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Castration in Cattle: Techniques and Animal Welfare Issues

KEY FACTS

- Castration is an accepted and important animal husbandry procedure in today's beef industry.
- Castration of very young animals is apparently less stressful than castration of older animals.
- Additional research is needed to accurately evaluate the effects of various castration methods on the welfare and production performance of calves at different ages.

North Carolina State University
Dawn J. Capucille, DVM, MS, DABVP
Matthew H. Poore, PhD
Glenn M. Rogers, DVM, MS, DABVP

ABSTRACT: Castration is deemed a necessary practice in U.S. cattle production systems. The procedure is primarily advocated to reduce damage to animals, humans, and facilities by decreasing aggressive male behavior. Castration is also advocated to improve carcass quality. Pointing to European practices, some have argued that castration is painful and would not be a necessary procedure in cattle production if changes were made in management practices to facilitate finishing intact bulls. However, this argument fails to recognize the intensive management and higher animal numbers processed in U.S. cattle production systems. The technique employed and the timing of the procedure may have a substantial effect on both actual and perceived pain. Several techniques have been developed for castration. All of them appear to produce some pain. Although local anesthesia may be advocated to reduce pain associated with castration, it may actually elevate the animal's stress from increased handling. Less pain has been associated with early castration (younger than 2 months of age) and is, therefore, recommended.

Castration or orchiectomy of young bulls is an animal husbandry procedure that has been practiced for centuries. There are written accounts from as early as the sixteenth century on how to perform the procedure.[1] The various indications for castration include prevention of aggressive male behavior, control of unwanted matings, and consumer prejudices against beef from intact male animals.[2,3] Many techniques have been tried and either adopted or discarded. Increasingly, the humane aspects of typical animal husbandry procedures (e.g., castration, tail docking, dehorning) are being questioned. This article reviews numerous techniques that have been used as well as animal welfare concerns regarding castration. Differences in carcass characteristics and morbidity and mortality associated with castration, although important, are not the focus of this article.

CASTRATION TECHNIQUES

Many different techniques have been developed for castrating cattle. Kent and colleagues[4] conducted a survey in the United Kingdom and found the emasculatome to be the most popular method of castration, followed closely by surgical

castration and elastrator bands (43%, 39%, and 32%, respectively). Based on 1997 figures released by the U.S. National Animal Health Monitoring System,[5] surgical castration is the preferred method used by cow/calf producers in the United States. Herd size tended to be a factor in the method of castration performed, with larger producers using primarily surgical castration and smaller producers almost as likely to use elastrator bands as surgical castration. These figures are based on the 74.5% of cow/calf producers that responded to the survey and indicated castration was performed before weaning. Castration techniques used postweaning were not surveyed. The length of time required to perform most castration techniques is essentially the same, once the user has become proficient. Because routine castration techniques are familiar to most veterinary practitioners, only brief discussions of some older techniques, as well as a few novel approaches that require further research before adoption, are presented.

Surgical

Several methods of surgical castration have been described in the literature.[6] The basic techniques are similar, with most differences described relating to the animal's age and size or the operator's preference. Excessive hemorrhage and ascending infection from the incision site are the most commonly encountered surgical complications.[6]

Operators may use any type of clean, sharpened blade or an instrument specifically designed for scrotal incisions, such as a Newberry castrating knife. Methods described include incising over each testis separately, transecting and removing the ventral third to half of the scrotum, or incising the ventral half of the scrotum through its lateral aspects (i.e., using a Newberry castration knife).[6] The common goal with each method is to establish an opening large enough to allow drainage and prevent fluid accumulation.

A modified closed technique involving testis removal after incising the common tunic and removing most of the spermatic cord is commonly performed on bulls of various weights. Closed and open techniques have also been described. The closed technique leaves the common tunic intact and is recommended for bulls under 500 lb. The open technique requires that all tunics be separated from the testicular vasculature, with the tunics and vasculature then ruptured in two steps. The open procedure is generally used on bulls over 500 lb.[6] Once the testis is exposed and retracted to reveal the spermatic cord, the calf's size and individual preference play a major role in the choice of technique.

Young calves may have their testes removed with only manually applied traction to compress the vasculature and provide hemostasis. When calves over 45 kg are castrated, manual traction of the spermatic cord has led to recoil of the ductus deferens into the abdominal cavity, which may form an adhesion with the abdominal wall and subsequent small intestinal obstruction due to incarceration of the bowel.[7,8] Larger calves require a method that crushes or ligates the vessels. Although this method is not commonly used in the field, ligation of the vessels has been accomplished with resorbable suture material or hemostatic clips (e.g., resorbable Cast-clip® [K-Vet, Inc., Washington, KS]).[9] Metal ligatures should not be used in animals intended for slaughter because of damage to equipment and the potential for human consumption. An emasculator, such as the Frank, Hausman, or White emasculator, can be applied alone or in addition to ligatures.[6] Emasculators that crush the spermatic cord should be held in place for at least 30 seconds. Some emasculators only transect the spermatic cord, while others transect and crush the cord. Double-crush emasculators, such as the Serra or Reimer, are advocated by some practitioners for very large bulls.

A more recently introduced instrument, the Henderson® castrating tool (Stone Manufacturing & Supply Co., Kansas City, MO; Figure 1) is recommended by the manufacturer for use in all ages of calves. After clamping the tool onto the spermatic cord, it is attached to a variable speed drill. Steady tension is maintained on the testis while the spermatic cord is twisted until it ruptures. This technique reportedly crushes vessels, ensuring adequate hemostasis. We are not aware of any published reports investigating the safety and efficacy of this device.

Nonsurgical

Most nonsurgical methods involve interrupting the blood supply to the testes or scrotum without hemorrhage. There are also methods, which cause scarring or atrophy of the testes, that do not aim to interrupt the blood supply.

Several companies produce elastrator bands and the instruments with which to apply them correctly. Banding has been advocated for bulls from birth to approximately 600 lb and is frequently used to castrate even larger bulls in feedlots. The earlier the band is applied, the less stressful it is believed to be for the animal. Banding causes ischemic necrosis of the testes, eventually leading to testicular atrophy and sloughing of the scrotum. This method requires the operator to place the specially designed elastic band around the neck of the scrotum proximal to the testes.

The size of the band depends on the size of the calf.

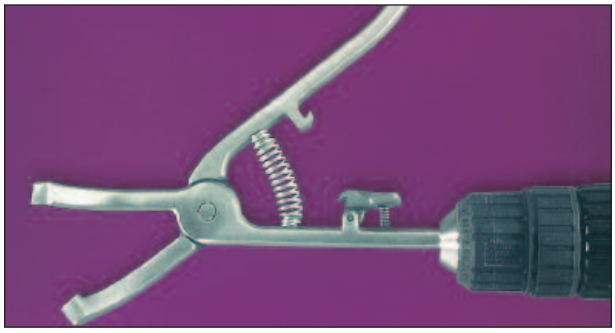

Figure 1—Henderson® castrating tool (Stone Manufacturing & Supply Co., Kansas City, MO) attached to a rechargeable variable-speed drill. After the incision is made and the testis is manually retracted, the tool is clamped on the spermatic cord just proximal to the testis. The drill is activated and with steady tension each testis is twisted until the spermatic cord ruptures. The twisting action encourages hemostasis.

In calves younger than 1 month, a small ring, similar to an O-ring, is placed with a device that stretches the elastrator band to allow it to be slipped over the testes. Larger bands are recommended for older calves with larger testes. The large bands are constructed of latex tubing. Once the band is placed, it is tightened using a specially designed ratchet device that evenly distributes pressure over the band surface. A grommet is crimped over the end to securely fasten the tubing (Figure 2). Excess tubing is trimmed at the grommet. It is important that an appropriately sized band is used and adequate tension is applied to the band. Bands that are not tight enough do not adequately constrict the blood vessels, leading to excessive pain, swelling, and complications, such as scirrhous cord (Figure 3). Immediate rebanding is advocated in these cases. Overtightened bands are likely to break; however, this generally occurs during band application, and rebanding can be performed immediately. Both the Callicrate Bander® (No-Bull Enterprises, LLC, St. Francis, KS) and the EZE Bloodless Castrator® (Cowboy Creations, Huson, MT) have been modified so that band tension is monitored and the device stops before overtightening.

AVMA Policy on Castration and Dehorning of Cattle[19]

"The AVMA supports the use of procedures that reduce or eliminate the pain of dehorning and castrating of cattle. These procedures should be completed at the earliest age practicable. Research in developing improved techniques for painless, humane castration and dehorning is encouraged. In addition, it is recommended that viable alternatives to castration and dehorning be developed and applied."

Figure 2—The Callicrate Bander® (No-Bull Enterprises, LLC, St. Francis, KS) is used to place a thick latex band *(shown)* around the neck of the scrotum above the testes. The band is tightened and fastened in place, causing ischemic necrosis of the testes and scrotal sac.

Before placing the band, both testes must be below the band. It is also important when placing the band to ensure that the calf does not have an inguinal hernia. Tetanus has been reported in banded calves[10]; therefore, it is strongly recommended that older calves be vaccinated with tetanus toxoid 7 to 10 days before banding. When calves are banded at birth, tetanus has not been reported to be a common problem; however, the risk should be considered.

Emasculatomes were designed to castrate calves without some of the potential health hazards of surgery or elastration. With this method, the scrotum is not opened and the testicular vasculature is only crushed, not cut. When performed properly, this method eliminates the chance of infection and excessive hemorrhage. It is suggested for use only in immature males because older males have larger cremaster muscles that may prevent adequate vasculature crushing.

Appropriate instrument maintenance and proper technique are crucial for effective results. The instrument must never be applied across the entire width of the scrotal neck because this will damage the superficial blood supply to the scrotal skin, leading to necrosis and sloughing (not unlike the concept of elastrators). Also, applying the instrument across the entire scrotum may not completely crush the testicular vasculature, possibly leaving the calf intact. The emasculatome should be placed across each spermatic cord individually as the cord is held against the lateral wall of the scrotal neck. Bulls should be separated for 3 to 6 weeks from females to allow the testes to atrophy completely.[6] Steers castrated with emasculatomes may appear intact to an uninformed buyer due to the remaining scrotum and atrophied testes, resulting in discounts on these animals at sale. Emasculatomes have not been widely used in the United

Figure 3—A calf with scirrhous cord, a consequence of improper elastrator band placement. The excess fibrous tissue often contains abscesses and draining tracts.

States since the eradication of screwworms in the 1960s.

A product previously marketed involved the injection of a sclerosing agent (i.e., lactic acid) directly into the testes, which led to atrophy of the germinal tissue.[11–13] This product is no longer available in the United States. This method was recommended only for calves less than 70 kg, and the dose depended on weight.[13] Healing time after castration was found to be faster than with other methods. Although this was an innovative idea, problems occurred in the application. The time required to perform the procedure effectively was increased, and the practitioner had to be careful when injecting the lactic acid to ensure equal distribution throughout the testis.[14] Extratesticular injection of the chemical led to necrosis of surrounding tissues.[11] In the studies reviewed, a large percentage (18% to 50%) of calves were not castrated or were unilaterally castrated. This may have been related to the weight of the calves because many were over the 70 kg recommended weight.[11,12]

Another interesting concept is vaccination of calves against luteinizing hormone-releasing hormone (LHRH), also known as gonadotrophin-releasing hormone (GnRH).[15,16] The vaccine induces antibodies to LHRH, which causes slight testicular atrophy, interrupts sperm production, and decreases testosterone production, thus eliminating behavioral problems. Once antibody titers fall, the testes develop, and bulls show normal secondary sex characteristics.[17] Current research at the University of California, Davis, suggests that cattle can be adequately immunized against GnRH with two injections, the first at 1, 4, or 6 months of age with a booster at 12 months of age.[18] At 16 months of age, aggressive behavior was decreased in immunized bulls compared with nonimmunized bulls during exposure to a novel pen environment. When anti-GnRH titers were assessed at 16 months of age, they appeared to be declining for animals initially vaccinated at 1 or 4 months of age. The bulls initially vaccinated at 6 months of age had titers that still appeared to be increasing; however, all animals were slaughtered at 16.4 months of age (weighing 1000 to 1200 lb).[18]

If researchers can develop a safe and inexpensive vaccine for castration, it would be revolutionary. The concerns of animal welfare activists could be addressed, and the beef industry could still produce cattle that are more easily handled than bulls. However, these animals would likely need to be marketed through special channels to avoid the discounts generally received for intact calves.

ANIMAL WELFARE ISSUES

Recently, public concern has been raised over various routine animal husbandry procedures and the perceived pain or stress associated with these techniques. In the United Kingdom, legislation has been in place for several years specifying the acceptable age and method of castration without anesthetic agents (cattle over 2 months of age must be surgically castrated using local anesthesia).[2,4] The AVMA has a policy on the animal welfare aspects of castration; however, it is brief and provides only a foundation for developing personal guidelines (see box on p. *S*68).[19] The Federation of Animal Science Societies *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* advises that castration is least stressful when performed at a few days of age. Local anesthesia is recommended for calves older than 2 to 3 months of age or greater than 230 kg if spermatic cords are crushed or surgical castration is performed.[20] However, the guide also states that local anesthesia was not advantageous when using specialized instruments for bloodless castration in older animals.[20]

Most of the difficulty in developing more stringent policy guidelines centers on the practitioner's inability to accurately assess pain in animals. Another major difficulty in addressing animal welfare issues is the tendency toward anthropomorphism. Many people assume that any stimulus that could be stressful or painful to humans would also be so to animals.[21] Kitchell and Erikson[22] sum up the difficulty in addressing pain in animals: "Pain is a complex physiologic phenomenon; it is hard to define satisfactorily in human beings, and it is extremely difficult to recognize and interpret in animals." Most of the research on the pain associated with animal husbandry practices has been performed in sheep. However, pain responses are known to be different not only among species but among individuals of

the same species.[23] Nevertheless, comparative research shows that lambs and calves tend to react similarly, although calves apparently are slightly less sensitive than lambs to certain types of painful stimuli.[24]

Cortisol

There are numerous studies that evaluate blood cortisol concentrations in animals subjected to routine husbandry procedures. Cortisol increases very rapidly (within minutes) in response to stressful stimuli; however, it also declines rapidly (4 to 6 hours).[25–29] A complicating factor is that increases in cortisol have also been recorded in response to seemingly pleasant stimuli (e.g., anticipation of feeding).[30] Other confounding factors in studies measuring cortisol response were time of day cortisol measurements were gathered and whether the timing of sample collection was consistent. It is well established that blood cortisol concentration has a circadian pattern.[29]

Studies using cortisol as a measure of the pain associated with the use of various castration methods are equivocal. Some authors argue for the use of banding,[28,31] while others present results indicating that surgery is the least stressful method of castration.[32] In a study of 3- to 6-week-old lambs, Shutt and colleagues[32] found higher cortisol concentrations in surgical castrates but argued that behavioral evidence of pain was lower than in banded castrates. Macaulay and Friend[31] stated that 4-month-old calves appeared to be most stressed by surgical castration (versus using emasculatome or chemical castration) for the first 2 hours after the procedure (end of the observation period). Chase and colleagues[33] found that bulls surgically castrated at approximately 21 months of age had a higher rise in cortisol immediately after castration than did bulls castrated by banding ($P < .03$). Bulls castrated surgically in this experiment did have local anesthetic administered before castration. Because surgical castrates were restrained longer than banded castrates (3 additional minutes for anesthetic to take effect), it is plausible that the acute increase in cortisol was associated with increased restraint time.[33] Bulls castrated by both methods had higher cortisol concentrations for 36 days after castration than did the controls, but the difference was only significant on day 2 ($P < .04$).[33] King and colleagues[29] castrated calves at different ages (78 and 167 days) and by different methods (surgical or emasculatome). They found no difference in cortisol concentrations (measured for 30 hours) in 78-day-old calves castrated by either method. Calves surgically castrated at 167 days of age had lower cortisol concentrations 2 minutes after the procedure but higher concentrations at 6 hours after the procedure than emasculatome castrates ($P < .05$).[29] Robertson and colleagues[34] compared surgical, emasculatome, and elastrator band castration in calves at 6, 21, and 42 days of age. They found that the 21-day-old calves exhibited the least cortisol increase during the 3-hour observation period. Although banding produced the least intense cortisol response in calves at all ages, cortisol concentrations remained elevated longer with binding than with surgical or emasculatome castration. The study concluded that perceived pain based on behavioral response was not the same as pain based on changes in cortisol concentration.[34]

Other Objective Parameters

Some investigators have measured changes in blood leukocytes and β-endorphins following castration.[27,32,33,35,36] β-Endorphin concentrations vary but tend to return to normal in a time frame similar to that of cortisol.[27,32] Total white cell counts increased in castrated cattle but returned to normal in less than 7 days.[33,36] More research is needed before measurements of leukocytes and β-endorphins can be objectively used to reflect the degree of stress. Body temperature has also been measured as an indicator of inflammation and stress reaction to castration; however, no differences in technique or values outside the normal reference range were noted.[37]

Behavior

Behavior has been extensively studied and offers some insight into pain responses in animals.[24,38,39] When behavior has been monitored, researchers recorded activity that deviated from normal or that was seen more often than in noncastrated controls, such as foot stamping, tail wagging, licking at lesions, lateral recumbency, and restlessness, which were considered stress behaviors. Molony and colleagues[40] conducted a long-term study on the behavior of 1-week-old calves castrated by surgery, emasculatome, or elastrator bands. They found that stress behavior persisted for up to 42 days in calves that were banded.[40] This study followed behavior longer than any other study reviewed. Robertson and colleagues[34] observed behaviors for a 3-hour period after castration in calves at 6, 21, and 42 days of age that were castrated by surgery, emasculatome, or elastrator bands. They concluded that emasculatome was the least stressful method of castration but noted that stress behaviors still occurred at the end of the observation period, most notably in the banded group.[34]

Feed Intake and Average Daily Gain

In studies measuring feed intake, castration by emasculatome or surgery decreased feed intake for 1 to 2 weeks by 0.5 to 1 kg ($P < .05$).[25,26] Emasculatome castrates had decreased feed intake during the first week and surgical castrates had decreased feed intake for the second week compared with uncastrated controls

($P < .05$).[25] Average daily gain (ADG) has also been assessed in the period following castration.[25,26,33] Most studies support that there is at least some initial decrease in ADG; however, opinions differ as to which technique causes the most decrease. Chase and colleagues [33] found an insignificant decrease ($P \leq .13$) in ADG over a 35-day period between control bulls and bulls castrated at approximately 21 months of age by banding or surgery (controls gained 0.93 kg/day versus 0.42 kg/day in banded calves and 0.64 kg/day in surgical castrates). In a study using 5½-month-old bulls, Fisher and colleagues[25] found that ADG from day 0 to day 35 after castration was lower in surgical castrates than in emasculatome castrates ($P < .05$). This difference was primarily due to a decrease in ADG from day 0 to day 7.[25] In another study, Fisher and colleagues[26] found a decrease in ADG from day 0 to day 7 in surgical castrates versus control bulls ($P < .01$). There was no difference between the groups from day 8 to day 28 postcastration ($P > .05$).[26]

Technician Variability

The level of technician experience and expertise could result in obvious variability in the outcome of castration procedures. Professional training in aseptic technique is also a variable in performance of castration. Technique and instrument cleanliness make little difference during the actual procedure but likely affect subsequent morbidity and mortality.

Local Anesthesia

The use of anesthetics affects the perception of the pain involved in castration. The anesthetic most often used is lidocaine, which is generally injected directly into the spermatic cord for local anesthesia.[41] Sedatives or general anesthesia are rarely used and then only in older, mature bulls. Caulkett and colleagues[42] described a method of epidural anesthesia with xylazine for use in the castration of mature bulls. There are several arguments for and against the use of anesthesia. The use of anesthetics in cattle is extralabel because it has not been approved in the United States. After surgery, lidocaine wears off rapidly, especially since most of it is removed with the testis. Fisher and colleagues[25] found that during the initial 2 hours after the procedure, the cortisol response was lower if lidocaine was used, assuming time was allowed for the anesthetic to take effect (15 minutes). They also found that ADG was improved in the first 7 days after surgical castration if lidocaine was used ($P <. 05$).[25] In practical field situations, allowing sufficient time for appropriate anesthetic administration and effect may be perceived as a serious detriment to processing efficiency. When large numbers of bulls are processed (as in large feedlot operations), slowing the speed of processing by a few minutes per animal substantially increases processing costs and may increase handling-associated stress.

Faulkner and colleagues[43] described the use of intravenous butorphanol and xylazine before castration and found no difference in acute stress response between calves castrated with the anesthetic protocol or without administration of systemic anesthetics. In this study, the time between drug administration and the start of the procedure was approximately 90 seconds, posing the question of the adequacy of the interval between drug administration and castration.[43] In cattle, especially beef cattle, handling may be stressful.[44] Physical restraint, such as occurs in a squeeze chute, results in elevated cortisol levels independent of the performance of stressful procedures.[14,25] The use of anesthetic agents for castration increases animal handling times. Although short-term pain may be decreased, increased handling time increases the stress associated with the castration procedure. In the United States, producers and veterinarians who perform routine castrations in herd or feedlot environments generally do not use an anesthetic, even in large bulls.

CONCLUSION

Castration is a common animal husbandry procedure in today's beef industry. Currently, there does not appear to be a good objective measure of pain in calves with which to compare castration techniques and make solid recommendations. Observation of behavior, although subjective, appears to be the most reliable measure. Additional research is needed to evaluate the effects of various castration methods on the welfare and production performance of calves of different ages. The only consistent finding in the literature is that younger animals appear to be less affected. When older calves are castrated, addition of local anesthetic to the protocol may be of value in decreasing pain. Further research is warranted into postcastration performance improvement if anesthetics and/or analgesics are added to the protocol.

We generally recommend surgical castration, particularly for cow/calf producers. Regardless of which technique is used, it is strongly recommended that calves be castrated before 2 months of age, if possible. Practitioners working with feedlot and backgrounding operations know that calves are often not castrated before leaving the farm of origin. Therefore, the attending veterinarian should assess the environment and technical skill of the operators, and the appropriate method of castration should be recommended for each specific operation. Future developments may lead to increased use of immunocastration. This method addresses concerns with associated pain, especially in cases in which environment and operator expertise are poor.

Veterinarians must be concerned with minimizing pain associated with such procedures as castration and encourage producers to give proper consideration to this important animal welfare issue. Having researched these difficult questions enables practitioners to present a balanced view of the procedures and logically debate their necessity.

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44. Armstrong JR: Surgical and other animal husbandry procedures, in Moore BL, Chenoweth PJ (eds): *Grazing Animal Welfare Symposium.* Queensland, Australia, Australian Veterinary Association, 1985, pp 12–30.

ARTICLE #8 CE TEST

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. *Choose the best answer* to each of the following questions; then mark your answers on the postage-paid envelope inserted in *Compendium.*

1. Which of the following parameters has been studied as a method to assess pain of castration?
   a. plasma cortisol
   b. weight gain
   c. white blood cell counts
   d. behavior
   e. all of the above

2. The recommended minimum length of time that emasculators should be held in place to adequately crush the spermatic vasculature is ___ seconds.
   a. 15
   b. 30
   c. 45
   d. 60
   e. 120

3. Immunocastration involves vaccination against
   a. testosterone.
   b. spermatozoa.
   c. GnRH.
   d. follicle-stimulating hormone.
   e. spermatic fluid.

4. Injection of lactic acid into the testes (i.e., chemical castration) is no longer practiced in the United States because
   a. it is extremely expensive.
   b. extensive training is needed to perform the procedure.
   c. human contact with the product is dangerous.
   d. its results were inconsistent.
   e. none of the above

5. Which factor has the most potential as a long-term indicator of the pain associated with castration?
   a. behavior
   b. blood cortisol concentration
   c. blood endorphin concentration
   d. total white blood cell counts
   e. none of the above

6. Castration has been referred to in literature as early as the
   a. 1900s.
   b. 1500s.
   c. 1100s.
   d. 700s.
   e. 300s.

7. Increases in bovine plasma cortisol have occurred in response to which of the following?
   a. castration
   b. dehorning and/or tail docking
   c. anticipated feeding
   d. sexual stimulation
   e. all of the above

8. Based on the 1997 National Animal Health Monitoring System survey, the preferred method of castration among cow/calf producers in the United States is
   a. vaccination.
   b. chemical castration.
   c. emasculatome.
   d. elastrator bands.
   e. surgical technique.

9. The Henderson® castrating tool is used to perform what type of castration?
   a. vaccination
   b. chemical castration
   c. emasculatome
   d. elastrator bands
   e. surgical technique

10. The Callicrate® bander is used to perform what type of castration?
    a. vaccination
    b. chemical castration
    c. emasculatome
    d. elastrator bands
    e. surgical technique