History of endoscopic devices for the exploration of the small bowel

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Abstract

The small bowel has gained new attention since the development of the wireless videocapsule in 2000, opening up the last 'black box' of the gastrointestinal tract. Although conventional push enteroscopy has been available for decades, since the wireless videocapsule new enteroscopes have been developed to examine the entire small bowel endoscopically in order to perform all conventional endoscopic procedures. The present review highlights the historic evolution of enteroscopy, from the first complete enteroscopy in 1971 over the current balloon-assisted and overtube-guided methods of enteroscopy to future directions of evolutions towards perfection. (Acta gastroenterol. belg., **2009**, 72, **335-337**).

Key words : review, enteroscopy.

Introduction

The *wireless videocapsule* has opened the last 'black box' of the gastrointestinal tract, enabling complete endoscopic visualisation of the small bowel. The company Given Imaging developed the technique and made it commercially available in 2000 (1). Since then numerous new developments have emerged, provided by different companies. Image quality, number of images recorded per second and battery life duration have all improved. Also the software to read the images becomes faster and smarter, and newer developments focus upon the design of an "interventional" capsule enabling tissue sampling, directed medication delivery and functional evaluation of the small bowel. The usefulness of the wireless video capsule in case of suspected small bowel bleeding is reflected by the recent partial reimbursement by the Belgian social security system.

Parallel to the development of the still merely diagnostic wireless videocapsule, conventional push enteroscopy was also subjected to a new evolution in order to perform all conventional endoscopic interventions throughout the small bowel. A review of the endoscopic developments to explore the small bowel is given below.

Yesterday's enteroscopy

Already in the 1970s complete enteroscopy using a conventional fibre endoscope was shown to be possible (2). By means of the *ropeway method*, a long fibre endoscope was pulled down the gastrointestinal tract after a rope loaded with a weight travelled from mouth to anus along with gastrointestinal peristalsis.

The *sonde type method* involved a long thin fiberscope with an inflatable balloon at its distal tip. The scope was inserted through the nose into the stomach from where it was further progressed beyond the pylorus using a conventional endoscope. Then the balloon at the tip of the fiberscope was inflated serving as a bolus that was acted on by intestinal peristalsis to carry the fiberscope down the small intestine (3). Although both the ropeway and sonde type method were effective to visualise the entire small bowel, with the possibility of tissue sampling, the procedures were very inconvenient and could last several days.

In the 1980s *intraoperative enteroscopy* became available as a feasible alternative that still stands today, although it requires a surgical approach through laparotomy. It can be performed via the oral route or the anal route but often enterotomy is necessary (4,5). Because of its invasiveness the technique is generally reserved for a last-choice endeavour.

At the same time *push enteroscopy* was developed and rightfully replaced these inconvenient and invasive enteroscopy methods during the 1990s (6). Longer conventional endoscopes were developed to proceed beyond Treitz's angulus. Push enteroscopy allows endoscopic evaluation of the proximal jejunum through the oral route. Because of the flexibility of the enteroscope and the tortuous length of the small bowel, complete enteroscopy is not possible. The pushing force used to progress the enteroscope throughout the small bowel results in stretching of the jejunum and thus hampering further progression and causing patient's discomfort. External abdominal compression is seldom efficient to withstand this loop formation. Although fluoroscopic control may help to identify the intra-abdominal loops, systematic use of fluoroscopy is not advised because of the risks attributed to radiation exposure (7).

The introduction of a semi-rigid *overtube* allows deeper intubation of the jejunum because it helps to

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straighten the enteroscope avoiding jejunal stretching (8). The use of an overtube was the first important evolution leading to a major improvement of insertion depth and increasing the yield of push enteroscopy. However, overtube-guided push enteroscopy only allows intubation of the jejunum without complete enteroscopy (9,10).

Today's enteroscopy

Although both intraoperative enteroscopy and overtube-guided push enteroscopy are still in use, new developments have emerged resulting in superior enteroscopy performance. The concept of *balloon-assisted enteroscopy* is a second major breakthrough in the evolution of the endoscopic disclosure of the small bowel. In 2001 the Japanese endoscopist Hirohito Yamamoto revolutionised the concept of overtube-guided enteroscopy by adding an inflatable latex balloon at the distal end of the flexible overtube, allowing better mucosal grip of the overtube stabilising its position within the intestinal lumen. In addition, a second inflatable latex balloon was added to the distal end of the enteroscope. With this self-made double-balloon model, he was able to intubate the entire small bowel through the oral route (11). Since 2003 the *double-balloon enteroscope* is made commercially available by Fujinon.

Following the success of double-balloon enteroscopy, Olympus manufactured another method of balloon-assisted enteroscopy, that became commercially available in 2007. S*ingle-balloon enteroscopy* is largely comparable to double-balloon enteroscopy. It consists of a latex-free balloon-loaded overtube lacking the balloon at the distal end of the endoscope. Both balloon-assisted methods are based upon the push-and-pull principle (12,13). It is a stepwise progression of the enteroscope through the small intestine with the balloon-loaded overtube used as a straightening device, allowing stable position within the intestinal lumen. The extra balloon at the distal end of the endoscope in the double-balloon system allows better anchoring of the endoscope within the lumen, whereas the single-balloon system allows faster progression of the endoscope throughout the small bowel (14). Both balloon-assisted methods allow complete intubation of the small bowel within a reasonable procedure time, although often a combined approach through the mouth and the anus is necessary to complete enteroscopy. In addition, all conventional endoscopic interventions, ranging from mucosal tissue sampling, local hemostasis, polypectomy and balloon dilation, can now be performed throughout the length of the small bowel thanks to balloon-assisted enteroscopy. Moreover, excluded gastrointestinal segments after former small bowel surgery have come within endoscopic reach, allowing ERCP procedures in patients with Roux-en-Y reconstruction of the small bowel (15). These important advantages have led to a rapid spread of both balloon-assisted enteroscopy systems in endoscopy suites throughout the world (16).

A novel alternative balloon-assisted method is the *NaviAid balloon-guided enteroscopy*, developed by Smart Medical Systems and distributed in Europe by Pentax. It consists of a standard enteroscope loaded with a stabilising latex-free inflatable balloon at the distal end of the endoscope and an advancing balloon-catheter mounted on the outer perimeter of the endoscope. The principle is comparable with double-balloon enteroscopy, without an overtube. Preliminay results reveal that this technique allows deep intubation of the small bowel, but complete enteroscopy has not been achieved (17). The results of multicenter trials are awaited in order to determine the clinical value of this new device.

Next to balloon-assisted enteroscopy, Spirus Medical adapted the overtube resulting in the development of the EndoEase discovery small bowel overtube. This *spiral overtube enteroscopy* allows rapid and deep intubation of the small bowel through the oral route (18). The endoscope remains in a stable position and by rotating the overtube with its raised helices, the small bowel is pulled backwards over the endoscope. It appears a feasible and fast method, however mucosal and transmural traction lesions have been reported (19). Comparative studies between balloon-assisted enteroscopy and spiral overtube-guided enteroscopy are awaited.

Tomorrow's enteroscopy

Both wireless video capsule enteroscopy and balloon-assisted and overtube-guided enteroscopy are in the midst of an evolutionary process. None of the above-described methods is ideal. Although wireless video capsule enteroscopy allows complete visualisation of the small bowel without discomfort, it remains a merely diagnostic procedure with significant false negative results. On the other hand, balloon-assisted and overtube-guided enteroscopy are invasive and time-consuming techniques with a lesser chance to complete enteroscopy, allowing all conventional endoscopic interventions within the small bowel.

Both directions of research aim for a higher yield, less discomfort, no complications and better interventional options. Therefore, they will continue in their progress towards perfection. However, it is unlikely that both techniques will come together into one final and perfect endoscopic tool to investigate and treat pathology of the small bowel. Within the next years, wireless video capsule enteroscopy and balloon-assisted and overtube-guided enteroscopy will remain the "yin and yang" of small bowel visualisation, perfectly completing each other's imperfections.

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