

Diagnosis of penile denervation in the bull: a review

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Abstract

Healthy bulls with satisfactory breeding potential are important to the beef cattle industry. Erection, mounting, intromission, and ejaculation with deposition of semen into the cow's reproductive tract define successful mating for a breeding bull. Healthy bulls with satisfactory breeding potential are a vital part of the beef cattle industry. While injuries to the penile nerves are relatively uncommon, damage to the dorsal penile nerves is often a career ending injury for a bull. Disease processes that commonly affect the dorsal nerve of the penis include penile hematomas (via rupture of the tunica albuginea) and complex preputial injuries extending into penile tissues. Penile hematomas, cavernosal shunts, and complex preputial injuries can all cause failure of the penis to effectively achieve intromission. Evidence of failed intromission is most commonly described as continual searching of the bull's glans penis during mounting and absence of the ejaculatory lunge. Disturbance of the dorsal nerve of the penis is strongly suspected following a test mating where no structural or musculoskeletal abnormalities are noted, yet the bull fails to achieve intromission. Definitive diagnosis of denervation of the dorsal nerve of the penis requires advanced diagnostics. The sensory nerve conduction velocity test evaluates nerve functional integrity via measurements of amplitude and velocity of delivered electrical signals. An efficient and rapid diagnosis of dorsal penile nerve injury is important to provide the owner a useful prognosis so that they can make an appropriate management decision to diminish economic losses.

Keywords: Bull, penile, denervation, nerve, conduction, velocity

Introduction

The act of mating, which includes erection, mounting, intromission, and ejaculation in the bovine species is a rapid process that can be difficult to witness from afar as the entire process lasts approximately 15 seconds.^{1,2} When bulls present for infertility, whether that be due to a high percentage of open cows in the herd or inability to properly breed, the first step is to perform a bull breeding soundness examination (BBSE). A BBSE following the standards set by Society for TherioGenology includes, a physical exam, examination of the accessory sex glands (Figure 1), scrotal circumference, and evaluation of a sperm motility and morphology. Evaluation of libido or breeding ability is not included in a standard BBSE in the United States. When a bull suspected of infertility successfully passes a BBSE the next step in the infertility workup is to perform a test mating. A test mating will allow visualization of the act of coitus while allowing confirmation that the bull has the libido and structural soundness to achieve an erection, mount the female, and successfully achieve intromission and ejaculation.

Review of normal anatomy and normal mounting

Innervation to the penis is supplied by the paired pudendal nerves which eventually branches into the paired dorsal nerves of the penis (Figure 2).^{1,3} Injuries that result in the inability to successfully achieve intromission most commonly involve both of the paired dorsal nerves of the penis.² This was proven by Beckett et al. when bulls that underwent unilateral dorsal penile neurectomies were still able to achieve intromission and ejaculation; however, time from mounting to copulation and ejaculation was prolonged.⁴ Unilateral neurectomy did result in the inability of one bull to complete copulation and ejaculation, though it was noted that the affected dorsal nerve contained over 75% of the innervation for the penis of that particular bull. This finding led to speculation that if there is an uneven distribution of sensory neurons in the paired dorsal nerves, unilateral neurectomy can prevent copulation.⁵ In the aforementioned study, bilateral neurectomy of the dorsal nerves of the penis was performed and all affected bulls were unable to successfully achieve intromission and did not ejaculate.^{2,4}

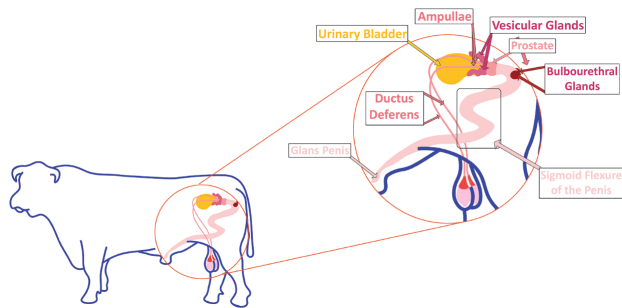


Figure 1. Gross reproductive anatomy of the bull, courtesy of Jamie M Douglas.

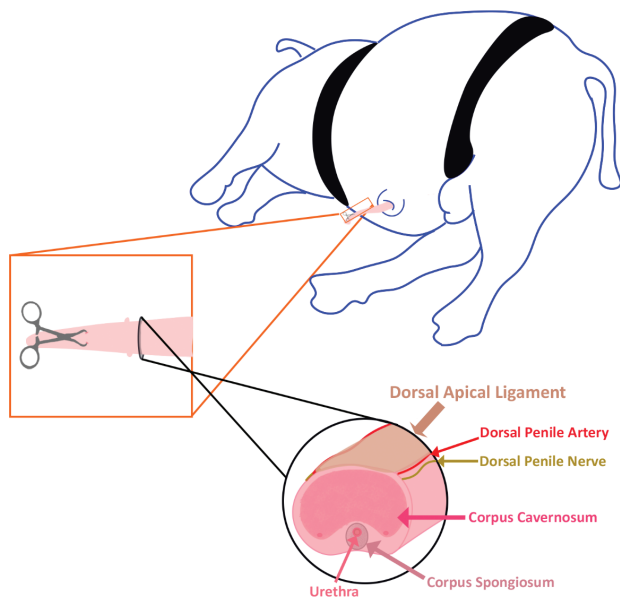


Figure 2. Bull in right laterally recumbency, penis is held in extension via the backhaus towel clamp secured by the dorsal apical ligament. Associated cross section of the bull distal penis, courtesy of Jamie M Douglas.

Etiology

Injuries such as rupture of the tunica albuginea with resultant hematoma formation can directly or indirectly cause insult to the dorsal nerve of the penis.⁵ Direct insults to the penile nerves occur when the nerves are directly injured. For example, with laceration of the glans penis (Figure 1) or tunica albuginea rupture, profuse hemorrhage from the ruptured corpus cavernosum penis could directly affect the penile nerves. Indirect insult occurs in instances of scar tissue remodeling or entrapment of the penis by scar tissue.⁵ Penile hematomas occur at the dorsal aspect of the distal bend of the sigmoid flexure (Figure 1) when the penis is at peak erection.¹ Rupture of the tunica albuginea occurs following an acute, severe increase in the corpus cavernosum penis pressure due to a sudden bending of the penis. Such bending can occur when the bull makes the ejaculatory lunge and fails to complete intromission, or because of similar bending associated with a sudden fall of either the bull or female during mating.¹ Clinically, rupture of the tunica albuginea is seen as a swelling directly cranial to the scrotum.¹ Penile hair rings associated with the homosexual riding of young bulls housed with other

young bulls, along with masturbatory behavior are other examples that threaten to result in indirect insult to the penile nerves. Injury in these instances often results from avascular necrosis of the penis and associated damage of the dorsal nerves of the penis due to the constriction of the penis from the entrapped hair.¹

Diagnostics

Diagnostics for accessing the function of the dorsal nerves of the penis include test mating, semen collection utilizing an artificial vagina, a direct noxious stimulus to the penile skin, and nerve conduction velocity testing.

The ability to achieve intromission (assess nerve function) is not routinely performed during a standard BBSE. If penile denervation is suspected, utilization of hemostats or fingers to manually pinch the skin on the free portion of the penis, in attempt to elicit a withdrawal response, can be performed.² However, absence of a withdrawal response does not confirm lack of penile sensation. Some normal bulls simply exhibit a decreased withdrawal reaction.²

The most commonly utilized diagnostic test for evaluating penile nerve innervation, ability to achieve a complete erection, and presence of any structural abnormalities, such as a ventral deviation of the penis is through the utilization of a test mating.^{1,4,5} While it is possible to perform a test mating with limited facilities, the test will always require the presence of a cow or heifer in standing heat. Ideally, evaluations of mating ability should be performed in a quiet small area that ensures room for movement or, better, in larger facilities employing stanchions to restrain the mount animal. The test mating area should also allow adequate observation of the copulatory event and limit any distractions for the bull.² The area should be level, providing for secure, well-maintained footing to ensure that adequate stabilization of the pelvic limbs can occur during mounting and the ejaculatory thrust. This area should also include viewing areas from all sides of the pen or enough room to safely observe the mating while in the pen along-side the animals.

The following events describe what usually occurs in a normal test mating. Initially, the bull will approach the female from the side, after which the bull will nuzzle the vulva once at her hind-quarters. The bull then traditionally exhibits the flehmen response, ensuring the female is in estrus.^{1,2} Once estrus is confirmed, the bull's prepuce will drop while the erection process is occurring. Just prior to mounting the pelvis of the cow the bull will chin press on the cow's rump. Provided the cow is standing still, the bull will then mount the cow. Once mounted, the bull will quickly align himself directly behind the cow and make two to three searching motions with the glans of the penis near the vulva. Once the vulva is located, a single ejaculatory lunge facilitates intromission and ejaculation, after which the bull will dismount.² Bulls experiencing penile denervation will elicit normal test mating behavior until they have mounted the cow, affected bull's often place their penis alongside the tail head of the cow or on the udder ventral to the cow's vulva, rather than on the vulva itself. The normally observed searching motions of the glans are not performed and intromission does not occur.² (see Video 1 for test mating).

The use of a testing mating using an artificial vagina can also be utilized for penile nerve assessment. Once the bull has

been properly stimulated to cause protrusion and erection, an artificial vagina may be placed over the penis.² Normal bulls ejaculate soon after the placement of the artificial vagina. Bulls with injury to the dorsal nerves of the penis fail to ejaculate.² False negative test results can occur when performing test mating with an artificial vagina if the artificial vagina was not correctly prepared, the bull is not fully stimulated, or if the bull is experiencing musculoskeletal pain associated with mounting.² The gold standard for definitive diagnosis of penile denervation in bulls is evaluation of the sensory ability of the dorsal nerves of the penis by evaluating the nerve conduction velocity of the suspected nerves, following a failed test mating. This technique described by Mysinger et al. will be further discussed in the following section.⁶

Sensory nerve conduction velocity testing

While most bulls suffering from penile denervation injuries can be diagnosed via a test mating or via history of reproductive decline in the form of open females in the herd, an advanced diagnostic modality of sensory nerve conduction velocity testing (SNCT) is available.⁵ The electromyography, or the recording of electrical activity in muscle tissue is a relatively fast diagnostic procedure with almost instant results. While the test mating requires little to no specialized equipment, SNCT requires specific specialized equipment and trained personnel. Equipment needed for an SNCT includes: a tilt table with restraint and an electromyography machine (EMG). Bulls being tested should be placed on the tilt table in right lateral recumbency, and their penis must be extended and remain extended for the duration of the procedure.^{2,6} After extension, 3 electrodes are placed along the penis through the skin to the level of the tunica albuginea as described by Mysinger et al.^{2,6} (Figure 3). For complete, detailed description of SCNT in the bull and test interpretation, please refer to Mysinger et al. and Wolfe et al.^{2,6} Bulls with normal penile nerve innervation exhibit the presence of nerve conductivity as seen in Figure 4. While results can be skewed if the test is interpreted incorrectly or the electrodes are placed improperly, the SNCT provides for a definite diagnosis of penile denervation. In bulls experiencing penile sensory denervation, they exhibit lack of nerve conductivity as seen in Figure 5. As with many further diagnostic testing modalities, cost is often a limiting factor for performance of an SCNT.

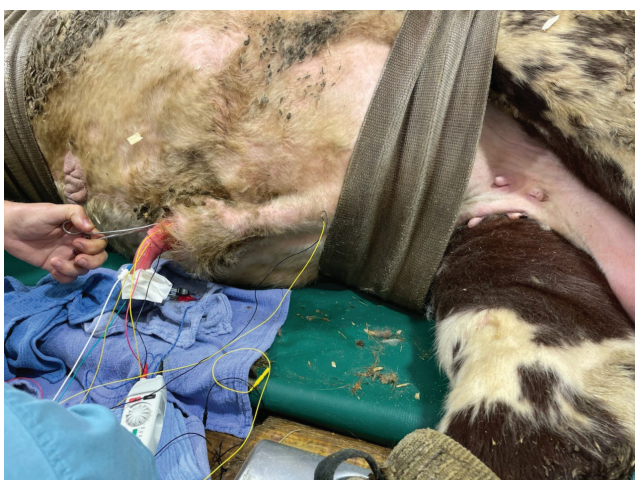


Figure 3. Example of the restraint of the bull and placement of the proximal electrodes, photo courtesy of Jessica Cowley.

Currently at our referral hospital, the cost associated with the SCNT and the interpretation from a boarded neurologist is approximately 150 dollars. However, when discussing the diagnosis of a valuable bull, the cost associated with SCNT maybe minute.

An example of the use of the SCNT from the authors' experience is its use in a 4-year-old, Shorthorn bull that presented to the clinic with history of a successful breeding as a 2-year-old, followed by low pregnancy rates observed 3-year-old breeding season. His previous BBSE information was unknown. At presentation, a BBSE was performed, and he was found to be a satisfactory potential breeder according to the standards set by the Society for Theriogenology. The bull had a scrotal circumference of 37.5 cm. Parameters of his sperm morphology were 70% normal spermatozoa, 11% with head abnormalities, and 19% with mid-piece abnormalities. During the BBSE, touching of the free portion of the penis elicited spiral deviation of the penis. Of note, spiral deviations can occur during a BBSE when utilizing electro-ejaculation and should not be



Figure 4. Normal evoked potentials, photo courtesy of Amy Yanke.

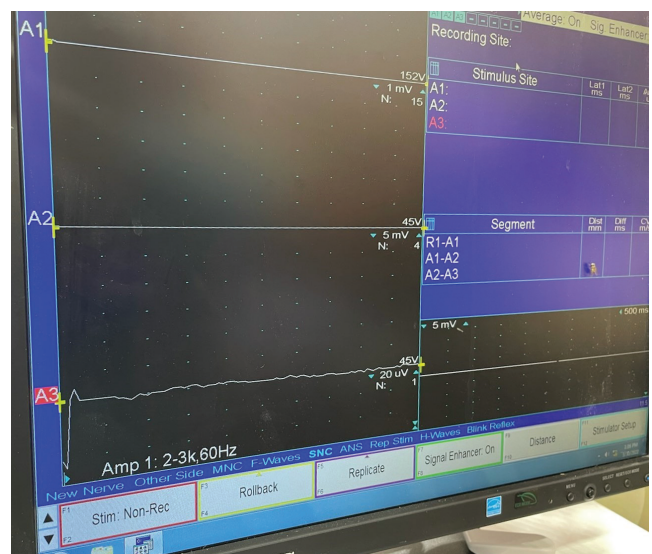


Figure 5. Example of an abnormal nerve conduction test on the electromyography machine, photo courtesy of Jessica Cowley.

diagnosed solely on the presence during the BBSE.⁵ Seidel and Foote even demonstrated that a spiral deviation of the penis can occur normally once intromission has occurred by utilization of a transparent artificial vagina.^{5,7} After passing of the BBSE by the Shorthorn bull, two test matings were performed. During the first test mating, though erection of the penis was appreciated, neither protrusion of the penis nor mounting of the teaser cow in estrus was achieved. During the second test, mating, erection, protrusion of the penis, and mounting of the cow in estrus were observed. Of note, the bull subsequently made several searching motions upon mounting the cow. However, despite these searching motions, the bull failed to achieve intromission. Each time the bull's penis came in contact with the cow's perivulvar region, the penis would undergo spiral deviation (corkscrew), the deviation rapidly resolving moments after contact. Several days following the test mating, the bull underwent SCNT and was found to have a lack of nerve conductivity at the level of the free portion of the penis just proximal to the glans penis. This bull is an interesting case, as it is possible the bull was experiencing both a spiral deviation due to a laxity in the dorsal apical ligament as well as sensory denervation of the distal penis. In this case, the bull would be a candidate for semen collection and cryopreservation to preserve his genetics.

Conclusion

Penile denervation injuries are career ending for natural breeding, but genetics can be preserved with the utilization of semen collection and cryopreservation. The SCNT serves as the testing modality for the definitive diagnosis of penile sensory denervation in bulls. Benefits of performing SCNT include, conclusion of a definitive diagnosis and confirmation that the penile nerves are intact, prior to surgical intervention for other penile or preputial injuries. Downfalls for SCNT are the need for specialized equipment and training, the tedious nature of performing and interpreting the test, along with the associated cost. The gold standard workup for evaluation of the sensory function of the dorsal nerves of the penis is the utilization of a test mating followed by definitive diagnosis of denervation of the sensory nerves of the penis via the sensory nerve conduction velocity test.

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Conflict of interest and funding

None to declare.

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