Original Article

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To examine the spectrum of bowel wall thickening on computed tomography (CT) scans and to provide an academic interpretation of these findings

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Abstract

Background: Computed tomography (CT) is a highly effective noninvasive modality for the assessment of bowel wall thickening. **Aim:** The objective of this study is to examine the spectrum of bowel wall thickening on computed tomography (CT) scans and to provide an academic interpretation of these findings. **Subjects and Methods:** The research was a prospective study carried out within the department of radiology at Dhanalakshmi Srinivasan Medical College and Hospital. Inclusion criteria encompassed patients who had a documented medical history of subacute or chronic bowel obstruction. This study included patients who exhibited clinical manifestations indicative of bowel disease, such as hematemesis, melena, or rectal bleeding. Inclusion criteria encompassed patients who had a documented medical history of subacute or chronic bowel obstruction. 70 subjects were chosen for the study without considering their age or gender, from both inpatient and outpatient department. A computed tomography (CT) examination will be conducted using a 64-slice spiral CT machine. **Results:** A total of 50 cases (71.43%) were identified as proven malignant bowel wall lesions, while 20 cases (28.57%) were diagnosed as benign instances of bowel wall thickening. In the present study, it was observed that the identification of pronounced, asymmetrical, localized, and varied thickening of the bowel wall yielded sensitivity values of 61.58%, 79.15%, 91.47%, and 55.39% respectively. Furthermore, the specificity values for the aforementioned characteristics were determined to be 89.74%, 77.11%, 83.41%, and 89.14% respectively, in relation to the detection of malignant etiologies associated with bowel wall thickening. **Conclusion:** It is concluded that computed tomography (CT) features and enhancement patterns exhibit a high level of sensitivity and specificity in distinguishing between benign and malignant bowel wall thickening.

Keywords: Spectrum, bowel wall thickening, computed tomography (CT).

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Introduction

The inception of gastrointestinal imaging occurred shortly after the discovery of X-rays by Roentgen in 1895. Since its inception, the field has made remarkable advancements and now includes a diverse range of techniques that enable accurate diagnoses, along with therapeutic interventions that enhance and frequently supplant more intrusive surgical methods. The utilization of computed tomography (CT) has emerged as a multifunctional instrument for evaluating the gastrointestinal (GI) tract. The resource offers precise and reliable information pertaining to the anatomical composition of the gastrointestinal wall and its adjacent structures. The evaluation of the gastrointestinal (GI) tract can present challenges due to its dynamic peristaltic activity.[1] The utilization of Multidetector CT (MDCT) enables the collection of isotropic data and provides the ability to conduct high resolution multiplanar reconstructions.[2] The utilization of three-dimensional (3-D) interactive workstations and advanced software has significantly enhanced the visibility of lesions and even enables the virtual visualization of the interior of the bowel through a technique known as virtual endoscopy. The utilization of barium studies and angiography, which were previously standard procedures for evaluating conditions such as suspected small bowel obstruction and mesenteric ischemia respectively, has now been supplanted by the use of CT scans.[3] Computed tomography (CT) is not capable of illustrating minor superficial mucosal alterations that can be observed on barium studies. However, it is a remarkably sensitive technique for identifying intramural pathology and the spread of colonic disease beyond the colon wall.[4] Specifically, CT enterography obtained following luminal distension by administering large amounts of neutral contrast material (1,500-2,000ml of

water, water methylcellulose solution, polyethylene glycol electrolyte solution, or low-concentration barium) is beneficial for visualizing the thickness and enhancement of the small bowel wall.[2,5] Currently, computed tomography (CT) is widely recognized as the primary imaging technique for assessing various pathologies affecting the small bowel.[3] A diverse range of abnormalities in the morphology and enhancement of the intestinal wall can be observed in cases of bowel disorders, encompassing normal variations, inflammatory conditions, and neoplastic diseases. Upon the detection of an abnormality, the radiologist must employ a systematic approach to ascertain the precise etiology of the intestinal abnormality.

Subjects and Methods

The research was a prospective study carried out within the department of radiology at Dhanalakshmi Srinivasan Medical College and Hospital. This study included patients who exhibited clinical manifestations indicative of bowel disease, such as hematemesis, melena, or rectal bleeding. Inclusion criteria encompassed patients who had a documented medical history of subacute or chronic bowel obstruction. The study excluded individuals who had acute intestinal obstruction and exhibited inadequate bowel preparation.

Methodology

The research conducted was a prospective study that involved the examination of a total of 70 cases. Participants were chosen for the study without considering their age or gender, from both inpatient and outpatient departments. A computed tomography (CT) examination will be conducted using a 64-slice spiral CT machine. The initial step in the imaging process will involve obtaining a non-contrast computed tomography (CT) scan of the abdomen. Subsequently, a contrast-enhanced CT study will be conducted, contingent upon a thorough assessment of the adequacy of bowel preparation and the absence of any indications of acute intestinal obstruction on the non-contrast CT scan. The administration of 2% mannitol solution was employed as a negative oral contrast agent. Positive oral contrast and rectal contrast were administered in specific instances. The administration of non-ionic contrast material iohexol 350mg/ml was provided to all patients. Adult patients received a dose of 80-100ml, while paediatric patients were given a dosage of 2 ml/kg body weight. The analysis of thickened bowel in this study involved examining several CT findings, including the pattern of enhancement, degree of thickening, symmetry of thickening, extent or length of bowel involvement, and any associated abnormalities. The categorization of the pattern of enhancement of the thickened bowel wall includes various types, such as white attenuation, gray attenuation, black attenuation, water halo sign, fat halo, and mixed attenuation. The term "gray attenuation" pertains to a thickened intestinal wall exhibiting slight enhancement, with its attenuation being similar to that of skeletal muscle. The term "black attenuation" pertains to the air densities present within the thickened wall of the bowel. “White attenuation” is a term used to describe the significant enhancement of contrast material in the thickened wall of the bowel. The presence of a water halo sign is indicative of the stratification of a thickened bowel wall, characterized by the presence of two or three continuous, thickened layers arranged symmetrically. These layers exhibit alternating white and gray attenuation. The term "fat halo" is used to describe a target-shaped appearance characterized by three layers of thickened bowel. In this configuration, the middle layer, known as the submucosal layer, exhibits a higher density consistent with fatty tissue.

Based on the observed computed tomography (CT) features of the affected bowel wall and the presence of other associated findings, a tentative diagnosis was provided. The cases were subsequently pursued in order to establish a definitive diagnosis. The diagnosis was confirmed through different methods depending on the case. In cases where surgery was performed, the confirmation was obtained through biopsy of the surgical specimen. For cases that did not undergo surgery, cytology was used as the diagnostic method. Inflammatory pathologies were diagnosed based on the clinical course and management of the condition. The calculation of sensitivity and specificity involved the comparison between the CT diagnosis and the final diagnosis.

Statistical analysis

Results were expressed as numerical values and percentages, depending on the distribution of the variables. The data was analyzed using Statistical Package for Social Sciences (version 25.0) and Microsoft Excel 2000 software.

Results

A total of 50 cases (71.43%) were identified as proven malignant bowel wall lesions, while 20 cases (28.57%) were diagnosed as benign instances of bowel wall thickening. The prevalence of benign causes of bowel wall thickening was found to be higher among individuals in the younger age group, while malignant causes of bowel wall thickening were predominantly observed in significantly older patients. The research was carried out on a sample consisting of 45 males, accounting for 64.29% of the total, and 25 females, representing 35.71% of the total. No clear sexual preferences were observed in the benign, inflammatory, or malignant lesions.

Table 1: Demographic data of the patients

	Number =70	Percentage
Malignant	50	71.43
Benign	20	28.57
Gender		
Male	45	64.29
Female	25	35.71

The post-contrast computed tomography (CT) scan revealed that the majority of patients with malignancy exhibited gray and heterogeneous attenuation while the benign pathologies exhibited a water halo and white attenuation. There was no black, white, or fat halo

attenuation that was observed in any of the malignant lesions.

Table 2: Attenuation pattern of bowel wall abnormalities on post contrast CT study

	Malignancy=50	Benign=20
Gray	26	4
black	0	1
white	0	4
Water halo	2	9
Fat halo	0	1
Heretogeneous	22	1

Table 3: Morphological pattern of bowel wall thickening

Degree of bowel wall thickening	Number	Percentage (%)
Malignant mild (<2 cm)	21	42
Malignant marked (>2 cm)	29	58
Benign mild (<2 cm)	17	85
Benign marked (2> cm)	3	15
Symmetry of bowel wall thickening		
Benign symmetric	15	75
Benign asymmetric	5	25
Malignant symmetric	12	24
Malignant asymmetric	38	76
Extent of bowel wall thickening		
Benign focal (<10 cm)	2	10
Benign diffuse (>10 cm)	17	85
Malignant focal (<10 cm)	43	86
Malignant diffuse (>10 cm)	8	16

Within the benign category, a total of 17 out of 20 patients, accounting for 85% of the sample, exhibited mild bowel wall thickening measuring less than 2 centimeters. The malignant category included a total of 29 out of 50 patients, accounting for 58% of the sample, exhibited significant bowel wall thickening measuring greater than 2 centimeters. Out of the 50 cases examined, it was found that nearly 42% (21 cases) with marked thickness did not receive a diagnosis of malignant etiology. Out of the total cases of bowel wall thickening attributed to benign causes, 15 cases (representing 75% of the total) exhibited symmetrical involvement of the bowel wall. In contrast, it was observed that 38 out of a total of 50 cases (76%) with a malignant etiology exhibited asymmetrical involvement of the bowel wall. Out of the total number of patients with malignant bowel wall thickening, specifically 43 individuals, which accounts for 86% of the sample, exhibited focal bowel wall thickening. Out of the total sample of 17 patients with benign bowel wall thickening, a majority of 85% exhibited the diffuse type of bowel wall thickening.

Table 4: Sensitivity and specificity of various CT features for diagnosing a lesion of malignant and benign

CT features	Sensitivity (%)	Specificity (%)
Benign		
Mild thickening	89.21	61.31
Symmetric	77.24	79.54
Diffuse	83.61	91.36
Water halo	24.52	76.31
White attenuation	19.14	100
Malignant		
Marked thickening	61.58	89.74
Asymmetric	79.15	77.11
Focal	91.47	83.41
Heterogeneous	55.39	89.14

In the present investigation, it was observed that the identification of pronounced, asymmetrical, localized, and varied thickening of the bowel wall yielded sensitivity values of 61.58%, 79.15%, 91.47%, and 55.39% respectively. Furthermore, the specificity values for the aforementioned characteristics were determined to be 89.74%, 77.11%, 83.41%, and 89.14% respectively, in relation to the detection of malignant etiologies associated with bowel wall thickening. The presence of marked and focal bowel involvement, as well as a heterogeneous pattern of enhancement, exhibited a high level of specificity in indicating the presence of malignant bowel wall thickening. The presence of diffuse bowel wall thickening and white attenuation is indicative of benign bowel wall thickening. Bowel wall thickening exhibits a high degree of sensitivity and specificity in detecting malignant lesions. Likewise, the presence of diffuse involvement of bowel wall thickening demonstrated a high degree of sensitivity and specificity in identifying benign lesions. The presence of mild bowel wall thickening demonstrated a high degree of sensitivity in detecting benign bowel wall thickening; however, it lacked specificity. The combination of asymmetric, marked, focal, and heterogeneous patterns in categorizing a lesion as malignant resulted in an observed increase in specificity.

Table 5: Diagnosis by CT scan

	Number	Percentage (%)
Benign	19	
Tuberculosis	6	31.58
Ulcerative colitis	1	5.26
Crohn's disease	1	5.26
Non-specific colitis	9	47.37
Reactive sigmoid colon thickening due tubo-ovarian abscess	1	5.26
Non specific enteritis	1	5.26
Reaction cecal thickening due to appendicitis	1	5.26
Malignant	51	100
Carcinoma	40	78.43
Lymphoma	6	11.76
Metastatistic involvement	3	5.89
Malignant GIST	2	3.92

Table 6: Final diagnosis

	Number	Percentage (%)
Benign	20	
Tuberculosis	6	30
Ulcerative colitis	4	20
Crohn's disease	2	10
Non-specific colitis	6	30
Infectious enteritis	1	5
Gastritis	1	5
Malignant	50	
Adenocarcinoma	33	**66**
Metastatistic involvement	6	12
Lymphoma	7	14
Malignant GIST	3	6
Squamous cell carcinoma	1	2

Discussion

Following the administration of intravenous contrast material, it is typical for the bowel wall to exhibit enhancement. The mucosa, which is the innermost layer of the bowel wall, exhibits the highest degree of enhancement. This enhanced appearance can manifest as a clearly distinguishable layer. On the other hand, the submucosa exhibits a lower degree of vascularization and is rarely observed as an independent entity on computed tomography (CT) scans, unless it presents with edema, hemorrhage, or fat infiltration.[6] According to Macari M et al.[7], when the enhancement of the bowel wall is equal to or greater than the venous opacification observed in the same scan, it should be categorized as the white attenuation pattern. This pattern is predominantly observed in two clinical conditions: ischemia and inflammatory bowel disease. The pattern of gray attenuation refers to a thickened bowel wall that exhibits minimal distinct enhancement and possesses a uniform attenuation level similar to that of enhanced muscle tissue. The observed phenomenon of black attenuation can be considered analogous to the occurrence of pneumatosis. The attenuation pattern described is frequently observed in clinical diagnoses such as ischemia, infection, and trauma. The term "water halo sign" is commonly employed to denote the presence of stratification within a thickened bowel wall, characterized by the existence of two or three consistently thickened layers that are symmetrically arranged. Idiopathic inflammatory bowel diseases, vascular disorders, infectious diseases, and radiation damage are frequently observed in clinical contexts. The phenomenon known as the fat halo sign is characterized by the presence of a three-layered target sign, indicating thickened bowel walls, wherein the middle layer, also referred to as the "submucosal" layer, exhibits a fatty attenuation. This particular manifestation is frequently observed in cases of Crohn's disease affecting the small intestine, as well as in instances of ulcerative colitis or Crohn's disease affecting the colon. The occurrence of this pattern is observed in rare diagnoses such as exposure to cytoreductive therapy and chronic radiation enteritis.[8]

Mixed attenuation is frequently observed in cases of adenocarcinoma and stromal cell tumors.[9] In cases of inflammatory bowel wall thickening, it is typically possible to differentiate the brightly enhancing mucosa from the thickened submucosa, which exhibits lower attenuation.[10] In contrast to the typical presentation of neoplastic thickening, where the tumor infiltrates the layers of the bowel wall resulting in heterogeneous enhancement, this case exhibits a different appearance.[11,12] Mural stratification is also observed to be diminished in the chronic stage of ulcerative colitis and Crohn's disease. Benign conditions frequently give rise to mild wall thickening in entities, while neoplastic conditions typically exhibit marked wall thickening.[13] Intestinal inflammatory conditions, intestinal infections, and bowel ischemia are associated with the occurrence of symmetric thickening in the intestines. Certain neoplasms, such as linitis plastica and lymphoma, have been observed to exhibit symmetrical thickening as well.[14] Malignant conditions often exhibit the presence of asymmetric wall thickening.[9] In the chronic stage, Crohn's disease and tuberculosis of the bowel may exhibit asymmetrical thickening.[15] Frequent observations include the presence of focal bowel wall thickening, which is commonly associated with malignant and diffuse patterns in inflammatory pathologies. The assessment of various patterns and morphologies of bowel wall thickening, in conjunction with related observations such as lymph nodes, mesenteric fat stranding, calcifications, abscesses, sinus tracts and fistulas, fibro fatty proliferation, vascular occlusion, and solid organ abnormalities, contributes to a more precise differential diagnosis.[16-19]

In a study conducted by Insko et al.[20], a cohort of 38 patients with abnormal bowel wall thickening was examined, revealing 14 cases of malignancy and 24 cases of benignity. In line with our previous investigation, wherein a bowel wall thickness exceeding 2 centimeters exhibited a sensitivity of 61.58% and specificity of 89.74%, the study conducted by Erik K. Insko et al. reported a sensitivity of 50% and specificity of 88%. In a study conducted by Erik K Insko et al., it was observed that 71% of malignant cases exhibited asymmetrical bowel wall thickening, while 29% showed symmetrical thickening. In our study, we found comparable proportions of 79.15% and 20.85% for asymmetrical and symmetrical bowel wall thickening, respectively. In our study, the sensitivity and specificity of asymmetrical bowel wall involvement in classifying a thickened bowel wall as malignant were found to be 79.15% and 77.11% respectively. Similarly, in a study conducted by Erik K Insko et al., the sensitivity and specificity were reported as 71% and 75% respectively. In our study, we observed that malignant lesions exhibited focal involvement in 91.47% of cases, while diffuse involvement was present in 8.53% of cases. These findings align closely with the distribution reported by Erik K. Insko et al, where focal involvement was observed in 93% of cases and diffuse involvement in 7% of cases. When the combination of marked, asymmetric, focal, and heterogeneous patterns was utilized to classify a lesion as malignant, there was an observed enhancement in specificity, resulting in a value of 95.25%. The findings of this study are similar to those reported in a study conducted by Erik K. Insko et al. In our investigation, computed tomography (CT) demonstrated an overall sensitivity of 97.06% and specificity of 89.21% in distinguishing between a malignant and benign cause of abnormal thickening of the bowel wall. These findings align with the conclusions drawn by Erik K Insko et al. in their study.[20]

Conclusion

It is concluded that computed tomography (CT) features and enhancement patterns exhibit a high level of sensitivity and specificity in distinguishing between benign and malignant bowel wall thickening. This is particularly evident when multiple features are taken into consideration. The presence of both asymmetric, marked, focal bowel wall involvement and a heterogeneous

enhancement pattern demonstrates a high level of specificity in classifying a lesion as malignant. It is imperative for radiologists to possess knowledge regarding the computed tomography (CT) features and enhancement patterns in order to effectively distinguish between benign and malignant lesions.

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