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**ORIGINAL ARTICLE**

# Non-enhanced abdominal Computed tomography( CT) for demonstration of painful abdominal conditions in patients not candidates for contrast-enhanced study, how does it help?

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## Abstract

**Background**: There is a wide variety of abdominal painful conditions that necessitate computed tomography (CT) imaging; our study was aimed to demonstrate the utility of non-enhanced computed tomography (NECT) of the abdomen as a standalone study to detect the cause of abdominal pain in patients who are not candidates for iodinated contrast administration. **Methods:** Non-enhanced CT was performed to one hundred and seventy patients who presented with abdomino-pelvic pain that necessitates abdominal imaging by CT in conjunction with inability to use iodinated contrast media. **Results:** There was 134/170 patients (~79%) showed clinically relevant radiologic diagnosis. The gastrointestinal system was the most commonly affected system (n= 81/170 ~ 48%). Of the total, 22 patients were presented with right lower quadrant pain and clinically suspected to have appendicitis; 14 of them were diagnosed with acute appendicitis on NECT with sensitivity, specificity and accuracy of 73.6%, 100% and 86.3% respectively. About 20% of patients required urgent management. Final diagnostic confirmation was made operatively in 20/134 cases whereas in remaining cases was based on the presence of specific imaging features, the response to specific therapy, and long-term follow-up. The percent agreement in the study was excellent between the readers; the inter-reader reliability was calculated at 97%. **Conclusion**: Non-enhanced computed tomography has the potential to detect the cause of abdominal pain in the setting of contraindication to iodinated contrast media in most situations. Using an appropriate checklist, a wide spectrum of clinically-relevant diagnoses could be identified with a significant impact on patient management.

**Keywords**
Non-enhanced CT, abdominal CT, abdominal pain, renal impairment, contraindication to iodinated contrast.

## Background

Non-enhanced computed tomography (NECT) of the abdomen is a part of the entire CT study in many abdominal CT protocols; it is performed in many situations as a pre-contrast phase such as in multi-phasic examination of the liver and urinary system, and when the detection of calcifications or high attenuation materials is an imaging concern [1, 2]. As NECT does not utilize iodinated contrast material that could help in tissue discrimination, its use carries a considerable challenge for image interpretation especially if used alone for disease detection [3]. Painful abdominal conditions can overlap clinically and may need further imaging by CT to clarify the diagnosis and guide the clinical management pathway[4].

The utility of contrast enhanced CT (CECT) has been established in many clinical settings including both acute and on-acute conditions; the same statement would exist for NECT but in a fewer situations, such as when used for diagnosis of acute appendicitis in adults and when low-dose non-enhanced protocol is used for diagnosis of urinary tract calculi. Even used as a standalone study, NECT can provide useful imaging features based on the detection of size changes and alteration in tissue attenuation values, NECT could visualize extra-urinary calculi and calcifications, and can detect ancillary findings and secondary signs as fat stranding and obliteration of fat/tissue planes that would indicate presence of disease process[5-7].

**Aim of the work**

The aim of this study was to demonstrate the utility of NECT of the abdomen as a standalone study to detect the cause of abdominal pain in patients who are not candidates for iodinated contrast administration.

**Methods**

This observational analytic study was conducted during May 2022 through February 2023; the study was approved by the research ethical committee of Faculty of Medicine, Minia University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. Written informed consent was obtained from all participants.

***Study participants***

One hundred and seventy patients (ninety eight males and seventy two females), were referred from emergency room at the discretion of the ordering surgical team in our hospital to undergo NECT using a 16-detector row CT scanner (Bright Speed 16; GE Medical Systems, GE Healthcare-America: Milwaukee, USA).Informed written consent was obtained from all patients prior to study.

***Inclusion criteria***

Patients' implication in the study was based on the presence of abdomino-pelvic pain that necessitates abdominal imaging by CT in conjunction with inability to use iodinated contrast media due to either impaired renal function or presence of a history of an adverse reaction to iodinated contrast media. So, inclusion criteria for the patients were: 1- acute diffuse abdominal pain with or without concurrent vomiting, 2- abdominal and/or pelvic pain with positive history of urinary tract calculi, 3- acute right lower quadrant pain.

***Exclusion criteria***

Pregnancy, pelvic pain in a female patient with suspected gynecologic problem, and right hypochondrial pain were the exclusion criteria in the study.

**Non-enhanced CT of the abdomen technique**

Non-enhanced CT was performed as follow: Patient position; supine with arms above head, scanogram; above the diaphragm to the below pubic symphysis, scan direction; cranio-caudal, respiration phase; inspiration, start point; at the diaphragmatic dome, end point; at the caudal border of the symphysis pubis, KVp; 130, mAs; 200, rotation time; 0.5 s. helical pitch; 1.375, slice thickness; 1.25 mm, interval; 1.25 mm, reformat; axial, coronal and sagittal in 5-mm thickness.

**Image analysis**

All studies were analyzed in different display windows without knowledge of patient's identity and their final diagnosis, the following checklist was used:

On routine abdomen window (WW/WL = 400/60) for: organ-based size evaluation for abdominal organs as liver and spleen, organ-based focal or diffuse attenuation value changes, checking anatomic landmarks of all abdominal and retro-peritoneal structures for possible disruption including the para-renal spaces and the abdominal aorta, fat stranding or density alteration of the adipose tissue at right iliac, mesenteric and peri-colic regions in axial and coronal planes, gross colonic wall thickening and/or attenuation changes in axial and coronal planes, presence of urinary calculi and extra-urinary calcification anywhere in the abdomen and pelvison all image planes, presence of adnexal lesion in female patients in axial and coronal planes.

On thick slab (15-mm) maximum intensity projection (MIP) abdomen window for: presence of abdominal lymphadenopathy and mesenteric lymph nodes on axial and coronal planes.

On lung window (WW/WL = 1500/-400) for any abnormally located gas in mesenterico-bowel structures.

The images were read independently by two radiologists; they have fifteen and eleven years' experience in body imaging. Inter-rater reliability was obtained.

**Statistical analysis**

Results were recorded and tabulated, the statistical analysis was done using SPSS-16; the data were represented as number and percent.

**Results**

Ninety eight males (57.6%) and seventy two females (42.4%) underwent NECT; their mean age was 41 years (range 16-72y).

Of the total, 134/170 patients (~79%) showed clinically relevant radiologic diagnosis, whereas the other patients (n=36/170~21%) had either clinically irrelevant incidental finding or their CTs were found to be unremarkable.

There were various clinically relevant radiologic diagnoses found in the current study; the most common affected system was the gastrointestinal system including the mesentery and the hepato-biliary system (n= 81/170 ~ 48%). Other pathologies involved the urinary system, abdominal aorta and the female pelvis **(Table 1) (Figure 1-5).**

**Table (1). Distribution of abdominal pathologies according to the system involved**

| Pathology | | N (%) |
|---|---|---|
| **Bowel and Mesentery** | **Acute appendicitis** | 14 |
| | **Colitis** | 11 |
| | **Epiploic appendagitis** | 4 |
| | **Omental infarction** | 2 |
| | **Diverticulitis** | 12 |
| | **Internal hernia** | 2 |
| | **Panniculitis with or without lymphadenopathy** | 8 |
| | **Isolated mesenteric adenitis** | 6 |
| **Hepato-biliary** | **Hepatomegaly** | 9 |
| | **Hepatic focal lesion** | 5 |
| | **Acute pancreatitis** | 8 |
| **Renal** | **Renal mass** | 4 |
| | **Complicated renal cyst** | 4 |
| | **Urolithiasis** | 32 |
| **Others** | **Abdominal aortic aneurysm** | 3 |
| | **Adnexal lesion *** | 7 |
| | **Basal lung consolidation** | 3 |
| **Total** | | 134 (100%) |

**** One of them was ovarian torsion***

**Figure 1:** Axial (A) and coronal (B) NECT images in a 28 year-old female complaining of right sided abdominal pain with a history previous ureteric stone, the ascending colon (white arrows) shows gross circumferential mural thickening with low attenuation consistent with edema and colitis, the para-colic fat appears hazy (yellow star) with minimal para-colic fluid (yellow arrow), note the long segment of affection on coronal image. Final diagnosis was colitis.

**Figure 2:** Axial (A & B) coronal (C) and sagittal (D) NECT images in a 33 year-old male complaining of recurrent vague right sided abdominal pain. There is a right lower intra-abdominal hernia sac (white arrows) containing collapsed loops of bowel, note that the proximal small bowel loops are not dilated (yellow arrows). The patient was managed conservatively. Final diagnosis was internal hernia.

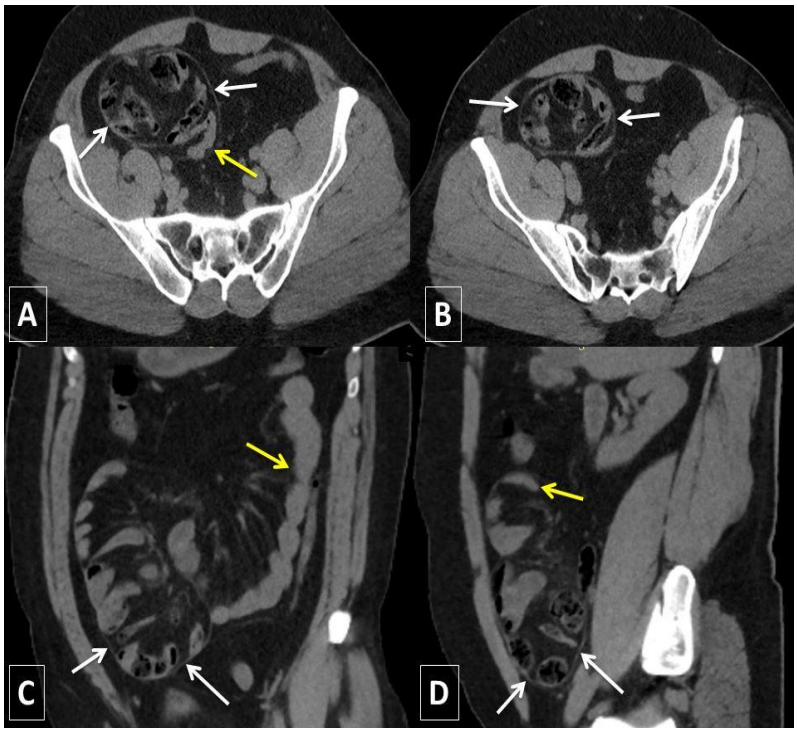



**Figure 3:** Axial NECT images (A & B) in a 45 year-old female complaining of left sided abdominal and flank pain. There is heterogeneous renal parenchymal hyper-attenuation (white arrow) along with unusual contour bulge along the medial renal cortex (yellow arrows), no urolithiasis detected, axial thick slab MIP image (C) demonstrated renal hilum lymph node, the patient underwent nephrectomy and histopathology revealed transitional cell carcinoma. Final diagnosis was renal mass.

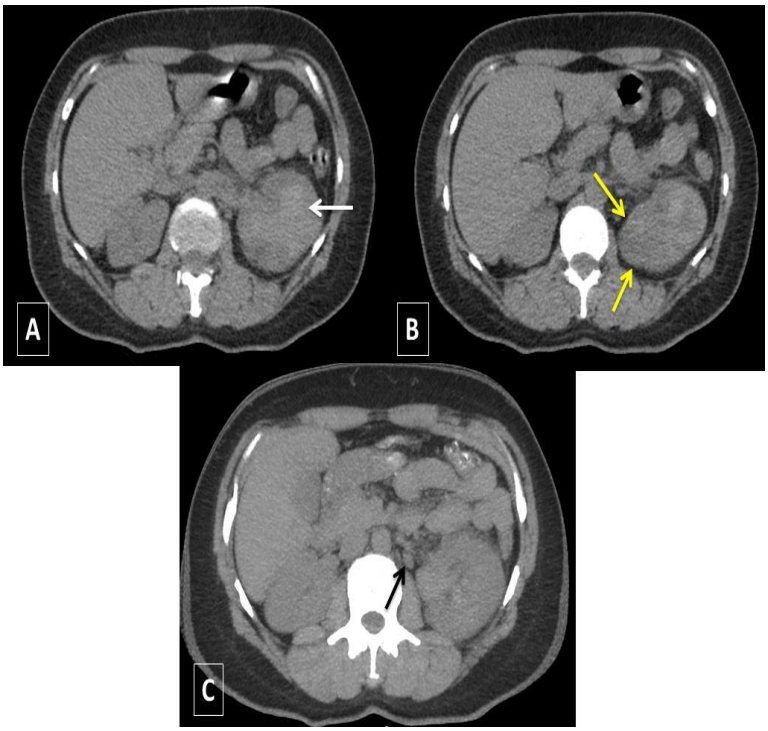


**Figure 4:** Axial NECT images (A & B) in a 50 year-old male complaining of acute abdominal pain more severe centrally, there is an infra-renal abdominal aortic aneurysm (white arrow) with loss of fat planes between the aorta and the adjacent bowel (light blue arrow), the adjacent loop of the jejunum is focally thickened (yellow arrows) suggesting impending fistula formation. The patient was urgently referred to vascular team for immediate intervention. Final diagnosis was abdominal aortic aneurysm.

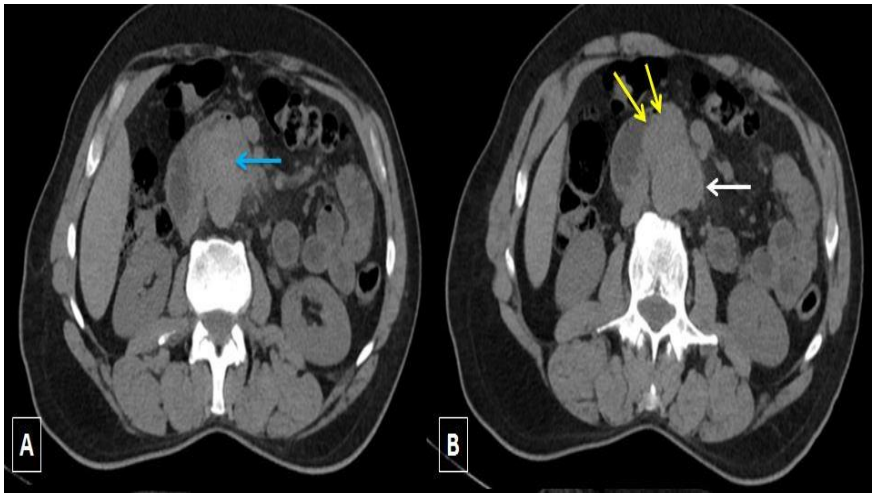
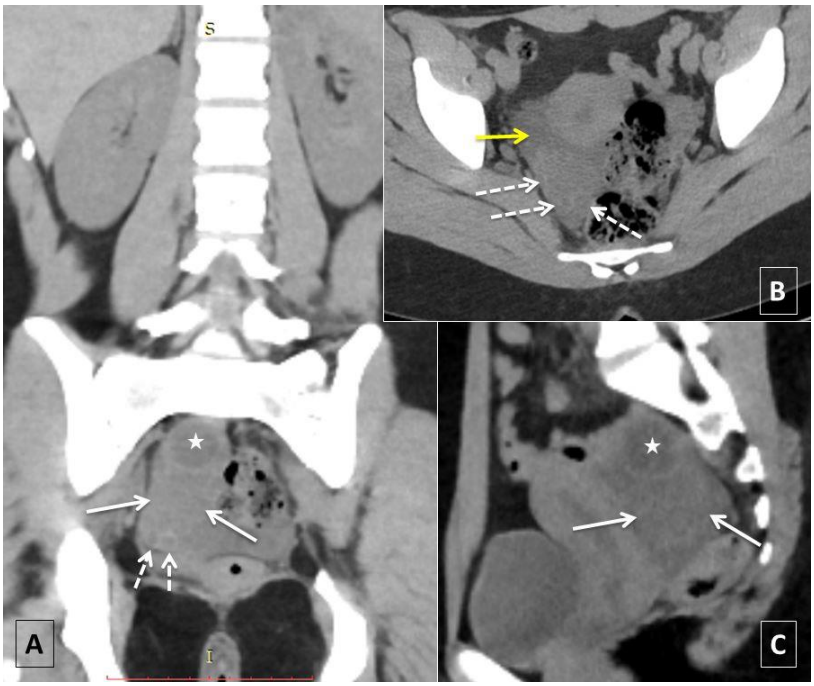



**Figure 5:** Coronal (A), axial (B) and sagittal (C) NECT images in a 19 year-old female complaining of acute right lower quadrant pain with concurrent vomiting and a history of previous ureteric stone, the right ovary appears enlarged and hypoattenuated (white arrows) suggesting stromal edema, small fluid attenuation cyst (star) was observed at the upper pole and multiple smaller peripherally located immature follicles were observed distally (dashed arrows), note minimal pelvic fluid (yellow arrow). No urolithiasis was detected. The final diagnosis was right adnexal lesion, ovarian torsion was found in laparotomy.




Of the total, 22 patients were presented with right lower quadrant pain and clinically suspected to have appendicitis; 14 of them were diagnosed with acute appendicitis on NECT and confirmed operatively, 3 of them showed epiploic appendagitis, 1 patient had adnexal lesion confirmed operatively to be ovarian torsion, and 1 patient shows lower 1/3 right ureteric stone. The other three patients showed unremarkable NECT; however, based on their clinical and laboratory features, they were diagnosed with

appendicitis in the next day and confirmed operatively. The sensitivity, specificity and accuracy of NECT in appendicitis were 73.6%, 100% and 86.3% respectively.

Among all diagnoses, there were 27/134 patients ~ 20% required urgent management which varied from immediate vascular surgical referral in case of abdominal aortic aneurysm to urgent consultation to appropriate surgical team in case of appendicitis and ovarian torsion, and urgent oncology consultation in renal mass and hepatic focal lesions. **(Table 2)**

| Table (2) Abdominal pathologies requiring urgent management. (n=27, ~ 20 %). | |
|---|---|
| **Pathology** | **N (%)** |
| **Abdominal aortic aneurysm** | 3(~2.2%) |
| **Appendicitis** | 14 (~10%) |
| **Ovarian torsion** | 1 (<1%) |
| **Renal mass** | 4 (~3%) |
| **Hepatic focal lesion** | 5 (~3.7%) |

**Final diagnostic confirmation** for the clinically relevant diagnoses in the study was made operatively in 20/134 cases (Table 3), whereas confirmation of the remaining cases was based on the presence of specific imaging features, the response to specific therapy, and long-term follow-up.

| Table (3) Surgical procedures and intervention in the study. (n=20 ~ 15%). | |
|---|---|
| **Pathology** | **N (%)** |
| **Aortic graft stenting for abdominal aortic aneurysm** | 2 |
| **Laparotomy for appendicitis** | 14 |
| **Laparotomy for ovarian torsion** | 1 |
| **Nephrectomy for renal mass** | 3 |

The other 36/170 patients (~21%), who had clinically irrelevant incidental finding or whose NECTs were marked unremarkable, were managed appropriately; the majority of them (33/170 patients ~19.5%) showed considerable pain reliefwith conservative treatment and their symptoms were clinically thought to be related to exacerbation of irritable bowel syndrome or colitis. The remaining three patients were subsequently diagnosed with appendicitis based on clinical and laboratory features.

**Inter-rater reliability**

The percent agreement in the study was excellent between the two readers; the inter-reader reliability (IRR) was calculated at 97 % (130/134) and is listed in table 4.

| Table (4) Non-detection rate and inter-rater reliability between the two readers. | | | | |
|---|---|---|---|---|
| **Diagnosis** | **R#1** | **R#2** | **Non-detection %** | **Match** |
| **Acute appendicitis** | 14 | 14 | 0% | 1 |
| **Colitis** | 11 | 10 | 4.5% | 0 |
| **Epiploic appendagitis** | 4 | 4 | 0% | 1 |
| **Omental infarction** | 2 | 2 | 0% | 1 |
| **Diverticulitis** | 12 | 12 | 0% | 1 |
| **Panniculitis** | 8 | 8 | 0% | 1 |
| **Mesenteric LNs** | 6 | 6 | 0% | 1 |
| **Internal hernia** | 2 | 2 | 0% | 1 |
| **Hepatic focal lesion** | 5 | 4 | 10% | 0 |
| **Acute pancreatitis** | 8 | 7 | 6.25% | 0 |
| **Renal mass** | 4 | 4 | 0% | 1 |
| **Complicated renal cyst** | 4 | 3 | 12.5% | 0 |
| **Urolithiasis** | 32 | 32 | 0% | 1 |

| | | | | |
|---|---|---|---|---|
| **Abdominal aortic aneurysm** | 3 | 3 | 0% | 1 |
| **Adnexal lesion** | 7 | 7 | 0% | 1 |
| **Basal lung consolidation** | 3 | 3 | 0% | 1 |
| **Total** | 125 | 122 | Average ~1.5% | 122/125<br>IRR = 97.6% |

**Figure 6:** Axial unenhanced CT KUB images (A & B) in a 51 year-old male complaining of left renal pain demonstrate fluid attenuation left peri-pelvic renal lesion (white arrow) insinuating about the renal vessels (yellow arrow), no urolithiasis detected, coronal CT urographic images (C, D & E) done on the next day reveal non-enhanced cystic lesion insinuating between the calyces (yellow arrow on D & E), note normal ureter (white arrow on C). Final diagnosis was peri-pelvic cyst.

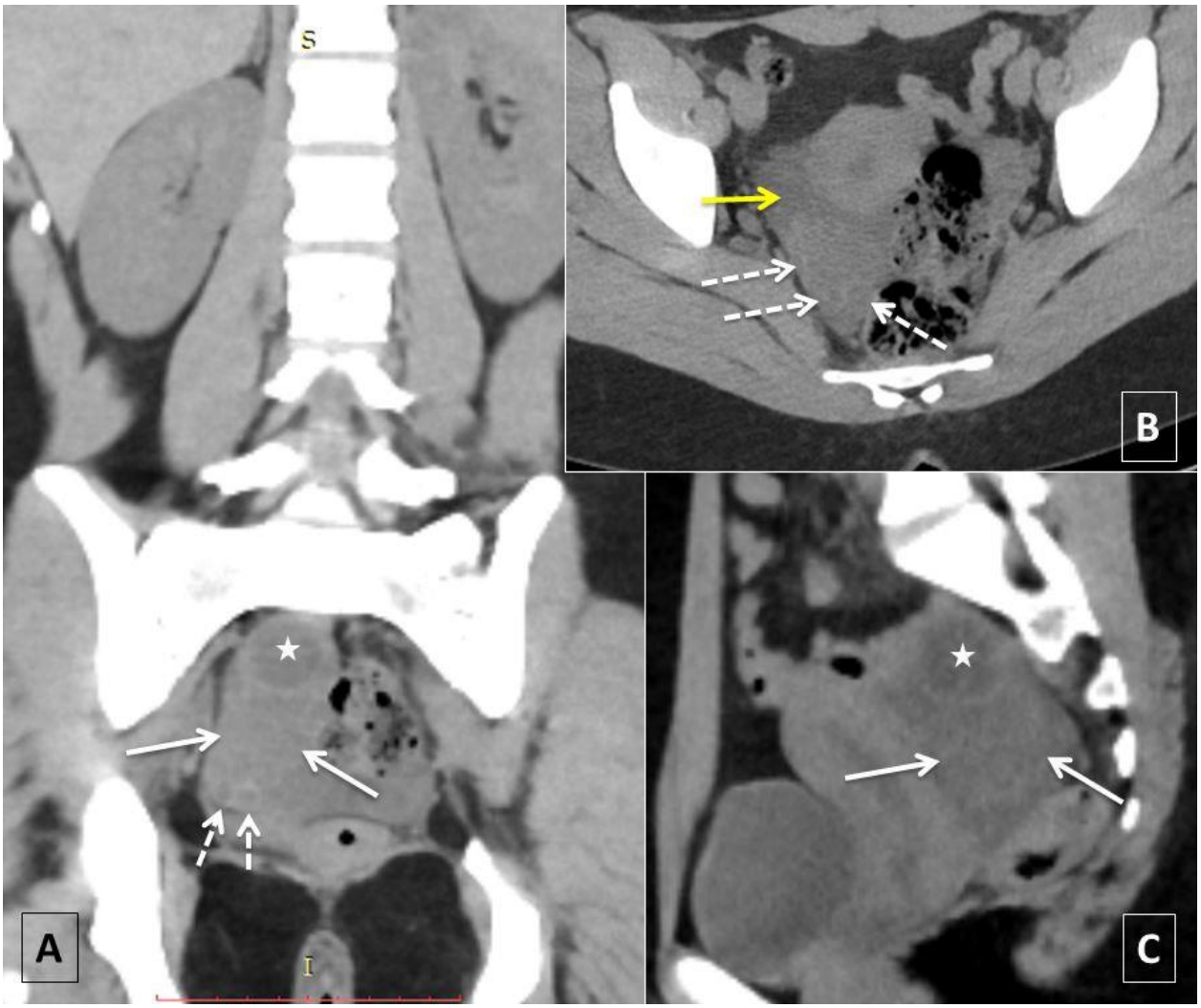
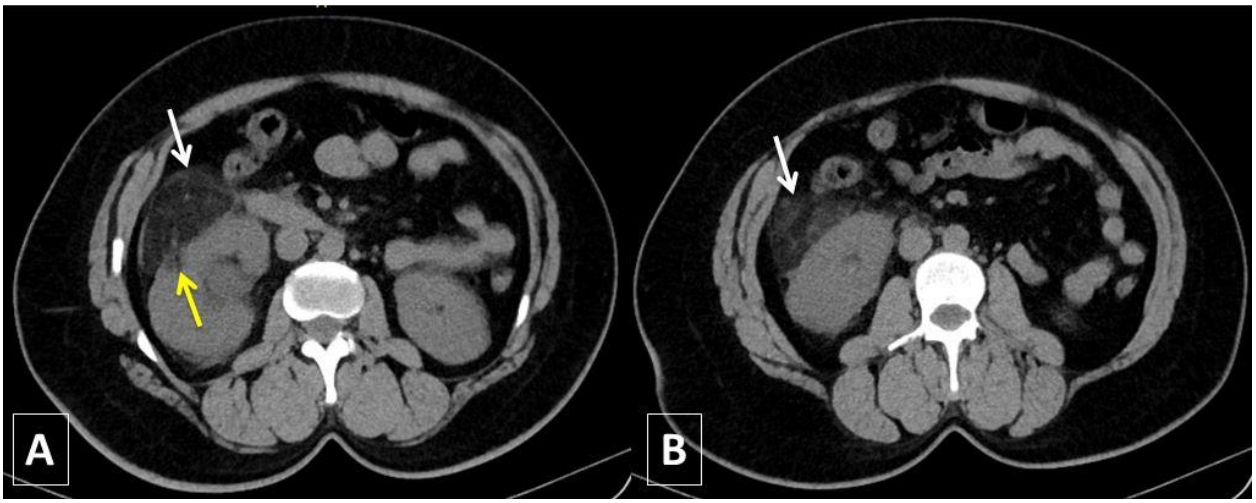



**Figure 7:** Axial unenhanced CT KUB images (A & B) in a 36 year-old female complaining of right renal pain demonstrate fat attenuation exophytic right renal mass (white arrow) with adjacent renal parenchymal defect (yellow arrow), features are consistent with renal angiomyolipoma. The patient was managed conservatively. Final diagnosis was fat-containing renal mass (angiomyolipoma).




## Discussion

In many clinical situations, CT imaging could be primarily indicated for evaluation of abdominal pain, and when administration of iodinated contrast media is contraindicated, the CT protocol will be limited to NECT. The current study utilized the NECT in abdominal pain at the discretion of the ordering team; patients with right hypochondrial and female pelvic pain were not recruited in the study in order to eliminate the indication creep, as both entities are primarily investigated by ultrasonography [(8)].

Using a simple but detailed checklist approach in image analysis, the current study revealed relatively wide varieties of clinically relevant diagnoses observed in about 79% of the patients (n=134/170), the most frequently affected system was the gastrointestinal system including the mesentery and the hepato-biliary system (n= 81/170 ~ 48%). Regarding NECT diagnosis of acute appendicitis; the present study revealed sensitivity, specificity and accuracy of 73.6%, 100% and 86.3% respectively. Few reports studied the use of NECT in acute appendicitis. **Eurboonyanun et al [9]** studied the accuracy of NECT versus CECT for diagnosis of acute appendicitis in 140 adult patients, they found no significant difference in the diagnosis of acute appendicitis among the NECT and CECT, with sensitivity, specificity, and accuracy80.7%, 86.7%, and 84.3% for NECT and 86.0%, 81.9%, and 83.6% for CECT, and because of comparable diagnostic accuracy, they recommended that for patients whom iodinated contrast media is contraindicated or who has high risk of adverse reaction, NECT use would be encouraged without further exposing these patient to iodinated contrast media. This data could be in partial agreement with what found in the present study; the differences in sensitivity, specificity among both studies could be attributed to a lower number of patients in the present study presented with right lower quadrant pain and subsequently diagnosed with acute appendicitis. On the other hand; **Tamburrini et al [10]** studied the use of NECT for conclusive diagnosis of acute appendicitis in five hundred and thirty-six patients, they found that NECT had sensitivity and specificity for diagnosis of acute appendicitis of 90% and 96.0%in patients with conclusive NECT, and of 95.6% and 92.3% in patients with inconclusive NECT followed by repeat CT with contrast, they recommend the use of additional CECT in selected cases when NECT is inconclusive. In another study, **Chiu et al [11]** compared the pre- and post-contrast CT for visibility of vermiform appendix in 100 patients and found no significant difference in overall accuracy for the visibility of appendix between the CECT and NECT groups; however, the diagnostic sensitivity of CECT was significantly better than that of NECT [(9- 11)].

Regarding the detection of other non-surgical bowel disorders demonstrated in the present study, they could be in agreement with **Sarofim et al [12]** who studied the detection rate of alternative diagnoses other than ureteric calculi in 215 patients using non-enhanced CT of the kidney, ureter and the urinary bladder. Although they used different CT technique in their study, they reported many alternative diagnoses in 72 patients, about 2/3 of them were classified as gastrointestinal. Regarding detection of mesenteric lymph nodes in the current study, their observation was enhanced by the use of MIP images which allows easy differentiation between mesenteric vessel and mesenteric nodularity. Although using routine non-enhanced abdominal

images in mesenteric nodal detection, **Semaan et al[13]** who studied the diagnostic accuracy of NECT in cancer patient follow-up with an established cancer diagnosis, they revealed very high accuracy (99.1%)of NECT in cancer detection when excluding venous thrombosis, with 100% accuracy of mesenteric lymph node detection **(12- 14).**

**Limitations of the study**

NECT could suffer from lack of tissue differentiation in many organs when used alone. To overcome such limitation during image analysis, the present study depended on some anatomic points as size changes and tissue landmark alteration, in addition to attenuation changes which is an inherent characteristic of CT images such as in case of adipose tissue alteration or fat stranding found about an abdominal lesion. So, NECT could be considered as good positive study in patients who are not candidate for CECT.

**Conclusion**

Non-enhanced CT has the potential to detect the cause of abdominal pain in the setting of contraindication to iodinated contrast media in most situations. Using an appropriate checklist, a wide spectrum of clinically-relevant diagnoses could be identified with a significant impact on patient management.

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