Reproductive disorders, such as oophoritis, salpingitis, follicular stasis, retained eggs, dystocia, and ectopic eggs, are common in captive female chelonians. Surgical access to the reproductive tract in chelonians has traditionally been achieved via plastron osteotomy, resulting in creation of a bone flap. Although this technique has been successfully used for many years, it is associated with prolonged healing times and may be complicated by sequestration of the bone flap. As an alternative to plastron osteotomy, coeliotomy via the prefemoral region has been recommended.

Objective—To describe a coelioscopic-assisted prefemoral oophorectomy technique for use in chelonians.

Design—Descriptive report.

Animals—11 adult female turtles (6 red-eared sliders, 2 box turtles, 1 painted turtle, 1 four-eyed turtle, and 1 Chinese red-necked pond turtle). Five turtles required oophorectomy because of reproductive tract disease; the remaining 6 underwent elective oophorectomy.

Procedures—Turtles were anesthetized and positioned in dorsal recumbency. An incision was made in the prefemoral fossa, and a 2.7-mm rigid endoscope was inserted into the coelomic cavity and used to identify the ovaries. Each ovary was grasped with forceps and exteriorized through the prefemoral incision. The ovarian vasculature was ligated, and the mesovarium was transected. Closure was routine.

Results—In 8 turtles, bilateral oophorectomy was performed through a single incision. In 2 turtles, unilateral oophorectomy was performed in an attempt to maintain reproductive potential. In 1 turtle with a unilateral ovarian remnant from a previous surgery, unilateral oophorectomy was performed. Nine turtles recovered. One box turtle with severe hepatic lipidosis died 7 days after surgery. A second box turtle died 2 days after removal of retained eggs and a large bacterial granuloma.

Conclusions and Clinical Relevance—Results suggest that coelioscopic-assisted prefemoral oophorectomy is a practical and safe method for treating reproductive disorders and performing elective oophorectomy in turtles. This technique represents a potential alternative to plastron osteotomy in sexually mature chelonians. (J Am Vet Med Assoc 2007;230:1049–1052)
A skin incision was made in the center of the prefemoral fossa, and subcutaneous connective tissue and fat were bluntly dissected to expose the tendinous aponeurosis of the transverse and oblique abdominal muscles. The aponeurosis was incised to expose the coelomic viscera, and a ring retractor with elastic stays was used to provide exposure. Coelomic insufflation was not required.

Coelioscopy was performed with a 30°, 18-cm × 2.7-mm rigid endoscope inserted through a 3.5-mm or 14.5-F sheath and connected to a xenon light source. The liver, gall bladder, heart, stomach, intestines, urinary bladder, ovaries, and oviducts were identified and examined. A 5-mm Babcock forceps or 3-mm fenestrated atraumatic forceps inserted into the coelomic cavity alongside the endoscope was used for manipulation (Figure 1).

After examination of the coelomic cavity, an avascular area of ovarian interfollicular connective tissue was selected for placement of grasping forceps, taking care to avoid perforation of any ovarian follicles (Figure 2).

Gentle traction was applied under endoscopic visualization, and the ovary was gently retracted toward the incision. With the ovary held just deep to the prefemoral incision, the endoscope was removed. The ovarian follicles were then gently exteriorized. If numerous large ovarian follicles that could not be easily exteriorized were present, the coelomic incision was extended as necessary. Rarely, fine-needle aspiration of individual follicles was used to reduce follicle diameter.

Exteriorization was continued until all follicles were visible, along with clear cranial and caudal borders of the mesovarium. The ovarian vasculature was ligated with stainless steel surgical ligation clips, and the mesovarium was transected with scissors or a radiosurgery unit (Figure 3). Coelioscopic examination of the ligation site was performed to verify hemostasis and to verify complete excision of all ovarian tissue. In cases in which bilateral oophorectomy was desired, the second ovary was exteriorized and resected through the same prefemoral incision.

The coelomic aponeurosis was closed with 3-0 polydioxanone in a simple continuous pattern. Skin was closed with 3-0 nylon or polydioxanone in a horizontal mattress pattern or with skin staples. Analgesics were administered upon return of spontaneous respiration. Patients with evidence of tissue necrosis or infection were treated with cefotaxime (20 mg/kg [9 mg/lb], IM) or amikacin (5 mg/kg [2.3 mg/lb], IM) during surgery. Antimicrobial treatment was adjusted on the basis of results of bacterial culture and continued for 4 weeks after surgery.

Results

Coelioscopic-assisted prefemoral oophorectomy was performed on 11 privately owned adult female turtles belonging to 4 species (6 red-eared sliders [Trachemys scripta elegans], 2 box turtles [Terrapene carolina], 1 painted turtle [Chrysemys picta], 1 four-eyed turtle [Sacalia bealei], and 1 Chinese red-necked pond turtle [Chinemys kwangtungensis]). Five turtles required oophorectomy because of reproductive tract disease; the remaining 6 underwent elective oophorectomy. The exact age of the turtles was unknown, as all had been obtained through the pet trade as mature animals. Mean ± SD weight was 806 ± 489 g; mean straight carapace length was 15.7 ± 3.7 cm.

Preoperative physical examination revealed a 2-cm-long portion of necrotic prolapsed oviduct in the four-eyed turtle and in the red-necked pond turtle; a 3-cm-diameter soft tissue mass was identified in the left caudal portion of the coelomic cavity in 1 of the box turtles. In the remaining turtles, results of preoperative physical examination were unremarkable.

Results of preoperative hematologic and plasma biochemical testing in 4 red-eared sliders were within reference limits. One box turtle with an ovarian remnant had high plasma calcium (19.1 mg/dL).
and triglycerides (670 mg/dL) concentrations consistent with reproductive activity and hepatic lipidosis. In this turtle, coelomic ultrasonography revealed several large, fluid-filled cystic structures on the right side that resembled ovarian follicles. Radiography revealed a single abnormally small, shelled egg in the left caudal portion of the coelomic cavity in 1 box turtle; a normal-appearing egg in the left caudal portion of the coelomic cavity in the four-eyed turtle; and 3 normal-appearing eggs in the mid portion of the coelomic cavity in 1 slider. The remaining turtles either were not radiographed or did not have radiographic abnormalities.

In 8 cases, bilateral oophorectomy was performed through a single incision. In 4 of these cases, surgical time was accurately recorded. Mean ± SD surgery time was 36 ± 6 minutes. In 2 cases, unilateral oophorosalpingectomy was performed because of unilateral oviduct damage, with the goal of maintaining future reproductive potential. Ectopic eggs were easily removed from the coelomic cavity, and the oviducts were easily exteriorized for salpingectomy or salpingotomy. One box turtle was examined because of a right ovarian remnant following incomplete oophorectomy performed via plastron ostectomy 3 years previously. This remnant was successfully removed via a right prefemoral approach. During coelioscopy, the liver appeared swollen and pale, and histologic examination of an endoscopic biopsy specimen revealed severe hepatic lipidosis. Although the turtle recovered from surgery and received supportive care, including placement of an esophagostomy tube to allow for fluid therapy, provision of nutritional support, and administration of medication, the turtle died a week after surgery. Necropsy was declined by the owner. In a second box turtle, the ovaries of immature females were involuted, and all 11 turtles recovered from anesthesia. Full access to water was provided for aquatic species within 24 hours after surgery. In the 9 turtles that survived, skin healing appeared complete by 4 to 8 weeks after surgery. These 9 turtles appeared healthy at the time of final follow-up 6 to 26 months after surgery.

Discussion

Results for the 11 turtles described in the present report suggest that coelioscopic-assisted prefemoral oophorectomy is a practical and safe method for treating reproductive disorders and performing elective oophorectomy. Importantly, healing time in these turtles (4 to 8 weeks) was substantially shorter than healing times reported for turtles that have undergone plastron ostectomy (1 to 2 years). In addition, although controlled studies are lacking, it is likely that this approach is less painful than plastron ostectomy. One of the main benefits of plastron ostectomy over prefemoral coeliotomy is improved visualization of the coelomic viscera. In the turtles described in the present report, coelioscopic-assisted prefemoral coeliotomy provided greater visualization of the coelomic viscera than did prefemoral coeliotomy and allowed for examination of the coelomic viscera, biopsy of various tissues, and verification of hemostasis and complete ovarian excision. In this regard, coelioscopic-assisted prefemoral coeliotomy may permit some surgical procedures that previously were only possible via plastron ostectomy.

Prefemoral unilateral oophorosalpingectomy has previously been described in a loggerhead sea turtle (Carretta caretta) with a prolapsed oviduct. In this large, mature turtle, the prefemoral region was large enough to permit access to the ovary and oviduct through standard surgical techniques. Importantly, reproductive potential was preserved, and successful nesting was noted in subsequent years. Unilateral oophorosalpingectomy was performed on 2 turtles described in the present report to allow them to continue to be part of a captive breeding program. It remains unclear whether unilateral oophorectomy is necessary if an ipsilateral oviduct is removed. follicles from 1 ovary have been documented to ovulate and enter the contralateral oviduct in some turtle species. Until this phenomenon is better understood, the decision to remove an ipsilateral ovary when salpingectomy is required is left to the discretion of the surgeon.

Although insufflation is often used for coelioscopic procedures in reptiles, visualization of the ovaries in turtles generally does not require insufflation. Additionally, our technique did not require placement of endosurgical cannulae. Although cannulae may be used successfully in chelonians, especially when instruments are placed through both prefemoral fossae, we found them unnecessary for the technique described in the present report. The prefemoral incision needed to be large enough to allow exteriorization of the ovary and was, therefore, sufficient to allow introduction of the endoscope and forceps through a single surgical incision without the need for separate cannulae.

Selection of turtles for coelioscopic-assisted prefemoral oophorectomy should be limited to mature females. The ovaries of immature females are involuted, and the mesovarium may not have enough laxity to

Figure 3—Photograph of a method for coelioscopic-assisted prefemoral oophorectomy in a turtle. The ovary has been exteriorized through the incision in the prefemoral fossa, vascular clips have been applied to vessels in the mesovarium, and a bipolar radiosurgery unit is used to dissect the ovary free.
allow exteriorization. In these patients, intracorporeal coelioscopic oophorectomy would be required, with the ovaries being isolated and excised within the coelomic cavity through the use of endosurgical techniques. Given the common risk of reproductive tract disease and the relative simplicity of the described technique, the authors recommend prophylactic coelioscopic-assisted oophorectomy as a practical and safe method of sterilizing mature female chelonians that are not required for breeding purposes.

References

Avian Diagnostic Endoscopy

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University of Georgia

ABSTRACT:

Most companion birds do not tolerate invasive diagnostics or surgery as well as companion mammals. However, the ability to evaluate and sample internal structures and organs for histopathology and microbiology is key to making a definitive diagnosis. This is particularly true for exotic birds in which reliable and validated pathognomonic clinicopathologic data may be lacking. The ability to examine and sample using fine-diameter telescopes allows clinicians to make a diagnosis using a minimally invasive single-entry technique. This article summarizes the benefits of diagnostic rigid endoscopy in companion birds.

Endoscopy is the internal examination of structures and organs using an endoscope or telescope and has become a useful diagnostic tool in human and veterinary medicine. In zoological medicine, the application of diagnostic endoscopy has shown great promise in a variety of species but has probably been most accepted in avian medicine. Avian endoscopy has evolved since the 1970s and includes coelioscopy, tracheoscopy, gastrointestinal endoscopy, and, more recently, endosurgery.

This technology allows clinicians to examine and sample the internal organs of birds via a single, small surgical incision. The benefits include:

- Minimally invasive internal examination
- Rapid and reliable biopsy techniques
- Avoiding invasive, lengthy surgery

Avian veterinarians have been endoscopically assessing the avian reproductive tract for many years, and despite the advent of DNA probes for sex identification of many species, clinicians involved with breeders, wholesalers, or retailers may still be asked to perform this service. Over the past 20 years, endoscopy has become more popular and an important tool for antemortem disease diagnosis; more recently, endoscopy has also evolved into a means of minimally invasive surgery. The ability to exploit the air sac system of birds enables endoscopists to visualize most, if not all, of the major organs of clinical interest, including the liver, lungs, air sacs, heart, kidneys, adrenal glands, spleen, pancreas, gonads, oviduct, shell gland, and intestinal tract.

In addition, the oral approach permits examination of the oral cavity, esophagus, crop, proventriculus and ventriculus, glottis, and trachea down to the level of the syrinx. The cloacal (vent) approach permits examination of the cloaca and openings to the shell gland and ureters.

A modern rigid endoscopy system costs $10,000 to $20,000, representing a capital investment similar to that of ultrasonography or
radiography. Like most diagnostic imaging modalities, rigid endoscopy has multispecies appeal, with extensive applications in mammals (including dogs, cats, rabbits, ferrets, and rodents), reptiles, amphibians, and fish. Therefore, it is a practical, affordable, and versatile tool for companion animal practice.

This article has been written with the general practitioner in mind, and only the most commonly employed avian diagnostic techniques have been described. For a more extensive description, readers should consult the references, which have been specifically limited to scientific conferences, established texts, and peer-reviewed journals to minimize anecdotal information.6,10,11

**EQUIPMENT**

**Rigid Endoscope**

The compact body size of most companion avian species coupled with their coelomic air sac body design makes them ideally suited to rigid endoscopy.6 Traditionally rigid endoscopes incorporated a convex glass lens system in which small glass lenses were separated by larger air spaces. In contrast, the modern rod lens telescope, invented by Professor Harold Hopkins of England, uses comparatively longer rods of glass and smaller air spaces. The advantages of this rod lens design are greater light transmission, better image resolution, a wider field of view, and image magnification.12 We have used various makes and models but think that rod lens scopes are superior; we currently prefer the system designed by Karl Storz Veterinary Endoscopy for human cystoscopy and modified by Taylor for birds5,12 (available commercially; see box on page 840). The Tay-

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**Recommended 2.7-mm Rigid Endoscopy Equipment**

- Hopkins telescope (2.7 mm × 18 cm, 30°)
- Operating sheath (5-Fr), instrument channel, and two ports (14.5 Fr)
- Examination and protection sheath (3.5-mm outer diameter)
- Cleaning brushes and instrument lubrication oil
- Nova xenon light source (175 W)a
- Light guide cable (3.5 mm × 230 cm)
- Biopsy forceps (5 Fr)
- Scissors (3 Fr)
- Fine aspiration or injection needle with Teflon guide
- Grasping forceps (5 Fr)
- Wire retrieval-basket forceps (5 Fr)
- Veterinary video camera (cold and gas sterilizable)
- Medical-grade monitor
- Documentation (e.g., videocassette recorder, digital recorder, still-image printer)
- Mobile cart for storing equipment

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**Definitive diagnosis of avian disease often requires demonstration of a host response by cytology or histopathology and, if the disease is infectious, identification of the offending pathogen.**
A modification of the operating sheath permits the telescope tip to protrude approximately 2 mm past the terminal end of the sheath. The advantages of this are easier penetration of the air sacs when using the leading edge of the exposed telescope and the ability to clean the terminal lens of the telescope by gently wiping it against a membrane. However, if a practitioner is likely to perform endoscopy in mammals or reptiles, the unmodified sheath that encompasses the entire length of the telescope may be preferable because the dangers of mucosal laceration and tissue damage are reduced.

The system consists of a 2.7 mm × 18 cm Hopkins telescope with a 30° oblique view. This angle allows not only a straight-ahead view but also, by simply rotating the telescope around its longitudinal axis, a greater field of vision than a telescope with a 0° angle. The 2.7-mm telescope can be used with a 3.5-mm protection sheath or a 14.5-Fr operating sheath. The operating sheath provides two stopcocks for gas or fluid insufflation, aspiration, and irrigation as well as a 5-Fr channel for various endoscopic instruments. The most useful instruments are scissors, grasping forceps, biopsy forceps, a fine aspiration or injection needle, and a wire retrieval basket (Figure 1). The flexible biopsy forceps are useful in harvesting tissue samples for histopathology and microbiology. The small sample size permits collection of several biopsy specimens for multiple tests, sequential biopsies to monitor progress, and endoscopic biopsy techniques in patients weighing less than 100 g. The fine aspiration or injection needle can be used for...
documentation equipment should all be placed on a mobile cart that can be easily moved around the hospital. This promotes use of endoscopy in the examination, procedural, and operating rooms and ensures appropriate positioning for maximizing surgeon ergonomics (Figure 2).

Telescope, Sheath, and Instrument Preparation

It is essential to use properly cleaned and sterilized equipment to prevent postsurgical infection. Equipment should first be cleaned using a neutral pH enzymatic cleaner, ensuring that all stopcocks and channels have been thoroughly scrubbed with appropriate brushes. Instruments should be regularly lubricated using instrument oil. Autoclaving is seldom recommended (although modern autoclavable telescopes are available) because the longevity of the equipment may be reduced. The two practical options are gas (e.g., ethylene oxide or hydrogen peroxide) or cold (e.g., 2% glutaraldehyde solution) sterilization. Endoscopic equipment should not be soaked in any solution for more than 30 minutes, and the manufacturer’s recommendations should always be followed. Plastic telescope protectors as well as dedicated storage and sterilization containers can help minimize the risks to equipment.

ENDOSCOPY TECHNIQUES

Anesthesia

Examination of the oral cavity and cloaca may be possible in a conscious or sedated patient with a mouth gag or other appropriate restraint, but we prefer general anesthesia to reduce the risk of damage to the equipment and injury to the patient and staff. Performing coelioscopy on conscious birds is no longer tenable, and general anesthesia is required for all surgical procedures, including endoscopy.3 Isoflurane or sevoflurane administered by facemask, followed by intubation, is the norm for psittacines, although anesthesia should be maintained via an air sac tube when performing prolonged tracheoscopy. For a complete description of avian anesthesia, current reviews should be consulted.13,14

Light Sources, Cameras, and Documentation

Two major types of light source are available: the less expensive tungsten halogen and the more expensive rare-earth xenon. Halogen is sufficient for rigid endoscopy when using the eyepiece, but xenon is preferred for videoendoscopy or documentation and is essential for animals heavier than 4.4 lb (2 kg). The light source is connected to the endoscope via a flexible fiber-optic cable. The efficiency of light transmission is reduced as cable length increases. A xenon light source with a dedicated endoscopy camera and some form of documentation capability (e.g., videocassette recorder, digital video recorder, digital still image capture, still image printout) is recommended for case records and client education. A common mistake in practice is to store endoscopy equipment in its shipping container, making it impractical to use frequently. The monitor, camera, light source, and

remote aspiration, irrigation, and drug administration. The grasping forceps are useful for manipulation of tissues, debridement, and foreign body retrieval, although the wire retrieval-basket forceps may be better suited for larger items. A smaller 1.9-mm telescope with an operating sheath that can accommodate 3-Fr instruments is also available and is particularly suited to birds weighing less than 150 g.

Figure 3. Patient positioning and technique for left-sided avian coelioscopy. (Illustration by Mr. Kip Carter; Educational Resources, University of Georgia)

The bird should be positioned in right lateral recumbency with its wings dorsal and pelvic limb cranial to expose the flank. Close-up of the surgical site demonstrating insertion of the sheathed telescope (T) behind the last rib (arrow), just ventral to the flexor cruris medialis muscle (F). The pubis (P) is the third anatomic landmark.
**Description:** DERAMAXX® (deracoxib) is an analgesic and a non-steroidal anti-inflammatory drug of the coxib class.

**Indications:** DERAMAXX tablets are indicated for the control of pain and inflammation associated with orthopedic surgery in dogs four pounds body weight or greater, and for the control of pain and inflammation associated with osteoarthritis in dogs.

**Contraindications:** Dogs with known hypersensitivity to deracoxib should not receive DERAMAXX tablets.

**Warnings:** Not for use in humans. Keep this and all medications out of reach of children. Consult a physician in case of accidental ingestion by humans.

**Precautions:** Sensitivity to drug-associated adverse events varies with the individual patient. As a class, NSAIDs may be associated with gastrointestinal and renal toxicity. Patients at greatest risk for NSAID toxicity are those that are dehydrated, on concomitant diuretic therapy, or those with existing renal, cardiovascular, and/or hepatic dysfunction. Since many NSAIDs possess the potential to produce gastrointestinal ulceration, concomitant use of DERAMAXX tablets with other anti-inflammatory drugs, such as NSAIDs or corticosteroids, should be avoided or closely monitored.

**Adverse Reactions:** In placebo-controlled field study of postoperative orthopedic pain, involving 207 dogs dosed for 7 days, the following adverse reactions were reported:

- Vomiting
- Diarrhea
- Hematocrit
- Melaena
- Anorexia
- Inclusion body lesion (stomach, colon)
- Non-infection Skin Lesions (must dermatitis, pyoderma)
- Otitis Externa
- Positive joint culture
- Plebitis
- Hematuria
- Conjunctivitis
- Splenomegaly
- Hepatomegaly
- Death

In placebo-controlled field study of osteoarthritis involving 299 dogs dosed for 43 days, the following adverse reactions were reported:

- Vomiting
- Diarrhea
- Weight Loss
- Abdominal Pain (spiking)
- Seizure
- Lethargy
- Pyoderma/dermatitis
- Unilateral Conjunctivitis
- Scleral Injection
- Hematuria/PT
- Splenomegaly
- Grade II Murrumbidgee Sepsis

* Dogs may have experienced more than one of the observations during the study.

**Abnormal Health Findings in the Postoperative Orthopedic Pain Field Study**

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<td>Grade II Murrumbidge Sepsis</td>
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(1) Dogs may have experienced more than one of the observations during the study.

**Abnormal Health Findings in the Osteoarthritis Field Study**

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</table>

(1) Dogs may have experienced more than one of the observations during the study.

**Post Approval Experience:** The following adverse reactions are based on voluntary post-approval reporting. The categories are listed in decreasing order of frequency by body system:

Gastrointestinl: vomiting, anorexia, diarrhea, melaena, hematemesis, hematochezia, weight loss, nausea, gastrointestinal ulceration, gastrointestinal perforation, salivation.

Hematological: anemia, thrombocytopenia.

Hepatic: hepatic enzyme elevations, decreased or increased total protein and globulin, decreased albumin, increased BUN, creatinine, aspartate aminotransferase, alanine aminotransferase, total bilirubin, alkaline phosphatase, increased BUN and decreased creatinine, follow-up treatment included food and fluid therapy.

Neurological/Behavioral: ataxia, aggression, tremor, glazed eyes, uveitis, mydriasis, nystagmus.

Urinary: azotemia, polydipsia, polyuria, urinary tract infection, hematuria, urinary incontinence, renal failure.

Cardiovascular: Respiratory: tachypnea, bradycardia, coughing.

Dermatological/Immunological: fever, facial/muzzle edema, pruritis, urticaria, moist dermatitis.

In rare situations, death has been reported as an outcome of the adverse events listed above. For technical assistance or to report suspected adverse events, call 1-800-332-2761.

**Coelioscopy (Laparoscopy):**

There are four basic approaches to the coelom: left, right, ventral, and interclavicular. Physical examination, diagnostic imaging (including radiography and ultrasonography), and clinical pathology should be used to identify the most appropriate approach. For example, the spleen is best visualized via a left approach and the psittacine pancreas from the right, and more of the liver can be seen from a ventral approach.

There are few contraindications for endoscopy, but insurmountable anesthetic risks are an obvious example. In addition, gross obesity and large masses or other space-occupying lesions that severely compress or obliterate the air sacs can greatly hamper coelioscopy. Left or right approaches should be avoided in birds with ascites because fluid leakage into the air sac system is almost unavoidable; however, in such cases, a ventral midline approach into the hepatoperitoneal cavities is practical.

The left approach to the coelom is most commonly...
used because the female reproductive organs are located on the left side of most avian species. The bird should be positioned in right lateral recumbency with its wings secured dorsad over its back using self-adhesive tape. To expose the left flank, the left pelvic limb should be pulled craniad and secured to the neck using a self-adhesive bandage. The entry site is located immediately behind the last rib and just ventral to the flexor cruris medialis muscle as it courses from the caudal stifle to the ischium (Figure 3). Very few feathers, if any, need to

**Figure 5. Avian coelioscopy.**

Dilated proventriculus (P), liver (L), and heart (H) observed from the left cranial thoracic air sac in a cockatoo with proventricular dilation disease.

Proventriculus (P), liver (L), and cranial membrane of the caudal thoracic air sac (A) observed from the left cranial thoracic air sac in an Amazon parrot.

Caudal ventriculus (V), testis (T), and spleen (S) observed from the left abdominal air sac in a common pigeon.

Middle (Kb) and caudal (Kc) divisions of the kidney and the ureter (arrow) observed from the left abdominal air sac in a male cockatoo.

Intestinal loops observed from the left abdominal air sac in an eclectus parrot.

Pancreas (P) and duodenum (D) observed from the right abdominal air sac in an Amazon parrot.

Because your patients’ health is your first priority, reliable laboratory information is crucial. We understand the importance of quality results and are proud to introduce the NEW VetScan® HMII, advanced veterinary hematology system. The HMII provides reference-lab quality CBC analyses, in-clinic, in minutes. Finally, a reliable tool to support diagnosis, treatment and therapeutic monitoring of your patients in the same visit. Operational simplicity, optimized accuracy and expanded database flexibility give you the results you need, when you need them. **Let us prove how simple accuracy can be. Call us today to schedule a free, in-clinic evaluation!**
be plucked before aseptically preparing the area. Following a 2- to 4-mm skin incision, straight hemostats directed in a slight craniodorsal direction should be used to bluntly dissect between the thin subcutaneous tissues and enter the caudal thoracic air sac. The hemostats should be replaced by the sheathed telescope, and correct position within the caudal thoracic air sac should be confirmed by identifying the lungs (straight ahead), cranial thoracic air sac (to the left), abdominal air sac (to the right), caudal edge of the liver and proventriculus (ventral), and ribs and intercostal muscles (dorsal). Adjacent air sacs can be explored by pressing the tip of the telescope against the proximal air sac membrane and advancing the telescope in a sweeping motion until the air sac membranes are breached. Normal membranes are transparent, and tissues in the adjacent air sac can be visualized and avoided. Great care is required when breaking through thickened opaque air sacs because vision is impaired and trauma can occur if the telescope is blindly advanced. The lungs, liver, heart, and associated great vessels can be examined from the cranial thoracic air sac, whereas the genitourinary system, intestine, spleen, adrenal gland, and associated vasculature can be visualized from the abdominal air sac (Figures 4 and 5). There is no need to repair the small holes punctured in the air sac membranes because they generally heal within 10 days. Postoperative subcutaneous emphysema may be seen in some birds when only skin closure has been performed. Therefore, a single absorbable (i.e., polyglactin or polydioxanone) suture incorporating the body wall and skin is recommended.6

The right approach to the coelom is essentially the same as the left approach. Of particular note is the asymmetric location of the psittacine pancreas, which can be accessed from the right abdominal air sac (Figure 5).

The ventral approach to the coelom provides excellent access to much of the liver. In cases of ascites, the ventral approach is preferred because the telescope can enter the hepatoperitoneal cavities without penetrating an air sac. The bird should be positioned in dorsal recumbency, and following aseptic preparation, the ventral midline should be entered just caudal to the keel (Figure 6). The hepatoperitoneal cavity is divided into left and right sides, and the midline membrane can be perforated as previously described.6

To identify and preserve the crop, a larger (1 cm) surgical approach (the interclavicular approach) is required in the midventral coelomic inlet with the bird in dorsal recumbency. The telescope must be carefully advanced because of the close proximity of major car-
diovascular structures in this region (Figure 7). The interclavicular approach is less commonly used but does provide access to the syringeal region, heart, and great vessels and has been useful in identifying, sampling, and treating cranial coelomic masses.15

Biopsy Technique

One of the great benefits of endoscopy is that when an abnormal structure or pathologic lesion is observed, biopsy specimens can be taken under direct visual control. Biopsy specimens can be harvested from the kidneys, gonads, liver, spleen, pancreas, lungs, fat, air sac, coelomic musculature, and generally any abnormal soft tissue structure. It is important to examine as much of the target structure as possible to determine whether pathology is focal, multifocal, or diffuse. In cases of diffuse renal or hepatic disease (e.g., tubulonephrosis, nephrocalcinosis, hepatic lipidosis, hepatitis), two or three biopsy specimens taken from the most convenient sites are generally diagnostic. Ultrasound-guided and blind-percutaneous biopsy techniques may be equally effective in diagnosing diffuse disease. However, poorer visualization of closely associated structures makes iatrogenic trauma more likely. Most diagnostic failures occur because of poor tissue selection for biopsy, and this is especially true when dealing with focal (e.g., abscess, neoplasia, cyst) and multifocal (e.g., pyogranulomata, mycobacteriosis) diseases. In these cases, direct endoscopic visualization offers the best chance of sampling the most appropriate area(s). In cases of focal or multifocal disease, single or multiple discrete lesions are visible and biopsy specimens should ideally be harvested from the edge of the lesion, taking normal and abnormal tissue in the same biopsy sample for both microbiology and histology. For a technically easier alternative, small biopsy specimens can be collected from the abnormal and normal areas and submitted together for comparison. Although rare, focal disease deep within an

Figure 8. Kidney biopsy viewed from the left abdominal air sac in an Amazon parrot.

Cranial division of the kidney, illustrating urate deposits below the capsule. Advancement of the biopsy forceps–sheath–telescope unit toward the kidney. Gentle closure of the biopsy forceps. Postbiopsy site with minimal hemorrhage.

Early diagnosis of avian disease directs appropriate case management and helps maximize clinical success.
endothelium of the sheath and into the endoscopic field. The forceps should be advanced until they are in the center of the field of view and the opening and closing mechanism is unhindered by the sheath. The instrument–sheath–telescope unit should be advanced as a single instrument. Attempts to move the forceps independently of the sheath tend to create erratic, uncontrolled movements inside the bird. When immediately in front of the organ or tissue of interest, the biopsy jaws should be opened and the instrument–sheath–telescope unit advanced to the tissue. Sharp, well-maintained biopsy forceps close automatically when the handle is released and harvest excellent tissue samples with only minimal, if any, additional force (Figure 8). The biopsy forceps should be removed from the sheath, ensuring that the instrument is withdrawn in straight alignment with the operating channel. Delicate biopsy samples are best removed from the forceps by rolling them onto moistened cotton-tipped applicators and sandwiching them between the foam inserts of a biopsy cassette. Biopsy cassettes, available from any pathology service, reduce the chances of tissue damage and loss during submission. Tissue samples may also be submitted for microbiologic culture and antimicrobial sensitivity testing. Postsampling hemorrhage tends to be inconsequential because of the avian extrinsic coagulation pathway and, in particular, tissue-associated thromboplastin. As an example, approximately 500 endoscopic splenic biopsies were performed in research pigeons at the University of Georgia without a single serious hemorrhagic incident.

In cases of diffuse liver pathology, the most accessible sampling site is the caudal edge of the liver, located on the ventral floor of the caudal (or sometimes cranial) thoracic air sac. To access the liver, it is necessary to incise the air sac and hepatoperitoneal membranes using scissors that have one fixed and one movable blade. The scissors should be opened and the fixed blade gently inserted through the membranes parallel with the caudal edge of the liver. While keeping the blades open, the scissors–sheath–telescope unit should be elevated and advanced to extend the incision. Once the incision is large enough to introduce biopsy forceps, the blades should be closed and the scissors retracted. Biopsy forceps should then be inserted through the incision, and a clean liver sample can be collected (Figure 9). Multiple biopsy samples can be taken from the same site.

Renal biopsy specimens are most easily collected from the cranial division of the kidneys but can also be harvested from the middle and caudal divisions. In general, there is no need to use scissors because the renal parenchyma protrudes into the abdominal air sac and is easily accessed.

Lung tissue is most accessible from the left or right caudal thoracic air sacs. The air sac and pleural membranes must first be incised using scissors. It is generally easier to rotate the scissors within the operating channel so that the fixed blade is dorsal. The scissors–sheath–telescope unit should be advanced and the point of the fixed blade inserted through the membranes covering the lungs. The scissors–sheath–telescope unit should then be gently moved ventrad, creating a dorsoventral incision through which biopsy forceps can be inserted to collect lung biopsy specimens.

The spleen can be best visualized from the left abdominal air sac, and although greater hemorrhage is
usually associated with biopsy, the clinical consequences appear minimal.17

Pancreatic biopsy specimens are most easily collected from the right abdominal air sac of psittacines.

**Tracheoscopy**

The lower respiratory tract can be evaluated using the left and right approaches to the air sacs and lungs. However, to complete the respiratory examination, an oral approach to the choanae, trachea, and syrinx and an external approach to the nares are required. Parrots that are severely dyspneic or suddenly lose their voice and present in acute respiratory distress must first be stabilized. Oxygen and, when necessary, an air sac tube to provide an alternative airway should be used. Gas anesthesia can be delivered by an air sac tube, leaving the mouth and trachea clear for endoscopy, biopsy, and debridement. In birds heavier than 400 g (e.g., Amazons, African greys, macaws, cockatoos), a 2.7-mm telescope should be used to allow tracheoscopy (Figures 10 and 11). In smaller birds, a 1-mm semirigid endoscope or 1.9-mm telescope is required. The 1.9- and 2.7-mm telescopes can be used without a sheath; however, the advantages of reduced diameter should be weighed against increased risks of damaging the telescope. With the bird in dorsal (preferred) or ventral recumbency and its head and neck extended, the telescope can be inserted through the glottis and into the trachea. A surgical plane of anesthesia is required to prevent coughing, but irritation and mucosal damage can be reduced by raising the leading edge of the 30˚ telescope above the mucosal surface while advancing it down the trachea. Even when the tracheal diameter prevents use of a sheathed telescope, retrieval and biopsy forceps can be inserted alongside the telescope for retrieval of foreign bodies, debridement, and sample collection.

**Gastrointestinal and Cloacal Endoscopy**

Examining the oral cavity, esophagus, crop, proventriculus, and ventriculus is possible in most birds weigh-
When cadavers are the only available option, additional instruction from an experienced endoscopist who has worked with live birds is recommended. In countries that permit and regulate the use of live animals for training veterinarians, nonrecovery endosurgery laboratories using anesthetized pigeons offer an unparalleled opportunity for establishing competence before managing clinical cases. Such courses are offered regularly by the University of Georgia, the Association of Avian Veterinarians, and continuing education meetings throughout the United States and Europe.

ACKNOWLEDGMENTS
The authors thank Karl Storz Veterinary Endoscopy for providing inserts B and C in Figure 1 as well as Mr. Kip Carter of Educational Resources, University of Georgia, for illustrating Figures 2 and 3.

REFERENCES
6. Taylor M: Endoscopic examination and biopsy techniques, in Ritchie BW, Harrison GJ, Harrison LR (eds): Avian Medicine: Principles and Appli-
2. Which of the following is not a benefit of endoscopy?
   a. Internal examination can be minimally invasive.
   b. Major surgical exposure for biopsy can be avoided.
   c. Biopsies can be safely performed.
   d. There are no risks associated with endoscopic procedures.
   e. Diagnosis can be expedited by facilitating lesion histology and culture.

3. A rod lens telescope
   a. is flexible.
   b. is robust.
   c. provides better image quality than traditional endoscope designs.
   d. provides worse image quality than traditional endoscope designs.
   e. provides the same image quality as traditional endoscope designs.

4. When performing single-entry endoscopy in birds, a sheath is least effective for
   a. preventing damage to the telescope.
   b. providing a means for insufflation.
   c. providing a means for irrigation.
   d. facilitating instrument use.
   e. preventing iatrogenic tissue trauma during entry.

5. What is the preferred method of restraint for prolonged tracheoscopy in a dyspneic bird?
   a. repeated intermittent use of a facemask and isoflurane
   b. placing an air sac tube for continuous delivery of oxygen and isoflurane
   c. connecting the anesthesia line to one of the stopcocks on the sheath for isoflurane delivery
   d. using injectable anesthetic agents
   e. not using anesthesia and relying on physical restraint alone

6. The preferred entry site for examining the avian reproductive tract is the
   a. left side, caudal to the last rib and ventral to the flexor cruris medialis muscle.
   b. left side, caudal to the pubis and ventral to the flexor cruris medialis muscle.
   c. right side, caudal to the last rib and ventral to the flexor cruris medialis muscle.

7. The liver can be visualized and a biopsy performed from all of the following approaches except the
   a. left lateral.
   b. right lateral.
   c. interclavicular.
   d. ventral midline.
   e. dorsal.

8. From which air sac can direct examination and biopsy of the kidneys be performed?
   a. clavicular
   b. cervical
   c. cranial thoracic
   d. caudal thoracic
   e. abdominal

9. From which air sac are examination and biopsy of the psittacine pancreas most easy?
   a. left abdominal
   b. right abdominal
   c. left caudal thoracic
   d. right caudal thoracic
   e. right cranial thoracic

10. From which air sac are examination and biopsy of the spleen most easy?
    a. left abdominal
    b. right abdominal
    c. left caudal thoracic
    d. right caudal thoracic
    e. left cranial thoracic

Coming Soon in Compendium
- Albumin in Health and Disease
- Flank Approach to Ovariohysterectomy
- Meningiomas
1. Which statement regarding avian endoscopy is incorrect?
   a. Birds tolerate coelioscopy better than coeliotomy.
   b. Coelioscopy should be performed in conscious birds.
   c. Coelioscopy is a minimally invasive technique.
   d. Rigid endoscopes are preferred over flexible endoscopes for most diagnostic applications.
   e. The cost of endoscopy is comparable with that of radiography and ultrasonography.

Minimally Invasive Endoscopic Surgery of Birds

Stephen J. Hernandez-Divers, BVetMed, Dipl ZooMed (Reptilian), Dipl ACZM, RCVS Specialist in Zoo & Wildlife Medicine

Abstract: Endoscopy has proven to be an important diagnostic tool for avian veterinarians to observe and biopsy internal structures. To date, most of the described endoscopic procedures are single-entry techniques. The use of miniature endoscopic equipment has been pioneered in human pediatric laparoscopy, and many of these techniques can be used in avian medicine. The addition of a second and third port using 2.5- or 3.5-mm cannulae has facilitated the use of 2- or 3-mm instruments within the avian coelom. Triangulation of various instruments coupled with radiosurgical hemostasis has made several endoscopic procedures possible, including salpingohysterectomy and orchidectomy. In addition, endoscope-assisted, minimally invasive procedures, including enterotomy, enterectomy, cloacopexy, and pneumotomy, may be initiated internally and completed by standard surgical techniques. The advent of minimally invasive endoscopic surgery offers important benefits, including rapid and accurate diagnosis, reduced need for an extensive coeliotomy, reduced surgical stress, improved pulmonary function, more stable anesthesia, and reduced surgical and hospitalization periods.

Key words: avian, bird, endoscopy, surgery, orchidectomy, salpingohysterectomy

Introduction

Endoscopy has proven to be a very useful diagnostic tool in veterinary medicine. In zoological medicine, diagnostic endoscopy has shown great promise in a variety of species but has probably been most used by avian veterinarians.1-3 Avian veterinarians routinely use endoscopy to evaluate the respiratory tract, gastrointestinal tract, and coelomic viscera, particularly the urogenital tract, liver, and kidneys.4-7

Rigid endoscopy is most commonly used for diagnostic purposes in birds.3,8 Most endoscopic systems use a rigid telescope housed within a sheath, through which basic instruments can be inserted into the field of view. This technique has been extremely effective for examination and biopsy of internal structures but is severely limited in its ability to facilitate surgery, where the triangulation of multiple instruments is often required. The purpose of this report is to describe the evolution of the rigid telescope from a purely diagnostic tool to a surgical system for minimally invasive endoscopic surgery (endosurgery) in birds.

Coelioscopy equipment

The basic rigid telescope system for avian veterinarians has been developed from human cystoscopy equipment and has been recently reviewed (Table 1).9,10 Probably the most commonly used endoscope is the 30° Hopkins telescope (2.7 mm × 18 cm) connected to a halogen or xenon light source by a fiber-optic cable (Karl Storz Veterinary Endoscopy America Inc, Goleta, CA, USA). The telescope is housed within an examination and protection sheath (3.5 mm) or an operating sheath (14.5 Fr) that possesses twin insufflation/irrigation ports and a 5-Fr instrument channel (Fig 1A). Biopsy forceps (3 and 5 Fr), grasping forceps (3 and 5 Fr), single-action scissors (3 Fr), injection/aspiration needle with Teflon guide, wire basket retrieval device, and radiosurgery needles are most commonly used by means of the operating sheath (Fig 1B and C). A smaller, 1.9-mm telescope and sheath system is also available and is preferred for birds weighing less than 100 g. Previously, endoscopic cameras were considered optional; however, clinical, research, and teaching experience has clearly indicat-
Table 1. Equipment used for diagnostic and minimally invasive endoscopic surgery of birds.

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Manufacturer and Model Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard rigid avian endoscopy system—Karl Storz Veterinary Endoscopy America Inc</td>
<td>64018BSA, Hopkins telescope, 2.7 mm x 18 cm, 30°</td>
</tr>
<tr>
<td>67065CV, Taylor operating sheath, 14.5 Fr, 5-Fr instrument channel</td>
<td>64018US, examination and protection sheath, 3.5-mm outside diameter</td>
</tr>
<tr>
<td>69117Z, biopsy forceps, 5 Fr</td>
<td>61071T, grasping forceps, 5 Fr</td>
</tr>
<tr>
<td>61017J, grasping forceps, 3 Fr</td>
<td>62501EK, single-action scissors, 3 Fr</td>
</tr>
<tr>
<td>67071X, aspiration and injection needle with Teflon guide</td>
<td>67023 VK, wire basket retrieval device, 5-Fr flexible</td>
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<td>67159L, polypectomy snare, 5 Fr flexible</td>
<td>67772A, needle end radiosurgery electrode, 5 Fr</td>
</tr>
<tr>
<td>201315-20, Nova xenon light source, 175 W</td>
<td>495NA, light-guide cable, 3.5 mm x 230 cm</td>
</tr>
<tr>
<td>69235106, veterinary video camera II</td>
<td>9213-B, medical-grade monitor</td>
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<tr>
<td>Human pediatric laparoscopy equipment, 20 cm—Karl Storz Veterinary Endoscopy America Inc</td>
<td>11603G, 2.5-mm graphite and plastic cannula with valve and trocar</td>
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<td>11603G1, 2.5-mm graphite and plastic cannula with valve and stopcock and trocar</td>
<td>30114GK, 3.5-mm graphite and plastic cannula with valve and trocar</td>
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<tr>
<td>30117GK, 3.5-mm graphite and plastic cannula with valve and trocar (no insufflation stopcock)</td>
<td>30114HK, 2.5-mm metal cannula with valve and stopcock and trocar</td>
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<td>30114HL, 3.5-mm metal cannula with valve and trocar</td>
<td>30117MT, 5-mm endotip cannula with valve and trocar</td>
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<td>30223KJS, 2-mm Reddick-Olsen dissecting forceps, plastic handle without racket</td>
<td>30221MSS, 2-mm Metzenbaum scissors, plastic handle without racket</td>
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<tr>
<td>30240AS, 2-mm Babcock forceps, plastic handle with racket</td>
<td>30322KS, 3-mm fenestrated grasping forceps, plastic handle with Mahnes racket</td>
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<tr>
<td>30322ULS, 3-mm Reddick-Olsen dissecting and grasping forceps, plastic handle with</td>
<td>30322MMS, 3-mm long curved Kelly dissecting and grasping forceps, plastic handle with Mahnes racket</td>
</tr>
<tr>
<td>30322MLS, 3-mm short curved Kelly dissecting and grasping forceps, plastic handle</td>
<td>30341AS, 3-mm Babcock forceps, metal handle without racket</td>
</tr>
<tr>
<td>30321DBS, 3-mm Blakesley dissecting and biopsy forceps, plastic handle without racket</td>
<td></td>
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</tbody>
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Table 1. Continued.

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Manufacturer and Model Information</th>
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</thead>
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<tr>
<td>30321MWS, 3-mm scissors with serrated curved, double-action jaws, plastic handle</td>
<td>30321MSP, 3-mm scissors with long, sharp, curved double-action jaws, plastic handle</td>
</tr>
<tr>
<td>without racket</td>
<td>30321EHS, 3-mm microhook scissors, single-action jaws, plastic handle</td>
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<tr>
<td>26184HCS, 3-mm Mahnes bipolar coagulation forceps</td>
<td>26167LHS, 3-mm irrigation and suction cannula</td>
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<tr>
<td>26167TS, 3-mm palpation probe with centimeter markings</td>
<td>30341RES, 3-mm distendable palpation probe</td>
</tr>
<tr>
<td>26167FNS, 3-mm ultramicro needle holder</td>
<td>26167SS, 3-mm knot tier for extracorporeal suturing</td>
</tr>
<tr>
<td>Radiosurgery equipment—Ellman International Inc</td>
<td>3.8- or 4.0-MHz dual radiofrequency unit with foot pedal</td>
</tr>
<tr>
<td>Monopolar lead to connect to plastic instrument handles</td>
<td>Bipolar lead to connect to Mahnes bipolar coagulation forceps</td>
</tr>
<tr>
<td>Laser equipment—AccuVet Lumenis Inc, SurgiMedics Inc</td>
<td></td>
</tr>
<tr>
<td>AccuVet 25D 980-nm diode laser</td>
<td></td>
</tr>
<tr>
<td>400- and 600-μm conical and flat-tipped fibers</td>
<td></td>
</tr>
<tr>
<td>AccuVet High Power LX 20 SI CO2 laser</td>
<td></td>
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<tr>
<td>Long semirigid ceramic probe for use with 14.5-Fr sheath</td>
<td></td>
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</tbody>
</table>

* Essential entry-level equipment for endosurgery.

ed that surgeon ergonomics and ability are greatly improved by the use of an endovideo camera (Figs 1A and 8).8,11

To evolve from observation and biopsy into endosurgery, accurate hemostasis becomes increasingly critical. Radiosurgical and laser devices have become available to veterinarians and have facilitated the ability to incise and debride internally without significant hemorrhage (Table 1). Diode laser (AccuVet Lumenis Inc, Norwood, MA, USA) is, by design, able to pass through flexible fiber-optic probes that can be inserted through instrument channels or cannulae (Fig 2A).11–13 A variety of diode laser probes are available; however, 400- to 600-μm conical or flat tips at 2–10 W are preferred (SurgiMedics Inc, The Woodlands, TX, USA).11 Until recently, CO2 lasers (AccuVet Lumenis Inc) could not be inserted into endoscopic instrument channels because of the inflexible nature of the ceramic delivery probes. The recent development of a long, semirigid probe (AccuVet Lumenis Inc), however, has enabled the use of the CO2 laser through the instrument channel of the 14.5-Fr operating sheath (Fig 2B). A variety of radiosurgery devices are available for use with foot-pedal-acti-
Figure 1 (top). Basic rigid avian endoscopy system. (A) A 2.7-mm telescope housed within a 14.5-Fr operating sheath with light-guide cable and endovideo camera attached; (B) close-up of the end of the operating sheath illustrating biopsy forceps protruding from the instrument channel; (C) 5-Fr endoscopic instruments for use with the 14.5-Fr operating sheath—grasping forceps (1), biopsy forceps (2), aspiration/injection needle (3), and single-action scissors (4).

Figure 2 (bottom). Endoscopic laser systems for use with the 2.7-mm telescope and 14.5-Fr sheath. (A) A 600-μm diode laser fiber inserted down the instrument channel with the precarbonized tip protruding in front of the telescope (insert); (B) semirigid CO₂ laser probe inserted down the instrument channel and protruding in front of the telescope (insert).

vated 3.8- and 4.0-MHz radiosurgery units (Ellman International Inc, Hewlett, NY, USA). The most useful instruments compatible with the 14.5-Fr operating sheath are the needle electrode (Ellman International Inc) and polypectomy snare (Karl Storz Veterinary Endoscopy America Inc) (Fig 3). Compared with open surgery, the degree of radiosurgical power required during endosurgery varies with op-
Figure 3 (top). Radiosurgical polypectomy snare. (A) Handle of the snare illustrating the thumb control (arrow); (B) snare retracted into outer sheath; (C) snare extended and open.

Figure 4 (bottom). Cannulae and trocars. (A) Plastic and graphite cannulae and trocars with valves but no insufflation stopcocks, 2 mm (top) and 3 mm (bottom); (B) plastic and graphite cannulae and trocars with valves and insufflation stopcocks, 2 mm (top) and 3 mm (bottom); (C) surgical steel cannulae and trocars with valves and stopcocks, 2 mm (top) and 3 mm (bottom); (D) 5-mm endotip cannula with valve and stopcock. Please note that any cannula stopcock must be closed when used within avian air sacs.
Figure 5 (top). Endoscopic instruments, 20 cm × 3 mm. (A) Forceps—Babcock forceps (1), atraumatic dissecting and grasping forceps with single-action jaws (2), Reddick-Olsen dissecting forceps (3), fenestrated grasping forceps (4), long, curved Kelly dissecting and grasping forceps (5), short, curved Kelly dissecting and grasping forceps (6); (B) scissors and biopsy instruments—microhook scissors with single action jaws (1), Blakesley dissecting and biopsy forceps (2), scissors with long, sharp, curved double-action jaws (3), scissors with serrated curved double action jaws (4); (C) probes—distendable palpation probe (1), palpation probe with centimeter markings (2), irrigation and suction cannula (3).

Figure 6 (bottom). Human pediatric laparoscopy system. (A) Endoscopic instrument (I) inserted through cannula (C) and coupled to a plastic handle (H) with a radiosurgical monopolar lead (R) connected; (B) close-up demonstrating radiosurgical connection (R) and instrument (I) insertion/release by pressing the button (arrow).
erating conditions and the instrument being used, but because of the microsurgical nature of most endosurgical procedures, lower settings are generally required. Considerable growth in endoscopic radiosurgery has led to the availability of a large number of monopolar and bipolar devices.

The availability of 2- and 3-mm human pediatric laparoscopy equipment (Karl Storz Veterinary Endoscopy America Inc) has facilitated the development of multiple-entry endoscopy in small exotic species, including birds. While the original sheathed telescope is still used to provide visualization, additional operating cannulae provide access ports for inserting additional instruments. Instrument triangulation permits surgery within the avian coelom without the need for extensive coeliotomy. Each additional access port is created by using a 2.5- or 3.5-mm cannula and trocar. Once inserted, the trocar is removed and a 2- or 3-mm instrument is inserted (Table 1). The cannulae are of surgical steel or plastic and graphite construction and have internal valves and optional stopcocks for insufflation (Fig 4). These valves are designed to prevent loss of CO2 during insufflation. Although CO2 insufflation is contraindicated when working within the avian air sac system, these valves are still essential for preventing gas exchange between the respiratory system and the environment, therefore assisting in maintaining safe and effective anesthesia. Insufflation stopcocks on cannulae are optional but are not required for avian coelioscopy and should be closed if present; however, they are essential when using the same system with mammals, reptiles, amphibians, or fish. The plastic-graphite models are extremely light and ideally suited to most avian species (Fig 4A and B). The metal cannulae are more robust and heavier and therefore are used only for the largest birds (Fig 4C and D).

The endotip cannula is a recent improvement that has an external screw thread to enable gradual advancement by rotation (Fig 4D). The cannula does not require trocar or axial penetration force during insertion. A telescope within the cannula provides a magnified view during entry into the coelom. As the cannula is advanced, the fascia and then the muscle fibers spread radially and are transposed onto the outer thread of the cannula. The thin air-sac membrane is transilluminated so that viscera, vessels, or adhesions are visible before the air sac is entered, thereby reducing the risks of iatrogenic visceral damage. A 5-mm-endotip cannula can be used with a 2.7-mm telescope within a 3.5-mm protective sheath. In large birds, endotip cannulas can be placed under direct visual control and, because of their 3.5-mm internal diameter, telescope and instruments can be used interchangeably between multiple endotip ports.

Currently, 2-mm instruments are limited to Babcock forceps, dissecting forceps, and scissors. However, a greater variety of 3-mm instruments is available, including dissection forceps, grasping forceps,
scissors, biopsy forceps, bipolar forceps, palpation probes, needle holders, and extracorporeal knot tiers (Table 1, Fig 5). These instruments have a standard attachment that enables them to be used interchangeably with a variety of different handles (Fig 6). Most handles are constructed of plastic or metal and possess a radiosurgical connection that can turn scissors or forceps into monopolar devices. Some handles have a hemostat or Mahnes-style racket mechanism to maintain a firm hold on tissue even if the endoscopist releases his or her grip on the instrument (Fig 7).

Coelioscopy and endosurgery should be done with the bird under general anesthesia and with appropriate aseptic techniques and sterilized instruments. Equipment sterilization with hydrogen peroxide vapor or ethylene oxide gas is preferred, but cold sterilization with 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 be within easy reach (Fig 8).

**Single-entry techniques**

Unless anatomic or disease considerations dictate otherwise, a left approach to the avian coelom is preferred. The pelvic limb is extended craniod to expose the flank, and very few feathers are generally removed. A 2- to 3-mm skin incision followed by gentle blunt dissection permits entry of the telescope just caudal to the last rib and craniod to the flexor cruris medialis muscle as it courses from the caudal stifle to the ischium (Fig 9). Some veterinarians prefer to extend the pelvic limb craniod 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 because of the restricted surgical field. Positioning the limb craniod maximizes exposure of the caudal flank and facilitates placing additional ports for double- and triple-entry techniques.

Single-entry endosurgery is limited to a single instrument that cannot be manipulated independently of the telescope. This technique provides access to the heart, liver, gastrointestinal tract, spleen, and urogenital tract by endoscopic approach through the cranial thoracic, caudal thoracic, or abdominal air sacs. Salpingohysterectomy has been described in juvenile cockatiels by using the 2.7-mm telescope, 14.5-Fr sheath, and grasping forceps to break down the suspensory ligaments and remove the infundibulum, oviduct, and uterus. Completing this surgery required exteriorizing the reproductive tract through the single surgical entry site, with final crushing and transection of the uterus performed outside the coelom by a second surgeon. Additional hemostasis 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 en-
Figure 10. Endoscopic debridement and diode laser ablation of a fungal granuloma in the caudal thoracic air sac of an African grey parrot (*Psittacus erythacus*).11 (A) Coelioscopic view of the fungal granuloma attached to the lung and the caudodorsal aspect of the caudal thoracic air sac; (B) debridement of the granuloma using 5-Fr biopsy forceps; (C) diode laser ablation of the remaining granuloma using a 600-μm fiber with precarbonized tip at 3 W continuous power; (D) local application of amphotericin B delivered using a fine aspiration/injection needle.

Endoscopy-assisted rather than endoscopic because a major part of the surgery was done outside the coelom with standard surgical instruments. Nevertheless, endoscopy prevented the need for a more invasive coeliotomy and reduced surgical trauma. A greater risk of severe hemorrhage would be expected if this technique was used in mature hens because of the greater vascular supply to the adult reproductive tract and lack of effective endoscopic hemostasis.

Air sac granulomas have been removed successfully in several parrots by using a combination of endoscopic debridement and diode laser ablation (Fig 10).11 Because of the avascular nature of the granulomas, debridement with a 5-Fr biopsy forceps was possible without additional hemostasis. Diode laser was used to ablate and sterilize the infected areas. With this technique, resection is restricted to relatively small avascular masses. Hemostasis would be more difficult if the masses were larger or more vascular. Additionally, the small size of the biopsy forceps would result in excessively long surgery.

The main disadvantages of single-entry techniques are restriction to single instrument use, the small size of a limited number of available instruments, and the codependence between instrument and telescope. However, for very small avian species, single-entry techniques may provide the only practical alternative to standard coeliotomy.

**Double-entry techniques**

An additional operating port enables the endoscopist to use a second instrument independently of the telescope. Placement of a second port (port 2) requires more extensive surgical-site preparation, as more feathers must be removed to expose the caudal pubic region. The telescope is introduced as previously described, and a second cannula and trocar are inserted through the obliquus abdominis externus muscle just caudal to the midpoint of the pubis.
Figure 11. Patient positioning and technique for double-entry avian endosurgery. (A) The bird is positioned in lateral recumbency with the pelvic limb held cranial to expose the flank; (B) close-up of the surgical site demonstrating insertion of the sheathed telescope behind the last rib (port 1) and the cannula behind the pubis (port 2). Telescope and instrument ports can be reversed as required.

(Fig 11). After a 1–2-mm skin incision is made, the cannula and trocar are gently forced by rotational motion into the coelom. Entry into the coelom is guided by direct observation using the telescope. Once positioned within the abdominal air sac, the trocar is removed, leaving the cannula in place. The cannula must be inserted gently into the coelom to ensure that it is held in place by the soft tissues. A loose cannula may be easily dislodged or permit gas exchange between the air sacs and the environment, causing anesthetic instability. A mattress or purse-string suture can help secure the cannula. In general, the greater the distance between the 2 ports, the easier instrument triangulation becomes. Therefore, in large birds, placement of the telescope (port 1) between the last 2 ribs may be beneficial. An instrument can then be inserted through port 2 into the telescopic field of view and used independently of the sheathed telescope. If necessary, the instrument channel of the sheath can also accommodate an additional instrument. The endoscopist controls both instruments while the telescope position is either maintained by a supporting sandbag or an assistant. With practice, the telescope and associated instrument can be controlled together in 1 hand while the second instrument is manipulated with the other, facilitating a single-surgeon procedure.

Salpingohysterectomy can be performed by this double-entry technique (Fig 12). The sheathed telescope with grasping forceps is inserted through port 1. The forceps are used to grasp the uterus, while monopolar scissors are introduced through port 2. The scissors are placed across the caudal uterus, close to cloacal insertion, and the tissue is coagulated by radiosurgery before the uterus is transected. For large birds, bipolar forceps can be used to ensure appropriate coagulation before transecting with scissors. By intermittent radiosurgical activation of the partially closed scissors, vessels are coagulated before the suspensory ligaments of the uterus and oviduct are incised. As the dissection continues cranial, the sheathed scope and grasping forceps are retracted to maintain tension on the reproductive tract. The oviduct must be released and grasped repeatedly because the grasping forceps cannot be used independently of the telescope. The dissection continues until the entire oviduct and uterus are freed, at which point they are removed along with the sheathed telescope and forceps from the first port. No attempt is made to remove the ovary. The scissors and cannula are removed from the second port. Both surgical sites are closed in a routine manner with a single suture or tissue adhesive. Unlike the previously described single-entry salpingohysterectomy of juvenile cockatiels (*Nymphicus hollandicus*), the use of radiosurgical scissors has made this surgery possible in mature hens.

Orchidectomy is also performed by a similar double-entry technique, but a bilateral approach is usually required (Fig 13). Entry ports 1 and 2 are created as previously described with the telescope inserted through port 1. The technique involves in-
Figure 12. Endoscopic salpingohysterectomy in a common pigeon (*Columba livia*) using a double-entry technique. (A) The sheathed telescope with grasping forceps is inserted behind the last rib with monopolar scissors inserted behind the pubis; (B) the caudal uterus is elevated with grasping forceps, and monopolar scissors initiate the incision across the caudal uterus close to the cloacal insertion; (C) the grasping forceps are retracted as dissection continues craniad; (D) the oviduct is excised from its cranial attachments using scissors; (E) postoperative view of the cranial division of the kidney demonstrating the remnant of the oviductal attachment; (F) postoperative view demonstrating the transected and radiosurgically sealed caudal uterus, close to the cloaca.

...inserting a polypectomy snare through port 2 and over the testis. The snare is gently closed around the mesorchium while the ligament and associated vessels are cut and coagulated with radiosurgery to free the testis. The polypectomy snare is then replaced with forceps to retrieve the freed testis through port 2. To remove a particularly large testis, the port opening may need to be enlarged with hemostats. Because of the close association of the adrenal gland and the vena cava, risk of serious hemorrhage as a potential complication can be reduced by using a 3-port technique.

Double-entry techniques can also facilitate endoscope-assisted coelomic procedures. The telescope is used to identify the specific structure or organ of interest. Small hemostats are pressed against the coelom until the most appropriate coeliotomy site is visibly identified by using the telescope. A small, targeted coeliotomy incision is made with a scalpel directly over the structure of interest, and the coelom is then entered by blunt dissection with hemostats. Endoscope-guided forceps can be used to exteriorize the structure, or minor procedures can be done internally by using the endoscope to provide focal illumination and magnification. Examples are biopsy, enterotomy, enter-
Figure 13. Endoscopic orchidectomy in a common pigeon using a double-entry technique. (A) Telescope view of the testis from port 1, behind the last rib; (B) cannula and trocar placement behind the pubis under telescope guidance; (C) placement of the radiosurgical polypectomy snare over the testis; (D) elevation of the testis using grasping forceps inserted down the operating sheath of the telescope in preparation for activating the radiosurgery polypectomy snare and freeing the testis.

Figure 14. Patient positioning and technique for triple-entry avian endosurgery. (A) The bird is positioned in lateral recumbency with the pelvic limb held cranial to expose the flank; (B) close-up of the surgical site demonstrating the sheathed telescope cranial to the pubis (port 1), one cannula behind the pubis (port 2), and the second cannula behind the last rib (port 3).
Figure 15 (top). Triple-entry salpingohysterectomy and cloacopexy in a female Moluccan cockatoo (*Cacatua moluccensis*) that presented with chronic cloacal prolapse of reproductive etiology. (A) Perioperative view demonstrating the central placement of the sheathed telescope midway between the last rib and pubis, and 2 cannulae, 1 cranial through the last intercostal space and the second caudal to the pubis; (B) perioperative view demonstrating the surgeon manipulating the 2 instruments inserted down the 2 cannulae and an assistant holding the sheathed telescope and camera in position.

Figure 16 (bottom). Triple-entry salpingohysterectomy and cloacopexy in a female Moluccan cockatoo that presented with chronic cloacal prolapse of reproductive etiology. (A) Transection of the caudal uterus using monopolar scissors; (B) further dissection of the suspensory ligaments to free the uterus and oviduct; (C) cranial transection of the oviduct near the ovary; (D) postoperative view from the port caudal to the pubis illustrating the sutured attachment of the lower intestinal tract to the last rib (arrow).
ectomy, duodenostomy tube placement, cloacopexy, syringeal surgery, pneumonectomy, proventriculectomy, and ventriculotomy. The surgical trauma associated with double-entry procedures would be less than that of standard coeliotomy, which often requires transection of ribs and causes permanent damage to air sacs.17

The main disadvantage of double-entry techniques is the codependence between the instrument housed within the sheath and the telescope. However, the ability to use 2 ports and hence operate with 2 independent instruments is a significant advantage, particularly given the variety of 3-mm instruments available.

**Triple-entry techniques**

The most complicated but versatile techniques involve the use of 3 ports. Aseptic preparation requires removing feathers from the last intercostal space to the caudal pubic region of the flank. A triple-entry technique enables the simultaneous use of 2 instruments that are both independent of the telescope (Fig 14). The telescope is inserted just cranial to the pubis (port 1). The 2 instrument ports are placed caudal to the pubis (2), and just caudal to the last rib (3). Because of triangulation, the instrument ports must be kept as far apart from each other as possible. Moving the cranial port (3) to the last intercostal position may reduce telescope manipulation and impingement on the instruments. The primary endoscopist controls both instruments and the foot-pedal-activated radiosurgery device while support sandbags or an assistant maintain the telescope in position (Figs 15 and 16). If the need arises, a third instrument can be inserted down the channel of the sheath.

All of the procedures previously described can be accomplished more easily in large birds by a triple-entry technique. Endosurgery is generally easier to perform, as the structures can be handled and manipulated by using 2 independent instruments without adversely affecting telescope position and hence the surgical field of view. For example, gonadectomy can be performed more safely by elevating the gonad away from the vena cava with forceps and carefully dissecting the suspensory ligaments with a radiosurgery needle or monopolar scissors.

The main disadvantages of triple-entry techniques are the difficulty of placing and maintaining 3 ports in small birds combined with initial difficulties of depth perception and coordinating independent instruments. In general, the use of 3 ports is restricted to large species, typically weighing over 400 g, although initial experience and proficiency are easier to attain in birds weighing 1 kg or more. The ability to use 2 independent instruments makes endosurgery a practical alternative to more extensive standard coeliotomy procedures.

### Summary

The most substantial limitation to successful soft-tissue surgery involving the coelom is the relative small size of most avian patients and the limited surgical access afforded by standard coeliotomy techniques.17 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.18–23 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.18,23 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.22 The efficacy, complications, or long-term effects of endosurgery have not been extensively documented in birds, although ongoing research at the University of Georgia continues to critically evaluate these procedures. Nevertheless, it would seem reasonable to explore the virtues of minimally invasive endosurgery in avian species that, because of their air sac system, are ideally suited to a coelioscopic surgical approach.

The miniature laparoscopy system described here was designed for human pediatric use, and no major modifications are required to use the same equipment in exotic animal practice. The equipment list in Table 1 is provided so that veterinarians can evaluate equipment that would have the most application in their individual practices. However, as most avian veterinarians possess radiosurgery and a standard 2.7-mm endoscopy system, endosurgery could be initiated by acquiring 2 cannulae and trocars, a pair of dissecting forceps, a pair of scissors, 2 handles, and a monopolar lead.

The ability to perform endosurgery is not innate, and human surgeons undergo extensive training by using artificial teaching devices and receiving supervised instruction from experienced endoscopists. Such educational tools are not readily available to veterinarians, although mini-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 because of 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 veterinary training, nonrecovery endosurgery laboratories using anesthetized pigeons or chickens offer an unparalleled opportunity for establishing competence before embarking on clinical cases.

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References
Small Mammal Endoscopy

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ENDOSCOPY EQUIPMENT

ENDOSCOPY PROCEDURES

- Otoscopy
- Rhinoscopy
- Oral Cavity
- Tracheal Intubation
- Vaginoscopy/Cystoscopy
- Laparoscopy

Endoscopy is the visual examination of internal structures with an endoscope. The endoscope can be used in any hollow or viscous organ (e.g., mouth, ear, trachea, or esophagus) or, by insufflation, in any potential space (e.g., peritoneal cavity or bladder). Endoscopy has proved to be a useful diagnostic tool in veterinary medicine, providing direct visualization and biopsy of internal organs. In the field of zoological medicine, diagnostic endoscopy has shown great promise in a variety of species but has probably been most used by avian veterinarians. Endoscopy of small mammals, specifically rabbits, is a novel use of this equipment but one that holds great promise for improved disease diagnosis and management.

ENDOSCOPY EQUIPMENT

We prefer the use of the 2.7-mm rigid, rod-lens Hopkins telescope (Karl Storz Veterinary Endoscopy America Inc., Goleta, CA), 18 cm in length and with a 30-degree viewing angle, because of its versatility in exotic pet practice, the variety of available accessories, and the dedicated company support (Fig. 36-1). The telescope is housed inside a protective sheath and connected to a xenon light source by a light guide cable. Endoscopic instruments of particular interest include the biopsy forceps, grasping forceps, single-action scissors, fine aspiration and injection needle with Teflon guide, and wire retrieval basket. For laparoscopy, we prefer insufflating with a dedicated endotracheal with medical-grade carbon dioxide gas and a Veress pneumoperitoneum needle. Sterile saline can be beneficial for irrigation and to improve visualization of internal structures, especially epithelial or mucosal surfaces. The modern endoscopy cameras greatly enhance the endoscopist's capabilities and are available in both European PAL and U.S. NTSC formats.

Recording still images and video are also practical means of marketing endoscopic procedures to small herbivore owners and keepers. More complete reviews of endoscopic equipment are available. To prevent postoperative infection, endoscopic instruments must be properly sterilized. The three practical options are gas sterilization with ethylene oxide gas, hydrogen peroxide vapor, and 2% glutaraldehyde solution.

ENDOSCOPIC PROCEDURES

For all procedures described, general anesthesia is recommended. Any contraindication for general anesthesia is often a contraindication for endoscopy. Participating in a course on endoscopic techniques and practicing on necropsy specimens are strongly recommended before working with client-owned animals.

Otoscopy

To examine the ear canal of a rabbit, position the animal in sternal recumbency with an assistant supporting the rabbit's head and holding the pinna erect. Gently insert the telescope down the external ear canal until the aural sulcus, a blind-ending diverticulum off the vertical canal, is seen. Continue advancing ventrally until the vertical canal deviates medially and becomes the horizontal canal before terminating at the malleus tympanum. Epithelial lesions and exudate are often visible, and the integrity of the tympanum can be easily assessed (Plate 1). Typanum perforation and oitis media, if present, will be evident. As needed, take a biopsy of any lesion and collect samples of exudate for cytologic, histopathologic, and microbiologic examination. Irrigate with sterile saline and clear debris as necessary. Use chemical cleansing agents only after samples for microbiologic culture are collected or if culture is not required.

Rhinoscopy

For rhinoscopy of a rabbit, position the intubated animal in sternal recumbency with the head held down. Flush both naris with sterile saline to clear mucus and debris from the nose. Depending on the size of the rabbit, an examination sheath may or may not be used with the telescope. However, use extreme care when working with the unprotected telescope to prevent
damage to the instrument. With an assistant supporting the head, gently advance the endoscope into one nostril past the alar fold. The first area encountered is the nasal meatus, which is divided into dorsal, middle, and ventral areas (Plate 2). Advance the telescope further caudal to the dorsal and ventral nasal conchae (moving the telescope between the dorsal and ventral areas can be difficult in small rabbits). Finally, the cranial aspects of the ethmoid labyrinth are visible. Because the nasal membranes are highly vascular, take care to avoid trauma and subsequent hemorrhage. Irrigating with saline greatly aids visibility of these structures. Collect biopsy samples of lesions and exudate as necessary. Biopsy instruments may need to be inserted independently of the telescope if the small working space precludes the use of a sheath. Hemorrhage after biopsy is minor.

Oral Cavity

The very small oral commissure tends to preclude a thorough examination of the cheek teeth in rabbits and rodents. As a result, malocclusion tends to progress undetected until it becomes severe enough to elicit overt clinical signs. The rigid endoscope is ideally suited to examine the oral cavity in these small mammals and offers considerable advantages over a standard otoscope. As an alternative to the Hopkins telescope, an 8.5-cm otoscope (Karl Storz Veterinary Endoscopy) can be used to examine the oral cavity and offers the advantage of not requiring a protective sheath.

Food material is often retained in the mouth after eating, especially in guinea pigs. Therefore fasting small mammals for 1 to 4 hours before examination may be helpful. With the patient appropriately sedated or anesthetized, hold the mouth open with a self-retaining mouth gag and a cheek retractor to enhance visibility of the dental arcades (Spectrum Surgical Supply, Stow, OH) (Fig. 36-2). Insert the telescope within its protective sheath into the oral cavity. Examine the upper arcades with the endoscope in its normal position (30-degree reflection up). Then, to examine the lower arcades, take advantage of the 30-degree offset by rotating the telescope 180 degrees. This allows a good view of the lower teeth (if a camera is used, it should not be rotated; rotate just the telescope).

Evaluate every tooth, including the lingual, buccal, and occlusal aspects (Plate 3). Use an appropriately sized and curved dental probe to palpate each tooth, attempting to detect movement or other evidence of disease. Additionally, pay particular attention to the gingiva. Chinchillas often have a subgingival point on the buccal aspect of the first upper premolar as the sole cause of "slobbering." Most commonly, malocclusion involves overgrowth of the lower arcade to the lingual aspect and of the upper arcade to the buccal aspect of the oral cavity. If left untreated, severe tongue injury and laceration can occur. In guinea pigs with severe malocclusion, the mandibular teeth can actually bridge and entrap the tongue.

Once identified, trim the maloccluded teeth with either a motorized dental handpiece or rongeurs (see Chapter 34). When using the latter, take exceptional care to avoid fracturing the tooth. Because of the possibility of fractures, the dental handpiece is preferred. To avoid damage to the telescope, remove it while trimming and reinsert it after the dental procedure is finished to verify all points have been trimmed.

Tracheal Intubation

In addition to limiting access to oral structures, the small oral commissure of small herbivores drastically limits access to the caudal oropharynx, including the glottis. As a result, tracheal intubation tends to be a "blind" procedure with varying degrees of success. This limited ability to routinely and consistently establish a patent airway may pose significant problems during the anesthetic management of these species. As a further complication of the problems associated with intubation, the laryngeal structures can be extensively traumatized during attempts to blindly pass an endotracheal tube.

Similar to other small herbivores commonly encountered in practice, the larynx of rabbits is situated caudal and slightly ventral to the angle of the jaw. Rabbits are obligate nasal breathers and the anatomy of their larynx is somewhat different than that of dogs or cats. The epiglottis is a relatively large structure with a butterfly-shaped distal aspect that is normally entrapped on the dorsal surface of the soft palate (Plate 4). This arrangement
permits passage of air directly from the nasopharynx into the larynx and trachea without entering into the oral cavity.

The rigid endoscope is easily used as an aid to place an endotracheal tube. This can be performed by either slipping the endotracheal tube over the endoscope or passing the tube beside it (Plate 5). Remember, only tubes with an inside diameter greater than that of the telescope, in most cases 3.0 mm and greater, can be fit over the instrument. As the instrument is slowly advanced into the caudal oral cavity, apply gentle pressure on the dorsal soft palate to free the epiglottis and reveal the glottal opening. Slowly advance the endotracheal tube, the tip of which should be lubricated with a sterile xylocaine gel, between the arytenoid cartilages and into the trachea. Manipulate the beveled tip of the endotracheal tube to facilitate the movement of the tube between the vocal folds. After placing the tube, remove the endoscope and secure the tube to the rabbit in a normal fashion.

**Vaginoscopy/Cystoscopy**

Cystoscopy is a technique to diagnose and potentially treat diseases of the lower urinary tract. In rabbits, transurethral cystoscopy is limited to females. Endoscopic evaluation of the lower urinary tract is possible in males; however, it usually requires some form of abdominal approach to the bladder. Similarly, vaginoscopy is used to diagnose diseases of the distal reproductive tract. The most common indication of vaginoscopy is as an adjunct to cystoscopy in the diagnostic workup of hematuria because bloody urine is often associated with uterine adenocarcinoma, endometrial hyperplasia, or uterine polyps (Plate 6).

With the animal appropriately anesthetized, place it in dorsal (preferred), ventral, or lateral recumbency. Create an optical cavity by infusing warmed sterile saline through the infusion port of the sheath system. An egress path must be established as well: as the bladder fills, open the egress path to protect against bladder rupture. Also, palpate the bladder frequently to ensure that overfilling does not occur. Examine all portions of the lower urinary tract; it is usually necessary to rotate the telescope 180 degrees for a complete evaluation. Collect diagnostic samples for histopathologic or microbiologic examination. Cystoscopic examination is particularly helpful in animals with urolithiasis. In some patients, the cystoscope can be used intraoperatively to aid in retrieving small uroliths from the neck of the bladder.

Vaginoscopy may be indicated in rabbits with suspected vaginal or cervical disease or as an adjunct to cystoscopy in rabbits with hematuria of suspected genital tract origin. In female rabbits that have bloody urine, a unilateral, blood-tinted discharge, which can result from uterine neoplasia or other endometrial disease, is often visible from one cervix. The technique for vaginoscopy is similar to that for cystoscopy; bear in mind that the reproductive tract is dorsal to the urinary tract. Again, egress for infused fluids must be facilitated. Slow infusion rates are typically adequate to distend the vagina in most small mammals.

**Laparoscopy**

Laparoscopy requires insufflating the abdomen and creating a pneumoperitoneum, which places increased pressure on the diaphragm. To perform this procedure in a rabbit, the anesthetized animal must be intubated and provided with some form of respiratory support. The Vetronics Ventilator (Bioanalytical Systems, Inc., West Lafayette, IN) has proved useful for intermittent positive-pressure ventilation in small mammals that undergo laparoscopy. For this procedure, position the rabbit according to the organs of interest; however, abdominal fat can mask certain structures such as the kidneys, uterus, and ovaries. We prefer a left flank approach to examine the liver, stomach, jejunum, spleen, cecum, sacculus rotundus, ampulla coli, ascending colon, and left kidney. A right flank approach is useful to examine the liver, duodenum, pancreas, cecum, and right kidney. Use a ventral midline approach to examine the liver, stomach, jejunum, and cecum.

The technique for laparoscopy in rabbits and other small mammals is the same as that in dogs. Prem inflate the abdomen to 8 to 12 mm Hg with carbon dioxide and a Veress pneumoperitoneum needle. Remove the Veress needle and perform a 1- to 2-cm cut-down procedure at the proposed entry site. To reduce gas leakage around the telescope, minimize the length of the incision in the muscles or linea alba. Once the telescope is in place, attach the insufflator to one of the ports on the sheath and adjust the pressure setting to maintain the desired pneumoperitoneum. Proceed with the examination of the organ(s) of interest and collect biopsy or microbiologic samples as needed (Plate 7). A biopsy of the liver, spleen, or pancreas can be performed easily; however, a biopsy of the kidneys requires incising the perirenal fat (Plate 8). Because of possible intestinal perforation and peritonitis, do not biopsy the intestinal wall unless grossly proliferative lesions are present.

The endoscope is no longer the extraordinary tool of the board-certified specialist but an essential instrument of any clinician who regularly treats exotic animals. The current indications for small herbivore endoscopy include examining and collecting diagnostic samples from the ear, mouth, nose, glottis, trachea, esophagus, vagina, bladder, and visceral organs. Other indications for endoscopy will undoubtedly become apparent as the true potential of this technology in ferrets, rabbits, and rodents is realized.

**ACKNOWLEDGMENTS**

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**REFERENCES**

Plate 1  Endoscopic view of the horizontal ear canal and the normal tympanum (T) of a rabbit. (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)

Plate 2  Endoscopic view of the ventral nasal concha (V) and the nasal septum (N) as seen from the common nasal meatus of a rabbit. (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)

Plate 3  Typical wide-angle view into the oral cavity as provided by the rigid endoscope. Rotating the scope 180 degrees downward provides a view of the lower arcade. Closer, magnified view of individual teeth is made possible by advancing the telescope toward the tooth. (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)

Plate 4  Nasal breathing in rabbits is facilitated by the entrapment of the epiglottis dorsal to the soft palate. The butterfly-shaped epiglottis (black arrows) is clearly visible through the relatively transparent caudal soft palate (white arrows). The vascular pattern depicted here is typical for a rabbit. (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)
Plate 5 Gentle pressure on the soft palate (black arrow) frees the epiglottis (E) and allows the endotracheal tube (T) to be advanced and inserted between the arytenoid cartilages (white arrows). (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)

Plate 6 Cystoscopic view of the mucosal surface of the rabbit urinary bladder. Note the air bubble (B). This rabbit had hematuria; a space-occupying mass (arrow) was outlined by the positive contrast of the urine within the bladder. Histologic diagnosis of epithelial hyperplasia was made from a biopsy sample. (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)

Plate 7 Laparoscopic (left cranial flank) view of the duodenum (D), pancreas (P), and cecum (C) of a rabbit. (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)

Plate 8 Endoscopic biopsy of the liver of a rabbit. The biopsy forceps (B) are used to take a tissue sample from the caudal edge of the liver (L). (Courtesy Stephen Hernandez-Divers, Ithaca, New York, and Michael Murray, Monterey, California.)
Clinical Technique: Dental Endoscopy of Rabbits and Rodents


Abstract
Dental disease remains a major cause of morbidity and mortality in rabbits, rodents, and other small herbivores. Because of their small oral commissure, the rigid telescope is an ideal tool for examining and working within the buccal cavity of these animals. Focal illumination and magnification provide greater sensitivity and accuracy for identifying occlusal dental disease than other modalities. In addition, the telescope provides intraoperative visualization during dental trimming, extractions, and exploration of abscess, nasal, or paranasal cavities associated with dental structures. Copyright 2008 Elsevier Inc. All rights reserved.

Key words: rabbit; rodent; dental disease; endoscopy; telescope; minimally invasive surgery

Endoscopy has proven to be a most useful diagnostic tool in veterinary medicine, for direct visualization, biopsy, and increasingly endoscopic intervention. In the field of zoological medicine, the application of diagnostic endoscopy was initially adopted by avian veterinarians, but has subsequently gained acceptance in a wide variety of zoological species, including exotic pet mammals. With specific regard to rabbits and rodents with their small oral commissures, rigid endoscopy offers focal illumination and magnification, which provide an unparalleled view of the buccal cavity.

Endoscopy Equipment
The 2.7-mm 18-cm, 30° viewing angle rod-lens Hopkins telescope, (64018BS; Karl Storz Veterinary Endoscopy America Inc., Goleta, CA USA) is preferred because of its versatility in companion animal practice and variety of available accessories. However, a variety of other sizes of endoscopes ranging from 1 to 5 mm in diameter are available depending on specific needs and application. The 2.7-mm telescope is housed inside a 3.5-mm protective or 4.5-mm operating sheath, connected to a xenon light source using a light guide cable, and a video camera (Karl Storz Veterinary Endoscopy America Inc.). Endoscopic instruments that can be used within the 5-Fr channel of the operating sheath include biopsy forceps, grasping forceps, single-action scissors, and fine aspiration/injection needle. Modern endovideo cameras greatly enhance the endoscopist’s capabilities and are available in both European PAL and US NTSC formats. Recording of still images and video is also a practical means of illustrating the problems encountered in a case, and greatly assist with ensuring client compliance. More extensive reviews of endoscopy equipment are available in the literature.

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Dental Endoscopy

For all endoscopic procedures, general anesthesia is required, and any contraindication for anesthesia is often a contraindication for performing endoscopy.

**Table 1. Recommended 2.7-mm rigid endoscopy equipment for companion animal practice**

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
<td>Hopkins telescope, 2.7 mm × 18 cm, 30°</td>
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<tr>
<td>Operating sheath, 5-Fr instrument channel and ports, 14.5-Fr</td>
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<td>Examination and protection sheath 3.5 mm O.D.</td>
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<td>Cleaning brushes and instrument lubrication oil</td>
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<td>Nova xenon light source 175 W*</td>
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<td>Light guide cable 3.5 mm × 230 cm</td>
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<tr>
<td>Biopsy forceps 5 Fr†</td>
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<td>Scissors 3 Fr†</td>
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<td>Fine aspiration/injection needle with Teflon guide†</td>
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<tr>
<td>Grasping forceps 5 Fr†</td>
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<tr>
<td>Wire basket retrieval forceps 5 Fr†</td>
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<td>Veterinary video camera II, cold and gas sterilizable</td>
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<tr>
<td>Medical-grade monitor</td>
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<tr>
<td>Documentation (e.g., VCR, digital recorder, still-image printer)</td>
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<td>Mobile cart for equipment storage</td>
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*Can use halogen light source if only intending to endoscope animals < 2 kg, but, if considering expansion to include larger species (e.g., dogs and cats), then xenon is a better investment.
†Delicate endoscopy instruments are less commonly used during the evaluation of dental disease but are useful for soft tissue biopsy and foreign-body retrieval.

Although it may be tempting to use the telescope in the oral cavity of a conscious rabbit or rodent, most animals resent such invasion, making examination near impossible, and increasing the chances of damage to animal and equipment. Preanesthetic evaluation should include physical examination and, if possible, complete blood count, biochemistry, and urinalysis. Premedication and general anesthesia should follow established guidelines, and, although fasting is seldom required, a 1- to 2-hour fast is recommended to reduce the amount of food within the oral cavity.  

**Figure 1.** (A) A budget rigid endoscopy tower complete with light source, camera, monitor, and photodocumentation system. (B) A 2.7-mm Hopkins telescope housed within the operating sheath with light guide cable and camera attached. (C) A 5-Fr biopsy instrument emerging from the operating sheath. (D) 5-Fr endoscopic instruments for use with the operating sheath—retrieval forceps (1), biopsy forceps (2), injection/aspiration needle (3), and scissors (4).

**Figure 2.** Positioning of an anesthetized rabbit for intraoral endoscopy. The 2 nasal lines provide isoflurane and oxygen, while the head is supported and the mouth held open with a dental restraint device and cheek spreaders. This system of restraint allows considerable positional versatility for rabbits and rodents.
Intraoral Endoscopy

By far the most common dental endoscopy procedures involve the insertion of the telescope into the oral cavity.3,5 The rigid endoscope is ideally suited to examine the oral cavity in these small mammals, and offers considerable advantages including up to 20× magnification using focal illumination and the ability to display and record the images. The limited access to the oral cavity may preclude the use of endotracheal tubes; however, anesthetic gas and oxygen can be supplied via nasal intubation (Fig 2) or by placing a small face mask over the nostrils. It is important to consider the use of active scavenging from the area to reduce anesthetic gas exposure to staff. Alternatively, injectable anesthetic agents may be used, and, although this does not negate the need for supplying oxygen via nasal line or mask, it does reduce staff exposure to inhalant agents.

The anesthetized patient is positioned in sternal recumbency on a heated surface with the head and neck extended, and the mouth held open with a mouth gag or dental restraint device (rodent table restrainer; Sontec Instruments Inc., Englewood, CO USA). A cheek spreader is placed inside the mouth to retract the buccal mucosa laterally (Sontec Instruments Inc.) (Fig 2). The telescope, within a sheath, may then be inserted into the oral cavity to perform a detailed examination. The 30° angle afforded by the telescope has advantages over 0° endoscopes. With the telescope in a normal position (light guide connector facing down), the 30° angle favorably permits detailed examination of the upper arcades, and, with the telescope (but not the camera) rotated 180° around its longitudinal axis (light guide connector facing up), the lower arcades are easily visualized.

The lingual, buccal, and occlusal aspects of every tooth should be evaluated with appropriately sized and curved dental probes. A clear understanding of normal dental anatomy of rabbit and rodent species is critical to appreciate deviations from normal (Fig 3). Abnormalities can include alterations of the occlusal plane, tooth laxity, exudates, and gingival changes (see other pertinent articles in this issue) (Fig 4).

Treatment of dental abnormalities is discussed in detail in this journal. The telescope can also be used periodically to evaluate the intraoperative progress of premolar or molar extractions, or to examine the alveolus following extraction (Fig 5, D and E). The telescope has also been used when target flushing and with the placement of antimicrobials directly into dental cavities via the oral cavity (Fig 5, F). These techniques have been used to successfully treat retrolabular abscesses in rabbits via the oral cavity, thereby avoiding enucleation.11 Although rare, soft tissue masses may be biopsied with the 5-Fr biopsy forceps, whereas foreign bodies may be removed with retrieval forceps.

Extraoral Endoscopy

There are occasions when correction of dental disease requires an extraoral approach, either alone or in conjunction with intraoral surgery, and the telescope can serve as a useful surgical aid. The extension of hypsodont roots into the nasal cavity may warrant rhinoscopy via the nares or through a surgical rhinotomy approach (Figs 6 and 7). Dental ab-
Figure 4. Endoscopic dental pathology in rabbits. (A) Abnormally long maxillary premolars 1 and 2 due to inadequate dietary forage. (B) Close-up of even more severe elongation of maxillary premolars 1 and 2. In this case, the teeth have caused severe ulceration in the buccal mucosa (arrow). (C) Mild elongation of maxillary premolar 3, and molars 1 and 2 (molar 3 appears normal). Note that molar 1 also has a small, sharp spur associated with its buccal border (arrow). This spur would be buried in the buccal mucosa and would be impossible to visualize without focal illumination, magnification, and lateral retraction of the mucosa. (D) Gross elongation of left mandibular premolar 2 with associated lingual spur (arrow), and fracture or wear of premolar 1 to the level of the gingiva. (E) Caseous exudate emanating from around the left maxillary molar 2 after the application of pressure using a dental probe. (F) End-stage dental disease. In this view of the left maxillary arcade, only premolars 1 and molar 3 are clearly visible and premolars 2 and molar 2 are missing, whereas part of molar 1 (arrow) can be seen emerging from swollen gingiva, which may well indicate a dental abscess.

Figure 5. Endoscopic dental treatment in rabbits. (A) Preparation for trimming elongated maxillary premolars and molars with a dental burr (1). Note the metal probe (2) being used to retract and protect the buccal mucosa from the burr. (B) High-speed dental burring requires great care to protect the soft tissues and the telescope. Metal probes and guards should always be used. (C) Immediate postoperative view of the maxillary arcade after burring down to the level of the gingiva. (D) Immediate postoperative view after intraoral extraction of molars 2 and 3, that were associated with a retrobulbar abscess. (E) Close-up of the extraction site demonstrating the ability of the 30° telescope to look into the abscess cavity and visualize the maxillary bone (arrow). (F) Placement of an intravenous catheter (arrow) into the abscess cavity to instill antibiotic-impregnated synthetic bioactive ceramic material.
Figure 6. Maxillary incisor abscess in a woodchuck that presented with unilateral nasal discharge. (A) Three-dimensional computed tomography reconstructed view from within the nasal cavity looking out cranially through the nostrils (n). Dorsal (d), ventral (v), and the midline nasal bone (b) are labeled for orientation. Note the obvious crater affecting the left maxilla (arrow); this represents an abscess originating from the left upper incisor. (B) Endoscopic view of the left nasal meatus after introduction of the telescope through a small lateral rhinotomy approach. Note the caseous exudate filling the nasal cavity. (C) Endoscopic view after debridement and now revealing the terminal portion of the elongated root of the maxillary incisor that has penetrated into the nasal cavity (arrow). After removal of the crown via an intraoral approach and the removal of the root via rhinotomy, the site was packed with antibiotic-impregnated beads strung on nylon suture (to facilitate later retrieval). (D) Endoscopic view 3 weeks later after the removal of the beads. Note the resolution of the infection and the normal appearance of the nasal mucosa.

Figure 7. Maxillary dental abscess and rhinitis in a rabbit. (A) Intraoperative view illustrating the use of the telescope to examine the nasal cavity after rhinotomy. Insert, close-up of the introduction of the telescope through the rhinotomy approach. (B) Endoscopic view of caseous exudate (arrow) within the ventral nasal meatus after the debridement of chronically infected turbinates. The nasal septum (s) is labeled for orientation. (C) Exposure of the tooth (arrow) that has extended into the nasal cavity and caused the infection. The nasal septum (s) is labeled for orientation, and the suction probe (p) is also visible. (D) Intraoperative view after tooth extraction and flushing of the site, now revealing a clear and unhindered ventral nasal meatus leading to the nasopharynx (arrow).
cesses affecting the maxilla may enter the paranasal sinuses, and the telescope can provide evaluation via a small (4-5 mm) osteotomy (Fig 6). Even when extensive surgical osteotomy or rhinotomy are performed, surgical access is often very limited in small herbivores, but the telescope enables detailed evaluation including those areas cranial and caudal to the surgical site (Fig 7). It is important to use copious warm sterile saline solution to flush and clean the area before introducing the telescope, otherwise debris and mucus can obscure the view. The recent advent of 2- and 3-mm rigid instruments also permits biopsy and debridement within the nasal or paranasal sinuses despite limited surgical access.12

Summary

Endoscopy can no longer be considered the extraordinary tool of the university or large referral hospital. Diagnostic endoscopy has become an essential instrument for any clinician dealing with exotic species on a regular basis. The current indications in small herbivores include oral examination, biopsy of masses, retrieval of foreign bodies, and as a surgical aid in the evaluation of dental/bone, nasal, and paranasal cavities.

References