EDITORIAL

Small-bowel imaging: multiple paths to the last frontier

Within the past decade, there have been dramatic advances in our ability to image the small intestine. We can now more thoroughly evaluate the small-intestinal mucosa by using capsule endoscopy (CE) and small-intestinal wall abnormalities with CT or magnetic resonance imaging (MRI) enterography than we could with older methods. The new modalities are less invasive than intraoperative enteroscopy and enable more complete imaging than push enteroscopy. Yet the new technologies also have their limitations. For example, although MRI and CT enterography may play a role in evaluating Crohn's disease or small-bowel neoplasms, their utility in diagnosing flat lesions such as angiodysplasia, or neoplasms less than 15 mm in diameter is limited.[1-3] In addition, all of these newer imaging techniques are unable to provide a tissue diagnosis or render any therapy.

Only with the description of double-balloon enteroscopy (DBE) by Yamamoto et al[4] in 2001 did the ability to simultaneously visualize the entire small bowel and sample lesions finally become a reality. DBE can be performed on an outpatient basis by using only conscious sedation. Antegrade DBE can examine 3 times the length of small bowel as push enteroscopy, with a corresponding increase in diagnostic yield.[5] In addition, retrograde DBE allows more consistent evaluation of the ileum and, when combined with antegrade DBE, the possibility of complete small-bowel examination. The literature on DBE has mushroomed in recent years as the new scopes have been applied for various conditions, including some outside the small bowel.[6,7]

DBE has had the small-bowel endoscopy market to itself since becoming commercially available in the United States in 2004. However, last year a single-balloon enteroscope was introduced in the United States (Olympus America, Center Valley, Pa). Kawamura et al[8] describe their early experience with single-balloon enteroscopy (SBE) in this issue of *Gastrointestinal Endoscopy*. The 2 systems share many features, including scope length, diameter, accessory channel size, and overtube design. Both require 2 people to manipulate and advance the scope/overtube as well as control the balloons. The most important design difference between the systems is that the SBE does not have a distal balloon on the scope; the only balloon is on the tip of the overtube. As a result, the sequence of steps to advance the scope through the small bowel is slightly shorter in SBE. After the DBE scope is advanced but before the overtube is advanced, the DBE scope balloon is inflated to stabilize the tip. In the SBE system, the scope is turned in toward the bowel wall to help fix the tip as the overtube is advanced over the scope. This position is maintained as the scope and the advanced overtube, now with its balloon inflated, are pulled back to pleat the intestine onto the scope. After the pullback of the scope and overtube in the DBE system, the scope's balloon is deflated before advancing the scope. This step is avoided in SBE because the tip is simply turned toward the forward-viewing position for renewed advance. Minor differences between systems include the following: (1) the DBE balloons are latex, whereas the SBE balloon is silicone; (2) the DBE scope balloon must be attached before the case, analogous to the placement of the balloon for endoscopic US; and (3) the DBE balloon pump has auditory signals during inflation, whereas the SBE system does not. Use of either scope requires a technician to assist with handling of the overtube as well as balloon inflation/deflation. In addition, fluoroscopy to monitor scope position and sedation appropriate for prolonged procedures are requirements shared by both systems.

DBE is recommended to follow up any CE demonstrating lesions that require sampling or endoscopic therapy.

THE DBE EXPERIENCE

In experienced hands, DBE evaluation of the entire small bowel is possible in 45% to 84% of patients in whom it is attempted.[9-11] Complete small-bowel examination usually requires a combination of antegrade and retrograde DBE; it can rarely be achieved with antegrade DBE alone.[9,10] Reported mean examination times are 73 minutes for antegrade DBE and 78 minutes for retrograde examinations.[12] Findings significant enough to change management are reported in most patients (65%-76%).[9,11,13] In fact, as the likelihood of complete small-bowel traversal increases with experience, so does the probability that the test will

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be clinically helpful.[13] Therapeutic maneuvers are reported in a large proportion of patients (41%-61%).[9,13]

The diagnostic yield of DBE is highly dependent on the indication for the study.[11] In the evaluation of obscure GI bleeding—the most common indication for enteroscopy—DBE identifies the bleeding source 53% to 80% of the time, with complete visualization of the small bowel in 56% to 61% of attempted cases.[11,14,15] These DBE results are comparable to those with CE in a recent series of patients with obscure GI bleeding in which CE identified the bleeding source in 53% of patients and complete small-bowel visualization was achieved in 74%.[16]

How does DBE compare with capsule endoscopy? Only 3 small prospective studies directly comparing CE to DBE have been published in peer-reviewed journals.[17-19] All included patients with obscure GI bleeding. Nakamura et al[19] reported on 28 patients who underwent CE and then DBE, with the endoscopist blinded to the results of the CE. The authors divided the findings into 2 groups: A1 lesions that required immediate hemostatic measures, and A2 lesions that could be closely observed rather than immediately treated. CE detected lesions in 17 patients (11 with A1 lesions and 6 with A2 lesions). DBE was positive in 12 patients (all but one had A1 lesions). Both CE and DBE found 3 A1 lesions that the other modality missed. Thus, both modalities found 11 of 14 A1 lesions. In addition, CE found 5 A2 lesions not found by DBE. Complete small-bowel traversal by DBE was attempted in 16 cases and was successful in 10.

In the study of CE versus DBE by Hadithi et al,[18] the endoscopist knew of the preceding CE results when performing DBE in all 35 patients. Findings were not classified as in the study by Nakamura et al[19]; rather, they were all considered to have equal clinical significance. Complete small-bowel imaging was achieved in 86% of CE examinations and in 57% of DBE attempts. CE findings were abnormal in 80% of the cases. However, one of these abnormal cases was not confirmed by DBE or surgery, so the positive rate was 77% (27/35). DBE found abnormalities in 60% of cases, and all were treated with coagulation devices or were endoscopically removed. DBE found only 1 lesion not seen on CE.

Matsumoto et al[17] reported on 13 patients with obscure GI bleeding evaluated initially by a diagnostic DBE and then CE. The reader of the CE was blinded to the results of the DBE. The CE and DBE agreed on 6 patients with positive findings and on 3 with negative examinations. Two CE findings were not confirmed by DBE. On one patient a confirmatory DBE was not performed, and in another, DBE found an ulcer missed by CE. The authors concluded that the 2 studies were equivalent in diagnosing obscure GI bleeding.

Combining the results of the 3 studies, CE and DBE agreed in 68% of all cases and in 63% of positive cases.[17-19] DBE found lesions missed on CE 7% of the time, and CE found lesions not found by DBE in 26% of cases. However, some of these CE findings—such as the five A2 lesions, and one not confirmed at surgery—are of dubious significance.

A recent meta-analysis that included these 3 prospective studies as well as results published only in abstract form compared the diagnostic ability of CE and DBE for small-bowel conditions, including obscure GI bleeding. The authors found no difference in diagnostic yield between CE and DBE.[20] A meta-analysis by Chen et al[21] reached the same conclusion, with the caveat that the yields were comparable if DBE evaluated the entire small bowel. However, none of the comparative studies included a diagnostic criterion standard such as surgery or intraoperative enteroscopy. Thus, the true clinical impact of DBE compared with CE remains to be elucidated.[20]

THE SBE EXPERIENCE

In contrast with the literature on DBE, the previously published data on SBE are sparse, with most reports in abstract form.[22-26] Only 107 patients undergoing 147 SBE examinations have been previously reported. The rate of complete examination of the small bowel, given in only 2 reports, has been 25%.[24-26] Mean procedure times have been 45 minutes to 63 minutes for antegrade SBE.[25,26] Diagnoses have been reached in 69% of cases,[22] and only one serious complication has been previously reported. To this small data set, Kawamura et al[8] add their experience with 37 SBE examinations in 27 patients. These examinations were performed by 3 endoscopists with no prior experience with balloon enteroscopy. The mean procedure time was 83 minutes for antegrade SBE and 90 minutes for retrograde SBE. The diagnostic yield was only 41%. Complete small-bowel examination was attempted in 8 cases but was successful in only one. There was one bowel perforation.

Although the SBE experience of Kawamura et al[8] does not approach the levels of technical success with DBE reported from institutions that have substantial experience, these SBE results do compare favorably to reports of initial experiences with DBE.[27,28] For example, in their first 40 patients undergoing 62 DBE examinations, Kaffes et al[27] had no complete traversals of the small intestine in 10 attempts, and 1 bowel perforation occurred. In a report of the initial DBE experience at 6 U.S. tertiary-care centers—188 patients undergoing 237 DBEs by 8 different endoscopists—the overall mean procedure time was 93 minutes, with institutional mean times ranging from 81 to 118 minutes.[28] A statistically significant decline was seen in the mean time for antegrade DBE after the first 10 procedures were performed at a given institution, but no such decrease was seen in retrograde DBE times. However, there was no improvement in the length of small bowel examined with greater experience. Complete small-bowel traversal was achieved in only 5% of attempts, and the rate of failure to maintain intubation of the terminal ileum on retrograde DBE was 29%. The diagnostic yield in these early reports was only 43% to 47.5%, and therapeutic maneuvers were carried out in 27% to 33% of patients.[27,28]