3.ENDOSCOPY

INTRODUCTION:

Endoscopy is the examination of internal body cavities using a specialized medical instrument called an *endoscope*. It is a powerful medical tool used for diagnosis and treatment of human diseases. These instruments can be inserted through natural body orifices (mouth, nose, anus, urethra) to access hollow organs, such as the oropharynx, esophagus, stomach, small intestine, colon, larynx, bronchial tree, and urinary bladder. Depending on the body part, each type of endoscopy has its own special term, such as

- laparoscopy (abdomen, uterus, fallopian tube)
- laryngoscopy (vocal cords)
- bronchoscopy (lungs)
- colonoscopy (colon)
- arthroscopy (joint)
- Gastroscopy (Stomach).

Endoscopy gives visual evidence of the problem (e.g. cancer, ulceration or inflammation), also can be used to collect a sample of tissue or remove problematic tissue and take photograph of the hollow internal organs; So that physicians use endoscopy to diagnose, monitor, and surgically treat various medical problems. Technological innovation has significantly changed the practice of endoscopy in recent years. The first endoscopes consisted of crude, rigid tubes that provided only a limited view of easily accessible organs.

Rigid Endoscopy :

- Giulio Cesare Aranzi (1530–1589), an Italian physician, was the first medical practitioner to direct sunlight into a body cavity. This medical examination took place in 1585. He used a flask of water to reflect light into his patient's nose.
- The first technologically successful attempt to guide light into the human body was undertaken by Philipp Bozzini (1773–1808). His apparatus which he called 'Lichtleiter' (German, translated to English: light conductor) was constructed from a metal casing which was designed to hold a candle, A

schematic drawing of the Lichtleiter can be seen in Fig. 1. On the one side of the casing Bozzini placed holes to which he attached metal tubes. The tubes were used to guide the light into the human body. Tubes of different sizes were available for different body openings. He even invented a tube with a mirror to redirect the light to the vocal cords. On the other side of the casing was an opening for the observer to look into. The disadvantages were the heat and smoke created by the candle.

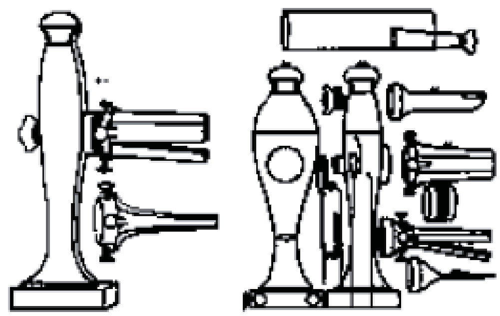


Figure 1. schematic drawing of Bozzinis Lichtleiter

- ❖ Antoin Jean Desormeaux (1815–1882) replaced the candle with a mixture of alcohol and turpentine to increase the illumination. However, this solution still created heat and sometimes smoke while burning. Furthermore, he used condenser lenses to concentrate the illumination on a single spot during the examinations. Desormeaux conducted the first successful operative endoscopic procedures in living patients and is considered by many as the ’father of endoscopy.
- ❖ The lighting system was further improved by Julius Bruck (1840–1902). He was the first to suggest inserting a light source into the human body.
- ❖ Max Nitze (1848–1906) was a general practitioner interested in the medical examination of the urinary bladder. He was the first inventor who created an endoscope with the light source at its tip.
- ❖ After experimenting with Julius Bruck’s platinum wire he miniaturized Edison’s filament globe and created the first cystoscope in 1877. The cystoscope contained several optical lenses used to guide the light through the tube and to the observer's eye.

- ❖ Johann von Mikulicz-Radecki (1850-1905) introduced a mirror to create the angular field of view still found in many of today's endoscopic devices. He also added an air canal to his endoscope which enabled the examiner to inflate the body cavity under observation. This greatly increased the field of view and allowed the inspection of otherwise collapsed body cavities. His rigid gastroscope was 650 mm long and 13 mm in diameter.
- ❖ A new type of light transmission was introduced by Fourestier in 1952. A rigid quartz rod with a mere 1.5 mm diameter was inserted in a 2 mm stainless steel tube.
- ❖ In 1957 Basil Hirschowitz developed his prototype fiberscope.

Basic Components of an Endoscope

A schematic diagram detailing the individual components of the endoscope is shown in **Figure2**. The distal tip contains the **optics** required for illuminating and collecting endosocpic images**, channels** for delivery of instruments, and the mechanisms for providing air, water, and suction. The bending section contains a set of hinges that allow the distal tip to deflect at large angles as high as 270°. The insertion tube comprises the distal part of the endoscope and is covered with a rugged plastic. The proximal end of the endoscope contains the entry into the instrument channel, the angulation control knobs for manipulating the distal end, a lock for maintaining distal tip deflection, air/water and suction valves, and remote switches for freezing, capturing, and storing images. An umbilical cord connects the endoscope to the video processor, and contains the light guide, electrical connectors, and conduits for air, water, and suction. The total length of the upper endoscope is about 1.5 meters, and can be longer for a colonoscope or enteroscope.

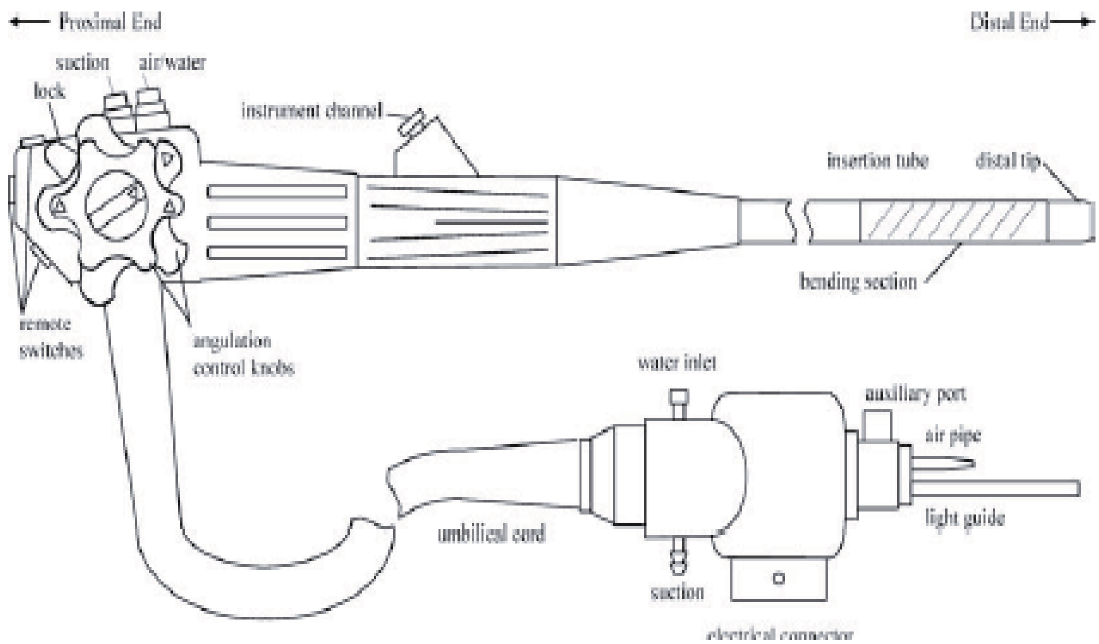


FIGURE 2: The basic components of a conventional endoscope.

Distal End

The distal end of an endoscope contains the:

- **optics** that form the endoscopic images. A cross section view of a forward-viewing endoscope is shown in Figure 3.
- A large instrument channel is present for delivery of instruments, removal of tissue, and suction. The air/water channel directs either water flowing across the outer surface of the objective to clear debris or air to insufflate and expand the organ being examined.
- The first endoscopes used a coherent optical fiber imaging bundle to transmit the image to the proximal end of the endoscope where it could be viewed directly by the endoscopist through an eyepiece. Because of recent advances in semiconductor technology, the imaging bundles have now been replaced by miniaturized charge-coupled device (CCD) detectors located in the distal tip directly behind the objective lens to produce a video image.

The Objective Lens

The objective lens of the endoscope is designed to provide a large field of view with high image resolution. Since it is very difficult to achieve both of these requirements with a simple lens, endoscopes use multiple lenses to form the image. The optical train of lens elements required to produce the endoscopic image is shown in Figure 3a. The angle between a ray of light and the normal to the objective is defined as q.

- A diverging lens (negative focal length) is needed to produce a large angle q to maximize the field of view.
- A pupil is located behind the objective lens to block extraneous internal reflections.
- An intermediate lens helps focus the image onto the detector.
- An achromat corrects for chromatic aberrations so that all the colors in the visible spectrum will focus onto the same plane at the detector.

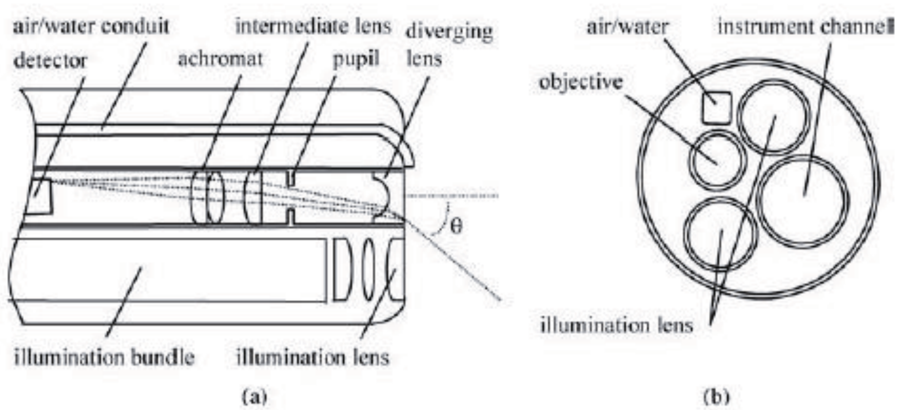


FIGURE 3: A detailed view of the distal tip. (a) A cross-section view shows the design of the optics, detector, and air/water conduits; (b) the end-view shows the relative location of these elements.

Insertion Tube

An exposed cross section of the insertion tube is shown in (Figure 4), the outside consists of a:

- Durable plastic covering capable of withstanding caustic bodily fluids, such as gastric acid and bile, and disinfectants for cleaning the instrument.
- Under the covering is a wire mesh that runs along the length of the tube to prevent twisting or stretching during use.
- Below the mesh are helically shaped steel bands that maintain the round shape and provide mechanical protection.
- The contents of the insertion tube include the light guide, imaging bundle, angulation control wires, air and water pipes, and instrument channel.
- The tube is designed with a stiffness that varies along the length of the endoscope in order to facilitate its insertion into the GI tract. The distal end can be manipulated to produce large bending angles that are needed for visualization of tissue located behind the endoscope (retroflexed view), and for fine movements to traverse tortuous internal organs, such as the intestines.

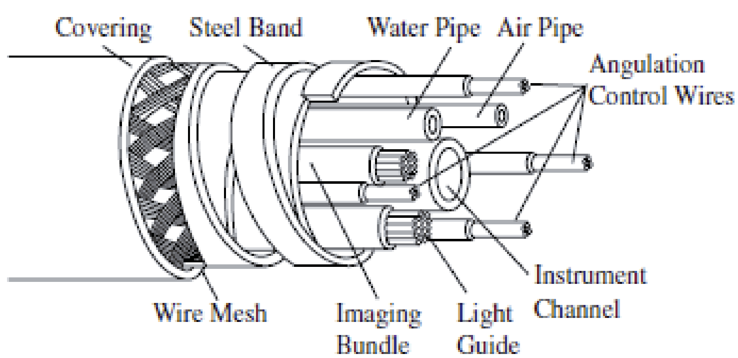


FIGURE 4: The contents of the insertion tube

Angulation Control

The angulation control of the distal end is performed by the left hand of the endoscopist, leaving the right hand free to hold and manipulate the insertion tube. These angulations are produced by a durable set of guide wires that deflect the distal end in four directions, termed up, down, left, and right, by convention. The angulation control knobs are connected to a sprocket that moves the guidewires connected to the distal tip. If desired, a brake can be applied to lock the position of the deflection.

Air, Water, and Suction Valves

A set of buttons and valves are located on the proximal end of the endoscope to deliver air and water or to suction intraluminal contents. Air is introduced into an organ, such as the colon or stomach, to expand the mucosal folds for better visualization. Air can also be removed from a distended organ for decompression. When the air/water valve is depressed, water is delivered from the pressurized water container located on the video processor and out the nozzle on the distal tip, and over the surface of the objective lens. Water is sprayed over the outer surface of the objective to remove debris that is obstructing the view. Intraluminal contents, such as fluid or stool, can be aspirated through the endoscope to a collection bottle via an external suction pump that provides negative pressure.

Connector section

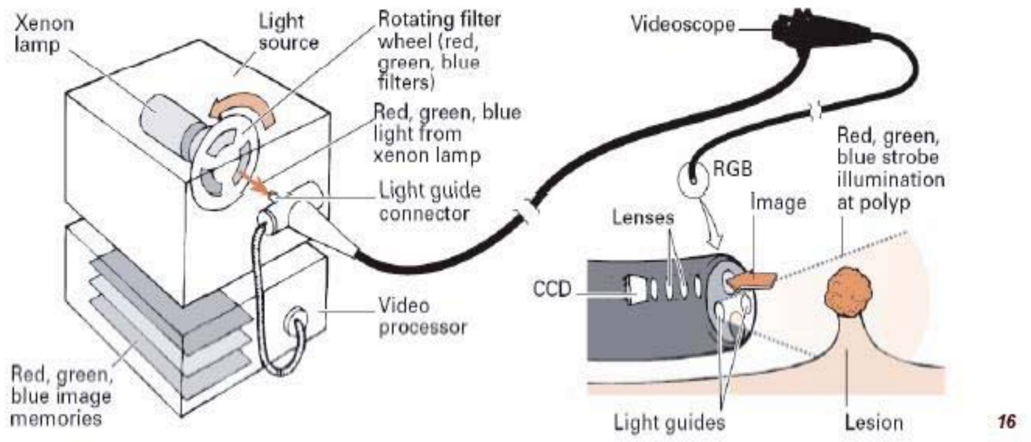
• A light guide,

• An air-pipe

• Electrical contacts compatible with the processor/light source.

• Side connectors for a water container, suction, CO_2, insertion tube venting

• An S (safety)-cord connecting mount, which grounds the endoscope, reducing the electrical shock hazard to the operator.



Endoscopic Accessories

• Biopsy forceps

• Graspers

• Dilators

• Knives

• . . . too many types of accessories.

Fiberoptic instruments

Characteristics:

• Based on optical viewing bundles

• 2–3·mm in diameter and contains 20·000–40·000 fine glass fibers, each close to 10·µm in diameter

• Each individual glass fiber is coated with glass of a lower optical density to prevent leakage of light from within the fiber

• The space between the fibers causes a dark 'packing fraction' so fine mesh frequently apparent in the fiberoptic image

Advantages

• Fiberoptic bundles are extremely flexible, and an image can be transmitted even when tied in a knot.

• Small diameter

• Direct view (monitor not necessary)

Limitations

• The image a fibreoptic bundle 10 quality of bundle, though excellent, can never equal that of a rigid lens system or a video-endoscope

• Limited number of "pixels"

Video-endoscopes

Characteristics:

• Mechanically similar to fiber-endoscopes,

• A CCD chip and supporting electronics mounted at the tip

• To and fro wiring replacing the optical bundle

• Further electronics and switches occupying the site of the ocular lens on the upper part of the control head.

Advantages

• Improved image quality

• View through a monitor

Limitations

• No direct viewing

• Can not be made <5 mm

Capsule Endoscopy

One of the recent developments in the field of endoscopy is capsule endoscopy where a mini-camera in capsule form is given the patient for swallowing.

Inside a Capsule Camera

1. *Optical Dome*

• This shape results in easy orientation of the capsule axis along the central axis of small intestine and so helps propel the capsule forward easily.

• The Optical Dome contains the Light Receiving Window .

2. *Lens Holder*

• The Lens Holder is that part of the capsule which accommodates the

lens. The lens is tightly fixed to the holder so that it doesn't get

dislocated anytime.

3. *Lens*

• The Lens is an integral component of the capsule.

• It is arranged behind the Light Receiving Window.

4. *Illuminating LED's*

• Around the Lens & CMOS Image Sensor, four LED's (Light Emitting Diodes) are present. These plural lighting devices are arranged in donut shape.

5. *CMOS Image Sensor*

• CMOS (Complementary Metal Oxide Semiconductor) Image Sensor is the most important part of the capsule. It is highly sensitive and produces very high quality images.

• It has 140º field of view and can detect objects as small as possible.

6. *Battery*

• Two batteries

• Silver Oxide primary batteries are used (Zinc/Alkaline Electrolyte / Silver Oxide). Such a battery has a even discharge voltage, disposable and doesn't cause harm to the body.

7. ASIC Transmitter

• The ASIC (Application Specific Integrated Circuit) Transmitter is arranged behind the Batteries as shown. Two Transmitting Electrodes

are connected to the outlines of the ASIC Transmitter.

• These electrodes are electrically isolated from each other.

8. Antennae

• As shown, the Antennae is arranged at the end of the capsule. It is enclosed in a dome shaped chamber.

How does Capsule Endoscopy Work?

- Capsule is swallowed by the patient like a conventional pill.
- It takes images as it is propelled forward by peristalsis.
- A wireless recorder, worn on a belt, receives the images transmitted by the pill.
- A computer workstation processes the data and produces a continuous still images.

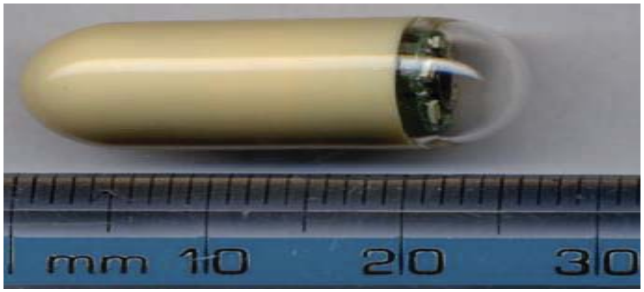


Figure 5. Image of a capsule endoscope (pill-cam) with size reference.