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Carcinoid tumors of the small-bowel: Evaluation with 64-section CT-enteroclysis

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ABSTRACT

Purpose: To describe the imaging presentation of carcinoid tumors of the small-bowel at 64-section CT-enteroclysis and determine the sensitivity of this technique for tumor detection.
Patients and methods: The 64-section CT-enteroclysis examinations of 22 patients with histopathologically proven small-bowel carcinoid tumors and those of 6 patients with suspected recurrence after small-bowel resection for carcinoid tumor were reviewed. Images were analyzed with respect to imaging presentation. Sensitivity, specificity, and accuracy, of 64-section CT-enteroclysis for the diagnosis of carcinoid tumor of the small-bowel were estimated with 95% confidence intervals (CIs).
Results: Twenty-five carcinoid tumors were confirmed in 22 patients (prevalence, 22/28; 79%). Overall sensitivity for carcinoid tumor detection was 76% (19/25; 95%CI: 55–91%) on a per-lesion basis. On a per-patient basis, 64-section CT-enteroclysis had a sensitivity of 86% (19/22; 95%CI: 65–97%), a specificity of 100% (6/6; 95%CI: 54–100%) and an accuracy of 89% (25/28; 95%CI: 72–98%) for the diagnosis of carcinoid tumor. Focal small-bowel wall thickening, mesenteric stranding, and mesenteric mass were found in 20/22 (91%), 18/22 (82%) and 15/22 (68%) patients with pathologically confirmed tumors.
Conclusion: 64-Section CT-enteroclysis shows highly suggestive features for the diagnosis of carcinoid tumor of the small-bowel and achieves high degrees of sensitivity for tumor detection.
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1. Introduction

Carcinoid tumors represent 20–30% of all primary neoplasms of the small-bowel [1,2]. They originate from enterochromaffin cells and are predominantly located in the distal ileum [2]. Although hypervascular, carcinoid tumors are often difficult to depict on routine CT when confined to the small-bowel [3,4]. In this regard, in the absence of optimal luminal distension of the small-bowel, up to 78% of carcinoid tumors can be undetected [4]. However, carcinoid tumors of the small-bowel usually induce a desmoplastic reaction within the mesentery and are often associated with mesenteric masses and tethering of adjacent small-bowel loops [5–7]. These findings, as observed on CT images, are highly suggestive for the diagnosis of carcinoid tumor [4–6].

Helical CT-enteroclysis has rapidly emerged as a useful tool for the diagnosis of a wide range of small-bowel diseases [3,8,9]. In this regard, a meta-analysis found that helical CT-enteroclysis has a pooled sensitivity of 92.8% for the detection of small-bowel tumors [10]. In addition, dramatic refinements in CT technology have occurred since the first results were reported [11–13]. Sixty-four section CT systems allow the abdomen and the pelvis to be imaged at a resolution of less than 1 mm in the three axes so that resulting voxels are submillimetre and isotropic [3,5]. In theory, such major improvements are important for detecting subtle small-bowel abnormalities [5,14,15]. Consequently, in light of these

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Table 1
Imaging parameters for 64-section CT-enteroclysis.

Parameters	Somatom sensation 64
Source of X rays	Single
Number of rows	32 × 2
Configuration (mm)	64 × 0.6
Beam collimation (mm)	38.4
Voltage (kVp)	120
Tube current (effective mAs)[a]	120–170
Gantry rotation time (s)	0.5
Table speed (mm/gantry rotation)	46
Beam pitch	1.2
Volume of iodinated contrast material (mL)	100–120
Injection rate (mL/s)	3

[a] An online, real time, anatomy-adapted, attenuation-based current modulation technique (Care Dose, Siemens Healthcare) was used in all patients.

refinements, a reappraisal of the capabilities of CT enteroclysis with regard to the diagnosis of carcinoid tumors of the small-bowel is needed.

The purpose of our study was to describe the imaging presentation of carcinoid tumors of the small-bowel at 64-section CT-enteroclysis and determine the sensitivity of this technique for tumor detection.

2. Materials and methods

2.1. Study population

This retrospective study was performed according to the review board guidelines of our institution and informed consent was obtained from all patients. From August 2007 to August 2012, 64-section CT-enteroclysis was performed in 28 consecutive patients with either histopathologically confirmed carcinoid tumors of the small-bowel ($n = 22$) or with suspected recurrence after small-bowel resection for carcinoid tumor ($n = 6$); these latter patients were ultimately deemed free of recurrent disease. There were 15 men and 13 women, with a mean age of 59.3 years ±17.8 (SD) (range; 20–83 years). The indication for 64-section CT-enteroclysis included confirmation of small-bowel tumor detected at videocapsule endoscopy ($n = 7$), abdominal pain in association with clinical symptoms of subileus ($n = 4$), obscure gastrointestinal bleeding ($n = 4$), carcinoid syndrome ($n = 2$), hypervascular liver metastases at abdominal ultrasonography ($n = 2$), tumor mass of the terminal ileum at optical ileocolonoscopy ($n = 3$), and suspected small-bowel recurrence of carcinoid tumor after prior small-bowel resection ($n = 6$).

2.2. 64-Section CT-enteroclysis protocol

All examinations were performed after an 8-F nasojejunal tube (815 NF Biosphere Medical, Louvres, France) was placed beyond the duodenojejunal flexure using fluoroscopy. Water was infused with an electric pump (Enteroclyseur, Laboratoire Guerbet, Roissy, France) at a rate of 130–150 mL/min. The mean quantity of water was 1700 ± 75 mL (SD) (range 1600–1900 mL). Tiemonium methylsulfate (Viscéralgine®, Laboratoires Organon, Puteaux, France) was used to reduce small-bowel peristalsis [11,12,15].

Patients were imaged while in the supine position. A single-source multidetector CT unit (somatom sensation 64, Siemens Healthcare, Forchheim, Germany) was used with imaging parameters as reported in Table 1. Water infusion through the nasojejunal tube was maintained during helical CT. Images were acquired after intravenous administration of iodinated contrast material (ioversol, Optiray 350®, Guerbet, Roissy-Charles de Gaule, France or iohexol, Omnipaque 300®, GE-Healthcare, Cork, Ireland). An automated power injector (OptiVantage, Mallinckrodt-Tyco/Healthcare, Cincinnati, OH, USA) was used in all patients. For 17 patients, a single pass was obtained at 50 s after the start of the bolus injection, when bowel wall enhancement was optimal (enteric phase). For 11 patients, two imaging passes were obtained; a first pass during the arterial phase with the use of bolus tracking and automated triggering technology (Care Bolus, Siemens Healthcare) and a second pass during the enteric phase. Images were acquired in a cephalocaudad direction from the hepatic dome to the symphysis pubis, during one breath-hold.

After acquisition, helical CT data were reconstructed twice. A first axial images set was obtained at 2-mm thickness at 2-mm intervals. A second set was obtained at 0.6-mm thickness at 0.5-mm intervals for multiplanar reconstructions and maximum intensity projection (MIP) views. Additional three-dimensional reconstructions were performed in patients with abnormalities of mesenteric vessels. MIP views were interpreted along with axial and multiplanar images. Images were subsequently sent to a picture archiving and communication system (PACS) workstation (Directview, 11.3 version, Carestream Health Inc., Rochester, NY, USA) for further analysis, including 3-mm thickness multiplanar reconstructions and 10- to 15-mm thickness MIP views.

Table 2
64-Section CT-enteroclysis features in 22 patients with histopathologically proven carcinoid tumors of the small-bowel.

	Raw numbers	Proportions (%)	95%CI
Visible small-bowel mass at CTE	19	19/22 (86)	65–97
Small-bowel wall thickening (>3 mm)	20	20/22 (91)	71–99
Small-bowel mass with calcification	1	1/22 (5)	0–23
Hyperenhancing small-bowel mass	3	3/22 (14)	3–35
Mesenteric mass	15	15/22 (68)	45–86
Hyperenhancing mesenteric mass	3	3/22 (14)	3–35
Mesenteric mass with calcifications	3	3/22 (14)	3–35
Mesenteric stranding	18	18/22 (82)	60–95
Visible lymph nodes	11	11/22 (50)	28–72
Enlarged lymph nodes	5	5/22 (23)	8–45
Vascular encasement	2	2/22 (9)	1–29
Peritoneal nodules	2	2/22 (9)	1–29
Free-fluid effusion	3	3/22 (14)	3–35
Small-bowel luminal narrowing (>50%)	17	17/22 (77)	55–92
Small-bowel dilatation	3	3/22 (14)	3–35
Hepatic metastases	5	5/22 (23)	8–45

Note: Data are raw numbers, proportions, numbers in parenthesis are percentages, followed by 95% CIs. Results are given on a per-patient basis. CTE indicates 64-section CT-enteroclysis.

2.3. Image analysis

For this retrospective study, 64-section CT enteroclysis images were reviewed using the PACS workstation by two experienced abdominal radiologists working in consensus, blinded to the clinical history and results of the original reports, biological tests and other imaging techniques. During the reading sessions, axial and multiplanar reformatted images were reviewed with a standard window level (50 HU) and width setting (350 HU), with adjustments made when needed.

A first reading session was made during which enteric phase images obtained in all patients were analyzed. Several findings were evaluated by using a standardized data collection form (Table 2). They included the presence of visible small-bowel

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