Reproductive Disorders of Marsupials

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KEYWORDS

• Marsupial • Reproductive disorders • Sugar glider • Opossum • Wallaby

KEY POINTS

- Marsupial reproduction differs from that of placental mammals, as the female gives birth to a fetus that develops outside of the uterus.
- Pouch infections are unique to marsupials and may jeopardize the development of the joey.
- Marsupial reproductive tract diseases include infectious and traumatic etiologies and are similar to those of placental mammals.
- Castration and ovario-vaginal-hysterectomy surgeries differ from those of placental mammals because of the marsupial anatomy, especially in the female; inattention to differences can lead to inadvertent ligation of the ureters.

Captive marsupials are occasionally presented to practitioners. Many owners are breeding marsupials such as sugar gliders, wallabies, and short-tailed opossums for the pet trade. Reproductive disorders, such as dystocia, found in placental mammals are not seen in marsupials. A brief discussion of the unique anatomy and physiology of the marsupial is necessary to evaluate reproductive health and disease.

The most commonly presented captive marsupials are the sugar glider (*Petaurus breviceps*), the Brazilian (short-tailed, laboratory, gray) opossum (*Monodelphis domestica*), and macropods including the Tammar or Dama wallaby (*Macropus eugenii*) and, more commonly, the Bennett's wallaby (*Macropus rufogriseus*). In North America, injured or orphaned Virginia opossums (*Didelphis virginiana*) are frequently brought into clinics or rehabilitation centers and occasionally kept as pets. Marsupial infants are called joeys. Sex determination is usually easy, even at a young age (**Fig. 1**).

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Fig. 1. Red arrows show infant Virginia opossum premature scrotal sac (*Left*) and pouch (*Right*).

REPRODUCTIVE ANATOMY AND PHYSIOLOGY

Marsupial reproductive anatomy and physiology is considerably different than that of placental mammals.[1] The gastrointestinal tract, urinary ducts, and genital ducts all open into a cloaca.[1,2]

Female Marsupials

The reproductive tract of the female marsupial is smaller than that of placental mammals. It consists of the ovaries, oviducts, and paired uterus bodies that form the proximal half and the 2 lateral and central (median) vaginal canals that form the distal half (**Fig. 2**). The 3 vaginal canals join and form a urogenital sinus that also contains the urethral opening before entrance into the cloaca. The ureters are contained within the vaginal canals unlike in placental mammals, where they arrive at the bladder from around the lateral aspect of the reproductive tract.

All marsupials except the potoroo (*Potorous* sp.) give birth through the median vaginal canal.[3,4] The reproductive tract of the sugar glider has been described in detail by Smith[5] and is similar to that of all marsupials, with differences primarily in sizes and relative dimensions. The ovaries lie against the medioventral side of the uterus, near the junction of the uterus and oviduct. The oviduct is convoluted with a voluminous

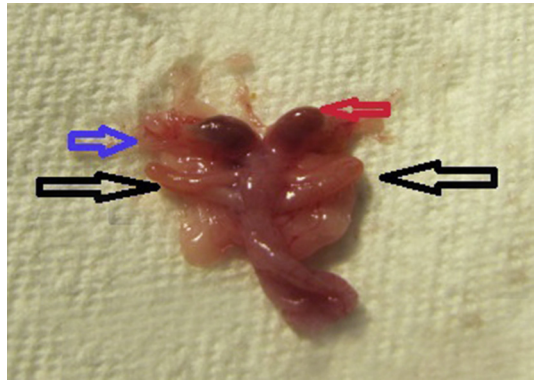

Fig. 2. Female sugar glider tract. Red arrow indicates ovary, the blue arrow indicates uterus body, and the black arrows indicate lateral vaginal canals.

funnel. Each uterus is a fusiform-shaped body that is elongated caudally into a narrow uterine neck. The necks of both uteri run parallel for about 3 mm and are ensheathed in a common tunic of connective tissue. Each uterine neck opens into the vaginal cul-de-sac of its own side at the os uteri that is situated ventrolaterally on the uterine papilla. A median septum between the right and left vaginal cul-de-sacs arises in the midline at the junction of the uterine papillae. In the sugar glider, the median canal is short and has long lateral canals. In opossums and macropods, the median canal and lateral canals are nearly equal in length. In all, the median vaginal canal from each uterus merges with the lateral vaginal canal. Posterior to the bladder, the 2 merged lateral and median vaginae and the urethra join to form the urogenital sinus, which may be long, relative to the anterior components of the system.[5]

Other unique features of the many female marsupials are marsupial bones and pouches (marsupium); however, not all have them (**Figs. 3** and **4**). The sugar glider does not have marsupial bones but does have a pouch. The short-tailed opossum has marsupial bones but no pouch and has a variable number of mammae arranged in a circle on the abdomen. The Virginia opossum has both marsupial bones and a pouch and 13 mammae; wallabies have marsupial bones and pouches with 2 pairs of mammae near the base of the pouch and can have milk with different compositions in each mammae to support joeys of different ages. In particular, the milk in the teat of a newborn wallaby is lower in fat and protein content than that of a teat used by and older joey. As the pouch young grows, the milk changes to suit the joey's needs.

As marsupial fetuses are expelled early in gestation, dystocia is virtually unknown. About 1 week before birth, the dam will fully clean the pouch, which contains a brown scaly secretion when there are no young. The fetus emerges from the urogenital opening into the cloaca fully enclosed in an amniotic sac. The fetus breaks free from the sac with its claws, usually in about 10 to 15 seconds, and then climbs from the cloacal opening up to the pouch or abdominal area and firmly attaches itself to a teat, which may take up to 5 minutes in most macropods (kangaroos and wallabies).[1] To aid the newborn joey, the dam will lick a path from the cloaca to the pouch entrance or abdominal mammae. The newly emerged joey has no visible external ears or eyes and is red in color.[6]

The dam usually has a postpartum estrus, during which breeding and fertilization occur.[2,3] If the joey currently in the pouch survives, the fertilized egg stops development in the blastocyst stage and remains unimplanted until the pouch young have either died or finished suckling and left the pouch. At this point, the blastocyst continues development, and the new joey is born in a few weeks. This phenomenon is known as fetal diapause.[3]

Fig. 3. Female Virginia opossum with pouch opened, exposing teats.

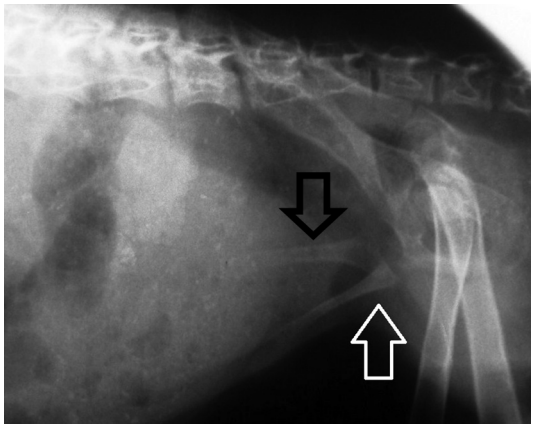

Fig. 4. Radiograph shows marsupial bones (*Black and white arrows*) in Virginia opossum.

Male Marsupials

The penis of the male is located in the ventral floor of the cloacal. It is bifid or forked, which owners often mistake for an abnormal structure or injury (**Fig. 5**). In the sugar glider, each half has a ventral groove from the base to the pointed tip.[5] The scrotum and testes are external and found proximal to the cloacal opening.[2,3] Spermatorrhea seems to be a normal condition in some marsupial males.[3] The paired testes and epididymides connect via the vasa deferentia to the prostatic portion of the urethra with a large disseminate prostate gland and one or more pairs of Cowper (bulbourethral) glands. The duct of each Cowper gland enters the urethra on the ventral surface near the crus penis. The sugar glider, has 2 pairs of multibulbed Cowper glands dorsal and lateral to the rectum.[5] The male marsupial reproductive system lacks seminal vesicles and coagulating glands. Methods for control of testicular temperatures in possums and gliders are uncertain; however, observation of male marsupials finds they may use scrotal licking and evaporative cooling to modify temperature of the scrotal pouch.[7] Male kangaroos have been observed pulling the scrotum up against the body wall in periods of high ambient temperature. Of interest, comparison between wild and captive male sugar gliders finds that captive males often have a marked

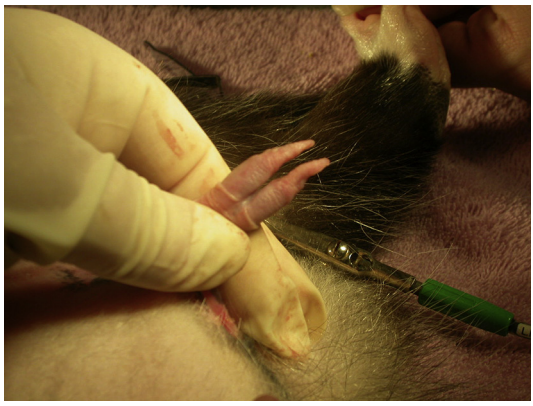

Fig. 5. Bifid penis of the male Virginia opossum.

reduction in the size of sex organs and glands.[3] Wild sugar gliders actively defend their territories, with continual hormonal stimulation. In addition, they normally urine and scent mark using secretions from the sex and cloacal glands. In captivity, the territory is small, and little territory defense or marking takes place, resulting in little stimulation of the sex organs or glands.

Both males and females possess paracloacal glands, which discharge a white, oily secretion that may be released when the animal is frightened or stressed. Secretions may also be deposited with urine and feces.[5] **Table 1** lists reproductive parameters for companion marsupial species.

REPRODUCTIVE DISORDERS

Spontaneous disease of the reproductive system in marsupials is uncommonly reported; however, the increase in numbers in the pet trade may increase overall incidence. **Table 2** lists reported reproductive disorders.

Pouch Eviction

Pouch eviction, or premature ejection of the joey, is a commonly described reproductive problem. This can occur when captive females clean the pouch excessively or become overexcited or stressed or when a yearling joey evicts the new joey. Accidental expulsions may occur secondary to stress owing to loss of tone in the wall of the pouch. If there is no pouch infection, the joey can be replaced. One technique is the use of a thin strip of surgical adhesive tape placed over the pouch entrance positioned so that the anterior and posterior lips of the pouch entrance are held together centrally.[3] The dam is then housed in a small, quiet, and dark area with minimal stimulation; ultimately she will remove the strip, but this may allow time for the problem to resolve.[3] If the joey is evicted repeatedly, another investigator suggested using 2 button sutures through the pouch that allow the dam to reach the joey and interior to clean but not fully open the pouch.[2] Continually evicted joeys may require foster care, which is challenging, depending on the stage of development.[2] Joeys without fur are particularly vulnerable to dehydration and hypothermia. Guidelines for temperatures for hand-reared joeys are unfurred, 32°C (89.6°F) with 70% humidity; and furred, 28°C (82.4°F). Moisture barrier–warmed gels or lotions (Keri Lotion; Bristol-Myers Squibb, Princeton, NJ) may help prevent dehydration of the unfurred joey.[12,13]

Pouch Infections

An infected pouch exhibits an odor, can be brown instead of the normal pink coloration, and can have a thick discharge (**Fig. 6**).[14] Various bacteria including *Pseudomonas aeruginosa* and yeasts have been cultured from infected pouches. There may also be mastitis. Diagnostics should include culture and sensitivity of the exudates.[15] Systemic antibiotics and treatment of the pouch itself should be done. The author cleans the pouch gently using cotton buds and a 2% chlorhexidine solution every 12 hours followed by a saline swabbing then drying with soft cotton until resolution. Silver sulfadiazine cream applied in the pouch has been used if no joeys are present. If young are present, as much exudate as possible should be removed without dislodging the joey using cotton buds and saline; main treatment consists of systemic antibiotics. If mastitis is present and the joey cannot nurse, it may be fostered or hand reared. Prevention of pouch infections and mastitis in breeders relies on optimal husbandry sanitation of environment and good hygiene of cage mates. In macropods, long-term use of antibiotic therapy seems to predispose development of pouch infection.[16]

Table 1
Reproductive parameters for selected marsupials

	Sugar Glider	Short Tailed Opossum	Virginia Opossum	Wallaby Tammar	Wallaby Bennett's
Reproductive Characteristics	Polyestrus Monogamous	Polygynandrous (Promiscuous)	Promiscuous	Promiscuous	Promiscuous
Sexual Maturity (mo)					
Male	12–14	4–5	6–8	24	18–24
Female	8–12			9	12–18
Breeding season	All year	All year in captivity	Seasonal-late winter through summer	Seasonal, January/February wild	Seasonal
Gestation (d)	16	14–15	12.5–13	25–28	30
Time in Pouch	70 d	No pouch	70 d	8–9 mo	7–8 mo
Birth Weight (mg)	190	100	130	460	460
Litter Size	2	4–14	Up to 21, only 13 can be suckled	1	1
Litters/y	2	Up to 5	1–3	1–2	1–2
Weaning Age	3–4 mo	3–4 wk	3 mo	28–36 wk	52 wk
Independent	17 wk	50 d	4.5–5 mo	11–12 mo	12–17 mo

Data from Refs.[1,3,8–11]

Table 2
Reproductive disorders

Species	Disorders
Captive Species (Sugar glider, short-tailed opossum, Virginia opossum, macropods-wallabies, kangaroos)	Failure-to-thrive joeys Mastitis Metritis Pouch eviction Pouch infection Vaginitis
Sugar glider	Infertility Penile mutilation/necrosis Prostatis
Short-tailed opossum	Female: Endocrine alopecia caused by pituitary adenoma, prolactinemia Endometritis Mammary gland abscess Mammary gland papillary cystadenoma Ovarian cysts Ovarian mineralization Uterine cyst, hemorrhage, leiomyoma Male: Accessory sex glands adenitis, cysts, hypertrophy Hydrocele Penile fibrosarcoma Testicular atrophy, cyst, granuloma, necrosis
Virginia opossum	Cushingoid syndrome secondary to genital tract infection Endometritis Mammary carcinoma, hyperplasia Prostatitis Uterine prolapse
Macropods	Herpesvirus genitorurinary infection (infertility, lesions, ulcerations) Neoplasias: Mammary adenocarcinoma, carcinoma Ovarian stromal tumor Pouch basal epithelioma Sertoli cell tumor Testicular seminoma
Brush-tailed phascogale, brown antechinus, dusky antechinus	Cytomegalovirus-related prostatitis

Data from Refs.[2,3,12–24]

Mastitis

Teats may be enlarged, erythemic, hardened, painful, and secreting an exudate rather than milk. The joey may also be ill or dead because of the infective exudate or starvation. A culture with sensitivity may be done from the exudate. The joey usually needs to be administered antibiotics and fostered or hand reared. Prognosis for the joey is poor if it is ill and nonfurred. The female should also be given analgesics and nonsteroidal anti-inflammatory drugs meloxicam (0.1–0.2 mg/kg subcutaneously or orally every 24 hours), and the pouch should be kept clean from the exudates by swabbing it out with saline or 2% chlorhexidine solution.

Fig. 6. Female sugar glider with brown discharge typical of a pouch infection.

Failure-to-Thrive Joeys

Pouch trauma, infection, dislodgement from a nipple, or presence of mastitis may result in development problems by the joeys. Affected joeys may need supportive care, including treatment of fluid deficits and antibiotics and be hand reared or fostered to a lactating female. Suggested fluid deficits are based those of on other mammals of similar weight. Antibiotics such as amoxicillin at 25 mg/kg orally every 12 hours have been used for sugar gliders, short-tailed opossums, and Virginia opossums. Enrofloxacin at 5 mg/kg orally every 24 hours has been used for macropods. These are extrapolated from dosages used in other mammalian species. The affected female should be treated accordingly; this often requires separation from an aggressive cage mate and improvement in the environment.

Female Reproductive Tract Infection

Ascending infections from the cloaca may cause vaginitis and metritis. There may be secondary peritonitis. The author has cultured *Staphylococcus aureus*, *Streptococcus* sp., *Escherichia coli*, and *Proteus* sp., although others are possible. The cloaca is the common opening for the digestive and urinary systems along with the reproductive tract. Infection may also result from tears made from an overly aggressive male during breeding. Along with antibiotics and analgesics, ovario-vaginal-hysterectomy may be required if medical therapy does not lead to resolution.

Species-Specific Conditions

Sugar glider

Infertility is commonly seen in certain lines of mosaic color mutations. Mosaic gliders have characteristic white patches on the body, feet or tail (https://www.google.com/?gws_rd%20=%20ssl&gws_rd=ssl#q=sugar+glider+mosaic). The trait is codominant to the standard wild-type coloration. Certainly lines of mosaics may produce sterile males.[15] The male is more likely affected. It is thought likely that it is linked to one of the genes associated with the color mutation. Infertility may also involve underlying medication conditions; obesity or inappropriate social situations may cause failure to breed in the females.

A common problem of sugar glider males is mutilation or necrosis of the penis.[15] Etiologies may include concurrent prostatitis or urinary tract infection, trauma, or self-mutilation syndrome in socially deprived or isolated captive males. Trauma may stem

from aggressive cage mates, either male or female. Affected gliders present with varying degrees of necrosis, hemorrhage, and swelling. Pain may result in dysuria and bladder distention. In severe cases, septicemia and shock may result. Treatment includes supportive care and broad-spectrum antibiotics such as enrofloxacin (5 mg/kg orally every 12–24 hours) an analgesic such as buprenorphine (0.01–0.03 mg/kg subcutaneously every 12–24 hours) a nonsteroidal anti-inflammatory drug such as meloxicam (0.1–0.2 mg/kg subcutaneously or orally every 24 hours). Severe bladder distention can be temporarily addressed with cystocentesis, preferably under general anesthesia. Surgical removal of the necrotic portion of the bifid penis is performed, avoiding the urethral opening. If the entire penis is necrotic, urethrostomy may be required, which is especially difficult when tissue surrounding the urethra is inflamed. In some cases, surgery is delayed until the patient is stable and swelling is reduced. Castration seems to be preventive and indicated once the sugar glider is stabilized.

Prostatitis in intact males presents with hematuria, local pain, constipation, anorexia, and elevated rectal/cloacal temperature. Treatment includes broad-spectrum antibiotics, analgesics, anti-inflammatory medications, and supportive care.[17] Antihormonal medications such as bicalutamide (Casodex; AstraZeneca, Wilmington, DE, at 5 mg/kg orally every 24 hours) and leuprolide acetate, depot formulation (Lupron 30; Abbvie Inc, North Chicago, IL), may be useful in controlling hormonal stimulation to the prostate. Castration is recommended.

Brazilian, Laboratory, Gray, Short-Tailed Opossum (M domestica)

There are few gross and histologic lesions of the genital tract reported in *M domestica*. In females these include ovarian cyst, mineralized ovary, metritis, uterine cyst, endometritis, uterine hemorrhage, and uterine metaplasia. Mammary gland abscesses have also been found. In males, lesions include testicular atrophy, testicular granuloma, testicular cyst, edematous testicle, hydrocele, and necrotic testicle. There are also sporadic reports of adenitis, hypertrophy, or cysts in the accessory sex glands.[18]

Although uncommon, various neoplasia of the genital tract has been reported.[18] Neoplasms include uterine leiomyoma, mammary gland papillary cystadenoma, and penile fibrosarcoma. Of interest are reports of pituitary adenoma with prolactinemia.[19] These tumors are apparently similar to hemorrhagic adenomas found in Wistar rats.[19] Although noninvasive tumors are locally expansive and may compress adjacent neuroparenchyma, they stain strongly for prolactin. Affected animals present with patchy, endocrine alopecia (**Fig. 7**).[19]

Virginia Opossum (D virginiana)

Conditions reported in female Virginia opossums include uterine prolapse, endometritis, mastitis, mammary hyperplasia, and mammary adenocarcinoma.[2,20] In males, prostatitis presents with clinical signs of hematuria, local pain, constipation, anorexia, and elevated rectal/cloacal temperature.[2] Treatment includes broad-spectrum antibiotics, analgesics, anti-inflammatory medications, and supportive care. Antihormonal medications such as bicalutamide (Casodex at 5 mg/kg orally every 24 hours) and leuprolide acetate, depot formulation (Lupron 30), may be useful in controlling hormonal stimulation to the prostate. Castration is recommended.

An unusual Cushingoid syndrome secondary to genital tract infection in female Virginia opossums has been described.[21] Although clinical signs mimic true Cushing's disorder, a primary lesion in either the pituitary or adrenal glands has not been confirmed. Cases featured obese females, with a history of previous or current urinary tract infections and periodic mucoid discharge from the genitourinary opening. Affected animals have had previous trauma altering normal urinary patterns; they

Fig. 7. Endocrine alopecia in a short-tailed opossum.

may have held urine longer than normal or incompletely evacuated the bladder. Clinical presentation included brown discoloration of the fur and slight thinning to full alopecia. All seemed to be slightly to moderately depressed and had variable anorexia and pelvic limb weakness. Many had neutrophilia with elevated left shift, and some were anemic. Urinalysis found high bacterial loads (various coliforms, *Staphylococcus* sp.), and antibiotics were selected based on culture and sensitivity results. Amoxicillin at 20 mg/kg orally every 12 hours and trimethoprim sulfa at 10 to 20 mg/kg every 12 to 24 hours are the most commonly used. Many animals responded to therapy but relapsed once antibiotics were discontinued. It was postulated that urinary tract infection can lead to metritis or vice versa. Treatment was complete ovario-vaginal-hysterectomy including the lateral canals. If the vaginal canals are left, they may continue to serve as a nidus to infection. Surgery was curative.[1,21]

Macropods: Tammar Wallaby (M eugenii); Bennett's Wallaby (M rufogriseus)

A herpesvirus has been linked with transient infertility, ulcerations, and lesions in the genitourinary area of Tammar wallabies living on Kangaroo Island, South Australia. Diagnosis was via serology and histopathology. There were no mortalities. Herpesviruses may also cause ocular/nasal discharge, lingual ulcers, depression, anorexia, and death in other wallaby species.[22] A Sertoli cell tumor was reported in an aged red kangaroo.[2] Neoplasias of the reproductive tract have been documented in several species of macropod and include ovarian stromal tumor, pouch basal cell epithelioma, mammary carcinoma with pulmonary and renal metastases, and testicular seminoma.[16]

Although bacterial diseases of the reproductive tract of macropods are poorly documented, antibiotics described for use in macropods include oxytetracycline (long acting, 20 mg/kg intramuscularly every 72 hours), clindamycin (unpalatable, 11 mg/kg orally every 12 hours), metronidazole (use benzoate for palatability, 20 mg/kg orally every 12 hours), enrofloxacin (5 mg/kg subcutaneously, 1 injection or orally every 24 hours), ceftiofur sodium (1–2 mg/kg intramuscularly or intravenously every 24 hours), gentamycin plus amoxicillin (4–7 mg/kg intramuscularly every 12 hours plus 10 mg/kg intramuscularly every 8 hours, respectively), and procaine penicillin/benzathine penicillin G (30 mg/kg intramuscularly every 48 hours).[16]

Other Marsupials

A cytomegalovirus-related prostatitis was reported in Australian dasyurid marsupials, *Phascogale tapoatafa* (brush-tailed phascogale), *Antechinus stuartii* (brown antechinus), and *Antechinus swainsonii* (dusky antechinus).[23,24] Lesions were most common in mature animals during breeding, times of stress, or in animals treated with high levels of corticosteroids. Venereal transmission was postulated. Affected dusky antechinus males succumbed and often died 2 to 3 weeks after breeding.

SURGERY OF THE REPRODUCTIVE TRACT OF MARSUPIALS

Anesthetic techniques are described elsewhere but should include premedication (an opioid and a sedative such as midazolam at minimum) and induction and maintenance with inhalant agents. Testicular and incisional blocks are easy to perform; the authors use 2 mg/kg each lidocaine and bupivacaine combined into a single syringe. In many cases, drugs must be diluted for accurate dosing in small patients (Figs. 8 and 9B).

Marsupial Castration

Castration is performed to reduce the natural odors of some species, in particular the sugar glider, to reduce social tension and for birth control.

Castration can be performed scrotally or prescrotally along the scrotal stalk. This distinction is often referred to by sugar glider breeders or enthusiasts as *pom on* or *pom off*, and some appear to have a preconceived preference for one technique over the other. However, in the authors' experience, both techniques are equally suitable for all marsupials if performed correctly.

For the prescrotal technique, an incision is made in the stalk midway between the scrotum and the abdominal wall. The spermatic cord is easily separated from the skin, clamped, ligated close to the body wall, and transected. The entire scrotal sac including the testes is removed. Subcuticular sutures can be used to close the incision. Alternatively, a radiosurgical unit or surgical laser can be used to simply ligate the stalk.

One author has seen opening of the suture site when the incision is made too close to the abdominal wall, possible caused by retraction of the remaining cremaster muscle.

For the scrotal technique, a single incision can be made into the scrotal sac and both testicles isolated and the spermatic cord ligated with suture or hemostatic slips. In sugar gliders, a single small hemostatic clip can be placed over the spermatic cords of both testes. The incision is then manually sealed without glue or suture (Fig. 9).

Fig. 8. Incisional block in a wallaroo (*M robustus*).

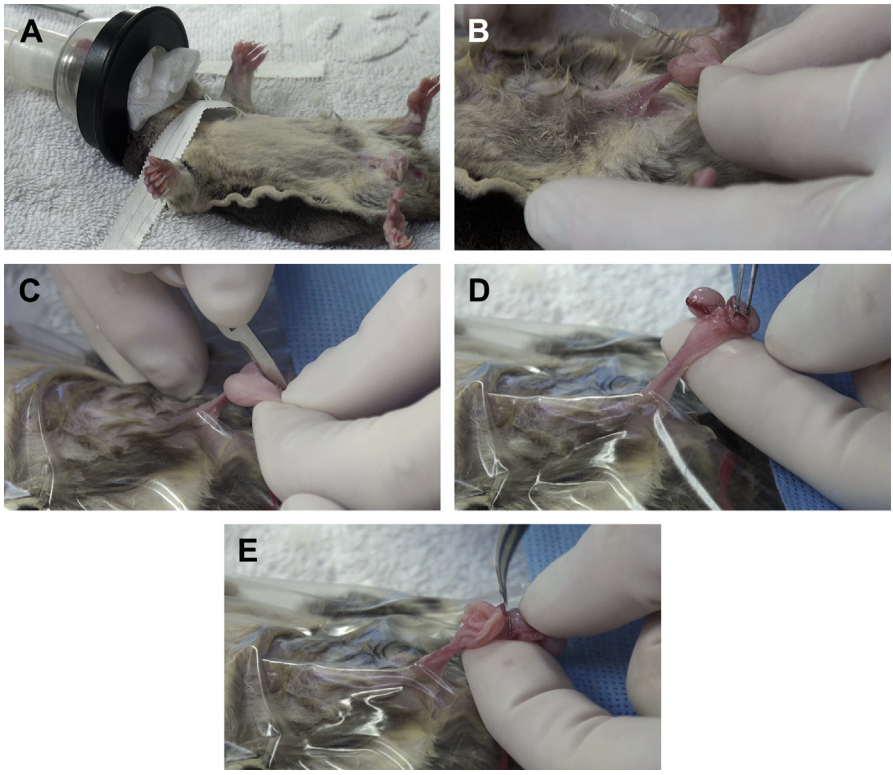

Fig. 9. Scrotal castration in the sugar glider. (*A*) After premedication, the patient is mask induced and placed in dorsal recumbency. (*B*) Lidocaine/bupivacaine testicular block is administered. (*C*) Note the use of transparent drapes to allow direct visual monitoring of the patient. A single incision is made into the scrotal sac. (*D*) Both testicles and spermatic ducts and vessels are isolated. (*E*) A single small hemostatic clip is used to ligate both. After ligation, the incision is opposed without suture or glue.

Techniques to prevent post castration mutilation include careful aseptic surgical technique, minimal use of sutures, clips or glue, and multimodal analgesia.[15,17,25,26]

Marsupial Ovario-Hysterectomy and Ovario-Vaginal-Hysterectomy

There are no confirmed health benefits associated with elective altering of female marsupials; however, the procedure may be performed therapeutically or for birth control in mixed groups.

As mentioned above, in females, most of the genital tract can be removed, but this is complicated by the position of the ureters. In obese animals, it may not be possible to isolate the ureters. If the ureters cannot be clearly isolated, the ovaries and uterus can be removed, leaving the central and lateral vaginal canals. In marsupials with pouches, the incision is made midline through the inner wall of the pouch. The mammae should be avoided. Ovarian vessels should be ligated and each ovary lifted. The uterus can be clamped as a pedicle at the junction with the vaginal canals if these will not be removed. The uterus is then ligated at the junction with the vaginal canals using a pedicle ligation. If the ureters can be isolated, then the vagina is

clamped just proximally to where the bladder empties into the urogenital sinus. Careful blunt dissection is necessary to avoid tearing the ureters (Fig. 10). The abdominal incision should be closed, as in other mammals. Subcuticular sutures may prevent disruption of the suture line. Postoperative analgesics are indicated, as in other species.[1,15,17]

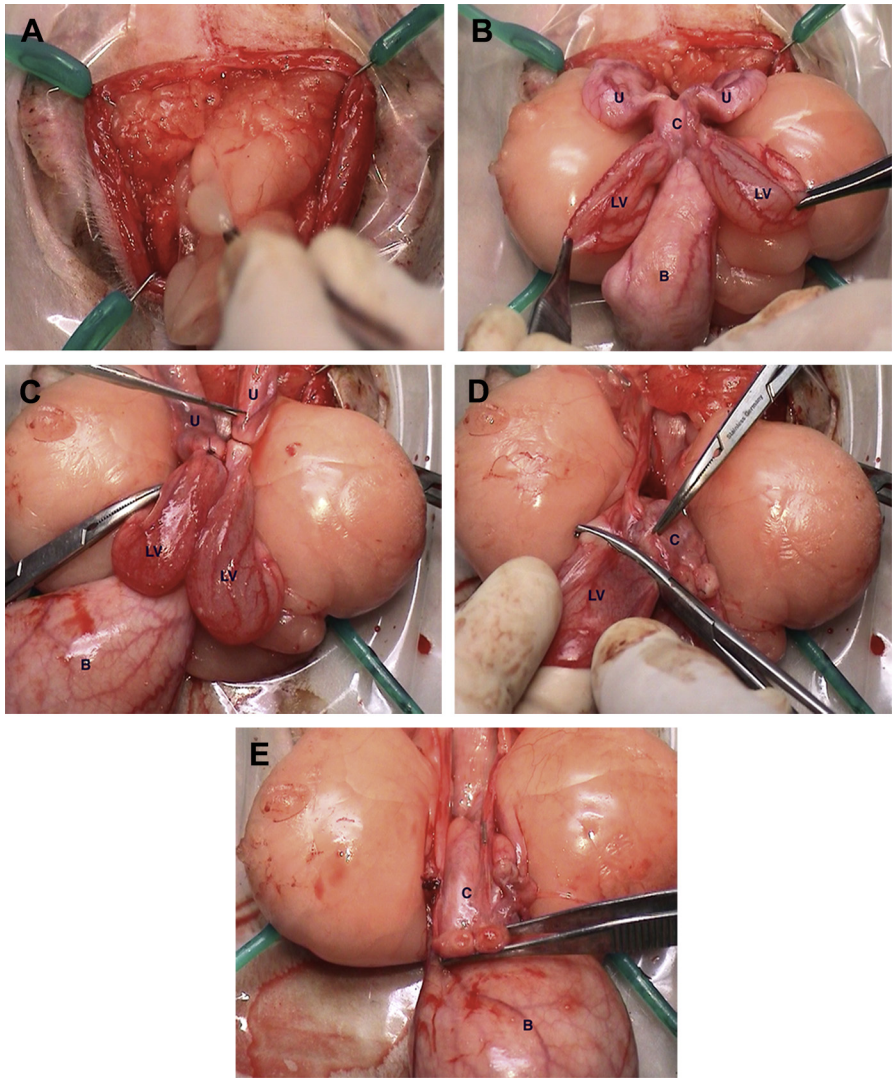

Fig. 10. Ovario-vaginal-hysterectomy in the Virginia opossum. (*A*) The incision is midline, directly into the skin of the pouch. In most patients, there is ample abdominal fat. (*B*) Surgical appearance of the reproductive tract. Note the bladder (*B*), the uterus (U) and the lateral vaginas (LV). The central vaginal canal (C) contains the openings of the ureters. (*C*) Ligation of both uterine horns (U). (*D*) Clamping for transection of the right lateral vagina (LV). (*E*) Finished procedure with removal of both uterine horns and lateral vaginas, leaving the central vaginal canal (C).

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