Abstract
Any abnormality that impinges on the bull’s ability to achieve either erection and extension of the penis or insertion and penetration of the vagina results in immediate infertility. Abnormalities may be congenital: persistent frenulum, micro-vascular shunts of the corpus cavernosum penis; infectious: fibropapilloma; or acquired: penile hematoma, preputial prolapse, phimosis, paraphimosis, hair rings, etc. Some conditions such as penile deviations may be developmental in nature or result from injury. Repair in turn may be relatively simple such as transecting a frenulum tag or removing a single wart. Severely damaged preputial tissue resulting in either phimosis or conversely paraphimosis with extensive damage to preputial tissue may require lengthy hospitalization and aggressive surgical intervention. Additionally, provision of an accurate prognosis and reliable cost estimate is critical to the prospective consumer (client) of these services.

Keywords: Bull, penis, prepuce, injury, hematoma, prolapse, surgery

Introduction
With recent increases in the value of breeding bulls, procedures both medical and surgical that are aimed at restoring breeding function should increase in demand. Economics, both the value of elite genetic bulls and the costs of providing surgical and medical treatments are factors in the demand for these techniques. Phenotype and breed popularity likewise impact demand as many surgical conditions have breed/type predisposition. Virtually all of the restorative surgery techniques utilized today for injuries and conditions affecting the penis and prepuce of the bull were first described over 30 years ago. These procedures, any updates or improvements, as well as cost saving measures will be the focus of this paper.

Persistent frenulum
Separation of the skin that connects the penis to the prepuce begins around four months of age in bull calves and should be complete by one year of age. Partial or complete failure of separation results in an inability to extend the penis. Individuals with Brahman influence may however have enough redundant preputial tissue that extension is possible, but these must be corrected as well because this tissue is extremely prone to injury. In the vast majority of cases diagnosis is made during the breeding soundness examination (BSE) and this is of course a reason that full extension of the penis allowing complete visualization is a crucial aspect of a correctly performed BSE. This also represents an appropriate time to correct this abnormality and in fact some will tear when the penis is extended. Correction is straightforward. Simply transect the tissue band, utilizing hemostats or sutures if needed.

Fibropapilloma
Fibropapilloma or warts are a common finding in young cattle under the age of 24 months. Group housing of young bulls along with a predisposition for homosexual behavior both increase the incidence and add to the possibility that the penis will be among the affected locations. Penile warts are usually identified at the time of breeding soundness examination and again underscore the importance of visualizing the penis during semen collection. Alternatively, young bulls that are reluctant or unable to breed may be affected. Bulls may present with either phimosis or paraphimosis. Careful surgical removal whether it be by excision, cryotherapy, use of a laser, alone or in conjunction with immunization are possible management modalities. Immunization can be accomplished with the use of either a commercial or prepared autogenous wart vaccine. For many years one of the authors (Hopper) recommended the use of a commercial wart vaccine for clients with bulls being prepared for shipment to bull test stations where they would be housed with multiple bulls from multiple
sources. Additionally, this author found the use of an autogenous vaccine to be of value in herds that were experiencing a high incidence. A description of the preparation of autogenous wart vaccine is included as an addendum.

Hair rings

Less common than warts, the presence of a hair ring is likewise due to homosexual behavior and group housing of young bulls. Accumulation of hair during riding and the continuous action of riding, extension and retraction of the penis serves to create a tight band of hair. These are typically identified during a BSE and treatment is simply removal and application of a suitable ointment. Careful examination to determine the depth of the lesion and possible damage to the urethra\textsuperscript{2} is warranted. Small fistulae will typically heal, but those that are larger, more proximally located should be closed.

Preputial injury

Preputial prolapse is alternatively a predisposing factor or result of trauma and bruising of the prepuce. It is more common in the Brahman influenced breeds due to their pendulous sheath, redundant preputial tissue, and larger preputial orifice.\textsuperscript{2,5} Polled breeds typically lack the preputial retractor muscle thus exacerbating the condition when combining genetics with the Brahman. Minor trauma with prolapse (Grade 1) can be treated with various medications and wrapped. More extensive trauma with swelling and the presence of necrotic tissue (Grades 2-4) requires a more aggressive approach and because these cases result in fibrosis of the preputial tissue surgical correction.

Prior to bandaging the prepuce the wounds should be cleaned and an attempt should be made to replace the prolapse. This can be facilitated with hydrotherapy (water hose spray, showerhead spray, or soaking). Soaking the prolapsed prepuce in a hypertonic solution (water with salt and/or sugar added) with the addition of povidone iodine also serves to aid in the debridement of the tissue. After drying an ointment is applied. The author prefers the petrolatum, tetracycline, and scarlet red oil mixture (Petercillin-Auburn)\textsuperscript{5} for severely traumatized, necrotic wounds and utilizes less irritating ointments (Sugardine or mammary infusion ointments) for less affected tissue or after several days of treatment when the tissue is less inflamed. A 6-10 inch rigid plastic hose (milk line or equine nasogastric tubes can be used) is then placed within the prepuce to allow urination and the prepuce is wrapped with elastic tape (Elasticon\textsuperscript{TM}, Johnson and Johnson, New Brunswick, NJ). In addition to facilitating urination, the placement of the tube helps decrease the circumferential scarring down of the preputial orifice which results in phimosis. Bandage change intervals are dictated by the extent of damage, the bull’s tolerance for the bandage, and whether or not you can completely replace the prepuce within the sheath. Following resolution of swelling (infection/inflammation) a decision can be made to return the bull to use or surgically correct.

Often a client will choose to cull, rather than allow treatment. Because these bulls are the victims of severe price discrimination the author will offer a salvage type procedure. A large swine rectal prolapse ring or short length of polyvinyl chloride (PVC) pipe is placed within the preputial lumen dorsal to the lesion and a band is placed around the prepuce. This will amputate the damaged prepuce, but fibrosis and stenosis will likely occur. Alternatively holes can be drilled in the PVC pipe prior to placement and rather than a band, heavy (6 mm) synthetic suture material is utilized in an overlapping pattern that serves to both fix the tube and provide for hemostasis when the end of the prepuce is amputated. This is the “ring amputation” procedure and can be performed with the bull standing, utilizing local analgesia and chute restraint. This procedure usually results in some degree of stricture, and also may be considered for the client that desires a more economical option than treatment followed with surgical correction by circumcision. It should be noted that correction with the circumcision technique remains an option for bulls in which the ring amputation resulted in a stricture.

The surgical technique that is advocated by the authors is the circumcision or “reefing” technique. This procedure can be performed with regional analgesia, specifically the pudendal nerve block (described in: Management of urogenital injury and disease in the bull: the scrotum and its contents. Clinical Theriogenology, Volume 4, Number 3) and mild sedation. Prior to surgery, the bull is fasted for
48 hours and water withheld overnight. The bull is placed in right lateral recumbency and the hair of the sheath is clipped. The penis is extended and maintained in extension with towel forceps that engage the apical ligament. The penis and prepuce are prepared for surgery (no alcohol) and draped. Apply a tourniquet (one inch Penrose tubing) proximal to the area to be transected. The amount of prepuce to be resected is then determined, marker sutures (to insure that tissues are returned to the proper alignment) are placed, and two circumferential incisions are made. These incisions are joined with a longitudinal incision. These incisions are to be very superficial so that with careful, sharp dissection; underlying tissue, blood vessels, and lymphatics will be spared. The area of fibrosis should be included in the tissue removed. Following dissection and tourniquet removal (the tourniquet can be maintained safely for up to one hour); hemorrhage is controlled by vessel ligation and/or cautery. When hemostasis is achieved, the area is lavaged with a warm solution of sterile saline and povidone iodine solution (50 ml povidone iodine per liter of saline). The edges are sutured with a simple continuous subcuticular pattern using the surgeon’s choice of 2-0 absorbable suture material.

Do not use one continuous suture, but instead end the pattern and re-start in three stages to avoid a constrictive (purse-string) effect. Do not close dead space. Follow this with a row of staples. Then suture in place Penrose tubing over the end of the penis. An antibiotic ointment is applied to the wound and placing the free end of the Penrose tubing into a 6 to 10 inch rigid tube, the penis and prepuce are carefully returned into the sheath and bandaged. The bandage can stay on as long as a week; the staples can be removed in two weeks. A support wrap (bull diaper) can be employed to protect the bandage and prevent pendulous swelling.
Preputial injuries that occur in bulls of English or Continental breeds typically result in phimosis rather than prolapse and therefore represent a different sort of challenge. If the penis is forcefully extended and then not repaired and replaced within the sheath at the same time, paraphimosis may result. The prepuce can be lavaged with an antiseptic solution. Then apply an ointment of the operator’s choice and allow second intention healing to occur. Ascertain the extent of fibrosis and whether or not the penis can be extended (some bulls that can extend will still require surgery). The scar tissue must be removed to allow easy, painless, and full extension of the penis. Unlike the Brahman influenced bull, these bulls rarely have enough preputial tissue to allow for a circumcision. A scar revision technique is utilized. Following a pudendal block and preparation as described previously, an elliptical incision than includes the scar is made. Simply stated, the incision is made on whatever plane necessary to facilitate dissection of the scar, but closed on a longitudinal plane. Closure technique is crucial. A “bootlace” pattern is initiated distally (on the extended penis) and then continued proximally.

After completion the penis is released and allowed to return back within the prepuce before the suture ends are tied. Tightening and tying off the suture prior to this will prevent retraction. A Penrose
drain is sutured to the end of the penis to facilitate urine drainage as described in the previous technique, but bandaging is usually not required. The sutures can be removed in two weeks or an absorbable suture can be used. The penis should be extended and examined prior to return to service.

In the case of either circumcision or scar revision the bulls should receive three months of sexual rest prior to return to service.

**Hematoma of the penis**

Hematoma of the penis is probably the most common injury of the penis. This injury occurs when the penis misses the intended target, hits the cow’s perineum, and bends. Although it usually occurs in young inexperienced bulls it can also occur in the older bull, which due to orthopedic injury or pain has altered his approach during mounting. The hematoma results due to rupture of the tunica albuginea and the subsequent hemorrhage from the corpus cavernosum. The initial volume of blood escaping is less than 250ml but the size of the resultant hematoma varies as each subsequent erection results in further hemorrhage. Thus the hematoma may range in size from 15 to 30 cm. The resultant swelling occurs in the sheath over and cranial to the rudimentary teat.

A prolapsed prepuce often results and this in fact may be the owner’s reason for seeking help. Diagnosis may be aided with ultrasound. Do not attempt to aspirate the swelling as inadvertent introduction of bacteria can convert a hematoma to an abscess. From a prognostic standpoint, smaller (<20cm) hematomas respond equally well to conservative, medical therapy as they do to surgery, but larger (>20cm) hematomas have a much better response (75-80% versus 33%) with surgery.

Regardless which treatment plan is to be followed, systemic antibiotic treatment should be started. Medical treatment consists of continuation of antibiotics (procaine penicillin- 22,000 IU/kg, IM, bid), hydrotherapy, and sexual rest. Surgical correction should occur immediately. Given that the owner or attendant typically may not notice this problem for two to three days, that the patient must be fasted for two days prior to surgery, and that after 10 days organization of the clot and fibrosis has occurred; time is of the essence.

Once the decision is made to attempt surgical correction, antibiotic therapy is instituted if not already begun and feed is removed. The bull is fasted for 48 hours and water withheld overnight. General anesthesia can be utilized or regional anesthesia with heavy sedation. Either way the bull is tabled in right lateral recumbency with the left hind leg pulled back and up; fastened securely. The surgical area is prepared and a vertical incision 20-25 cm long is made just cranial to the rudimentary teat.
Careful dissection, attention to hemostasis, and manual removal of the blood clot follows. Lavage with a warm saline povidone iodine solution aids in the removal of additional clots and coupled with blunt dissection, identification of the lesion. Careful blunt or manual dissection is not just preferred over scalpel or scissor dissection, but mandatory as injury to area vasculature and nerves must be avoided.

Once the tear or rent is identified, carefully lavage the area again and debride the often tattered edges of the rent. This must be minimal as excessive removal of tissue complicates closure and following healing there is the potential that the bull will have trouble extending his penis. Closure of the defect with number 1 polyglycolic acid (PGA) in a bootlace pattern is the long-standing recommendation and justifiably so, as there is enough wound tension to make simple interrupted suture patterns problematic. The elastic layers over the penis can be closed with 3-0 chromic catgut in a simple continuous pattern. The penis is then returned to its normal position, the subcutaneous tissues are closed with 0 chromic catgut and the skin can be closed with 6 mm synthetic non-absorbable suture material typically with a Ford interlocking pattern. Antibiotics are continued for five to seven days. The bull should have 60-90 days of sexual rest following surgery. Seroma formation occurs often enough that it probably should not be considered a true complication.

Complications include abcessation, suture dehiscence, reoccurrence in subsequent breeding seasons, and permanent analgesia of the penis. Loss of sensation, however, likely results from the initial injury, rather than the surgery.

Penile deviations
This discussion will be limited to diagnosis of the two common deviations; spiral deviation (corkscrew) and ventral deviation. Both likely result from abnormalities of the apical ligament and both are amenable to surgical correction. Diagnosis of the spiral form should be made by observation of a natural mating attempt. The penis normally spirals to some extent upon intromission and this same level of spiraling is often manifested during electroejaculation. When this is severe enough to interfere with normal copulation the decision must then be made to cull the bull or attempt correction. Diagnosis of a ventral deviation can be made by observation during electroejaculation or mating.
Ventral deviation of the penis

Spiral deviation of the penis

The surgical procedure which the authors recommend for correction is the fascia lata implant technique previously described by Walker and Young. A rectangular strip of fascia is harvested from the bull, cleaned (areolar tissue removed), and placed between the apical ligament tunica albuginea. Alternatively, synthetic surgical mesh material can be used to substitute for the fascia implant. Utilization of the mesh has the obvious advantage of removing the time-consuming fascia harvesting step and has recently been successfully utilized without complication. However, problems with post-operative infection with the mesh materials of the day along with dissatisfaction with the apical ligament “strip” technique were the impetus stated by Walker for the development of this technique. Thus, the fascia lata technique will be described and those that prefer can easily modify the technique to utilize surgical mesh.
The bull is fasted 48 hours and water withheld overnight. Depending on his nature, the bull is sedated with 10-20 mg xylazine and 10 mg acepromazine IV. With the bull restrained and standing, the surgical site, an area on the upper left hind limb, is prepared since the bull will later be placed in lateral recumbency on his right side. A local block utilizing an inverted L injection pattern is administered. A 15-20 cm incision is then made utilizing the patella and greater trochanter as anatomical guides, with the incision being midway between. When the fascia lata is exposed, remove a rectangle shaped section. Removing a 3 cm wide by 15 cm long section will provide more than enough tissue for the graft.

Place the tissue in saline maintaining sterility and suture the edges of the fascia with a continuous pattern utilizing any number 1 or 2 absorbable suture. Failure to do so will result in painful muscle herniation. Close dead space and suture the skin with number 3 nonabsorbable synthetic suture material utilizing a Ford interlocking pattern. The harvested tissue is then prepared by rinsing in saline and removal of any attached tissue.

The bull can then be prepared for the placing of this graft material or synthetic mesh material of the same size. As with the other surgeries described, general anesthesia can be utilized or regional anesthesia with heavy sedation. Next the bull is tabled in right lateral recumbency and the preputial area is clipped and prepared. The penis is then extended and the apical ligament identified and grasped with towel forceps. The penis is prepared with povidone iodine surgical scrub, rinsed with sterile water or saline, and dried. Unlike when performing a circumcision a tourniquet is not utilized as the surgeon will want to be able to easily visualize the area vasculature. An incision is made on the central dorsal aspect of the penis from a point 3 cm from the tip and extending 20 cm proximally. With careful dissection, identify the apical ligament and incise through it for its entire length. This incision will expose the tunica albuginea and this is where the fascia or alternatively the synthetic mesh implant will be placed. The proximal aspect is placed first and sutures (2-0 chromic catgut) are placed in the corners attaching the implant material to the tunic. Interrupted sutures are then placed on the lateral sides of the implant, stretching the implant so as to avoid crumpling of the tissue. Care is taken to not penetrate too deeply into the tunic and to avoid suture placement that impinges on the dorsal vasculature. The distal end of the implant is trimmed if necessary and the distal end is sutured as previously described.
The edges of the apical ligament are then closed utilizing 0 chromic catgut with every other or every third suture engaging the implant. This suture will keep the apical ligament from slipping to the side which is crucial in correcting a spiral deviation. The elastic tissues and dead space are closed with a continuous suture pattern (3-0 or 4-0 chromic catgut) and the skin can be closed with 0 chromic catgut or other absorbable suture using an interrupted pattern. The incision site is gently rinsed with a dilute povidone iodine solution, an antibiotic ointment (bovine intramammary infusion medication) is liberally applied, and the penis is returned to the prepuce. Systemic antibiotics are administered for four to five days and the penis can be manually extended for examination in seven to 10 days. Three months of sexual rest is recommended.

Conclusion

Increasing sale prices for bulls should increase demand for these procedures. Foregoing general anesthesia through the use of regional analgesia, sedation, and proper restraint decreases the cost associated with these surgeries, making these procedures more economical for owners and more profitable for the veterinarian. Careful evaluation of penile and preputial injuries provides better diagnosis and allows for a more valid prognosis. All of these factors could possibly combine to signal a return to the time when bull doctors ruled the veterinary world!

References

Addenda

Preparation of an autogenous wart vaccine
- Excise wart material
- Trim off exterior material and clean with soap and water
- Mince tissue with scissors or scalpel and mix with saline 10:1
  Or mix with saline and place in blender
- Strain homogenate through gauze
- Add 5 cc of 10% formalin to 95cc homogenate
- Incubate for 24 hours at 37° C
- Culture a small aliquot for 24 hours to check for sterility
- Balance pH with bicarbonate solution
- Refrigerate until used
- Inject subcutaneously
  OWNER CONSENT and when dispensed the author provided epinephrine.

Material list for construction of a “bull diaper”
- 11/2 yards of heavy cotton material
- Large laundry bag for the netting
- Nylon straps- ( 3 per diaper)
- Grommets --hardware or craft store
- Bungee cords
- Pipe insulation for padding
- Duct tape

Petercillin recipe
- 500 g anhydrous lanolin
- 2 g tetracycline powder
- 60 ml scarlet oil

Editor’s Note: The photographs in this paper appear in color in the online version of Clinical Theriogenology (http://st.omnibooksonline.com/).