Abstract

Purpose: To evaluate role of multidetector CT Enterography (CTE) in diagnosis of small intestinal tumors.

Material and Methods: Sixty six patients (40-76 years) presented with clinical suspicion of small intestinal tumors. They underwent CTE with a 64 multidetector CT before operation. Two independent gastrointestinal radiologists analysed CTE images. Post operative histopathological examination was considered the reference standard. Sensitivity, specificity, accuracy, positive and negative predictive value were calculated.

Results: Positive radiological findings suggestive of small intestinal tumors were obtained in 34 cases and negative in 32 cases. Pathology confirmed diagnosis in 29 cases: Gastrointestinal stromal tumor (n=13), Non Hodgkin lymphoma (n= 11), Carcinoid tumor (n=2), one case of adenocarcinoma of the deodenum, one case of liomyosarcoma of the ileum and one case of metastatic deposits from colonic adenocarcinoma. Overall sensitivity, specificity and accuracy of CTE in detection of small intestinal tumors were 82.8%, 83.8% and 83.3% respectively with positive predictive value of 85.2% and negative predictive value of 81.2%.

Conclusion: Multidetector CTE is a promising valuable tool that helps in precise localization, characterization and staging of small bowel tumor with high diagnostic accuracy.

Key Words: CT Enterography (CTE) – Intestinal masses.

Introduction

SMALL intestine is a difficult organ to examine by clinical or radiographic means. The upper gastrointestinal (GI) tract is accessible by direct endoscopy, as is the colon. The small intestine, however, is beyond the reach of most flexible endoscopes [1].

Capsule endoscopy is one alternative for the evaluation of the small intestine. It yields excellent endoscopic images of a variety of pathologies of the small bowel lumen. However, limitations in the field of view and frame rate mean that capsule endoscopy can miss a lesion if it does not capture an image as it passes through an area of disease [2,3].

Follow-through is time-consuming, especially in the case of poor peristalsis or partial obstruction. It achieves poor distention of the bowel, because the pylorus restricts gastric emptying. Enteroclysis is uncomfortable for patients. It can be time-consuming to intubate the patient and achieve bowel distension. It is associated with a moderate level of radiation exposure. Enteroclysis is, however, unequivocally the best test for detecting partial obstruction and masses within the lumen [4,5].

Conventional CT is well established for the overall evaluation of the abdomen and pelvis, including portions of the bowel, the lymph nodes, and abscesses that may be related to bowel pathology. However, positive oral contrast medium impairs the assessment of the bowel wall and lumen, precluding visualization of abnormal mucosal enhancement [6].

Increased speed and resolution of multi-detector row computed tomography (CT) have made CT a first-line modality for the examination of small bowel disease. CT enterography differs from routine abdominopelvic CT in that it makes use of thin sections and large volumes of enteric contrast material to better display the small bowel lumen and wall. CT enterography is a study based on distension of bowel loops by neutral peroral enteric contrast medium associated with intravenous iodinated contrast injection [7]. CT enterography has several advantages: It displays the entire thickness of the bowel wall, it allows examination of deep ileal loops in the pelvis without superimposition, and it permits evaluation of the surrounding me-
sentery and perienteric fat. CT enterography also allows assessment of solid organs and provides a global overview of the abdomen [8,9].

The purpose of this study is to discuss the role of multidetector CT in the diagnosis of malignant small intestinal tumors.

**Patients and Methods**

The total number of patients included in this study was 66 patients 45 males and 21 females with age range of 40-76 years and mean age of 52 years. They presented with chronic abdominal pain with illness (n=31), abdominal swelling (n=15), emaciation and iron deficiency anemia (n=5), melena (n=4), intestinal obstruction (n=9), family history of bowel neoplasms (n=1) and presence of carcinoid syndrome. Their diagnosis was confirmed by pathological evaluation after surgery which was considered as the reference standard.

They underwent MSCT examination on a 64 multidetector CT (Philips 64 Brillience, Philips Medical System, Best, Netherlands) one to two weeks before operation after an informed consent. Patients were fasting for 12 hours before CT examination. A spasmolytic agent (1 5ml of Tienonium methylsulphate, Visceralgine: Laboratories Organon, Puteaux, France) was administered intravenously for reducing abdominal discomfort and avoiding spasm. Oral administration of 1350mL of low-concentration barium was according to the following schedule: 450mL 60 minutes before scanning, 450mL 40 minutes before scanning, 225mL 20 minutes before scanning and 225mL 10 minutes before scanning.

At the beginning of the examination, 150mL of nonionic iodinated contrast material (Ultravist 300 [iopromide], Schering, Berlin) was injected IV through a 20-gauge cannula at 3ml/s using an automated power injector. The delay between the start of contrast administration and the start of helical scanning was approximately 10 seconds to achieve the arterial phase using the CARE bolus-triggering program and 72 seconds for the delayed phase. Images were obtained from the dome of the liver to the lower margin of the symphysis pubis during a single breath-hold. Scanning parameters were 120 kV, 200mAs, reconstructed slice thickness/interval of 3/2mm and 1/0.7mm for coronal MPR.

**Image reconstruction and post processing:**

Images were acquired with a section thickness of (2.0-2.5mm) and a reconstruction interval of (1.0-1.5mm). Coronal reformatted images were generated (3-mm-thick sections every 2mm) at the workstation (Philips Brillience, Philips Medical System, Best, Netherlands), overlapping images from the anterior abdominal skin to the posterior gluteal skin were also generated (to ensure that any fistulous tracts are displayed). We also performed maximum intensity projection (MIP) reconstructions from the axial images.

Two gastrointestinal radiologists (GH and GG) with 15 and 12 years of experience in gastrointestinal radiology blinded to the clinical and radiological data, consensually reviewed all CT images. Symmetry of parietal thickening, focal intraluminal masses, focal areas of bowel wall thickening (was considered if more than 3mm thickness), or areas of increased mural enhancement and the presence of associated extraluminal abnormalities were analysed. Visceral metastasis was considered if nodules were identified within the peritoneal cavity or hypodense lesions within the liver. Lymph nodes were considered positive if more than 10mm.

**Statistical analysis:**

The CT Enterography results were considered as the test while results of post operative definitive histopathology were considered as the reference standard. The sensitivity was defined as the number of true positive test results divided by the overall positive cases in the reference standard, and specificity as the number of true negative test results divided by the overall negative cases from the reference standard. The accuracy was defined as true positive and true negative test results divided by the total number of specimens examined. The positive predictive value (PPV) was defined as the number of true positive test results divided by the overall test positive results, and the negative PV (NPV) as the number of true negative test results divided by the overall test negative results.

All patients underwent diagnostic Radiology Dept. Faculty of Medicine, Mansoura University from 2012 – 2013.

**Results**

The examination was well-tolerated by all the patients, with appropriate ingestion of the neutral oral contrast, which allowed adequate luminal distension. Among the 66 patients included in the present study, positive radiological findings were obtained in 34 cases. Size of detected masses ranged from 5 to 60mm. A pedunculated or predominantly exoenteric mass was diagnosed radio-
logically as gastrointestinal stromal tumor (GIST) (n=15) (Fig. 1). Three cases showed liver metastasis.

An exoenteric mass combined with adjacent lymphadenopathy or aneurysmal ulceration of small bowel suggestive of Non Hodgkin lymphoma were diagnosed in 14 cases. Two cases demonstrated mural thickening and kinking of the affected small bowel loops with desmoplastic reaction in the mesentery giving satellite appearance and calcification but none of them showed liver metastasis and were suggestive of carcinoid tumors (Fig. 2).

One case was suggestive of adenocarcinoma of the duodenum with annular thickening of the wall with eccentric lumen (Fig. 3) and one case of liomyosarcoma of the ileum which was an enhancing mass with central necrosis and metastatic focal lesion of the liver. Finally, one case with multiple small intraluminal masses with poor contrast enhancement (Fig. 4) suggestive of metastatic deposits in a patient with history of resection of colonic adenocarcinoma and presented with intestinal obstruction.

Most of the masses were located in the ileum (n=21), then duodenum (n=7), and jejunum (n=6) (Table 1). Patients with negative radiological findings (32 patients) were followed-up for one year. Symptoms resolved after conservative medical treatment in 26. Regarding the 6 false negative patients with persistence of symptoms; 2 patients were explored because of recurrent intestinal obstruction and revealed lymphoma in one patient and GIST in another. Four patients were investigated by videocapsule, 3 were proven to be jejunal polyps and one small intestinal angiodysplasia.

Pathologic diagnosis was correlated with CTE findings in 29 cases. Gastrointestinal stromal tumor (n=13), Non Hodgkin lymphoma (n=11), Carcinoid tumor (n=2), one case of adenocarcinoma of the duodenum, one case of liomyosarcoma of the ileum and one case of metastatic deposits from colonic adenocarcinoma. On exploration, 5 cases were proven to be false positive. The three patients who were falsely diagnosed as lymphoma were proven to be fold thickening in surgery and pathology obtained from lymph nodes showed reactive hyperplasia. The 2 patients falsely diagnosed as GIST showed negative intraoperative findings. Notably, the diagnosed masses in these 2 patients were 5 and 6mm in diameter.

The overall results among 66 cases who underwent CT enterography, true positive findings were obtained in 29 cases (43.9%), true negative in 26 cases (39.3%), false positive in 5 cases (7.1%), false negative in 6 cases (9%) with overall sensitivity, specificity and accuracy of CTE in detection of small intestinal tumors of (82.8%, 83.8%, 83.3%) respectively with positive predictive value of 85.2% and negative predictive value of 81.2% (Table 2).

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Table (1): Radiological results of detected small intestinal tumors.

<table>
<thead>
<tr>
<th>GIST</th>
<th>Lymphoma</th>
<th>Carcinoid</th>
<th>Liomyosarcoma</th>
<th>Adenocarcinoma</th>
<th>Metastasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deodenum</td>
<td>4</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Jejunum</td>
<td>4</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Ileum</td>
<td>7</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table (2): True and false positive and negative results of the CT Enterography (test) as controlled by post operative histopathological diagnosis (gold-standard).

<table>
<thead>
<tr>
<th>Post operative histopathological diagnosis (gold standard)</th>
<th>Small intestinal tumor +ve</th>
<th>Small intestinal tumor –ve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results of CTE (test)</td>
<td>CTE positive</td>
<td>True positive</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>CTE negative</td>
<td>False negative</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>31</td>
</tr>
</tbody>
</table>
Fig. (1-A,B): Axial and coronal CTE scan of the abdomen and pelvis after oral and IV contrast administration of a male patient aged 61 years complaining of nausea and vomiting showing: A well defined soft tissue mass involving the 3rd and 4th part of the duodenum with areas of degeneration and gas density inside seen contacting the aorta and IVC posteriorly. The intestinal loops are seen displaced anteriorly. Pathologically proven to be gastrointestinal stromal tumor (GIST).

Fig. (2-A,B): Coronal CTE scan of the abdomen after oral and IV contrast administration of a male patient aged 66 years complaining of crampy abdominal pain, weight loss and diarrhea, showing: Mural thickening and kinking of the affected small bowel loops with desmoplastic reaction in the mesentry giving the stellate appearance, and calcification. Pathologically proven to be carcinoid.

Fig. (3-A,B): Axial CTE scan of the abdomen after oral and IV contrast administration of a female patient aged 56 years, complaining of nausea, vomiting and abdominal pain, showing multiple small intraluminal masses with poor contrast enhancement. Pathologically proven to be duodenal adenocarcinoma.

Fig. (4-A,B): Axial CTE of the abdomen after oral and IV contrast administration of a male patient aged 40 years with history of cancer colon showing multiple small intraluminal masses with poor contrast enhancement, pathologically proven to be small intestinal metastatic deposits from colonic adenocarcinoma.
Discussion

Primary benign and malignant neoplasms of the small bowel are rare representing approximately 3% to 6% of all cancers of the digestive tract [10,11]. The most common small bowel tumors (in decreasing order of frequency of occurrence are adenocarcinoma, carcinoid tumor, lymphoma, and gastrointestinal stromal tumor [8]. Malignant tumors often present late symptoms resulting in a poor prognosis. Early detection of small bowel neoplasm is desirable but challenging for both clinicians and radiologists. Conventional radiologic and endoscopic evaluations of the small bowel are often limited by the length, caliber and motility of the small bowel loops. The development of new multidetector-row CT scanners, with faster scan times and isotropic spatial resolution, allows high-resolution multiphasic and multiplanar assessment of the bowel wall and lumen [12].

Multidetector CT (MDCT) produces high-resolution cross-sectional imaging of the abdomen and the small bowel. It allows multiplanar visualization of small bowel tumors, demonstrates signs of small bowel obstruction as well as the mural and extramural extent of small bowel malignancies. They also improve the quality of the 3-dimensional CT images that are valuable to the clinicians and surgeons for surgical planning [13,14]. In addition, liver metastases or peritoneal seeding can be detected by CT.

CT Enterography (CTE) is a variant of routine abdominal scanning, aiming at more sustained bowel filling with oral contrast material, and the use of multiplanar images, that can enhance gastrointestinal tract (GIT) imaging [15,16]. It has distinct advantage over conventional CT, wireless capsule endoscopy and barium examination. CTE is noninvasive and allows rapid mapping of disease activity before endoscopy and in cases where the endoscope cannot reach the diseased segment. CTE is readily available, operator independent and allows evaluation of extraenteric complications of small bowel disease [17].

In a study done by Sodhi et al., [18], on a 64 multislice CT machine et al., adequate luminal distension of small bowel was seen in 29 (90.6%) patients, fifteen of 32 (46.9%) patients had positive findings on CT-EG; 12 of them underwent exploratory laparotomy. The surgical findings were in conformity with CT-Enterography findings in all patients, which included gastrointestinal stromal tumors in 6 patients, carcinoid in one, Meckel’s diverticulum in one, small bowel adenocarcinoma in two patients and jejunal vascular malformation in two patients.

Up to our knowledge, there is no literature critically addressing the diagnostic accuracy of such modality. In this contribution CTE was tolerated by 66 patients with adequate small bowel distention and was able to detect tumors affecting small bowel in 34 cases, 29 of them were confirmed by pathological diagnosis. False positive results in (7.1%) notably, the missed masses by CTE were less than 1cm in diameter, false negative results in (9%). The overall Overall sensitivity, specificity and accuracy of CTE in detection of small intestinal tumors were 82.8%, 83.8% and 83.3% respectively with positive predictive value of 85.2% and negative predictive value of 81.2%.

Enteroclysis although having higher sensitivity and specificity in detecting small bowel tumors, it is less tolerated by patients. A study done by Pilleul, et al. [19], found that CT enteroclysis was well tolerated in 96.3% of patients (211 of 219) with sensitivity and specificity in identifying patients with small-bowel lesions were 84.7% and 96.9%, respectively. The negative and positive predictive values were 94.5% and 90.9%, respectively. However, Wold et al., [20] have demonstrated that there is no statistically significant difference between enterography and enteroclysis regarding intestinal loops distension.

Metastases to small bowel from primary tumors in extraabdominal sites are uncommon. The common primary tumours that metastasise to the bowel are malignant melanoma, carcinoma of the breast and lung. CT enteroclysis allows the detection of liver metastases and/or peritoneal carcinomatosis in the same session [21]. Pilleul, et al. [19], were able to detect liver metastasis in 15 patients from 55 with small bowel tumors. In our study, there were 4 cases with liver metastasis. In our study there was one case of metastatic deposits from colonic adenocarcinoma.

These results suggest that CT enterography facilitates an adequate evaluation of patients with small-bowel tumors, moreover, CT enterography could replace the combination of abdominopelvic CT and barium follow-through examination that is commonly performed for the evaluation of patients with small-bowel tumors, thus decreasing the patient’s exposure to ionizing radiation.

The limitations of our study are, the limited number of patients studied and absence of prospective randomization with other promising diagnostic modalities in this clinical setting such enteroclysis or MRI enterography.
Conclusion:

CT Enterography provides distension and optimal imaging of the small bowel wall along with MDCT, they help in precise localization and characterization of lesions as well as delineation of the tumor extent and involvement of other organs. CTE is a promising valuable tool for diagnosis and staging of small bowel tumor which is less invasive for the patient and has high sensitivity and specificity for diagnosis.

References
4- FEDELE M.: CT of the small intestine: Enterography and angiography CT enterography out perform conventional barium studies and serve as good complement to direct and capsule endoscopy. Hot Topics in CT, 55-62, 2007.