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Mastectomy in 25 small ruminants (2002-2019)

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Abstract

Objective: To describe the outcome of small ruminants treated with unilateral and bilateral mastectomy by using three surgical techniques.

Study design: Retrospective study.

Animals: Twenty-five small ruminants (24 goats and one sheep).

Methods: Medical records of animals that underwent mastectomy between November 1, 2002, and May 1, 2019, were reviewed. Follow-up information was obtained by telephone questionnaire with owners. Signalment, surgical data, intraoperative and postoperative complications, bacterial culture results, histopathologic diagnoses, short- and long-term outcomes, and other procedures performed were recorded.

Result: Procedures consisted of six unilateral (with an elliptical incision) and 19 total (with inverted cloverleaf or elliptical skin incisions) mastectomies. All animals survived to hospital discharge. Intraoperative complications included contamination of the surgical site with mammary-gland fluid, hemorrhage, and difficulty dissecting skin from the mammary gland. Postoperative complications included seroma formation (7/25), surgical-site infection (5/25), and dehiscence of the skin incision (3/25). Mammary neoplasia was diagnosed in seven of 15 animals with histopathologic examination. No association was detected between surgical technique, diagnosis of neoplasia, and long-term outcome. Overall, client satisfaction was high.

Conclusion: Mastectomy was effective at removing abnormally enlarged udders secondary to chronic mastitis, inappropriate lactation, idiopathic causes, or neoplasia and was associated with a low rate of complications in small ruminants.

Clinical significance: Unilateral mastectomy with an elliptical skin incision or total mastectomy, preferably with inverted cloverleaf skin incision, may be indicated to remove diseased mammary tissue in small ruminants and can result in long-term survival with low morbidity and cosmetically pleasing results.

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1 | INTRODUCTION

Chronic, acute gangrenous, and suppurative mastitis have been reported in small ruminants.[1,2] Bacterial pathogens and physiologic abnormalities of the mammary gland are the main considerations for predisposition of pathological conditions of the udder.[1,3] Animals with mammary gland abnormalities can present with inappropriate lactation and an enlarged, painful udder, which is susceptible to trauma and affects animal well-being.

Mastectomy has previously been performed in ruminants by mammary vascular ligation for gangrenous mastitis with and without amputation of the teat, total mastectomy with elliptical incisions around the udder and primary closure, unilateral (partial) mastectomy, and the inverted cloverleaf skin incision pattern for radical (total) mastectomy.[3-8] Total mastectomy in ruminants most commonly involves elliptical incisions around the udder.[1,4,7] Skin closure after radical mastectomy can be difficult to achieve without excessive tension.[9,10]

Several techniques have been reported for radical mastectomy, but no study has focused on associated intraoperative and postoperative complications in small ruminants.[2-4,6,11] The objective of the study reported here was to describe the outcomes of small ruminants undergoing unilateral and total mastectomy. Our null hypothesis was that intraoperative and postoperative complications and short- and long-term outcomes would not differ between surgical techniques currently described for unilateral or total mastectomy in small ruminants.

2 | MATERIALS AND METHODS

2.1 | Case selection and medical records

Medical records from Purdue University Teaching Hospital of all small ruminants treated with partial or total mastectomy between November 1, 2002, and May 1, 2019, were reviewed. Signalment, age, body weight, packed cell volume/total protein (PCV/TP), history of pregnancy, duration of illness, previous treatments, anesthesia techniques, time of surgical procedure, medications administered, intraoperative and postoperative complications, bacterial culture results, histopathologic diagnoses, short- and long-term outcomes, and any other procedure performed in addition to the mastectomy were recorded. Short-term survival (alive at hospital discharge) was determined from the medical record, and long-term follow-up (>1 year after surgery) was obtained by telephone questionnaire with owners. Owners were asked whether postoperative complications occurred, what the treatments for the complications were, and their level of satisfaction with the surgical procedure.

For the purposes of the study, any recorded contamination of the surgical site with mammary-gland fluid, difficulties with dissection of the udder, excessive skin tension associated with wound closure, or hemorrhage was considered an intraoperative complication. Surgical site infection, dehiscence of the skin incision, and incisional seroma were considered postoperative complications.

2.2 | Statistical analysis

Numerical data were assessed for normality by using the Shapiro–Wilk test. Because of small sample sizes and many variables that were nonparametrically distributed, summary statistics are presented as median and range. Proportional distributions were compared by using Fisher's exact test because greater than 50% of expected frequencies were less than 5. $P < .05$ was considered statistically significant.

3 | RESULTS

Twenty-five small ruminants (24 goats and one sheep) underwent total or partial mastectomy. Total mastectomy was performed in 19 of 25 animals; the inverted cloverleaf technique was used in 14 animals, and the elliptical incision technique was used in five animals. Unilateral mastectomy was performed in six of 25 animals with an elliptical skin incision. Among the 25 animals, 17 were companion animals, four were used for breeding (one Dorset horn and three Boer goat), and four were used in dairy production (one French alpine, one La Mancha, one Saanen, and one mixed breed). Age at admission ranged from 2 to 12 years (median, 5), and weight ranged from 26.4 to 152 kg (median, 64). For the 24 goats, breeds represented were mixed breed (8), pygmy (6), boer goat (4), French alpine (2), La Mancha (2), Anglo-Nubian (1), and Saanen (1). There was one dorset horn sheep. Seven of the 24 goats had an unknown breeding history. Twelve of the 25 animals were reported to have produced offspring.

The most common complaint at admission was chronic mastitis (n = 18/25 [72%]), followed by abnormally enlarged udder (n = 6/25 [24%]) and precocious udder (n = 1/25 [4%]) ranging in duration from 1 to 36 months (median, 6). The most common physical examination abnormalities at admission included firm swelling, hyperemia, and pain on palpation of the udder.

3.1 | Preoperative treatment and anesthesia

Minimum blood work (PCV and TP) was performed in all animals. The PCV ranged from 12% to 45% (median, 28%), and the TP concentration ranged from 6.2 to 11 g/dL (median, 7.5). Ten animals had PCV lower than 28%, which may have been related to anemia of chronic disease. A whole blood transfusion was performed in one small ruminant with a PCV of 12%. All animals received preoperative antimicrobials and anti-inflammatory medication. Antimicrobials administered included procaine penicillin G (22 000-44 000 IU/kg IM every 12-24 hours) or ceftiofur sodium (2.2 mg/kg IM every 24 hours). Twenty-four animals received flunixin meglumine (1.1 mg/kg IV every 12-24 hours) and one animal received meloxicam (1 mg/kg orally every 24 hours) as anti-inflammatories.

Food and water were consistently withheld for 24 and 12 hours, respectively, prior to surgery. An IV catheter was placed prior to premedication and anesthesia with various combinations of drugs. All animals were premedicated with butorphanol tartrate (0.02-0.33 mg/kg IV) and with a combination of one or more of diazepam (0.05-0.5 mg/kg IV), xylazine hydrochloride (0.02-0.13 mg/kg IV), and/or midazolam (0.1-0.15 mg/kg). General anesthesia was induced with combinations of ketamine hydrochloride (1.2-4.5 mg/kg IV), diazepam (0.07-0.12 mg/kg IV), guaifenesin (5% solution), propofol (0.5-0.8 mg/kg IV), and midazolam (0.12 mg/kg IV) and maintained with isoflurane in oxygen. All animals received plasmalyte solution IV during surgery; three received hetastarch, and one received whole blood because of anemia and low TP concentration before surgery.

3.2 | Surgical techniques

All animals were positioned in dorsal recumbency. After clipping and aseptic skin preparation, the skin incision was made with a scalpel blade. In all surgeries, the skin incision was made approximately two-thirds of the distance between the attachment of the udder to the body wall and the teats to preserve skin for closure.[10] For the inverted cloverleaf technique (14 animals), four semi-elliptical incisions were made through the skin with the upper half of an ellipse toward the teats forming four skin flaps one cranially, one caudally, and two laterally (Figure 1).[10] For total mastectomy with an elliptical incision technique (in five animals), a fusiform incision was made around the udder or semi-udder for the partial mastectomies to create two skins flaps (one on each side). After skin flaps were created, the subcutaneous tissue was dissected away from the mammary gland with sharp

FIGURE 1 Schematic representation of three of the four flaps created during the inverted cloverleaf-skin incision

and blunt dissection; blunt dissection was preferred to minimize intraoperative hemorrhage. After the skin flaps or the subcutaneous tissue was dissected free from the mammary gland and the external rectus sheath was visualized, the external pudendal vessels, caudal perineal vessels, and the subcutaneous abdominal vein were identified and ligated (size 2-0, 0, or 1 polyglactin 910). The dissection was continued until the mammary gland was separated from the external rectus sheath via transection of the medial and lateral suspensory ligaments and removed. The dissection of the abnormal tissue was started on the lateral aspect in each side and then directed cranially and caudally with the aid of retraction via an assistant.

After the mammary gland was removed and the surgical site was lavaged, the incision was closed with different skin suture patterns, depending on the amount of skin tension present. In cases with extensive dead space, interrupted walking sutures (size 2-0 or 0 polyglactin 910) were placed from the deep dermal layer of the skin flaps to the external rectus sheath to obliterate dead space. Minimal amounts of subcutaneous tissue were available for closure, and no attempt was made to incorporate subcutaneous tissues in the skin closure. In small ruminants treated with partial mastectomy, the suture included the fibrous tissue between the two mammary glands. Supramammary lymph nodes were removed and submitted for histopathology for four animals.

Latex Penrose drains (18 × 3/8 in) were placed after each mastectomy. These drains were introduced in the most proximal aspect of the dead space and the most caudal aspect (positioned cranial to caudal) exiting stab incisions separate from the original incision. One Penrose drain was used after partial mastectomy (n = 6/25) and after a total mastectomy with an elliptical skin incision (n = 1/5). Two Penrose drains were used in 13 of 14 mastectomies with inverted cloverleaf skin incision and in four of five total mastectomies in which an elliptical skin incision was made. Three Penrose drains were used in one mastectomy in which inverted cloverleaf skin incision was made (1/14).

Skin closure varied between surgical techniques. The inverted cloverleaf skin incision was closed with an "X" shape or a double "Y" pattern, depending on the amount of skin saved with the four semielliptical skin incisions when opposing the flaps (Figure 2). Each segment of the skin closure was completed in a simple continuous pattern with 2-0 poliglecaprone 25 (n = 2/14), 2 polypropylene (n = 1/14), and 1 nylon (n = 11/14). The skin closure with the inverted cloverleaf skin incision was accomplished successfully in all cases. The total mastectomy with elliptical skin incision was closed with an inverted cruciate pattern (n = 3/5), a combination of near-far-far-
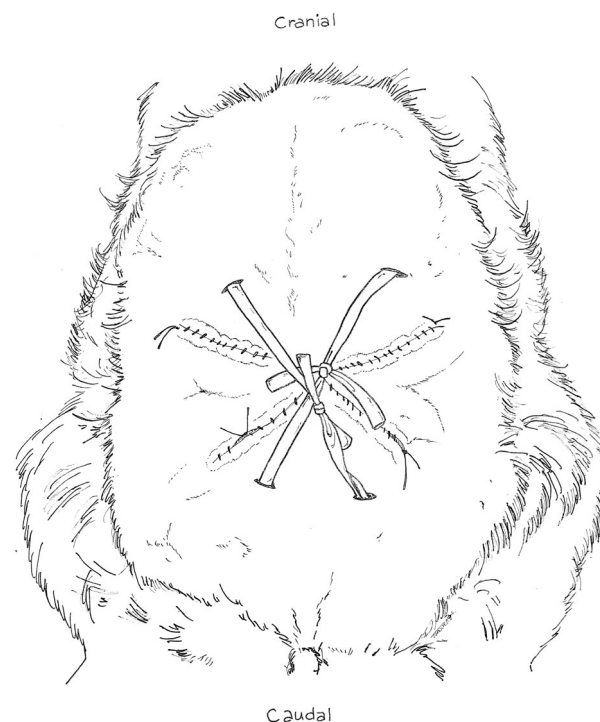

FIGURE 2 Schematic representation of skin closure after the cloverleaf-skin incision pattern and placement of two Penrose drains

near and inverted cruciate pattern (n = 1/5), and a simple continuous pattern (n = 1/5). The elliptical skin incision for all partial mastectomies was closed with a combination of near-far-far-near, inverted cruciate, and/or simple interrupted suture patterns. Bandaging of the surgical site was not performed in any animal at the completion of the surgical procedure.

3.3 | Operative and postoperative complications

The duration of surgery ranged from 40 to 98 minutes (median, 59). Intraoperative complications included contamination of the surgical site with mammary fluid (n = 6/25), excessive bleeding associated with a failed ligature (n = 2/25), and difficult surgical dissection secondary to enlarged udder size (udder weight of 14.5 kg, animal weight of 68.9 kg; n = 1/25). Intraoperative complication rates did not differ between surgical techniques (P = .611). Contamination of the surgical site was managed with extensive wound lavage, and hemorrhage was controlled with ligation of the bleeding vessel. Two goats had an ovariohysterectomy performed at the time of the radical mastectomy. During surgery, one to three Penrose drains were placed to manage intraoperative dead space. Penrose drains were removed

3 to 8 days after surgery (median, 4). Skin sutures were removed 14 days after surgery in all animals.

Fifteen complications were recorded in 11 animals, affecting six of 14 inverted cloverleaf closures, three of five total mastectomies with elliptical incision, and two of six unilateral mastectomies. The postoperative complication rates did not differ between techniques ($P = .75$). The most frequent complication consisted of seroma formation, recorded in seven animals 2 and 3 days after surgery. Four animals returned to the hospital for treatment of complications 11 to 15 days after discharge, three with surgical site infections (11 and 13 days after discharge) and one with dehiscence of the surgical site (10 days after surgery). The second most common postoperative complication was surgical site infection in five animals, with concomitant seroma formation in two cases. Surgical site dehiscence was recorded in three animals 10, 11 and 13 days after surgery.

All animals with surgical site infections responded to treatment with procaine penicillin G (22 000 IU/kg or 44 000 IU/kg IM every 12 hours) for 5 to 8 days and wound cleaning with dilute betadine solution. Among the three animals with incisional dehiscence, two animals developed dehiscence due to a surgical site infection, and dehiscence was secondary to seroma formation which resolved via second intention healing in one animal. All surgical sites ultimately healed completely. Days of hospitalization ranged from 3 to 21 days (median, 8).

3.4 | Postoperative management

All animals received postoperative antimicrobials and anti-inflammatory medication until the Penrose drains were removed 3 to 8 days postsurgery. The skin sutures were removed 14 days after surgery. Antimicrobials administered included procaine penicillin G (22 000-44 000 IU/kg IM every 12 hours) or ceftiofur sodium (2.2 mg/kg IM every 24 hours). Flunixin meglumine (0.5-1.1 mg/kg IV every 12 hours) or meloxicam (1 mg/kg orally every 24 hours) were used as anti-inflammatories. Butorphanol tartrate (0.2 mg/kg IV) or buprenorphine (0.05 mg/kg IV) were administered as postoperative analgesics.

3.5 | Histology and culture results

Histopathology results of the removed udder were submitted for 15 animals. The histopathologic diagnosis included mammary carcinoma (five animals), other neoplasia (two animals, one with lymphoma and ductal carcinoma and one with fibroadenoma and intraductal papillary adenoma), necrosuppurative mastitis with chronic suppurative lymphadenitis (two animals), lymphoplasmacytic mastitis with eosinophilic lymphadenitis (two animals), and one each of lymphocytic interstitial mastitis with fibrosis, mammary gland hyperplasia, granulomatous lymphadenitis, and severe chronic active necrotizing mastitis. Three of seven animals with neoplasia and eight of 18 animals in which neoplasia had not been diagnosed had postoperative complications. Microbial culture of samples from the removed udder was performed for 11 animals, with eight yielding positive results. Bacteria cultured were *Peptoniphilus assaccharolyticus* (one animal), *Staphylococcus aureus* (4 animals)*, Escherichia coli* and *Enterococcus faecium* (one animal), *Pseudomonas aeruginosa* (one animal), and *Staphylococcus epidermis* (one animal).

3.6 | Survival and follow-up

All animals were discharged alive from the hospital (short-term survival). Nineteen animals were available for long-term follow-up (inverted cloverleaf, 13 animals; unilateral mastectomy, four animals; and total mastectomy with elliptical incision, two animals). Time to follow-up ranged from 12 to 112 months (median, 29). Long-term survival information was available for 19 animals. Distribution of animals with long-term survival was inverted cloverleaf incision for total mastectomy 11 of 13 (84.6%), unilateral mastectomy two of four (50%), and elliptical incision for total mastectomy two of two (100%). Long-term survival rates did not differ between the groups ($P = .21$).

Among the seven animals in which neoplasia of the udder was diagnosed, one goat that had mammary carcinoma was found dead of undetermined causes 1 month after surgery. Six goats (6/7) survived at least 1 year post operatively, but three were dead by the time of follow-up. One goat died twenty-four months after surgery because of complications of diarrhea, and two goats in which lymphoma, ductal carcinoma, and mammary carcinoma had been diagnosed died 48 and 18 months after surgery from unrelated causes (dog attack and coxofemoral joint luxation). All twelve animals without neoplasia were alive at least 1 year after surgery and at last follow-up. No association between a diagnosis of neoplasia and long-term outcome was detected ($P = .368$). Four goats had behavioral changes, aggressiveness (two animals at 3 and 4 months), and male sexual behavior (two animals at 6 and 9 months) after discharge. None of these four animals had ovariectomy performed at the time of mastectomy. All owners contacted were satisfied with the final

result and would be willing to consider mastectomy in the future were it required to treat their animals.

4 | DISCUSSION

Mastectomies were most commonly performed to resolve clinical signs associated with chronic mastitis and an enlarged, pendulous udder in the small ruminants in this study. Both conditions resulted in chronic poor health and affected quality of life manifested as difficult ambulation, anorexia, and weight loss. Clinical signs consistently recorded in this population included a swollen and hyperemic udder found hard and painful on palpation. Discomfort and pain associated with the udder justified mastectomy. After mastectomy, appetite, weight, and ambulation improved in all treated animals. Mastectomy seems to be an effective surgical technique to resolve the clinical signs of chronic mastitis and also when the udder is enlarged, and painful in small ruminants.

In our experience, regardless of the method chosen, skin closure after total mastectomy can be difficult to achieve without excessive skin tension. The presence of surgical dead space is common and can result in seroma formation[9] and we have experienced dehiscence of the primary to closure occur. With these difficulties in mind, the authors have commonly used the inverted cloverleaf technique. We have observed that this surgical technique minimizes skin tension after removal of the udder and aids in the primary closure of even large defects. To the best of the authors' knowledge, the inverted cloverleaf technique was developed by Tex S. Taylor (Tex S. Taylor [Texas A&M University], personal communication,) and described in two textbooks in the veterinary literature.[1,10]

After mastectomy, the surgeon must address the resulting dead space and skin tension associated with the procedure. Large surgical defects after radical mastectomy are typical.[3,7] Other authors have recommended second intention healing after resections of large tumors because of the lack of skin available for closure.[3,5] One of the authors of this study (A.N.B.) has extensive experience with the inverted cloverleaf surgical technique for radical mastectomy in small ruminants. The four semi-elliptical skin incisions of the inverted cloverleaf pattern result in conservation of skin to aid in surgical wound closure. The inverted cloverleaf technique is a "skin-sparing" technique in contrast to an elliptical skin incision. Determining the amount of skin that can be removed without generating excessive tension during skin closure is difficult when an elliptical skin incision is used and requires subjective evaluation. We propose the creation of four equal skin flaps used for the inverted cloverleaf

technique facilitates closure by minimizing how much skin is removed with the udder and preserving skin for a tension-free closure.

Primary mammary neoplasia in small ruminants is uncommon, and only a few reports describing this have been published since 1992.[12] The number of animals with mammary neoplasia reported here was unexpected because all were admitted for chronic mastitis and an enlarged udder rather than mammary neoplasia. The relationship between chronic mastitis and mammary neoplasia is difficult to determine. Inflammation may be associated with chronic mastitis and contribute to the development of neoplasia.[13] During surgery, the supramammary lymph nodes were removed in four animals. Similarly to Cable et al,[4] we recommend histopathological examination of the lymph nodes to evaluate the presence of metastasis. Three of our cases with lymph node biopsies had evidence of chronic inflammation but not metastasis. However, all our cases were alive at long-term follow-up with no specific treatment for neoplasia except the mastectomy. We recommend the submission of tissue for histopathologic examination and culture because of the high incidence of neoplasia in this study. Despite the presence of neoplasia, there was no evidence of metastatic disease or long-term complications associated with these masses.

In 1980, Peaker et al[11] reported a pronounced effect on estrus cycles and disturbances in different reproductive functions in mastectomized goats and concluded that the mammary gland contributes to the release of hormones that regulate blood concentration of solutes such as insulin and glucagon into the general circulation. In the series of cases reported here, four animals had behavior changes of aggressiveness and male sexual behavior. It is possible that the observed behavioral changes could be secondary to hormonal imbalance after radical mastectomy.[11,14] Ovariectomy or ovariohysterectomy (OHE) can be considered in conjunction with radical mastectomy when the owner has no interest in breeding the animal after surgery. We successfully performed a caudal midline OHE concurrently with mastectomy in two cases without complications.

When we considered the size of lesions and amount of surgical dissection, surgical site infections were less common than expected in our population. This finding is consistent with previous reports.[3,4] Surgical site infections in this study were observed in animals that had previous seroma formation, contamination of the surgical field with infected mammary fluid, and an indwelling extra drain placed a few days later. Additional risk factors for surgical site infections include the absence of wound bandaging and recumbency in a stall contaminated with urine and fecal matter. All animals with surgical site

infections were successfully managed with postoperative antimicrobials and local wound care.

In summary, the three described techniques were suitable for mastectomy in small ruminants and resulted in acceptable long-term survival, low morbidity, and cosmetically pleasing outcomes for the owners. However, we recommend inverted cloverleaf incisions rather than elliptical skin incisions to improve skin closure after total mastectomies.

CONFLICT OF INTEREST
The authors declare no conflicts of interest related to this report.

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