Endoscopy equipment

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The endoscope is a medical instrument used for the visual examination of a body cavity or a hollow organ such as the lung, abdomen, ileum, colon, bladder, duodenum, nasal passages, or stomach. It is a rigid or flexible hollow tube fitted with a lens system and/or fiber-optic bundles to aid in the diagnosis and potential treatment of the patient. The function of the endoscope is to allow visualization of the mucosal surface to assess the degree of disease and allow tissue sampling for histopathology, culture, and cytology.

Endoscopy procedures have been a part of veterinary medicine since the 1970s. Today, these procedures are routinely performed in veterinary practices throughout the world. Types include bronchoscopy, esophagoscopy, gastro-duodenoscopy, colonoscopy, nasopharyngoscopy, rhinoscopy, laparoscopy, and arthroscopy.

ENDOSCOPIES

Endoscopes are manufactured in a variety of sizes with different function capabilities, depending on the needs of the endoscopist. Endoscopes are divided into two groups: rigid and flexible. Both types of endoscopes start with the construction of a hollow tube. To drive light through the endoscope, thin fiber-optic filaments assembled into bundles are used to transmit light (non-coherent), and the image (coherent) to the distal tip. The different uses of fiber-optics in endoscopes include the way in which images are transmitted back to the endoscopist and the functional characteristics of the endoscope. While all-fiber-optic endoscopes use coherent fiber-optic bundles to transmit the image, video endoscopes use a video chip and rigid telescopes utilize a lens/rod system.
Figure 1.1 Sigmoidoscope with (from top) rigid biopsy forceps, large cotton tip applicators, sigmoidoscope with light handle and obturator. Inset: example of foreign body retrieved.

Rigid Endoscopes

Rigid endoscopes include sigmoidoscopes, pictured in Figure 1.1, and telescopes. The sigmoidoscope is used for visualization of the descending colon and rectum, and can be used in the esophagus to aid in the removal of foreign bodies. The sigmoidoscope is a hollow tube that can range from 10 to 19 mm in outer diameter (o.d.) with a length of 5–25 cm. When the viewing window is closed and the bulb insufflator engaged, a luminal view is obtained. Visualization is magnified through the lens of the viewing window and light is transmitted through fiber-optic bundles that encircle the inner recesses of the tube. Owing to the large inner diameter, multiple types of biopsy and retrieval forceps may be inserted when the viewing window is opened.

Telescopes are a higher quality medical-grade rigid endoscope. The hollow tube houses a series of glass rod lenses that magnify the image back to the eyepiece. The image is viewed on a monitor via an attached camera or with the naked eye. Light is transmitted from a remote light source through light cables that attach at the light guidepost. Fiber-optic light bundles pass through the insertion tube to the distal tip. Light cables may be steam sterilized for laparoscopy and cystoscopy, and most models can be immersed for disinfection (check with the manufacturer). Be sure that the light cables in your inventory attach securely to the telescope. Adapters are available for different models.
Rigid telescopes differ in outer diameters, viewing angles, and lengths, depending on their use (shown in Figure 1.2). These differences make them a versatile endoscope, especially when used in conjunction with an operating sheath. The o.d. can range from 1 to 10 mm, with lengths ranging from 18 to 30 cm. The most common telescope used in veterinary medicine is 2.7 mm by 18 cm with a 25 or 30° viewing lens.

The viewing angle refers to the middle of the viewing field, shown in Figure 1.2. A 0° tip will allow for a frontward view, whereas an angled tip allows for an increased field of view by rotating the instrument. The angle of the tip can range from 10 to 120°.

Operating sheaths surround the rigid scope by attachment at the base of the eyepiece. Although the operating sheath will increase the outer diameter of the
scope, it will also increase the telescope’s versatility. Sheaths possess different functioning components. Fixed stopcocks positioned at the proximal end allow attachment for irrigation, or suction. Sheaths that have a working channel allow flexible instruments to pass beyond the telescope for biopsies and retrieval of foreign bodies. Levers on the stopcock control whether the port is opened or closed. When these features are utilized, the telescope becomes a multipurpose scope used to perform procedures such as cystoscopy, rhinoscopy, and arthroscopy.

**Flexible Endoscopes**

Flexible endoscopes are categorized into video and all-fiber-optic endoscopes. Fiber-optic endoscopes are commonly used in the veterinary setting since they are less expensive to operate, despite the fact they lack the superior technology of a video endoscope.

Video endoscopes offer greater image quality, resolution, and color. Incorporated in the distal tip behind the objective lens is a video chip that converts the image to a digital signal. This signal transmits through connection wires to the video processor. The image is sent to an image capturing device, monitor, printer, or computer.

Instead of a video chip, the all-fiber-optic fiberscope, seen in Figure 1.3, utilizes coherent fiber-optic bundles that transmit the image to the eyepiece. In order to view the image on a monitor, a camera must be attached at the eyepiece. Both

![Figure 1.3 Basic flexible endoscope.](image-url)
types of endoscopes utilize non-coherent fiber-optic bundles to transmit light to the distal tip for illumination.

The fibers are as thin as a human hair and are pliable. They are arranged in a bundle inside the endoscope and can bend in response to the endoscope's movements. Once these fibers come into contact with moisture, they become hard and brittle and can break, resulting in either a loss of light (non-coherent) or a loss of image (coherent). As a result, all ports are sealed to protect the interior from water intrusion.

There are wide varieties of endoscopes available in today’s market. The o.d. can range from 2.5 to 11 mm and greater, with insertion tube lengths varying from 55 to 240 cm. Other mechanisms that will vary are a two- or four-way tip deflection, insufflation, aspiration, irrigation, and the size of the operating channel. When selecting an endoscope, it is important to understand the needs of the procedure and versatility of the endoscope, plus the length and outer diameter of the insertion tube of each endoscope. A small 2.5 mm o.d. by 100 cm endoscope can be utilized as a male cystoscope and a bronchoscope for a cat or toy-breed dog. A 5.3 mm by 100 cm pediatric gastroscope can double as a small toy-breed gastroscope or a bronchoscope for a large-breed dog. For the cat or small- to medium-sized dog (10–15 kg), a 7.8 mm o.d. × 100–110 cm scope would be adequate for an upper gastrointestinal procedure. In some medium- to large-sized dogs, this would only allow visualization just past the pylorus. If the same scope was 140 cm long, the duodenum would be obtainable for viewing and a more thorough evaluation could be accomplished. Table 1.1 gives examples of flexible endoscope sizes and procedures. The procedural chapters review and discuss the best endoscope(s) for a given procedure.

An endoscope with four-way deflection, aspiration, and air/ water capability is essential for performing a gastrointestinal procedure. The degree of deflection should be 90 to 100 in a left and right direction with 180 to 210 deflections up and down. A bronchoscope may only need a two-way deflection with angulations of 90 degrees whereas a cystoscope may have two-way deflection of 270 degrees.

**Nomenclature**

Whether video or fiber-optic, all flexible endoscopes have similar features. Proper endoscope handling, troubleshooting, and maintenance of the endoscope are accomplished when the inner workings of the endoscope are understood. There will be slight differences depending on the manufacturer, but for our purposes, a four-way gastroscope will be discussed.

The basic sections of a flexible endoscope (Figure 1.3) are the light guide connector or terminal end, universal or umbilical cord, control section, operating channel, insertion tube, bending section, and distal tip. Each section houses delicate internal structures.
### Table 1.1 Examples of flexible endoscopes and their uses.

<table>
<thead>
<tr>
<th>Use</th>
<th>2.5 mm × 55 cm/2-way deflection</th>
<th>3.8 mm × 55 cm/2-way deflection</th>
<th>5.0 mm × 55 cm/2-way deflection</th>
<th>5.3 mm × 100 cm/4-way deflection/air/water</th>
<th>7.9-8.3 mm × 100-140 cm/4-way deflection/air/water</th>
<th>11 mm × 240 cm/4-way deflection/air/water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystoscopy/male dog</td>
<td>×</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronchoscopy/small breed and cat</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bronchoscopy/large breed</td>
<td></td>
<td></td>
<td>×</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasalpharyngoscopy</td>
<td></td>
<td>×</td>
<td>×</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esophagoscopy/gastroscopy</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td></td>
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<tr>
<td>Duodenoscopy</td>
<td>×</td>
<td>×</td>
<td>×</td>
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<td>×</td>
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<tr>
<td>Colonoscopy</td>
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</tr>
</tbody>
</table>
Light guide connector
The light guide connector contains the light guide, air pipe, electronic contacts for a video system, water bottle connection, suction port, and pressure compensation valve. The light guide connector inserts into an external light source.

Umbilical cord
The umbilical cord connects the light guide connector to the control section. It houses the non-coherent fiber-optic bundles, air channel, water channel, and aspiration channel.

Control section
The control section houses the angulation control knobs, air/water and aspiration valves, operating channel port, and an eyepiece with a focus mechanism for the fiberscope, as shown in Figure 1.4. The angulation knobs, one for up and down and the other for left and right, control the deflection of the bending

Figure 1.4 Control handle: A, locking device; B, knob that controls left and right movement of the distal tip; C, knob that controls up and down movement of the distal tip; D, eyepiece; E, suction valve; F, air/water valve; G, locking device.
section. Small wires travel from the knobs to a steel mesh at the distal part of the insertion tube. As the wires engage, the deflection occurs. The left thumb and right hand are used to manipulate the deflection knobs. Many endoscopes have a locking device associated with each knob that allows the endoscopist to maintain a desired degree of deflection while freeing up the right hand. Failure to disengage the locks can stretch control wires, causing them to snap, resulting in costly repairs.

The left first and second fingers manipulate the suction valve and the air/water valve, respectively. Air is introduced into the patient by lightly covering the top of the air/water valve. This forces air from the air/water bottle attached at the light guide through the insertion tube to the distal tip. Insufflation of the cavity will occur, which assists in visualization. Water is used to rinse the lens of debris – depressing the air/water valve completely will engage the air/water bottle to force water to the distal tip. The air/water system begins as two individual tubes that connect separately to the air/water valve. Depending on the manufacturer, the two may combine to become a common channel within the insertion tube or at the distal tip. Refer to the schematics in the manual when troubleshooting the air/water system.

**Operating channel**

The operating channel supports the suction and instrumentation function. A tube from the suction connector at the light guide travels through the umbilical cord connecting with the suction valve on the hand piece. From there, the tubing travels to the distal tip. The insertion tube is where the suction and biopsy share the operating channel. When the suction valve is depressed, the hole in the valve stem enters the channel, allowing external suction to pull fluids and air from the body cavity.

Flexible instruments are introduced into the operating channel at the instrument channel port. Biopsy and retrieval forceps are most common, but laser fibers can also be utilized.

**Insertion tube**

The insertion tube is the working end of the endoscope. It is composed of a hollow tube made from steel coil, fiber mesh, and vulcanized rubber. The outer layer is marked with metric measurements. It provides protection for the delicate internal components while maintaining the flexibility needed to maneuver within the body cavities, as shown in Figure 1.5b. Within the tube are the angulation wires, air/water channels, operating channel, non-coherent bundles, and coherent bundles or microchip connection wires, as shown in Figure 1.5a. Manipulating the insertion tip should be performed with caution. Over-torquing can
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Figure 1.5 (a) Internal components of the insertion tube include deflection wires ×4, fiber-optic bundles, air/water channel, and biopsy/instrument channel. (b) Clear sheathed scope showing manipulation of internal components. (c) Bending section: flexible steel mesh holds the wires that travel from the control knobs to the bending section.

compromise fiber-optic bundles, which can lead a decrease in either illumination or visualization. The length and outer diameter of the insertion tube will vary depending on the function of the endoscope.

Bending section
This is where tip deflection occurs. The angulation wires (see Figure 1.5c) attach to the control knobs and act as a pulley system at the distal tip. There is one wire for each direction – up, down, left, and right. The degree of deflection should be monitored. Over time, the wires begin to stretch and may break, which can inhibit or prevent the endoscope from functioning properly during the diagnostic test performed.

Distal tip
At the end of the insertion tube is the distal tip, which is where the light guides, operating channel, and air/water nozzle terminate. The objective lens protects fiber-optic bundles or a video chip and is housed here. A complete diagram is shown in Figure 1.6.
ANCILLARY EQUIPMENT

Instrumentation
A wide variety of instrumentation is available. The instrument diameter needs to be slightly smaller than the biopsy channel diameter. For example, an endoscope with a 2 mm channel will need a 1.8 mm o.d. instrument. Forceps larger than the biopsy channel can cause breaks or tears in the channel, which can lead to further internal damage and costly repairs. Forceps should also be at least 10 cm longer than the biopsy channel to allow the assistant to obtain diagnostic biopsy samples comfortably. Biopsy instruments are flexible forceps that pass through the operating channel of either rigid or flexible endoscopes. Variations can include spiked, cup, oval, fenestrated, serrated, or smooth. As the jaws are opened outside the endoscope, then closed onto the mucosa, a biopsy sample is taken. The forceps are removed and the sample is retrieved.

Cytology brushes and guarded microbiology brushes are used to obtain mucosal cytology/culture samples. Brushes are deployed to retrieve the sample, then pulled back into the casing to shield the sample from contamination.

Foreign body retrieval forceps are used to retrieve items such as bones, toys, or any other foreign material. Snares, baskets, rat tooth, two-prong, and Roth nets are some examples (shown in Figure 1.7). Chapter 4 outlines their usage, and additional equipment essential to a procedure is reviewed in later chapters.
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Light source
A powerful light source is essential for the illumination of the mucosa. The quality of the video images obtained for patient documentation is dependent on the quality of the light produced. Light sources include 150 W halogen and 300 W xenon bulbs. LED light sources are also available. Xenon bulbs are recommended for video endoscopes. The xenon bulb produces more light, which creates better illumination. The quality of the light created produces a “white light” that is closer to natural light, and truer color of the tissue is observed. The light intensity of the halogen bulb is controlled manually. The xenon bulb can be controlled manually or automatically by the video processor and continuously adjusts for illumination and color. Most light sources have light guide adaptors to complement scopes made by different manufacturers. For smaller fiberscopes that do not require air/water capabilities, a portable battery-operated LED light source is available. It attaches to the light guidepost and eliminates the need for a large component. Further information on light sources in relation to laparoscopy can be found in Chapter 9.

Suction
A portable or in-house suction device is necessary for aspiration of air and fluids in a body cavity. Suction tubing is attached at the terminal end of flexible endoscopes or on the sheath of rigid telescopes.

Figure 1.7 Instrumentation used for foreign body retrieval and cytology sampling.
Always make sure that the biopsy cap is closed before suctioning. Note that the hole in the suction valve is no larger than a grain of rice, so be wary of aspirating large particles that could plug the endoscope.

**Monitor**
The monitor is used for viewing the procedure. Cables attached from the camera or the video processor transport the image. High-definition (HD) monitors provide clear, precise images. A medical-grade monitor with full HD (1920 × 1080) resolution will provide an image with true color, brightness, and resolution. The monitor should include various video inputs such as a 15-pin VGA computer input, two-way BNC composite video, Y/C, and HDMI video formats of 720, 1080I, and 1080P. It should also include video outputs for incorporation of image-capturing devices if needed. They come in various sizes from 19 to 55 in. Some models are also available with wireless features.

Monitors can be set for a “live feed,” where just the image is seen, or be programmed to incorporate patient information through an attached keyboard. When images are captured, this information is also included. Comments such as image location can also be attached.

**Image capture**
A video endoscope has a control button on the hand piece that captures an image, or a foot pedal controlled by the endoscopist can be used. Some video processors incorporate an SD card. Other image-capturing systems are connected either from the camera attachment or to the video processor. Image-capturing devices permit documentation of the procedure. Images and video clips can be transferred to the patient record through a computer program or stored in another storage device.

**Endoscopy tower**
An endoscopy tower houses the equipment necessary to perform an endoscopic procedure. It includes a monitor, video processor, camera, insufflation device for laparoscopy, and image-capturing device. Towers can be stationary or mobile. A complete endoscopy station is shown in Figure 1.8 and is discussed further in Chapter 10.

Cables leading to and from the monitor, video processor, and so on can be confusing and difficult to troubleshoot, especially if a procedure is imminent and the image is lost. Labeling of cables at both ends (inputs) and on the components can help quickly pinpoint where a loose cable should be connected. Cable attachments should be checked periodically on mobile cart components that travel over rough or unstable surfaces.

Endoscopic procedures are less invasive, decrease hospital recovery times, and are utilized in internal medicine in addition to the surgical operating room. Multiple endoscopes can be used with one system allowing for greater versatility. New devices such as battery-powered light sources and wireless receiver systems
Figure 1.8 Work station with endoscopy tower.

are helping to transform endoscopy procedures performed outside the veterinary hospital. Endoscopes with HD technology have been recently introduced into the veterinary setting. Endoscopy continues to play a vital and important role in veterinary medicine.

SUGGESTED READING


RECOMMENDED WEBSITES
