Choosing the Right Cross-sectional Imaging Technique: Trading Image Quality for Radiation Risk

Radiographic techniques have greatly enhanced our ability to determine Crohn's disease (CD) extent and severity, and identify complications such as strictures, abscesses, and fistulae. They have provided insights into patients' symptoms and have helped us more appropriately direct therapy or intervene with surgery. They are complementary to colonoscopy and capsule endoscopy, adding significant information about the bowel wall and involvement of adjacent tissues. Due to its broad availability and high resolution, computerized tomography (CT)-based imaging, especially CT enterography (CTE), has become the most widely used cross-sectional imaging technology for CD and has nearly completely replaced small bowel follow-through at many centers.[1,2] CTE has become the "gold standard" to which other imaging techniques are compared. Growing concern and increased awareness about the risks associated with the cumulative radiation dose secondary to repeated imaging, particularly in young patients, have led to growing interest in alternative imaging modalities.[3] At the same time, improved resolution of magnetic resonance imaging (MRI)-based techniques, along with more effective methods to deal with bowel motion and improved availability, have driven a rapid increase in the use of MR enterography (MRE) for CD imaging, even before the clinical usefulness of MRE has been completely elucidated. The two articles presented by Fiorino et al[4] on the comparison of CTE and MRE techniques for assessing disease activity and complications and Jensen et al[5] on the interobserver and intermodality agreement using CTE and MRE are part of mounting academic research aimed at comparing the sensitivity and diagnostic yield of MRE with CTE to validate the appropriateness of using the radiation-free MR technique to answer important clinical questions in the management of patients with CD.

The two articles add important information to our understanding of MRE as a tool to assess disease severity and identify complications of CD. Fiorino et al show that CTE and MRE similarly identify disease localization, presence of wall thickening, bowel wall enhancement (with MRE being slightly more sensitive for ileal wall enhancement than CTE), presence of fistula, and mesenteric adenopathy. There was a slightly higher sensitivity for MRE to detect enteric strictures. Their study concluded that both CTE and MRE are highly effective techniques in assessing ileocolonic CD with broadly similar accuracy. Technical differences in the performance of scans between institutions on different continents raises questions as to the generalizability of their conclusions. Even between US centers, differences in protocols based on scanner manufacturer, oral and intravenous contrast agents, and other scan characteristics exist. With respect to the current studies, differences in protocols are relatively minor and do not limit the generalizability of the authors' conclusions. Indeed, the major difference between scans performed in the US compared with non-US centers appears to be cost, which is bewildering high in the US compared to European and Asian institutions.

Jensen et al compared CTE and MRE with respect to image quality in addition to disease evaluation, with assessment of both interobserver and intermodality agreement for four different reviewers. As noted in earlier studies, the image quality was superior for CTE, which is not degraded by motion artifact due to the fast acquisition time, especially with the use of multidetector CT (MDCT) technology. For disease evaluation, the interobserver agreement was high for CTE and moderate for MRE. On the other hand the intermodality agreement was fair to substantial depending on the reader. This suggests that the evaluation of small bowel CD is both observer- and modality-dependent. However, despite these differences both techniques had comparable diagnostic yields. Therefore, given an experienced radiologist, MRE offers an acceptable alternative to CTE despite the difference in image quality. While interobserver agreement between radiologists at different institutions would give a more complete perspective, this study is an important step in validating this technique.

The relevant information in patients with suspected or known CD includes the extent and distribution of disease, presence or absence of stricture (with or without proximal dilatation), assessment of disease activity, as well as detecting the transmural/extraenteric complications (fistula and abscess formation). The diagnostic imaging modalities available to the gastroenterologists are vast and include: optical endoscopy (upper endoscopy, colonoscopy, video capsule endoscopy, and advanced small bowel endoscopic techniques) and radiologic techniques (plain radiography, small bowel follow-through (SBFT), CTE, MRE, CT, and MR enteroclysis, ultrasound, and positron emission tomography

DOI 10.1002/ibd.21536
Published online 15 November 2010 in Wiley Online Library (wileyonlinelibrary.com).

[PET] examination). Which imaging modality is "best" or "most informative" cannot be addressed simply, and in clinical practice the information desired cannot usually be derived from a single test. The optimal patient management will incorporate clinical information with complementary information provided by several modalities.

Endoluminal direct visualization likely offers a superior and more detailed view of the mucosal changes that may be more important in the early diagnosis of nonstricturing CD. In addition, endoscopic assessment is valuable for obtaining biopsies and in assessing potent therapeutics for evidence of mucosal healing. In the context of a clinical trial colonoscopic assessment of disease activity may include the use of the Crohn's Disease Endoscopic Index of Severity (CDEIS)[6,7]; no similarly validated scoring system exists for cross-sectional imaging techniques. For small bowel between the reach of the upper endoscope and the colonoscope, capsule endoscopy and advanced endoscopic applications such as double balloon enteroscopy are available. In several studies, capsule endoscopy has been shown to be more sensitive than cross-sectional imaging for detecting mucosal lesions, although it is argued that many of the lesions are not clinically significant.[8,9] Capsule retention and secondary obstruction can complicate the use of capsule endoscopy in structuring CD.[10,11] Ultrasound imaging of CD is popular in Europe and is gaining interest in the US, but is limited due to its operator-dependent nature and difficulty in visualizing the entire length of the bowel.[12] PET imaging is highly sensitive to inflammation but is not widely used due to expense and limited availability.[13]

CTE provides exquisite bowel images that lend amazing insight into disease pathology. The introduction of multidetector technology has allowed faster examinations, leading to higher resolution of mucosal/bowel wall details. The introduction of negative or neutral enteric oral contrast allows for the evaluation of the mucosal details by achieving the needed bowel distension and creating the visual contrast needed for the evaluation of the mucosal details and enhancement patterns.[14] Cross-sectional diagnostic imaging can evaluate the extent of disease throughout the small bowel and the large bowel in the same setting; detects the presence of strictures with or without proximal dilatation; as well as detects signs of penetrating disease such as fistula and extraluminal abscess formation. CTE is not as sensitive as endoscopic techniques for early changes of CD that may primarily only include mucosal aphthous ulceration, and therefore, the cross-sectional studies may be more suitable for evaluation of patients with moderate to severe disease or with stricturing/penetrating disease.[8] Supporting its usefulness in clinical practice, Higgins et al[15] showed that CTE can add unique and unsuspected information to the clinician assessment, especially in detecting strictures, and that this additional information can change the clinicians' assessment of the likelihood of successful medical therapy.

Cumulative radiation dosage from diagnostic imaging has gained attention in the medical community and in the lay press.[3] Measurement of effective radiation doses in CT is dependent on several factors including scanning technique and patient body habitus. A study by Jaffe et al[16] found that the effective dose for abdominopelvic MDCT was 16.1 mSv, which was up to five times higher than SBFT. They emphasized that the long-term biologic impact of this type of radiation exposure is not known. In addition, studies suggest that cumulative exposure of lower-dose radiation may have a similar effect as a single acute dose. More recently, several changes were introduced to CT scanning techniques that would allow the acquisition of "low-dose CT" leading to decrease in the overall dose of radiation delivered to the patient undergoing CT examination while trying to maintain image quality. These changes include lowering the tube current (mA) and voltage (kVp) settings used in the CT scanner along with introduction of more effective algorithms for image reconstruction that aim at reducing the increased image noise typically associated with these techniques.[17]

MRI of the gut has become more feasible with improvement in the spatial resolution and speed of the MR sequences which, in combination of the lack of ionizing radiation and the better signal-to-noise ratio, can offer parallel evaluation of both disease status assessment and evaluation of the extraenteric complications.[18–20] MRE was shown to be of similar diagnostic value to CT in the evaluation of acute complications of CD, providing an alternative to image patients in the acute setting.[21] Further, MR-based techniques allow addition of sequences that may add novel insight into the natural history of the disease such as magnetization transfer that specifically detects tissue stiffness and correlates with tissue fibrosis.[22] The two studies by Fiorino et al and Jensen et al further validate the adequacy of MRE as a satisfactory examination that can replace CTE examinations without the added risk of radiation.

The trade-off appears to be image quality for radiation risk, with MRE having no radiation exposure but overall inferior image quality compared to CTE. Despite the compromise in image quality, in experienced hands the diagnostic yield may be equivalent. So how does a clinician make the decision about the optimal technique on an individual patient? Like many decisions we make in caring for these challenging patients, we balance risks and benefits, incorporating the literature, local expertise, and patient factors, and then make the best decision possible. In many cases this will mean choosing MRE over CTE in young patients, saving CTE for difficult cases where defining pathology using the technique with the optimal resolution is essential. One strategy that is frequently employed at our institution is to use CTE for the initial exam, especially if an abscess or fistulae is suspected, but use MRE for monitoring progress if follow-up scans are required. When evaluating patients with serious symptoms, common sense should prevail to avoid the situation that can occur in pregnant patients with acute G1 symptoms where fear of diagnostic radiation can lead to delayed diagnosis and bad patient outcomes. Finally, additional factors such as availability of MR, cost of the exam, and experience of the radiologists need to be addressed before MRE is widely utilized for imaging patients with CD.

Mahmoud M. Al-Hawary, MD[*]
Ellen M. Zimmermann, MD[†]
[*]Department of Radiology
Abdominal Division
University of Michigan Medical Center
Ann Arbor, Michigan
[†]Department of Internal Medicine
Division of Gastroenterology
University of Michigan Medical Center
Ann Arbor, Michigan

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