

RESEARCH

Open Access



# Non-traumatic abdominal pain: assessment of diagnostic value of MDCT enterography in small bowel diseases—a retrospective study

Sally Y. Shokralla\* and Farid G. Amin

## Abstract

**Background:** Because of its unique anatomy, overlap of its loops, and its continuous peristaltic motion, imaging of the small bowel is a big challenge. Non-traumatic abdominal pain of small bowel origin includes a spectrum of medical and surgical conditions ranging from minor to life-threatening conditions. Accurate diagnosis of these diseases is essential to reduce morbidity and mortality. The aim of our study is to assess the role of MDCT enterography in evaluation and diagnosis of different small bowel causes of non-traumatic abdominal pain.

**Results:** Data analysis of 47 patients' files included in this study revealed a high diagnostic accuracy of MDCTE in diagnosing variable small bowel-related pathologies that were confirmed histopathologically.

**Conclusion:** MDCTE can be used as a reliable diagnostic imaging modality for the detection of small bowel diseases. However, operative data and tissue biopsy are still the confirmatory *methods* for diagnosis.

**Keywords:** CT enterography (CTE), Non-traumatic, Abdominal pain

## Background

Technically, imaging of the small bowel is a big challenge. This is because of its unique anatomy being a long, narrow, and serpentine viscus. Appreciable overlap of the small bowel loops is adding to the imaging difficulty. Motion, both intrinsic due to peristalsis and extrinsic due to breathing, is another big challenge. In addition, most of the common small intestine diseases present with subtle changes that make their early diagnosis difficult [1].

Non-traumatic abdominal pain of small bowel origin includes a spectrum of medical and surgical conditions ranging from minor to life-threatening conditions. Prompt and accurate diagnosis of these conditions is essential to determine the need for surgical intervention and to reduce morbidity and mortality rates [2].

For decades, small bowel follow-through and enteroclysis were and are still widely used for small bowel imaging. However, these techniques provide indirect information about the bowel wall itself. Their interpretation is still problematic due to overlapping bowel loops [3]. Abdominal ultrasound is a non-invasive imaging modality; however, it is an operator dependent. The overlying bowel gas is a significant obstacle for diagnosis of small bowel disorders by ultrasound [4]. Endoscopic examination of the small bowel allows direct assessment of the bowel lumen and allows also having biopsy from suspicious lesions, but it is an invasive maneuver and it is hard to assess the whole length of the small bowel [5]. Currently, the accessibility of multidetector CT of the abdomen and pelvis and its improved resolution have allowed better detection and proper characterization of small bowel diseases. In addition, it allows for evaluation of the surrounding mesentery as well as assessment of solid organs and provides a global overview of the

\* Correspondence: [sallykozman@yahoo.com](mailto:sallykozman@yahoo.com)  
Radiology Department, Faculty of Medicine, Cairo University, Cairo, Egypt

abdomen and the pelvis [4, 5]. MDCT enterography differs from routine abdomino-pelvic CT in that it makes use of thin sections and proper enteric expansion to better display the small bowel lumen and wall. The combined use of intravenous contrast material along with proper small intestine distension permits excellent assessment of hypervascular lesions and hyperenhancing segments [6].

The aim of this study is to evaluate the role of MDCT enterography in diagnosis of small bowel diseases causing non-traumatic abdominal pain.

## Methods

A retrospective data analysis of 47 patients who presented with referral criteria of non-traumatic abdominal pain clinically suspected to be of small bowel origin and were evaluated with multidetector computed tomography enterography (MDCTE) between January 2019 and September 2019 were enrolled in this study. Data regarding the laboratory and interventional procedures were obtained from the records of all patients.

### Inclusion criteria:

- All adult patients with non-traumatic abdominal pain clinically suspected to be of small bowel origin.

### Exclusion criteria:

- People having history of abdominal trauma.
- People diagnosed with extra-bowel cause of abdominal pain like pain of renal origin.
- Pregnant patients.
- Age below 18 years old.

Retrospective data analysis included the following:

- Patient records review regarding clinical symptoms, associated symptoms, and whether they performed laboratory tests or not.
- Dedicated CT protocol was revised, and both the CT studies as well as the written reports were also revised.
- Operative data and or histopathological diagnosis were obtained from the records whenever available.

### Protocol for MDCT

Data analysis from patient records regarding the examination protocol revealed that MDCTE studies were performed using multidetector row helical CT scanner (GE; Discovery CT 64-row). All patients were fasting for food only for at least 6 h prior to the beginning of the examination. They were ensured to be well hydrated by drinking 2.5 L of water over the last 3 h before the examination. They were informed to drink 500 mL of oral contrast; Mannitol diluted by 20% with normal water over the last 30 min to obtain a good distension of

**Table 1** MDCTE diagnosis in the study population

MDCTE diagnosis	Number of patients (%)
Inflammatory bowel disease	27 (57)
Fibrotic stricture	4 (8)
Intestinal neoplasms	3 (6)
Intussusception	2 (4)
Mesenteric ischemia	2 (4)
Others	9 (21)
Adhesive bowel obstruction	1
Superior mesenteric artery syndrome	1
Rectal AVM	1
Internal hernia	1
Non-specific findings	5

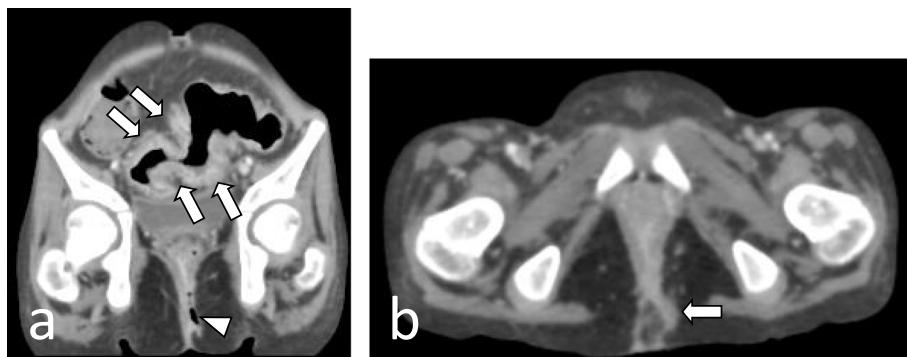
the small bowel loops. The region of interest from the lower chest till the inguinal region was scanned two consecutive times to obtain images in early arteriographic and in venographic phases.

### Data analysis and interpretation

Revisions of the CT slices on GE workstation 4.6 where 2D multiplanar axial, coronal, sagittal, and curved reformatted images as well as 3D volume-rendering, multiplanar reformatted (MPR), and/or maximum-intensity-projection (MIP) were obtained. All small bowel abnormalities were based upon the following criteria: location along the course of the small bowel, whether it is solitary or multiple; length of the lesion; degree of thickening, whether the thickening is symmetrical or not; and any associated abnormalities in the mesentery, vessels, and other scanned abdomino-pelvic organs.



**Fig. 1** A 29-year-old male patient with recurrent abdominal pain and alternating bowel habits. MDCTE axial cuts show mild uniform enhancing ileal small bowel thickening with stranding of the adjacent mesenteric fat. Diagnosis: active Crohn's disease



**Fig. 2** An 18-year-old female patient with attacks of abdominal pain and mucous diarrhea. MDCTE **a** coronal cuts show enhancing bowel thickening involving the sigmoid colon (arrows) and perianal fistula (arrow head), and **b** axial cuts show the perianal fistula track (arrow). Diagnosis: active Crohn's disease with perianal fistula

#### Verification of data

In all patients (100%), endoscopy and biopsy and/or surgical procedures and biopsy were revised. Records of histopathology were obtained.

Follow-up data of some patients were also retrieved from the records.

The aforementioned data were put in interface with the MDCTE films and reports for comparison and validation



**Fig. 3** A 46-year-old male patient with recurrent abdominal pain, diarrhea, and weight loss. MDCTE shows enhancing bowel thickening involving the ileal loops (arrows) and mesenteric fat stranding (arrow head). Diagnosis: active ulcerative colitis disease

#### Results

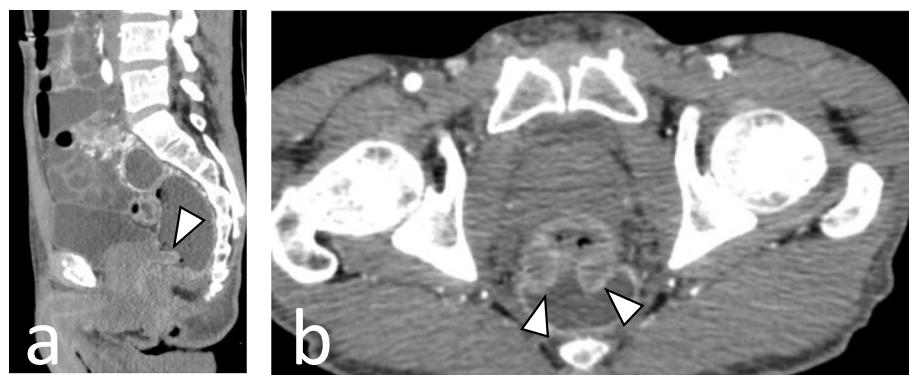
Retrospective data analysis from patient records resulted in inclusion of a total of 47 patients, 21 males (45%) and 26 females (55%) who were referred for MDCTE to help other specialities in diagnosis of non-traumatic abdominal pain clinically suspected to be of small bowel origin.

The age range of patients included was from 18 to 72 years old. All patients were evaluated with **multidetector** computed tomography enterography (MDCTE) between January 2019 and September 2019.

Data regarding the patients' laboratory and other interventional procedures were obtained from the records of all patients. Table 1 shows the MDCTE diagnosis in the study population. There were 27 inflammatory bowel diseases (Figs. 1, 2, 3, 4, and 5), 4 fibrotic strictures (Fig. 6), 3 intestinal neoplasms (Fig. 7), 2 intussusceptions (Fig. 8), 2 mesenteric ischemia (Fig. 9), and 9 others (Figs. 10, 11, and 12).



**Fig. 4** A 21-year-old male patient with recurrent abdominal pain. MDCTE axial cuts show non enhancing bowel wall thickening and mucosal stratification involving the sigmoid, recto-sigmoid colon, and adjacent rectum (arrow heads). Average calibre of the terminal ileum is noted. Diagnosis: chronic ulcerative colitis disease



**Fig. 5** A 31-year-old male patient with abdominal pain and reddish discoloration of the stool. MDCTE **a** sagittal and **b** axial cuts show a rectal enhancing inflammatory polyp protruding into the lumen (arrow heads). Diagnosis: ulcerative colitis with inflammatory polyp

To validate the above data retrieved from revision of MDCTE, we compared it to the retrospective analysis of the endoscopic and/or operative histopathological data available (Table 2).

#### Inflammatory bowel disease

##### Crohn's disease

The main diagnostic findings of active Crohn's disease in MDCTE were mucosal hyper enhancement, intestinal wall thickening (thickness being more than 3 mm), mural stratification with a prominent vasa recta (comb sign), and mesenteric fat stranding (Fig. 1). Other findings were also seen such as perianal fistula (Fig. 2).

##### Ulcerative colitis

CT criteria of active ulcerative colitis are similar to those of active Crohn's disease like mucosal hyper enhancement, intestinal wall thickening, mural stratification with

a prominent, and mesenteric fat stranding (Fig. 3). It affects mainly the large bowel in a continuous pattern with no skip lesions.

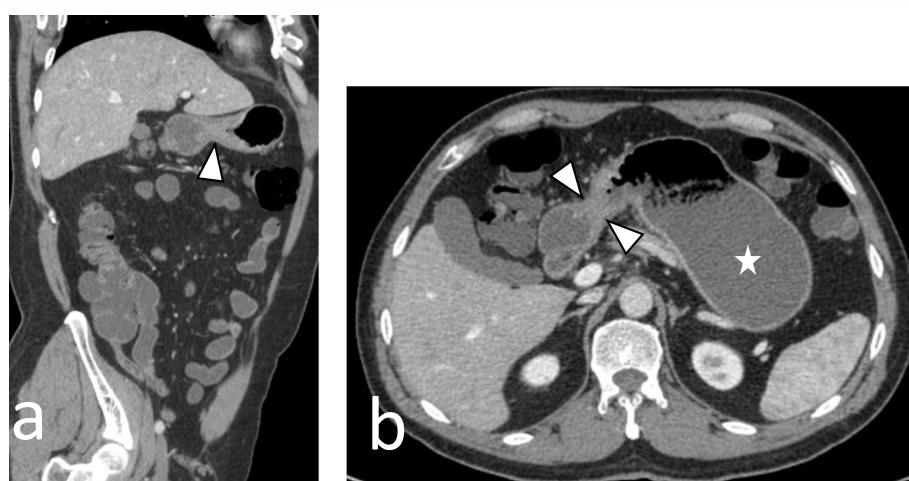
Figure 5 shows a case of ulcerative colitis associated with a rectal inflammatory polyp which is considered one of its complications.

##### Fibrotic strictures

Two cases of fibrotic strictures were found in this study and were proved by operative findings and histopathology as shown in Fig. 6.

##### Small bowel neoplasms

Small bowel neoplasms were found in three cases while the operative data revealed five neoplastic cases. All of them were proved by histopathology (Fig. 7).



**Fig. 6** A 48-year-old male patient with epigastric pain and repeated vomiting. MDCTE **a** sagittal oblique and **b** axial cuts show mural thickening of the pyloric canal with mucosal defects, overlying serosal thickening, stranding of the adjacent fat, narrowed lumen (arrow heads), and mild proximal gastric dilatation (star). Diagnosis: pyloric stenosis secondary to peptic ulceration fibrotic stricture



**Fig. 7** A 39-year-old male patient with vague abdominal pain and weight loss. MDCTE shows an ill-defined heterogeneously enhancing soft tissue mass lesion with serrated outline (arrows) and soft tissue stranding of the adjacent fat with few small adjacent nodules and engorged vessels (arrow heads). Diagnosis: small bowel malignant neoplastic lesion and was confirmed pathologically to be an adenocarcinoma. PS, an incidental right oblique inguinal hernia with fat contents is noted

### Intussusception

Intussusception was found in two cases with characteristic target like mass, the entering bowel wall, the returning bowel wall, the mesenteric fat, and intraluminal space (Fig. 8).

### Mesenteric ischemia

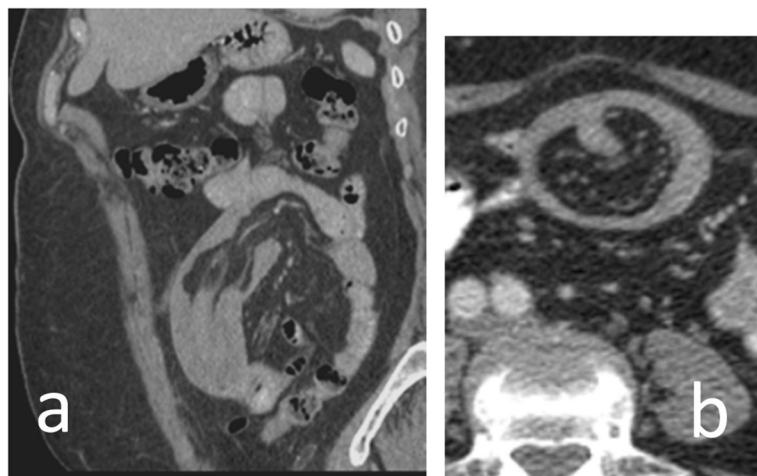
Two cases of mesenteric ischemia were diagnosed by MDCTE and were confirmed after surgical procedures. The diagnostic findings as shown in Fig. 9 are thickened edematous bowel wall with air loculi. CT enterography allowed proper assessment of the mesenteric vessels showing portal and mesenteric venous thrombosis.

### Others

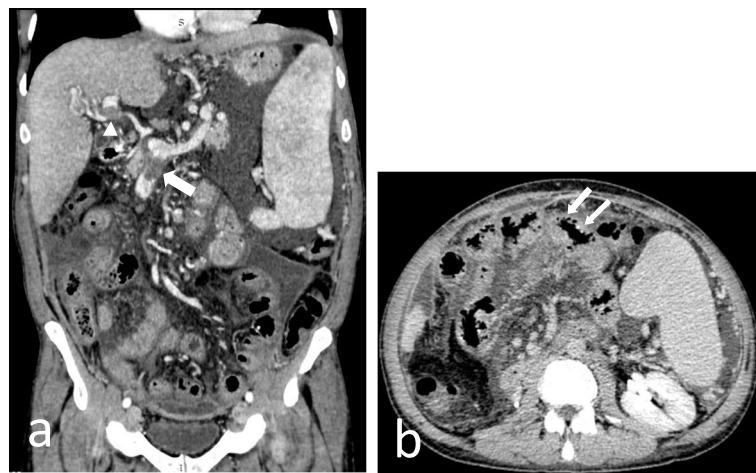
In our study, nine patients out of the total forty-seven patients (21%) were having other less common pathologies that are considered causes of abdominal pain of non-traumatic origin or non-specific pathologies which could not be interpreted as being characteristic of certain pathology. Four cases of them were diagnosed by MDCTE as follows: one adhesive small bowel obstruction (Fig. 10), one SMA syndrome (Fig. 11), one rectal AVM (Fig. 12), and one internal hernia, while five cases were found to have non-specific findings and a final diagnosis was not obtained by MDCTE.

### Discussion

Non-traumatic abdominal pain of small bowel origin includes a spectrum of medical and surgical aetiologies ranging from minor to life-threatening conditions. Diagnosis of the aetiology has been a dilemma due to many factors related to the unique anatomy of the small bowel and its continuous motion [2].



**Fig. 8** A 43-year-old female patient with recurrent abdominal pain. MDCTE **a** sagittal and **b** axial cuts show a target like mass, the entering, and the returning bowel loops. Diagnosis: small intestinal intussusception with no underlying cause revealed after surgical intervention



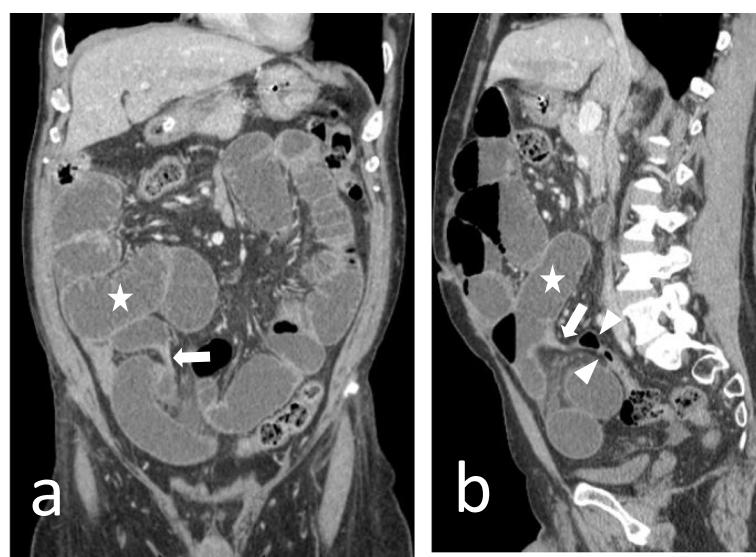
**Fig. 9** A 53-year-old male patient with abdominal pain. MDCTE **a** coronal cuts show thrombosed mesenteric vein (arrow), partially thrombosed portal vein (arrow head), and **b** axial cuts show ischemic changes of the bowel loops showing mural thickening, thickened valvulae conniventes, edema, variable enhancement, non-enhancing segments, and few air loculi (arrows). Cirrhotic liver, splenomegaly, and ascites are also noted. Diagnosis: acute on top of chronic mesenteric ischemia

In this study, a retrospective data analysis was done for 47 patients complaining of non-traumatic abdominal pain for whom MDCT enterography has been done in attempt to reach the aetiological diagnosis. The MDCTE diagnosis was correlated with the histopathological findings in all cases.

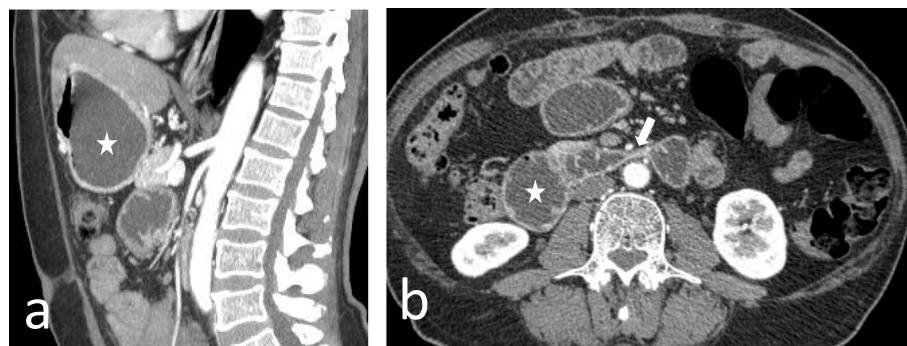
Inflammatory bowel disease was the most common cause of non-traumatic bowel-related abdominal pain in our study. This is consistent with Paulsen et al. who stated that inflammatory bowel disease and intestinal ischemia are the two most common causes of bowel-related non-traumatic abdominal pain [6]. Twenty-seven

cases (57%) were diagnosed as having inflammatory bowel disease by CT enterography. Twenty-five cases (93%) of them were proven pathologically to have IBD. Tochetto et al. stated that the estimated sensitivity of MDCT enterography for detecting ileal inflammation is about 75–90% using mucosal inspection and biopsy as a reference standard. This percentage improves to 90–95% if associated with clinical and follow-up data [7].

In our study, the terminal ileum was involved in most patients showing characteristic skip lesions. Karlinger et al. and ElSayes et al. stated that Crohn's disease may affect any



**Fig. 10** A 57-year-old male patient. MDCTE **a** coronal and **b** sagittal show a beak (arrows) with a transition between a proximally dilated bowel loops (stars) and collapsed distal bowel loops (arrow heads) with no evidence of extrinsic mass compression or mural wall thickening. Diagnosis: adhesive small bowel obstruction



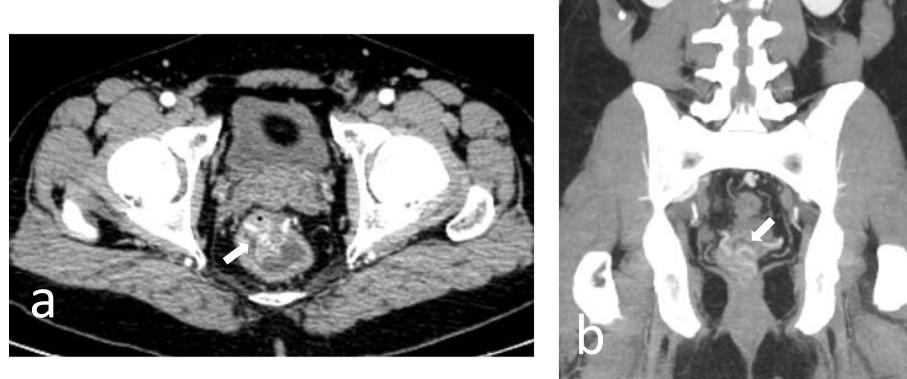
**Fig. 11** A 22-year-old female patient complaining of attacks of post prandial pain. MDCTE **a** sagittal and **b** axial cuts show compression of the third part of the duodenum (arrow) between the descending aorta and the superior mesenteric artery (SMA), acute aorto-mesenteric angle "16°" and attenuated aorto-mesenteric distance "8 mm" with proximal dilatation involving the stomach, and the second part of the duodenum is noted (stars). Diagnosis: superior mesenteric artery syndrome

segment of the gastrointestinal tract with a special predilection for the terminal ileum [8, 9]. According to Macari et al., there is significant correlation between the presence of homogeneous mural hyper enhancement and the active Crohn's disease histopathological findings which was confirmed in our study. Another finding that correlates well with the degree of activity of Crohn's disease is the presence of peri-enteric inflammation in the form of increased fat density and vascular engorgement of the vasa recta [10]. Eleven patients were found to have the aforementioned findings, and they were clinically suggested to have active acute exacerbation.

In our study, one patient with ulcerative colitis was found to have a rectal inflammatory polyp as an associated finding. Other extra-enteric finding such as sacroiliitis was found separately in one patient with active Crohn's disease.

In our study, four cases were diagnosed as fibrotic stricture. The main points to differentiate fibrotic stricture from active inflammatory process are the absence of vasa recta engorgement or reactive lymphadenopathy in case of fibrotic stricture and the pattern of bowel wall enhancement which is seen restricted to the mucosa compared to wall stratification in active cases. Sakurai et al. and Minordi et al. stated that bowel stenosis due to fibrotic structure is the thickening of the bowel wall with subsequent narrowing of its lumen. According to the degree of luminal narrowing, proximal bowel dilatation may be present [11, 12].

Two cases were diagnosed as having intussusception with the characteristic target like mass. Kim et al. stated that the main advantage of CT is to clearly identify the entering bowel wall, the returning bowel wall, the mesenteric fat, and intra-luminal space. An added value of



**Fig. 12** A 37-year-old male patient with abdominal pain and bleeding per rectum. MDCTE **a** axial and **b** coronal cuts show an intensely enhancing vascular mass protruding into the rectal lumen (arrows). Diagnosis: rectal arterio-venous malformation forming an intra-luminal vascular mass

**Table 2** Correlation between the histopathological data and MDCTE diagnosis

Diagnosis	Number of patients diagnosed by MDCTE	Number of patients diagnosed by operative, endoscopic, and/or histopathological data
Inflammatory bowel disease	27	25
Fibrotic stricture	4	4
Intestinal neoplasms	3	5
Intussusception	2	2
Mesenteric ischemia	2	2
Adhesive bowel obstruction	1	1
Superior mesenteric artery syndrome	1	1
Rectal AVM	1	1
Internal hernia	1	1
Non-specific	5	0
Familial Mediterranean Fever	0	2
Celiac disease	0	3
Total	47	47

the MDCTE is detection and proper characterization of a lead point mass as aetiology [13].

Another cause of non-traumatic bowel-related pain is bowel ischemia. In our study, only two cases were diagnosed as having bowel ischemia. Both of them showed superior mesenteric venous thrombosis associated with portal venous thrombosis as well in one patient. As per Furukawa et al., the diagnosis is based on the identification of more than two of the following signs: circumferential mural thickening, decreased enhancement of the bowel wall, intramural gas, mesenteric edema, mesenteric vascular engorgement, and an intravascular filling defect [14]. In our study, the combination of these five signs or at least four of them resulted in accurate diagnosis of all cases of intestinal ischemia. The diagnosis was confirmed by obtaining operative data in 2 cases (100%). In contrast to Gangadhar et al., who stated that intestinal ischemia is the second most common cause of bowel-related non-traumatic abdominal pain coming in order of frequency after IBD [15]. In our study, only 2 cases (4%) of the total population were diagnosed as having bowel ischemia. This can be explained by emergency surgical interventions that were done for other patients that were suspected clinically to have mesenteric ischemia.

In our study, four patients were diagnosed as having other pathologies or having non-specific findings. Two of them were found to be presenting clinically at time of

examination with picture of subacute intestinal obstruction for which they were surgically operated upon. By MDCTE, one patient was diagnosed as adhesive bowel obstruction with a beak transition between proximally dilated bowel loops and collapsed distal bowel loops. No evidence of extrinsic mass compression or mural wall thickening was detected. The other one was diagnosed as left para-duodenal internal hernia. The operative records of both patients confirmed the diagnosis.

One case of SMA syndrome was diagnosed showing the characteristic pattern of compression of the third part of the duodenum between the descending aorta and the superior mesenteric artery (SMA). Proximal dilatation involving the stomach and the second part of the duodenum is noted. This is agreeing with Gangadhar et al. who stated that acute aorto-mesenteric angle of less than 25° and attenuated aorto-mesenteric distance of less than 10 mm at the level of the third part of the duodenum are the main diagnostic criteria of SMA syndrome along with proximal bowel dilatation [15].

One case of rectal AVM was also diagnosed showing a polypoidal highly vascular mass.

The diagnosis was not sure in five patients out of 47 cases. Non-specific findings were detected like diffuse bowel dilatation. No specific enhancement pattern was retrieved. Revision of their histopathological records revealed one IBD, one FMF, one celiac disease, and two neoplastic lesions confirmed to be GIST. This is compared to a study by Misra et al. who reported a sensitivity and specificity of MDCTE to be 95.83% and 100% respectively with accuracy of 96.66% in diagnosis of small bowel diseases [16].

## Limitations

Some limitations that were encountered in our study included the wide varieties of pathologies that cause bowel-related pain like inflammatory, ischemic, neoplastic, and miscellaneous lesions. This variation affected the sample size in each pathological category. Further study on a large number of patients may be of value in retrieving better results with more understanding of the small bowel pathologies causing abdominal pain.

## Conclusion

This study stated that MDCTE is a reliable imaging modality for patients presented with non-traumatic abdominal pain suggested to be of small bowel origin. Operative findings, biopsy, and histopathology however are still the confirmatory methods of diagnosis and can help validation and reproducibility of MDCTE examination.

## Abbreviations

AVM: Arterio-venous malformation; CT: Computed tomography; FMF: Familial Mediterranean Fever; IBD: Inflammatory bowel disease; MDCT: Multi detector computed tomography; MDCTE: Multi detector computed tomography enterography; SMA: Superior mesenteric artery

## Acknowledgements

The authors would like to thank all those who contributed to this study.

## Authors' contributions

F.A. shared in the study's conception and design; acquired, analysed, and interpreted data; processed CT findings at the CT workstation; revised clinical data; and contributed to the drafting of the manuscript. S.S. contributed to the study's conception and design, collected patients' data, processed CT findings at the CT workstation, and shared in writing and revising the manuscript. All authors mentioned read and approved the final manuscript.

## Funding

This study was not funded by any resource.

## Availability of data and materials

The sets of data used and/or analyzed during the study are available upon sensible request.

## Ethics approval and consent to participate

No individual data was included in the study.

This study was approved by the Research Ethics Committee of the Radiology Department of the Faculty of Medicine at Cairo University in January 2019. Reference number of approval: 107-2019.

All patients participating in this study were informed of what it entails and gave verbal informed consent to take part in this research.

If the patient was unconscious at the time of the study, written informed consent for their participation was provided by their legal guardian.

## Consent for publication

Revision of the patients' records included in this study revealed that all patients gave written informed consent to use and publish the data obtained within this study.

If the patient was unconscious when consent for publication was requested, written informed consent for the publication was provided by their legal guardian.

## Competing interests

The authors of this study declare that they have no competing interests.

Received: 26 May 2020 Accepted: 30 July 2020

Published online: 13 August 2020

## References

1. Patak MA, Mortele KJ, Ros PR et al (2005) Multidetector row CT of the small bowel. *Radiol Clin N Am* 43:1063–1077
2. Das CJ, Manchanda S, Panda A et al (2016) Recent advances in imaging of small and large bowel. *PET Clin* 11(1):21–37
3. Hong SS, Kim AY, Byun JW et al (2006) MDCT of small-bowel disease: value of 3D imaging. *AJR* 187:1212–1221
4. Bradbury MS, Kavanagh PV, Bechtold RE et al (2002) Mesenteric venous thrombosis: diagnosis and noninvasive imaging. *Radiographics* 22:527–541
5. Boudiaf M, Jaff A, Soyer P et al (2004) Small-bowel diseases: prospective evaluation of multi-detector row helical CT enteroclysis in 107 consecutive patients. *Radiology* 233:338–344
6. Paulsen S, Huprich J, Fletcher JG et al (2008) CT enterography as a diagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. *RadioGraphics* 28:641–662
7. Tochetto S, Yaghmai V (2009) CT enterography: concept, technique, and interpretation. *Radiol Clin N Am* 47(1):117–132
8. Karlinger K, Gyorke T, Mako E et al (2000) The epidemiology and the pathogenesis of inflammatory bowel disease. *Eur J* 35:154–167
9. Elsayes KM, Al-Hawary MM, Jagdish J et al (2010) CT enterography: principles, trends, and interpretation of findings. *RadioGraphics* 30(7):1955–1970. <https://doi.org/10.1148/rq.307105052>
10. Macari M, Megibow A, Balthazar E (2007) A pattern approach to the abnormal small bowel: observations at MDCT and CT enterography. *AJR* 188:1344–1355
11. Sakurai T, Katsuno T, Saito K et al (2017) Mesenteric findings of CT enterography are well correlated with the endoscopic severity of Crohn's disease. *Eur J* 89:242–248
12. Minordi LM, Vecchioli A, Mirk P et al (2007) Multidetector CT in small-bowel neoplasms. *Radiol Med (Torino)* 112(7):1013–1025
13. Kim YH, Blake MA, Harisinghani MG et al (2006) Adult intestinal intussusception: CT appearances and identification of a causative lead point. *RadioGraphics* 26(3):733–744. <https://doi.org/10.1148/rq.263055100>
14. Furukawa A, Kanasaki S, Kono N et al (2009) CT diagnosis of acute mesenteric ischemia from various causes. *AJR Am J Roentgenol* 192(2):408–416
15. Gangadhar K, Kielar A, Dighe M.K., et al. (2016) Multimodality approach for imaging of non-traumatic acute abdominal emergencies. *Abdom Radiol (NY)*: 41 (1) (2016), pp. 136–148
16. Misra RN, Bajaj SK (2019) Role of CT enterography in evaluation of small bowel disorders. *Int J Res Med Sci* 7(2):537–543

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Submit your manuscript to a SpringerOpen® journal and benefit from:**

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

**Submit your next manuscript at ► [springeropen.com](http://springeropen.com)**