# Gastrointestinal Endoscopy: Applications and Advances

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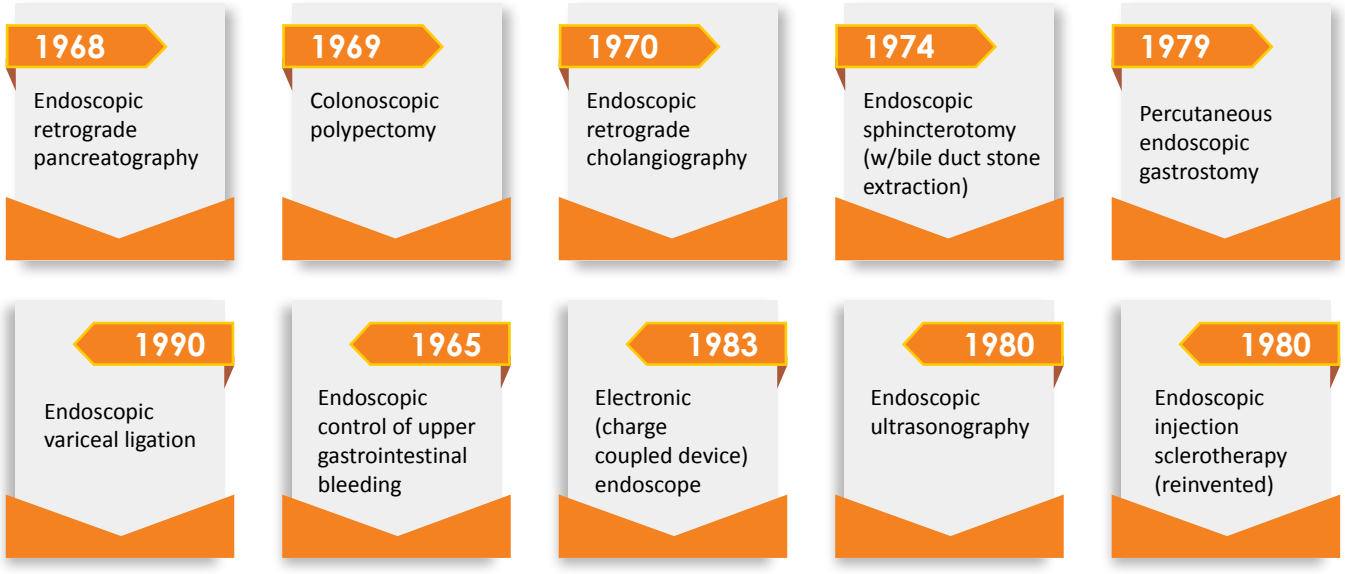
## History of gastrointestinal endoscopy: How we reached here

To predict the future, it is helpful, even advisable, to understand the past, and the history of endoscopy reveals much about the mechanisms whereby innovation occurred. From the time when the early pioneers faced two obvious problems in gastrointestinal endoscopy (GE): the gut being not straight and dark inside, to the present date when artificial intelligence (AI) is going to provide an effective and practical method for endoscopists in lesion detection and characterization, lie valuable lessons and great hopes for further advancements in endoscopy in this field. The major milestones in the history of endoscopy are as follows:[1]

- First gastroscopy in 1868; Kussmaul being credited for it
- Almost 25 years elapsed, after illumination problem was solved around 1878 by Thomas Edison, before the incandescent lamp could be incorporated into endoscopes
- An instrument with articulated lenses and prisms, as proposed by Hoffmann in 1911, was the first approach to the tortuosity of the gut
- Hopkins built a model of a flexible fibre imaging device in 1954
- The flexible fibreoptic endoscope in 1958 was the most significant development in the history of endoscopy. The availability of highly transparent optical quality glass made this instrument possible.

From 1968 to 1990 there was an explosion of technical achievements that transformed the practice of gastroenterology. This remarkable 22-year period was so formative that it was considered as the golden era of gastrointestinal endoscopy (Figure 1).[1]

**Figure 1: Highlights from the Golden Era of Gastrointestinal Endoscopy**




**Adapted from:** Sivak MV. Gastrointestinal endoscopy: Past and future. *Gut.* 2006;55(8):1061-1064.

**Table 1: Clinical Applications of Gastrointestinal Endoscopy**

| Esophageal disorders | Gastric disorders | Colonic disorders | Pancreatic and biliary disorders | Obesity | Small bowel disordres | Biopsy procedures |
|---|---|---|---|---|---|---|
| Carcinoma | Carcinoma | Colorectal carcinoma | Pancreatic carcinoma | Laparoscopically placed devices to reduce the effective capacity of the stomach have been used successfully in morbid obesity when other measures have failed. The procedure is indicated in subjects aged 18-60 years with a body mass index greater than 35kg/m$^2$ who have failed to maintain weight loss using non-surgical methods and who have no congenital anomalies of the gastrointestinal tract. | The recent development of wireless capsule endoscopy, which entails swallowing a pill-sized (capsule) device with a mounted camera, has enabled images to be obtained from the entire bowel. The images captured as the capsule transits the bowel are recorded on a transducer worn as a belt by the patient. The capsule is subsequently expelled in the faeces and the recorded images downloaded onto a computer for analysis. | Liver and peritoneal biopsies are possible via peritoneoscopy or laparoscopy, though these are surgical procedures. |
| Gastroesophageal reflux disease | Gastric and duodenal ulcer | Polyps | Biliary obstruction | | | |
| Varices | Foreign bodies | Vascular anomalies | | | | |
| Barrett's esophagus | Polyps | | | | | |
| Mallory–Weiss tear | | | | | | |
| Diffuse esophageal spasm | | | | | | |
| Zenker diverticulum | | | | | | |
| Stricture | | | | | | |

**Adapted from:** Otegbayo JA. Clinical applications of gastrointestinal endoscopy. *Nigerian Journal of Gastroenterology and Hepatology.* 2011; 3:15-19.

## Applications of gastrointestinal endoscopy

Gastroenterology provides the most vivid visual assessment of human anatomy. The entire small bowel can now be viewed with enteroscopes. Besides, endoscopy brings with it the possibility of performing biopsies, recording images, and undertaking therapeutic interventions that obviate the need for surgery and general anaesthesia, as well as the ability to send images via the internet for exchange of information and ideas. The clinical uses of GE are advancing. It is hoped that they will continue to play a major role in saving patients from surgical procedures. Laparoscopic surgery is also an expanding field with wide applications in surgical practice. GE is a major technique in the practice of gastroenterology, hepatology and pancreatology. There are endoscopy procedures for obesity, such as endoscopic balloon placement and endoscopic sleeve gastroplasty. For small bowel evaluation, capsule endoscopy is used for diagnosis only; whereas single balloon enteroscopy, double balloon enteroscopy, and power spiral enteroscopy are used for diagnosis and therapy. Table 1 summarises various clinical applications of gastrointestinal endoscopy.[2]

## Endoscopy in gastrointestinal cancers

### Carcinoma

Endoscopy is the gold standard for the diagnosis and treatment of GI diseases, where GI cancers are the second leading cause of cancer-related death.3 In recent years, revolutionary developments have occurred in endoscopy.

- The chromoendoscopy method developed by Kudo et al has increased the frequency of detection of early-stage cancers and precancerous lesions.
- This dye-based method being time-consuming resulted in the development of new technologies (e.g., digital chromoendoscopy, flexible spectral imaging color enhancement, narrow-band imaging, and I-Scan).
- The use of virtual optical filters, magnification, and mobile, high-resolution optical systems and software enables development of the endoscopic lesion images without the need for dyes. Generation of chromoendoscopy-like images in a short time, simply by pressing a button on the endoscope, is a considerable advantage without the need for dye usage.[4,5]
- The confocal laser endomicroscopy (CLE), which uses a laser rather than white light as a light source, represents a marked advance in endoscopy. The mucosa can be examined with a miniature microscope placed on top of the endoscope, enabling simultaneous in vivo histologic diagnosis of lesions. This technology has given rise to the concept of optical biopsy.[6]
- The use of new endoscopic systems has increased the rate of diagnosis of precancerous lesions and early-stage cancers.[7]
- Removal of precancerous and early-stage cancers by endoscopic methods, such as polypectomy, endoscopic mucosal resection, and endoscopic submucosal dissection, reduces the need for surgery and the associated morbidity and mortality rates.[8,9]

## Advances in gastrointestinal endoscopy

Since the introduction of flexible gastrointestinal endoscopy in the 1960s there has been a relentless advance in endoscopic imaging technology to assist clinicians to make better decisions.

## Chromoendoscopy

Chromoendoscopy offers improved visualization of mucosal lesions by using several dyes and enables histopathologic diagnosis during the procedure. It is often used with magnification and allows several hundred-fold-magnification of images by means of adjustable lenses.

- It has application in the diagnosis of intestinal metaplasia, dysplasia, early-stage GI cancers, and colorectal polyps.
- The major disadvantages of chromoendoscopy include the requirement for operator experience, prolonged procedure duration, and problems related to the use of dyes.
- However, the procedure is safe, and provides important clinical information for the treatment and monitoring of lesions.[7, 10]

## Narrow-band imaging

Narrow-band imaging (NBI) can provide up to 1000-fold magnification. The white-light components used in conventional endoscopy are reflected by the mucosal surface in a narrow-band interval and are revealed in such a way that the contrast difference and superficial patterns of the lesions and vascular architecture enable visualization of fine details. Lesions can be detected by NBI without the need for dyes.[5]

## Flexible spectral imaging color enhancement

The prototype of FICE technology was developed by Fujinon (Saitama, Japan). It is a software-based system that changes the color of endoscopic images in real time. The original image is processed arithmetically at a specific wavelength of light. The actual images obtained using 10 preset FICE programs are processed by blue, green, and red filters to generate new images.

- The colors in the actual image are changed by using the absorption and emission properties of the light, thus revealing fine mucosal details to obtain a clearer image.
- FICE does not increase the frequency of detection of colorectal polyps but can determine whether an adenoma is neoplastic.
- The capillary patterns of adenomas are better demonstrated by FICE than by conventional endoscopy.[5]

## I-Scan

The prototype of I-Scan technology was developed by Pentax Inc. (Tokyo, Japan). Endoscopic images reveal mucosal details by creating digital contrast. This technology involves modification of each image element obtained using white light. More specifically, images obtained by conventional endoscopy are converted into new images simultaneously by processing in the software. Thus, the superficial details and capillary architecture of the mucosa are visualized, enabling detection of previously invisible lesions.[5,11]

- I-Scan technology increases diagnostic accuracy by revealing fine details of the GI mucosa.
- Unlike chromoendoscopy, no dye or contrast material is used with I-Scan.
- Moreover, I-SCAN does not make use of the contrast created by light of different wavelengths, as does NBI. I-Scan is a software-based imaging method.[5,11]

## Confocal laser endomicroscopy

CLE has enabled non-invasive assessment of the cellular and molecular properties of tissues in real time, resulting in the concept of optical biopsy. A conventional endomicroscope is miniaturized and placed on the end of the endoscope. Alternatively, probe-based endomicroscopy involves acquisition of images using probes passed through a conventional endoscope. The image can be magnified several hundred-fold.[5]

## Endocytoscopy

Endocytoscopy is a novel ultra-high magnification endoscopic technique enabling high-quality in-vivo assessment of lesions found in the gastrointestinal tract with the use of intraprocedural stains.

- It allows visualization of details down the level of nuclei by contact light microscopy after staining the mucosa with methylene blue and crystal violet.
- It has good accuracy of endocytoscopy in the diagnosis of esophageal and gastric lesions.
- EC seems to help in the in-vivo diagnosis of gastrointestinal tract lesions and may, in the future, revolutionize the field of in-vivo endoscopic diagnosis of gastrointestinal cancer.[12]

## Extended viewing field

While considered the standard of care, traditional forward-viewing (TFV) endoscopes only allow between a 140-170° field of view (FOV). A revolutionary new endoscopic technology, “full spectrum endoscopy (Fuse)”, now allows a panoramic 245° (gastroscope) to 330° (colonoscope) FOV. It makes it possible for the physicians to view formerly difficult- or impossible-to-view areas within the GI tract, such as behind the pylorus/within the duodenal bulb or the proximal side of colonic folds/flexures.[13]

## Spiral enteroscopy

Spiral assisted endoscopy is based on a novel concept of advancing an endoscope by pleating of the bowel on the instrumentation shaft by active rotation instead of applying pushing force. Principle of spiral enteroscopy is the conversion of rotational energy of the spiral into linear force to pull the intestine on the enteroscope. This technique has been widely used for anterograde enteroscopy. For this purpose the manually rotatable Endo-Ease Overtube is used with a standard thin flexible enteroscope. By manually rotating the overtube, the spiral engages the small bowel which is thus pleated onto or unpleated from the overtube, respectively, depending on the direction of the spiral rotation. Spiral assisted endoscopy has been also approved and evaluated for retrograde enteroscopy via the anal route.[14]

## Bariatric endoscopy

Endoscopic bariatric therapies provide an effective and minimally invasive treatment approach to obesity that would

increase treatment options beyond surgery, medications, and lifestyle measures. Endoscopy can be applied in various ways in bariatrics, including preoperative evaluation to study the anatomy, preoperative planning for revisions, intraoperative management to address inadvertent technical errors, postoperative management for complications, primary bariatric procedures, among other applications. Bariatric endoscopy is an essential tool in the armamentarium of surgeons dedicated to the management of morbid obesity. These less-invasive endoscopic techniques serve as a promising alternative for the management of bariatric patients. The weight loss effects of endoscopic bariatric treatment are greater than medications and the complications rates are less than bariatric surgery.[15,17]

## Endoscopic submucosal dissection

Endoscopic submucosal dissection (ESD) is a well-accepted and widely employed modality in Asia for resection of advanced mucosa-derived lesions of the GI tract including early tumor. It allows the direct dissection of the submucosa and en bloc resection of large lesions with precise pathological staging and potential cure. ESD is not limited by resection size and it has enabled resection of larger and more histologically advanced epithelial-based lesions including early cancer of the upper and lower GI tract as well as a broad array of submucosal lesions, that previously had necessitated surgical removal.[18,19]

## Third space endoscopy

Third space endoscopy, also commonly known as submucosal endoscopy, is based on the principle that the deeper layers of the GI tract can be accessed by tunneling in the submucosal space without compromising the integrity of the overlying mucosa. Peroral endoscopic myotomy (POEM), endoscopic submucosal dissection (ESD), endoscopic full-thickness resection (EFTR), and submucosal tunneling endoscopic resection (STER) are some of the innovative techniques within the field of third space endoscopy in the management of esophageal disorders. POEM is now considered an accepted minimally invasive therapy for achalasia and related motility disorders with excellent short-term results. Compared to conventional treatments including endoscopic pneumatic dilatation and laparoscopic Heller myotomy, POEM has the advantage of achieving the definitiveness of myotomy without surgical incisions.[20-21]

## Endoscopic retrograde cholangiopancreatography

Endoscopic retrograde cholangiopancreatography (ERCP) is a standard diagnostic-therapeutic and endoscopic-radiological procedure used for many pancreaticobiliary disorders. The indications for ERCP intervention are mainly pancreaticobiliary maljunction (PBM) with complications such as biliary pancreatitis, obstructive jaundice, cholangitis, and choledochal dilatation, bile duct calculi, or pancreatic protein plugs. Apart from diagnosing PBM, ERCP can also provide access for therapeutic interventions such as sphincterotomy, stricture dilations with balloon or rigid dilators, stone extraction, stent insertion in stricture or biliary leak, or biopsy.[22,23]

## Endoscopic ultrasound guided procedures

Endoscopic ultrasound (EUS) is an important diagnostic and therapeutic technique in the field of gastrointestinal endoscopy. EUS facilitates access to many organs and lesions in vicinity of the gastrointestinal tract, thus providing an opportunity to approach them for therapeutic and diagnostic purposes. It also provides a real time opportunity to target the desired area while avoiding nearby vascular and other structures. EUS is now employed for various therapeutic interventions, such as management of pancreatic fluid collections, biliary and pancreatic duct drainage in cases of failed ERCP, drainage of gallbladder, celiac plexus neurolysis/blockage, drainage of mediastinal and intra-abdominal abscesses and collections and in targeted cancer chemotherapy and radiotherapy.[24]

## Artificial intelligence in gastrointestinal endoscopy: Looking into the future

EArtificial intelligence (AI) is now a trendy subject in clinical medicine and especially in GI endoscopy. AI has the potential to improve the quality of GI endoscopy at all levels. It will compensate for humans' errors and limited capabilities by bringing more accuracy, consistency, and higher speed, making endoscopic procedures more efficient and of higher quality. Scientific studies show that AI is showing promising results in diagnostic and therapeutic endoscopy in all parts of the GI tract. AI might provide an effective and practical method for endoscopists in lesion detection and characterization as well as in quality control in endoscopy. Further research, ethical clearance and new legislations might be needed in this area. Introduction of AI will be a big breakthrough in the field of GI endoscopy in the upcoming years and it might bring never-before-changes in GI endoscopy at all levels.[25,26]

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