents communicate with the CSP, hemorrhage through the rent into the urethral lumen was thought to occur when pressure within this cavernosal space increases at the end of urination when the bulbospongiosus muscle contracts to expel the last vestige of urine.[100] Recent research, however, showed that the rise in pressure within the CSP associated with contraction of the bulbospongiosus muscle is slight. Investigators theorized that the most likely explanation for hemorrhage at the end of micturition in horses with a urethral rent is that the intraluminal urethral pressure suddenly decreases at the end of urination while the pressure in the CSP remains high.[104]

Even though the lesion in stallions is identical in appearance to that responsible for hematuria of geldings, the lesion in stallions rarely causes macroscopic hematuria.[94,100] The reason for the difference in clinical signs between stallions and geldings is probably that during urination, pressure within the CSP of geldings is nearly double that of stallions.[104] The CSP of geldings is not as well developed as that of stallions, and the difference in volume of the cavernosal space between geldings and stallions results in different pressures in the CSP at the end of urination.

Diagnosis

Blood in urine that results from a urethral rent is characteristically discharged at the end of urination (i.e., terminal hematuria).[100] Occasionally, a horse with a urethral rent may show signs of dysuria, such as tenesmus at the end of urination. Endoscopic examination of the urethra reveals a 5- to 10-mm linear urethral defect on the convex surface of the urethra, distal to the openings of the bulbourethral glands, near the level of the ischial arch. Gross evidence of inflammation around the defect is not observed.

Treatment

Some urethral rents heal spontaneously,[105] but horses with hematuria caused by a urethral rent can be treated successfully by temporary perineal urethrostomy (see "Temporary Perineal Urethrostomy," p. 833, for a description of the surgical technique).[94,100,101] Surgery eliminates hematuria, presumably by reducing vascular pressure in the CSP, which prevents escape of blood through a rent at the end of urination, thereby allowing the rent to heal. A perineal incision that extends into the CSP but does not penetrate the urethra seems to be as effective as temporary urethrostomy in eliminating hematuria and may reduce the risk of complications associated with temporary urethrostomy, such as development of a urethral fistula[101] or stricture.[106] Although horses may bleed substantially from the perineal wound, especially at the end of urination, macroscopic hemorrhage from the urethral orifice and evidence of pain during urination are not observed after surgery.

GENERAL SURGICAL PROCEDURES

Segmental Posthetomy

Indications

Segmental posthetomy, or resection of a circumferential segment of the internal preputial lamina, is indicated for removal of preputial neoplasms, granulomas, or scars so extensive that simple excision of the lesion is impossible. Other terms for the procedure include posthioplasty, circumcision, and reefing.[107] Provided that the preputial lesions do not involve the underlying tunica albuginea, penile amputation can be avoided by segmental posthetomy. With removal of most of the internal lamina of the prepuce, a paralyzed penis can be maintained permanently within the preputial cavity.

Surgical Technique

Segmental posthetomy can be performed with the horse standing after anesthetizing the pudendal nerves (see "Diagnostic Procedures," earlier), but the procedure is most easily and safely accomplished with the horse anesthetized and positioned in dorsal or lateral recumbency. The urethra is catheterized, and the penis is extended by traction on gauze looped around the collum glandis. A tourniquet placed proximal to the surgical site may facilitate surgery. Parallel circumferential incisions through the preputial epithelium are created distal and proximal to the lesion, and these incisions are connected by a longitudinal incision (Fig. 66-15). Care must be taken to avoid severing the large, longitudinal, subcutaneous branches of the external pudendal arteries and veins that lie superficial to the tunica albuginea.

In cases where segmental posthetomy is performed to maintain a paralyzed penis within the external lamina of the prepuce, the distal circumferential incision should be made through the penile epithelium at the level where the internal preputial lamina inserts on the free body of the penis. The proximal circumferential incision should be made close to the preputial orifice.[108]

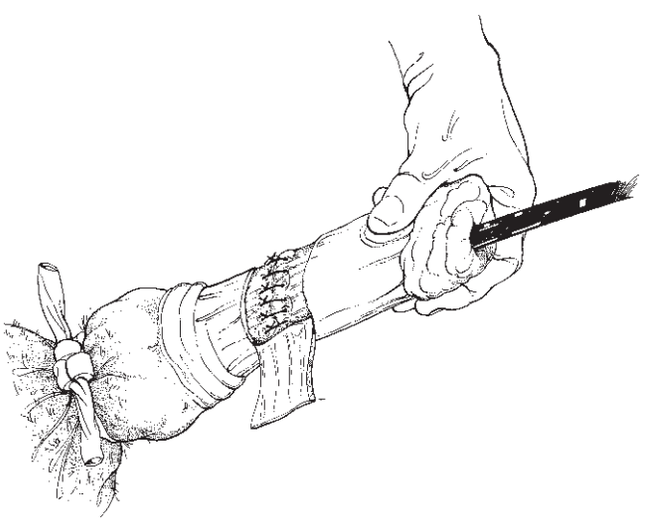

Figure 66-15. Segmental posthetomy. A cuff of epithelium is removed from the shaft of the penis.

The cuff of integument between the incisions is dissected from the penis with scissors, taking care to avoid the large vessels. Normal alignment of tissue is maintained by placing four sutures at equidistant points around the circumference of the penis before the cuff of tissue is removed. The tourniquet is released, and all bleeding vessels are identified and ligated with absorbable sutures or cauterized. Loose adventitia is apposed with interrupted 2-0 absorbable sutures. The epithelium is apposed with interrupted no. 0 or 2-0 absorbable or nonabsorbable sutures.

Aftercare

Stallions should wear a stallion ring for at least 2 weeks and must be isolated from mares for 2 to 4 weeks.[109] Regular exercise reduces postoperative edema. Nonabsorbable sutures should be removed 10 to 12 days postoperatively.

Bolz Technique of Phallopexy

Indication

The Bolz procedure is a technique used to permanently retract a paralyzed penis into the preputial cavity and is performed to avoid phallectomy.[40] This method of permanent retraction cannot be used if the penis or internal lamina of the prepuce is badly damaged or if the horse is still capable of attaining an erection. Damaged sections of prepuce, however, can be removed by segmental posthetomy during the same procedure.

Surgical Technique

The horse is anesthetized and positioned in dorsal recumbency. The urethra should be catheterized for easy identification. A 10-cm longitudinal incision is made on the perineal raphe just caudal to the scrotum (Fig. 66-16, *A*), and the penis is bluntly separated from surrounding fascia, taking care to avoid damaging the surrounding large pudendal vessels (see Fig. 66-16, *B*). The penis is retracted until the annular ring of the reflection of the internal preputial lamina onto the free body of the penis is visible at the cranial extent of the incision (see Fig. 64-16, *C*). The penis is anchored in this position with two heavy, nonabsorbable percutaneous sutures through the annular ring on each side of the penis.

The anchoring sutures should penetrate the skin 2 to 4 cm from the incision at about the level of the middle of the incision. The sutures are inserted through the annular ring on the lateral surface of the penis, taking care to avoid entering the preputial cavity, the urethra, or cavernous tissue. An assistant should palpate the fornix of the preputial cavity during placement of the sutures through the annular ring to ensure that the sutures do not penetrate the preputial epithelium. The sutures exit the skin 2 to 3 cm from their entry points. They are tightened until the glans penis is flush with the preputial orifice and tied over rolls of gauze or large buttons to prevent the suture from cutting through the skin (see Fig. 66-16, *D*). The subcutaneous tissue and skin are each closed separately.

The percutaneous anchoring sutures are removed after 10 to 12 days; at this time, adhesions of sufficient strength to maintain the penis in its retracted position have formed.

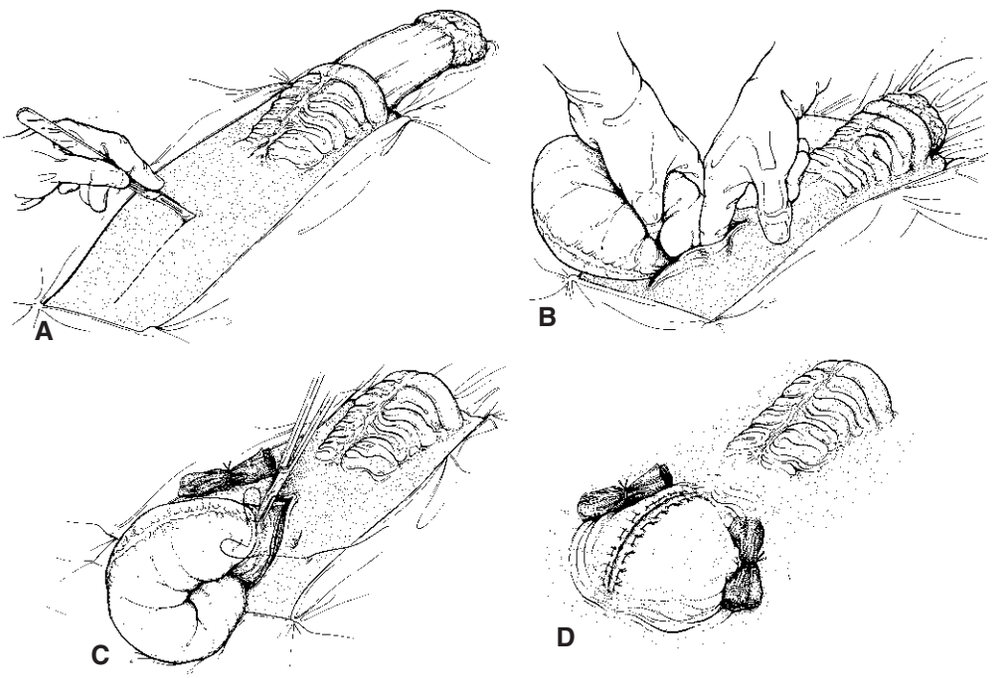

Figure 66-16. A, Bolz technique of phallopexy. A 10-cm incision is made on the perineal raphe just caudal to the scrotum. **B,** The penis is bluntly separated from surrounding fascia, taking care to avoid damaging the surrounding large pudendal vessels. **C,** The penis is retracted until the annular ring of the reflection of the internal preputial lamina onto the free body of the penis is visible at the cranial extent of the incision. The penis is fixed in this position with two heavy nonabsorbable percutaneous sutures through the annular ring on each side of the penis. **D,** The sutures are tightened until the glans penis is flush with the preputial orifice and tied over rolls of gauze or large buttons to prevent the suture from cutting through the skin. The subcutaneous tissue and skin are closed separately.

Necrosis of skin beneath the rolls of gauze is inevitable, but the technique allows adjustment of tension on the percutaneous sutures and repositioning of the penis. Precise positioning of the penis in the prepuce is important because, if the penis is inadequately retracted, the glans penis may protrude excessively through the preputial orifice, or if the penis is excessively retracted, the horse may develop urine scald from urinating in the preputial cavity. Two heavy absorbable sutures, substituted for the nonabsorbable percutaneous sutures, can be used to anchor the annular ring to the subcutaneous fascia.[110] Necrosis of skin is avoided, but the sutures cannot be adjusted after surgery.

Aftercare

The horse should be walked daily to minimize swelling, and heavy exercise can be resumed 2 to 3 weeks after skin sutures have been removed. Retraction distorts the penis into a sigmoid curvature with acute bends, but penile blood supply and urination remain unaffected. The horse can be castrated during the same procedure, using either an inguinal or a scrotal approach. The incision should be sutured because an open inguinal or scrotal wound may interfere with healing around the anchoring sutures. If the horse is castrated before the procedure and the scrotal wound is left unsutured to heal by secondary intention, the surgeon is confronted with the tedious task of caring for the protruded penis for several weeks while the scrotal incision heals.

Amputation of the Urethral Process

Indications

The urethral process is most commonly excised to remove a granuloma caused by cutaneous habronemiasis, when the affected horse fails to respond to medical therapy.[93] The urethral process is sometimes excised to remove a neoplastic lesion.[97]

Patient Preparation

The urethral process can be amputated with the horse standing and sedated after infiltrating the base of the urethral process with a local anesthetic agent, but the procedure is most easily and safely accomplished with the horse anesthetized and in dorsal recumbency.[93] The penis is prepared for aseptic surgery, and a urinary catheter is passed into the urethra. After placing traction on the urethral process with one or two Allis tissue forceps, two small-gauge needles (e.g., 23 or 25 gauge) are placed through the urethral process and the catheter at right angles to each other, proximal to the diseased portion of the urethral process (Fig. 66-17). These needles anchor the urethral process to

Figure 66-17. This urethral process was amputated to eliminate hemospermia caused by carcinoma of the urethral mucosa. The urethral process was stretched with tissue forceps, and two small-gauge needles were placed through the urethral process and the catheter at right angles to each other, proximal to the diseased portion of the urethral process, to anchor the urethral process to the catheter.

the catheter, making the incised margin of the process more stable and accessible for suturing.

Surgical Technique

A circumferential incision extending through the skin, CSP, and urethral mucosa is made around the base of the urethral process proximal to the affected tissue and distal to the anchoring hypodermic needles. The urethral mucosa is apposed to the epithelium of the remaining stump of the process with simple-interrupted or simple-continuous sutures of 4-0 or 5-0 absorbable suture.[97] The sutures should be closely spaced to compress the erectile tissue of the CSP. A simple-continuous suture pattern is probably more effective than a simple-interrupted suture pattern in compressing the erectile tissue of the CSP. The entire length of the process can be removed.

Aftercare

Stallions and recently castrated geldings should be isolated from mares for at least 3 weeks. Hemorrhage from the stump of the process, especially at the end of urination, should be expected for at least several days after amputation of the urethral process.

Phallectomy

Indications

Phallectomy is indicated when permanent penile paralysis is accompanied by irreparable penile damage, and more commonly, when neoplasia has invaded the tunica albuginea or is so extensive that more conservative treatment by cryosurgery, hyperthermia, local excision, or segmental posthetomy is impossible. For geldings, phallectomy may be the most expedient means of treating urethral stenosis distal to the preputial orifice. Phallectomy of stallions is generally performed to salvage the horse for purposes other than breeding, but amputation of just the glans penis may not interfere with copulation.[111]

Patient Preparation

A stallion should be castrated 3 to 4 weeks prior to phallectomy, if possible, to avoid postoperative erection, which leads to hemorrhage and dehiscence. The procedure can sometimes be performed with the horse standing and sedated after anesthetizing the pudendal nerves (see "Diagnostic Procedures," earlier),[28] but the procedure is most easily performed with the horse anesthetized and positioned in lateral or, preferably, dorsal recumbency. The urethra is catheterized with an equine male urinary catheter, and the penis is extended with gauze looped around the collum glandis. A tourniquet placed proximal to the proposed site of transection facilitates surgery.

Surgical Techniques

VINSOT'S TECHNIQUE OF PHALLECTOMY

One of the simplest techniques of phallectomy is Vinsot's procedure.[43,112] A triangular section of tissue that includes epithelium, fascia, bulbospongiosus muscle, and CSP is removed from the ventrum of the penis proximal to the proposed site of transection, taking care not to enter the urethral lumen (Fig. 66-18). The triangle has a 2.5-cm base and 4-cm sides. Its apex points distally and is located about 4 or 5 cm proximal to the proposed site of transection. The exposed urethra is incised on its midline from the base to the apex of the triangle, and the incised edges of the urethra and the triangle's epithelial border are apposed with simple-interrupted or simple-continuous absorbable sutures. The sutures should include the tunica albuginea of the CSP, and they should be closely spaced to compress the erectile tissue

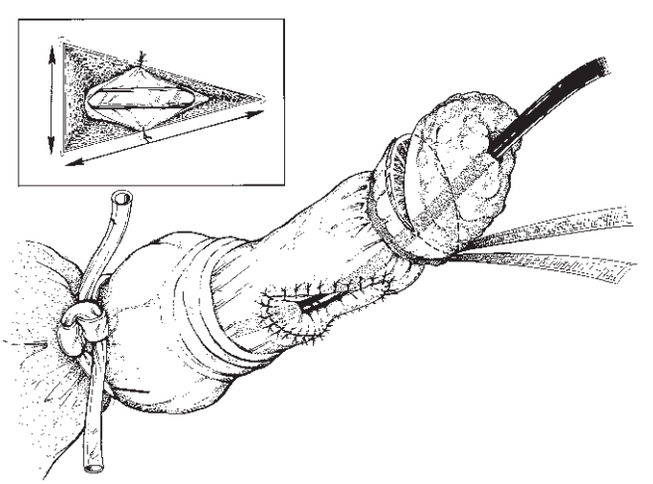

Figure 66-18. Vinsot's technique of phallectomy. A triangular section of tissue is removed from the ventrum of the penis proximal to the proposed site of transection, taking care not to enter the urethral lumen. The exposed urethra is incised on its midline from the base to the apex of the triangle, and the incised edges of the urethra and the triangle's epithelial border are apposed with simple-interrupted, absorbable sutures. A nonabsorbable ligature is placed around the penis distal to the apex of the triangle, and the penis is severed distal to the ligature.

of the CSP. A simple-continuous suture pattern is probably more effective than a simple-interrupted suture pattern in compressing the erectile tissue of the CSP. The diseased portion of the penis is removed 4 to 5 cm distal to the urethrostomy using a wedge-shaped incision. Large vessels on the dorsal and lateral aspects of the tunica albuginea are ligated with absorbable suture, and the corporeal bodies are compressed with absorbable sutures placed through the tunica albuginea in an everting or appositional pattern. The penile or preputial integument is sutured with absorbable or nonabsorbable sutures placed in an everting or appositional pattern.

Instead of suturing the end of the stump, the surgeon can leave it unsutured to heal by secondary intention. To prevent hemorrhage from the corporeal bodies, a tightly fixed, nonabsorbable ligature is placed around the penis 2 to 3 cm distal to the apex of the triangle, before the penis is transversely severed 1 to 2 cm distal to the ligature.

Rather than removing a triangle of tissue overlying the urethra, the technique can be simplified by making a 4- to 5-cm longitudinal incision into the urethral lumen.[113] The incised edges of the urethra and the integument are apposed with simple-interrupted or simple-continuous absorbable sutures. These sutures incorporate and compress the cavernous tissue of the CSP. Vinsot's technique, especially its modification,[113] can often be performed with the horse standing. A primary disadvantage of the technique, or its modification, is the tendency of the urethra to stricture.[43]

WILLIAMS' TECHNIQUE OF PHALLECTOMY

The likelihood of urethral stricture is decreased when the Williams' technique of phallectomy is employed.[111] With this technique, a triangle of tissue with similar dimensions to those described in Vinsot's technique is removed from the ventrum of the penis (Fig. 66-19, *A*). The triangle's apex is directed proximally, rather than distally, and the base of the triangle is the site of penile transection. The urethra is split on its midline from the base to the apex of the triangle, and the incised edge of the urethra and the triangle's epithelial edge are apposed with simple-interrupted or simple-continuous absorbable sutures. These sutures incorporate and compress the cavernous tissue of the CSP: A simple-continuous suture pattern is probably more effective than a simple-interrupted suture pattern in providing compression.

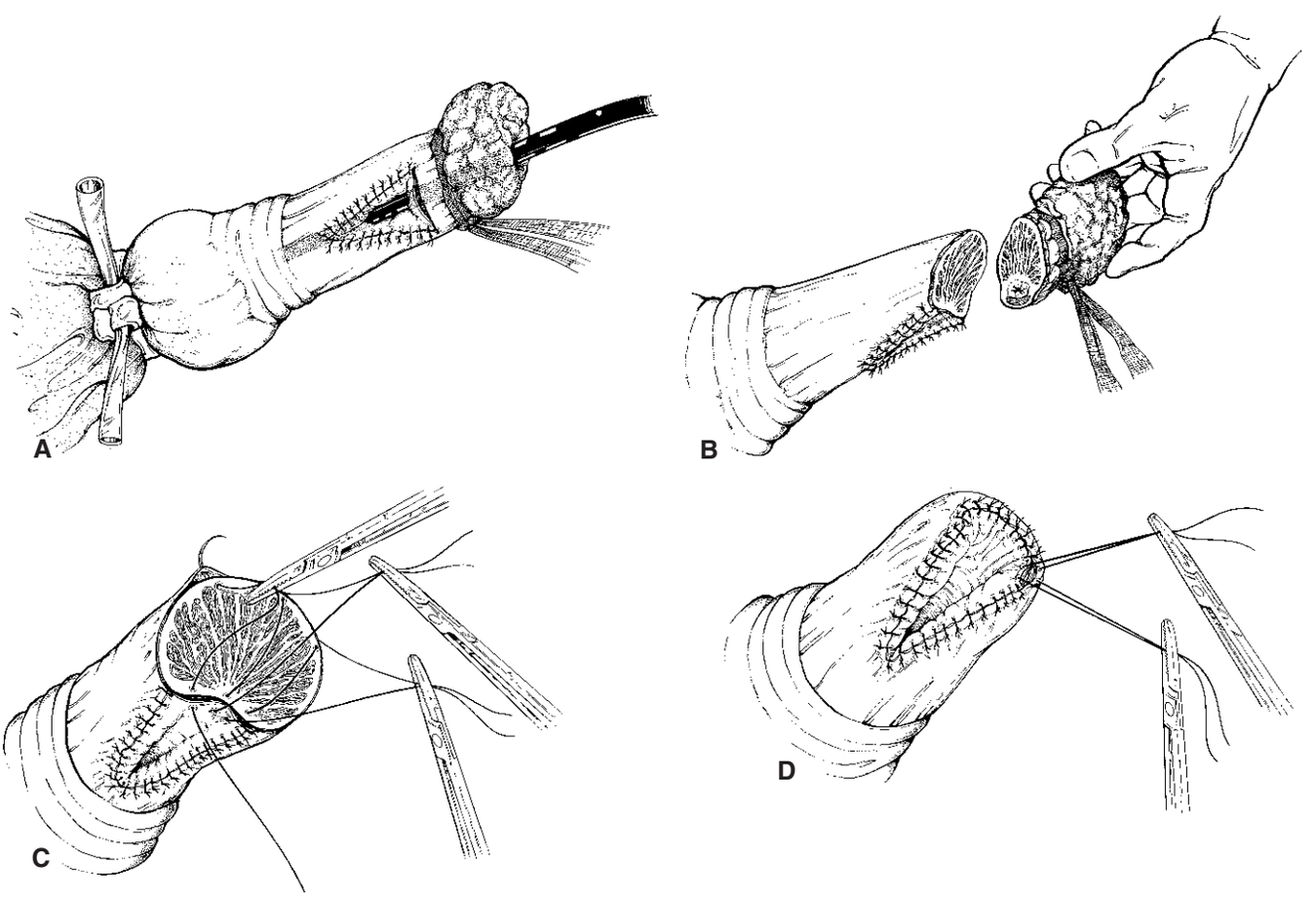

Figure 66-19. A, Williams technique of phallectomy. A triangle is removed from the ventrum of the penis. The triangle's apex is directed proximally. The urethra is split on its midline from the base to the apex of the triangle, and the edges of the urethra and the triangle's epithelial edges are apposed with simple-interrupted absorbable sutures. **B,** The base of the triangle is left unsutured. The urethral catheter is removed, and the penis is obliquely transected at the base of the triangular urethrostomy in a craniodorsal direction. **C,** The stump is closed with interrupted sutures that pass through the urethra, the tunica albuginea of the urethral groove, and the tunica albuginea of the dorsum of the corpus cavernosum penis (CCP) and the penile or preputial epithelium. The sutures should be pre-placed at equidistant intervals for an even closure. **D,** The sutures are tightened and tied, compressing the cavernous spaces, and the epithelium is apposed to the urethral mucosa.

The base of the triangle is left unsutured. The urethral catheter is removed, and the penis is obliquely transected at the base of the triangular urethrostomy in a craniodorsal direction, so that the dorsum of the penile stump is longer than the ventrum (see Fig. 66-19, *B*). Large branches of the external pudendal vessels that reside in loose fascia on the dorsal and lateral aspects of the tunica albuginea are ligated with absorbable suture.

The stump is closed with interrupted absorbable or nonabsorbable sutures that pass through the urethra, the tunica albuginea of the urethral groove, and the tunica albuginea of the dorsum of the CCP and the penile or preputial epithelium (see Fig. 66-19, *C*). The sutures should be pre-placed at equidistant intervals for an even closure. When these sutures are tightened and tied, the erectile bodies are compressed, and the epithelium is apposed to the urethral mucosa (see Fig. 66-19, *D*). Alternatively, the stump can be closed in two layers by first suturing the tunica albuginea of the dorsum of the CCP to the tunica albuginea of the urethral groove with interrupted absorbable sutures placed at bisecting intervals and by suturing the penile or preputial integument to the urethral mucosa with interrupted absorbable or nonabsorbable sutures.

SCOTT'S TECHNIQUE OF PHALLECTOMY

With this technique, a circumferential transverse incision through the epithelium of the body of the penis or prepuce is made at the intended site of transection, and branches of the external pudendal vessels are ligated.[79] Dissection is continued through the CCP to the urethral groove. The CSP is circumferentially incised to the urethra, which is easily identified by the urinary catheter in its lumen, and a 4- to 5-cm segment of urethra is dissected free from the amputated section of penis (Fig. 66-20, *A*).

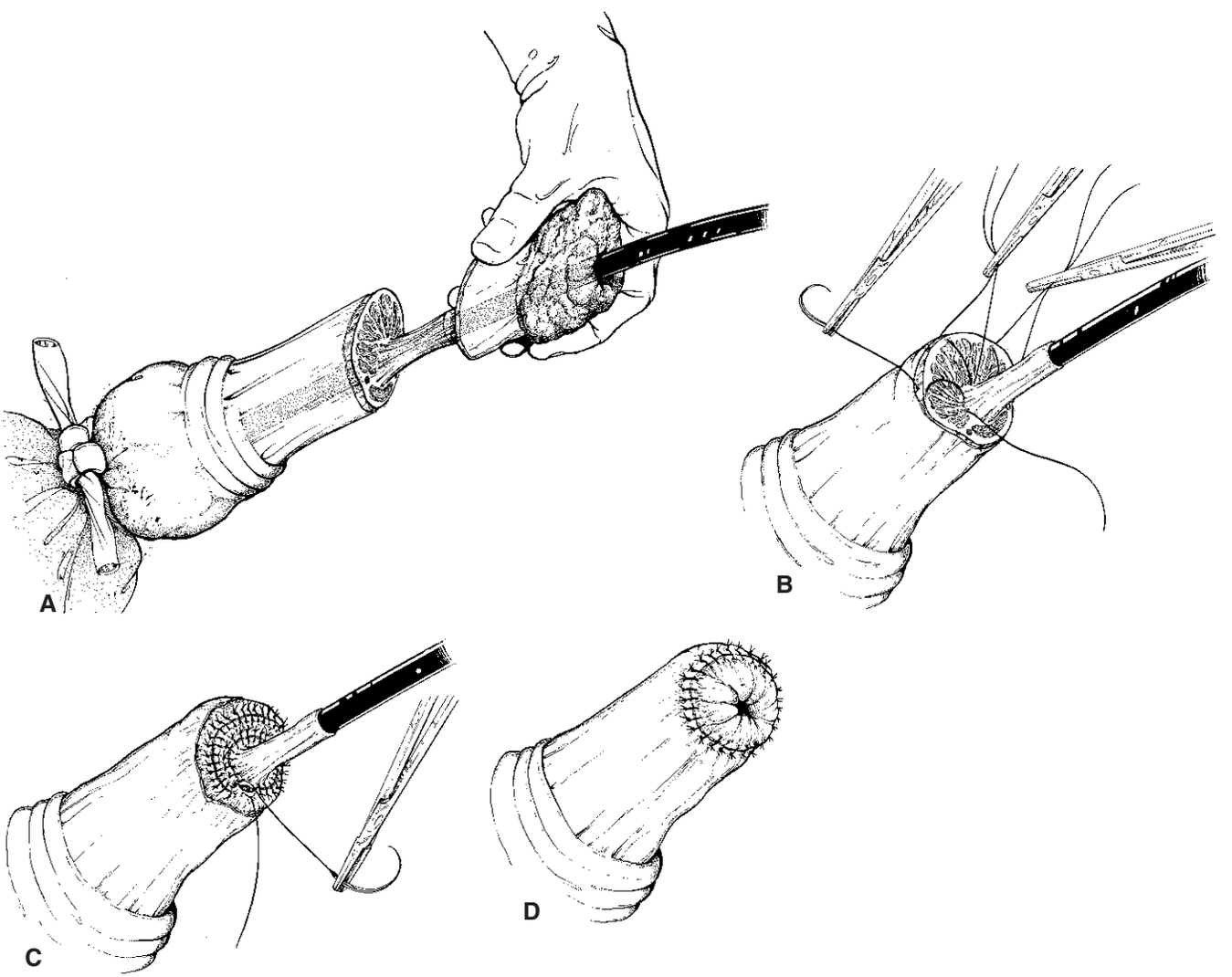

Figure 66-20. Scott's technique of phallectomy. **A,** A circumferential transverse incision through the epithelium of the body of the penis or prepuce is made at the intended site of transection. Dissection is continued through the corpus cavernosum penis (CCP) to the urethral groove. The corpus spongiosum penis (CSP) is circumferentially incised to the urethra, and a 4- to 5-cm segment of urethra is dissected free from the amputated section of penis. **B,** The stump of the CCP is closed by apposing the outer perimeter of its tunica albuginea to the tunica albuginea of the urethral groove with interrupted absorbable sutures pre-placed at equidistant intervals. **C,** The sinusoidal spaces of the CSP are closed by suturing the tunica albuginea surrounding the CSP to the submucosa of the urethra with interrupted absorbable sutures. **D,** The urethral stump is stretched and folded back over the end of the penis, where it is sutured to the penile or preputial epithelium and underlying tunica albuginea.

The stump of the CCP is closed by apposing the outer perimeter of its tunica albuginea to the tunica albuginea of the urethral groove with interrupted absorbable sutures pre-placed at equidistant intervals (see Fig. 66-20, *B*). The sinusoidal spaces of the CSP are closed by suturing the tunica albuginea surrounding the CSP to the submucosa of the urethra with interrupted absorbable sutures (see Fig. 66-20, *C*). The urethral stump is divided into three equal triangular segments, with the apex of each triangle pointing distally. These segments are intermeshed with similarly prepared segments of penile or preputial integument and are apposed with simple-interrupted absorbable or non-absorbable sutures. Sutures should include underlying tunica albuginea. Instead of dividing the urethral stump into three triangles, the urethral stump can be stretched and folded back over the end of the penis, where it is sutured to the penile or preputial epithelium and underlying tunica albuginea (see Fig. 66-20, *D*).

PHALLECTOMY BY EN BLOC RESECTION WITH PENILE RETROVERSION

Removal of the free portion of the penis, the internal lamina and external lamina of the prepuce, and regional lymph nodes may be indicated when these structures are extensively affected with neoplasia.[83] With this technique of phallectomy, a fusiform incision is created around the preputial orifice. The incision begins 6 cm cranial to the orifice and ends 10 cm caudal to it. The incision is carried to the deep fascia of the abdominal tunic, and if neoplasia has metastasized to the superficial lymph nodes, dissection is extended through this plane to both superficial inguinal rings, and the superficial inguinal lymph nodes are removed. The penis is amputated approximately 6 to 8 cm caudal to the fornix of the prepuce, and the amputated portion of the penis and the prepuce are removed en bloc. The penile shaft is amputated using a method similar to that described by Scott, so that 4 cm of urethra is left protruding from the penile stump[79] (Fig. 66-21, *A*). The technique can be modified by amputating the penis using Williams' or Vinsot's technique of phallectomy.[114]

By bluntly separating penile fascia, the stump of the penis is retroverted through a 6-cm subischial incision created approximately 20 cm ventral to the anus, so that its distal end points caudally and extends just beyond the subischial incision (see Fig. 66-21, *B*). The tunica albuginea of the CCP and the fascia of the penis are sutured to the subcutaneous tissue of the subischial incision. The ventral aspect of the urethra is incised longitudinally over its 4-cm length, and the edges of the urethra are sutured to the surrounding edges of the incised subischial skin. Penrose drains are placed deeply at the cranial incision, and the subcutaneous tissue and skin are each closed separately.

PHALLECTOMY BY EN BLOC RESECTION WITHOUT PENILE RETROVERSION

This technique of phallectomy is similar in many respects to phallectomy by en bloc resection with penile retroversion, but with this technique, the stump of the penis is not retroverted but is maintained in its normal ventral position.[115] With this technique, a fusiform incision is created on the midline beginning at the umbilicus. The incision extends caudally on each side of the preputial orifice and continues on the midline to a point 10 cm caudal to the preputial orifice. The caudal portion of the incision is extended and deepened to expose and remove the inguinal lymph nodes, if neoplasia has metastasized to these structures.

Figure 66-21. En bloc resection of the penis. **A,** Four centimeters of urethra is left beyond the penile stump. **B,** The position of the penile stump when retroverted is demonstrated. (From Markel MD, Wheat JD, Jones K: Genital neoplasms treated by en bloc resection and penile retroversion in horses: 10 cases 1977-1986. J Am Vet Med Assoc 1988;192:396.)

Blunt dissection is continued into the loose areolar tissue of the prepuce, ligating large vessels as they are encountered. After the shaft of the penis is exposed, dissection is redirected along the shaft of the penis in a plane superficial to the loose subcutaneous tissue overlying the vasculature of the penis. At least 10 cm of the shaft should be exposed. A tourniquet is applied around the shaft of the penis proximal to the site of amputation. The dorsal arteries and veins of the penis are ligated and transfixed to the tunica albuginea. The penis is transected caudal to the fornix of the prepuce, using the method described by Williams.[111] After the tourniquet is removed, the stump is fixed to the body wall on the midline with heavy absorbable interrupted sutures. The subcutaneous tissue cranial to the penile stump surrounding the exposed penile shaft is apposed. Skin is sutured to the tunica albuginea and the urethral mucosa of the new urethral orifice. The skin cranial and caudal to the urethral orifice is sutured.

This technique of en bloc resection requires a smaller incision and results in less alteration to the appearance of the horse than does the retroversion technique, while still allowing the surgeon to remove extensive portions of the penis and extirpate the regional lymph nodes.[115]

Aftercare

Because the procedure is generally performed to salvage the horse for purposes other than breeding, stallions should be castrated several weeks in advance of phallectomy. Stallions and recently castrated geldings should be isolated from mares for 2 to 3 weeks and should wear a stallion ring on the penile stump during this time.

Complications

Hemorrhage from the penile stump, especially at the end of urination, should be expected for at least several days after phallectomy. Hemorrhage usually emanates from the CSP. Phallectomy of geldings is attended by less hemorrhage than phallectomy of stallions. Excessive hemorrhage may be accompanied by minor dehiscence, which is usually of no consequence. Dehiscence of sutured erectile tissue may lead to the formation of a large hematoma. Other complications of phallectomy in the immediate postoperative period include pain, infection of the surgical wound, edema of the prepuce, and acute urinary obstruction caused by edema of the urethra.[73,74,83,115] Long-term complications include cystitis, urine scalding, dysuria caused by urethral stricture, recurrence of neoplasia at the site of amputation, and neoplastic metastases to inguinal lymph nodes and internal organs.

Temporary Perineal Urethrostomy

Indications

Temporary urethrostomy at the ischial arch is performed to provide access to small cystic calculi, for treatment of horses affected with hemospermia or hematuria, and to divert the flow of urine from the penile urethra for such conditions as urethral laceration or urethral urolithiasis.

Surgical Technique

Temporary perineal urethrostomy is best performed with the horse standing and sedated after administering epidural anesthesia or infiltrating the tissue at the proposed site of incision with a local anesthetic agent. A 6- to 8-cm vertical incision is created on the perineal raphe about 2 to 3 cm below the anus. The incision is extended through the skin, the retractor penis and bulbospongiosus muscles, the CSP, and the urethral mucosa (see Fig. 66-2).

Preoperative insertion of a large-bore urethral catheter facilitates identification of the urethra. The perineal incision should "funnel" to a short urethral incision as it deepens to avoid postoperative pocketing of urine in the tissues. If the incision strays from the midline, profuse hemorrhage can result from laceration of branches of the external pudendal artery.[36] The urethrostomy is generally allowed to heal by secondary intention; development of clinically apparent urethral stenosis after this procedure is rare. The urethrostomy normally heals within 2 weeks.[104]

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CHAPTER 67

Vulva, Vestibule, Vagina, and Cervix

Brett Woodie

The caudal aspect of the reproductive tract is composed of the vulva, vestibule, vagina, and cervix. These structures are susceptible to a variety of injuries during breeding and foaling. Conformational abnormalities of the caudal reproductive tract may predispose the mare to pneumovagina, urovagina, and other problems. Ultimately, problems associated with the caudal reproductive tract can lead to infertility.

ANATOMY

The external genitalia of the mare are composed of the perineum and the vulva. The *perineum* is the region bound dorsally by the base of the tail, *l*aterally by the semimembranosus muscles and sacrosciatic ligaments, and ventrally by the ventral commissure of the vulva[1] (Fig. 67-1). The fibromuscular perineal body lies between the anus and the vulva. Fibers of the external anal sphincter and the constrictor vulvae muscles form the perineal body (Fig. 67-2).

The *vulva* includes the two labia and the clitoris. The external orifice of the vulva is typically 12 to 15 cm long.[2] When the architecture of the external genitalia of the mare is normal, the labia of the vulva are vertical and meet dorsally to form the dorsal commissure, which is located just ventral to the anus. The labia meet ventrally to form the ventral commissure, which is located caudal and ventral to the ischial arch. Approximately two thirds of the vulvar cleft is ventral to the ischial arch.[3] Normally, the labia of the vulva are muscular and resist manual separation, as a result of the paired constrictor vulvae muscles, which lie deep to the skin of the labia. The internal pudendal vessels provide