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CASE REPORT

Left-lateral laparotomy using a dorsoventral incision for unilateral ovariohysterectomy in free-ranging African lions (*Panthera leo*)

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Population management of the African lion (*Panthera leo*) is often necessary in smaller non-contiguous systems. Ovariohysterectomies are commonly performed as a means of surgical birth control in many species by ventral-midline celiotomy, although a lateral laparotomy is used routinely in certain species and clinical settings. Ovariohysterectomies have been carried out in both captive and free-ranging African lion populations for birth control. This paper presents a left-lateral laparotomy (left-flank approach) for ovariohysterectomy in the free-ranging African lion, using the greater trochanter of the femur and the iliac crest as anatomical landmarks in order to determine the correct location for the abdominal incision. Unilateral ovariohysterectomies were successfully performed in three free-ranging lionesses by left-flank approach with no intra- or postoperative complications and rapid recovery. The procedure is swift, safe and provides an alternative to the ventral-midline celiotomy.

Keywords: left-lateral laparotomy, left-flank approach, unilateral ovariohysterectomy, free-ranging African lion

Introduction

In free-ranging African lion (*Panthera leo*) populations managed on small, fenced reserves, population control is often necessary, whether surgical, pharmacological, translocation or culling methods (Miller et al. 2013; McEvoy et al. 2019; Miller 2024). With adequate prey densities and low rates of mortality, lion populations can grow quickly (Miller & Funston 2014). Various studies have shown cub recruitment of approximately 50% and up to 87% in small fenced systems (Miller et al. 2013). This can lead to a rapid increase in lion numbers, putting pressure on the system, and leading to a decrease in overall genetic diversity due to high numbers of closely related individuals.

Ovariohysterectomies are commonly performed as a method of surgical birth control in many species, but may also be indicated in cases of neoplasia, genitourinary tract infections, ovarian pathology, cystic endometrial hyperplasia, or peripartum complications (MacPhail & Fossum 2019). The procedure is most commonly performed by a midline celiotomy (ventral-midline approach), although a lateral laparotomy, often left sided (left-flank approach), is employed routinely in certain species or settings, such as domestic cat spaying in the United Kingdom and domestic dog spaying in shelter medicine in India (Dorn 1975; Hickman 1980; Rozanska et al. 2016). Ovariectomies are also a common method of surgical birth control which can similarly be undertaken by a midline or flank approach. They confer much the same advantages as ovariohysterectomy although they generally require smaller surgical incisions and may be faster, however, the risks of uterine disease remain.

Ovariohysterectomy and ovariectomy may be carried out, unilaterally or bilaterally, in both captive and free-ranging lion populations for birth control. In a captive setting this is usually bilateral ovariohysterectomy, which may be preferred versus implantation with hormonal contraception due to the temporary nature and variable duration of action of hormonal contraception (Moresco et al. 2014) and as it removes the risk of pyometra, and both ovarian and uterine neoplasia (c.f. ovariectomy) (MacPhail & Fossum 2019). A unilateral ovariohysterectomy or ovariectomy may be preferred to retain normal pride breeding dynamics whilst aiming to reduce litter sizes, thereby reducing population growth rate. However, although studies have shown a decrease in litter size after unilateral ovariohysterectomy, it has not been statically significant (McEvoy et al. 2019). Ovariohysterectomy is irreversible, and for a smaller, fenced, free-ranging population, having a higher number of females with unilateral ovariohysterectomies versus fewer with bilateral ovariohysterectomies may present a lower risk option; reducing population growth rates whilst retaining a higher number of breeding females. Non-cycling females may negatively affect pride dynamics and may have negative health effects for the female herself due to the dysregulation of luteinising hormone (LH) as can be seen in domestic dogs (Reichler et al. 2005; Kutzler 2020). Permanently elevated LH levels (> 5 x normal) due to lack of negative feedback has been demonstrated in other species (Beijerink et al. 2007), which has been associated with urinary incontinence, obesity, diabetes, increased risk of neoplasia, musculoskeletal disorders and cognitive dysfunction (Reichler et al. 2005; Kutzler 2020).

The aim of publishing this case report is to highlight an alternative surgical approach for ovariohysterectomy/ovariectomy in free-ranging lionesses, which is simpler to undertake in the field, decreases operating time, and may reduce some risks associated with a ventral-midline celiotomy.

Case history

Signalment

Three, adult female, African lions (*Panthera leo*), of three, six and seven years-old, body weights approximately 125, 140 and

150 kg (estimated), were immobilised for surgical birth control between December 2018 – October 2019.

Clinical history

The animals were part of a reintroduced population in Akagera National Park, Rwanda. Based on a clinical evaluation all patients were deemed healthy. One animal was nulliparous whereas the two others were multiparous (two litters of four cubs for each female). The population of lions was six times larger than at reintroduction four years previously. Two males and four females were originally introduced, and the population had grown to 20 males and 17 females by the time of these surgeries. Other reproductive measures were also undertaken in this population (vasectomies and contraceptive implants).

Immobilisation

The animals were immobilised with ~0.8 mg/kg of zolazepam/tiletamine (Zoletil 100 made up to 100 mg/ml; Virbac, Bury St Edmonds, UK) in combination with 0.04 mg/kg medetomidine (40 mg/ml compounded Medetomidine; Kyron Labs, Johannesburg, South Africa) by intramuscular (IM) injection using a 1.5 ml dart and a 19 mm needle (P-Type; Pneudart Inc.) delivered by a dart projector (JM Special 25; DANiNJECT, Kolding, Denmark). Once recumbent the animals were repositioned into right lateral recumbency, and the airways were visually evaluated with a custom laryngoscope (self-made, long plastic shoe horn with LED torch attached) and confirmed clear, with no risk or respiratory obstruction. An intravenous cannula (Jelco 20G, 1.25", Smith's Medical, UK) was placed in the left cephalic vein. The dart wounds were treated with 1 000 mg of oxytetracycline (Terramycin Injectable; Zoetis) instilled directly. A top-up dose of ~0.33 mg/kg zolazepam/tiletamine in combination with ~0.02 mg/kg medetomidine was given by IM injection at 25–35 minutes post-immobilisation to ensure a surgical plane of anaesthesia for surgery, evaluated by assessment of reflexes (palpebral), eye position, and monitoring of respiratory rate and heart rate. Heart rate was monitored using a handheld pulse oximeter with a transmission probe (EDAN H100B, Edan Instruments, Shenzhen, China). Pain-relief was achieved with an IM injection of 0.2 mg/kg meloxicam (Metacam 20 mg/ml; Boehringer-Ingelheim, Bracknell, UK) and 0.1 mg/kg butorphanol (Torbugesic 10 mg/ml; Zoetis, Leatherhead, UK).

Surgical approach

Unilateral ovariohysterectomies were undertaken by a left-lateral laparotomy (left-flank approach). The site was shaved, surgically prepared and draped, with the surgeon gloved and gowned. The pelvic limbs were tied together just above the tarsus and retracted to full extension, then fixed in position to avoid an incision into the pelvic limb musculature (sartorious) as has been reported in domestic cats. A 4–6 cm dorsoventral incision was made, with a size 15 scalpel blade and scalpel (No 3, Swann-Morton, Sheffield, UK), through skin, subcutaneous tissue, muscle and peritoneum, using the greater trochanter of the femur and the most cranial aspect of the wing of the ileum as anatomical landmarks to locate the incision site, as per Ladlow 2015:354. This is an equilateral triangle, with the most cranial aspect of the iliac crest, the great trochanter of the femur and the centre of the incision site, being the three corners of the triangle (Figure1).

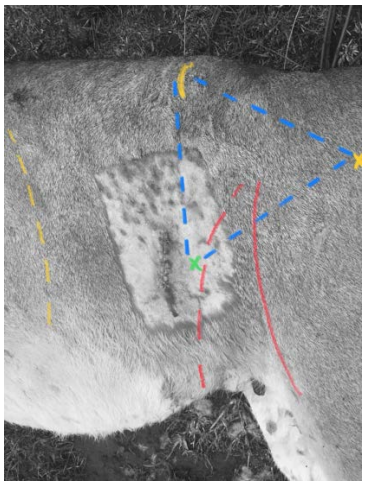

Figure 1: Location of the incision site. The line of the pelvic limb musculature marked in a solid red line, with the possible cranial extent at rest marked in dashed red lines. The greater trochanter marked with a yellow cross, the most cranial aspect of iliac crest is outlined in yellow. The caudal border of the ribs is marked with a yellow dashed line. The equilateral triangle is marked in dashed blues lines and the centre of the incision marked with the green cross.

In all cases the left ovary was easily located under the incision site and externalised above the level of the incision without tension, which made placing ligatures easy. The right ovary was also examined in all animals to ensure there were no issues that would render the animal infertile and assess the ease of removing the dependent ovary, and therefore the feasibility for a bilateral ovariectomy/ovariohysterectomy from a single-sided flank incision. The procedure was performed using a three-clamp technique (MacPhail & Fossum 2019) using 260 mm curved Rochester-Pean forceps, in this technique three forceps/haemostats were placed proximal to the ovary/uterine horn with the most proximal forceps being placed a short distance (approx. 7 mm) from the adjacent pair, to leave enough tissue distal to the ligature to avoid ligature slippage. The most proximal forceps was used to form a crush bed ('one-click' on the ratchet handle) and then was removed. This technique can be achieved with 2 clamps (a modified three-clamp technique), using the most proximal forceps to form a crush bed and then moving them to be the most distal forceps. Ligatures were tied in the crush bed. The tissue was then sharply dissected between the remaining two clamps. The left ovarian pedicle and left uterine horn (approximately 3–5 cm cranial to the uterine bifurcation, in one animal approximately 1/3 of the uterine horn length proximal to the bifurcation) were ligated with double encircling ligatures (a single ligature can be used depending on surgeon preference) using size 0 polydioxanone (PDS II; Ethicon Inc., Leeds, UK). The left uterine horn and left ovary were then resected by sharp dissection and removed. The final clamp was released once the ligated tissue had been secured with Treves rat tooth forceps, allowing assessment of the ligatures to ensure no haemorrhage, before gentle release into their normal position. The muscles were closed in separate layers (transverse abdominis, internal abdominal oblique, external abdominal oblique) incorporating

the peritoneum with the transverse abdominis, using size 0 PDS II with a cruciate mattress suture pattern. Subcutaneous tissue was closed with size 0 polyglactin 910 (Vicryl; Ethicon Inc., Leeds, UK) in a simple interrupted suture pattern. The dermis was also closed with size 0 polyglactin 910 using an intradermal suture pattern with buried knots. The skin wound was sprayed with oxytetracycline spray (Terramycin Spray; Zoetis).

Recovery and outcome

Anaesthesia was antagonised at between 1 hour 35 minutes and 1 hour 50 minutes with IM injection of 0.3 mg/kg atipamezole (Sedastop 5 mg/ml; Animalcare, York, UK). Reversals were unremarkable and there was no resedation, with time to regain standing being 20–40 minutes from antagonist administration. The surgical procedures were performed successfully with no complications. The surgical wounds healed with no adverse effects, monitored visually with binoculars daily for three days after surgery and weekly thereafter for three weeks, with regularly but less frequent monitoring thereafter. The animals were fitted with GPS/VHF tracking collars for monitoring after the procedure (Lion Collar; Africa Wildlife Tracking). One lioness was observed successfully hunting the evening after the procedure. Four years of follow-up have found no negative effects of the surgery on the animals.

Discussion

A lateral laparotomy offers many benefits compared to a midline celiotomy, especially in a field setting, and is uniquely suited for a unilateral ovariohysterectomy or unilateral ovariectomy due to the incision being directly over the ovarian pedicle. The incision is generally smaller and operating time less for a lateral versus a midline celiotomy (Kiani et al. 2014); in domestic cats, the average surgical time for a midline celiotomy is approximately 30 minutes and lateral laparotomy 24 minutes, with incision sizes of 7.2 cm and 4.5 cm respectively (Kiani et al. 2014). A lateral laparotomy in domestic cats has been shown in some studies to be superior to a midline celiotomy in terms of wound healing time and complication rates (Kiani et al. 2014). It is easier to maintain an animal in lateral recumbency compared to in dorsal recumbency and in a non-intubated animal, positional airway protection is achieved, should there be any regurgitation or hyper-salivation. Importantly in the free-ranging setting, where there may be limited follow up after release and it may be challenging to recapture the animal, an incision high on the flank has a reduced chance of evisceration should wound dehiscence occur. Another advantage of the flank approach in the free-ranging setting is the ability to visually assess the postoperative wound from a distance, without handling the animal.

The draw-backs of a lateral laparotomy are the difficulty in dealing with complications (haemorrhage and potentially limited space for ligatures) on the contralateral ovary during a bilateral procedure (McGrath & Hardie 2004) and this approach may be associated with more discomfort compared to a midline celiotomy in the direct postoperative period (Grint et al. 2005; Swaffield et al. 2020). A lateral laparotomy is usually contraindicated in conditions such as pyometra where it can be difficult to manipulate an enlarged reproductive tract through a smaller, one-sided, incision (McGrath & Hardie 2004), and is usually more technically difficult in very large or overweight animals. There is only one other report of a lateral laparotomy in a lion, which is from a zoo lioness with a ruptured pyometra (Yun et al. 2021). In this report they approached from the right-side with a large oblique incision. Although they could access and remove the ovaries, they were unable to fully remove the uterus due to difficulties in manipulating it through the surgical incision, and undertook a partial ovariohysterectomy. This report highlights that this approach may be used to access the dependent ovary, but is not suitable for certain reproductive surgeries.

A lateral laparotomy can be undertaken from either the left or right. The left-flank is normally used as it provides easier access to the more cranially located ovary which may be more difficult to access in a bilateral procedure when dependent. However, it is predominately chosen as it feels more natural to right-handed surgeons, and suspensory ligament breakdown (if necessary) can be more easily achieved with the right hand. Left-handed surgeons may prefer a right-flank approach. In domestic cats, younger animals, especially those before first season, can have tighter suspensory ligaments making placing ligatures more difficult. In the nulliparous animal in this case report the reproductive tract was generally smaller overall but the technique was no different from the other two larger and older animals. However, it is difficult to draw conclusions from one animal.

Although a unilateral ovariohysterectomy was chosen in these animals, a unilateral ovariectomy may be preferable as it may be quicker with a smaller incision. Tubal ligation may also be an option, which would be quicker still and carries less risk as no vessels are incised. In unilateral procedures the risks are similar for all three options, as at least one ovary and a portion of the uterine horn remains, therefore the risk of pyometra and ovary/uterine disease remains, although there may be some influence on the effectiveness of birth control depending on the amount of uterine horn remaining. In the case of bilateral procedures, ovariohysterectomies and ovariectomies carry benefits over tubal ligation, specifically with regard to removing the risk of pyometra and ovarian neoplasia, which likely outweighs the benefits of a quicker operation in the case of tubal ligation. Although bilateral ovariectomy does not remove the risks associated with uterine disease, if the prevalence in dogs (Candetoft 2020) can be extrapolated to lions, the risk is low.

Before surgery the two multiparous animals had an average litter size of four (two litters each). In the four years since surgery the average litter size was 2.33 cubs per litter across all three animals, the average in the literature is 2–4 cubs with a range of 1–6 cubs (Packer & Pusey 1995). Interestingly, the single nulliparous animal had an average of 1.75 cubs per litter, which may suggest the procedure is more effective in nulliparous females. The number of animals in this study makes it difficult to draw meaningful conclusions, for two of these animals their average litter sizes have reduced, but it is within the normal range.

There are a number of possible improvements to the technique. The muscle layers may benefit from being closed in one layer

rather than individually, and the peritoneum not included, to reduce foreign material and accelerate the procedure. Subcutaneous and skin layers could also be closed as one unit. The muscle layers were incised in these cases; in small animals blunt dissection of the abdominal musculature is recommended (McGrath & Hardie 2004). In domestic cats, some clinicians prefer to angle the incision cranio-caudally as this may aid access to the uterine bifurcation and aid visualisation and access to the ovary. Local anaesthetic injection at the incision site could also have been considered to aid multi-modal pain relief and reduce postoperative discomfort.

Ovariohysterectomies in the field may be more logistically challenging than in a practice location, but surgery in the field should still adhere to aseptic principles and welfare standards with regards pain-relief (Chinnadurai et al. 2016; Fiorello et al. 2016). Although there is likely to be a higher risk of infection compared to operating in an operating theatre, the principles of responsible use of antibiotics should still be followed (Anthony et al. 2001; Morley et al.2008; Littmann et al. 2015). The animals were not given additional antibiosis other than treatment of the dart wound. Given the controlled entry into the genitourinary tract this operation could be classified as "clean-contaminated" (which warrants prophylactic antibiosis), however, in veterinary literature ovariohysterectomies are usually classified as a "clean" procedure. This must be assessed on a case-by-case basis bearing in mind the risks to the animal and the risks of antibiotic resistance.

Conclusion

This paper presents a novel surgical approach for ovariohysterectomy in African lions in a free-ranging setting, which is applicable to other large felids, both wild and captive. The left-flank lateral laparotomy approach should result in quicker, safer surgeries with a lower complication rate compared to the ventral-midline celiotomy approach, and is easier with regard to patient positioning in a field setting. Further study must be undertaken to refine the technique, as well as objectively quantify the complication rates, but this technique offers a viable alternative to a ventral-midline celiotomy, which is especially useful in the case of unilateral procedures.

Conflict of interest

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

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Ethical approval

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010. All institutional and national guidelines were followed.

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