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ORIGINAL ARTICLE

Multidetector CT evaluation of alternative diagnosis of clinically suspected acute appendicitis, appendicular and nonappendicular lesions

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KEYWORDS

Multidetector CT;
Appendicitis;
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Abstract *Objective:* To assess the accuracy of MDCT in diagnosis and preoperative evaluation of alternatives of acute appendicitis causing RLQP and associated complications.
Patients and methods: 350 consecutive patients (250 males and 100 females) with ARLQP underwent MDCT examinations with contrast. Each scan was evaluated independently for the presence of inflammatory process (appendicitis), associated complications and for the detection of other findings rather than acute appendicitis causing RLQP. The radiological findings were compared with histopathological results for operated cases.
Results: 146 typical cases out of 350 patients received CT diagnosis of acute appendicitis, 62 with complications such as appendicular abscess ($n = 32$), appendicolith ($n = 7$), mucocele ($n = 15$), retrocecal appendix ($n = 5$), and retroileal appendix ($n = 3$); 63 patients received nonappendicular GIT causes, and 79 patients received alternative diagnosis of extra-GIT causes; patients who were operated upon based on either clinical diagnosis or US findings or both, with negative CT findings and pregnant women were excluded from the study.
Conclusion: MDCT can be used effectively in the preoperative evaluation of appendicitis, provides high accuracy for detecting complications, detects other findings causing RLQP, and better guides physicians for proper management of these patients.

1. Introduction

Right lower quadrant pain is one of the most important causes of visit to the emergency department; the usual assumption is that this pain represents acute appendicitis, however other causes beyond appendicitis involve the ileocecal region such as cancer cecum, ileocecal intussusception, mucocele of the

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Table 1 Age incidence of the study population.

Age group	Frequency	%
< 10	37	10.57
10–19	77	22
20–29	127	36.28
30–39	48	13.71
40–49	39	11.14
+ 50	22	6.29
Total	350	100

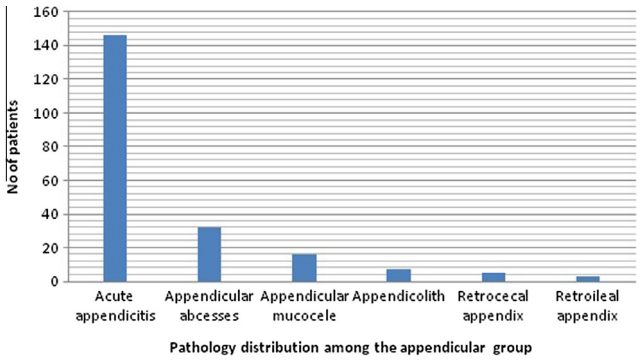

Fig. 1 Column chart shows pathology distribution among appendicular GIT group.

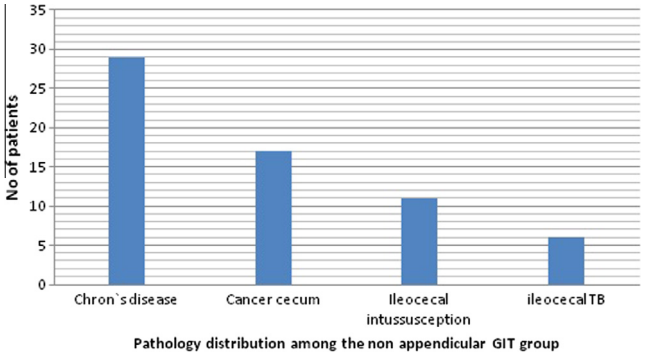

Fig. 2 Column chart shows pathology distribution among non-appendicular GIT group.

appendix, appendicular abscesses, retroileal appendix, dissecting aneurysm, complicated ovarian cyst and ureteric stones can cause RLQP (1).

Multidetector CT is the modality of choice to confirm or exclude appendicitis, and help to detect an alternative pathologic conditions that may cause RLQP (2,3).

The aim of this work was to represent a series of challenging cases, common in daily practice, in which knowing the main radiological findings can improve the diagnosis, to discuss the main imaging features of these conditions using Multislice CT as a diagnostic tool to review the surgical and nonsurgical pathologic conditions that cause RLQP

2. Materials and methods

The study included a total of 350 patients: 250 males and 100 females with age ranging from 3 to 61 years with ARLQP from the period between October 2013 and December 2015, and exclusion criteria in our study include the following: patients who were operated upon based on either clinical diagnosis or US findings or both, pregnant patients, or negative CT findings for RLQP, patients were referred with high suspicion of acute appendicitis according to the clinical examination, and laboratory findings for multi-slice CT. When possible, detailed clinical history was obtained from a nonsedated patient with special emphasis on pain's location, radiation as well as onset, duration, severity, and quality of pain. The patient's general appearance and vital signs were helpful to narrow the differential diagnosis; patients were referred to the radiology department for multi-slice CT, and 204 patients showed alternative diagnosis rather than acute appendicitis. The non-appendicular group was considered in our study as a control group for normal CT imaging features of the appendix, and the diagnosis of appendicitis either simple or complicated was settled. Follow-up MDCT studies were performed for nonsurgical candidates who were diagnosed to have benign infectious or inflammatory lesions.

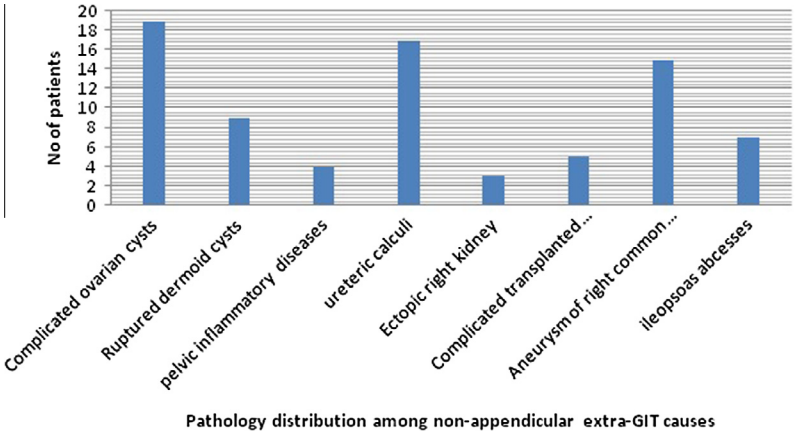

Fig. 3 Column chart shows pathology distribution among non-appendicular extra-GIT group.

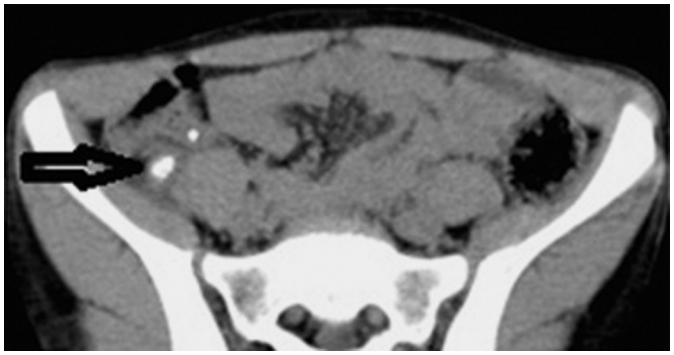

Fig. 4 A 19-year-old female patient with acute appendicitis grade 2: MSCT axial non-contrast image shows mild dilated appendix measuring 8 mm with internal calcification likely appendicolith (arrow).

3. MDCT protocol

Scanning was performed from the dome of the diaphragm through the pubic symphysis with a 64 row-MDCT scanner Toshiba Aquilion. Oral contrast was given to the patients 2–4 h before the exam during their stay in the emergency department. Patients with a high suspicion of viscous perforation or those who could not drink contrast were submitted first for plain CT without oral contrast. Hydration was recommended without solids – 4 h prior to the examination. We injected nonionic contrast material intravenously at a rate of 3–4 mL/s. A bolus of saline following the iodinated contrast media injection may reduce the volume of contrast media required to achieve adequate vascular opacification. In our protocol because the majority of lesions were discovered in an emergency condition, oral administration of water or contrast material varied depending on the clinical condition of the patient and the suspected abnormality. In the pediatric age group, we injected nonionic contrast material intravenously at a rate of 1.5–2 mL/s. Before CT examination, sedation with oral Chloral hydrate (in a dose of 25–50 mg/kg body weight) was given. The parameters were 140 kVp, 350 mA, pitch 1.75 mm, and 0.5 s per rotation. The axial data were reconstructed with a 5-mm thickness at 5-mm intervals. The second set of reconstructed axial images was then reformatted in the coronal and sagittal plane with a thickness of 3 mm at 5-mm intervals.

4. Image analysis

Axial and coronal images were transferred to a PACS workstation (Toshiba Aquilion) as a separate series of images for interpretation, In each patient, ileocecal imaging findings were assessed for the following: the location of the appendix, the presence of inflammatory change enlargement of the diameter of the appendix greater than 6 mm; thickened wall with enhancement; long standing inflammation with contraction and fibrosis, appendicolith; periappendiceal fat stranding or fluid; focal thickening of the cecum, mesenteric fat stranding; and the assessment of associated complications including appendicular mass, appendicular abscess, mucocele formation, and CT severity score of appendicitis is (1) possibly abnormal appendix (6-mm diameter without other abnormality or one containing an appendicolith); (2) abnormal appendix ($\geqslant$6-mm diameter with wall enhancement) without adjacent fat stranding; (3) abnormal appendix surrounded by fat stranding; (4) abnormal appendix surrounded by fat stranding and fluid; and (5) inflammatory mass or abscess. Extra gastrointestinal causes of pain, genitourinary causes as ureteric stones, gynecologic causes as complicated cyst and pelvic inflammatory diseases, vascular causes as aneurysmal dilatation as iliopsoas abscesses were also evaluated.

5. Results

The study included a total of 350 patients: 250 males and 100 females with age ranging from 3 to 61 years (Table 1) who presented with high suspicion of appendicitis, and clinical symptoms are mainly RLQP followed by fever, nausea, vomiting, among the appendicular group and nonappendicular GIT group and nonappendicular extra-GIT group pathology distribution was mentioned in Figs. 1–3. In our study, diagnosed cases from reconstruction CT images without contrast are the ureteric stones, and appendicolith. The appendicular diameter ranges from 7 to 13 mm, size lesser than 7 mm (n = 16), size greater than 7 mm (n = 192), and score 1 is detected in 16, score 2 in 50, score 3 in 55 cases, score 4 in 33 cases and score 5 in 54 cases; CT findings in nonappendicular GIT causes include: Crohn's disease (n = 29), ileocecal TB (n = 6), cancer cecum (n = 17), ileocecal intussusception (n = 11), and extra-GIT causes such as complicated ovarian cysts (n = 19), rupture dermoid cysts (n = 9), pelvic inflammatory diseases (n = 4), stones at distal end of the right ureter (n = 17), ectopic right kidney (n = 3), complicated transplanted kidney (n = 5), iliopsoas abscesses (n = 7), and aneurysm of the right common iliac artery (n = 15), are mentioned in Fig. 3; operative interference is applied to all cases of acute appendicitis and cancer cecum, surgical drainage is applied to all cases of appendicular abscesses, and conservative treatment is applied for Crohn's diseases and TB with improvement after treatment.

6. Discussion

There is a broad differential diagnosis beyond appendicitis when the patient is referred with right lower quadrant pain and clinically diagnosed as acute appendicitis (4). CT plays an important role in the evaluation of patients with RLQP due to its capacity to obtain thinner sections (1). Multiplannar

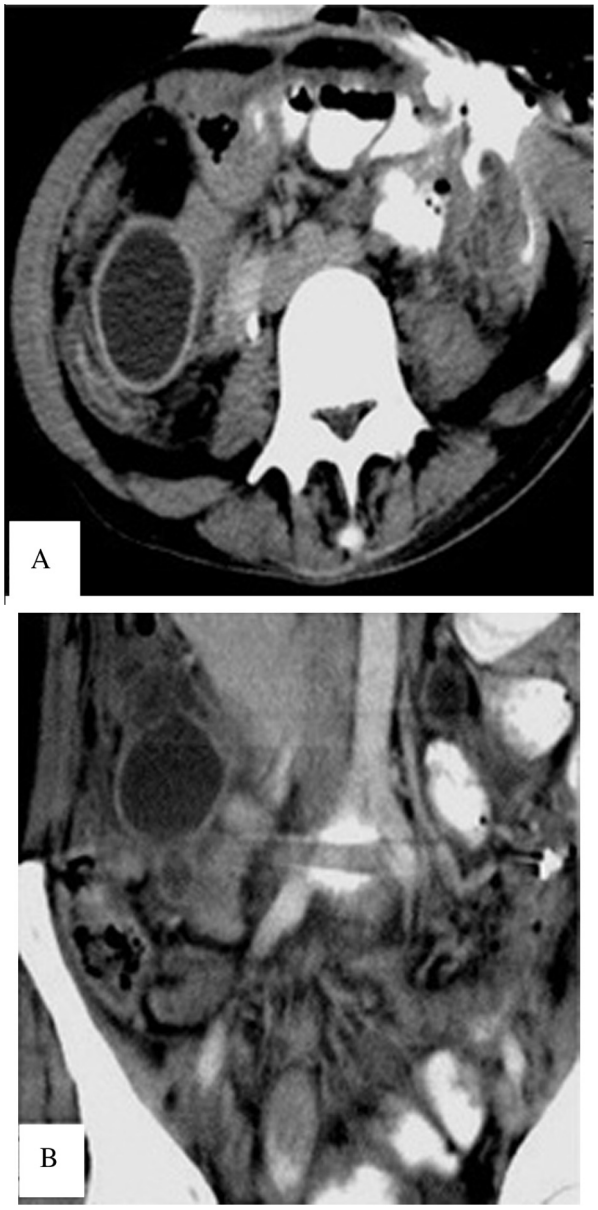

Fig. 5 A 48-year-old Female patient 48 years with appendicular abscess: (A and B): MSCT axial and coronal contrast enhanced images respectively show a marginally enhanced appendicular abscess in the ileocecal region, with periappendicular fat stranding.

Fig. 6 A 50-year-old female patient 50 years old with mucocele of the appendix: (A and B): MSCT Axial and sagittal contrast enhanced images respectively show a hypodense structure in the right iliac fossa with marginally enhanced wall, and internal hyperdensities.

reformatting allows depiction of the structures located in the ileocecal region as well as their pathologic conditions (5), and radiologists should be familiar with all the conditions involving the ileocecal region to help to ensure correct diagnosis and appropriate treatment for the patient (6).

The availability of CT scan for the immediate investigation of RLQP would help the surgeon to quickly differentiate between ileocecal pathology, gastrointestinal and extra tract gastrointestinal pathology mimicking appendicular and ileocecal pathology (7).

Acute appendicitis is one of the most common causes of acute abdominal pain with elevated white cell count. CT has become part of the standard of care in managing patients with suspected acute appendicitis. CT signs include appendicular diameter of more than 7 mm, an appendicolith, an appendicular wall thickness of more than 3 mm, periappendiceal inflammatory changes. CT has long been recognized as having high diagnostic accuracy in patients with appendicular abscess with enhancement of the appendiceal wall as a specific sign of inflammation (8,9), in contrary to Jeremy study (10), that detected 27% of appendicolith, 20% of appendicular abscesses and 1% mucocele of the appendix in the appendicular group, in our study we detected appendicolith in 7/208 (3.36%) (Fig. 4), appendicular abscess in 32/208 (15.38%) of the appendicular group, with thin marginal enhancement in contrast enhanced images (Fig. 5) 15/208 appendicular mucocele, (7.21%) with mural calcification in 4 cases, and internal hyperdensities in 12 cases (Fig. 6). Mucocele of the appendix results from an obstructive dilatation of the appendix caused by intraluminal accumulation of mucoid material (11), and in cases of

Fig. 7 A 39 year-old male patient with retroileal appendix: MSCT sagittal contrast enhanced image shows a long, dilated retroileal appendix with thick hyperenhancing wall and adjacent fat stranding.

Fig. 8 A 49 year-old male patient with ileocecal intussusception due to submucosal polyp MSCT axial contrast enhanced image shows the target sign in an ileocecal intussusception,.the inner intussusceptum (thin arrow), and the outer intussuscipiens (thick arrow).

acute appendicitis the diameter ranges from 7 to 14 mm (average 11.5 mm). When the inflamed appendix is in retrocecal and retroileal position it is shielded from the anterior abdominal wall by the overlying cecum and ileum. RLQP may be scanty or absent in retrocecal or retroileal appendix (12), in our study

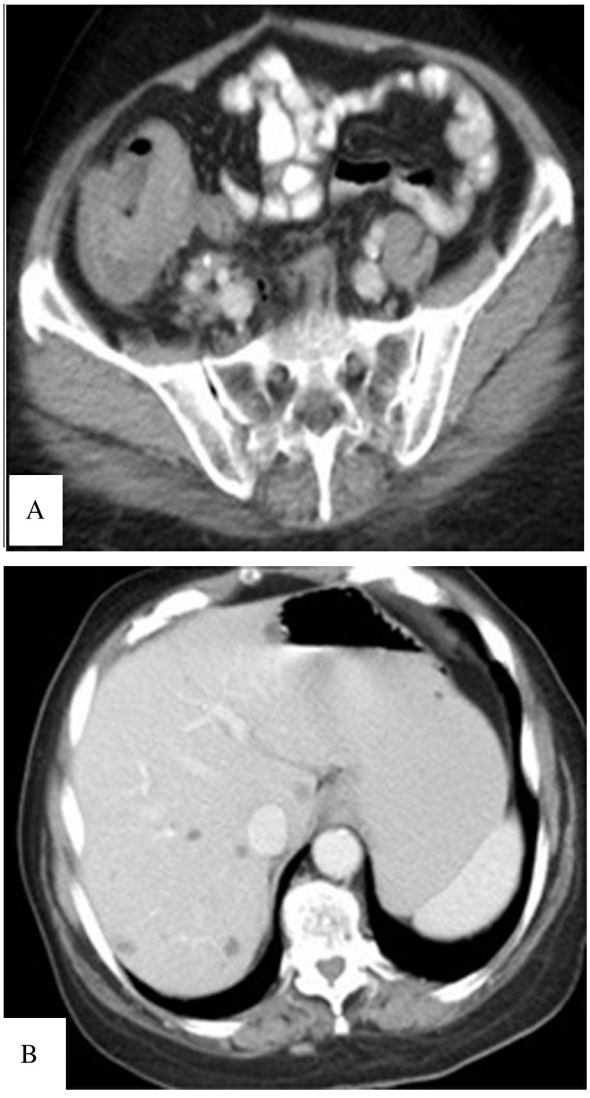

Fig. 9 A 51 year-old male patient with cancer cecum and liver metastasis: (A and B), MSCT axial contrast enhanced images show diffuse mural thickening of cecum (A), liver deposits (B).

in the appendicular group 5/208 showed retrocecal appendix 2.4%, and 3/208 showed retroileal appendix 1.4% (Fig. 7).

Dustin et al. (13) stated that in a study of 1571 patients the most common broad categories of disease included nonappendiceal gastrointestinal conditions (46.0%), gynecologic conditions (21.6%), genitourinary conditions (16.9%), and hepatopancreaticobiliary conditions (7.7%). In our study non-appendiceal gastrointestinal conditions are presented in (18%), gynecologic conditions (9.14%), genitourinary conditions (7.14%) and hepatopancreaticobiliary conditions are not included.

Intussusception refers to the invagination of a part of the intestine into itself. It is the most common abdominal emergency in early childhood, particularly in children younger than two years of age (14). The majority of cases in children are idiopathic, and childhood intussusception is a leading cause of intestinal obstruction. Intussusception is unusual in adults constituting less than 5% of intussusception cases. There is a

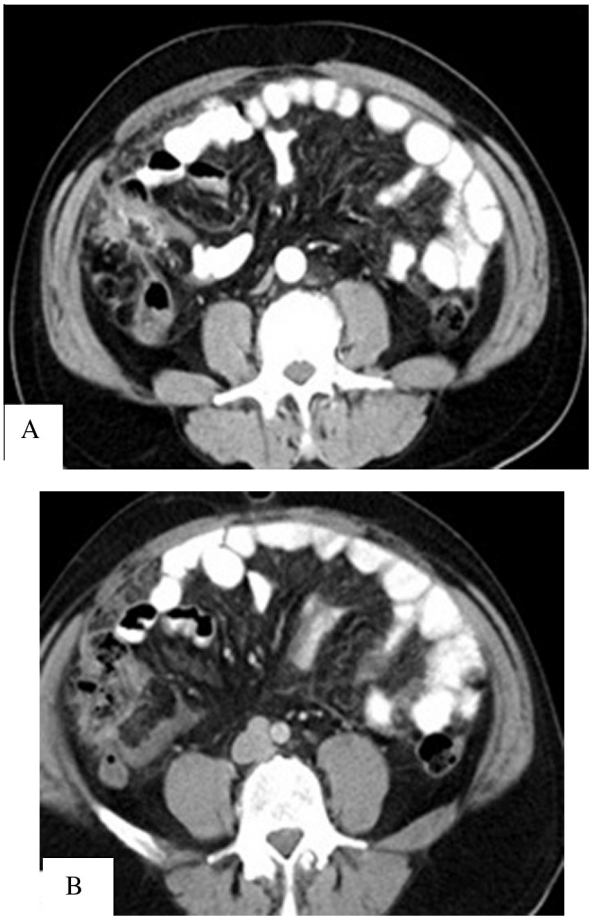

Fig. 10 A 33- year-old male patient with ileocecal TB: (A and B):MSCT axial contrast enhanced images show contracted fibrosed pulled up cecum with mesenteric linear fibrous strands and internal fluid collection.

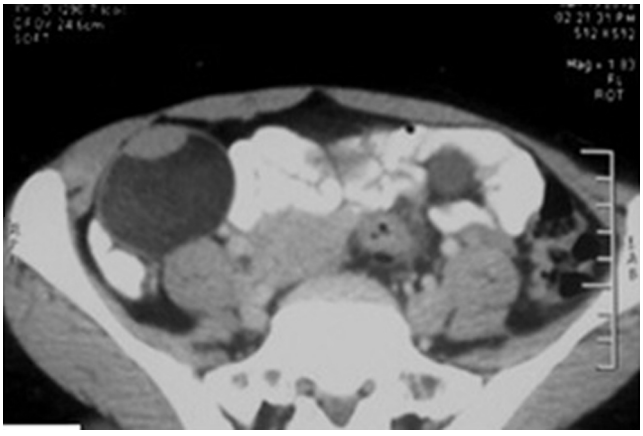

Fig. 11 A 35 year-old female patient with complicated ovarian cyst: MSCT axial contrast enhanced image shows a hypodense structure in the right iliac fossa with peripheral enhanced solid component, and internal hyperdensities.

demonstrable cause in the majority of cases, usually an intraluminal neoplasm. These are mainly polyps and colonic malignancies (14). In the majority of cases in adults, a pathologic

Fig. 12 A 40 year- old male patient with right distal end ureteric stones, MSCT: coronal noncontrast image shows right sided hydronephrosis and hydroureter and right distal end ureteric stones.

cause is identified (15,16), and in our study 9/11 cases are detected in childhood 81.8%, and two cases adults presented with cecal carcinoma and cecal submucosal polyp 18.1% (Fig. 8).

Adenocarcinomas of the cecum account for one-fourth of all colonic adenocarcinomas (17). Approximately 50% of these malignancies develop in the rectosigmoid area and 25% in the cecum and ascending colon. Many likely arise from a malignant transformation of an adenomatous polyp and these tumors tend to form annular constricting lesions or bulky exophytic masses, ranging from 2 to 6 cm in diameter. They have the same MDCT features as all other colonic adenocarcinomas, including marked asymmetric wall thickening, short segment involvement, and abrupt change from normal to abnormal segments of colon. Although they tend to be large, polypoid, and bulky they rarely cause obstruction and often grow without clinical manifestations for long periods of time (18). Apple-core constricting lesions, tumor masses, nodal involvement, and metastases may be visualized (19). In our study 14/17 are bulky exophytic masses (82.35%) and 3/17 are annular constriction (17.64%), 4/17 cases showed metastatic deposits to the liver (23.5%) (Fig. 9).

Crohn's disease has a propensity to involve the terminal ileum and the cecum and less commonly the appendix, long segmental circumferential wall thickening of the terminal ileum and cecum, and inflammation that is centered away from the

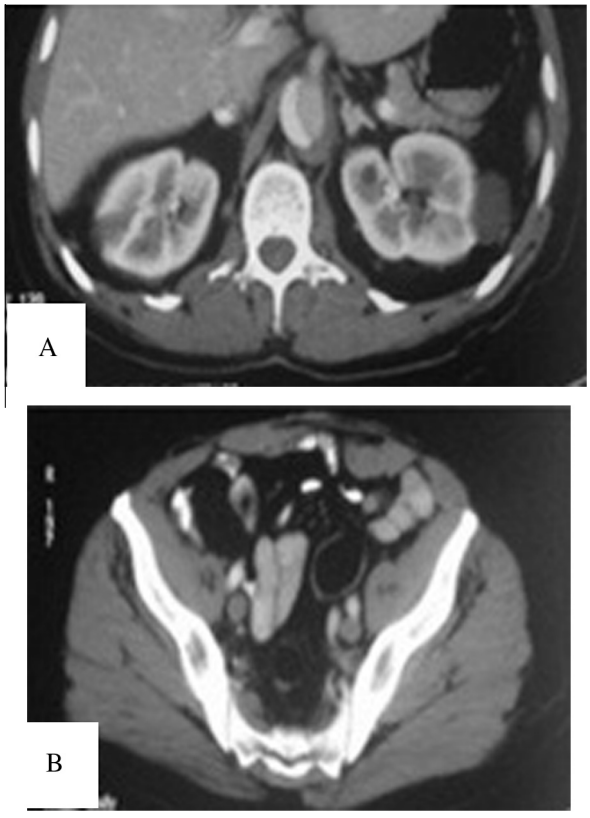

Fig. 13 A 49 year-old Male patient with dissecting aneurysm in the right common iliac artery: (A and B): MSCT axial contrast enhanced images show dissecting aneurysm of the abdominal aorta extending to the dilated right common iliac artery.

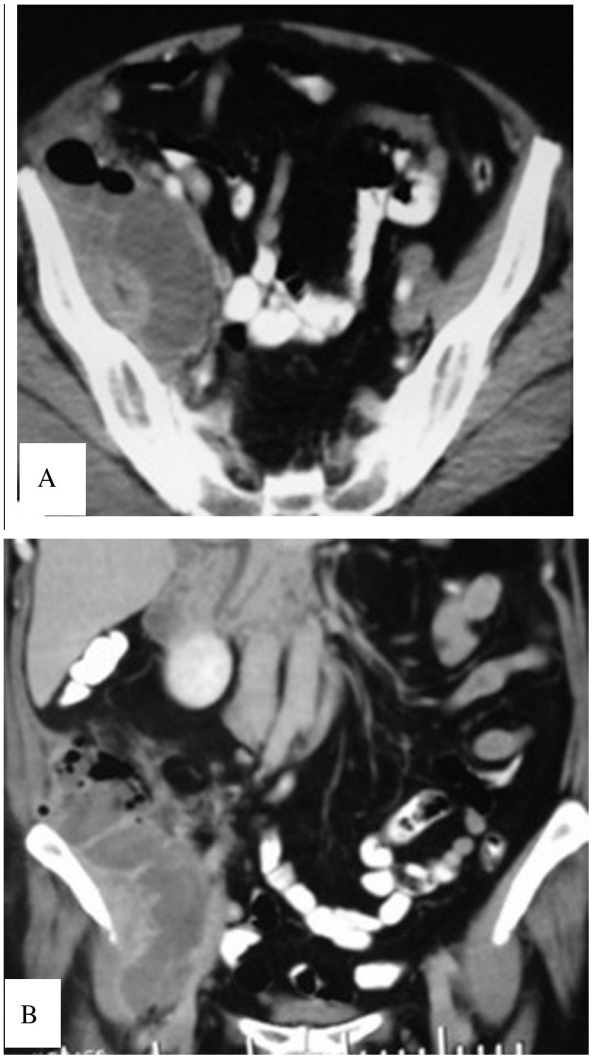

Fig. 14 A 35 year old female patient with right iliopsoas abscess: MSCT (A) axial and (B) coronal contrast enhanced images respectively show loculated fluid-density mass, with peripheral enhancement beginning on the right iliac fossa, extending anteriorly up to rectus sheath involving the psoas muscle and extending inferiorly through the inguinal region until the root of the thigh (B).

appendix (20). For our 29 cases of Crohn's disease CT findings include mild segmental bowel wall thickening, narrowing of the lumen, mesenteric fat stranding, mesenteric lymph node enlargement, and skip lesions. Multiplanar reformations are particularly helpful in identifying complications such as strictures, abscesses and fistulous tracts (21).

TB in the ileocecal region is the most common area of involvement in the gastrointestinal tract, due to the abundance of lymphoid tissue, and Barium studies may show mucosal ulcerations, thickening of the ileocecal valve and a wide gapping between the valve and the narrowed terminal ileum (Fleischner sign) (22). In advanced disease the cecum appears conical and shrunken. US may reveal regular and concentric bowel wall thickening. At CT, the most common findings are circumferential wall thickening of the cecum and terminal ileum and asymmetric thinking of the ileocecal valve (23), and in our 6 cases of ileocecal TB, cecum appears inflamed edematous in two cases, shrunken fibrosed and pulled upward with mesenteric fibrous strands, and internal fluid collection is detected in four cases (Fig. 10).

Ultrasound and Doppler tests are readily available in the gynecology emergency department, and demonstrate features of hemorrhagic follicular cysts, ovarian cyst rupture, endometriotic cysts and pyosalpinx. Computed tomography (CT) is employed in diagnosing acute gynecologic complications (24), and it is frequently used as the initial imaging modality and recognition of features of gynecologic complications. US and CT characterization of lesions such as simple cysts, complex cysts, or mixed cystic or solid structures helps narrow the diagnostic possibilities (25). It is important also to remember the general difficulty of distinguishing between lower abdominal pain and pelvic pain (26). We detected 19 cases of complicated ovarian cysts (Fig. 11) and 9 cases of rupture dermoid cysts.

Pelvic inflammatory disease (PID) is defined as a spread of inflammation from the endometrial cavity and fallopian tubes into the pelvis. Ultrasound can demonstrate dilated fallopian tubes containing heterogeneous fluid with echogenic internal debris typical of pyosalpinx. CT appearances of PID are frequently non-specific and can include a small volume of free fluid, parapelvic fatty stranding and thickened uterosacral ligaments. The development of tubo-ovarian abscesses (27), all 4

cases of PID showed thickened irregularly enhancing complex adnexal masses with septations and thick walls containing complex fluid collections, and two cases show free fluid.

Ureteric colic occurs as a result of obstruction of the urinary tract by calculi at the narrowest anatomical areas of the ureter: the pelviureteric junction (PUJ), near the pelvic brim at the crossing of the iliac vessels and the narrowest area, the vesicoureteric junction (VUJ). Location of pain may be related but is not an accurate prediction of the position of the stone within the urinary tract. As the stone approaches the vesicoureteric junction, symptoms of bladder irritability may occur (28). In our study 17 cases of the nonappendicular extra-GIT group showed right lower end ureteric stones with moderate backpressure changes on the right kidney and ureter (21.5%) (Fig. 12).

Aortic emergencies have to be detected quickly. Early diagnosis and treatment are essential for improving the prognosis, and the choice of CT scan as the first radiological investigation of loin to groin pain has enabled us to quickly establish the diagnosis of infra-renal abdominal aortic dissection (common iliac artery aneurysm); CTA is reliable in diagnosing and grading aortic trauma, measuring aortic diameter in aortic aneurysms and detecting vascular wall pathology, the wall and contents including the thrombus, thereby allowing a more accurate measurement of aneurysm size and intimal flap, and the evaluation of surrounding structures (29,30), in contrary to the study by El kheshen (31) who detected only 4 cases of dissecting aneurysm in a study of 500 patients; we detected 15 cases in a series of 350 patients, and our study includes 15 cases of right common iliac aneurysm (18.9%), aneurysm with mural thrombus was detected in 10 cases and with intimal flap in 5 cases (Fig. 13), and all five cases of intimal flap show dissection starting from the abdominal aorta.

Psoas (or iliopsoas) abscess is a collection of pus in the iliopsoas muscle compartment (32). It may arise via contiguous spread from adjacent structures or by the hematogenous route from a distant site. The incidence is rare but the frequency of this diagnosis has increased with the use of computed tomography (CT), prior to which most cases were diagnosed at postmortem (33). In our 7 cases there is prominent rim enhancement within small loculated areas of fluid infection located in the right paraspinal muscles. Two cases out of five extend to the inguinal region (Fig. 14).

Treatment approaches for these conditions range from patient monitoring to surgery. The availability of CT scan for the immediate investigation of RLQP would help the surgeon to quickly differentiate between ileocecal pathology and extra renal tract gastrointestinal pathology mimicking ileocecal pathology. In this case, the choice of CT scan as the first radiological investigation of loin to groin pain has enabled us to quickly establish the diagnosis to confirm or exclude appendicitis, and help to detect an alternative pathologic conditions that may cause RLQP (34,35).

Conclusion: MDCT can be used effectively in the preoperative evaluation of appendicitis and provides high accuracy for detecting its complications and other incidental findings rather than appendicitis causing right lower quadrant pain, guiding the treating physicians for the proper management of these patients. Treatment approaches for these conditions range from patient monitoring to surgery.

Conflict of interest

The authors declare that there is no conflict of interest

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