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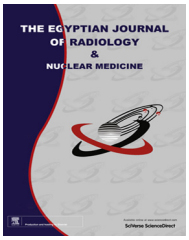

ORIGINAL ARTICLE

Celiac disease: Do not miss that diagnosis!

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KEYWORDS

Celiac disease;
CT enterography;
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Abstract *Background:* Celiac disease (CD) is a chronic autoimmune disorder induced in genetically susceptible individuals after ingestion of gluten proteins
Aim of the work: To highlight the utility of abdominal CT/enterography in diagnosis of CD.
Subjects & methods: This retrospective study included 12 patients presented to our institute during the period from May 2011 till April 2013 with vague abdominal symptoms, performed abdominal CT/enterography. The final diagnosis was reached in all patients through upper GI endoscopy, duodenal biopsy and serological tests including anti-tissue transglutaminase and anti-endomysial antibodies.
Results: The sensitivity of different CT signs was calculated against the diagnostic standard of reference (biopsy & serology). The jejuno-ileal fold reversal pattern was detected in 100% of patients. Other findings included (in descending order): Enlarged mesenteric lymph nodes in eight patients (66.5%); jejunal wall thickening, dilated jejunal loops, and cavitating lymph nodes in six patients (50%); dilated ileal loops in four patients (33%); ileal wall thickening in three patients (25%); thickened duodenum, and small bowel intussusception in two patients (16.5%).
Conclusions: CT is an efficient imaging tool in diagnosis of CD. The jejuno-ileal fold reversal pattern is highly in favor of the diagnosis of CD.

1. Introduction

Celiac disease (CD) is a chronic autoimmune disorder induced in genetically susceptible individuals after ingestion of gluten proteins, which are found in wheat, rye, barley, and certain other grains that affects slightly more than 1% of the general population in many countries. However, less than 10% of cases are currently diagnosed with a diagnostic delay of more than 10 years from onset of symptoms (1,2).

The small bowel mucosa is primarily affected, resulting in progressive degrees of villus inflammation and destruction with resulting induction of crypt hyperplasia (3). The destruction begins in the duodenum and over time progresses distally to the ileum. Loss of villi, which absorb fluid, and hypertrophy of crypts, which produce fluid, result in chronic fluid excess in the small bowel lumen (4).

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Celiac disease can cause a spectrum of symptoms ranging from a subclinical form, which may be incidentally detected in patients without symptoms, to the classic malabsorptive form (5,6). Laboratory tests show variable degrees of malabsorption, including anemia secondary to malabsorption of iron, folic acid, or vitamin B12; hypocalcemia; hypoalbuminemia; and vitamin deficit. Also, CD can be associated with thrombocytosis, thrombocytopenia, leucopenia, venous thromboembolism, hyposplenism, and immunoglobulin A deficiency. Gastrointestinal neoplasms especially are found in patients with persisting mucosal injury who do not completely adhere to a gluten-free diet (7).

If celiac disease is suspected, confirmation is with endoscopy and duodenal biopsy in addition to antibody testing (8). Antibody testing has been shown to be both sensitive and highly specific for anti-tissue transglutaminase and anti-endomysial antibodies (9). According to the revised criteria of the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN), duodenal biopsy demonstrating the reduction or disappearance of the 'villi' associated with crypts hyperplasia, remains the mandatory requirement for definite CD diagnosis (10).

The effective treatment of adult patients with CD is based on total lifelong elimination of food products containing gluten. It is now recognized that if diagnosis is delayed for more than a decade from the time symptoms develop, there is increased morbidity (including iron deficiency anemia, lactose intolerance, osteoporosis, increased fracture risk, miscarriage, low birth weight, lymphoma, seizures, and depression) and increased mortality. Studies show a fourfold increase in deaths during a 45-year follow-up of undiagnosed cases of CD (1,2).

Table 1 Shows the clinical presentation of the studied patients.

Clinical presentation	Number of + ve cases	%
Chronic diarrhea	9	75
Weight loss	7	60
Abdominal distension	6	50
Abdominal pain	3	25
Anemia	3	25
Generalized subcutaneous edema	2	16.5
Recurrent vomiting	3	25

It is still challenging to diagnose many patients with CD because they often present with non specific signs and symptoms of malabsorption like chronic diarrhea, abdominal distension, anemia and weight loss. In non-specific and doubtful conditions, computed tomography is often performed. In a clinical practice, a review of computed tomography signs is therefore mandatory (11).

In this study, we will highlight the utility of abdominal CT or CT enterography in diagnosis of CD and we will demonstrate the different CT findings which are useful in suggesting this diagnosis.

2. Materials and methods

This retrospective study included 12 patients that presented to our institute during the period from May 2011 till April 2013 with vague recurrent abdominal symptoms including nausea, vomiting, abdominal pain and distension or unexplained

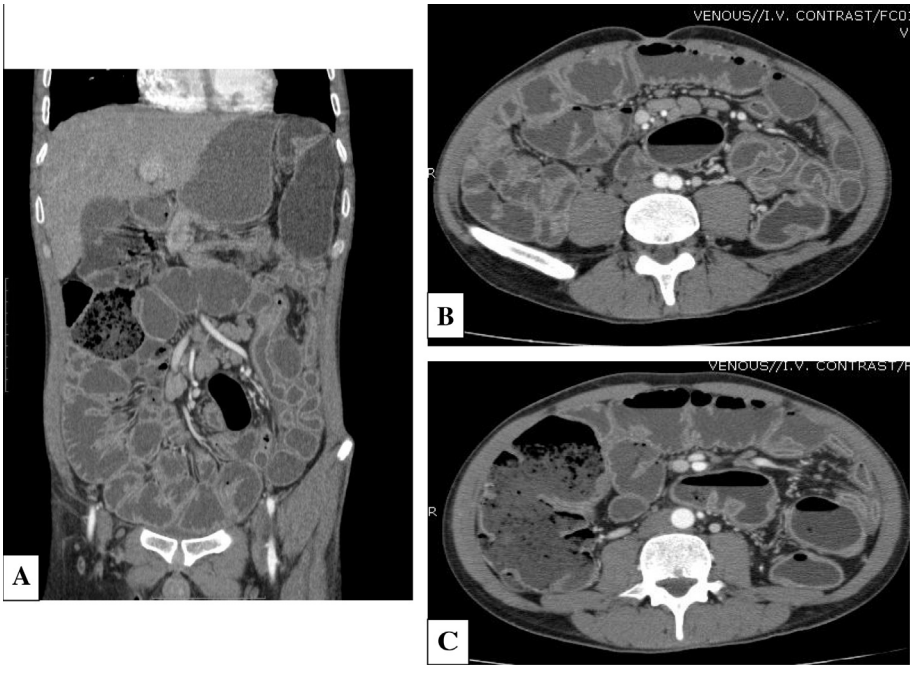

Fig. 1 A 35-year old male presenting with chronic diarrhea, abdominal pain and distension. Multislice contrast enhanced CT enterography images of the abdomen: coronal (A), axial (B & C) images showing Jejuno-ileal fold pattern reversal (JFPR), mild jejunal wall thickening with mucosal enhancement and submucosal edema (water halo sign), mild ileal dilatation, reaching 4 cm in caliber, abundant enlarged mesenteric adenopathies, reaching 17 mm in short axis and mesenteric vascular congestion. The diagnosis of celiac disease was suggested and confirmed histopathologically via endoscopy with duodenal biopsy.

Table 2 Shows the distribution of the different CT findings in the twelve patients included in this study.

CT finding	Number of +ve cases	%
Reversed jejuno-ileal fold pattern	12	100
Duodenal wall thickening	2	16.5
Jejunal wall thickening	6	50
Ileal wall thickening	3	25
Jejunal dilatation	6	50
Ileal dilatation	4	33
Intussusception	2	16.5
Cavitating mesenteric lymph nodes	6	50
Mesenteric vascular engorgement	3	25
Atrophic spleen	2	16.5
Abdominal wall edema	2	16.5

anemia, chronic diarrhea and symptoms suggestive of malabsorption syndrome with request for either abdominal CT or CT enterography.

Clinical features and laboratory investigations of all patients in the study were recorded.

All patients underwent either abdominal CT for those with non-specific symptoms, or CT enterography for those with symptoms suggestive of malabsorption syndrome.

We used a multislice CT machine (Aquilion CX – Toshiba) having a 64 detector-row and 128-slices per rotation. The scanning parameters were 102 Kvp, 350 mA, 0.75 s rotation time, a rotation pitch of 0.8, and 0.625 mm reconstructed slice thickness. Low osmolar iodinated contrast medium (350 mg iodine/ml) was injected using an automatic power injector at a dose of 1.5 ml/kg body weight, and an injection rate of 3 ml/s. A non-contrast then a single post contrast portal phase was used at 60 s after the start of contrast injection. In cases where CT enterography was performed, the same above protocol was used, but patient preparation included ingestion of 2 L of iso-osmolar mannitol solution over 1 h preceding the scan. We prepared the iso-osmolar mannitol solution by diluting the commercially available 10% mannitol in water (ratio 1:1), to have a total volume of 2 L. The patient preparation begins 1 h before the study by drinking 4 aliquots of 500 cc each of this iso-osmolar mannitol, the last being in the CT room, just before the IV contrast injection. The patient also receives two ampoules of Visceralgin, aiming to relax the intestinal smooth muscles thus helping the bowel distention.

Diagnostic serological tests for CD disease were performed for all patients including anti-tissue transglutaminase and anti-endomysial antibodies. Diagnostic endoscopy and duodenal biopsy were performed for all patients. Both serology and histopathology confirmed the CT diagnosis of CD (Diagnostic standard of reference). The sensitivity of the different CT signs was calculated against this standard.

Viewing the retrospective nature of the study, detailed patient consent was waived by our Institutional Research Ethics Committee. Still, the confidentiality of patients' data and anonymity of the studies were respected.

3. Results

This study included 12 patients out of which there were seven males (60%) and five females (40%). Their ages ranged between 19 and 54 years. All patients presented with vague

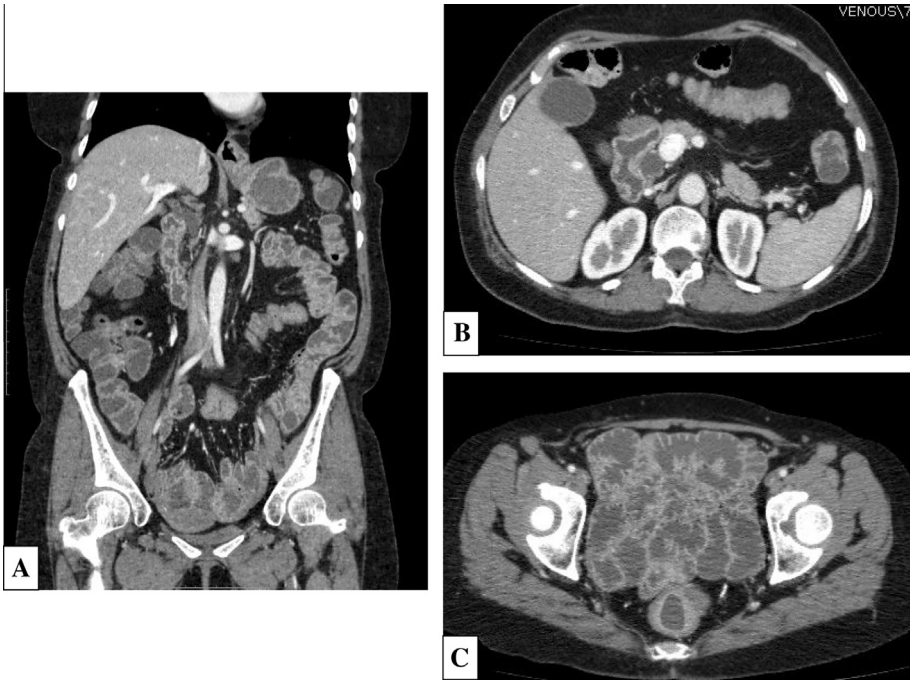

Fig. 2 A 54-year old female presenting with chronic diarrhea, weight loss and anemia. Multislice contrast enhanced CT images of the abdomen: coronal (A), axial (B & C) images showing inflammatory changes involving the duodenum and proximal jejunal loops manifested by mucosal hyperenhancement and submucosal edema (water halo sign). This is associated with atrophic jejunal fold pattern, as well as jejunized ileal fold pattern (Fold pattern reversal). The diagnosis of celiac disease was suggested and confirmed by positive serology and histopathologically via endoscopy with duodenal biopsy.

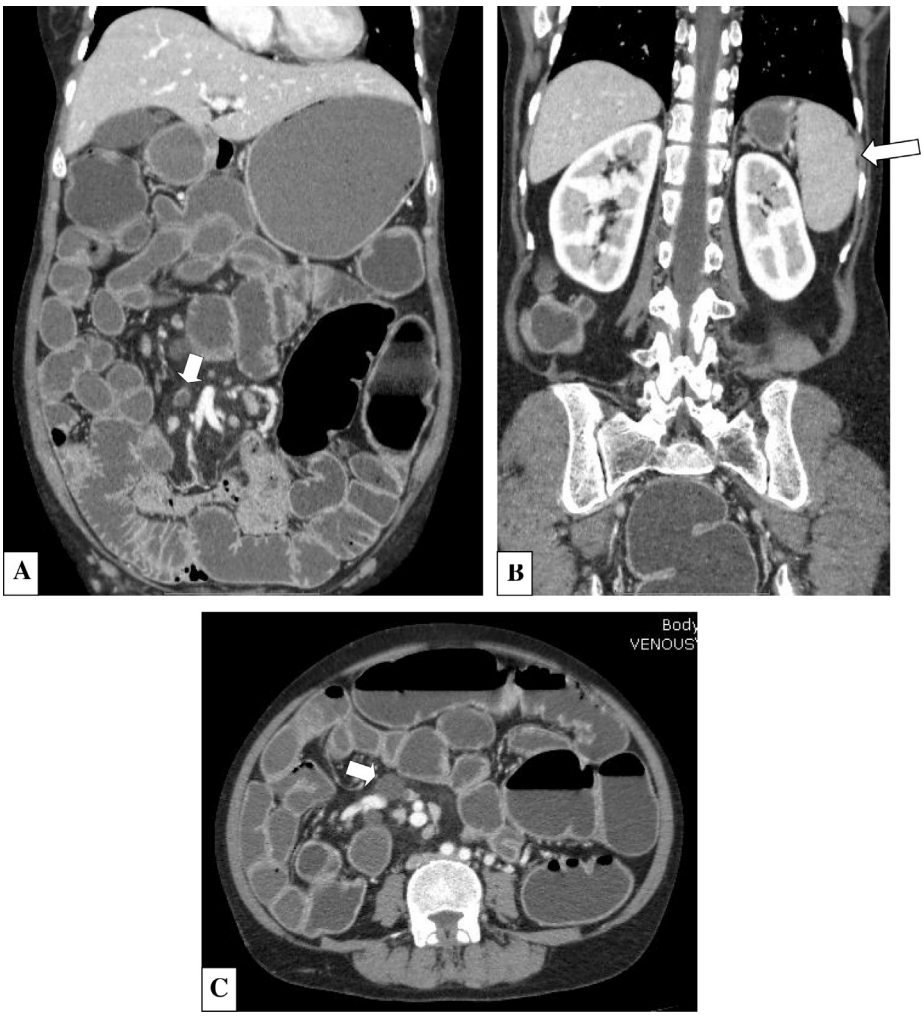

Fig. 3 A 45-year old female presenting with abdominal pain and distension. Multislice contrast enhanced CT enterography of the abdomen: coronal (A and B) and axial (C) images showing effaced jejunal folds, with jejunization of the ileal fold pattern reflecting reversed small bowel fold pattern. The spleen is of relatively small size (long white arrow in B), with normal tissue characters. Multiple nodal enlargements noted at the mesenteric root, reaching 17 mm with internal liquefaction (short white arrow in B & C). The diagnosis of celiac disease was suggested and confirmed by positive serology and histopathologically via endoscopy with duodenal biopsy.

recurrent and/or chronic abdominal symptoms including chronic diarrhea in 9 patients (75%), weight loss in seven patients (60%), abdominal distension in six patients (50%), abdominal pain in three patients (25%), anemia in three patients (25%), generalized subcutaneous edema in two patients (16.5%) and recurrent vomiting in three patients (25%) (Table 1).

CT was performed for all patients without definite preliminary clinical diagnosis. The bowel loops were adequately assessed as regards fold pattern of both the duodenal and jejunal loops, thickness of the wall of the bowel loops, diameter of the bowel loops and presence of bowel intussusception. The intestinal mesentery and its vascularity were also assessed with inspection for the presence of enlarged mesenteric lymph nodes.

Abnormalities of the intestinal fold pattern were defined qualitatively as a decreased number of jejunal folds and/or as an increased number of ileal folds ('jejunization'); the presence, in the same patient, of both of them was defined as jejunoileal fold pattern reversal. This abnormal jejunoileal fold pattern reversal was detected in all the 12 patients included in this study (100%).

Intestinal loops were considered dilated if more than three segments measured more than 3 cm in the absence of distal intestinal stenosis or an identifiable transition zone. Dilated jejunal loops were noted in six patients (50%) while dilated ileal loops were noted in four patients (33%). No associated obstructing lesions were detected.

The bowel wall was considered thickened when it measured more than 4 mm in the transverse section of a fully distended loop. Intussusception was described as a target lesion or as a more complex layered lesion within the bowel lumen. Jejunal wall thickening was detected in six patients (50%), ileal wall thickening in three patients (25%) while thickened duodenum was detected in two patients (16.5%) and small bowel intussusception was detected in two patients (16.5%).

Mesenteric lymph node enlargement was considered present if nodes measured greater than 1 cm in diameter in the short axis; cavitation of nodes was seen as multiple mesenteric nodes with low-density center. Enlarged mesenteric lymph

nodes were detected in eight patients (66.5%) out of which six patients had cavitating lymph nodes (50%). Engorgement of mesenteric vessels was also detected in three patients (25%).

On examination of solid organs an obvious finding of the atrophic spleen (cut off value less than 145 cc) was detected in two patients (16.5%).

CT findings denoting hypoproteinemia were also detected in two patients, subcutaneous edema of the abdominal wall was detected in two patients (16.5%) and bilateral pleural effusion as well as edema of the lower oesophogeal wall was detected in one patient.

The diagnosis of CD was confirmed in all patients histopathologically via endoscopy and duodenal biopsy. Variable endoscopic features were detected in our patients; villous atrophy in 9 patients (75%), cobble stone appearance of duodenal mucosa in 4 patients (33%), notched appearance of duodenal folds (scalloping) in two patients (16.5%), visible submucosal vessels in two patients (16.5%) and no characteristic endoscopic features in one patient (8.3%). A single endoscopic sign was detected in only 4 patients and more than one endoscopic sign in 6 patients.

The histopathological features in our patients according to Marsh classification showed the presence of stage 3 (villous atrophy) in 9 patients (75%); 4 patients were stage 3a, 2 patients were stage 3b and three patients were stage 3c. Stage 2 was detected in 3 patients (25%).

All patients showed positive serology for anti-tissue transglutaminase and anti-endomysial antibodies.

Table 2 shows the distribution of the different CT findings in the twelve examined patients.

Fig. 1–7 show the different CT findings detected in seven patients included in this study.

4. Discussion

This study included 12 patients presenting with vague recurrent abdominal signs and symptoms and had CT findings suggesting for the diagnosis of CD which was confirmed via duodenal biopsy and positive serologic antibody testing in all patients.

To explain the different CT findings related to the bowel loops detected in these patients we have to understand the pathology of celiac disease. The gliadin fraction of wheat gluten and similar alcohol-soluble proteins (so-called protamins) that are present in other grains, such as barley and rye, are environmental factors responsible for the gastrointestinal damage of CD (12,13). Celiac disease is an autoimmune enteropathy caused by an inappropriate T-cell–mediated immune response to ingested gluten (14). The autoimmune destruction of small bowel villi is a histologic diagnosis; the degree of inflammatory infiltrate and villous atrophy is quantified with the Marsh grading system. Stage 0 is the quiescent phase, during which biopsy results and the clinical state are normal. During the attack phases of stages 1 and 2, progressive lymphocytic infiltration is noted. This will produce nodular and thickened duodenal and jejunal folds. During the destructive stage 3, chronic excess intraluminal fluid stretches the small bowel, delaying transit and resulting in small bowel malabsorption. In the atrophic stage 4, there is complete villous atrophy and crypt hyperplasia with progression to wall thinning. As the jejunal mucosa and the absorptive capacity are destroyed, with compensatory increase in number of ileal folds producing the jejuno-ileal fold reversal the ileum is then exposed to gluten. The ileal folds become inflamed and thickened by progression of the autoimmune process. The advanced small bowel disease overwhelms the fluid-absorbing capacity of the colon, resulting in diarrhea (15).

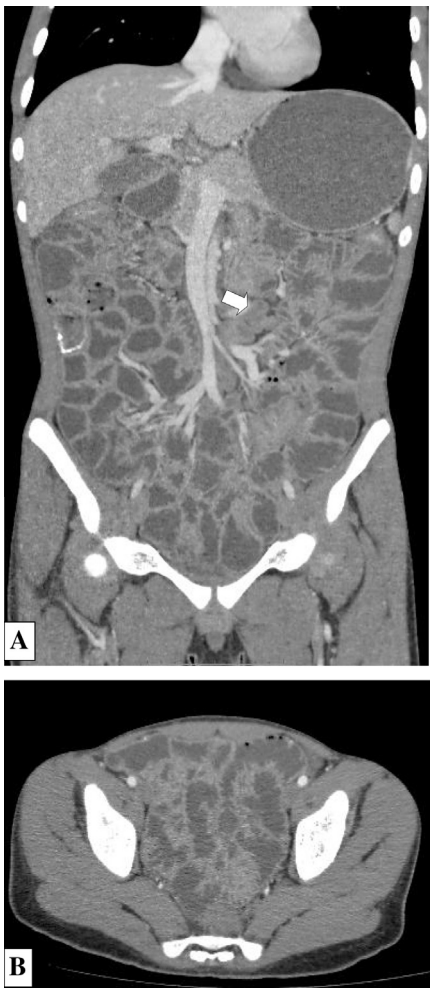

Fig. 4 A 22-year old male presenting with chronic abdominal pain and diarrhea. Multislice contrast enhanced CT of the abdomen: coronal (A) and axial (B) images showing evident dilatation of the small bowel loops from the duodenum to the ileum, reaching 3.3 cm in caliber. This is associated with multiple enlarged mesenteric lymph nodes, reaching 23 mm in diameter, with central low density cavitations (white arrow in A), and jejunization of the ileal loops. The diagnosis of celiac disease was suggested and confirmed histopathologically via endoscopy with duodenal biopsy.

The jejuno-ileal fold reversal pattern was detected in 100% of patients included in our study. This feature was found in 63.64% (28 of 44) of patients included in a study performed by Soyer et al. (16) by using CT scanning and concluded that reversed jejunoileal fold pattern is highly indicative of CD and this feature associates an ileal "jejunization" with a major loss of jejunal folds. A greater number of ileal folds is observed in contrast with a paucity or even an absence of jejunal folds. Loss of jejunal folds indicates radiologic evidence of CD with total villous atrophy in most cases. Tomei et al. (17) also found

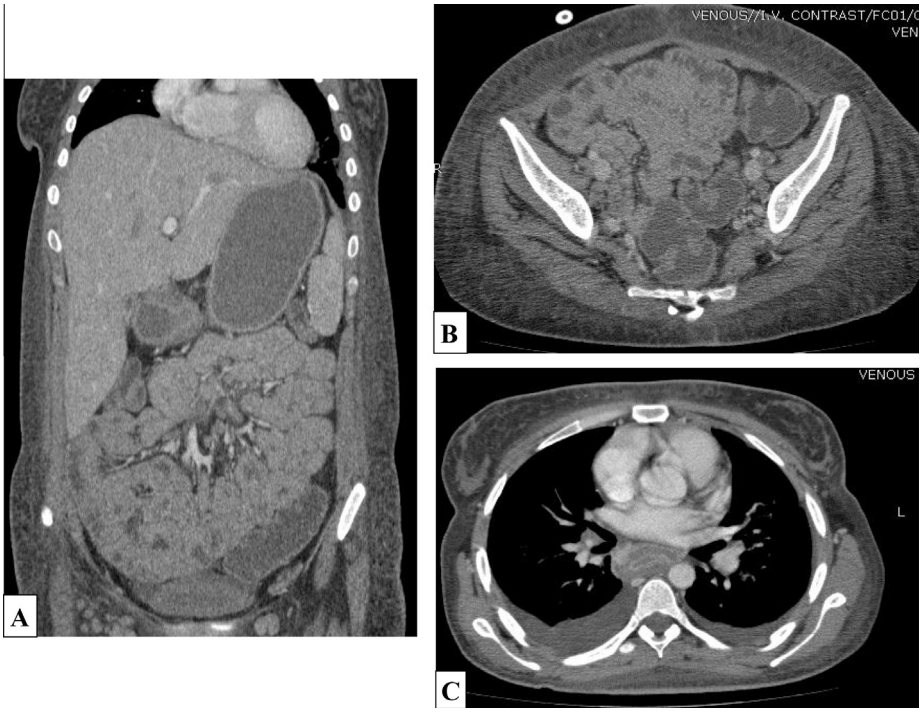

Fig. 5 A 26-year old male presenting with abdominal distension and diarrhea as well as generalized subcutaneous edema. Multislice contrast enhanced CT enterography images of the abdomen: coronal (A), axial (B and C) images showing marked mural thickening of the jejunal loops, with effaced villous pattern and Jejunization of the ileal loops (Reversed small intestinal villous pattern). Signs of hypoproteinemia are seen in the form of bilateral pleural effusion, marked esophageal submucosal edema (white arrow in C) and edema of the abdominal wall. The diagnosis of celiac disease complicated by protein losing enteropathy was suggested and confirmed by positive serology and histopathologically via endoscopy with duodenal biopsy.

a reversed jejunoileal fold pattern in 68.18% (15 of 22) of patients with untreated CD.

In our study jejunal wall thickening was detected in six patients (50%), ileal wall thickening in three patients (25%) while thickened duodenum was detected in two patients (16.5%). Dilated jejunal loops were noted in six patients (50%) while dilated ileal loops were noted in four patients (33%). In the study performed by Soyer et al. (16) 29% of the patients had jejunal wall thickening while 24% had ileal wall thickening and 3.5% of the patients had dilated jejunal and ileal loops. Scholz et al. (18) stated that CD has varying severity among patients as well as in each patient. The disease may usually start in the duodenum, followed by the jejunum, and then progresses to the ileum. The initial phase in any segment is inflammation with fold and wall thickening. If small bowel wall thickening is observed in any segment, in conjunction with other imaging findings of CD, the likelihood of CD diagnosis is further increased. The other obvious finding also noted is the presence of non obstructed dilated bowel loops which is attributed to chronic fluid excess within the bowel lumen due to lack of absorptive ability sequel to atrophy of the villi.

Transient intussusception in CD is rarely symptomatic and presumably is related to uncoordinated peristalsis in dilated flaccid loops of small bowel. On MDCT scans, transient small-bowel intussusception is correctly identified owing to the presence of a typical bowel-within-bowel feature, which produces a target sign with or without a fatty component. When the intussusception is less than 3 cm long, occurs in the absence of a lead-point tumor, and is not responsible for small bowel obstruction at MDCT, the findings are consistent with transient self limiting small-bowel intussusception. However, because gastrointestinal malignant tumors can cause intussusception in adult patients with celiac disease, MDCT images have to be carefully analyzed for confident exclusion of lymphoma and carcinoma (19). Small bowel intussusception was detected in two patients (16.5%) included in our study, both were less than 3 cm in diameter and were not associated with malignant lesions.

In our study atrophic spleen was detected in two patients (16.5%). CD is a well-known cause of splenic atrophy, found in 30–50% of adult patients with CD. It has been found that the mean splenic volume in a population of adult patients with celiac disease is 162 cm^3 (range, 37–321 cm^3); in the healthy population, the mean volume is 215 cm^3 (range, 107–341 cm^3). The degree of splenic atrophy correlates with the severity of disease. Because splenic size has been found to correlate with splenic function, it is not surprising that there is a trend toward serious infectious diseases due to streptococcus pneumonia in these patients (20).

In our study enlarged mesenteric lymph nodes were detected in eight patients (66.5%) out of which 6 patients had cavitating lymph nodes (50%). As described by Matuchansky et al. (21) the association of villous atrophy, splenic atrophy, and mesenteric cavitating lymphadenopathy is highly suggestive of the diagnosis of celiac disease. If the association is pres-

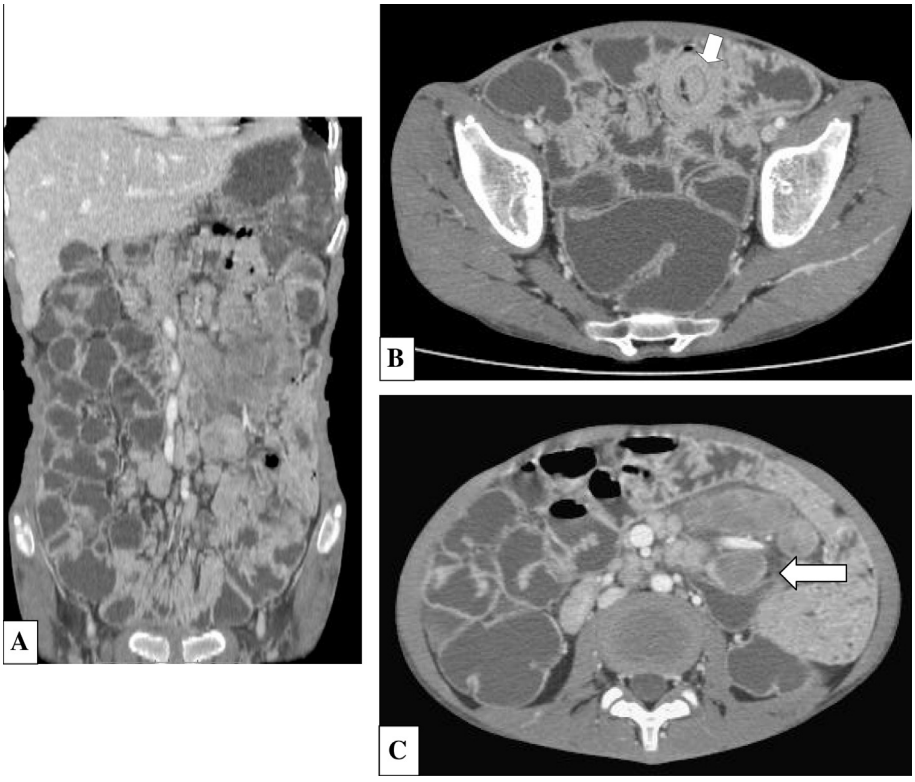

Fig. 6 A 19-year old male presenting with abdominal pain, weight loss and diarrhea. Multislice contrast enhanced CT enterography: coronal (A) and axial (B and C) images showing jejunal wall thickening, with jejunization of the ileal fold pattern reflecting reversed small bowel fold pattern, multiple enlarged mesenteric lymph nodes with internal liquefaction (long white arrow in C) and evidence of a small bowel intussusception (short white arrow in B). The diagnosis of celiac disease was suggested and confirmed by positive serology and histopathologically via endoscopy with duodenal biopsy.

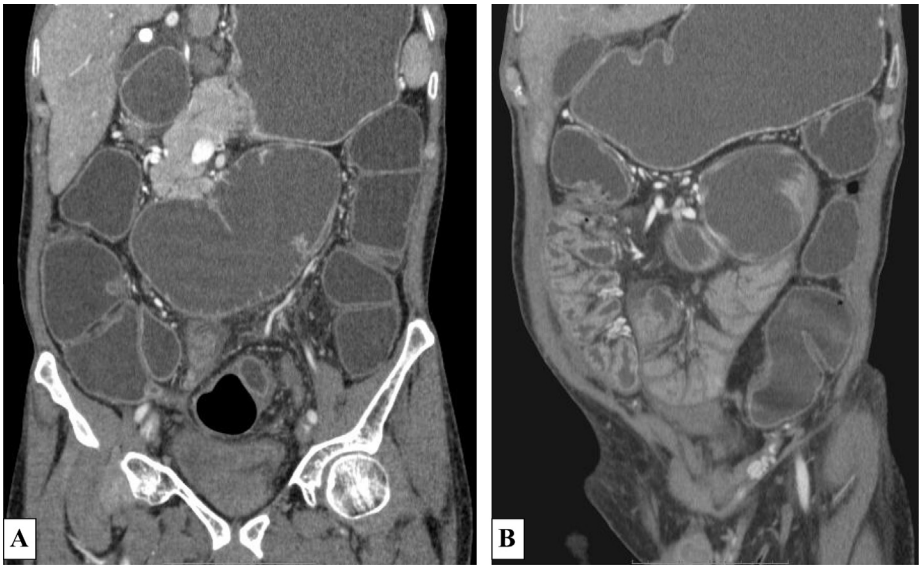

Fig. 7 A 25-year old male presenting with abdominal distension and diarrhea. Multislice contrast enhanced CT enterography: coronal (A & B) images showing markedly dilated jejunal loops reaching around 5 cm in diameter with thickening of the wall of the ileal loops showing jejunization of the ileal fold pattern reflecting reversed small bowel fold pattern. The diagnosis of celiac disease was suggested and confirmed histopathologically via endoscopy with duodenal biopsy.

ent, lymph nodes in the jejunal and ileal mesentery are affected by acidophilic central liquid necrosis and have a peripheral fibrotic rim. At MDCT, the central areas of such involved lymph nodes have an attenuation of 0 HU or less. In general, such lymphadenopathy is found in association with marked villous atrophy.

The small bowel mesentery may appear hypervascular in patients with celiac disease, particularly during the active inflammatory phase. Vessels may be engorged, with the superior mesenteric vein equal in diameter to the aorta. An edematous or "misty" mesentery has been seen, but this is a common finding in healthy patients and is still of uncertain significance (18). In this study engorgement of mesenteric vessels was detected in three patients (25%).

In patients with prolonged course of undiagnosed CD, signs of protein losing enteropathy could be detected in CT (22). In our study signs of hypoproteinemia were detected in two patients, subcutaneous edema of the abdominal wall was detected in the two patients (16.5%) and bilateral pleural effusion as well as edema of the lower oesophogeal wall was detected in one patient.

The main advantage of CT enterography over the routine abdominal CT is its ability for detailed study of the bowel wall and mucosal pathology. This target is realized through two main factors: Bowel loop distention, and neutral luminal contrast. It is thus only used in clinical conditions aiming to diagnose primary small bowel pathologies, and not in every routine abdominal exam.

Regarding the endoscopic findings in our patients, the sensitivity and specificity of endoscopic findings were 93.5% and 100%, respectively. Similar to our findings, Brocchi et al. (23) reported that the sensitivity and specificity of endoscopic features were 93.5% and 99.3%, respectively. Most of our patients (75%) had shown villous atrophy. However, Ravelli and colleagues (24) previously reported that villous atrophy in endoscopy was detected in 100% of cases. The difference between the last report and our results can be explained by the difference in age groups in the included patients.

The histopathological features in our patients demonstrated the presence of stage 3 (villous atrophy) in 75% and Stage 2 in 25% of our patients. None of our patients showed mild histopathological feature (stage1) of CD. Our radiological, endoscopic and histopathological findings were matching with each other and can be explained with increasing severity of CD with the progression of age of patients and all of our patients were in the adulthood period.

Our results shed the light on the role of CT interpretation by experienced radiologist as well as the presence of high index of clinical suspicion of physician to reach the diagnosis of CD.

5. Conclusions

We conclude that CT is an efficient imaging tool in diagnosis of CD. The jejuno-ileal fold reversal pattern is the most specific CT finding suggesting the diagnosis of CD, still other CT findings as bowel wall thickening, dilatation of the bowel loops, small bowel intussusception, atrophic spleen, enlarged cavitating mesenteric lymph nodes and mesenteric vascular engorgement are also frequently encountered and could support this diagnosis, however it is still mandatory that the interpretation of CT images should be performed by an experienced radiologist who is familiar with the pathology and different CT findings detected in this disease.

Conflict of interest statement

None.

References

(1) Green PH, Cellier C. Celiac disease. N Engl J Med 2007;357:1731–43.
(2) West J, Logan RF, Hill PG, et al. Seroprevalence, correlates, and characteristics of undetected celiac disease in England. Gut 2003;52:960–5.
(3) Herlinger H. Radiology in malabsorption. Clin Radiol 1992;45(2):73–8.
(4) Catassi C, Kryszak D, Louis-Jacques O, et al. Detection of celiac disease in primary care: a multicenter case-finding study in North America. Am J Gastroenterol 2007;102(7):1454–60.
(5) Corazza GR, Frisoni M, Treggiari EA, et al. Subclinical celiac sprue: increasing occurrence and clues to its diagnosis. J Clin Gastroenterol 1993;16:16–21.
(6) Green PH, Jabri B. Coeliac disease. Lancet 2003;362:383–91.
(7) Swinson CM, Slavin G, Coles EC, Booth CC. Coeliac disease and malignancy. Lancet 1983;1:111–5.
(8) Van der Windt DA, Jellema P, Mulder CJ, Kneepkens CM, van der Horst HE. Diagnostic testing for celiac disease among patients with abdominal symptoms: a systematic review. JAMA 2010;303(17):1738–46.
(9) Sanders DS, Hopper AD, Azmy IA, et al. Association of adult celiac disease with surgical abdominal pain: a case-control study in patients referred to secondary care. Ann Surg 2005;242(2):201–7.
(10) Cataldo F, Pitarresi N, Accomando S, Greco L, SIGENP, GLNBI Working Group on Coeliac Disease. Epidemiological and clinical features in immigrant children with celiac disease: an Italian multicentre study. Dig Liver Dis 2004;36:722–9.
(11) Strobl PW, Warshauer DM. CT diagnosis of celiac disease. J Comput Assist Tomogr 1995;19:319–20.
(12) Farrell RJ, Kelly CP. Celiac sprue. N Engl J Med 2002;346:180–8.
(13) Fasano A, Catassi C. Current approaches to diagnosis and treatment of celiac disease: an evolving spectrum. Gastroenterology 2001;120:636–51.
(14) Sollid LM, Thorsby E. HLA susceptibility genes in celiac disease: genetic mapping and role in pathogenesis. Gastroenterology 1993;105:910–22.
(15) Marsh MN. Gluten, major histocompatibility complex, and the small intestine: a molecular and immunobiologic approach to the spectrum of gluten sensitivity ('celiac sprue'). Gastroenterology 1992;102(1):330–54.
(16) Soyer P, Boudiaf M, Dray X, et al. CT enteroclysis features of uncomplicated celiac disease: retrospective analysis of 44 patients. Radiology 2009;253(2):416–24.
(17) Tomei E, Marini M, Messineo D, et al. Computed tomography of the small bowel in adult celiac disease: the jejunoileal fold pattern reversal. Eur Radiol 2000;10:119–22.
(18) Scholz F, Afnan J, Behr S. CT Findings in adult celiac disease. Radiographics 2011;31:977–92.
(19) Boudiaf M, Jaff A, Soyer P, Bouhnik Y, Hamzi L, Rymer R. Small-bowel diseases: prospective evaluation of multi-detector row helical CT enteroclysis in 107 consecutive patients. Radiology 2004;233:338–44.
(20) Rubesin SE, Herlinger H, Saul SH, Grumbach K, Laufer I, Levine MS. Adult celiac disease and its complications. Radiographics 1989;9:1045–66.

(21) Matuchansky C, Colin R, Hemet J, et al. Cavitation of mesenteric lymph nodes, splenic atrophy and a flat small intestinal mucosa: report of six cases. Gastroenterology 1984;87:606–14.
(22) Paulsen SR, Huprich JE, Fletcher JG, et al. CT enterography as a diagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. Radiographics 2006;26:641–57.
(23) Brocchi E, Tomassetti P, Misitano B, et al. Endoscopic markers in adult coeliac disease. Dig Liver Dis 2002;34(3):177–82.
(24) Ravelli AM, Tobanelli P, Minelli L, et al. Endoscopic features of celiac disease in children. Gastrointest Endosc 2001;54(6):736–42.