Computed Tomography Enterography

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KEYWORDS

• Computed tomography (CT) • Enterography • CTE • Small bowel

KEY POINTS

- Computed tomography enterography (CTE) has several advantages over other radiologic and optical imaging modalities and is ideally suited for imaging of the small bowel.
- Ingestion of a large volume of neutral oral contrast material combined with imaging during peak small bowel enhancement increases conspicuity of small bowel abnormalities.
- A major limitation of CTE is the need for ionizing radiation; radiologists should use the latest available dose reduction techniques for CTE, particularly for young patients and for those with chronic inflammatory bowel disease who often require repeated imaging.
- CTE excels at detection and surveillance of small bowel inflammatory processes, evaluation of suspected small bowel bleeding, and detection and characterization of small bowel masses.

INTRODUCTION

Superb spatial and temporal resolution of multidetector row computed tomography (CT) has made CT the first-line imaging modality for many abdominopelvic indications. CT enterography (CTE) is a modification of the standard abdominopelvic CT and is tailored specifically to evaluate the small bowel (SB). Patients are required to ingest a large volume of (usually neutral) oral contrast material to optimally distend the SB. Following rapid injection of intravenous (IV) contrast material, thin-section image acquisition during the peak bowel wall enhancement allows for increased conspicuity of abnormally enhancing processes of the SB.

CTE has many advantages over other SB radiologic and optical imaging techniques, including widespread availability, lack of need for sedation, reproducible high-quality images, the ability to visualize the entire thickness and length of SB, and the ability to also assess extraenteric structures in high resolution. Therefore, CTE is well suited for evaluation of SB in many scenarios (**Box 1**).

In this review, the authors describe their protocol for performing CTE and potential modifications depending on the clinical scenario as well as opportunities for dose reduction. The authors

Box 1
Common clinical indications for computed tomography enterography

- Detection/surveillance of inflammatory SB conditions and complications (eg, CD and CeD)
- Unexplained diarrhea
- Evaluate suspected SB bleeding
- Detect/characterize SB masses
- Detect low-grade SB obstruction
- Combined high-quality evaluation of other organs and SB

Disclosure Statement: The authors have no funding or conflicts of interest to disclose.
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Radiol Clin N Am ■ (2018) ■–■
https://doi.org/10.1016/j.rcl.2018.04.002

discuss and provide illustrative examples of technical limitations of CTE and of common interpretive pitfalls. Last, they describe several of the more common CT enterographic findings encountered in their practice, including Crohn disease (CD), celiac disease (CeD), SB tumors, vascular lesions, and nonsteroidal anti-inflammatory drug (NSAID) enteropathy.

TECHNIQUE

Oral Contrast

Adequate SB distension is necessary to maximize detection of SB abnormalities and requires ingestion of a large volume of oral contrast material over a relatively short period of time (45–60 minutes) (**Table 1**). Neutral contrast agents, VoLumen (Bracco Diagnostics, Inc, Monroe Township, NJ, USA) and Breeza (Beekley Medical, Bristol, CT, USA), have attenuation values near or just above water attenuation and are the preferred agents for most CTE examinations because they provide superior conspicuity of hyperenhancing SB abnormalities.

Side effects of both of these agents include loose stools, diarrhea, and cramping. Water can be administered to patients who are unable or unwilling to drink the above agents. Although water does not incur additional cost to the examination, it is more rapidly absorbed from the SB; therefore, distal SB distension may be suboptimal.

Some abnormalities may be obscured by neutral contrast agents especially in poorly distended bowel. New oral contrast agents that are able to provide biphasic characteristics using dual-energy techniques are being developed. For more information on dual-energy technique, please see Benjamin M. Yeh and colleagues' article, "Dual Energy CT of the Bowel: Benefits, Pitfalls, and Future Directions," in this issue.

Intravenous Contrast and Scan Timing

IV contrast should be used unless there are contraindications because it helps demonstrate areas of hyperenhancement that can be seen with inflammation and masses. CTE can be performed as a single-phase or multiphase examination (mpCTE). **Table 1** provides a summary of the technique used in the authors' institution. Single-phase CTE is more commonly performed and is used for most indications. Iodinated contrast is administered at a rapid rate, and imaging can be performed during the enteric phase when there is peak SB wall enhancement[1] or during the portal venous phase when the liver is more enhanced.

In the evaluation of patients with occult gastrointestinal (GI) bleeding, mpCTE can be helpful for improving the detection and characterization of lesions causing SB bleeding. The authors perform an mpCTE using a bolus triggering threshold of 150 HU for the arterial phase, an enteric phase at 50 seconds, and delayed phase at 90 seconds.[2] Some sites prefer to obtain unenhanced images to help differentiate pathologic condition from high-attenuation ingested material (**Fig. 1**) and only perform 2 phases with IV contrast to reduce the overall radiation exposure. If dual-energy technology is available, virtual noncontrast (VNC) images can be generated without the need for additional radiation. More information regarding multiphase technique for GI bleeding can be found in Trevor C. Morrison and colleagues' article, "Imaging Workup of Acute and Occult Lower Gastrointestinal Bleeding," in this issue.

Computed Tomographic Parameters and Dose Reduction Strategies

The Society of Abdominal Radiology, the American College of Radiology, and the Society of Pediatric Radiology have established technical parameters for the performance of CTE in CD.[3,4] As CTE examinations generate thin (2–4 mm) multiplanar images, the examination should be performed on 16-slice and higher multidetector CT systems.[3] Multiphasic imaging is used in patients with acute and overt SB bleeding and with suspected SB bleeding; however, currently there is no clear consensus on the technical requirements in these settings.[5] The field-of-view should be adapted to fit the patient, with some practices reducing the scan range to image only the SB to minimize radiation dose and exclude the lung bases and breast tissue.[6] Every CTE should image the anal sphincter complex owing to the potential for unsuspected perianal CD.[7] For older CT systems, the detector configuration should be chosen so that image acquisition can be performed in a single breath-hold with the minimal possible configuration chosen so as to maintain z-axis spatial resolution on coronal and sagittal images.

Radiation dose should be minimized to perform the diagnostic task, and CT enterography examinations should additionally be adapted to patient size, with volume CT Dose Index ($CTDI_{vol}$) generally between 5 and 15 mGy.[3] Radiation dose can be reduced by reducing the scan coverage, lowering the tube potential, reducing tube current, and using automatic exposure control (AEC), and tolerating more noise in CT images. "Low kV" scanning is the term used for CT imaging performed with a tube potential of less than 120 kV, with the potential for low kV scanning depending