REVIEW

Benign focal small bowel lesions : a review of the features on multiphasic multidetector computed tomography

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Abstract : The detection of small bowel lesions and their discrimination from normal bowel tissue are the most elementary and important factors in the computed tomography (CT) diagnosis of focal small bowel lesions. The detection and characterization of small bowel lesions have recently improved with advances in CT technology. Post-contrast multiphasic multidetector CT (MDCT) aids in the assessment of the vascular features of focal small bowel lesions. Understanding the typical multiphasic MDCT features of focal small bowel lesions is valuable because CT features overlap, and the severity and associated complications need to be assessed. However, it is often difficult to accurately diagnose focal small bowel lesions on MDCT, and histological examination is required in many cases in clinical practice. Clinical applications have been recently developed to effectively utilize dual-energy CT in the image analysis of small bowel lesions. In addition, the challenge of evaluating small bowel lesions with the aid of artificial intelligence has attracted attention in recent years. This review aimed to provide a comprehensive guide for the relevant imaging features of different types of benign focal small bowel lesions. J. Med. Invest. 72 : 1-7, February, 2025

Keywords **:** *computed tomography, small bowel, adenoma, Schwannoma, ectopic pancreas*

INTRODUCTION

A review of the current literature reveals limited studies dedicated to the imaging of benign focal small bowel lesions using multidetector computed tomography (MDCT). It is well-accepted that traditional barium examinations and routine CT do not have sufficient diagnostic capacity for focal enteric pathology. The clinical presentation of focal small bowel lesions varies widely and is usually nonspecific. Patients may present with pain, obstruction, bleeding, anorexia, weight loss, perforations, or jaundice (1). The nonspecific nature of these symptoms and the lack of reliable clinical findings may result in a significant delay in diagnosis (2).

MDCT enterography is commonly performed for new cases, recurrence, or complications of enteric inflammatory processes, infectious enteritis, mesenteric ischemia, benign small bowel neoplasms, and malignant small bowel neoplasms.

Capsule endoscopy is considered an excellent imaging modality for patients with suspected small bowel lesions. However, improved time resolution and bolus tracking technology in late-generation MDCT scanners have improved the radiological conspicuity of hyperenhancing small bowel lesions (3). MDCT enterography is increasingly used for the identification and diagnosis of small bowel lesions.

The aim of this review article is to present the CT features of various benign focal small bowel lesions and to review their characteristics on post-contrast multiphase MDCT. Additionally, we discuss advanced CT imaging techniques and analytical methods available in clinical practice.

Received for publication June 6, 2024 ; accepted January 10, 2025.

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VASCULAR LESIONS

Arteriovenous malformation

Abnormalities of the small bowel vessels, including arteriovenous malformations (AVMs). They account for 20–30% of cases of small bowel bleeding (4-6). Arterial lesions, including Dieulafoy's lesion and AVM, are most brightly enhanced during the arterial phase and become invisible during the enteric and delayed phases (Fig. 1). Most small bowel AVMs are congenital, appear as relatively large lesions, and sometimes harbor an early draining vein during the arterial phase (7). Multiphasic MDCT angiography can be a useful imaging tool for localizing the bleeding area as extravasation when the bleeding rate is > 0.3 mL/min in patients with overt GI bleeding (8). Multiphasic MDCT shows multiple small vascular ectasias during the arterial phase accompanied by early draining veins (9), and CT angiography with multiphasic MDCT has been reported to be an important tool for the diagnosis of small bowel AVM (10).

Blue rubber bleb nevus syndrome (Bean syndrome)

Blue rubber bleb nevus syndrome (BRBNS) is a rare entity consisting of multiple venous malformations involving several organ systems, especially the skin and gastrointestinal tract. Gastrointestinal lesions, which mostly involve the small bowel and colon, commonly cause chronic anemia due to gastrointestinal bleeding (11).

Several diagnostic techniques may be needed to visualize

gastrointestinal lesions of BRBNS. Fluoroscopic barium examination may reveal multiple polypoid filling defects that represent venous malformations, possibly mimicking polyposis syndrome. Endoscopy is more sensitive for small lesions of the stomach, duodenum, and colon. On unenhanced CT, some lesions contain millimetric calcifications, likely representing phleboliths. Post-contrast multiphasic MDCT can reveal the vascular nature of small bowel lesions in BRBNS (Fig. 2) and evaluate complications, including intestinal intussusception, volvulus, infarction, and active gastrointestinal bleeding related to BRBNS. Senturk *et al*. reported more than 30 small bowel lesions with peripheral discontinuous enhancement in the portal venous phase and homogeneous enhancement in the late phase (12).

NEOPLASMS

Adenoma

Adenomas are benign tumors that arise from the glandular epithelium and account for 14–20% of benign small bowel tumors (13). Adenomas are commonly found in the duodenum, particularly near the ampulla of Vater (14). Patients with adenomas are usually asymptomatic but occasionally present with gastrointestinal bleeding or obstruction secondary to intussusception (15). On contrast-enhanced CT, most adenomas appear as well-defined soft tissue masses showing moderate enhancement after intravenous contrast application with clear fat planes around the tumor (16). Multiplanar reconstruction (MPR) images can help differentiate adenomas from adenocarcinomas by identifying smooth margins, lack of mesenteric invasion, and clear fat planes around tumors (17). However, in clinical practice, small adenomas cannot be detected on contrast-enhanced CT scans or identified because the CT density of the adenoma is similar to that of the surrounding small bowel wall (Fig. 3). A previous report demonstrated that tubulovillous adenomas have moderate and mostly uniform enhancement, with the greatest enhancement observed in the venous phase on multiphasic CT (18).

Schwannoma

Schwannomas are benign neurogenic tumors that arise from Schwann cells of the peripheral nerve sheath. Schwannomas can arise from any nerve in the body, and the incidence is less than 10% in the gastrointestinal tract (19, 20). On CT, the gastrointestinal schwannomas, including those in the stomach and small bowel, predominantly appear as exophytic masses with

Figure 1. A 50-year-old woman with a small bowel arteriovenous malformation.
(a) Small vascular ectasias (arrowheads) are observed along the wall of the jejunum during the arterial phase. The jejunal wall is more contrast-enhanced than the surrounding small bowel walls. (b) Early-phase CT during arterial portography (CTAP) shows clearly dilated vessels in the jejunal wall (arrowheads). (c) Angiography of the superior mesenteric artery showing early filling of a branch of the superior mesenteric vein (arrowheads) from the AVM of the jejunal wall during the late arterial phase.

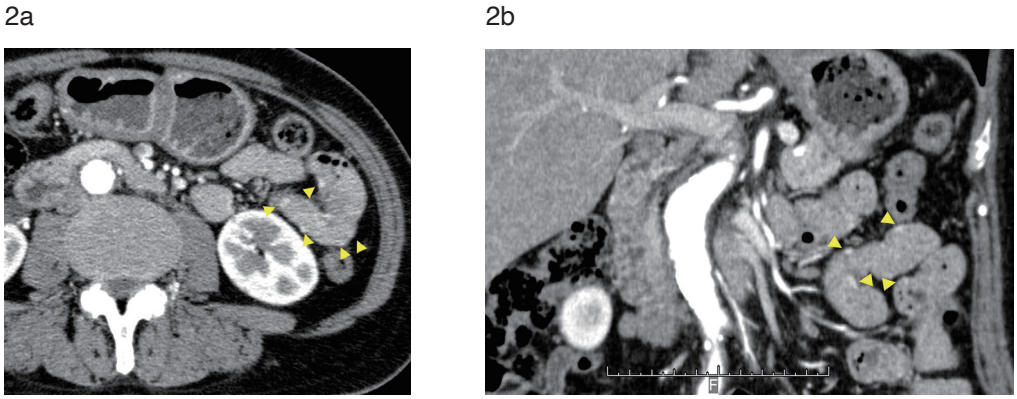

Figure 2. A 69-year-old woman with blue rubber bleb nevus syndrome.
Arterial-phase (a) and coronal (b) multiphasic CT revealing multiple contrast-enhancing polypoid lesions in the jejunum (arrowheads).

homogeneous enhancement. Cystic changes, cavity formation, necrosis, and calcification are uncommon (21-23). A previous study reported that MPRs showed a hypervascular tumor in the duodenum (24). However, schwannomas cannot be enhanced with contrast material in cases of severe ischemic changes in the bowel wall (Fig. 4).

Leiomyoma

Leiomyomas originate from the muscle coat of the small intestine and present mostly as solitary lesions. They are the most common benign tumors of the small bowel, with incidence ranging from 22 to 43%. They often present as incidental solitary

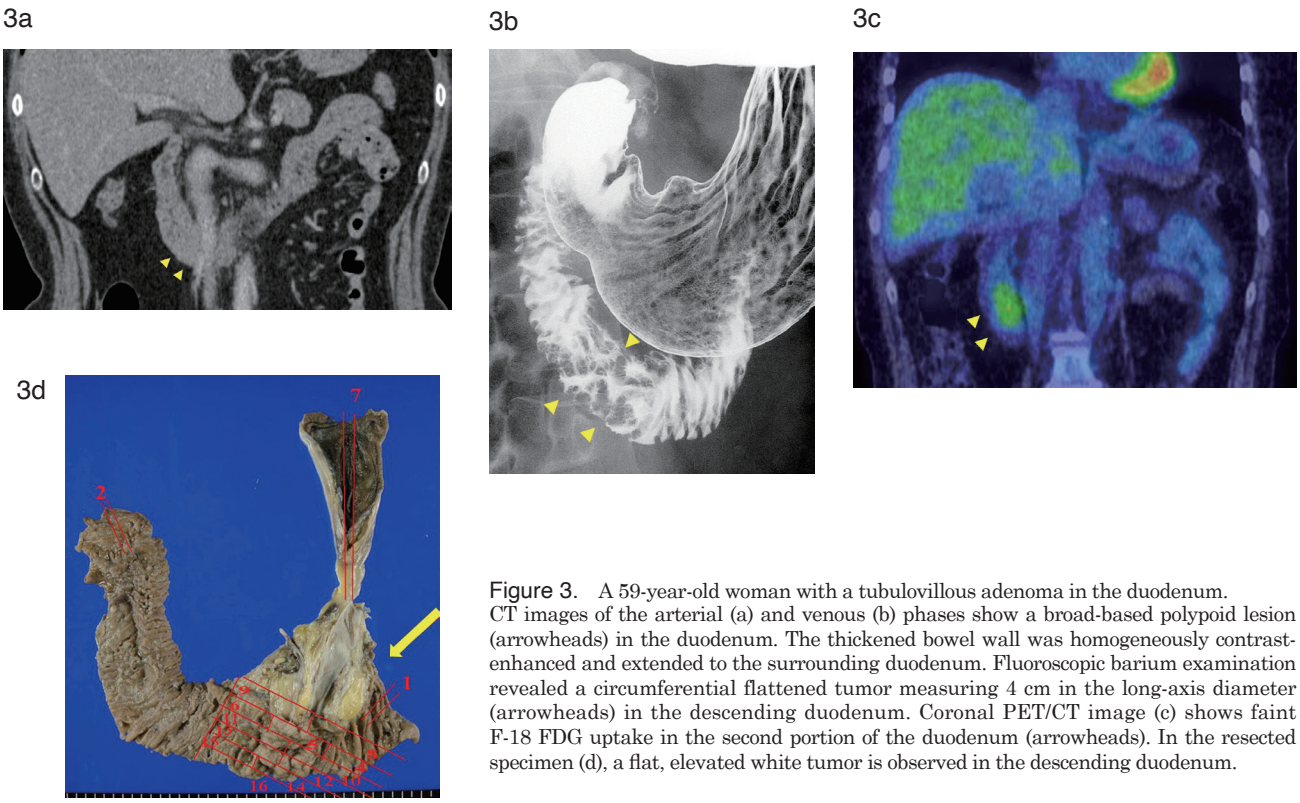

Figure 3. A 59-year-old woman with a tubulovillous adenoma in the duodenum.
CT images of the arterial (a) and venous (b) phases show a broad-based polypoid lesion (arrowheads) in the duodenum. The thickened bowel wall was homogeneously contrast-enhanced and extended to the surrounding duodenum. Fluoroscopic barium examination revealed a circumferential flattened tumor measuring 4 cm in the long-axis diameter (arrowheads) in the descending duodenum. Coronal PET/CT image (c) shows faint F-18 FDG uptake in the second portion of the duodenum (arrowheads). In the resected specimen (d), a flat, elevated white tumor is observed in the descending duodenum.

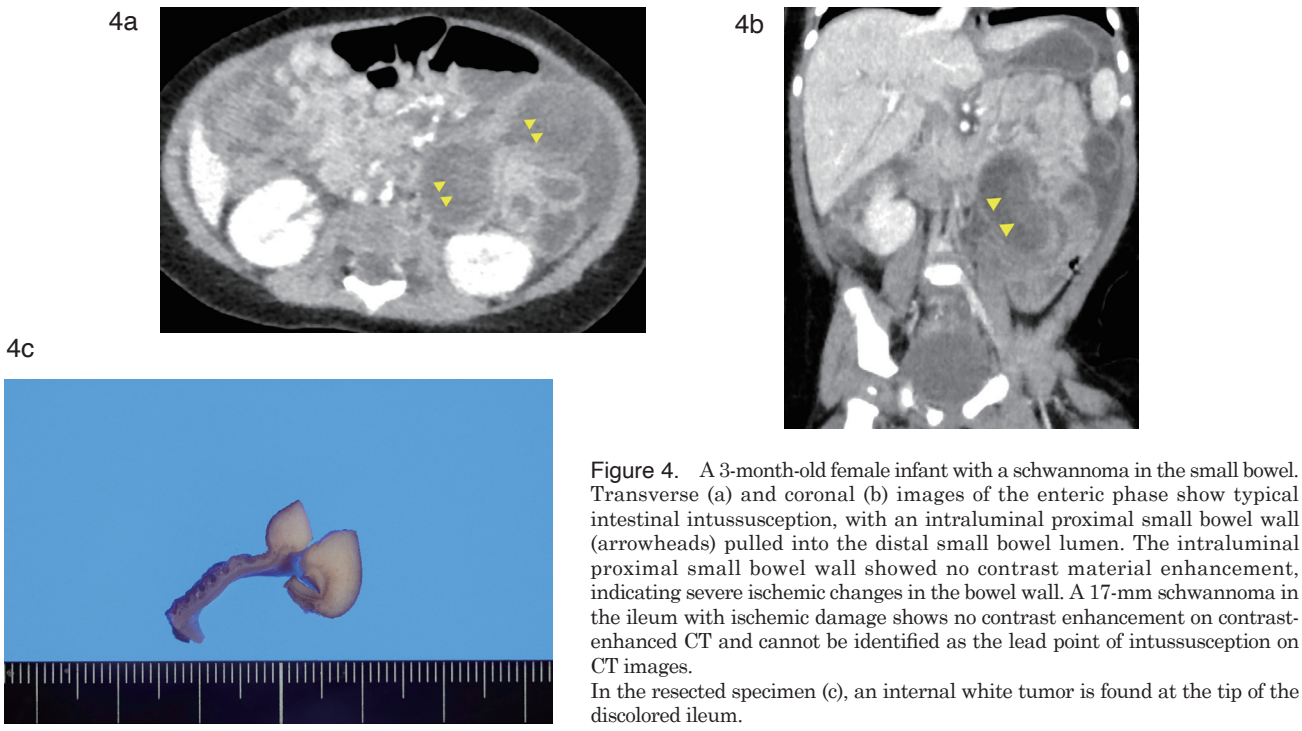

Figure 4. A 3-month-old female infant with a schwannoma in the small bowel.
Transverse (a) and coronal (b) images of the enteric phase show typical intestinal intussusception, with an intraluminal proximal small bowel wall (arrowheads) pulled into the distal small bowel lumen. The intraluminal proximal small bowel wall showed no contrast material enhancement, indicating severe ischemic changes in the bowel wall. A 17-mm schwannoma in the ileum with ischemic damage shows no contrast enhancement on contrast-enhanced CT and cannot be identified as the lead point of intussusception on CT images.
In the resected specimen (c), an internal white tumor is found at the tip of the discolored ileum.

tumors that predominantly develop in the jejunum (25). They may be located submucosally, intramurally, or subserosally. They appear on CT as sharply defined spherical masses with diameters of 1–10 cm that comprise homogenous tissue and show uniform contrast enhancement (Fig. 5). Larger lesions show dense focal calcifications (16). The imaging features of leiomyomas are neither specific nor distinguishable from those of gastrointestinal stromal tumors (GISTs). Lesions larger than 6 cm and those with irregular margins or surrounding lymphadenopathy raise the suspicion of malignancy such as leiomyosarcoma (14).

CONGENITAL AND ACQUIRED ANATOMICAL ABNORMALITIES

Diverticulum

Diverticula are sac-like protrusions of the bowel wall, and the incidence of small bowel diverticula (SBD) has been reported as close to 10% for the duodenum and 2.3% for the jejunum and ileum (26, 27). Diverticula can be congenital or acquired. Meckel's diverticulum is an acquired type that contains all three layers of the intestinal wall and typically presents earlier in life (28, 29). Approximately 90% of SBD are asymptomatic ; however, there are various complications, including diverticulitis, perforation, abscess formation, obstruction, anemia, and cholangitis (29, 30) (Fig. 6). MDCT typically shows normal SBD as an abnormal sac in the wall of the small bowel with a narrower neck than in the body, with a distinct fluid level surrounded by a thin wall (29). Previous reports have also shown that a small bowel diverticulum could induce small bowel volvulus because of its tumor-like effect, and inflammation of the small bowel diverticulum could cause small bowel adhesions (31-33). Multi-slice CT (MSCT) angiography can demonstrate the twisting of the mesenteric vessels on three-dimensional reconstructive images. In addition, MSCT can show signs of bowel ischemic changes, such as decreased contrast enhancement of the involved bowel segment, intramural gas, and mesenteric edematous changes (34).

Ectopic pancreas

Ectopic pancreatic (EP) tissue is a congenital abnormality whereby pancreatic tissue is found outside of the anatomical confines of the pancreas (35, 36). The incidence of ectopic pancreas in autopsy studies is approximately 0.6–15%, whereas the clinical incidence is 1 in 500 laparotomies (37). Most individuals with EP are asymptomatic ; hence, most cases are detected incidentally upon performing a procedure for another purpose. Some patients develop pancreatitis, pseudocysts, pancreatic cancer, and insulinoma and present with abdominal pain, gastrointestinal

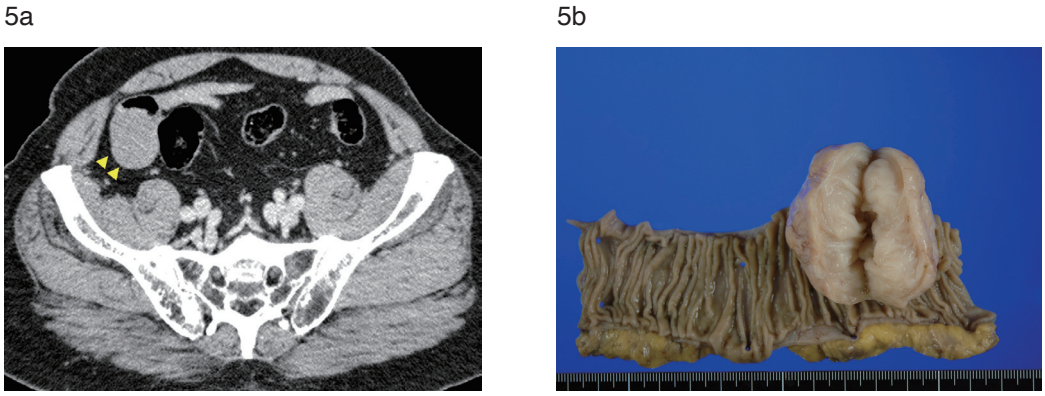

Figure 5. A 75-year-old man with a leiomyoma in the ileum.
An axial CT image of the venous phase demonstrates a 50-mm endoluminal mass with homogeneous enhancement in the ileum (arrowheads). In the resected specimen (b), a white elevated tumor is observed within the ileum.

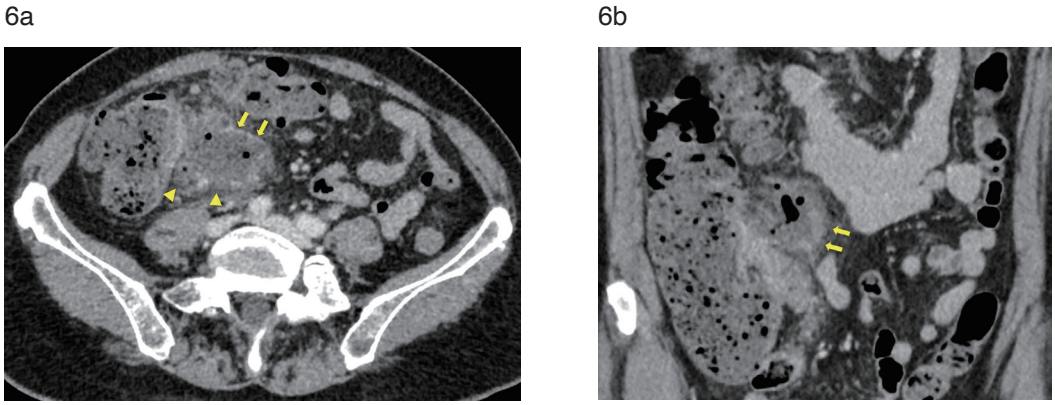

Figure 6. A 63-year-old man with ileal diverticulitis and perforation of ileal diverticulum.
Axial (a) and coronal (b) CT images of the venous phase showing feculent content mixed with gas bubbles in the ileal diverticulum, with localized edema in the adjacent mesenteric fat tissue. The diverticulum wall is partially thickened (arrows) with a partial defect (arrowheads).

bleeding, and obstruction (38). EP tissues may present on imaging as a submucosal lesion (Fig. 7) and are most commonly present within the duodenum (28%), stomach (26%), and proximal jejunum (16%). In addition, EP has been reported within SBD, including Meckel's diverticulum (15). Uslu *et al*. reported that EP tissue may be visualized on CT as isodense in the native pancreas (39). However, these results are not specific and cannot differentiate these lesions from other gastrointestinal tumors (40). Several radiological findings may help differentiate EP from GIST and leiomyomas. First, an ectopic pancreas is more likely to demonstrate prominent enhancement of the overlying mucosa, which is likely related to repeated inflammatory changes associated with the lesion. A long-axis, short-axis diameter ratio greater than 1.4 was found to be statistically significant in distinguishing EP tissue from GIST or leiomyoma. In addition, EP often demonstrates ill-defined margins in MDCT enterography (41).

The clinical role of multiphasic multidetector CT in diagnosing benign focal small bowel lesions

Benign focal small bowel lesions are often challenging to detect clinically because of nonspecific symptoms. MDCT scanning is a valuable diagnostic tool for evaluating the location, characteristics, and enhancement patterns of these lesions during post-contrast multiphasic CT scans (Table 1). MDCT is superior in characterizing mural or extraluminal lesions and assessing the extraluminal extent of disease. Current MDCT machines allow data acquisition with isotropic voxels, enabling the generation of MPR reformatted images with spatial resolution comparable to that of the axial plane without any loss of information. High-resolution MPR and curved reformats also enhance diagnostic confidence compared to standard axial images.

Multiphasic MDCT facilitates not only the precise localization of benign focal small bowel lesions but also aids in identifying their origin relative to bowel wall layers. Moreover, multiphase MDCT is instrumental in assessing lesion vascularity across arterial, enteric, and venous phases. The arterial phase, in particular, is crucial for predicting bleeding risk before biopsy or surgery. Imaging features of small bowel lesions and associated findings on multiphasic MDCT can significantly narrow the diagnostic possibilities. However, before performing multiphasic MDCT, consideration should be given to its appropriateness, taking into account the risks of ionizing radiation exposure (especially in pediatric patients) and the need for intravenous iodinated contrast material, which carries a risk of adverse reactions and the potential complication of contrast-induced nephropathy.

CLINICAL APPLICATION OF DUAL-ENERGY CT AND ARTIFICIAL INTELLIGENCE

Dual-energy CT (DECT) is a novel imaging technique that creates distinct datasets, such as iodine maps of tissue iodine accumulation, using two different X-ray energy levels (two tube voltages) during scanning. DECT also creates virtual monochromatic and virtual unenhanced images and provides a new approach to material discrimination. Previous studies have

Table 1. Summary of CT features of benign focal small bowel lesions

Diagnosis	CT features of benign focal small bowel lesions
Arteriovenous Malformation (AVM)	Multiple small vascular ectasias during the arterial phase accompanied by early draining veins
Blue rubber bleb Syndrome	Some lesions with calcification Homogeneous enhancement on the late phase
Adenoma	Well-defined soft tissue mass with clear fat planes Moderate enhancement after intravenous iodinated contrast administration
Schwannoma	Solitary exophytic tumor Homogeneous enhancement after intravenous iodinated contrast administration
Leiomyoma	Spherical homogenous mass Homogeneous enhancement after intravenous iodinated contrast administration Larger lesions can have calcification
Diverticulum	Abnormal sac in the small bowel wall Decreased contrast enhancement in case of ischemic change
Ectopic pancreas	Iso dense to the native pancreas Similar enhancing pattern to the pancreas

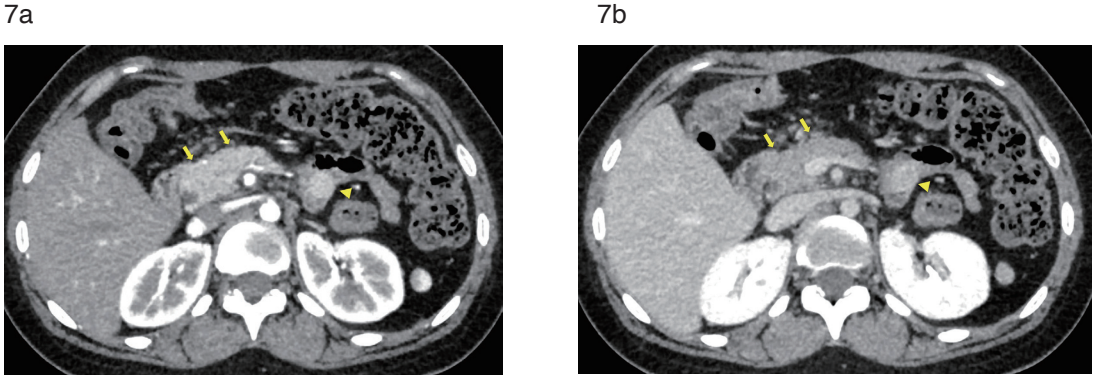

Figure 7. A 17-year-old girl with an ectopic pancreas in the jejunum.
Axial CT images of the arterial (a) and venous (b) phases demonstrating a hyperenhancing tumor within the jejunum (arrowheads). The enhancement pattern of the tumor was similar to that of the pancreatic tissue (arrows).

demonstrated that DECT has potential clinical applications in benign gastrointestinal diseases as a useful tool for diagnosing gastrointestinal bleeding, acute bowel ischemia, and gastrointestinal tuberculosis (42-45).

Computational image analysis and artificial intelligence (AI) have the potential to augment physician expertise and reduce errors and variability in the assessment of the small bowel using imaging. A recent report provided models that can extract the most discriminatory imaging features using a deep learning model (DLM) for the diagnosis of intestinal fibrosis in patients with Crohn's. The DLM performance was markedly superior to the ability of radiologists to identify fibrosis on CT (46). AI has the potential to provide automated data analysis by reducing inter-observer variation and improving diagnostic accuracy and radiology workflow.

Insights from future research on DECT and AI are expected to expand their applications and improve their performance in clinical settings.

CONCLUSIONS

Multiphasic MDCT is a valuable modality for the detection of small bowel diseases and the radiological diagnosis of focal small bowel lesions. Precise imaging diagnosis of focal small bowel lesions remains difficult in clinical practice, except for several small bowel lesions with characteristic imaging features. Further development of DECT and AI may dramatically improve the diagnosis and detection of focal small bowel lesions.

DISCLOSURES

The authors declare no conflicts of interest associated with this manuscript.

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