DEVELOPMENT AND APPLICATION OF GASTROINTESTINAL ENDOSCOPY

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The early beginings

Man's innate curiosity to study the internal organs of the human body dates back to the time of Hippocrates where basic speculums were invented to peer into the buccal cavity and vagina. The first instruments used to intubate the esophagus and stomach in the 16th and 17th centuries, were designed for the purpose of extracting foreign bodies stuck in the esophagus (or pushing them down into the stomach).

The first scopes invented used candle light for illumination (Bozzini, 1806) and subsequently gasogen which is a mixture of alcohol and turpentine (Desormeux, 1853). These scopes were however, mainly designed as urethro-cysto scopes. Desormeux was the first to call such instruments, "endoscopes".

Development of rigid scopes

Adolf Kussmaul in 1868 is credited with inventing the first gastroscope. Taking the cue from sword swallowers who were popular entertainers at that time, Kussmaul attempted to insert a long rigid hollow tube into a professional sword swallower at a meeting of the Society of Naturalists in Freiburg, Germany. Illumination was provided by a gasogen lamp but was poor and as a result the examination was unsatisfactory. Water cooled electrically heated wire platinum loops were then used by Nietze for providing light but these were found to be cumbersome and impractical. The "enlightenment" of endoscopy followed Edison's invention of the incandescent lamp in 1879. A miniaturized or "mignon" light bulb was used with oesophagoscopes by Leiter and Mickulicz (1887). Despite much effort at developing a gastroscope by many workers, the first really usable rigid gastroscope was produced by Elsner in 1911. Rudolf Schindler, who more than anyone else popularized upper gastrointestinal endoscopy at that time, called the Elsner instrument "the mother of all instruments". He himself modified this rigid scope in 1922 by adding an air-channel into the scope to clean the lens. Through numerous examinations and assiduous recording by color drawings he published his classic book, "Lehrbuch und Atlas der Gastroskopie" in 1923.

Schindler and the semiflexible gastroscope

But the rigid scope had serious drawbacks. Instrumental perforations were not uncommon and as a result, the initial enthusiasm for the procedure waned. Schindler set about to invent a semiflexible gastroscope with the collaboration of a Berlin instrument maker, Georg Wolf. Working on the optical principle proposed by Hoffmann in 1911 that lenses attached to a flexible wire at short focal intervals from one another would bend light, Wolf and Schindler produced such a scope in 1932. It had a flexible distal 30cm tip which was made of a bronze wire spiral and which incorporated a number of short convex lenses. This instrument was a major advance at that time, as not only was it much safer, it also provided significantly more information about the stomach. Despite the temporary setback of World War II and the incarceration of Schindler himself in a Nazi concentration camp, the semiflexible scope gained many ardent followers. This was in no small measure due to Schindler who was an enthusiastic and indefatigable teacher. Following his release from prison in 1934, Schindler and his family emigrated to the United States, where he was given an academic position at the University of Chicago. He continued his good work and Chicago soon became a "Mecca" for gastroenterologists and endoscopists. In 1941 Schindler, started, at a meeting in his own house, the American Gastroscopic Club, the forerunner of the American Society of Gastrointestinal Endoscopy (ASGE). The ASGE chose to recognize his tremendous contributions in 1962, as a Schindler Award Recipient, the society's highest tribute for contributions to the endoscopic field.

Dawn of a new era - Fiberoptic endoscopy

The Schindler-Wolf semiflexible gastroscope was the standard bearer for gastroscopes until 1957 when a further dramatic innovation, that of fiber optics was introduced into endoscopes. The inspiration for the making of a fiber scope was a 1954 paper appearing in Nature entitled "A flexible fiberscope using static scanning" co-authored by HH Hopkins and NS Kapany. In this paper Hopkins and Kapany showed that light could be transmitted through a single glass fiber based on the principle of total internal reflection. Basil Hirschowitz who was then a GI fellow at Ann Arbor, University of Michigan was fascinated about the possibility of using

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fiberoptics in endoscopes and with the encouragement of his former mentor, Sir Francis Avery Jones paid a visit to Hopkins and Kapany at the Imperial College, London. On his return, Hirschowitz enlisted the help of Wilbur Peters, a physicist and Larry Curtis, a sophomore student at the University of Michigan. Working feverishly with his co-workers, Hirschowitz was able to develop the first fiber optic gastroscope, which he presented to the American Gastroscopic Society in Colorado Springs in May 1957. Before the year was out, the American Cystoscopic Makers Inc (ACMI) contracted to manufacture fiberscopes under license and in October 1960 the ACMI 4990 Hirschowitz gastroduodenal fiberscope was available for sale and use. Hirschowitz reported his initial experience with the fiberoptic scope in the Lancet in 1961. By the late 1960s, fiber optics had almost completely displaced lens-optic gastroscopes. The Olympus Optical Company's (Tokyo, Japan) first fiber gastroscope was introduced in 1968. ACMI produced the panendoscope in 1970. Japanese and American manufacturers rapidly and competitively improved fiber-optic instruments. In the words of Hirschowitz, "There seemed to be no end to the ingenuity of endoscopists and instrument makers and the application of fiber-optic instruments to diagnosis and therapy".

While developments were taking place in the United States, Dr Tatsuno Uji and engineers from the Olympus Optical Company, Japan, had developed a gastrocamera in 1952. In essence it consisted of a miniaturized intragastric camera which could take high quality pictures. It was presented to Western endoscopists at the World Congress in Washington DC in 1958. Olympus Optical Company subsequently developed a model incorporating fiberscope and a gastrocamera in 1963 but the gastrocamera had been quickly rendered obsolete by fibreoptic scopes.

Fiberoptics was soon introduced for examination of organs other than in the upper gastrointestinal tract. Bergein Overholt presented his experience with the first fiberoptic sigmoidoscopy in 1967 at the ASGE meeting and subsequently in 1969 fiber optic colonoscopy and shortly thereafter, endoscopic polypectomy was performed by Wolff and Shinya in New York. Colonoscopy opened up a whole unexplored field of endoscopy and was particularly significant in the face of widespread skepticism at that time. Comments included: "it requires a tricky skill that few will be able to acquire", "it will tell you nothing a good radiologist couldn't show" etc.. Time has however, proven otherwise.

Further innovations

One of the most exciting and elegant innovations of fiber optic endoscopy was the canulation of the ampulla of Vater. WC Watson of Glasgow in 1966 reported in the Lancet, his observations of the ampulla of Vater with a flexible duodenoscope and concluded that " endoscopic examination of the ampulla of Vater could be helpful in the diagnosis of biliary and pancreatic disorders". McCune and colleagues from George Washington University reported in 1968 the first successful canulation of the pancreatic duct using an Eder duodenoscope with a makeshift housing for a canula. But the Japanese were responsible for developing endoscopic retrograde cholangiopancreatography (ERCP) as a standard diagnostic procedure. Itaru Oi and Kunio Takagi and colleagues together with engineers from the Machida Manufacturing Company and Olympus Optical Company developed specially designed "ERCP" scopes: the FDS and JF and JFB-2 models respectively. In 1973, Keichi Kawai from Japan and Meinhard Classen and Ludwig Demling from Germany simultaneously reported endoscopic electrosurgical sphincterotomy of the papilla for the non-operative extraction of common bile duct stones. In 1980, Nib Soehendra from Hamburg, Germany introduced stenting of the biliary system with plastic tubes. The range of innovations that have come out in this field from pioneer ERCP-dedicated endoscopists such as Peter Cotton and Kees Huibregtse have been truly amazing.

Endoscopic ultrasonography, a more recently developed specialty in the 1980s combines the diagnostic capability of an ultrasound probe and that of a fiber optic scope. Lutz and Rosch from Germany was the first to report on a transgastroscopic ultrasonography and subsequently Strohm and colleagues and Eugene DiMagno from Mayo Clinic, improved on the applicability of these instruments. The first mechanical sector scanning instruments for endoscopic ultrasound displayed 180 ^{0} images. The subsequent introduction of a full 360 ^{0} image endoscope, the Olympus GF-UM3, provided the first commercially available echoendoscope.

Videoendoscopy provided perhaps the latest innovation in GI endoscopy. It is certainly not a new technique of performing endoscopy but a new way of viewing, acquiring and storing images in the digital form. The mechanical control and internal lumen subsystems remained essentially unchanged. The first videoendoscope system was developed by Welch Allyn Incorporated (Skaneatales, USA) and exhibited at the ASGE meeting in 1983. It drew little interest the as the prevailing attitude was " why replace something that is perfectly good with one that provided an image of lesser definition and at greater cost?". Again time has been the best judge. With further development and refinement of the system predominantly by the Japanese companies, Olympus Optical Company,

Pentax and Fujinon, videoendoscopy has achieved not only "maximum" quality imaging, the ease of storage and transfer of images makes it the standard system in all forms of endoscopy today.

What of the future?

Videoendoscope instruments with even better imaging reaching a million pixels have been produced. Magnifying endoscopes and chromoendoscopy have enhanced the details of the GI mucosa and fluorescence and infra red spectroscopy have been able to demonstrate submucosal details. Endosonography and more recently optical coherence tomography (OCT) have enabled endoscopists to examine beyond the lumen of the GIT and OCT has allowed us to start thinking of an "optical biopsy" diagnosis. Miniaturization of electronic components may allow construction of new types of endoscopes that no longer require external wires, cables, or optical fibers. A "video pill" would allow the operator to perform a "drive through" endoscopy.

The development and the subsequent widespread use and application of GI endoscopy ranks as one of the landmarks in annals of medicine and gastroenterology. GI endoscopy is indispensable to the field of gastroenterology and gastrointestinal surgery. The "endoscope" has evolved from a candlelit instrument in the early 19th century to its current state of sophistication. Procedures are now performed in well-planned dedicated endoscopy units with dedicated staffing. Training, credentialling, audit, re-training and maintenance of standards of practice are important issues. The field of GI endoscopy has developed into a distinct and separate field on its own, with journals, workshops and international meetings and a global fraternity of its own. With continuing advances and technical sophistication, GI endoscopy will remain an exciting field stimulating further research and spearheading advances in the diagnosis and treatment of gastrointestinal diseases.

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