Association of Avian Veterinarians Australasian Committee Ltd.
Annual Conference 2015 23, 40-47

Avian Endosurgery

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Previously published in whole or part. Not peer-reviewed by AAVAC Ltd. - included with permission of the author.

Introduction

Avian endosurgery may be single-, double- or triple-entry in nature (Hernandez-Divers, 2005; Hernandez-Divers et al., 2007; Divers, 2010). Single-entry techniques are similar to those employed for diagnostic evaluations and biopsy. They rely on the use of a single instrument inserted through the operating channel of the sheathed telescope. While double- and triple-entry techniques utilise two or three separate devices simultaneously. The practical application of single-entry diagnostic endoscopy is relatively straightforward. With appropriate training veterinarians can quickly become proficient and utilize endoscopy to visualize internal organs and collect samples. This is thanks to the single-entry nature of the procedures such that the instrument is utilised along a single plane (advance or retract) within the endoscopy field without the need to triangulate instruments independently from the telescope. While this system has proven extremely effective for diagnosis, it has obvious drawbacks when attempting to perform endosurgical procedures because forceps, scissors, retractors, radiosurgery devices, etc, must be used independently within the endoscopy field. Trying to perform endosurgery through a single port is like trying to perform traditional surgery with one hand tied behind your back – You need two hands to use two independent instruments! So while the need for two or three independent ports is obvious, as soon as the instruments become independent of the telescope it becomes necessary to triangulate (coordinate) instruments with the telescope. Consequently the instrument is no longer restricted to the single plane within the operating sheath, but can now be wielded in all three planes independent of the telescope - creating a second variable. If a second instrument is added then there are three variables. There can be little doubt that using one or two instruments separate from the telescope raises the difficulty of endoscopy by at least an order of magnitude. Veterinarians that make the transition from single-entry diagnostic techniques to multiple-entry endosurgery tend to have most difficulty with:

- Multiple port placement. Accurate anatomical knowledge and surgical placement of cannulae is essential;
- Instrument triangulation and depth perception. Bringing two independent instruments into the endoscopy field of view, keeping them there and coordinated with the telescope takes practice;
- Reduced tactile feedback. Tissue handling occurs at a greater distance and it takes practice to appreciate how much force and tension can be applied; and
- Maintaining haemostasis. Fortunately, radiosurgery units can be attached to various endoscopy instruments to assist with dissection and haemostasis.

Consequently, endosurgery can never be the ultrafast two minute procedure that many have become accustomed to when performing "surgical sexing" of birds. On the contrary, it demands far greater planning, preparation, patience, and perseverance. However, once mastered endosurgery opens up many opportunities to perform procedures with minimal trauma, with advantages have been well documented in human medicine.

Patient Selection

In addition to the general indications and contraindications for performing endoscopy in birds (see avian diagnostic endoscopy), there are some additional patient issues to consider prior to attempting endosurgery. First and foremost the issue of physical size remains! It is simply not going to be possible to fit a telescope and two independent instruments inside a budgerigar or cockatiel! The size of the patient is still a major limiting factor, and in small birds, single- or double-entry techniques may be all that are possible.

Contraindications

Given the availability of small telescopes (1.9 and 2.7 mm), and more recent developments in 2-3 mm human pediatric instrumentation, the greatest limiting factor is probably the small size of most companion birds in combination with our limited but evolving abilities as avian endosurgeons. In addition to anaesthetic contraindications, gross obesity and ascites are common problems that strongly argue against laparoscopic surgery.

Instrumentation

Given the variation in size and the nature of the procedures that may be performed, consideration should be given the correct selection of telescope and instruments (see Table 1). The basic rigid telescope system for avian veterinarians has been developed from human cystoscopy equipment (Chamness, 1999a, 1999b). Probably the most commonly utilized endoscope is the 30° Hopkins telescope (1.9 mm x 18.5 cm, 2.7 mm x 18 cm) connected to a halogen or xenon light source via a fiber-optic cable (Karl Storz Veterinary Endoscopy America Inc, Goleta, CA, USA). The smaller 1.9 mm telescope and integrated sheath system is also available and is preferable for birds weighing less than 100 g. Endoscopy cameras and monitor display of the endoscopic field are essential for performing endosurgery (Hernandez-Divers, 2002, 2004). The miniature endoscopy system originally designed for human pediatric laparoscopy is now marketed specifically for cats, small dogs and small exotic species (Karl Storz Veterinary Endoscopy America Inc) (Fig 1).

Coelioscopy and endosurgery must be carried out under general anaesthesia using appropriate aseptic techniques and sterilized instruments. Equipment sterilization using hydrogen peroxide vapor or ethylene oxide gas is preferred, but cold sterilization using glutaraldehyde is acceptable. Operating room design and layout are important. An endovideo camera coupled to a monitor facing the surgeon at eye-level will greatly improve the endoscopist's ergonomics and surgical ability. Standard and endoscopic surgical equipment and supplies should also be arranged to be within easy reach.

Patient Evaluation

Endoscopic surgical procedures are more involved. Indeed total anaesthesia and surgery time is likely to be greater than for a traditional surgical approach until the surgeon becomes competent at endoscopic techniques. When first embarking upon endosurgery, it is wise to advise the client that the endoscopic procedure will be converted to a traditional surgical approach if necessary. In this way the veterinarian can build an endoscopy caseload while retaining the right to convert if difficulties arise. Initially, surgeons often find themselves having to convert to a traditional approach early on in the procedure, but with each subsequent experience they will advance further and further, until eventually the procedure is completed endoscopically.

Patient Preparation

The most common multiple-entry endosurgery performed by the author is salpingohysterectomy. Typically, birds initially present with some form of reproductive disease that are pre-treated with GnRH analogue (e.g. Deslorelin) (Carpenter, 2013). This has the advantage of reducing the size and vascularity of the reproductive tract prior to endoscopy.

Unless anatomical or disease considerations dictate otherwise, a left approach to the avian coelom is preferred. For unfamiliar species, survey radiographs can be extremely helpful in determining the precise location of additional ports. Some veterinarians prefer to extend the pelvic limb caudad and enter the coelom in front of the leg. While this technique is suitable for single-entry endoscopy it does not lend itself to multiple port procedures due to the restricted surgical field exposed. Positioning the limb craniad maximizes caudal flank exposure and facilitates additional port placement for double- and triple-entry techniques.

Anaesthesia and Monitoring

Given the degree of preparation required for telescope and cannula placement, and that inexperience may result in longer surgery times, high quality anaesthesia and monitoring is essential. Pre-operative stabilization and support are vital, and birds should routinely be intubated and ventilated. Body temperature must be monitored and maintained above 100°F using radiant heat sources, water-circulating blankets, or forced warm air heaters. Intravenous or intraosseous catheterization and intra-operative fluid support are the norm, and in larger birds intra-arterial catheterization and direct blood pressure monitoring is preferred. Monitoring should be performed and recorded by a dedicated individual, and could include reflexes, muscle tone, eye position and corneal/palpebral reflexes, pulse oximetry, ECG, and end-tidal capnography.

SURGICAL PROCEDURES

Single-Entry Techniques

Single-entry endosurgery is limited to a single instrument that cannot be manipulated independently of the telescope. This technique provides surgical access to the heart, liver, gastrointestinal tract, spleen, and urogenital tract via the cranial thoracic, caudal thoracic, or abdominal airsacs as described under coelioscopy, above. Salpingohysterectomy has been described in juvenile cockatiels by using the 2.7 mm telescope, 4.8 mm operating sheath, and grasping forceps to break down the suspensory ligaments and remove the infundibulum, oviduct, and uterus (Pye et al., 2001). Completing this surgery required exteriorizing the reproductive tract through the single surgical entry site, with final crushing and transection of the uterus performed externally by a second surgeon. Additional haemostasis was not used and, despite some minor bleeding from the cloaca, there was no mortality or apparent morbidity associated with the procedure. This technique is better described as 'endoscope-assisted' rather than endoscopic because surgery was completed outside the coelom using standard surgical instruments. Nevertheless, endoscopy prevented the need for a more invasive coeliotomy and reduced surgical trauma. A greater risk of severe haemorrhage would be expected if this technique was used in mature hens because of the greater vascular supply and lack of effective endoscopic haemostasis.

Airsac granulomata have been successfully removed in several parrots using a combination of endoscopic debridement and diode laser ablation (Hernandez-Divers, 2002). Because of the avascular nature of the granulomata, debridement with a 1.7 mm biopsy forceps was possible without additional haemostasis. Diode laser was used to ablate and sterilize the infected areas. With this technique, resection is restricted to relatively small avascular masses. Haemostasis is more of a concern when dealing with larger, more vascular structures, while the small size of the biopsy forceps would result in excessively long debridement times.

Disadvantages of single-entry techniques include reliance on a single instrument, small size of a limited number of available instruments, and co-dependence between instrument and telescope. However, for small birds, single-entry techniques may provide the only practical alternative to standard coeliotomy.

Multiple-Entry Procedures

Recently, the use of miniature endoscopic equipment, pioneered in human pediatric laparoscopy, has been applied to avian surgery Hernandez-Divers, 2005). The addition of a second and third operating port using 3.5 mm cannulae has facilitated the use of 3 mm instruments within the avian coelom. Triangulation of various instruments coupled with radiosurgical haemostasis has made several endoscopic procedures possible including salpingohysterectomy, orchidectomy, and mass resection (Hernandez, 2005; Hernandez-Divers et al., 2007). Endosurgical salpingohysterectomy and orchidectomy were developed using a pigeon model, and have subsequently been applied to psittacine birds and waterfowl in clinical practice.

Orchidectomy (double-entry technique, Fig. 2)

Initial positioning and preparation are similar to those previously described for the left approach for coelioscopy. However, more feathers are plucked from the left flank to reveal a surgical field that extends from the last intercostal space (cranial) to the pericloacal region (caudal), and from the dorsal border of the flexor cruris medialis muscle (dorsal) to the ventral border of the pubis bone (ventral). Following aseptic preparation, a 2 mm skin incision is made midway between the last rib and the pubis bone, at the ventral border of the flexor cruris medialis muscle. Blunt entry into the left abdominal airsac is achieved using straight haemostats. The 2.7 mm telescope housed within a 3.5 mm protection sheath is inserted into the left abdominal airsac. Following a brief examination to confirm the gender of the bird, the presence of a normal urogenital system, and a lack of any visible pathology, a second port is created just behind the pubis bone, at the ventral border of the flexor cruris medialis muscle. This equates to approximately midway along the palpable pubis bone. A 3.5 mm cannula and trocar are inserted through a 2 mm skin incision and, using gentle sustained axial pressure, are advanced into the caudal aspect of the left abdominal airsac under endoscopic guidance. Once inside the abdominal airsac, the trocar is removed and the cannula advanced 2-4 mm into the lumen of the airsac. The polypectomy snare attached to a radiofrequency unit (at an initial suggested power setting of 25% on cut and coagulation mode) is then inserted through the cannula and into the endoscopic field. The telescope is rotated in order to provide a view of the testis, as seen from within the left abdominal airsac. The polypectomy snare is advanced, extended, and placed over the testis taking care not to entrap any part of the cranial division of the kidney, adrenal gland or vena cava.

The snare is partially closed around the mesorchium, thereby isolating the testis and overlying abdominal airsac. With the snare further tightened around the mesorchium and slight lateral pressure applied to elevate the testis away from the kidney, the radiosurgery device is activated to coagulate the mesorchium, and facilitate separation of the testis. The radiosurgical snare is removed and replaced by forceps that are used to retrieve the testis. If necessary, the skin incision can be enlarged to permit the removal of a large testis. Following a final evaluation of the surgical site, the telescope is removed and both skin incisions closed routinely using single sutures. The bird is then placed into left lateral recumbency and the procedure repeated to remove the right testis.

Salpingohysterectomy (triple-entry technique, Fig. 3)

To perform salpingohysterectomy, the telescope and first cannula are placed utilizing the same anatomic landmarks and techniques as described above for orchidectomy. A second cannula is positioned immediately caudal to the last rib, at the ventral border of the flexor cruris medialis muscle. This second cannula is directed caudad into the left abdominal airsac using the telescope to provide direct visualization.

Once both cannulae are positioned within the left abdominal airsac, the telescope is rotated, taking advantage of the 30° angle, to provide a caudal view of the coelom. This is achieved by supporting the telescope using gel pads or sand bags such that the light guide cable exits from the left of the telescope and the 30° is directed caudad to image the uterus. Short Kelly dissecting forceps (3 mm) are inserted down the cranial cannula into the endoscopic field to grasp the caudal shell gland and uterus, and elevate it away from the caudal division of the kidney, ureter, vena cava, and cloaca. A racket handle ensures that the shell gland does not slip from the jaws of the forceps during manipulation.

Short, serrated scissors (3 mm) are connected to a radiofrequency unit (initial suggested power setting of 5-8 % on cut and coagulation), and inserted through the caudal cannula. For right-handed surgeons, the forceps are controlled with the left hand, the scissors with the right hand, and the radiosurgery unit by foot-pedal. With the reproductive tract elevated the uterus is cut transversely close to its cloacal insertion. The forceps and uterus are retracted craniad to expose the ventral and dorsal ligaments of the reproductive tract. The scissors are used to cut and coagulate the ventral and dorsal ligaments and their associated blood vessels, taking care not to damage the kidney, ureter, and intestinal tract. As the dissection proceeds craniad, the telescope and light guide cable are rotated 180° to view the more cranial oviduct. The cranial aspect of the infundibulum is incised as close to the ovary as possible, but no attempt is generally made to remove the ovary due to the difficulties of maintaining haemostasis. The cannula is slid up the shaft of the instrument to permit removal of the forceps and reproductive tract through the skin incision. Following a final inspection of the surgical site, the telescope and both cannulae are removed, and all skin incisions are closed routinely using single sutures.

Endoscopic orchidectomy and salpingohysterectomy take less than 40 minutes, and only minor complications have been reported including mild haemorrhage and focal coagulative damage to the kidney (Hernandez-Divers et al., 2007). However, surgical failures due to inexperience are likely, necessitating training and practice using endoscopy trainers or cadavers before embarking on clinical cases. In addition, salpingohysterectomy does not appear to prevent ovarian development and ovulation, and so is unlikely to resolve hormonally-derived problems in female birds. Development of an endoscopic ovariectomy technique is still required, and currently under development.

Mass Resection

Double- and triple-entry techniques have been sued to endoscopically debulked and remove coelomic neoplasia, abscesses and granulomas. In cases bacterial or fungal infection, it is often beneficial to treat locally (by intralesional injections) and systemically to reduce the size of the abscess or granuloma prior to effecting endoscopic removal. While systems exist in human medicine to resect and remove large masses without causing contamination, this is far more difficult in the confines of the avian coelom. Therefore, the endoscopist must take precautions to remove as much material as possible and be diligent in trying not to seed injection along the instrument tracts. In addition, antimicrobial therapy should continue for several days post-operatively.

Complications

The major complications encountered are typically associated with anaesthesia, and the advanced disease state of many birds at the time of presentation. The importance of stabilization, and a thorough pre-operative evaluation cannot be overemphasized. Endotracheal intubation, ventilation, intravenous or intraosseous catheterization with perioperative fluid support, and warm air/water blankets are important. Minor haemorrhage following tissue biopsy is common but generally insignificant. Most endoscopy issues are related to operator error until experience and ability have been gained. In general, the ability to examine birds internally and collect tissue samples greatly aids diagnosis and improves treatment success. To develop an endosurgery caseload without compromising clients or patients, it is recommended that the surgeon retains the option to convert to a traditional surgical approach if unable to perform the desired task endoscopically.

Post-Operative Care

Birds should be closely supervised on recovery as anaesthetic compromise can ensue following extubation and cessation of cardiorespiratory support. Fluid therapy and nutritional support should continue, with psittacine and passerine birds eating within 1-2 hours of recovery. Meloxicam is used routinely post-operatively, although opiates and local anaesthetics could prove useful as part of a balanced approach to analgesia. Typically birds quickly return to normal function following endoscopic procedures compared to more traditional, invasive surgery. Sutures are removed at 7-10 days if still present.

Outcome

The most substantial limitation to successful coelomic soft tissue surgery is the relative small size of most avian patients and the limited surgical access afforded by standard coeliotomy techniques (Bennett and Harrison, 1994). Both of these limitations can be largely overcome by endoscopic surgery which provides focal magnification, illumination, and surgical access within the coelom. Each of the described techniques has advantages and disadvantages. However, reports from human surgeons indicate that considerable benefits may be gained from minimally-invasive endoscopic surgery (Golditch, 1971; Corson and Grochmal, 1990; Vander Velpen et al., 1994; Yu et al., 2007; Kehlet, 1999; Lagares-Garcia et al., 2003). Human laparoscopy has been credited with more rapid and accurate diagnosis, reduced need for extensive laparotomy, reduced surgical stress, improved postoperative pulmonary function, reduced hypoxemia, reduced surgical time, and faster recovery (Golditch, 1971; Corson and Grochmal, 1990; Vander Velpen et al., 1994; Yu et al., 2007; Kehlet, 1999; Lagares-Garcia et al., 2003). The disadvantage of human laparoscopy appears minimal and restricted to misdiagnosis in less than 1% of cases. No significant morbidity has been demonstrated with appropriate laparoscopic technique (Vander-Velpen et al., 1994). The efficacy, complications or long term effects of endosurgery have not been extensively documented in birds, although on-going research at the University of Georgia continues to critically evaluate these procedures. For example, although endoscopic salpingohysterectomy prevents future egg production and dystocia, ovariectomy is required to stop reproductive physiology (including normal and abnormal behaviors, and ovulation). Safe gonadectomy remains the "Holy Grail" of avian endoscopic surgery, and is still under development.

The ability to perform endosurgery is not innate and extensive training is undertaken by human surgeons using artificial teaching devices and supervised instruction by experienced endoscopists. Such educational tools are not readily available to the avian veterinarian, although min-laparotomy trainers can be made economically. Therefore, initial training is best achieved through participation in continuing education courses and practical laboratories. While every opportunity should be taken to practice these techniques on animal subjects, cadavers represent a useful but imperfect model due to rapid deterioration after death. However, where this is the only available option, additional observation and assistance of an experienced endoscopist working with live birds is recommended. In those countries that permit and regulate the use of live animals for training veterinarians, non-recovery endosurgery laboratories using anaesthetised pigeons or chickens offer an unparalleled opportunity for establishing competence before embarking on clinical cases.

Acknowledgements

The author would like to thank Karl Storz Veterinary Endoscopy for supporting endoscopy research, development, and training in zoological medicine.

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Table 1. Endoscopic instrumentation for companion birds.

Equipment Description	Primary Indications
Visualisation and Documentation	
Endovideo camera and monitor Xenon light source and light guide cable Digital capture device (e.g. AIDA-DVD)	Required for all endoscopy procedures
Rigid Telescopes and Endoscopes	
2.7 mm x 18 cm telescope, 30° oblique	
Rigid Cannulae and Instruments	
3.9 mm graphite and plastic cannula (accommodates 2.7 mm telescope and 3.5 mm protection sheath) 3.5 mm graphite and plastic cannula (accommodates 3 mm instruments) 3 mm short curved Kelly dissecting and grasping forceps 3 mm Babcock forceps 3 mm Blakesley dissecting and biopsy forceps 3 mm scissors with serrated curved double action jaws 3 mm Mahnes bipolar coagulation forceps 2 plastic handles without rackets 1 plastic handle with Mahnes style racket 1 plastic handle with haemostat style racket	Used with the 2.7 mm telescope for endosurgery
Radiosurgery Equipment	
3.8 or 4.0 MHz dual radiofrequency unit with foot pedal Monopolar lead to connect to plastic instrument handles Bipolar lead to connect to 3 mm Mahnes bopolar coagulation forceps	Enables endoscopic instruments to be used as monopolar devices and facilitates bipolar coagulation

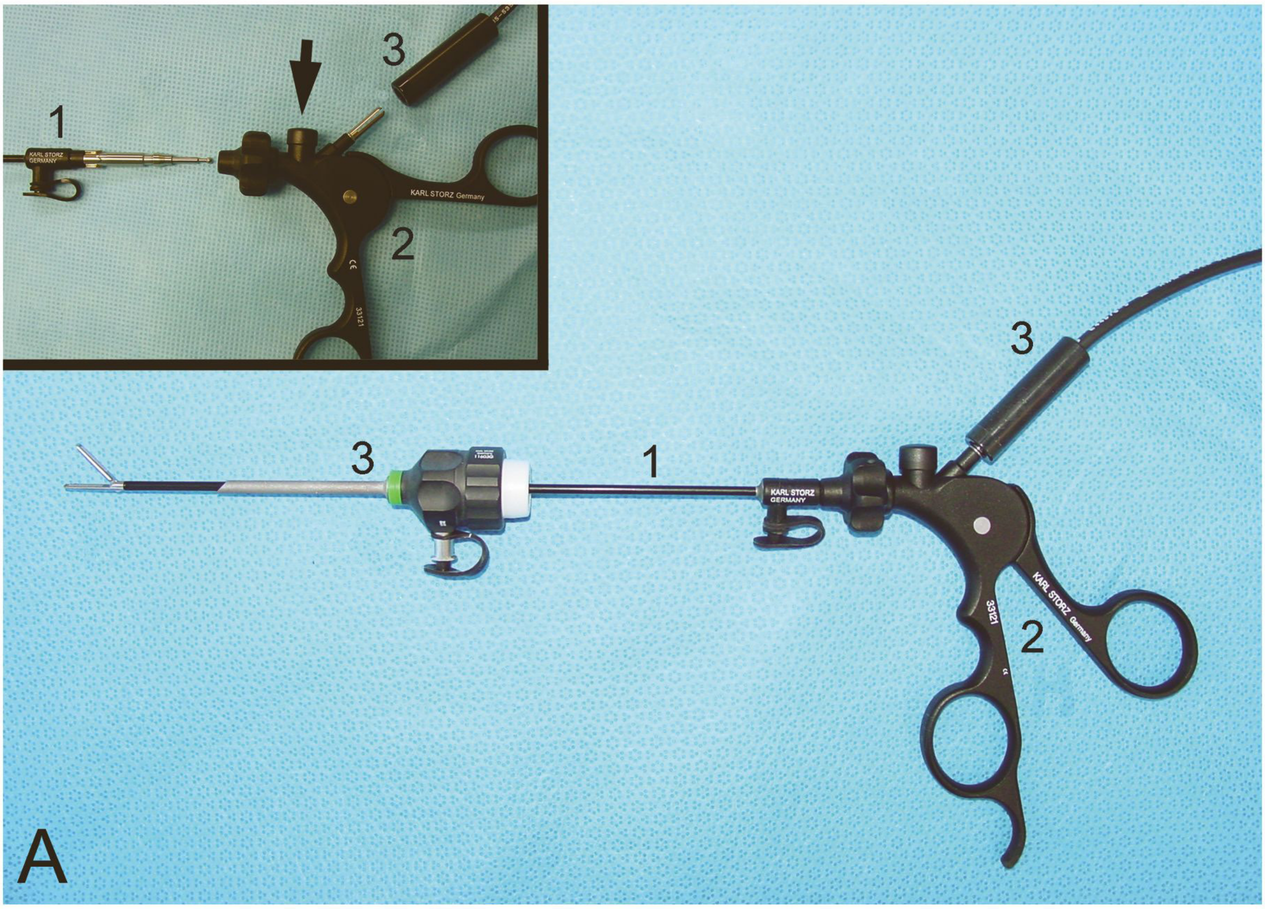

Figure 1. Human paediatric 3 mm laparoscopy equipment. (A) 3 mm instrument (1) attached to a standard ClickLine handle (2). The instrument, attached to a radiosurgery unit via a connector on the handle (3), has been inserted through a 3.5 mm graphite/plastic cannula (3). (Insert) Instrument (1) and handle (2) can be quickly exchanged by pressing on the release button (arrow). The radiosurgical connection is also shown (3).

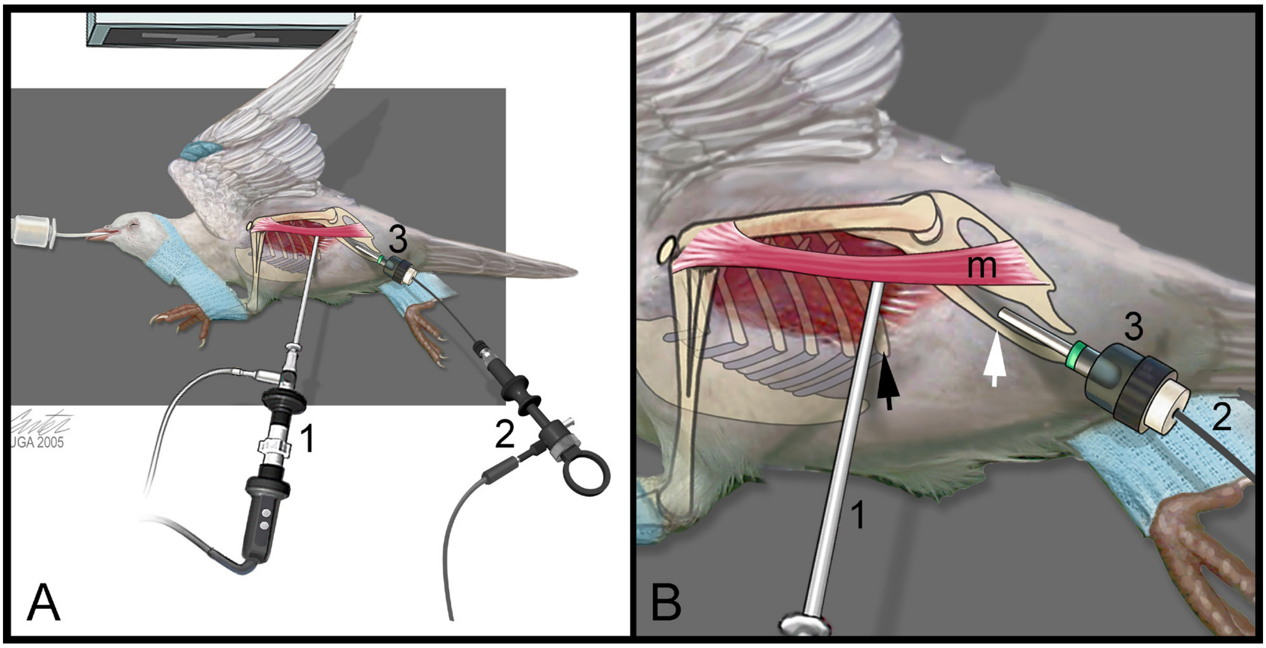

Figure 2. Double entry technique for orchidectomy in a pigeon. The telescope (1) is positioned as usual behind the last rib (black arrow) and just ventral to the flexor cruris medialis muscle (m). The radiosurgical polypectomy snare (2) is inserted through a 3 mm cannula (3) that has been placed behind the pubis bone (white arrow).

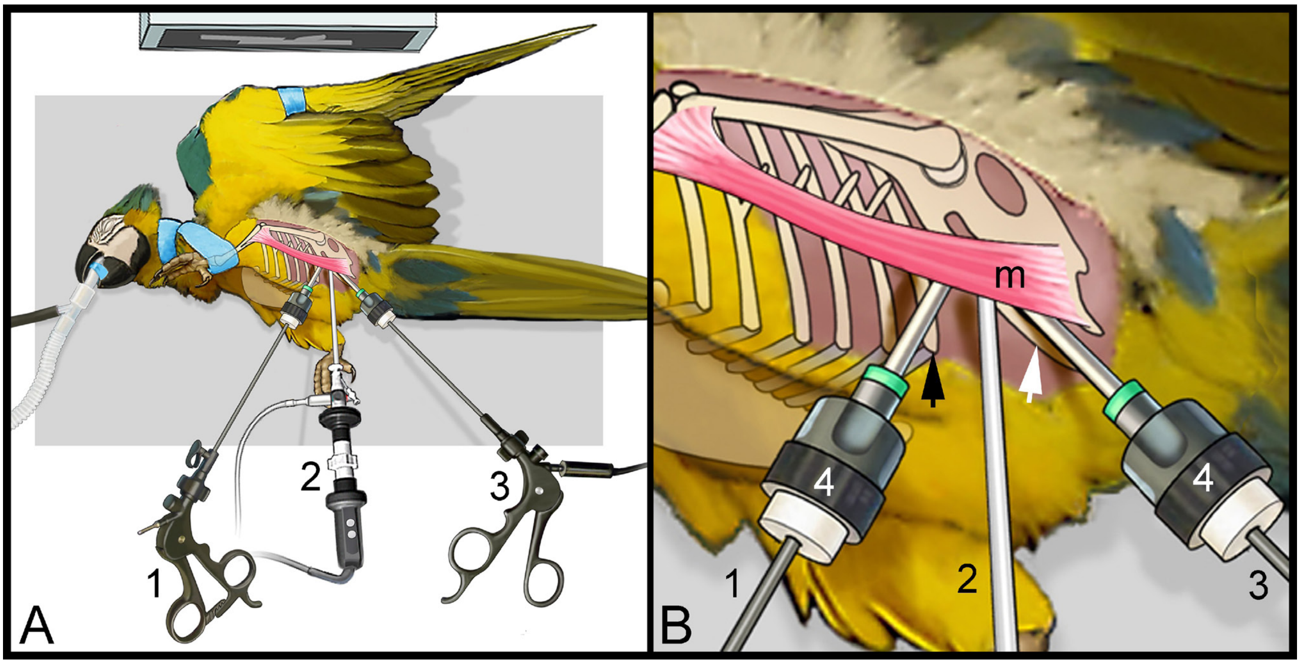

Figure 3. Triple entry technique for salpingectomy in a macaw. The 3 mm short curved Kelly forceps (1) are inserted through a 3.5 mm cannula (4) just caudal to the last rib (black arrow). The telescope (2) is inserted cranial to the pubis bone, just ventral to the flexor cruris medialis muscle (m). The 3 mm monopolar scissors (3) are inserted just caudal to the pubis bone (white arrow).