LAPAROSCOPIC-ASSISTED OVARIECTOMY OF TIGERS (PANTHERA TIGRIS) WITH THE USE OF THE LIGASURE™ DEVICE


Published By: American Association of Zoo Veterinarians
DOI: http://dx.doi.org/10.1638/2011-0242R1.1

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne’s Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.
LAPAROSCOPIC-ASSISTED OVARIECTOMY OF TIGERS (PANTHERA TIGRIS) WITH THE USE OF THE LIGASURE™ DEVICE


Abstract: Laparoscopic ovariectomy was performed in seven tigers with the use of a vessel-sealing device and a three-port technique. A comparison group of seven tigers that underwent traditional ovariohysterectomy was assembled with the use of a medical records search. Mean operative times for laparoscopic ovariectomy were compared to standard ovariohysterectomy, and mean combined laparoscopic incision length compared to standard ovariohysterectomy incision lengths. Significance was set at \( P < 0.05 \). Mean surgical time for laparoscopic ovariectomy (82 min, range 71–126 min) was significantly shorter than standard ovariohysterectomy surgical time (129 min, range 80–165 min, \( P = 0.007 \)). Mean combined laparoscopic incision length (8.07 cm, range 3.80–9.50 cm) was significantly shorter than the mean incision length for standard ovariohysterectomy (13.57 cm, range 12.00–20.00 cm, \( P = 0.009 \)). There were no clinically important complications observed in either group. Laparoscopic ovariectomy has a significantly shorter surgical time and combined incision length compared to standard ovariohysterectomy in tigers, and appears to be a safe and rapid sterilization method for tigers. Equipment cost and the necessity for advanced training may limit its use in some institutions. Further prospective evaluation is warranted to determine whether it is associated with decreased morbidity, mortality, or cost.

Key words: Laparoscopy, LigaSure™, ovariectomy, Panthera tigris, tigers, vessel-sealing device.

INTRODUCTION

In dogs, laparoscopic surgery is associated with decreased morbidity, stress, postoperative complications, and increased postoperative activity when compared with open laparotomy.5–7,11 These outcomes are primarily due to smaller incisions and less tissue dissection. Despite these advantages, minimally invasive procedures are not routinely performed in zoological species. Laparoscopic ovarioectomies, hysterectomies, ovariohysterectomies (OVH), and tubal ligations have been performed in a variety of nondomestic species, including white-tailed deer (Odocoileus virginianus), African lions (Panthera leo), and a brown bear (Ursus arctos).1,10,18,21

An early report of laparoscopic OVH of dogs relied on suturing methods that contributed to surgical time being longer than with the standard OVH.6 The advent of vessel-sealing devices has made laparoscopic procedures more efficient by reducing the need for intracorporeal suturing or placement of ligating clips.23 A vessel-sealing device (UltraCision® Harmonic Scalpel®, Ethicon Endo-Surgery, Cincinnati, Ohio 45242, USA) was used to perform OVH and hysterectomy in African lions;18 however, that device is recommended only for vessels up to 5 mm in diameter,23,32 and some ovarian vessels in adult lions and tigers can be up to 7 mm in diameter (J. Steeil, unpubl. data).

A novel, electrothermal, bipolar vessel-sealing system (LigaSure™, Valley Lab, Boulder, Colorado 80301, USA) has been approved for vessels as wide as 7 mm in diameter.14,32 Hemostasis is achieved with this device by high-current, low-voltage energy that denatures collagen and elastin within the vessel wall.14 The energy and the compression applied by the instrument create a strong seal with the vessel walls in apposition,14 and an approximately 5-mm translucent seal zone is created that can be safely transected with the built-in cutting blade.

This study was performed to optimize a laparoscopic ovariectomy technique for tigers (Panthera tigris), and to compare operative times and incision lengths of this technique with standard OVH technique for surgical sterilization of healthy, adult female tigers. The hypotheses were that mean surgical time and combined incision length for laparoscopic ovariectomy using the vessel-sealing device would be shorter than those for standard OVH; and the incidence of complications following laparoscopic ovariectomy would not exceed that noted for standard OVH.
MATERIALS AND METHODS

Tigers

In March and April of 2011, seven, healthy, adult female intact tigers with a familial history of mammary gland carcinoma or a history of intermittent vaginal discharge were identified to undergo laparoscopic ovariectomy (Group 1). At the time of the procedure, vaginal cytology to determine stage of estrus was not performed, as it would not preclude the tiger from having the procedure performed. Exclusion criteria included evidence of vaginal discharge or mammary masses (any subcutaneous nodule appearing contiguous with the mammary chain) at the time of anesthesia, and presence of abnormalities on complete blood count (CBC) or plasma biochemistry panel. Clinical pathology abnormalities were identified using clinical experience and established reference intervals for the domestic cat.

Medical records were reviewed for tigers that had standard OVH (via midline laparotomy) performed between 1 January 1996 and 31 December 2010. Tigers were included in the study (Group 2) if there was no evidence of pyometra during surgery and no histopathologic evidence of uterine infection. Exclusion criteria included incomplete medical records, lack of histopathology of excised reproductive tracts, and/or performance of additional surgical procedures such as mastectomy during the same operative period. Surgical times, incision lengths, and postoperative complications within the first 48 hr were collected from the medical record for each tiger in Group 2.

Anesthesia

Each animal in Group 1 was visually evaluated prior to immobilization by a veterinarian. Food was withheld from each tiger for 24 hr and water was withheld for 12 hr. Tigers were immobilized with a target dose of 20 mcg/kg of medetomidine (Wildlife Pharmaceuticals, Windsor, Colorado 80550, USA), 0.2 mg/kg of midazolam (Nova-Plus, Hospira, Lake Forest, Illinois 60045, USA), and 2 mg/kg of ketamine (Ketaset, Fort Dodge Animal Health, Fort Dodge, Iowa 50501, USA), administered intramuscularly via hand or remote injection based on estimated weights. Each tiger was weighed after immobilization, and actual ranges of dosages administered were 18-25 mcg/kg for medetomidine, 0.06-0.1 mg/kg for midazolam, and 1.9-3.5 mg/kg for ketamine. After immobilization, tigers received isoflurane (IsoFlo, Abbott Animal Health, North Chicago, Illinois 60064, USA) in 100% oxygen (4 L/min) via a face mask, and a complete physical examination was performed. An intravenous catheter was placed in the medial saphenous veins, and a venous blood sample was collected for a CBC and plasma biochemistry analysis.

When an appropriate anesthetic plane was achieved, tracheal intubation was performed orally with a 16- or 18-mm endotracheal tube. Tigers were positioned in dorsal recumbency on a padded table, and anesthesia was maintained with isoflurane in 100% O₂ (2 L/min) via a circle system. Tigers were mechanically ventilated to maintain end-tidal carbon dioxide partial pressure (PE\(_{\text{CO}_2}\)) between 35 and 45 mmHg (4.7–6 kPa).

Heart rate, ECG, and oxygen saturation (via pulse oximetry) were monitored continuously. Blood pressure was measured with indirect osimetry with the use of an appropriately sized cuff placed over one of the distal forelimbs. Body temperature was measured using an esophageal probe and maintained between 37.5 and 38.5°C with a warm air blanket. Intravenous crystalloid fluids were administered at a targeted rate of 10 ml/kg/hr. Meloxicam (Metacam, Boehringer Ingelheim, St. Joseph, Missouri 64506, USA; 0.1–0.2 mg/kg s.c.) and ampicillin (APP Pharmaceuticals, Schaumburg, Illinois; 15 mg/kg i.v.) were administered after transection of both ovarian pedicles. Upon completion of the surgical procedure, each tiger was moved to a transport cage, isoflurane administration was discontinued, and atipamezole (Antisedan, Pfizer Animal Health; dosage range 0.09–0.13 mg/kg) was given intramuscularly in the hind limb. The animal was observed closely during the recovery and transported to the holding facility for further observation.

The day after the procedure, each tiger was given 0.1 mg/kg of meloxicam (p.o. q. 24 hr) and 2 mg/kg of tramadol (Tramal, Pfizer Animal Health Inc., p.o. b.i.d.) for two additional days to provide postoperative analgesia.

Laparoscopic ovariectomy (Group 1)

Laparoscopic ovariectomy had never successfully been performed in this collection of tigers. As a result, the authors used several different port placements, insufflation pressure changes, and sequencing of gonad removal in the first three tigers to optimize surgical technique. For the optimized technique, the following method was used.

The tigers were positioned in dorsal recumbency. A 3-cm midline incision was made into the skin and subcutaneous tissue, and a stab incision into
the peritoneum (a modified Hasson technique) was performed 1 cm caudal to the umbilicus for placement of a 10.5-cm-long, 6-mm-diameter threaded laparoscopic cannula. When necessary, a purse-string suture was placed around the incision into the linea alba with 2-0 absorbable suture (PDS [polydioxanone], Ethicon, Somerville, New Jersey 08876, USA) to aid in maintaining appropriate insufflation. The abdomen was insufflated to 15 mmHg and thoroughly explored with a 5-mm, 29-cm, 0° Hopkins telescope (Karl Storz Endoskope, Tuttlingen, Germany). The tiger was then placed in a 25° Trendelenburg position to aid in visualization of the reproductive tract. Following sharp dissection, a 10-mm, smooth laparoscopic cannula was placed 4 cm lateral and 3 cm caudal to the first abdominal mammae under direct visualization, bilaterally. During cannula insertion, the abdomen was insufflated to 20–25 mmHg to decrease the risk of iatrogenic organ damage. A 10-mm laparoscopic Babcock forceps was placed in one of the lateral accessory ports and used to grasp the suspensory ligament of the contralateral ovary (Fig. 1). A Tankersley ovarian hook (Karl Storz Endoskope) was used to secure the ovarian pedicle to the abdominal wall. The ovarian hook was placed approximately 4 cm caudal to the ipsilateral laparoscopic cannula. Care was taken not to traumatize the ovary or ovarian pedicle. The Babcock forceps was removed, and a 10-mm, 37-cm vessel-sealing hand piece was advanced through the same port and used to ligate and transect the suspensory ligament, ovarian pedicle, and ovarian attachments to the uterus (Fig. 2).

The ovary was left secured to the body wall by the ovarian hook at this time. In cases where visualization was obscured by overlying tissues, retraction was achieved with the use of a fan retractor or Babcock forceps advanced through the ipsilateral accessory port.

This procedure was repeated on the remaining ovary with the use of the alternate accessory port and a second ovarian hook. After transection of the second ovarian pedicle, the ovaries were secured with the use of Babcock forceps and the ovarian hooks were removed. Both ovaries were then removed simultaneously from the midline incision, which had to be extended by 2 cm to facilitate their removal. Visualization of ovarian removal was performed with the use of the laparoscope, positioned through a lateral cannula. The abdomen was explored with the laparoscope for signs of hemorrhage, and then the laparoscope was removed from the abdomen. The tiger was taken out of the Trendelenburg position, and carbon dioxide was allowed to escape from the abdomen through the operative cannulae prior to removal and closure of the incisions. Incisions were closed in three interrupted layers with 0 or 1 absorbable suture (PDS) in the rectus fascia and 2-0 absorbable suture (PDS) in the subcutaneous tissue and intradermal layer. After closure, final skin incision lengths were measured with a standard 10-cm ruler and combined to determine the total incision length for the procedure. Total surgical time was recorded. Times were recorded at the start of the operation, start and finish of each ovary transection, each ovary removal, and the end of the operation. All surgeries were
performed by the same group of surgeons (JS, PS, and JW).

Complications

All tigers were observed postoperatively for 2 days in small enclosures for any complications, including incisional erythema, swelling, discharge, and dehiscence. Date of return of each tiger to its home enclosure was recorded.

Data analysis

Statistical analysis was performed with the use of a commercial statistical software package (Sigma Stat 3.0, Systat Software, Chicago, Illinois 60606, USA). Continuous data were analyzed for normality with the use of the Kolmogorov-Smirnov test. Operative times and total incision lengths for laparoscopic ovariections and standard OVHs were compared with the use of unpaired two-sided $t$-tests. A $P$ value $\leq 0.05$ was considered significant. Complications of laparoscopic ovariection and traditional OVH were collated and summarized by category (erythema, swelling, infection, and dehiscence).

RESULTS

Group 1

Seven tigers met the inclusion criteria of this group and underwent laparoscopic ovariection. Exact age was not known for two of the tigers, but all tigers were greater than 4 yr of age. Mean body weight $\pm$ SD was 133.6 $\pm$ 22.0 kg (range 103–162 kg). All tigers were healthy based on history and physical exam. No major abnormalities were observed on CBCs or plasma biochemical analyses.

Induction and maintenance of anesthesia was uneventful, and no major anesthetic complications were noted. Laparoscopic ovariection was performed successfully in each tiger. Mean total operative time for laparoscopic ovariection was 81.6 $\pm$ 22.1 min (range 71–126 min). Laparoscopic ovariection was started on the right ovary four times and the left ovary three times. Mean times to first and second ovary transection were 28.3 and 41.6 min, respectively. Mean combined incision length was 8.1 $\pm$ 1.3 cm (range 3.8–9.5 cm). All tigers recovered from anesthesia without complications.

The only intraoperative complication noted in this group was minor blanching of the internal body wall, adjacent to where the ovarian tissue was being transected ($n = 2$). This was presumptive thermal injury from the vessel-sealing device, and no long-term effects of this have been noted in any of the tigers 10 mo postsurgery. Postoperative complications included incisional erythema ($n = 4$) and midline incisional swelling ($n = 4$).

Group 2

Seven tigers met the criteria for inclusion in Group 2. Exact age was not known for all the tigers, but each tiger was greater than 5 yr old. Mean body weight was 117.7 $\pm$ 19.1 kg (range 99.3–156 kg). All were judged healthy at the time of surgery.

Mean operative time for traditional OVH was 128.6 $\pm$ 31.2 min (range 80–165 min). Mean incision length was 13.6 $\pm$ 4.5 cm (range 12.00–20.00 cm). Times until the tigers were returned to their outdoor enclosures were not recorded for animals in Group 2. There were no recorded intraoperative complications. Postoperative complications noted were incisional erythema ($n = 7$) and midline incisional swelling ($n = 7$).

Data analysis

Operative time and incision length were normally distributed for both laparoscopic ovariection and standard OVH. Mean surgical time was significantly shorter for laparoscopic ovariection than standard OVH ($P = .007$). Mean combined incision length for laparoscopic ovariection was significantly less than standard OVH incision length ($P = 0.009$).

DISCUSSION

Several reports identify the development of pyometra and mammary carcinoma in captive tigers. For nonbreeding female tigers, OVH or ovariection is recommended to reduce the risk of occurrence or recurrence of these diseases, and standard laparotomy OVH approaches have generally been used for these procedures. These surgeries are, however, time consuming, and visualization of the reproductive tract can be difficult due to the animal’s size and the depth of the abdominal cavity (J. Steeil, unpubl. data).

Several ovarian pedicle ligation techniques have been evaluated to decrease the surgical time associated with laparoscopic reproductive surgeries. Endoscopic clips were successfully used to perform OVHs in two African lions, but they are recommended only for vessels up to 5.3 mm in diameter. Additionally, clip displacement may occur, which may result in life-threatening hemorrhage. The UltraCision Harmonic Scalpel,
another vessel-sealing system, has been used for OVHs \( n = 2 \) or hysterectomies \( n = 3 \) in five African lions and an OVH in one brown bear,\textsuperscript{10,16} but that device is approved only for vessels up to 5 mm in diameter.\textsuperscript{3,14} In contrast, the Ligasure\textsuperscript{TM} vessel-sealing device used in the present study is approved for vessels as wide as 7 mm in diameter without failure at three times normal systolic blood pressure.\textsuperscript{3} In the authors‘ experience, ovarian pedicles in tigers are commonly between 5 and 7 mm in diameter.

As many as 20% of tigers undergoing prolonged anesthesia may develop life-threatening electrolyte abnormalities.\textsuperscript{12} These electrolyte abnormalities have been observed at the authors‘ institution and appear to occur as anesthetic time increases (J. Steeil, unpubl. data). During laparotomy procedures on tigers, the most time-consuming component of the procedure is the closure of the skin and subcutaneous tissues. Therefore, a smaller incision or incisions should decrease surgical times. Because the control group was retrospectively assembled, operative times may not have been as accurately documented as for the study group. For these reasons, skin incision length was chosen for comparison among groups as an independent surrogate marker of operative time that would not be significantly impacted by the removal of uteri in the retrospective group. In dogs, removal of the uteri via an open laparotomy technique has been shown to increase skin incision length significantly when compared to open ovariectomy technique.\textsuperscript{29} A study has shown that incision length for an ovariectomy in dogs is reduced by a factor of 10 when laparoscopic techniques are utilized.\textsuperscript{3} Therefore skin incision lengths in our study are significantly different not because of the lack of removal of the uteri, but because of the technique utilized.

In the present study, mean operative time was significantly less for laparoscopic ovariectomy compared to standard OVH in healthy tigers, but this was in part because the uteri were not removed in Group 1 animals. However, incision lengths were also significantly different, suggesting a difference in surgical times can be anticipated even when compared retrospectively. In several previous studies, operative times for laparoscopic procedures tend to decrease markedly with increased experience.\textsuperscript{5,7,31} We would anticipate a substantial improvement in operative time to mirror better the decrease in overall incision lengths with increasing laparoscopic experience and familiarity with the optimized technique. According to one study in dogs, standard OVH is technically more complicated, time consuming, and may be associated with more complications compared to ovariectomy.\textsuperscript{33} For these reasons, ovariectomy has become the preferred method of gonadectomy in dogs in Europe.\textsuperscript{33}

Tigers and lions have a very deep abdominal cavity, and even with long ventral midline incisions, it can be difficult to visualize and ligate ovaries and suspensory ligaments. Laparoscopy, however, provided good visualization of the reproductive tract when tigers were in the Trendelenburg position. The uterine horns were easily identified, and gentle traction on the proper ligament provided adequate visualization. The vessel-sealing device allowed for easy ligation and transection of the ovarian pedicle and suspensory ligament. It also provided reliable and adequate hemostasis for ligation and transection of the ovarian pedicles.

An initial intraoperative issue found in Group 1 tigers was the presence of abundant falciform fat, obscuring visualization via the lineal port laparoscope. These tigers were generally well-fleshed. To rectify this, the laparoscopic ovariectomy technique was modified after the third procedure to allow removal of the ovaries from the lateral accessory port sites, if necessary.

Incisonal complications, for both laparotomy and laparoscopic surgeries, could have occurred for several reasons. One factor that may contribute to incisonal complications is the inability to control exercise after return to outdoor enclosures.\textsuperscript{4} Additionally, tigers at this facility are housed in large enclosures, either alone or with conspecifics. The latter arrangement allows for natural behaviors to be exhibited, and aggression between conspecifics can happen postintroduction. To minimize incisional complications, the tigers were routinely held and monitored in transport cages following surgical procedures. This monitoring period usually lasts two postoperative days, but it can extend up to 1 wk. Tigers in the study were all released into their enclosures within 6 days after ovariectomy.

Because tigers are returned to an outdoor environment after surgical procedures, there is also an increased risk of incision site contamination. Incisions cannot be cleaned, protected with bandages, or closely monitored due to personnel safety concerns. Erythema may develop at incision sites due to inflammation and superficial infection. If infections penetrate through the subcutaneous tissues, incisional dehiscence can
The large amount of tissue dissection performed during standard OVH and long incision lengths can also increase the likelihood of seroma formation and incisional dehiscence postoperatively. Reduction in total anesthetic time reduced the incidence of incisional infections acquired during surgical procedures in domestic cats.  

In domestic dogs and cats, use of laparoscopy and thoracoscopy allows for reductions in surgical time, subcutaneous dissection, and incision lengths, and has been associated with decreased incidence of surgical site infections. It is likely that all three of these factors contributed to the lower rate of incisional complications seen in Group 1.

As minimally invasive procedures gain more favor over standard surgical procedures, it is anticipated more institutions will start to use this modality. Still, laparoscopic ovariectomy in exotic felids requires several pieces of specialized, expensive equipment. Equipment can cost up to $50,000, and these costs may preclude certain institutions from performing these procedures. In addition, some procedures may require multiple surgeons and may not be performed at certain institutions because of staffing concerns. It should be noted, however, that standard laparotomy OVH in large felids requires at least two surgeons (J. Steeil, unpubl. data).

There were a number of limitations to this study. Because data for tigers undergoing traditional OVH were collected retrospectively, operative times and incision lengths for those surgeries were not collected in a systematic manner. Additionally, retrospective evaluations may report lower complication rates than prospective studies because complications that do not impact patient outcome may not be reported. Thus, the use of a retrospective population for comparison may have resulted in a falsely low complication rate for traditional OVH. In spite of these potential biases, fewer complications were noted in the laparoscopic ovariectomy group. Another limitation of this current study is the standard OVHs were performed by several different surgeons, whereas the laparoscopic ovarioectomies were all performed by the same team of surgeons. This may have introduced bias due to variability in surgical expertise in general and experience with tigers in particular.

In conclusion, laparoscopic ovariectomy with the use of the vessel-sealing device was a safe and efficient method of sterilization and should be considered for elective sterilization in tigers. Its use was associated with decreased surgical times, shorter incision lengths, and decreased complication rates. Further prospective evaluation is warranted to determine whether laparoscopic ovariectomy is associated with decreased morbidity, mortality, or cost compared with traditional OVH.

Acknowledgments: The authors would like to thank the staff at Tiger Haven (Kingston, Tennessee, USA), particularly Mary Lynn Haven and Debbie Wilkins, for providing the LigaSure® hand pieces used in this study and financial support for this project; Covidien, Inc. for providing the Force Triad™ used in this study; and support staff at the University of Tennessee College of Veterinary Medicine for their time and patience during this project.

LITERATURE CITED


Received for publication 10 February 2012