Magnets in the GI tract

The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methodology is used, with a MEDLINE literature search to identify pertinent preclinical and clinical studies on the topic, and a MAUDE (U.S. Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported adverse events of a given technology. Both are supplemented by accessing the "related articles" feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but, in many cases, data from randomized controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors. For this review, the MEDLINE database was searched through February 2013 by using the keywords magnet, gastroesophageal, capsule, enteral feeding, colonoscopy, NOTES, endoscopic submucosal dissection, magnetic nanoparticle, reflux, incontinence.

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BACKGROUND

Magnets are of interest to the endoscopist or surgeon because they exert a force over a distance and can therefore be used to control instruments remotely or to create compression forces. Applications of magnets or magnetic materials in the GI tract will be reviewed.

0016-5107/$36.00
http://dx.doi.org/10.1016/j.gie.2013.07.020

EMERGING TECHNOLOGY AND POTENTIAL APPLICATIONS

Magnetic capsule manipulation

Until recently, capsule endoscopes have not been maneuverable. Currently available systems are propelled by spontaneous GI motility, which may result in areas of interest being passed too quickly and large cavities (eg, stomach, colon) being inadequately visualized. Capsules that use external magnetic fields for steering are being evaluated in clinical trials.

There are currently two device systems in late-stage development. The Magnetic Maneuverable Capsule (MMC, NEMO, and Given Imaging, Yoqneam, Israel) is a modification of a standard Given Imaging colon capsule, with magnetic disks inserted inside one dome. The capsule is maneuvered with the help of a handheld external magnet moved across the patient's abdominal surface. The MMC transmits images from one end of the capsule to the data recorder via a set of skin sensors. The images can be viewed in real time or after the examination is complete.[1]

The other magnetic capsule system (Siemens Medical, Erlangen, Germany and Olympus America, Center Valley, Pa) consists of a guidance magnet, an image processing and guidance information system (consisting of a console viewed by the operator and a scanner for the patient to lie in), and a capsule endoscope. After swallowing the capsule (11 × 33 mm), the patient is positioned on a bed that resembles a magnetic resonance imaging scanner, with the upper abdomen at the center of an electromagnetically generated field. The magnet system generates varying magnetic fields that are controlled by a "joystick" to navigate the capsule. Cameras at both ends of the capsule transmit images.[2,3] Neither of these systems are currently commercially available.

The performance of the MMC in the stomach was evaluated in a small study of 10 healthy volunteers with the use of a handheld magnet. The procedure appeared to be safe, well-tolerated, and technically feasible. Maneuverability of the capsule within the gastric lumen was considered excellent by the authors, and visualization of the mucosa was high in the majority of patients. However, visualization of the mucosa was not complete because of fluid blocking the view of the most apical parts of the fundus and suboptimal gastric distention.[1] Another study of 10 healthy volunteers evaluated the performance of the MMC in the esophagus. Magnetic forces were not strong enough to hold the capsule against peristalsis when it approached the gastroesophageal junction. The dwell time in the esophagus was found to be highly variable, leading to the conclusion that remote control of the MMC in the esophagus of healthy volunteers is feasible, but higher magnetic forces may be needed.[4]

The performance of the Siemens-Olympus system in the stomach was evaluated in a feasibility study of 53 participants (29 healthy volunteers and 24 patients). There was technical failure in 1 individual. In the 52 remaining cases, examiners determined that the antrum, body, fundus, and cardia were fully visualized in 98%, 96%, 73%, and 75% of cases, respectively. The mean duration of the examinations was 30 minutes (range 8-50 minutes). No significant capsule-related adverse events occurred. The authors also report that results improved with practice.[2]

Magnet-assisted enteral tube placement and electromagnetic tube tracking

Placement of nasoenteric feeding tubes past the pylorus is often done blindly at the bedside or under fluoroscopic guidance. Failure to pass the tube beyond the pylorus occurs frequently. Bedside methods that could confirm the correct placement, with the ability to guide the tube directly into the duodenum or monitor the progress of the tube while it is being manipulated, would be helpful.

Two magnet-assisted feeding tubes are commercially available. The Syncro-BlueTub (Syncro Medical Innovations, Macon, Ga) is a feeding tube (8F and 12F) with a stylet that has small magnets at its tip.[5] The distal end of the tube contains a magnetic field sensor that is connected to an indicator light at the proximal end of the tube. A handheld external steering magnet is used to maneuver the tube through the pyloric sphincter. The indicator light signals when the external magnet has captured the magnet on the distal tip. To verify placement in the duodenum, duodenal fluid is aspirated and applied to pH paper that comes with the kit. The presence of alkaline fluid suggests post-pyloric placement, which should be verified by radiography. The Syncro-BlueTube was evaluated in 288 critically ill patients (329 intubations). Mean procedure time was 15 minutes. In 293 cases (89.1%), the tube was placed beyond the pyloric sphincter. In 139 insertions (42.2%), the tube tip was in the distal portion of the duodenum or the jejunum.[5]

The Cortrak enteral access system (Corpak MedSystems, Buffalo Grove, Ill) consists of a feeding tube with a magnetic stylet. An electromagnetic sensing device is used to track the path of the feeding tube during placement; this device does not allow for external magnetic manipulation of the tube (Fig. 1). The Cortrak 2 enteral access system has U.S. Food and Drug Administration (FDA) clearance for use in confirming tube tip location in lieu of radiography.[6]

The Cortrak enteral feeding system was evaluated in 66 critically ill patients randomly assigned (2:1 ratio) to receive an electromagnetically visualized jejunal feeding tube or an endoscopically placed jejunal tube. The correct jejunal tube position was reached in 21 of 22 patients with the endoscopic technique and in 40 of 44 patients with the electromagnetically visualized jejunal tube (95% vs 91%; P = not significant).[7]

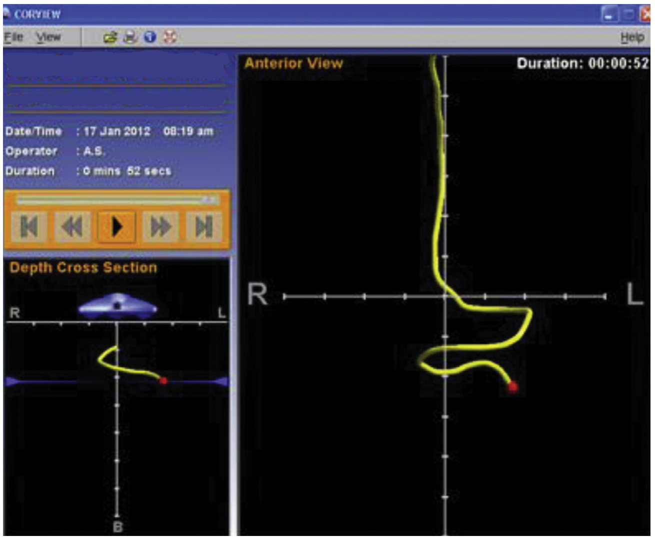

Figure 1. The Cortrak EAS system is based on the same principle as electromagnetic navigation colonoscopy. Changes of a magnetic field generated by a moving magnet are registered by an external antenna and rendered as an image by a viewing application. Image courtesy of CORPAK MedSystems.

Magnetic endoscopic imaging—magnetic navigation colonoscopy

Loop formation during colonoscopy often can impede colonoscope advancement, especially for trainees. Visualization of loops may be advantageous when a redundant colon is encountered and for teaching colonoscopy.

The ScopeGuide system (Olympus, Center Valley, Pa) uses electromagnetic fields to display colonoscope progress and loop formation. The original system used a through-the-scope probe, which is still commercially available. Newer Olympus colonoscopes have built-in magnetic coils, obviating the need to pass a probe through the colonoscope. Low-strength magnetic fields are generated by a series of tiny wire coils positioned along the length of the colonoscope or probe. The magnetic fields from these wire coils induce an electric current in an external sensor coil. The positional raw data are converted into real-time 3-dimensional views of the colonoscope shaft configuration and its location within the abdomen on a separate computer monitor.

A study of 810 consecutive patients randomized to magnetic endoscopic imaging (MEI) or standard colonoscopy with on-demand fluoroscopy showed that the cecal intubation rate for inexperienced endoscopists was significantly higher in the MEI group (77.8%) compared with that of the standard group (56.0%; $P = .02$) but not for experienced endoscopists (94.0% for MEI and 96.0% for standard group; $P = .87$).[8]