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CASE REPORT

A new approach to the vasectomy of African lions (*Panthera leo*)

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Four healthy, male, adult African lions (*Panthera leo*) were presented for vasectomy, which was performed for management purposes. After immobilisation with medetomidine and tiletamine/zolazepam the lions were intubated and anaesthesia was maintained with isoflurane. In each animal, the ductus deferens was located bilaterally, dissected and transected. Following ligation, a technique commonly used in human medicine called fascial interposition, was used to decrease the chances of recanalisation. Using this technique, the prostatic end of the ductus was fixated outside the tunica vaginalis, while the testicular end remained within the tunic. Histopathology was performed in all cases to confirm the presence of the ductus deferens tissue. During the follow up, twelve months later, no complications were noticed by the owner and no new litters have been born since.

Keywords: African lions, *Panthera leo,* vasectomy, medetomidine, tiletamine/zolazepam, ductus deferens, fascial interposition

Introduction

The African lion (*Panthera leo*) is currently regarded as "vulnerable" by the International Union of Conservation of Nature (IUCN) (Bauer et al. 2016). According to Bauer et al. (2016), the population of free-ranging lions is currently still declining. South Africa, however, has a substantial free-ranging and captive-bred population of African lions. The total number of lions living in captivity, is estimated to be around 8 000 animals (Hutchinson & Roberts 2020). Not only is there a large captive lion population, the areas in South Africa that are suitable for free-ranging lions are also saturated. Captive lions tend to breed well, necessitating population management to avoid unsustainable growth within these facilities and national parks (Bertschinger & Caldwell 2016). In South Africa, the long-term viability of the captive lion sector is currently in question due to the drafting of a policy position on the conservation and ecologically sustainable use of elephant, lion, leopard and rhinoceros (South African Government Gazette 2021). This policy calls for the closing of the captive lion sector and, if passed in its current form, raises serious questions about the fate of the 8 000 lions in captivity. Thus, solutions for preventing further population growth need to be urgently considered.

In attempts to curb overpopulation, several contraceptive methods are available of which the vasectomy of male lions is one. In human vasectomies, surgeons now use a method called "fascial interposition" to minimise the chance of recanalisation occurring. With this technique, the failure rate (not reaching azoospermia, based on semen analysis) has been reduced from 12.7% to 5.9% (Sokal et al. 2004). A modified version of the fascial interposition technique has successfully been developed for African lions to reduce the likelihood of vasectomy failure. This case series describes this modified technique for the vasectomy of African lions.

Material and methods

For this case series, four captive male African lions were presented for vasectomy. At the time of the procedure, the lions were between 3 and 16 years old, weighing between 150–190 kg. All animals were deemed healthy preoperatively and no abnormalities were detected during the initial physical examination. The owner opted for vasectomy due to the shortage of hormonal contraception in the country.

The patients were immobilised with tiletamine/zolazepam (Zoletil™ 100, Virbac, South Africa [SA]; 0.5–1 mg/kg IM) and medetomidine (Compounded 20 mg/ml, Kyron Labs, SA; 0.03–0.05 mg/kg IM). Both drugs were administered intramuscularly (IM) using a pneu-dart (Pneu-Dart. Inc., 0.5–1 ml, ¾"-needle) with a gas-powered dart projector (X-Caliber; Pneu-Dart. Inc., USA). The dosage was dependent on the size and age of the particular lion. Five to ten minutes after recumbency, the lions were approached with care, a blindfold was placed over the eyes and earmuffs were placed in both ears. If the anaesthesia plane was deemed too light, ketamine hydrochloride (Fresenius Kabi, [Pty] Ltd, SA; 0.5–1 mg/kg IM) was administered intramuscularly. An intravenous catheter (IV Catheter Radiopaque, 18G; Smiths Medical [Pty]. Ltd, SA) was then placed in the saphenous vein on the medial side of one hindleg. The catheter was fixated with a combination of superglue (Loctite® Super Glue, USA) and elastic tape (Leukoplast®; BSN Medical [Pty] Ltd, SA). An isotonic crystalloid solution (Lactated Ringer's Injection, USP; Fresenius Kabi, [Pty] Ltd; 2–6 ml/kg/hr) was administered intravenously throughout the procedure. The animals were intubated using a 20 mm large animal endotracheal tube (Jorvet Endotracheal Tubes, USA) and anaesthesia was maintained with isoflurane (ISOFOR®; Safeline Pharmaceuticals [Pty] Ltd, SA; 1–3%) in oxygen delivered via a vaporiser (Ohmeda, Isotec 3, BOC Health Care, Manchester M28 2UT, UK). A closed re-breathing system was used. Preoperatively, all lions received a dose of meloxicam (Metacam 5 mg/ml, Boehringer Ingelheim Animal Health, SA;

0.2 mg/kg SC), a vitamin supplement (Kyroligo, Kyron Labs, SA; 0.03–0.05 ml/kg IM) and a once-off, prophylactic, injection with a long-acting antibiotic (Duplocillin; Procaine benzylpenicillin 150 mg [150 000 IU] with benzathine benzylpenicillin 125 mg [150 000 IU], MSD Animal Health, SA, 0.08–0.1 ml/kg SC).

In surgery, all patients were placed in dorsal recumbency. The area around the testicles and prepuce was clipped and aseptically prepared with a 4% chlorhexidine gluconate skin cleanser (HiBiScrub®, Mölnlycke Health Care AB, Göteborg SE-402 52, Sweden) and 70% isopropanol. The surgical area was draped, after which the spermatic cord was manually palpated and fixated using a three-finger technique (Coe & Curington 2015) (Figure 2a). The cord was then retracted as superficially as possible underneath the skin. Starting on the left side, a three-to-four-centimetre skin-incision was made at the level of the prepuce in an anterolateral direction, over the spermatic cord. The subcutis and dartos muscle were then dissected from the underlying spermatic fascia (Figure 2b). This allowed the surgeon more room to lift the spermatic cord through the skin and fixate it using a clamp. The spermatic cord was then incised longitudinally. Several layers had to be incised to visualise the ductus deferens: the external and internal spermatic fascia, cremaster muscle (in some cases) and the parietal and visceral tunica vaginalis. Following the incision, the ductus was isolated by dissecting the ductus away from the mesoductus deferens and pampiniform plexus. Care had to be taken when handling the pampiniform plexus as damage to the plexus could lead to extensive bleeding. The ductus deferens is located medially of the plexus (Figure 1).

The isolated ductus was clamped on both the prostatic and the testicular side, using artery clamps placed 1.5–2 cm apart. A section (1.5–2 cm) of the ductus deferens was then removed using a surgical blade (nr. 20), leaving the two artery forceps in place on either end of the remaining ductus. The resected section of the ductus deferens was placed in a formalin solution and kept for histopathological confirmation.

Each end of the ductus deferens was then folded and ligated using monofilament absorbable suture material (MonoPlus® 3-0, B. Braun Surgical, SA). To fold the ductus, the needle was passed through the ductus deferens and the end of the ductus was then folded back, facilitated by the clamp. The thread was wrapped around the ductus deferens several times and a surgical knot was created. This procedure was performed on both ends of the ductus deferens (Figure 2c). After ligation, fascial interposition was performed to prevent possible recanalisation. The testicular end of the ductus deferens was positioned inside the spermatic cord. The prostatic end of the ductus was positioned and fixated outside the cord using the same monofilament absorbable suture material (MonoPlus® 3-0, B. Braun Surgical, SA). The spermatic cord was then closed using a continuous suture pattern with the same suture material (see Figure 2d), creating a natural tissue barrier.

The subcutis and dermis were closed using a continuous pattern with monofilament absorbable suture material (MonoPlus® 2-0, B. Braun Surgical, SA). The skin was closed intra-dermally with a

Figure 1: The ductus deferens (arrows) out of the spermatic cord; the ductus deferens is positioned medially of the pampiniform plexus (arrow heads)

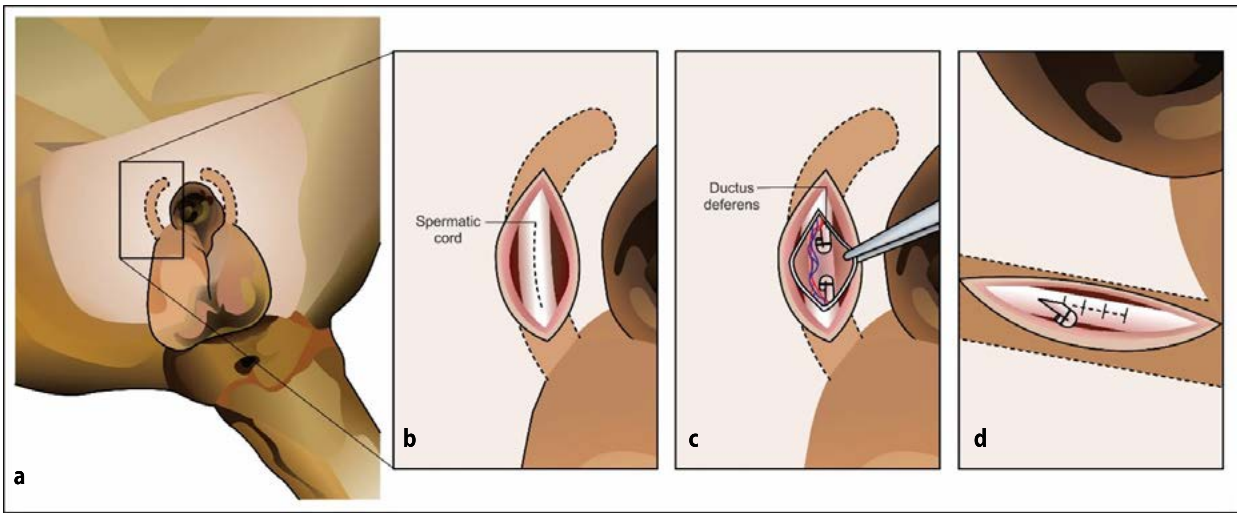

Figure 2: (a) Location of the spermatic cord – most easily accessed laterally of the penis; (b) After incision of the skin and subcutaneous tissues, the spermatic cord can be visualised; (c) After partial resection of the ductus deferens, both ends of the ductus deferens are folded and ligated using monofilament absorbable suture material; (d) The prostatic end of the ductus deference is left outside of the spermatic cord, after which the spermatic cord is closed; facilitating the fascial interposition

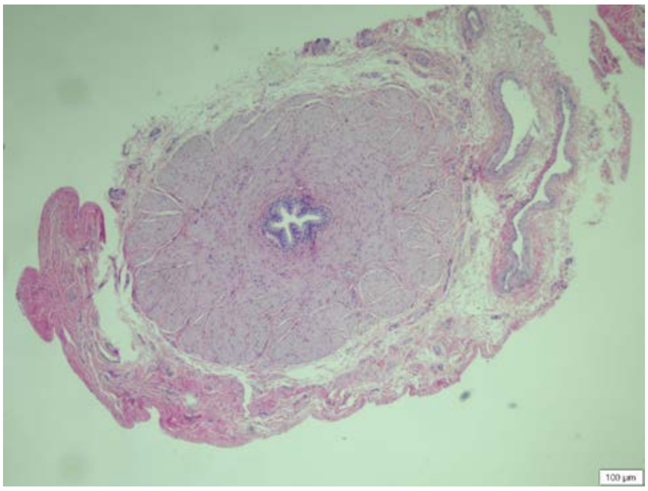

Figure 3: A central lumen that sometimes contains spermatozoa, lined by ciliated pseudo-stratified columnar epithelial cells, supported by a thin ring of connective tissue; The epithelial cells and supporting lamina propria are arranged in folds; The mucosal layer is circumferentially bordered by three layers of smooth muscles, namely the inner and outer longitudinal muscular layers separated by a middle circular muscular layer; The outer longitudinal muscular layer is surrounded by an admixture of adipose and loose fibrous connective tissue interspersed with arteries, veins and bundles of skeletal muscle (cremaster muscle)

buried knot, ensuring no suture material was protruding from the incision site. The same procedure was repeated on the ipsilateral side. A wound spray (Supona® Aerosol, Zoetis South Africa [Pty] Ltd., SA) was then applied to both incision sides.

Following the procedure, the lions were placed in their enclosure. The medetomidine was antagonised with atipamezole hydrochloride (Antisedan® 5 mg/ml, Zoetis South Africa [Pty] Ltd., SA; 0.09 mg/kg IM) at three times the initial medetomidine dose. All lions recovered smoothly after the surgery and were mobile within twenty minutes after reversal.

The resected sections of the vas deferens were sent for histopathology (Figure 3), after which the samples were destroyed.

Discussion

South Africa has a substantial captive-bred population of African lions, estimated between 8 000–8 500 individuals (Coals et al. 2019; Hutchinson & Roberts 2020), although it is suspected that this number could be much higher. The lions are kept for a variety of reasons including breeding for the international bone trade, trophy hunting, live animal export, conservation purposes or for protection and rehabilitation purposes (Green et al. 2021).

The need for contraception in (captive) lions has increased in the last years after changes concerning the lion bone trade and breeding with captive lions. The legal export of lion bones has stopped after a decision by the High Court of South Africa in 2019, declaring that the lion bone annual quotas set by the South African Department of Forestry, Fisheries and the Environment (DFFE) were unlawful and constitutionally invalid (SAFLII 2019). According to the South African High Court, there was no provision for animal welfare, regardless of the fact that the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) initially allowed South Africa to set a quota for lion bone trade in 2016 (during the CITES Conference of the Parties, 2016). Therefore, the sale and export of lion bones is currently illegal, regardless of the fact that it is legal to breed and hunt captive lions. Additionally, the export of captive bred lion trophies to the US was forbidden under the Endangered Species Act, until the US Fish and Wildlife Service withdrew the ban, allowing the import of lion (and other trophies) on an application basis (Outhwaite 2018).

Several methods are available to control breeding such as hormonal control, surgical procedures (vasectomy or ovariectomy) or immunocontraception. The use of hormonal contraceptives in female African lions is well described (Bertschinger et al. 2008; Kawase et al. 2021). Deslorelin acetate implants (Suprelorin®, Virbac, SA) are widely used in captive and free-ranging large felids such as lions, tigers and cheetahs, with positive results (Bertschinger et al. 2002, 2006 & 2008). When deslorelin is used in lionesses it induces anestrus and therefore infertility (Bertschinger & Sills 2013). Deslorelin implants are reported to have minimal effect on the behaviour of African lions in captivity (Jansen & Thodberg 2020). The implants are also used in male lions, but results in loss of the androgen-dependent manes (Bertschinger & Sills 2013) and might alter group interactions and hierarchy. For most animals that have not been trained for hand-injections, a general anaesthesia would be indicated in order to place such an implant. Although complications are rare, there are some serious complications associated with such procedures. Immunocontraception with a gonadotropin-releasing hormone (GnRH) vaccination is described as an alternative contraception method in lionesses. A two-dose administration of the hormone can provide a contraceptive effect up to 246 days (Kawase et al. 2021). The vaccination can be delivered by dart or hand-injection. The duration of the contraception is often unknown and can vary between individuals (Braga et al. 2020), making it particularly unreliable in certain cases. Behaviour and hormone monitoring is therefore crucial to determine whether the animal is returning to cyclicity. Hormonal contraceptive treatments in lions have other disadvantages, namely that the procedures have to be repeated every other year and even annually in some cases. Finally, these contraceptive methods are often associated with excessive weight gain. It is advised that animals contracepted with hormones have their diet controlled carefully (Bertschinger & Sills 2013).

Surgical alternatives such as (laparoscopic) ovariohysterectomy are described (Hartman et al. 2013; Kolata 2002). However, for these complex procedures, a skilled surgeon and the right equipment is necessary. The vasectomy of male lions is therefore seen as a more approachable, quicker, safer and cheaper option.

The current knowledge and available literature on the vasectomy in male African lions is limited and outdated (Hahn 1977; Reed & Tennant 1975; Robinson, Sedgwick & Lochner 1975). Although this procedure has to be performed under general anaesthesia, it only has to be performed once. Vasectomy in lions has been shown to be reversible, making it a non-permanent sterilisation (Marconi et al. 2020). The reversal of a vasectomy has been successfully performed by an experienced microsurgeon in a lion, whereafter fertility was resumed (Marconi et al. 2020). Reversal of vasectomies in humans generally has a success rate greater than 90% (Silber et al. 2013). It is important to note that these reversing surgeries are more successful when an 'open-ended vasectomy' technique is used. The key to this technique is leaving the distal (testicular) end open, to allow leakage and prevent the buildup of pressure in the epididymis. The pressure could lead to damage to these male reproduction organs, with epididymal complications leading to a lower success rate (Silber & Grotjan 2004). Using the 'open-ended vasectomy' should be considered when animals might need reversal surgery later on in life.

No surgical complications were observed postoperatively. Complications known to occur in humans include postoperative swelling, infection, haematoma formation and/or failure of the procedure (Adams & Wald 2009; Zhao et al. 2018). To the researcher's knowledge these complications have not been described in lions. Vasectomy will, however, not prevent potential adverse consequences to female carnivores from prolonged, cyclic exposure to endogenous progesterone (DeMatteo et al. 2006). Lionesses will most likely come back on heat after a period of pseudopregnancy, as a result of copulation-induced ovulation in felids. This may increase the chances of behavioural changes, pyometra and infertility (Bertschinger, pers. comm.; DeMatteo et al. 2006).

Conclusion

The use of this modified technique for the vasectomy of lions, using fascial interposition, has the major potential to decrease the risk of recanalisation. The vasectomy of lions could be a viable, cheap and reversible method for the captive lion sector if it is deemed necessary to prevent breeding in captive facilities. Further research is required to provide more evidence of the effectiveness and applicability of the use of fascial interposition during the vasectomy of lions. Careful consideration of the contraception method for lions in captivity is crucial.

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Conflict of interest

The authors declare they have no conflicts of interest directly or indirectly related to the research.

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Ethical approval

Prior to the commencement of the study, ethical approval was obtained from the following ethical review board: University of Pretoria – Research Ethics Committee – REC017-22. All institutional and national guidelines for the care and use of laboratory animals were followed.

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