Gadgets, Devices & Tools for Endoscopy

Anthony A. Starpoli, MD NYSGEF-AGAF
Associate Director of Esophageal Endotherapy
Lenox Hill Hospital - Northwell Health
Learning Objectives

- Endoscope design
- Endoscopic accessories
- Applications & Techniques
Endoscopic Imaging

1. Send out light to illuminate the mucosa

2. Have a “camera” to detect image
Earliest flexible endoscope, optical fibers

Described in a 1954 Nature paper by Hopkins & Kapany

Presented by Basil I. Hirschowitz in May 1957 at the annual meeting of the American Gastroscopy Society
Fiber-optic Endoscopes

- Original endoscopes (unlikely to encounter)
  - Based on optical viewing bundles
  - Need to view directly through eyepiece
  - Video adaptor (teaching head) needed to see on video monitor

- Each fiber is 2-3 mm diameter
  - Contains 20,000-40,000 glass fibers
  - Light focused on the face of one end of fiber is transmitted via internal reflections to distal end
  - Image requires fibers stay in same arrangement on both ends (“coherent bundle”)

- Image round, small
  - bare spots if fibers broken

Cotton & Williams, Prac GI Endo, 4th Ed.
Video-Endoscopes
“Modern Endoscopes”

- Video chips
- Individual photocells (pixels)
  - Each cell receives photons reflected from white light reflecting from mucosa → black/white signal
  - Sensor that converts light into electrical charges
Image Generation

- Insertion tube tip contains a digital imager for color image generation
  - Charge-coupled device (CCD)
  - Complementary Metal-Oxide Semiconductor (CMOS)
- CCD and CMOS image sensors convert light into electrons
  - Light converted to electricity
- Standard resolution of 400,000 pixels
- High-resolution endoscopes with high-density CCD sensors (600,000–1,400,000+ pixels)
  - Provide image enlargement up to 100+ times compared with 30 times of standard endoscopes
Video-Endoscopes ("Modern Endoscopes")

- **LIGHT SOURCE** and **VIDEO PROCESSOR**
  - High-Definition signal and monitors
  - Pure digital signals
Video-Endoscopes
(“Modern Endoscopes”)

Color Video

- **RGB sequential videoscope**
  - Light source has a pulsed or strobed light with color filter wheel with red, green, blue (RGB) filters

- **Color chip videoscope**
  - Color filters bonded to surface of black/white CCD allow detection of red, green or blue (RGB) colors
Processor and Light Source
What is “White Balancing”?  

- Light emitted from endoscope varies based on lamps and fiber bundle  
- “White Balancing” allows the processor to adjust signal interpretation for accurate color imaging  
- Point endoscope tip towards white object and press “white balance” button
Scope Tip in Cross Section

Cross-section:
- Light guide protection tube
- Water jet tube
- Illumination fibers
- Water jet
- Objective lens
- Air/water nozzle
- CCD unit and lenses
- Photosensitive surface of CCD

End view:
- Plastic distal end cap
- Biopsy channel
Endoscope Tip Deflection

EGD scopes
Up/Down 210°/90°
Left/Right 100°/100°

Colonoscopes
Up/Down 180°/ 180°
Left/Right 160°/ 160°
FYI: May use CO2 instead of room air. Cleared from colon 100x faster than room air - absorbed and exhaled. May result in improved patient satisfaction and fewer complications.
Irrigation Channel

Auxiliary Water Inlet
Irrigation Pump
CO2 Insufflation
Check list before starting each endoscopy...

- Air
- Water
- Suction
- Image on screen (brightness)
- Scope white balanced
- Irrigation available
General GI Endoscopes

- **Esophago-gastro-duodenoscope (EGD)**
  - Diagnostic
  - Therapeutic
    - Single Channel
    - Double channel
    - Extra large Channel
  - Ultra-thin

- **Colonoscopes**
  - Diagnostic
  - Therapeutic
  - Pediatric
  - Variable stiffness
Specialized GI Endoscopes

- **Duodenoscope (ERCP)**
  - Side viewing to see ampulla
  - Elevator to move accessories

- **Enteroscopes**
  - Long scopes (250 cm)
  - Double Balloon scope

- **Endoscopic Ultrasound**
  - Radial scanning
  - Linear array (FNA)

- **Choledochoscope**
  - Fits through duodenoscope
## Scope and Biopsy Channel Diameters

<table>
<thead>
<tr>
<th>Scope</th>
<th>Model</th>
<th>Outer Diameter</th>
<th>Accessory Channel Diameter</th>
<th>Accessory Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EGD</strong> (110-135 cm)</td>
<td>Ultrathin (trans-nasal)</td>
<td>4.9-5.4 mm</td>
<td>2.0 mm</td>
<td>1.8 mm (peds)</td>
</tr>
<tr>
<td></td>
<td>Diagnostic</td>
<td>9.5 mm</td>
<td>2.8 mm</td>
<td>2.4 mm (regular)</td>
</tr>
<tr>
<td></td>
<td>Therapeutic (single channel)</td>
<td>11.3</td>
<td>3.7 mm</td>
<td>3.4 mm (jumbo)</td>
</tr>
<tr>
<td></td>
<td>Therapeutic (double channel)</td>
<td>12.6</td>
<td>3.7 mm</td>
<td>3.4 mm (jumbo)</td>
</tr>
<tr>
<td></td>
<td>Giant Therapeutic (vacuum cleaner)</td>
<td>12.9</td>
<td>6 mm</td>
<td>5.6 mm (giant jumbo)</td>
</tr>
<tr>
<td><strong>Colonoscope</strong> (133-168 cm)</td>
<td>Pediatric</td>
<td>11.5</td>
<td>3.2 mm</td>
<td>2.4 mm (regular)</td>
</tr>
<tr>
<td></td>
<td>Diagnostic</td>
<td>12.8</td>
<td>3.7 mm</td>
<td>3.4 mm (jumbo)</td>
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<td>13.7</td>
<td>4.2 mm</td>
<td>3.4 mm (jumbo)</td>
</tr>
</tbody>
</table>
Accessories

- Biopsy forceps
- Polypectomy Snares
- Retrieval baskets
- Endoclips
- EndoLoops
- Injection Needles
- Tattoo
- Overtube
- Contrast Dyes
Biopsy Forceps

- Giant Jumbo/Jumbo/Regular/Pediatric
  - Jumbo give greater amount of mucosa, but not necessarily deeper
    - “bigger is better if tissue is the issue”
  - “Bite-on-bite”/”multi-bite” versus individual bites?
- Spike or no-spike?
Biopsy Forceps

<table>
<thead>
<tr>
<th></th>
<th>Giant Jumbo</th>
<th>Jumbo</th>
<th>Regular</th>
<th>Pediatric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaw Opening</td>
<td>12 mm</td>
<td>9 mm</td>
<td>7 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Diameter</td>
<td>5.5 mm</td>
<td>3.2 mm</td>
<td>2.3 mm</td>
<td>1.8 mm</td>
</tr>
</tbody>
</table>
These are NOT Biopsy Forceps

“Rat Tooth” Forceps for Object Removal – NOT BIOPSY
(These can perforate the GI tract!)
Snare

- Polyfilament, braided wire
- Generally use “hot” monopolar snare to cauterize the polyp stalk/base to help remove and prevent bleeding

- “Cold” or “guillotine” snare can be used for smaller polyps
  - Usually for polyps < 6 mm
Retrieval Net

- Allows object to be grabbed in net for removal (i.e. polyp or foreign body)
Endoclips
EndoLoops

PolyLoop
Ovesco: Over The Scope Clip Clipl

Open

Closed
Ovesco: Over The Scope Clip Clipl
Sclerotherapy Needle

- Used for submucosal injections
  - Tattoo, endoscopic mucosal resection, epinephrine for bleeding

- Injection of varices

- Usually 22g-25g

- Needle protrudes 5 mm
Mucosal Tattoo

- Goal to identify an area or lesion at a later time either by endoscopy or surgery
- Permanent ink (i.e. SPOT® tattoo or India Ink)
  - Must be sterile – otherwise risk of infection
- Submucosal injection using sclerotherapy needle
  - Ideally place small marks circumferentially around lesion
  - Well placed injection should be visible from serosal side
  - Avoid injecting too deeply or else will have dye throughout the peritoneal cavity
Biopsy/Suction Channel in Lower Half of Screen
6-7 o’clock corner of the screen
*Position lesions to suction or biopsy in this area*
Overtube

- Large tube placed into UGI tract through which scope can pass
  - Esophageal or gastric lengths

- Use special care not to perforate esophagus when placing
  - Consider placing over 54 Fr. Maloney or Guardus overtube

Indications

- Protects airway and esophagus when removing foreign bodies
- Allows frequent passage of scope during EMR
- Help keep stomach straight during enteroscopy
Disposable versus Reusable Accessories

Disposable accessories

- Specified by manufactures to be “single use only”
- Easy to use for staff
- Guaranteed sterile

Reusable accessories

- Should be labeled such by company
- Potentially less expensive
- Environmentally friendly
- Difficult to clean
- Potential risk to staff when cleaning
- Don’t throw away after using!
How Can We See More?

Improved Lens Positioning

Endoscopic Image Enhancement
   Image processing improves a given image

Image Analysis
   Analysis of a stored image and extraction of characteristics in numerical parameters for subsequent reconstruction
Pentax Retroview®
“Full Spectrum”
Spreading of the Folds

- Cap
- EndoCuff
- EndoRings
- G-Eye Balloon
- Third-Eye
Image Enhancement Techniques to Improve Visualization of Mucosal Surface

High-resolution and high-definition endoscopy

- Magnification endoscopy
- Chromoendoscopy
- Magnification chromoendoscopy
- Narrow band imaging
- Confocal Laser Endomicroscopy
Chromoendooscopy

Contrast stains
Indigo carmine - pools in mucosal grooves, pits, and depressed areas

Absorbed (Vital) stains
Lugol solution - stains glycogen in squamous epithelium
Methylene blue - actively absorbed by intestinal epithelium
Cresyl violet - stains gastric and intestinal epithelium

Acetic acid
Opacifies the mucosal layer
Magnification Chromoendoscopy

- Gastrointestinal epithelium is translucent
- Light beam reaches the subepithelial vascular network
- Absorption spectrum of hemoglobin creates red appearance

Opacification of mucosal surface allows visualization of mucosal pit pattern.
## Kudo Pit Patterns

### Pit-pattern classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Schematic</th>
<th>Endoscopic</th>
<th>Description</th>
<th>Suggested Pathology</th>
<th>Ideal Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><img src="image1.png" alt="Schematic" /></td>
<td><img src="image2.png" alt="Endoscopic" /></td>
<td>Round pits.</td>
<td>Non-neoplastic.</td>
<td>Endoscopic or none.</td>
</tr>
<tr>
<td>II</td>
<td><img src="image3.png" alt="Schematic" /></td>
<td><img src="image4.png" alt="Endoscopic" /></td>
<td>Stellar or papillary pits.</td>
<td>Non-neoplastic.</td>
<td>Endoscopic or none.</td>
</tr>
<tr>
<td>IIIa</td>
<td><img src="image5.png" alt="Schematic" /></td>
<td><img src="image6.png" alt="Endoscopic" /></td>
<td>Small tubular or round pits that are smaller than the normal pit</td>
<td>Neoplastic.</td>
<td>Endoscopic.</td>
</tr>
<tr>
<td>IIIc</td>
<td><img src="image7.png" alt="Schematic" /></td>
<td><img src="image8.png" alt="Endoscopic" /></td>
<td>Tubular or roundish pits that are larger than the normal pits.</td>
<td>Neoplastic.</td>
<td>Endoscopic.</td>
</tr>
<tr>
<td>IV</td>
<td><img src="image9.png" alt="Schematic" /></td>
<td><img src="image10.png" alt="Endoscopic" /></td>
<td>Branch-like or gyrus-like pits.</td>
<td>Neoplastic.</td>
<td>Endoscopic.</td>
</tr>
<tr>
<td>VI</td>
<td><img src="image11.png" alt="Schematic" /></td>
<td><img src="image12.png" alt="Endoscopic" /></td>
<td>Irregularly arranged pits with type IIIa, IIIc, IV type pit patterns.</td>
<td>Neoplastic (invasive).</td>
<td>Endoscopic or surgical.</td>
</tr>
<tr>
<td>V</td>
<td><img src="image13.png" alt="Schematic" /></td>
<td><img src="image14.png" alt="Endoscopic" /></td>
<td>Non-structural pits.</td>
<td>Neoplastic (massive submucosal invasive).</td>
<td>Surgical.</td>
</tr>
</tbody>
</table>

Diagnosis of colorectal tumorous lesions by magnifying endoscopy.

*Kudo S, Tamura S, Nakajima T, Yamano H, Kusaka H, Watanabe H*
Conventional Chromoendoscopy

Indigo Carmine (0.4%)

Contrast stain not absorbed by intestinal mucosa

Pools in mucosal grooves, pits, and depressed areas

Highlights details of mucosal surface
Conventional Chromoendoscopy

Lugol Solution (1% - 2%)

- Negative staining on nodular mucosa
- Biopsy consistent with Barrett’s esophagus with mild dysplasia
Conventional Chromoendoscopy

Methylene Blue Facilitates Diagnosis of Barrett’s Esophagus

Unstained

Canto MI et al. Gastrointest Endoscopy 1996

Stained
Colonic Adenoma + MB
Eleview

Sustained Lifting and Staining
Eleview
Magnification Chromoendoscopy
Indigo Carmine

Unstained

Stained
Magnification Chromoendoscopy
Cresyl Violet (0.25% - 0.5%)

Normal gastric mucosa

Intestinal metaplasia in Barrett’s esophagus
Conventional Endoscopy
Acetic Acid (1.5% - 3%)

Acetic acid opacifies the mucosal layer
Mucosa becomes whitish (acetowhite reaction)

Guelrud et al. Gastrointest Endosc 1998
Magnification Chromoendoscopy

Acetic Acid with Magnification
(Enhanced Magnification Endoscopy)

No magnification

Unstained

Surface Vascular Architecture

Unstained

Mucosal Pattern

Stained

Mag 40x

Mag 80x
Narrow Band Imaging (NBI)

- Filters decrease the red light, allowing only narrow band of blue light and green light to illuminate the mucosal surface.
- The system of NBI uses blue narrow band light (390-445 nm) and green narrow band light (530-550 nm).
- Blue light (short wavelength) that penetrates most superficially.
- Green light has deeper penetration.
- NBI improves the image of the mucosal surface patterns and highlights vasculature.

Gono, K et al. J Biomed Opt 2004
Machida H et al. Endoscopy 2004
**Narrow Band Imaging (NBI)**

- **Blue light penetrates only superficially**
- **Green light has deep penetration**
- **Hemoglobin absorbs blue light**
- **Superficial vessels appear black**
- **Deeper subepithelial veins appear cyan**
NBI

- Specific wavelengths sent are strongly absorbed by hemoglobin
  - enhances visualization of mucosal surface and microvasculature

- Offers chromoendoscopy-like effects
  - trigger deeper inspection and directed biopsy
Magnification NBI Endoscopy
NBI Helps to Define Pallisade Vessels

*landmark of the esophagogastric junction
Magnification NBI Endoscopy

Narrow Band Imaging
OE Optical Enhancement

How does it work?

- Optical filters create band limited light that focuses on the color spectrum associated with hemoglobin absorption. This provides an enhanced view of fine vascular and mucosal structures.

OE Optical Enhancement modes

- OE Mode 1 designed to improve visualization of microvessels with a sufficient amount of light.
- OE Mode 1 focuses on a similar light spectrum to NBI, but allows more white light to improve brightness.

- OE mode 2 is designed to improve contrast of white-light observation by bringing the color tone of the overall image closer to that of natural color.

i-SCAN and OE image enhancement technologies are intended to be used as an optional adjunct following traditional white light endoscopy and is not intended to replace histopathological sampling. i-SCAN and OE are compatible with PENTAX Medical video gastrointestinal endoscopes.
Flexible spectral Imaging Color Enhancement (FICE)
Mucosal Pattern Enhancement

- NBI, OE & FICE
- Specific color wavelengths and light frequencies enhance blood vessels & fine capillary patterns in the mucous membranes
Probe Based Confocal Laser Endomicroscopy

- pCLE: miniprobe (GastroFlex UHD, Cellvizio; Mauna Kea Technologies, Paris, France)
- Low-power laser is focused onto a single point within the tissue
- Light emanating from this point is focused through a pinhole to a detector
- Laser raster scans the two-dimensional imaging plane
- Field of view of 240 μm, lateral resolution of 1 μm
- Imaging depth of 60 μm below the tissue surface
- Injection of sodium fluorescein (2.5 mL, 10%)
- Targeted biopsy

Probe-based Confocal Laser Endomicroscopy

Nondysplastic Barrett’s esophagus (BE)

BE with early esophageal adenocarcinoma

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Nvision VLE OCT* Imaging System

- Evaluation of the esophageal tissue microstructure
- Analogous to B-mode ultrasound, using light instead of sound
- Low coherence near-infrared light pointed at tissue
- Cross sectional scanning through a 6cm length and 3mm depth
- Visualizes the squamous mucosa, submucosa, and muscularis propria
- Improved biopsy targeting

*Volumetric Laser Endomicroscopy Optical Coherence Tomography
Nvision VLE OCT Imaging System

- Real time image capture, 3mm beneath the mucosa at a 7 micron resolution
- Full-field view (~10,000mm$^2$) vs. “point” image typically obtained with confocal microscopy (0.25mm$^2$)
- 25X higher resolution than endoscopic ultrasound
Conclusions

▫ You are responsible for understanding how to use your equipment and accessories
  ➤ Sole dependency on your nurses or techs is risky
▫ Constantly educate yourself and your staff
▫ Keep current and stay sharp!
Good Luck!