

## **Spiral CT demonstration of hypervascularity in Crohn disease: “vascular jejunization of the ileum” or the “comb sign”**

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### **Abstract**

**Objective:** To report spiral CT imaging features of the vascular alterations observed in active, early, or recurrent Crohn disease of the small bowel and colon.

**Methods:** Spiral CT examinations of the abdomen and pelvis following oral and intravenous contrast were performed in two cases of active Crohn disease.

**Results:** Spiral CT features of hypervascularity involving the mesenteric vessels of affected segments of bowel include vascular dilatation, tortuosity, and conspicuous prominence and wide spacing of the vasa recta (the “comb” sign). This is attributed to the factors of increased flow and the fibrofatty proliferation in the mesentery and serosa of the affected bowel.

**Conclusion:** Clinical application of these observations may enhance the diagnosis of Crohn disease presenting initially or as an acute recurrence in the differential diagnosis from other conditions.

**Key words:** Crohn disease—Regional enteritis—Intestines—Spiral CT—Hypervascularity.

Spiral CT technology offers many advantages in the evaluation of multiple abdominal disorders [1–3]. Refinements in the imaging of diseases of the liver, biliary system, pancreas, spleen, kidneys, and great vessels have been explored. However, the potential value of spiral CT in diseases of the bowel has as yet been conspicuously overlooked.

Historically, the diagnostic features of Crohn disease of the small intestine [4] and colon [5, 6] have been

delineated by barium studies [7–11], by arteriography [12–20], and in the last decade by computed tomography [21–25].

Spiral CT now offers the capability of combining the evaluation of luminal and mural changes and extramural pathology with vascular alterations.

We report the spiral CT findings in two patients with active, early or recurrent Crohn disease. The morphologic features of the vascular alterations are described. The identification of these distinctive vascular changes, “vascular jejunization of the ileum,” or the “comb sign,” may be used to diagnostic advantage.

### **Materials and Methods**

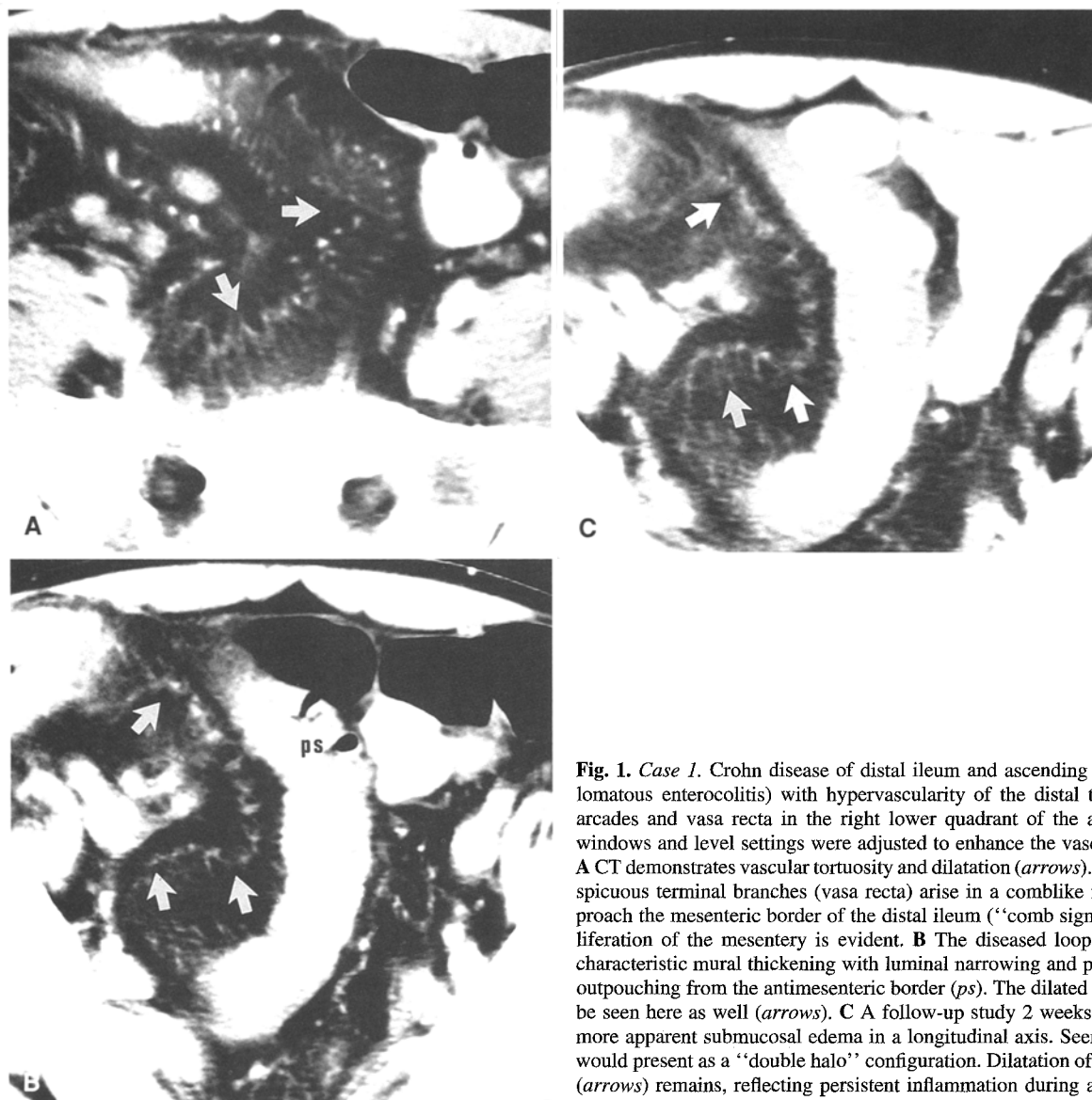
Two patients with clinical evidence of active Crohn disease, in accordance with the Crohn Disease Activity Index [26], underwent spiral CT examinations. Barium studies demonstrated the characteristic features of this disease.

All spiral CT images were acquired with a High Speed Advantage Unit (GE, Milwaukee, WI) utilizing the following: 10 mm collimation, 10 mm/s table speed, 120 kVp, and 280 mA. Intravenous infusion of 100 ml of a 60% iodinated contrast medium was performed with an injection rate of 2.5 ml/s. Oral administration of 1000 ml of diluted (1–2%) Gastrografin (MD-Gastroview, Mallinckrodt Medical, Inc., St. Louis, MO) 1–2 h before the examination provided gastrointestinal opacification. Scanning began 60 s after the injection of contrast material and during breathholding (end expiration, 7-s breath hold). Scan time per examination averaged 180 s.

### **Case Reports**

#### *Case 1*

A 29-year-old male with a 5-year history of Crohn disease of the small bowel and ascending colon presented to the emergency room with a several day history of right lower quadrant pain and diarrhea. Initial



**Fig. 1.** Case 1. Crohn disease of distal ileum and ascending colon (granulomatous enterocolitis) with hypervascularity of the distal tier of arterial arcades and vasa recta in the right lower quadrant of the abdomen. The windows and level settings were adjusted to enhance the vascular findings. **A** CT demonstrates vascular tortuosity and dilatation (arrows). Multiple conspicuous terminal branches (vasa recta) arise in a comblike fashion to approach the mesenteric border of the distal ileum ("comb sign"). Fatty proliferation of the mesentery is evident. **B** The diseased loop demonstrates characteristic mural thickening with luminal narrowing and pseudosaccular outpouching from the antimesenteric border (*ps*). The dilated vasa recta can be seen here as well (arrows). **C** A follow-up study 2 weeks later displays more apparent submucosal edema in a longitudinal axis. Seen en face, this would present as a "double halo" configuration. Dilatation of the vasa recta (arrows) remains, reflecting persistent inflammation during an acute exacerbation of Crohn disease.

spiral CT examination was performed on the day of admission to rule out abscess. This study demonstrated the mural and vascular alterations of active, early Crohn disease (Fig. 1A–B). Following 2 weeks of medical therapy for this acute exacerbation, a repeat spiral CT examination was obtained. At this time, many of these pathologic manifestations were shown to advantage (Fig. 1C).

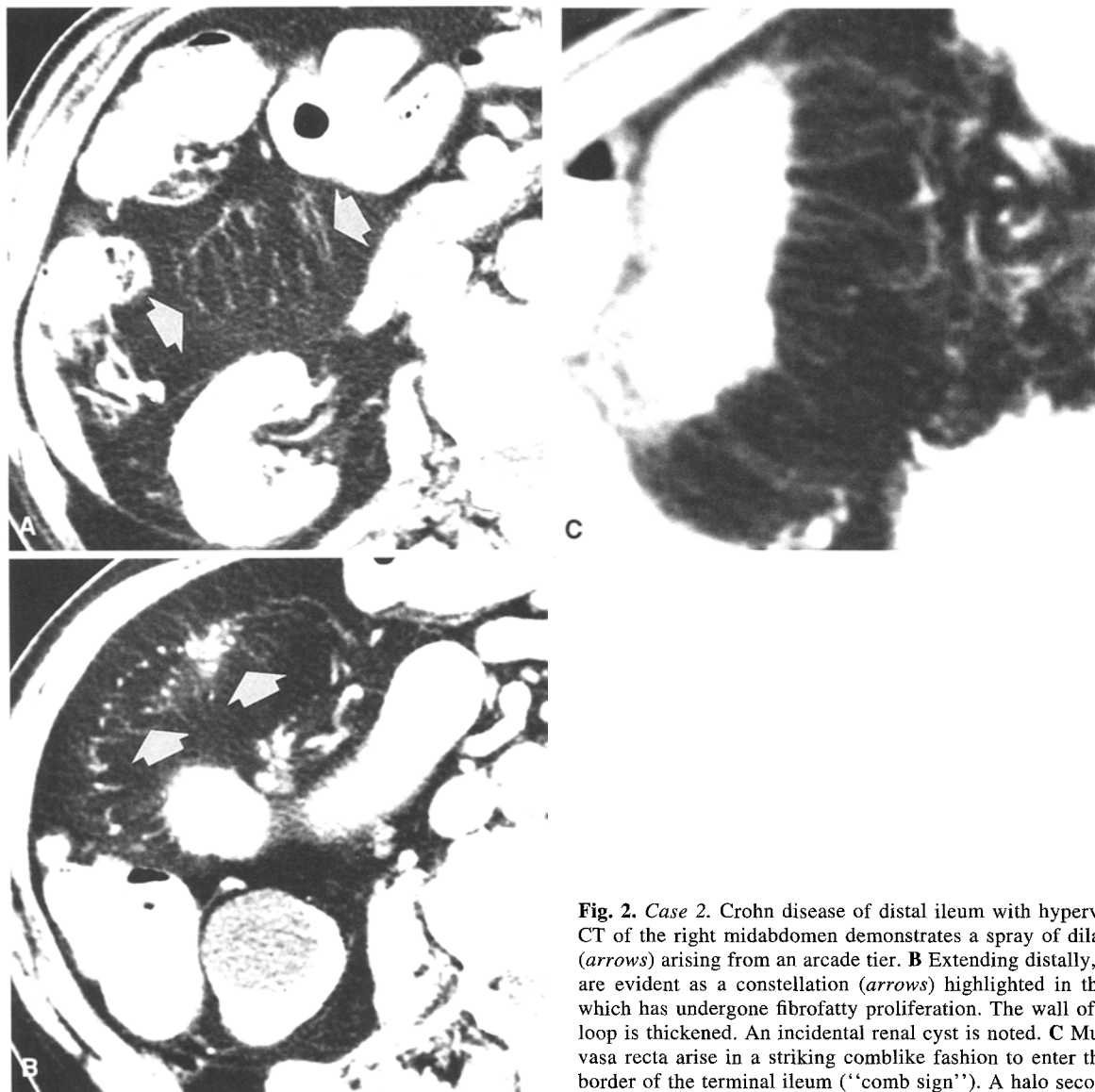
### Case 2

An 80-year-old male with a remote history of peptic ulcer disease underwent a work-up for hematuria, which included spiral CT examination of the abdomen for the evaluation of renal cysts. In addition to the mural and extramural changes of active Crohn disease, distinctive hypervascularity was demonstrated (Fig. 2). Subsequently, an upper gastrointestinal examination with a small bowel series demonstrated characteristic features of Crohn disease of the terminal ileum.

### Discussion

Identification of the characteristic diagnostic features of Crohn disease and refinement in its recognition have accompanied the successive stages of advances in imaging. First described in 1932 as an entity involving the small bowel [4] and, in the 1950s, in the colon [5, 6], the characteristic abnormalities by barium studies were then defined. These include early aphthoid ulcers, transverse and linear ulcers, mesenteric and then perhaps circumferential mural involvement of the affected segment of bowel, pseudosacculations, skip lesions an ulceronodular or cobblestone pattern, strictures, and fistulae [7–11].

Subsequently, during an era of clinical visceral arteriography, the vascular changes associated with Crohn



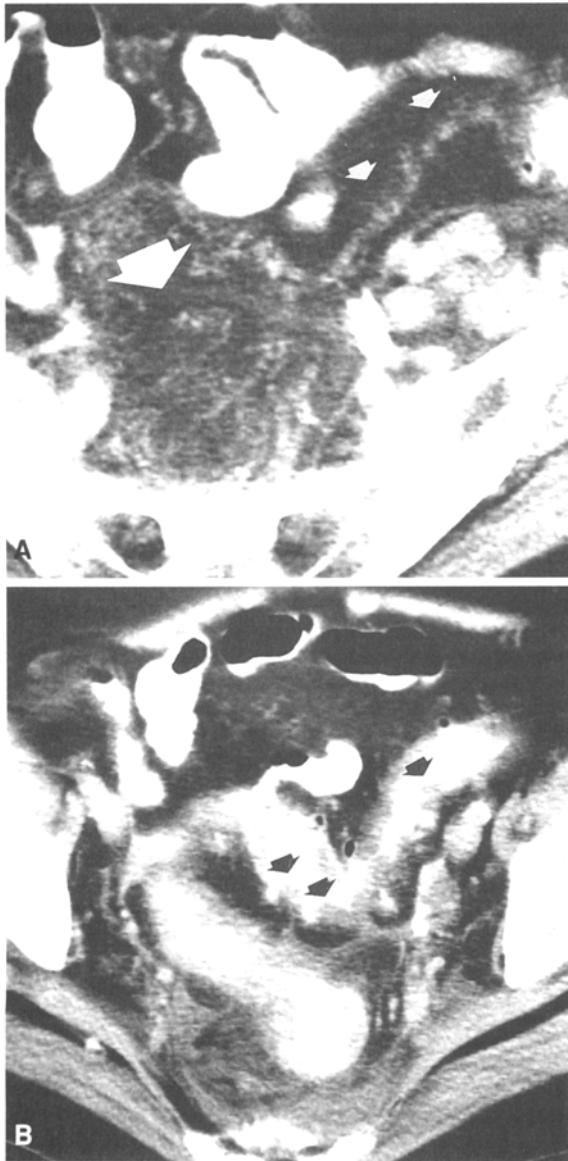
**Fig. 2.** Case 2. Crohn disease of distal ileum with hypervascularity. A CT of the right midabdomen demonstrates a spray of dilated branches (*arrows*) arising from an arcade tier. **B** Extending distally, the branches are evident as a constellation (*arrows*) highlighted in the mesentery, which has undergone fibrofatty proliferation. The wall of a distal ileal loop is thickened. An incidental renal cyst is noted. **C** Multiple dilated vasa recta arise in a striking comblike fashion to enter the mesenteric border of the terminal ileum (‘comb sign’). A halo secondary to submucosal edema is present within its thickened wall.

disease were actively investigated, particularly in the large intestine. These were often directed toward defining the differentiation from ulcerative colitis but yielded fundamental information that could be closely correlated with other pathological alterations.

The angiographic findings in Crohn disease reflect the underlying activity, severity, and duration of disease [12–20]. Angiographic features of active, early disease include increased vascularity, arterial dilation, right-angle bifurcation and tapering of vasa recta, increased parenchymal enhancement, and early, dense venous opacification. Recently, Doppler ultrasound studies have also demonstrated that activity of Crohn disease causes a substantial increase in arterial flow volume [27–28].

The etiology of these early vascular changes is not well understood. However, several theories have been proffered. Recent studies have demonstrated an increased expression of somatostatin receptors in the veins of inflamed intestines; somatostatin is a mediator of vasodilation [29]. Arachadonic acid metabolites could also play a role in the vascular response seen in the inflammatory bowel diseases [30].

The next phase in emphasis was brought about by the introduction of computed tomography and its widespread application to the abdomen and pelvis, particularly in regard to the mural and extramural manifestations of Crohn disease. Thickening of the wall sometimes accompanied by a ‘‘double halo’’ configuration reflecting underlying submucosal edema, fibro-



**Fig. 3.** Ischemic colitis with hypervascularity. **A** CT demonstrates hypervascularity of marginal artery (*small arrows*) and sigmoid arterial branches (*large arrow*). **B** At a lower level, a scan of the sigmoid colon demonstrates thickening of the wall with diffuse submucosal edema and nodular thumb-printing (*arrows*) on a narrowed lumen.

fatty proliferation of the mesentery, mesenteric adenopathy, fistulae, sinus tracts, and frank abscess formations adjacent to involved bowel segments are now visible [21–25].

Fibrofatty proliferation of the mesentery is the most common cause of bowel loop separation seen on CT studies in patients with regional enteritis [22]. Whereas the CT density of normal mesenteric fat is in the range of  $-100$  to  $-160$  Hounsfield units (HU), fibrofatty proliferation shows an attenuation value of  $-70$  to  $-90$  HU secondary to the influx of inflammatory cells and fluid

[22]. Creeping mesenteric fat as observed pathologically tends to extend over the serosa toward the anti-mesenteric border so that it may virtually encompass the bowel in areas of maximum involvement [22, 28].

Yet, despite over a decade's use of CT in inflammatory bowel disease, interest in the vascular changes attendant to Crohn disease has been abandoned. Many of the potential clinical advantages of spiral CT in the abdomen and pelvis have been detailed or forecast [1–3], but the application to diseases of the intestines has been conspicuously overlooked. The advent of spiral CT now favors the development and clinical use of bowel CT angiography combined with cross-section imaging.

Normally, second-order vascular branches in the abdomen and pelvis can be visualized routinely, so that in the small bowel many of the intestinal arcades and branches are seen [31].

By utilizing spiral CT, we have delineated the hypervascular changes in acute or recurrent Crohn disease (Figs. 1, 2). Tortuosity and dilatation of mesenteric arterial branches is striking. Branches radiating from an arcade tier, when examined axially, may be seen in the configuration of a spray or constellation, highlighted by increased mesenteric fat. Conspicuously dilated vasa recta extend in a parallel, widely spaced, comblike manner from the last arcade tier to the mesenteric border of acutely inflamed loops. This vascular pattern of vessel dilatation from the main mesenteric branches distally to the level of the vasa recta is a feature of early Crohn disease. Such findings would be unexpected in chronic disease with its characteristic fibrosis [11, 13, 22]. Recent correlative pathologic studies have demonstrated a spectrum of vascular changes, ranging from mesenteric vasculitis [32, 33] and associated vessel wall granulomas [33–35] to obliterative vascular lesions [14, 33].

The normal distribution and course of the intestinal arcades and branches are distinctive for the jejunum and ileum. In the jejunum, the last arcade tier is at some distance from the mesenteric border so that the vasa recta are long and widely spaced. In contrast, ileal loops are supplied by short, closely spaced branches [36]. These features are readily observed in spiral CT of the abdomen [31]. However, in our cases, there is reversal of this pattern in the affected ileal loops, which demonstrate long, dilated, widely spaced vasa recta. This is attributable to the factors of increased flow and the proliferation of mesenteric and creeping fat. We refer to these changes as "vascular jejunization of the ileum". We have termed the characteristic spiral CT manifestation of this morphologic alteration the "comb sign" (Figs. 1A, 2C).

Although delayed scans were not obtained, it could be anticipated that features of the parenchymal phase, perhaps with the "zoning sign" [17, 20], would be manifest. This reflects increased mucosal and submu-

cosal contrast enhancement combined with muscular edema and fat infiltration. In addition, early and dense venous opacification could be expected.

A rare complication of Crohn disease is lower gastrointestinal (GI) bleeding, occurring in 1–2.5% of patients [37–39]. Localization of the site of bleeding has generally been accomplished by arteriography [37, 40]. The value of conventional CT without oral contrast material, but immediately following negative arteriography in localizing the site of significant but intermittent GI hemorrhage, by demonstrating the presence of focally dense intraluminal contrast within the small bowel loops has recently been shown [41]. Spiral CT angiography with intravenous contrast offers the capability to document precisely the site of intraluminal extravasation.

In patients with Crohn disease involving the ileum and/or ascending colon, spiral CT features of hypervascularity should suggest an acute exacerbation. In patients presenting for the first time, these spiral CT findings should raise the possibility of this diagnosis. However, these are not pathognomonic and can be seen in other inflammatory bowel diseases (e.g., ulcerative colitis) and in ischemic colitis (Fig. 3).

The utility of identifying hypervascularity by spiral CT may come from facilitating the differentiation of other diseases that simulate Crohn disease on barium studies, most notably lymphoma [42, 43]. Metastatic breast carcinoma to the large intestine initially may be mistaken for an intrinsic inflammatory process such as granulomatous colitis [44] because the processes share several pathologic and radiographic characteristics. These include unilateral mural involvement, nodular irregularities, pseudosaccular outpouchings, and the occasional appearance of ulcerations. Hypervascularity in either of these entities would be unexpected.

In conclusion, the distinctive vascular alterations associated with the characteristic mural and other extramural manifestations of Crohn disease are clearly delineated with the use of spiral CT. Tortuosity and dilatation with prominent comblike arrangement of the vasa recta (vascular jejunitization of the ileum) are conspicuous features of active Crohn disease.

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