

Spectrum of bowel wall thickening on computed tomography (CT) and its interpretation; a prospective study

Aneesh M M¹, Tushant Kumar², Anil Rawat³, Bipin Augustine⁴, Harris Mohammed P⁵

¹Associate Professor, Department of Radiology, Malabar Medical college, Kozhikode, Kerala, India

²Additional Professor, Department of Radiology, Dr Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India

³Assistant Professor, Department of Radiology, King George Medical College, Lucknow, Uttar Pradesh, India

⁴Assistant professor, Department of Radiology, Malabar Medical College, Kozhikode, Kerala, India

⁵Associate Professor, Department of Surgery, Malabar Medical College, Kozhikode, Kerala, India

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Abstract

Introduction: Computed tomography (CT) study of patients with bowel pathologies may show bowel wall thickening with abnormal morphology and enhancement. Identification of these patterns may help better differentiate benign lesions from malignant lesions. **Aim:** To study and identify various CT enhancement patterns and other characteristics of thickened bowel wall and their usefulness in categorising bowel wall thickening as benign or malignant. **Materials and methods:** The study was a prospective study in which a total of 50 cases were studied by over a period of approximately 1 year by performing contrast CT scans using MDCT scanner. Based on certain CT findings and CT patterns, the bowel wall thickening were categorised as benign and malignant and probable diagnosis were given. Cases were followed up for final diagnosis and compared with the CT diagnosis. Relevant statistical analysis was done to assess the role of CT features & enhancement patterns, in differentiating benign and malignant disease processes. **Results:** Combination of asymmetric, marked, focal and heterogeneous patterns to categorise a lesion as malignant showed high specificity (94.1%). Overall CT characteristics and enhancement patterns has shown high sensitivity (96.9%) and high specificity (88.2%) in differentiating bowel wall thickening as malignant or benign. **Conclusion:** Contrast CT study is highly sensitive & specific for diagnosing a lesion as malignant or benign, especially when certain imaging features and enhancement patterns of thickening bowel wall are actively looked for.

Keywords: Bowel wall thickening, Enhancement pattern, Water halo, Fat halo.

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Introduction

The field of gastrointestinal imaging had its beginning just a few months after Roentgen's discovery of X-rays in 1895. Since then it has progressed with incredible speed and now encompasses a variety of diagnostic modalities that make possible the precise diagnosis, as well as therapeutic interventions that complement and often replace more invasive surgical procedures. In contemporary radiology practice computed tomography (CT) has almost replaced conventional and contrast radiographic studies, as a technique for evaluating most abdominal pathologies because of its speed, accuracy and cross sectional imaging capabilities. CT can give direct information about bowel lumen as well as intramural or extrinsic abnormalities. In the evaluation of bowel pathologies CT, variety of morphologic and enhancement patterns of thickening bowel are observed, which in isolation or as a combination of patterns helps to categorise the pathologies as benign or malignant.

Materials and Methods

Study design and settings

The study was a prospective study conducted in the department of radiology, Malabar Medical College, Kerala during the period of December 2020 and October 2021.

*Correspondence

Dr. Bipin Augustine

Assistant professor, Department of Radiology, Malabar Medical College, Kozhikode, Kerala, India.

E-mail: drbipinmmc@gmail.com

Inclusion criteria

- Patients presenting with signs and symptoms of bowel disease i.e. hematemesis, melena or bleeding per rectum.
- Those patients with history of subacute or chronic obstruction of bowel were also included.

Exclusion criteria

- Acute intestinal obstruction.
- Poor bowel preparation

Procedure

The study was a prospective study in which a total of 50 cases were studied between December 2020 and November 2021. Cases were selected irrespective of age or sex from inpatients and outpatients. CT examination will be carried out with 64 slice spiral CT machine. Plain CT of abdomen will be acquired first and then will be proceeded to contrast CT study, after evaluating reasonable bowel preparation and ruling out evidence of acute intestinal obstruction on plain CT. Negative oral contrast with 2% mannitol was used. Positive oral contrast and rectal contrast were used in selected cases. All patients were given injection non-ionic contrast material iohexol 350mg/ml, with in the dose 80-100ml for adult patients and 2 ml/kg body weight for paediatric patients. The CT findings that were analysed when assessing thickened bowel include pattern of enhancement; degree of thickening; symmetry of thickening; extent / length of bowel involvement; and associated abnormalities. Pattern of enhancement of the thickened bowel wall is categorised into; white attenuation, gray attenuation, black attenuation, water halo sign, fat halo and mixed attenuation. Gray attenuation refers to a thickened bowel wall that shows mild enhancement and its attenuation is comparable to skeletal

muscle. Black attenuation refers to air densities within the thickened bowel wall. White attenuation refers to marked contrast material enhancement of the thickened bowel wall. Water halo sign indicate stratification of thickened bowel wall which consists of two or three continuous, thickened layers in symmetric fashion showing alternating white and gray attenuation. Fat halo refers to a target sign with three layers of thickened bowel in which the middle submucosal layer having a fatty attenuation.

Based on these CT features of diseased bowel wall and other associated findings, probable diagnosis were given. Cases were followed up for final diagnosis. The confirmation of the diagnosis was either by biopsy of the surgical specimen in operated cases, cytology in cases which were not operated and on clinical course and management in case of inflammatory pathologies. Sensitivity and specificity were calculated by comparing CT diagnosis with the final diagnosis.

Statistical analysis

Depending on the variable distribution, results were expressed as numbers and percentages. The data was analysed by Statistical Package for Social Sciences (20.0) version and Microsoft Excel 2000 software.

Results

There were total of 33 proven malignant bowel wall lesions and 17 benign cases of bowel wall thickening. Benign causes of bowel wall thickening were noted to be commoner in the younger age group and malignant causes of bowel wall thickening were commonly noted in much older patients. The study was conducted in 30 males and 20 females. No definite sex predilections of the benign / inflammatory or malignant lesions were noticed.

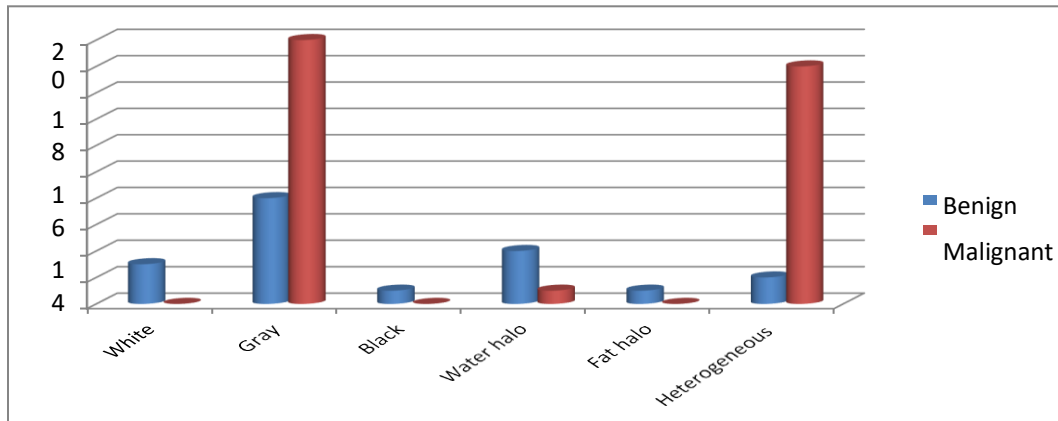


Fig 1: The graph shows distribution of patients based on attenuation pattern of bowel wall abnormalities on post contrast CT study. In the post contrast CT it was observed that maximum patients with malignancy had gray and heterogeneous attenuation. Benign pathologies predominantly showed water halo and white attenuation. None of the malignant lesions showed black, white or fat halo attenuation.

Table 2: Distribution of patients based on the morphological pattern of bowel wall thickening

Degree of bowel wall thickening	P
Benign mild (<2 cm)	15
Benign marked (>2 cm)	2
Malignant mild (<2 cm)	13
Malignant marked (>2 cm)	20
Extent of bowel wall thickening	
Benign focal (<10 cm)	2
Benign diffuse (>10 cm)	14
Malignant focal (<10 cm)	30
Malignant diffuse (>10 cm)	4
Symmetry of bowel wall thickening	
Benign symmetric	13
Benign asymmetric	4
Malignant symmetric	7
Malignant asymmetric	26

In benign category 15 out of 17 patients (88.2%) showed mild (<2cm) bowel wall thickening. In malignant category 20 out of 33 patients (60.6%) had marked (>2 cm) bowel wall thickening. Considering only marked thickness almost 13 out of 33 cases malignant etiology were not diagnosed. 13 (76.4%) out of the total cases of bowel wall thickening due to benign cause were showing symmetrical bowel wall involvement. On the other hand, 26 (78.7%) cases out of total 33 cases of malignant etiology were showing asymmetrical bowel wall involvement. 30 (90.9%) patients out of malignant bowel wall thickening showed focal bowel wall thickening. 14 (82.3%) patients out of benign bowel wall thickening showed diffuse type of bowel wall thickening.

Table 3: Sensitivity and specificity of various CT features for diagnosing a lesion of malignant and benign

CT features	Sensitivity (%)	Specificity (%)
Malignant		
Marked thickening	60.6	88.2
Asymmetric	78.7	76.4
Focal	90.9	82.3
Heterogeneous	54.5	88.2

Benign		
Mild thickening	88.2	60.6
Symmetric	76.4	78.7
Diffuse	82.3	90.9
Water halo	23.5	75
White attenuation	17.6	100.0

In our study, the finding of marked, asymmetric, focal and heterogeneous wall thickening had a sensitivity of 60.6%, 78.7%, 90.9% and 54.5 % respectively and a specificity of 88.2%, 76.4% . 82.3 % and 88.2 % respectively, for detection of malignant causes of bowel wall thickening. Marked & focal bowel involvement and heterogeneous pattern of enhancement were highly specific for malignant bowel wall thickening. Diffuse bowel wall thickening and white attenuation were specific for benign bowel wall thickening. The focal involvement of bowel wall thickening is highly sensitive and specific for malignant lesion. Similarly diffuse involvement of bowel wall thickening was highly sensitive and specific for benign lesion. Mild bowel wall thickening was a sensitive for benign bowel wall thickening but was not specific. When asymmetric, marked, focal and heterogeneous patterns were combined to categorise a lesion as malignant then there was an increase in specificity

Table 4: Diagnosis by CT scan

	Number	Percentage (%)
Malignant	34	100
Carcinoma	27	79.41
Lymphoma	4	11.76
Metastatic involvement	2	5.88
Malignant GIST	1	2.94
Benign	16	100
Tuberculosis	4	25.00
Ulcerative colitis	1	6.25
Crohn's disease	1	6.25
Non-specific colitis	7	43.75
Reactive sigmoid colon thickening due tubo-ovarian abscess	1	6.25
Non specific enteritis	1	6.25
Reaction cecal thickening due to appendicitis	1	6.25

Table 5: Final diagnosis

	Number	Percentage (%)
Malignant	33	
Adenocarcinoma	21	63.63
Metastatic involvement	4	12.12
Lymphoma	5	15.15
Malignant GIST	2	6.06
Squamous cell carcinoma	1	3.03
Benign	17	
Tuberculosis	5	29.41
Ulcerative colitis	3	17.64
Crohn's disease	2	11.76
Non-specific colitis	5	29.41
Infectious enteritis	1	5.88
Gastritis	1	5.88

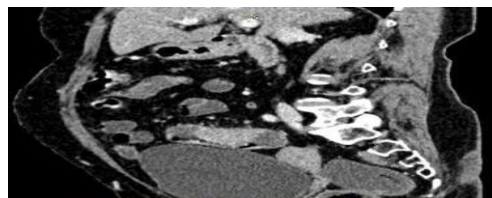


Fig 1:CECT showing area of focal, eccentric bowel wall thickening showing heterogeneous enhancement of sigmoid colon in a case of adenocarcinoma

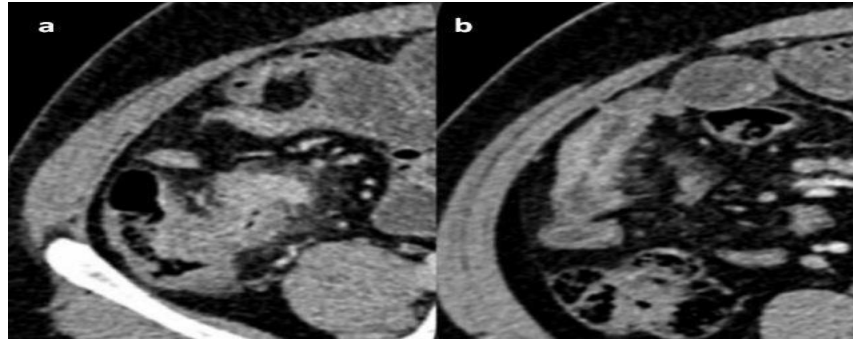


Fig 2: Proven case of Crohn's disease showing circumferential symmetrical segmental enhancing mild wall thickening with maintained mural stratification (water halo sign) involving terminal ileum and another similar segment bowel involvement of proximal ileum (skip lesions)

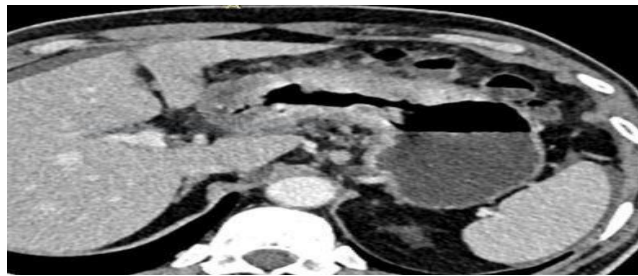


Fig 3: A case of linitis plastica due to scirrhus cell carcinoma- CECT images in a patient shows marked wall thickening involving the body, pyloric antrum and pyloric canal of stomach

Discussion

Normal cross sectional anatomy

The wall thickness of body and fundus of well distended stomach normally does not exceed 5mm in thickness. The antral wall thickness, may normally measure upto 12 mm [1]. When the lumen of the small bowel is well distended, the wall is measures between 1 and 2 mm . A measurement of 3mm as the upper limit of normal thickness can be used in well distended small bowel. If the wall is slightly collapsed, the bowel walls measures between 2 and 3mm in a symmetric fashion [2,3,4]. In cases with collapsed bowel it is suggested to compare the degree of thickness of similarly distended segments to exclude disorders [5]. Normal colonic wall thickness is less than 3 mm when colonic lumen is well distended and less than 5 mm when the lumen is collapsed [6,7].

CT characteristics useful in differentiation of pathologies

The white attenuation is commonly seen in inflammatory bowel diseases and ischemic bowel disease [8]. The gray attenuation pattern is the least specific of the all attenuation categories[8,4]. Black attenuation pattern may be seen in ischemia, infection and trauma[5, 9] Water halo sign is commonly seen in idiopathic inflammatory bowel diseases, ischemic bowel disease, infections, and radiation induced damage[8] . Submucosal fat deposition (fat halo sign) sign is seen commonly in Crohn's disease in the small intestine and ulcerative colitis or Crohn's disease in the colon [8,10,11]. Intramural fat may exist in both distal ileum and colon as a "normal" variant in patients without gastro intestinal symptoms or a history of gastro intestinal disease[8,12] . Mixed attenuation are commonly seen in adenocarcinoma and stromal cell tumors [5,13]. In inflammatory bowel wall thickening, the brightly enhancing mucosa is usually distinguishable from the thickened submucosa which is of lower attenuation [5,14]. This is unlike the appearance in most cases of neoplastic thickening, in which the tumor infiltrating the layers of bowel wall gives heterogeneous enhancement [5,15,16]. Mural stratification also lost in chronic stage of ulcerative colitis & Crohn's disease[2,10]. Entities that cause mild wall thickening are often

benign conditions, whereas marked wall thickening is usually present in neoplastic conditions [17]. Symmetric thickening is seen in intestinal inflammatory conditions, intestinal infections and bowel ischemia[5] . Some neoplasms like linitis plastica and lymphoma may also show symmetric thickening[5,18]. Asymmetric wall thickening is commonly seen with malignant conditions[5,8,13]. Crohn's disease and tuberculosis of the bowel may shows asymmetrical thickening in chronic stage[5,8,19]. Focal bowel wall thickening is seen commonly in malignant and diffuse pattern in inflammatory pathologies [5,4] . Evaluation of all these patterns and morphologies of bowel wall thickening along with associated findings like lymph nodes, mesenteric fat stranding, calcifications, abscess, sinus tracts and fistulas, fibrofatty proliferation, vascular occlusion and solid organ abnormalities lead to more accurate differential diagnosis [5, 20,21]. Erik K. Insko et al., in their study of 38 patients of abnormal bowel wall thickening had 14 malignant and 24 benign cases [22]. Similar to our study in which bowel wall thickness of more than 2cms had sensitivity and specificity of 60% and 88% respectively; the sensitivity and specificity in the study conducted by Erik K. Insko et al., were 50% and 88% respectively . Like in the study by Erik K Insko et al., where there were 71% and 29% of the malignant cases showing asymmetrical and symmetrical bowel wall thickening respectively, the similar values in our study turned out to be 78% and 22% . The sensitivity and specificity of asymmetrical bowel wall involvement to categorise a thickened bowel wall as malignant was 78.7 & 76.4% respectively in our study and in study by Erik K Insko et al., it was 71% and 75% respectively. In our study focal and diffuse involvement were seen in 90.9 and 9.1% of malignant lesions respectively which is similar to the distribution shown in the study done by Erik K Insko et al which was 93% and 7% respectively. When marked, asymmetric, focal and heterogeneous patterns were combined to categorise a lesion as malignant then there was an increase in specificity to 94.1%. which is comparable to the outcome of similar study by Erik K, Insko et al . In our study, CT showed an overall sensitivity of 96.9% and specificity of 88.2% in differentiating

between a malignant and benign etiology of abnormal bowel wall thickening which was similar to the conclusion of study by Erik K Insko et al.

Conclusion

We conclude that CT features and enhancement patterns has high sensitivity and specificity in differentiating bowel wall thickening as benign or malignant, especially when a combination of features are considered. Combination of asymmetric, marked, focal bowel wall involvement and heterogeneous enhancement pattern has high specificity to categorise a lesion as malignant. Radiologists should be aware of these CT features and enhancement patterns for better differentiation of benign lesions from malignant lesions.

References

1. Guniganti P, Menias CO, Mellnick VM. CT of Gastric Emergencies. *Radiographics*. 2015; 35(7):1909-21.
2. Gore RM, Balthazar EJ, Ghahremani GG, Miller FH. CT features of ulcerative colitis and Crohn's disease. *Am. J. Roentgenol.* 1996;167:3-15.
3. James S, DM Balfe, JK Lee, and D Picus. Small-bowel disease: categorization by CT examination. *Am. J. Roentgenol.* 1987;148: 863-868.
4. Fernandes, T., Oliveira, M.L., Castro, R. et al. Bowel wall thickening at CT: simplifying the diagnosis. *Insights Imaging*. 2014;(5):195-208.
5. Michael Macari and Emil J. Balthazar. CT of Bowel Wall Thickening Significance and Pitfalls of Interpretation. *Am. J. Roentgenol.* 2001;176: 1105-1116.
6. Teresa Fernandes & Maria I. et al. Bowel wall thickening at CT: simplifying the diagnosis. *Insights Imaging*. 2014; 5:195-208.
7. Karen M. Horton, MD, Frank M. Corl, MS and Elliot K. Fishman. MD CT Evaluation of the Colon: Inflammatory Disease. *Radiographics*. 2000;20:399-418.
8. Jack Wittenberg, Mukesh G. Harisinghani, Kartik Jhaveri, Jose Varghese, Peter R. Mueller. Algorithmic Approach to CT Diagnosis of the Abnormal Bowel Wall. *RadioGraphics*. 2002; 22:1093-1109.
9. RH Bassiouny, AA Maati. Acute right lower quadrant pain beyond acute appendicitis: MDCT in evaluation of benign and malignant gastrointestinal causes. *Egypt. J. Radiol. Nucl. Med.* 2014;45:627-640.
10. M.M. Amitai, T. Arazi-Kleinman, B. Avidan. Fat halo sign in the bowel wall of patients with Crohn's disease. *Clin Radiol.* 2007;62(10):994-997.
11. Maria d'Almeida, Jean Jose, Julieta Oneto, Ricardo Restrepo. Bowel Wall Thickening in Children: CT Findings. 2008;(28):727-746.
12. Dushyant V Sahani, Anthony E Samir. *Abdominal Imaging*. 2nd edition. Elsevier; 2016. 260 p.
13. Agarwala R, Singh AK, Shah J, Mandavdhare HS, Sharma V. Ileocecal thickening: Clinical approach to a common problem. *JGH Open*. 2019;3(6):456-463.
14. Elsayes KM, Al-Hawary MM, Jagdish J, Ganesh HS, Platt JF. CT enterography: principles, trends, and interpretation of findings. *Radiographics*. 2010; 30(7):1955-70.
15. Macari M, Megibow AJ, Balthazar EJ. A pattern approach to the abnormal small bowel: observations at MDCT and CT enterography. *AJR Am J Roentgenol.* 2007;188(5):1344-55.
16. Sailer, J., Zacherl, J., & Schima, W. MDCT of small bowel tumours. *Cancer imaging*. 2007;7(1): 224-233.
17. Karahan OI, Chintapalli KN, Rhim H, Chopra S. Gastrointestinal wall thickening in patients with cirrhosis: frequency and patterns at contrast enhanced CT. *Radiology*. 2000;215:103-107.
18. Balthazar EJ, Noordhoorn M, Megibow AJ, Gordon RB. CT of small-bowel lymphoma in immunocompetent patients and patients with AIDS: comparison of findings. *AJR Am J Roentgenol.* 1997;168(3):675-80.
19. Sharma R, Madhusudhan KS, Ahuja V. Intestinal tuberculosis versus crohn's disease: Clinical and radiological recommendations. *Indian J Radiol Imaging*. 2016;26(2):161-172.
20. Tolan DJ, Greenhalgh R, Zealley IA, Halligan S, Taylor SA. MR enterographic manifestations of small bowel Crohn disease. *Radiographics*. 2010 Mar;30(2):367-84.
21. Hoeffel C, Crema MD, Belkacem A, Azizi L, Lewin M, Arrivé L, Tubiana JM. Multi-detector row CT: spectrum of diseases involving the ileocecal area. *Radiographics*. 2006;26(5):1373-90.
22. Erik K Insko et al. Benign and Malignant lesions of the stomach: Evaluation of CT criteria for differentiation. *Radiology*. 2003;228:166-171.

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