Published in final edited form as:

Gastrointest Endosc. 2009 February ; 69(2): 260–261. doi:10.1016/j.gie.2008.06.030.

A novel capsule endoscope: Do we need new kids on the block?

Thomas D. Wang, M.D.,Ph.D.[Asst Professor]

Medicine and Biomedical Engineering Division of Gastroenterology, University of Michigan 109 Zina Pitcher Pl. BSRB 1522 Ann Arbor, MI 48109-2200

The first capsule endoscope was developed by Given Imaging Ltd and demonstrated in 2000 [1]. Known as M2A (**M**outh **t**o **A**nus), this instrument uses telemetry to transmit the video images to a portable recorder and the strength of the signal determines the position of the capsule within the body [2]. This innovation was made possible by the advancement and integration of 3 key technologies that require only small amounts of energy: 1) Complementary metal oxide silicon (CMOS) image sensors, 2) Application-specific integrated circuits (ASIC) and 3) White light-emitting diodes (LED). The M2A has been renamed as the PillCam SB (small bowel), and has become the first choice for many GI practitioners for detecting small bowel pathology, replacing more conventional radiological techniques [3]. Recently, new capsule endoscope designs have been developed by Given Imaging for visualizing the esophagus (PillCam ESO) [4], and by Olympus Medical Systems (Tokyo, Japan) for providing higher resolution images (EndoCapsule) [5]. The table provides a comparison of the imaging parameters for the MiRo, PillCam SB, and EndoCapsule.

A significant amount of clinical data has been collected that compares the performance of the PillCam capsule endoscope with other small bowel imaging modalities. A meta-analysis has been performed that includes a total of 14 studies (n = 396 subjects), and concludes that capsule endoscopy is superior to push enteroscopy and small bowel follow through (SBFT) for detecting the source of obscure gastrointestinal bleeding [6]. Capsule endoscopy is also making an impact in the diagnosis of small intestinal Crohn's disease. Another meta-analysis has found that capsule endoscopy is superior to all other imaging modalities, including SBFT, colonoscopy, CT, enteroclysis, push enteroscopy, and MRI, for diagnosing non-stricturing Crohn's disease in the small bowel [7]. Furthermore, capsule endoscopy has shown promise for clinical diagnosis in the small bowel of NSAID-related ulcers, tumors, polyposis syndromes, protein-losing enteropathy, Whipple's disease, celiac disease, graft-versus-host disease and post-operative monitoring after small bowel transplantation.

While the performance of the capsule endoscope has already shown great promise, improvements in image quality, device maneuverability, and capsule functionality remain on the horizon. The image sensor in the MiRo capsule has dimensions of 320×320 pixels, a significant improvement over the size of 256×256 in the Given PillCam SB. However, this level of performance is still much less than that of current video endoscopes, especially the high definition models. While the capsule images are excellent, greater detail may still be

© 2012 American Society for Gastrointestinal Endoscopy. Published by Mosby, Inc. All rights reserved.

Office: (734) 936-1228 Fax: (734) 647-7950 thomaswa@umich.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

The author has no disclosures to make.

achieved. Furthermore, while capsule endoscopy has been proven to be safe and well tolerated by patients, capsule retention (defined as non-expulsion of the capsule for longer than 2 weeks) is a concern that occurs in approximately 0.75% of uses, and usually requires some form of intervention [8]. The ability to remotely control capsule movement may reduce the frequency of retention and may also provide the capability to re-examine suspicious regions of mucosa. Moreover, the addition of miniature functional tools developed with MEMS (micro-electro-mechanical systems) technology to obtain tissue biopsy would significantly improve the diagnostic accuracy by providing correlation of imaging with histopathology.

The development of the MiRo capsule endoscope demonstrates that the innovation and progress for remote imaging of the small bowel is far from over. Novel methods that provide and conserve energy will create exciting new opportunities to improve imaging performance, including image resolution, frame rate, and operation time. By using the human body itself as a conductor, the MiRo induces an electric field that generates a current to provide a means of remote communication. This clever design avoids the need for a radio frequency antenna and high-frequency electronic circuits, providing savings in both device energy and space. Such savings may lead to future generation capsule endoscopes that have micro-actuators to guide instrument movement and miniature tools to capture tissue, aspirate fluids, and inject drugs. The future of capsule endoscopy appears to be limited only by the human imagination, thus new kids on the block are greatly needed indeed to provide new directions, solve old problems, and generate greater vision.

Acronyms

CMOS	complementary metal oxide silicon
ASIC	application-specific integrated circuits
LED	light-emitting diodes
SBFT	small bowel follow through
M2A	mouth to anus
MRI	magnetic resonance imaging
NSAID	nonsteroidal anti-inflammatory drug
MEMS	micro-electro-mechanical systems

References

1. Iddan G, Meron G, Glukhovskiy A, Swain P. Wireless capsule endoscopy. *Nature*. 2000; 405:417. [PubMed: 10839527]
2. Mishkin DS, Chuttani R, Croffie J, Disario J, Liu J, Shah R, Somogyi L, Tierney W, Song LM, Petersen BT, Technology Assessment Committee, American Society for Gastrointestinal Endoscopy. ASGE Technology Status Evaluation Report: wireless capsule endoscopy. *Gastrointest Endosc*. 2006; 63:539–45. [PubMed: 16564850]
3. Lewis BS, Eisen GM, Friedman S. A pooled analysis to evaluate results of capsule endoscopy trials. *Endoscopy*. 2005; 37:960–5. [PubMed: 16189768]
4. Eliakim R, Yassin K, Shlomi I, Suissa A, Eisen GM. A novel diagnostic tool for detecting oesophageal pathology: the PillCam oesophageal video capsule. *Aliment Pharmacol Ther*. 2004; 20:1083–9. [PubMed: 15569110]
5. Gheorghe C, Iacob R, Bancila I. Olympus capsule endoscopy for small bowel examination. *J Gastrointest Liver Dis*. 2007; 16:309–13. [PubMed: 17925927]

6. Triester SL, Leighton JA, Leontiadis GI, Fleischer DE, Hara AK, Heigh RI, Shiff AD, Sharma VK. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with obscure gastrointestinal bleeding. *Am J Gastroenterol*. 2005; 100:2407–18. [PubMed: 16279893]
7. Triester SL, Leighton JA, Leontiadis GI, Gurudu SR, Fleischer DE, Hara AK, Heigh RI, Shiff AD, Sharma VK. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with non-stricturing small bowel Crohn's disease. *Am J Gastroenterol*. 2006; 101:954–64. [PubMed: 16696781]
8. Cave D, Legnani P, de Franchis R, Lewis BS, ICCE. ICCE consensus for capsule retention. *Endoscopy*. 2005; 37:1065–7. [PubMed: 16189792]

Callout

The MiRo imaging system reduces the amount of power required to operate the capsule, thereby increasing the time of operation by saving energy and it creates room, currently taken up by a radio frequency antenna, for tiny functional tools.

Table

Comparison of imaging parameters among the MiRo, PillCam and EndoCapsule systems

Image Parameter	IntroMedic MiRo	Given Imaging PillCam SB	Olympus EndoCapsule
Image sensor	CMOS	CMOS	CCD
Field of View (deg)	150	140	145
Frame rate (per sec)	2	2	2
Dimensions	10.8mm × 24mm	11mm × 26mm	11mm × 26mm
Weight (gm)	3.3	3.7	3.8
Battery life (hours)	9-11	7	8