Surgical castration of dogs typically involves making an incision in the prescrotal area, exteriorizing both testes via the same incision, double ligating the blood vessels and spermatic cord, removing the testes, and closing the incision with absorbable suture. In high-quality, high-volume spay and neuter programs, a commonly used technique for castration of pediatric and juvenile dogs is one in which a single scrotal incision is made and both spermatic cords are autoligated in a manner similar to feline castration techniques. Depending on surgeon preference, the skin is then closed with cyanoacrylate skin adhesive or left open to heal by second intention.

Although a paucity of peer-reviewed literature exists regarding SLSC, the authors’ experience suggests that the main advantage is that it allows the spermatic cord to be ligated in less time than traditional double ligation, resulting in briefer durations of anesthesia and surgery. An additional benefit is the financial savings attributable to the lack of a need for suture material. However, these claims as well as the potential safety concerns associated with a novel surgical technique remain to be confirmed by comparison with the TPSC technique, which involves suture ligation.

The objectives of the study reported here were to determine complication rates associated with SLSC performed in a large number of pediatric and juvenile dogs and investigate whether procedure duration differed from that of traditional prescrotal castration (TPSC).

**OBJECTIVE**
To determine complication rates associated with sutureless scrotal castration (SLSC) performed in a large number of pediatric and juvenile dogs and investigate whether procedure duration differed from that of traditional prescrotal castration (TPSC).

**DESIGN**
Prospective case series and clinical trial.

**ANIMALS**
400 shelter-owned dogs that underwent SLSC and 18 shelter-owned dogs that underwent TPSC between 2 and 5 months of age.

**PROCEDURES**
In the first phase of the study, SLSC was performed for 400 dogs, which were monitored for ≥ 24 hours after surgery to identify surgery-related complications such as hemorrhage, signs of pain, self-trauma, swelling, and dermatitis at the incision site. In the second phase, the durations of 18 SLSC and 18 TPSC procedures were measured and compared.

**RESULTS**
No hemorrhage-related complications were identified in any dog during SLSC in the first phase. Complications were all minor and self-limiting and included peri-incisional dermatitis (9/400 [2.3%]), skin bruising (4/400 [1.0%]), and swelling (1/400 [0.3%]). No self-trauma was observed for any dog, nor did any dog require additional analgesic treatment after surgery. Procedure duration was significantly briefer for SLSC (mean ± SD, 1.0 ± 0.2 minutes) than for TPSC (3.5 ± 0.4 minutes).

**CONCLUSIONS AND CLINICAL RELEVANCE**
Results suggested that SLSC as evaluated was safe and significantly faster than TPSC when performed in healthy 2- to 5-month-old dogs. The SLSC technique has the potential to improve morbidity and mortality rates as well as financial costs associated with castration, particularly in high-quality, high-volume spay and neuter programs. (J Am Vet Med Assoc 2018;253:1589–1593)
body weight between 0.9 and 11.4 kg (2 and 25 lb) were considered for inclusion in the study. Age estimation, when required, was performed on the basis of dentition, size, and body weight, considering the likely breed. No specific exclusion criteria were applied other than a requirement that dogs be considered generally healthy enough for surgery as assessed via physical examination. Because few data exist regarding complication rates for SLSC and TPSC performed in dogs of ages similar to those in the present study, and because the SLSC technique was already being used in a high-quality, high-volume spay-neuter program at the shelter, our goal was to enroll 400 consecutive dogs over a 12-month period to provide a large enough cohort to allow detection of even a low complication rate (< 1%). Phase 1 therefore began on July 13, 2015, and concluded when 400 consecutive SLSC procedures had been performed (August 25, 2016).

In the second phase of the study in which durations of the SLSC and TPSC procedures were compared, 2 dog groups were populated by alternating between procedure types as dogs were successively castrated within a given day, such that 9 dogs were allocated to each group per day. The 18 dogs that were timed for the SLSC procedure were also monitored and included among the 400 dogs in phase 1. Owing to case load, scheduling, and availability of puppies for castration, phase 2 was completed over a 4-day period, continuing until each group contained 18 dogs. This sample size had been determined before the study began on the basis of historical data for TPSC and SLSC procedures performed for the OHS (ie, an expected difference in procedure durations between groups of 3.0 minutes and an expected SD of 2.0 for procedure durations). Given these data, sample size was calculated for a 2-tailed test, an α value of 0.05, and a power of 80%, and results indicated that 10 dogs would be needed per group. To allow for unexpected variability among dogs, 18 dogs were included in each group.

**Phase 1: safety evaluation of the SLSC technique**

In phase 1 of the study, 400 dogs were castrated with the SLSC technique. Three veterinarians experienced with spay and neuter procedures (WLR, LGD, and JMB) performed all surgeries in this phase. Dogs were monitored for complications during recovery and in the postoperative period before return to the kennel area. They were assessed again 24 hours after surgery by the same veterinarian (KPM), who did not perform any of the surgeries. Because puppies at the OHS are generally adopted quickly after they have been castrated and made available for adoption, we were precluded from scheduling later recheck examinations; however, owners were instructed to monitor their newly adopted puppies for postoperative concerns such as incisional complications (ie, swelling or discharge) or signs of lethargy or inappetence and return to OHS for further veterinary care at no cost if problems arose. Additionally, kennel personnel were instructed to identify and report any problems.

Potential complications that were monitored included hemorrhage, signs of pain, self-trauma, swelling, and dermatitis at the incision site. Presence of postoperative pain was assessed by general observation of the patient, with or without interaction, and patient response to palpation of the surgical incision. Swelling and dermatitis were visually assessed, noted, and treated if necessary. Any serious hemorrhagic complications were to be addressed and confirmed via exploratory surgery or confirmed via necropsy.

**Phase 2: comparison of procedure durations**

Two of the experienced veterinarians (WLR and LGD) performed the procedures in phase 2 of the study, with each performing half of the procedures per group. All surgeries were completed in the morning to minimize the effect of surgeon fatigue on procedure duration. The duration of each procedure was measured as the interval from when the scalpel touched the skin to complete skin closure.

**Surgical procedures**

Prior to castration, dogs received buprenorphine hydrochloride (0.015 mg/kg [0.007 mg/lb], IM). Anesthesia was induced with a combination of midazolam hydrochloride and ketamine hydrochloride (given IV to effect, typically at 0.55 mg/kg [0.25 mg/lb] and 5 mg/kg [2.3 mg/lb], respectively), and dogs were endotracheally intubated. Anesthesia was maintained with isoflurane in 100% oxygen for the duration of the procedure. The scrotal and prescrotal areas were clipped of hair and scrubbed with 4% chlorhexidine solution and alcohol before dogs were moved into the operating room.

For the SLSC procedure, a single scrotal incision was made on the ventral midline of each dog and both testes were accessed through this incision. It was left to the discretion of the surgeon whether the vaginal tunic was opened or a closed castration was performed. Each surgeon consistently performed either closed or open castration per their preference throughout the study, with no change in technique based on patient size. The testes were manually individually exteriorized with gentle traction to break down fibrous attachments between the testes and scrotum, and a hemostat was then directed parallel to the spermatic cord, pointed in a proximal direction. The hemostat was twisted to form a simple overhand knot in the spermatic cord; the spermatic cord was then cut distal to the hemostat and the cut end was slipped over the end of the hemostat to complete the knot. The scrotal skin incision was closed by application of 1 or 2 drops of cyanoacrylate skin adhesive, depending on the size of the incision.

For the TPSC procedure, the testes were individually advanced into the prescrotal area, where a single ventral midline skin incision was made. Again,
the choice of opening of the vaginal tunic versus performing a closed castraton was left to surgeon discretion, and again, each surgeon consistently used the same chosen technique throughout the study with no change based on patient size. Both testes were manually individually exteriorized with gentle traction to break down fibrous attachments between the testes and scrotum, and the spermatic cord was ligated with 2 absorbable circumferential ligatures. The spermatic cord was transected distal to the ligatures, and the testes were removed. Prescrotal incisions were closed by placement of a single absorbable suture in the subcutaneous tissue in a cruciate pattern followed by application of cyanoacrylate skin adhesive.

Statistical analysis

Statistical analysis was performed with statistical software.\textsuperscript{6} Surgical complication rates (proportions of dogs with complications) in phase 1 of the study were compared between open and closed techniques with the Fisher exact test. For phase 2, normality of collected numeric data (dog age and body weight and procedure duration) was assessed with the D’Agostino and Pearson omnibus test. Normally distributed data were compared with the unpaired t test with Welch correction and reported as mean ± SD, whereas non-normally distributed data were compared with the Mann-Whitney U test and reported as median (range). Two-tailed tests were used, and values of \( P < 0.05 \) were considered significant for all analyses.

Results

Phase 1: safety evaluation of the SLSC technique

Median age of the 400 dogs that underwent SLSC in phase 1 of the study was 3 months (range, 2 to 5 months), and median body weight was 3.6 kg (7.9 lb; range, 0.9 to 11.4 kg [2.0 to 25 lb]). All 400 dogs had 2 spermatic cords autoligated (800 cord autoligations in total). Two hundred eighty-five (71.3%) procedures were performed as open castrations and 16 of 36 (44%) were performed as closed castrations. Median (range) age in the SLSC (n = 18) and TPSC (18) groups was the same (2 months; range, 2 to 5 months). Median body weight was also similar between the SLSC group (2.6 kg [5.7 lb]; range, 0.9 to 7.7 kg [2.0 to 16.9 lb]) and TPSC group (3.4 kg [7.5 lb]; range, 1.4 to 7.0 kg [3.1 to 15.5 lb]). Procedure duration was significantly (\( P < 0.001 \)) briefer in the SLSC group (mean ± SD, 1.0 ± 0.2 minutes) than in the TPSC group (3.5 ± 0.4 minutes).

Discussion

Our hypotheses for the present study were that the complication rate associated with SLSC when performed in healthy dogs at 2 to 5 months of age would be low and that the duration of the SLSC procedure would be significantly briefer than that of a TPSC procedure. The first hypothesis was supported in that SLSC resulted in no observed hemorrhagic complications for any of the 400 SLSC procedures performed, and observed minor complications were few and self-limiting. The second hypothesis was also supported in that procedure durations for SLSC were significantly briefer than those for TPSC. On the basis of these results, we concluded that the SLSC technique provides a rapid and safe technique for juvenile canine castrations.

Major castration-associated hemorrhage is uncommon in dogs.\textsuperscript{7} Most complications involving hemostasis result in scrotal hematomas and are likely due to oozing from the vaginal tunic with open orchiectomy.\textsuperscript{7,8} In the authors’ experience, large dogs with large gonads will generally have a larger gonadal blood supply than small dogs with small gonads. Given the age and size of the dogs in the present study, the blood supply to the gonads was small, so excessive bleeding was not expected nor was it encountered. No differences in complication rates were identified between open and closed castration, in contrast to findings in a previous study\textsuperscript{9} in which a higher complication rate was observed with open castration (70%) than with closed castration (46%) in dogs. However, the dogs in that study\textsuperscript{9} were larger in size and older than the dogs in the present study.

Complications in dogs following prescrotal castration commonly involve scrotal inflammation and swelling, scrotal hematomas, incisional swelling or discharge, urethral trauma, and excessive patient attention to the surgical site.\textsuperscript{10} One study\textsuperscript{8} involving student surgeries at a teaching institution revealed an overall postoperative complication rate of 22%, with observed complications largely including scrotal hematomas, incisional swelling, and incisional discharge. In another study\textsuperscript{11} of complications following castration of dogs at 6 private veterinary practices, the overall complication rate was 15%. A third study\textsuperscript{12} in which scrotal castrations were compared with prescrotal castrations in dogs > 6 months of age revealed postoperative complication rates for prescrotal castration that ranged from 13% (postoperative signs of
pain) to 22% (postoperative swelling). Complication rates in the present study compare favorably with these historically reported rates. Collectively, these data support our conclusion that the SLSC technique is as safe or safer than the TPSC technique.

The dogs of the present study were ≤5 months of age, with a median body weight of 3.6 kg. However, the risk of postoperative complications following castration increases with age, particularly in dogs >2 years of age, and larger dogs are more likely to have hemorrhage-related complications than smaller dogs. Therefore, it was no surprise that the younger and smaller dogs in the present study had considerably fewer complications than commonly found in the literature.

Whether postoperative complications can be avoided depends on many factors, including, but not limited to, appropriate patient preparation, proper surgical procedures, and meticulous attention to aseptic technique. Cyanoacrylate skin adhesive was used to close the skin incisions in all dogs in the present study. The use of tissue adhesive provides an immediate moisture protective seal and minimizes the potential for contamination of the incision. Cyanoacrylates also have hemostatic and bacteriostatic properties that are beneficial in the postoperative period. Care must be taken to avoid allowing cyanoacrylates to penetrate the surgical wound because this may impede wound cicatrization.

The SLSC technique can be useful in clinics where a large number of dogs and cats are spayed and neutered. A high patient load, coupled with the potential for limited resources in such clinics, further emphasizes the importance of surgical efficiency and cost-effectiveness. The use of SLSC in these circumstances is supported by the finding that SLSC procedures were, on average, approximately 2.5 minutes faster to perform than TPSC procedures in the present study. Although a savings of 2.5 minutes may appear unimportant, when considering a large number of patients, this savings becomes more consequential. Indeed, use of the SLSC technique for 400 dogs saved 16.6 hours (≥2 full workdays) of surgical time, compared with the amount of time that would have been spent had the TPSC technique been used, resulting in payroll savings for at least 2 employees (a surgeon and anesthetist, both of whom would have had to be present for the 16.6 hours of extra surgical time). We believe that scrotal castrations in dogs have the added advantage in that the smaller testes of puppies are easier to stabilize within the scrotum than when pushed into the prescrotal position, likely contributing to the safety and efficiency of this technique. It should be noted that in the previously mentioned study involving comparison of prescrotal and scrotal castration in adult dogs, a distinct time advantage was also identified with the scrotal approach.

The present study had limitations that should be considered when interpreting the results. Further incisional complications could have developed beyond the 24-hour recheck examination. However, dog adopters were instructed to report any problems with the surgical incision or any other concerns. We believe that most, if not all, dogs would have returned to the shelter for no-cost treatment rather than taken to their community veterinarian, at the owner’s expense. We are therefore confident that any important postsurgical complications were captured in the study data. Additionally, in a previous study of complications in dogs following castration, most complications were discovered at the 24-hour recheck examination and no complications were found at the next recheck examination, performed 10 days after surgery. The investigators in that study advocated for rechecking of patients in the immediate postoperative period and questioned the value of rechecking those patients 10 days after castration.

Another limitation of the present study was that few studies of postoperative complications have been reported in the peer-reviewed veterinary literature that would allow direct comparisons with the findings of the present study. Although 1 study of castration protocols for pediatric puppies with a slightly different technique showed that scrotal castrations appeared safe given observations in the immediate postoperative period, only 6 male puppies were monitored for postoperative complications. A larger study in which TPSC was evaluated in pediatric and juvenile puppies revealed morbidity and mortality rates that compared favorably with those of dogs and cats castrated at the traditional age. In the published data for that study, findings for dogs were combined with those for cats and data for spays were combined with those of castrations, thereby precluding any meaningful comparison with our data.

Another potential limitation of the study reported here was the opportunity for experimenter bias. For obvious reasons, the surgeons could not be blinded to the procedure that they were performing so they could have, consciously or subconsciously, performed the TPSC procedure slower than the SLSC procedure. However, use of 2 surgeons in the timed portion of the study may have reduced the effect that any 1 surgeon could have on the data. Also, given that at least 2 people observed the surgeries (ie, the person monitoring anesthesia and the person timing the procedure), we considered it unlikely that the surgeon would have been able to slow down without drawing attention.

The low complication rate and time advantage associated with use of the SLSC technique for castration of dogs at 2 to 5 months of age suggested several advantages, including briefer durations of anesthesia and surgery than with the TPSC technique. We expect that as the SLSC technique is more widely used, morbidity and mortality rates associated with canine castration will improve as well savings in resources, such as time and suture material. Although pediatric gonadectomy is not without controversy or detractors, it is an important part of allowing animal shelters to proactively address pet overpopulation. Overall, the findings of the present study provide valuable information for the veterinarians who perform such surgeries.
Acknowledgments

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Footnotes

a. GraphPad StatMate, version 2.00 for Windows, GraphPad Software, San Diego, Calif.
b. GraphPad Prism, version 6.02 for Windows, GraphPad Software, San Diego, Calif.

References


From this month’s AJVR

Influence of injection protocol and measurement technique on computed tomographic assessment of glomerular filtration rate in healthy Beagles

Michael Wallimann et al

OBJECTIVE
To compare values of CT-derived glomerular filtration rate (GFR) determined by 3 contrast-medium injection protocols and 4 measurement techniques in healthy Beagles.

ANIMALS
9 healthy Beagles (mean ± SD weight, 13.2 ± 1.6 kg).

PROCEDURES
Each dog underwent 3 iohexol-injection protocols (700 mg of iodine/kg administered at a constant rate over 20 seconds, 700 mg of iodine/kg administered following an exponentially decelerated injection over 20 seconds, and 350 mg of iodine/kg at a constant rate over 10 seconds) during dynamic, whole renal-volume CT in randomized order with an interval of ≥ 7 days between experiments. Values of GFR determined from Patlak plots derived by use of 4 measurement techniques (standard transverse section, optimized transverse section, dorsal reconstruction, and volume calculation techniques) were compared.

RESULTS
The measurement technique influenced the mean ± SD GFR results (standard transverse section technique, 2.49 ± 0.54 mL/kg/min; optimized transverse section technique, 2.72 ± 0.52 mL/kg/min; dorsal reconstruction technique, 3.00 ± 0.60 mL/kg/min, and volume calculation technique, 2.48 ± 0.51 mL/kg/min). The lower iodine dose resulted in a significantly higher GFR value (3.00 ± 0.65 mL/kg/min), compared with that achieved with either higher dose administration (constant rate injection, 2.54 ± 0.45 mL/kg/min and exponentially decelerated injection, 2.47 ± 0.48 mL/kg/min).

CONCLUSIONS AND CLINICAL RELEVANCE
In healthy Beagles, the CT-derived GFR measurements obtained after injection of a full dose of contrast medium were reduced, compared with measurements obtained after injection of a half dose. This finding is important with regard to potential nephrotoxicosis in dogs with impaired renal function and for GFR measurement with CT-contrast medium protocols. (Am J Vet Res 2018;79:1298–1305)