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

In this issue of *Gastrointestinal Endoscopy*, Bang et al describe a novel design for a capsule endoscope, the MiRo (IntroMedic, Seoul, South Korea), that uses the technique of electric-field propagation to transmit data from inside the human body to a remote image recorder. With this technique, the patient’s own body is used to conduct the signal rather than using telemetry, as is conventionally done. This innovation offers 2 main advantages: (1) it reduces the amount of power required to operate the capsule, thereby increasing the time of operation by saving energy, and (2) it creates room, currently taken up by a radiofrequency antenna, that may potentially be used to include tiny functional tools. The capsule endoscope is a miniature camera that is particularly useful for imaging the small bowel and has already made a significant impact in the clinical evaluation and management of patients with obscure GI bleeding. Upon being swallowed, the capsule endoscope, literally the size of a capsule, passes through the GI tract to visualize regions of the bowel that cannot be easily accessed by flexible endoscopes.

The first capsule endoscope was developed by Given Imaging Ltd (Yoqneam, Israel) and was demonstrated in 2000. Known as M2A (“mouth to anus”), 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. 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, and (3) white-light–emitting diodes. The M2A has been renamed the PillCam SB (“small bowel”) and has become the first choice for many GI practitioners for detecting small-bowel pathology, replacing more conventional radiologic techniques. Recently, new capsule-endoscope designs were developed by Given Imaging for visualizing the esophagus (PillCam ESO), and by Olympus Medical Systems (Tokyo, Japan) for providing higher-resolution images (EndoCapsule). A comparison of the imaging parameters for the MiRo, PillCam SB, and EndoCapsule is provided in Table 1.

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 was performed that included a total of 14 studies (n = 396 subjects) and concluded that capsule endoscopy is superior to push enteroscopy and small-bowel follow-through (SBFT) for detecting the source of obscure GI bleeding. 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 magnetic resonance imaging, for diagnosing nonstricturing Crohn’s disease in the small bowel. Furthermore, capsule endoscopy has shown promise for clinical diagnosis in the small bowel of nonsteroidal anti-inflammatory drug–related ulcers, tumors, polyposis syndromes, protein-losing enteropathy, Whipple’s disease, celiac disease, graft-versus-host disease, and postoperative monitoring after small-bowel transplantation.

Although 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 $320 \times 320$ pixels, a significant improvement over the $256 \times 256$ pixels in the Given PillCam SB. However, this level of performance is still much less than that of current videoendoscopes, especially the high-definition models. Although the capsule images are excellent, greater detail may still be achieved. Furthermore, although capsule endoscopy has been proven to be safe and well tolerated by patients, capsule retention (defined as nonexpulsion 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. The ability to remotely control capsule movement may reduce the frequency of retention and may also provide the capability to reexamine suspicious regions of mucosa. Moreover, the addition of miniature functional tools developed with microelectromechanical
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 radiofrequency antenna and high-frequency electronic circuits, which provides savings in both device energy and space. Such savings may lead to future-generation capsule endoscopes that have microactuators 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.

### TABLE 1. Comparison of imaging parameters among the MiRo, PillCam, and EndoCapsule systems

<table>
<thead>
<tr>
<th>Image parameter</th>
<th>MiRo</th>
<th>PillCam SB</th>
<th>EndoCapsule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image sensor</td>
<td>CMOS</td>
<td>CMOS</td>
<td>CCD</td>
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<tr>
<td>Field of view (degree)</td>
<td>150</td>
<td>140</td>
<td>145</td>
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<tr>
<td>Frame rate (per s)</td>
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<td>2</td>
<td>2</td>
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<tr>
<td>Dimensions (mm)</td>
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<td>11 × 26</td>
<td>11 × 26</td>
</tr>
<tr>
<td>Weight (g)</td>
<td>3.3</td>
<td>3.7</td>
<td>3.8</td>
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<tr>
<td>Battery life (h)</td>
<td>9-11</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

**DISCLOSURE**

The author disclosed no financial relationships relevant to this publication.

**Wang Editorial**

**REFERENCES**