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...
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.\(^6\) Traditional 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 birds\(^{5,12}\) (available commercially; see box on page 840). The Tay-

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**Figure 1. Basic 2.7-mm rigid endoscopy system.** A 2.7-mm telescope housed within a 14.5-Fr operating sheath, with a light guide cable and an endovideo camera attached (A). Close-up of the end of the operating sheath illustrating biopsy forceps protruding from the instrument channel (B). Five-Fr endoscopic instruments used with the 14.5-Fr operating sheath (C): grasping forceps (1), biopsy forceps (2), aspiration or injection needle (3), and single-action scissors (4). (B and C are courtesy of Karl Storz Veterinary Endoscopy)

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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

\(^a\)A halogen light source can be used if performing endoscopy only on animals weighing less than 4.4 lb (2 kg). However, if considering the procedure for larger species (e.g., dogs and cats), xenon is a better investment.

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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.**
lor 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.\(^1\) 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.\(^13,14\)

**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.

**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
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.6

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.6

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 caudal 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.
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.

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.

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 syringleal region, heart, and great vessels and has been useful in identifying, sampling, and treating cranial coelomic masses.

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 organ and showing no surface lesions may be missed during endoscopic examination. It is important to correlate histopathologic and microbiologic biopsy results with clinicopathologic data when dealing with organ disease. It is often surprising how biopsy results provide a definitive diagnosis even in the face of unremarkable clinicopathologic data.

When confronted by a potentially cystic lesion or abscess, it is safer to first attempt drainage using fine-needle aspiration rather than risk postbiopsy leakage into the air sacs or coelom. When attempting to perform a liver, lung, or testicular biopsy from the left or right approach, it is preferable to first incise the air sac and serosal membranes using endoscopic scissors. This provides better access to the tissue parenchyma and yields biopsy samples of superior histologic quality with minimal artifacts. Biopsies of the spleen, kidneys, adrenal gland, and most pathologic lesions can usually be performed without using scissors. The biopsy instrument should be passed through the operating chan-

Early diagnosis of avian disease directs appropriate case management and helps maximize clinical success.

Figure 8. Kidney biopsy viewed from the left abdominal air sac in an Amazon parrot.
ing. Postsampling hemorrhage tends to be inconsequential because of the avian extrinsic coagulation pathway and, in particular, tissue-associated thromboplastin.\textsuperscript{16} As an example, approximately 500 endoscopic splenic biopsies were performed in research pigeons at the University of Georgia without a single serious hemorrhagic incident.\textsuperscript{17}

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

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**Endoscopy facilitates minimally invasive collection of diagnostic samples in birds.**

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 test-
usually associated with biopsy, the clinical consequences appear minimal.\textsuperscript{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.

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REFERENCES


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.
   d. right side, caudal to the pubis and ventral to the flexor cruris medialis muscle.
   e. ventral midline, just caudal to the keel.

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