MILESTONES IN THE EVOLUTION OF ENDOSCOPY: A SHORT HISTORY*

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INTRODUCTION

The earliest exploration of the interior of the human body was attempted in antiquity by Greek, Roman and Arab physicians peering into its orifices through specula, the dim illumination of candle or oil lamp being reflected internally with mirrors.

Rectoscopes were familiar to Hippocrates (460–377 BC). Quite advanced three- and four-pronged dilatation specula were recovered from the ruins of Pompeii (AD 79). Marasaumel in the Babylonian Talmud (AD 257) described vaginal specula. The first use of a glass mirror to view the uterine cervix was recorded by the great Arab surgeon, Albucasis of Cordoba (Abu Al-Qasim Khalaf ibn Abbas az Zahrawi) (AD 936–1013). No advance on these limited capabilities was recorded until the beginning of the nineteenth century.

THE ERA OF ENDOSCOPY WITH RIGID INSTRUMENTS

The earliest advances were made by urologists, perhaps because the female urethra is one of the shortest conduits into an interior viscus.

On a tombstone in a Frankfurt cemetery an epitaph records:

> . . . in memory of the devout deceased soul of Philipp Bozzini, medical doctor, German born. This urologist was the first who tried seriously to look into the hollow cavities of the human body by ingeniously conducted light . . .

FIGURE 1
Philipp Bozzini (1773–1809). Designer of the first endoscope.

Philipp Bozzini (Figure 1) was born in 1773, and his death from typhoid in 1809, aged 35 years, occurred only a few years after the publication of his experience with the Lichtleiter (light conductor) which he designed to accommodate different sizes and shapes of specula for the various bodily orifices. The essential components of the instrument were a beeswax candle as light source and a silver mirror to reflect the light through the speculum, down which he peered through a small hole in the centre of the mirror (Figure 2). This endeavour marks the beginning of the era of rigid endoscopes.[1] One of the instruments, delivered for trial by Bozzini in 1806 to the Josephinum, the surgical military academy in Vienna, appears to have been stolen by an English soldier in the Coalition Wars. It was eventually acquired by Irwin Bush of the American College of Surgeons; this is presumably the one, in silver covered in sharkskin, to be seen in that College's museum in Chicago.

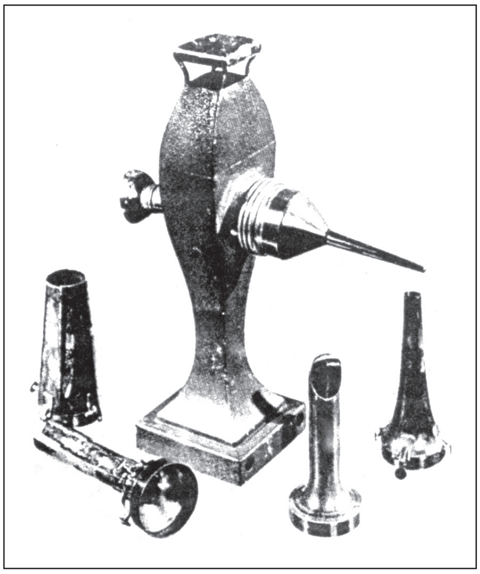

FIGURE 2
Bozzini's Lichtleiter, 1805.

The attachments allowed inspection of the vagina, urethra, the female bladder, the rectum and the upper air passages. The effectiveness of the Lichtleiter is uncertain because

*Based on a paper given on the occasion of the 50th anniversary of the Edinburgh Gastrointestinal Unit.

inter-faculty rivalry in Vienna led to the rejection of the instrument by one group as 'but a magic lantern'. Yet Bozzini had claimed that, with the device inserted into the vagina, writing on a piece of paper placed in the fundus of the uterus could be easily read.

In Paris in 1826 a speculum 'urethro-cystique' was demonstrated by Pierre Salomon Segalas to the members of the Academie des Sciences. This was modified from the Bozzini instrument and enabled Segalas to diagnose disorders of the urethra and bladder. It had a safety feature in a gum elastic catheter as introducer (Figure 3).[2] A year later, in the *Boston Medical and Surgical Journal*, an American, John Fisher, published an account of an instrument 'involving the same principles as Segalas'' which he claimed to have devised while still a student in 1824.[3] It was promoted in response to the need to examine the cervix of an unusually shy young woman who could not countenance him coming so close to her pudenda as was required by the standard vaginal speculum. In his paper he wrote that he had 'a strong and chivalrous desire to protect the feelings of delicacy of this maiden'. To achieve this he designed an elongated and angulated speculum and added a double convex lens to sharpen the image (Figure 4).

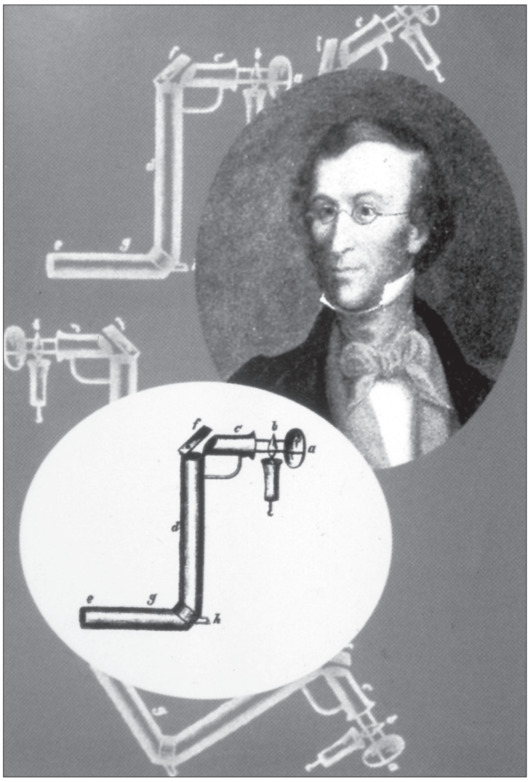

FIGURE 4
John Fisher (1797–1850) and his elongated, angulated speculum.

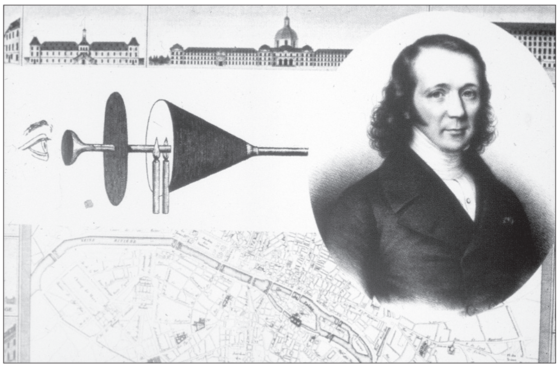

FIGURE 3
Pierre Salomon Segalas (1792–1875) and the speculum 'urethro-cystique'.

Fisher in this communication mentions that a Professor Patterson had suggested that galvanism might supply an answer to improved illumination of body cavities, a thought that preceded the actual introduction of electricity to endoscopy by some 50 years.

A generation later, in 1853, another urologist in Paris, Antonin Desormeaux, rejecting the available electricity-storing batteries as too heavy to move around (an assistant being needed to carry and adjust them), introduced the use of a lamp burning a mixture of alcohol and turpentine (Figures 5 and 6). To this a series of endoscopic tubes, of various diameters to suit the different orifices, were fitted. His rectoscope, demonstrated to the Academie des Sciences, was 12 cm long and thereafter sigmoidoscopes of increasing length were manufactured. By around 1890 the length of the rigid steel tube stabilised at 30 cm. This remained standard for the sigmoid colon for 60 years until the advent of flexible fibreoptic models.

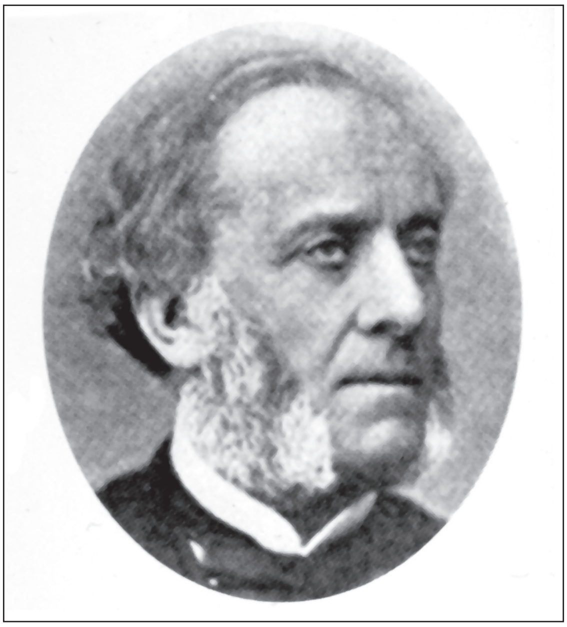

FIGURE 5
Antonin Desormeaux (1815–81), designer of the first functional cystoscope.

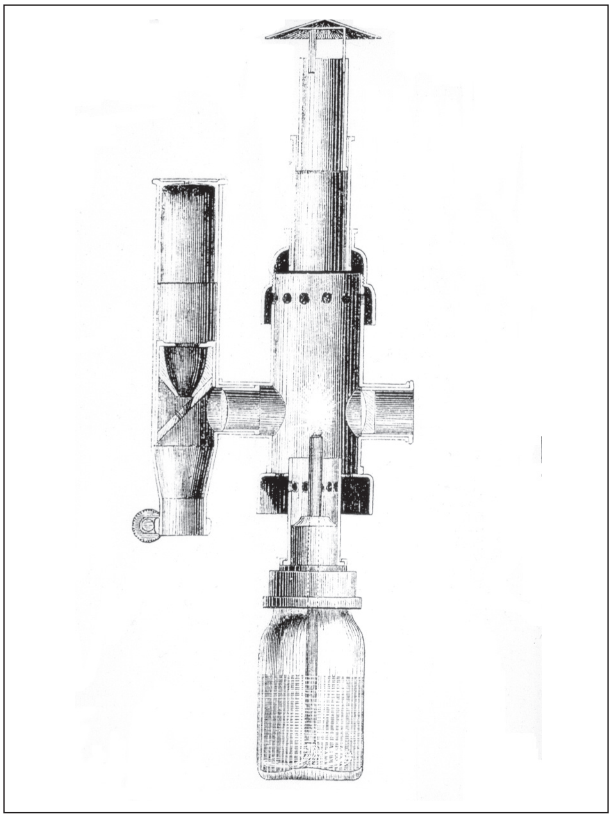

FIGURE 6
Desormeaux's alcohol and turpentine lamp.

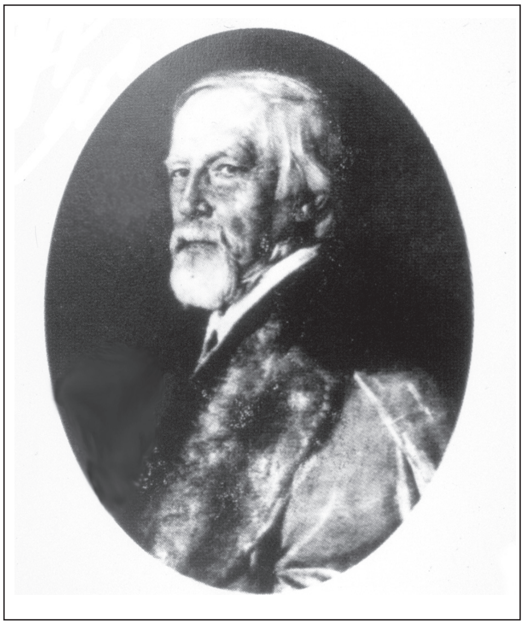

FIGURE 7
Adolf Kussmaul (1822–1902) who made the first attempts at gastroscopy in 1868.

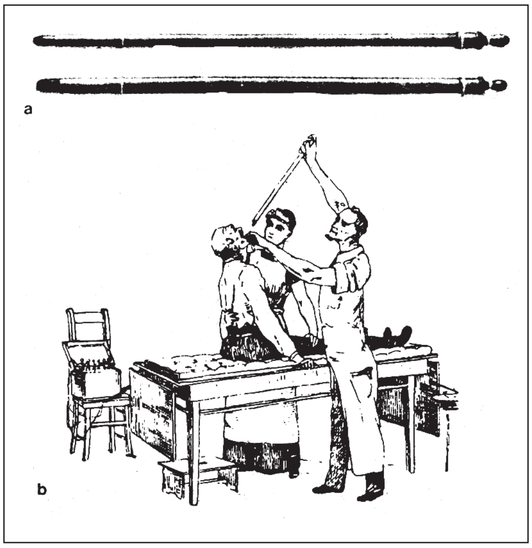

FIGURE 8
Kussmaul's technique for the introduction of his gastroscope.

Perhaps of greater impact was the monograph Desormeaux produced in 1865, *De l'endoscopie*, which greatly increased interest in the discipline and is said to have stimulated American instrument makers to commence the production of endoscopes.[4]

THE DEVELOPMENT OF ALIMENTARY ENDOSCOPY

The shift of interest to the alimentary tract began in 1868 at a meeting of the Freiburg Society of Naturalists when Adolf Kussmaul – with the good sense to use a professional sword-swallower for the demonstration – passed down the oesophagus into his subject's stomach a hollow, rigid metal tube – the first gastroscope (Figures 7 and 8). Illumination was provided by a Desormeaux lamp attached proximally, but visibility was poor. Kussmaul subsequently abandoned gastroscopy, but he had kick-started it as a medical pursuit and it took off when a convenient electricity supply became available.[5] This important step centred on a Viennese instrument maker, Joseph Leiter.[6] From 1870 he had worked on the development of cytoscopes with the urologist Maximillian Nitze. A number of others had been experimenting with loops of platinum wire as filaments for electric lamps, the current provided by galvanic batteries. Leiter and Nitze had some success when they devised a method of cooling the lamp and, in 1879, followed up a successful cytoscope with a crude gastroscope using the same technique.[7] Unhappily, when this was well received, they argued over the distribution of the resulting credit, and they are said to have come to blows and engaged in vituperative public correspondence.

Meanwhile others – principally Carl Stoerk and Freidrich Semleder – had devised oesophagoscopes but had failed to overcome the difficulties with illumination. Stoerk then interested Johannes von Mikulicz in the problem. This Polish surgeon (Figure 9) had been the assistant of the redoubtable Viennese abdominal surgeon Theodore Billroth. The collaboration with Nietze having ended, Leiter was free to begin work with von Mikulicz. They shifted the light to the distal end of the tube but retained

FIGURE 9
Johannes von Mikulicz (1850–1905) advanced oesophagoscopy and gastroscopy.

FIGURE 11
Porter carrying endoscope and battery, 1879.

the angulation of the shaft (during development, advantage was taken of a willing elderly female patient of von Mikulicz who had an aptitude for swallowing tubes). The prototype oesophagoscopes and gastroscopes were moderately effective but general anaesthesia was required for most subjects (Figure 10).[8] It seems from his writings, however, that von Mikulicz used his gastroscope almost entirely to investigate normal appearances on healthy persons; only once was there a description of a pathological lesion. Furthermore, the cumbersome nature of the apparatus required porterage (Figure 11).

Fortuitously, in 1885, the International Exhibition of Electricity was held in Vienna. There Leiter saw Edison's incandescent electric lamps and promptly adapted the endoscopes to incorporate them. Von Mikulicz contributed prodigiously to medicine but died of carcinoma of the stomach at 55 years of age. No less than 18 items of procedure and pathology are eponymously associated with him.

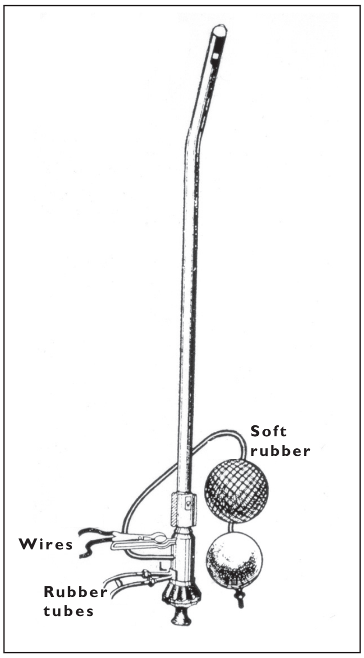

FIGURE 10
The Leiter–Mikulicz gastroscope, 1881.

The safe use of these rigid instruments required great care and demanded of the endoscopist a measure of virtuosity. At the end of the nineteenth century, Chevalier Jackson, a prominent American exponent of broncho-scopy, went on to develop, and successfully use, open-tube rigid oesophagoscopes and gastroscopes, under ether-induced general anaesthesia.[9] One use he made of a long oesophagoscope with a side-attached aspirating tube was to remove from their stomachs small toys swallowed by children. In the hands of the unskilled, however, these endoscopes were difficult to use and sometimes harmful, and were eventually abandoned by those with less skill as dangerous in practice. Jackson suggested that the problem with the early gastroscopes arose from their development out of cystoscopes by Nietze and Leiter and, as such, were unsuited to the anatomy and internal conditions of the stomach. Virtuosity for the introduction and manipulation of the endoscopes remained a requirement throughout the following seven decades until the appearance of fully flexible instruments utilising fibreoptics.

In 1896 Theodore Rosenheim, in Berlin, published his experience with a triple-tube gastroscope, the innermost tube bearing a row of short-focus lenses, the middle one a lighting system which had reverted to the use of a water-cooled platinum wire loop lamp and an outer tube with a scale of measurement (Figure 12). It is uncertain why, after using it successfully 100 times, he abandoned gastroscopy completely, but it was rumoured that a perforation had complicated a procedure.[10]

With existing instruments there remained the need to overcome the problem of the 'blind' areas of the stomach

(Figure 13). George Kelling in Dresden, in 1898, devised a gastroscope with a flexible lower segment, the tip of which could be angulated with a rather clumsy system of wires controlled proximally; this instrument did not find wide favour.[11] Elsner reintroduced, in 1911, the Rosenheim instrument modified with the safety device of a rubber tip for introduction. Despite the lens system being easily obscured by mucus and gastric contents, it was well taken-up and remained the standard gastroscope for the next 20 years (Figure 14).

Meanwhile, in Munich, Michael Hoffman, an optical engineer, had shown that light, and an image, could be conducted around a bend with a flexible tube containing a row of prisms and lenses. This work may have facilitated the next important step in the evolution of gastroscopes.

THE ERA OF SEMI-RIGID ENDOSCOPES

In 1920, in Munich, a charismatic physician, Rudolf Schindler, came across an old Elsner instrument while browsing in a shop where it had lain unused for ten years. He improved it with a facility for insufflating air which largely overcame the problem of the lens smearing. It had the rubber tip mounted separately on an inner tube used on introduction and then withdrawn, and in its place a tube carrying the lens and light system was inserted. At this time wholly rigid tubes were still in use and some strange claims were made: a German endoscopist, Sternberg, used one resembling an elongated cystoscope which he introduced with the patient in the knee-elbow position. He claimed to have carried out 20,000 examinations with only six adverse incidents and that one patient had been examined 100 times. When, however, he was, along with Schindler, invited to demonstrate his skill at a meeting of surgeons in Munich in 1923, he was unable to pass the instrument, and ruptured the subject's oesophagus; this unfortunate individual subsequently died of mediastinitis. Schindler, awaiting his turn, then declined to perform but did so later in more private circumstances.[12]

Schindler successfully used the modified Elsner gastroscope until 1932 when he reported his experience with a semi-flexible successor in which the lower third was replaced by a flexible bronze spiral covered in rubber, resulting from a collaboration with the renowned Berlin instrument maker George Wolf (1873–1938). Together they devised an inner tube filled with short-focus lenses which could be bent in any direction to an angle of 34° without visual distortion (Figure 15). The use of this instrument in Rudolf Schindler's uniquely capable hands spelled the end of the era of rigid endoscopy and the semi-flexible successor remained dominant until 1957.

Some of its success reflected other aspects of Schindler's personality: an inspiring teacher, he recorded meticulously every examination; researched into the structure and pathology of the upper alimentary tract; introduced photography and microphotography; and published his results. His monographs on gastroscopy and gastric mucosal pathology were groundbreaking and were read extensively in Europe and the US. Would-be endoscopists flocked to Munich for training. There was an additional

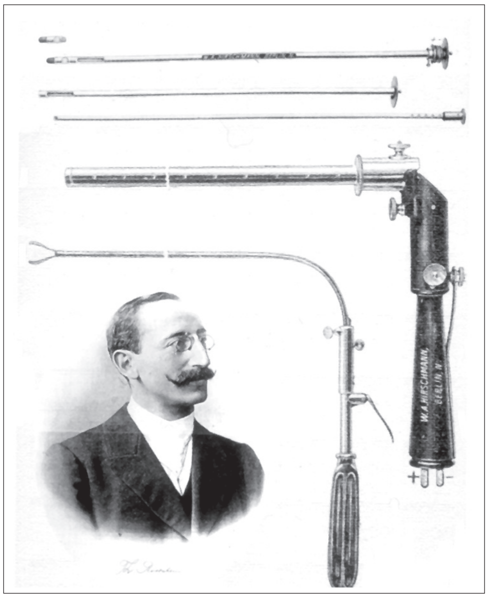

FIGURE 12
Theodore Rosenheim and his triple-tube gastroscope, 1896.

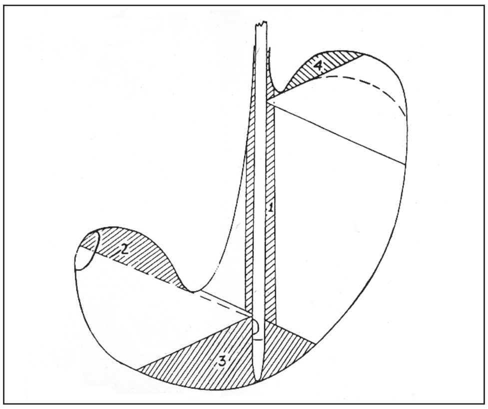

FIGURE 13
Diagram illustrating the areas of the stomach 'blind' to rigid gastroscopes.

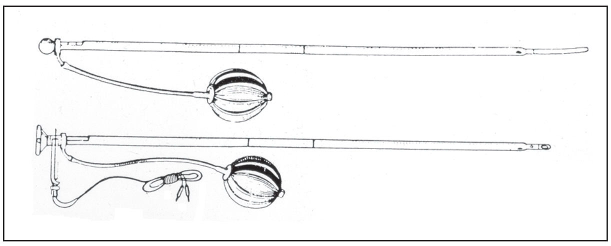

FIGURE 14
Rigid gastroscopes still in use by Schindler in 1922.

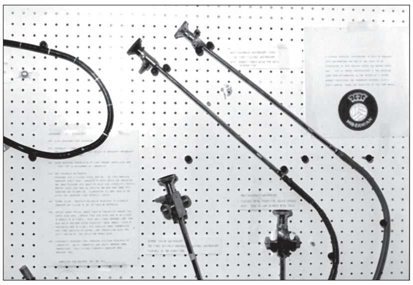

FIGURE 15
Examples of early, part-flexible, gastroscopes devised by Schindler and in use in the Edinburgh Gastrointestinal Unit in1952.

factor: his wife, Gabrielle Winkler. This charming lady, as beautiful as Schindler was handsome, had such a calming effect on patients about to undergo endoscopy, and was so adept at supporting and guiding the movement of the patient's head during and after introduction, that Schindler came to cancel any session at which, for some reason, Frau Schindler could not be present (Figure 16). Munich became the mecca of endoscopy.

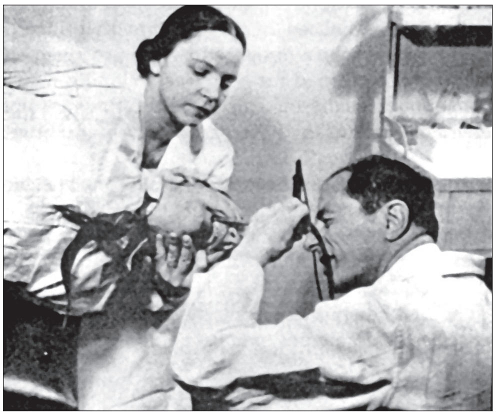

FIGURE 16
Rudolf Schindler assisted at gastroscopy by his wife, Gabrielle Winkler.

In the light of things to come, mention must be made of Heinrich Lamm, a medical student in Munich who, after hearing a lecture by Schindler in 1928, approached him and suggested that a bundle of glass rods might conduct light and images better than a system of lenses. Schindler was sufficiently impressed by Lamm to finance his further experiments. After two years of work, Lamm was able to observe the gastric interior with a prototype instrument and to photograph writing on a piece of paper placed in the stomach, though the image was somewhat blurred. Despite this, Schindler ceased his support of the project; there is no record of his reason for so doing. It is possible that Lamm had known of the studies of Daniel Colladon, an optical engineer in Geneva who drew attention, in 1841, to the phenomenon of light being carried around a curve in water, an observation that gave birth to the illuminated ornamental fountains which, in due course, began to decorate the great municipal squares and plazas of the world's cities. This was a clue relevant to endoscopy which was ignored by optical engineers, physicists and instrument makers for over a century.

Then, in 1934, when Schindler dismissed a housekeeper, the disgruntled woman went to the Gestapo, the National Socialists having seized power in Germany, and denounced him as holding anti-Nazi opinions. Schindler, a Jew, was arrested and sent to Dachau concentration camp. Non-Jewish German colleagues and colleagues in the US, Marie Ortomayer in particular, protested and urged his release. After six months in the camp, he was released and allowed to leave the country with his wife, who was not Jewish. They proceeded to the US where Schindler was given an appointment in Walter Palmer's department in Chicago as a visiting professor. From this time, Chicago became the new mecca of endoscopy and a by-product of Schindler's immigration was the promotion in the US of serious interest in the manufacture of endoscopes.

In 1941, the London surgeon Hermon Taylor had the Genito-Urinary Manufacturing Company devise a gastroscope with a flexible distal portion which, with proximal controls, greatly reduced the areas of the stomach that were difficult to visualise directly. This involved an increase in the diameter of the shaft and elongation of the rigid steel portion (Figure 17).[13] Schindler and others in the US were critical of this endoscope, believing it to be less safe for the patients, but in 1947, I taught myself gastroscopy with a Hermon Taylor and subsequently used one many thousands of times, without mishap, until the advent of the fully flexible instruments a decade later.

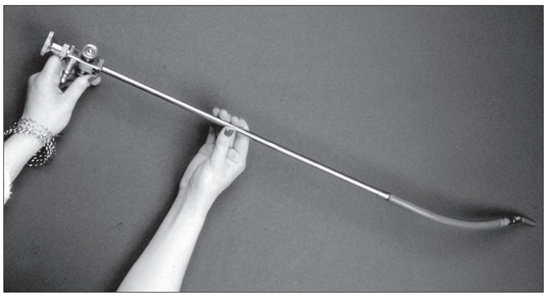

FIGURE 17
A Hermon Taylor gastroscope with controllable tip, used by the author from 1947 to 1957.

OESOPHAGOSCOPES: FURTHER MODIFICATIONS

Until 1947, oesophagoscopes remained fundamentally unchanged from those used by von Mikulicz in the 1880s, except for the incorporation of an Edison lamp for illumination. Chevalier Jackson's success, previously referred to, was achieved with rigid tubes of varying diameters for different purposes, with the illuminating lamp at the distal end. Edwin Boros in the US, altered the Jackson instrument (to facilitate introduction) by having the most distal portion of the shaft rendered as a metal spiral coil, similar to that used in the Wolf–Schindler gastroscope; this section was then straightened out with a rod after full insertion. This instrument was superseded in 1949 by the oesophagoscope manufactured by the Eder Instrument Company to the design of A Ray Hufford, especially when further improvement was made substituting a magnifying telescopic eyepiece for the previous lens-in-a-tube system. It became the standard instrument of the day.

In London, meanwhile, as a few physicians in the UK began to undertake oesophagoscopy, Frances Avery Jones devised an easy-to-pass slim instrument, but I found the internal diameter inadequate for the passage of bougies large enough to relieve strictures and the distally placed bulb was easily covered in blood and mucus, thereby obscuring vision. The Genito-Urinary Manufacturing Company made for me in 1956 a wide-bore oesophagoscope with a distal flexible section and a proximal lighting system which overcame the disadvantages of the Avery Jones model (Figure 18). By 1963, however, the principles of flexible fibreoptics were extended to oesophagoscopes and, in these, the excellent vision, the ease of biopsy and the later addition of a balloon dilatation facility eliminated the need for the traditional rigid instruments for almost all situations.[14]

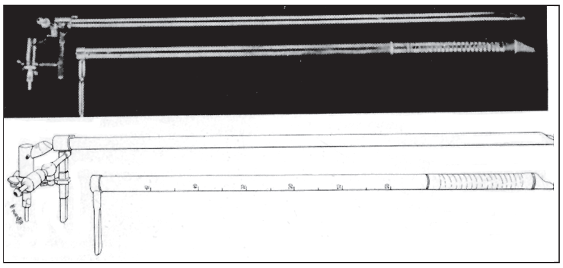

FIGURE 18
The wide-bore oesophagoscope with part flexible introducer and proximal lighting devised by the author in 1956.

THE THIRD ERA: THE APPLICATION OF FIBREOPTICS; FULLY FLEXIBLE ENDOSCOPES

At almost the same time as Lamm in Germany had his idea of supplanting lens systems with glass rods, Logie Baird in Britain had, in 1927, made a patent application for the use of curved glass rods to transmit light around a curve. He failed to take the idea any further.

The birth of fibreoptic endoscopy lies in three mealtime chats in 1954.[15] Timothy Counihan, a cardiology registrar at the Hammersmith Hospital in London, while lunching in the canteen with Keith Henley, a gastroenterology registrar, mentioned seeing in *Nature* a paper entitled 'A flexible fibrescope using static scanning' which, he mused, might have a practical application in gastroenterology.[16] A short while after this conversation, Henley was at Ann Arbour, Michigan, US in relation to a possible job opportunity (in due course he became Professor of Internal Medicine at that institution). During the visit he had lunch with a Gastroenterology Fellow, Basil Hirschowitz, born in South Africa and trained in the specialty with Avery Jones at the Central Middlesex Hospital in London. In the course of the meal, Henley heard from Hirschowitz of his research into the production of a miniature camera which could be introduced into the stomach to obtain images of diagnostic value. Henley told Hirschowitz about the paper in *Nature*, who then lost no time in telephoning Kapany, one of the paper's authors, and arranging to meet him in London the following week. Over dinner with Kapany he probed deeply into the details of the study reported in *Nature*.

In the same issue of *Nature* was a communication from Delft in Holland by ACS van Heel, describing the preparation of flexible image rods with bundles of transparent plastic, each coated with a layer of low refractile index and then with a thin coat of black paint.[17] Thus leakage of light through their walls from one fibre to another was prevented and an image projected on to one end of the bundle was recoverable at the other end, undistorted. In the paper by Hopkins and Kapany it is claimed that Hopkins thought of the idea in 1929 and only learned later of Baird's 1927 patent. It seems that Karl Storz (1911–96) had at some time earlier suggested to Hopkins (Professor of Applied Physics at Imperial College, London) the idea of coupling the transmission of light using fibres, together with a rod and lens optical system within an optical shaft to transmit images, an extension in effect of the idea of Hoffmann in Munich referred to earlier. With his postgraduate fellow Kapany, Hopkins researched the optimum way to coat glass fibres of 0·0025-inch diameter and to arrange them in a bundle so that the spatial relationship of each fibre to its neighbour remained unchanged throughout the length of the bundle. Light and image could then be transmitted even if the bundle was bent through 360°. They suggested the principle could replace the lens in endoscopes.

Hirschowitz returned to Ann Arbour with samples of glass fibres from Fibreglass Ltd in England and interested the Assistant Professor of Physics, C Wilbur Peters, in this potential for advancing endoscopy. Together with a student, Lawrence T Curtiss, Peters set to work. By 1956, Curtiss had resolved the problem of eliminating leakage of light through the wall of individual fibres by coating them with a mixture of highly refractive glass core and low refractoriness, melted together. A year later they had an assembly of a working fibre bundle of adequate length, a light source intense enough for colour photography, a system for applying torque and a waterproof coating overall. Hirschowitz then passed this bundle on himself without medication or surface anaesthesia and, a week later, successfully on a patient (Figures 19 and 20). Fibreoptic, fully flexible endoscopy was born.[18]

At a meeting in 1957 of the American Gastroscopy Society, Hirschowitz successfully demonstrated the prototype. Rudolf Schindler was in the audience and he mentioned the experience in 1928 with Heinrich Lamm and how the glass rods were unsatisfactory because they were not coated and they had failed to enrol a physicist to advance the idea. Curiously Lamm, in 1957, was now working as a general physician in Texas, having also had to flee Nazi Germany, but thereafter showed no further interest in endoscopy design and had no contact with Schindler.

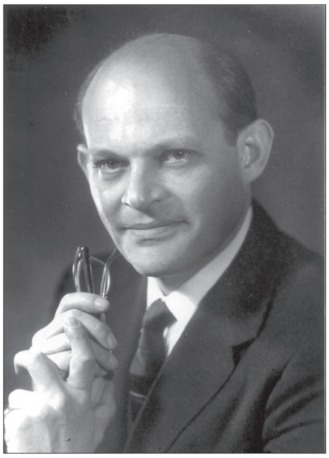

FIGURE 19
Basil Hirschowitz, 1958.

FIGURE 20
Hirschowitz tests the first ACMI fibreoptic gastroscope.

Three years later, in 1960, ACMI Ltd produced the first commercial gastroscope, a side viewing instrument with a distal incandescent lamp. In 1962 Robert Kemp, a Liverpool gastroscopist, suggested the introduction of a controllable directional tip which, taken up by ACMI, greatly improved the capability of the gastroscope.[19]

Between 1962 and 1972, a series of other modifications by both American and Japanese instrument makers resulted in endoscopes with separate channels for suction and the introduction of water and air, controlled tips acting in four planes and an elongated model for entry into the duodenum. There was also an ultraslim model which could be passed down a channel in a standard instrument. The Olympus Company introduced a lens-based gastrocamera, the film capsule of which lay in the tip of the gastroscope, but it had limited appeal and was soon replaced by effective 35 mm cameras with synchronised flashes which were mounted on the eyepiece.

EXTENSION OF ENDOSCOPY TO THE PANCREAS AND BILIARY SYSTEMS

In 1966 Willie Watson, a Glasgow gastroenterologist, viewed the Papilla of Vater with a duodenum-entering endoscope and suggested that the ampulla could be explored.[20] Indeed, in 1965, two radiologists, Keith Rabinov and Morris Simon, had cannulated the pancreatic duct with a tube introduced through the mouth and fluoroscoped into position.[21] In 1968, the ampulla was cannulated per endoscopy.[22]

By 1970, largely due to ideas from Itaru Oi and K Tagaki, Japanese endoscope manufacturers produced cannulae with four-way tip control which greatly widened the field of investigation. In 1974, Classen and Demling split the Papilla of Vater with a bowstring wire diathermy enabling the removal of a gallstone from the biliary tract.[23] In Britain Peter Cotton, first at Middlesex Hospital and later at the Dukes and Carolina venues in the US, became the premier exponent, extending the procedures through from endoscopic sphincterotomy and removal of calculi to lithotripsy and the therapy of biliary and pancreatic malignancy (Figure 21).[24]

APPLICATION TO THE LOWER ALIMENTARY CANAL

In 1955 Blankenhorn and colleagues, in order to measure the length of the entire alimentary canal, and to obtain samples of contents at different levels, had passed an anchored, long, soft, fine bore tube through the mouth and waited for it to appear at the anus.[25] Cognisant of this study, in 1963 two physicians at the University of Cagliari in Sardinia, Luciano Provencales and Antonio Revignas, repeated the procedure but modified the technique by the addition of a simple pulley system assembly with a small loop in the distal end of the 4·5 m proximally fed tube through which they threaded another 3 m tube doubled on itself. When the combined system emerged from the anus, a Hirschowitz side viewing gastroscope was attached to the end of it, and then by gentle pushing and traction on the pulley, the gastroscope was successfully passed to the caecum. Colonoscopy was born (Figure 22).[26]

A series of colon-dedicated endoscopes followed from

FIGURE 21
Peter Cotton, 2000.

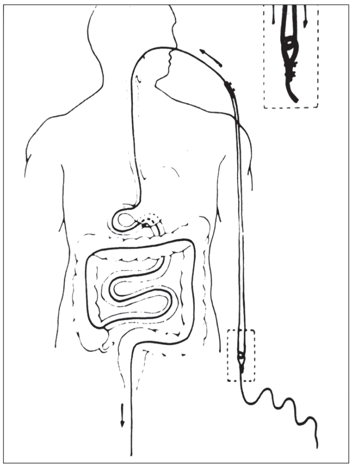

FIGURE 22
The end-to-end alimentary intubation with the Provenzales–Revignas pulley assembly attached, 1965. The progenitor of colonoscopy.

the ACMI Ltd and Olympus companies culminating in instruments with optimal angle of vision, steerability of tips through 360° and effective biopsy and other adjuvant facilities for diagnosis and treatment, in particular polypectomy. In Britain, Paul Salmon in Bristol was a prominent early exponent, and Christopher Williams at St Mark's Hospital became the supreme practitioner and teacher of colonoscopy (Figure 23).

In the US, Bergen Overholt developed along with the Eder Instrument Company a fully flexible sigmoidoscope and other American and Japanese models soon followed.[27] The superiority of this instrument for both patient and doctor (it could be safely used in family practice circumstances) thereafter limited the requirement for rigid sigmoidoscopy.[28] One of the most important advances was the development of polypectomy using wire loop snares passed through the flexible endoscopes. These were pioneered by William Wolff and Hiromi Shinya, and led on to colon cancer surveillance and timely interventions.[29–31]

THE ERA OF ELECTRONIC DEPENDENT ENDOSCOPY AND THE FUTURE

In 1983 the first endoscope without fibreoptic transmission of the image was produced by Welch Alleyn Incorporated in New York. At the tip of the instrument was an electronic sensor consisting of a packed grid of photocell receptors which transmitted images electronically to a video processor and then to a television monitor. Improved versions became available from the Olympus Company and other Japanese manufacturers. Subsequently, linkage with a computer enabled automated acquisition of data. This electronic advance facilitated the training of both endoscopists and nursing assistants as well as adding greatly to the interest of all present in endoscopy theatres including, often, the patients.

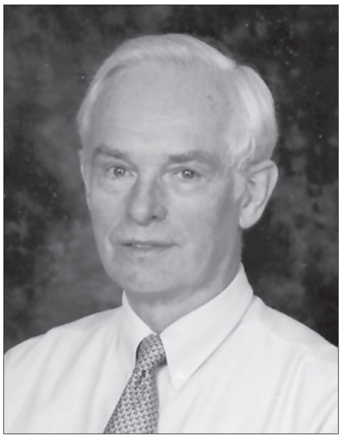

FIGURE 23
Christopher Williams in 2001.

Major changes in practice included the extension of the diagnostic and therapeutic capabilities of endoscopists to the pancreatic and biliary systems and the use of per-ampullary probes, balloons, retrieval baskets for stones and stents for strictures; also further facilitated was an attack on malignancy *in situ*. The need for intra-abdominal surgery was further restricted.

A major advance, not yet fully evaluated, is the incorporation of ultrasound technology. The use of ultrasonic pulses for measuring biological changes in tissues was promoted 50 years ago by JJ Wild.[32] A series of studies of ultrasonic probes attached to endoscopes, later with miniaturised probes passed through the endoscope channels, has imaged lesions in the pancreas, mediastinum and in the peri-gastric and peri-oesophageal tissues, thus facilitating enormously the evaluation of suspect malignancies, operability and also the variceal effects of portal hypertension. Needles can be guided into position for diagnostic sampling.[33–6] The assessment of lesions in the recto-sigmoid region has also been facilitated with these techniques.

Recently, zoom-equipped video endoscopes, capable of image magnification by 100-fold, promise to facilitate the diagnosis and management of mucosal disorders such as coeliac disease and the assessment of mucosal changes after transplantation of intestine for the short gut syndrome.

In the current era, there is promise of a wireless endoscopy. Research with miniaturised charge-coupled semi-conductor device cameras, linked with tiny transmitters, antennae, battery and light sources, suggests the possibility of transmitting moving colour television images without the need for electric or fibreoptic cables (Figure 24).[37] The tiny system would be swallowed by the patient in much the same fashion as were radio telemetering capsules (for measuring such parameters as pH in the alimentary canal) decades ago. Concomitantly, research is in hand on propulsion devices which, with external controls over the contractility of muscle in the wall of the gut, could propel such capsules to and fro as required.[38]

Thus, later in this century, traditional tube endoscopes may, for many purposes, be of historical interest only.

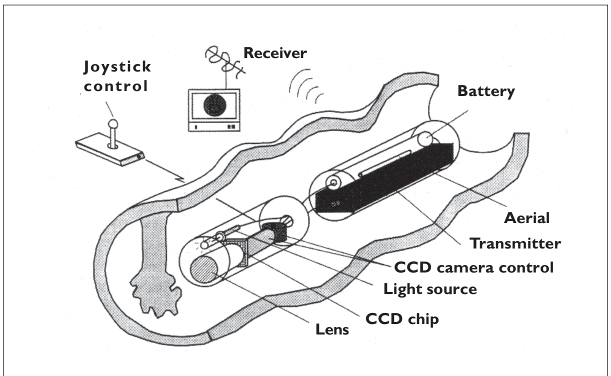

FIGURE 24
Wireless endoscopy.

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REFERENCES

1 Bozzini P. Lichtleiter, eine Enfindung zur Auschschauung innere Theiler und Krankheiten. *Journal der Practischen Arzneykunde und Wunderartzney kunst* 1806; **24:**107–24.
2 Segalas PR. Un moyen d'eclairer l'uretre et la vessie de maniere a voir dans l'interieur de ces organes. *Revue Medicale Francaise et de L'etrangere*. 1827; **1:**157–8.
3 Fisher J. Instruments for illuminating dark cavities. *Philadelphia J of Med and Physical Sciences* 1827; **14:**409.
4 Desormeaux AJ. De l'Endoscopie, instrument propre a' ec lairer certaines cavities interieures de l'economie. *Compte rendus de L'Academie des Sciences* 1855; **40:**692–3.
5 Killian G. Zur Geschichte der Oesophago und Gastroskopie. *Deutsche Zietschrift fur Chirirgie* 1900; **59:**499–512.
6 Newell OK. The endoscopic instruments of Joseph Leiter of Vienna and the present development of endoscopy. *Boston Med and Surg J* 1887; **117:**528–30.
7 Nitze M. Beitrage zur Endoskopie der mannlichen Hamblase. *Arch fur Klinische Chirurgie* 1887; **36:**661–732.
8 Mikulicz J. Uber Gastroskopie und Oesophagoskopie. *Weiner Medizinische Presse* 1881; **22:**1406–07.
9 Jackson C. Gastroscopy. *Medical Record* 1907; **71:**549–55.
10 Rosenheim T. Uber Gastroskopie. *Berliner Klinische Wochenshrift* 1896; **33:**298.
11 Kelling G. Endoskopie fur Spiesrohre und Magen. *Munchener MedizinischWochenschrifter* 1898; **49:**1556–9.
12 Schindler R. Gastroscopy with a flexible gastroscope. *Amer J Dig Dis Nutr* 1935; **2:**656.
13 Taylor H. A new gastroscope with controllable flexibility. *Lancet* 1941; **2:**276–7.
14 Lo Presti PA, Hilmi OM. Clinical experience with a new foreoblique fibre optic oesophagoscope. *Am J Dig Dis* 1964; **9:**690.
15 Henley KS. History of fibreoptic endoscopy. *Gastroenterology* 1980; **78:**1123.
16 Hopkins AH, Kapany NS. A flexible fibrescope using static scanning. *Nature* 1954; **173:**39–40.
17 van Heel ACS. A new method of transporting optical images without aberrations. *Nature* 1954; **173:**39.
18 Hirschowitz B, Peters CW, Curtis LE. Preliminary report on a long fibres cope for examination of stomach and duodenum. *Mich Med Bull* 1957; **23:**178–80.
19 Kemp R. A note on the fibrescope. *Lancet* 1962; **1:**88.
20 Watson WC. Direct visualisation of the Ampulla of Vater. *Lancet* 1966; **1:**902–3.
21 Rabinov KR, Simon M. Peroral cannulation of the Ampulla of Vater for direct cholangiography and pancreatography. *Radiology* 1965; **85:**693–7.
22 McCune WS, Shorb PE, Muscovitz H. Endoscopic cannulation of the Ampulla of Vater; a preliminary report. *Annals of Surgery* 1968; **167:**752–6.
23 Classen M, Demling L. Endoskopische Sphinkterotomie der Papilla Vateri and stein-extraction aus dem Ductus Choledochus. *Deutsche Mediziner Wochenschrift* 1974; **99:**496–7.

24 Cotton PB, Salmon PR, Blumgart LH *et al*. Cannulation of the Papilla of Vater via fibre-duodenoscope. Assessment of retrograde cholangiopancreatography. *Lancet* 1972; **1:**53.

25 Blankenhorn DH, Hirsch J, Ahrens EH. Transintestinal intubation: technique for measurement of gut length and physiologic sampling at known loci. *Proc Soc Exp Biol and Med*1955; **88:**356–62.

26 Provenzales L, Revignas A. Metodica originaledi esplorazione strumentale transanale polivalente del colon intero. *A Rap Med Sarda* 1966; **69:**131–40.

27 Overholt BF. Clinical experience with the fibreoptic sigmoidoscope. *Gastrointest Endosc*1968; **15:**27.

28 Winnan G, Berci G, Panish J *et al.* Superiority of the flexible to rigid sigmoidoscope in routine proctosigmoidoscopy. *NEJM* 1980; **302(18):**1011–12.

29 Wolff I, Shinya H. A new approach to colonic polyps. *Annals of Surgery* 1973; **178:**367–78.

30 Berci G, Panish J, Morgenstein L. Diagnostic colonoscopy and colonoscopic polypectomy. *Arch of Surgery* 1973; **106:**818.

31 Williams CB. Diathermy-biopsy – a technique for the endoscopic management of small polyps. *Endoscopy* 1973; **5:**215.

32 Wild JJ. The use of ultrasonic pulses for the measurement of biologic tissues and the detection of tissue density changes. *Surgery* 1950; **27:**183–8.

33 Lutz H, Rosch W. Transgastroscopic ultrasonography. *Endoscopy* 1976; **8:**203–5.

34 Hisanaga K, Hisanaga A, Nagata K *et al.* High speed rotating scanner for transgastric sonography. *Amer J Roentgenol* 1980; **85:**627–39.

35 Di Magno EP, Regan PT, Clain JE *et al.* Human endoscopic ultrasonography. *Gastroenterology* 1982; **83:**824–9.

36 Caletti GC, Brocchi E, Ferrari A *et al*. Value of endoscopic ultrasonography in management of portal hypertension. *Endoscopy* 1992; **24:**342–6.

37 Gong F, Swain P, Mills T. Wireless endoscopy. *Gastrointest Endosc* 2000; **51:**725–9.

38 Moss CA, Milis TN, Appleyard MN *et al*. Electrical stimulation for propelling endoscopes. *Gastrointest Endosc* 2001; **54:**79–83.