Brief Report

Imaging of non-traumatic acute abdominal pain in adults presenting to the emergency department

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Medical imaging is rapidly evolving due to advanced computer applications. Non-traumatic acute abdominal pain (AAP) is one of the most common symptoms in adults presenting to the emergency department (ED).[1,2] The emergency physician should have sufficient assessment skills to triage such patients. Clinical assessment is sufficient to decide on the level of urgency, but not on the specific cause of the AAP.[1] The causes of abdominal pain vary from life threatening to the self-limiting. Management decision on the basis of clinical and laboratory tests alone can result in unnecessary intervention or delayed management.[2] The use of diagnostic imaging has been blamed for increasing hospital costs and length of stay in the ED.[2] The underlying cause for AAP can be in the area of many different specialties' such as surgery, gynecology, internal medicine, and urology.[1]

There is a need to search for a diagnostic pathway with a balance between cost, amount of radiation exposure, accuracy, patient discomfort, and duration of stay in the ED.[1] The purpose of this brief report is to discuss the current practice and summarize the new trends and paradigm for imaging of AAP in adults presenting to the ED.

Stoker et al[3] summarized 22 different studies involving 3340 patients. He found that the most common presenting symptom was non-specific abdominal pain in 23% of all the 3340 cases followed by acute appendicitis (14%), bowel obstruction (9%), urinary tract disorders (9%), acute diverticulitis (8%), acute cholecystitis (5%), acute pancreatitis (4%), gynecologic disorder (3%), perforations (1%), and peritonitis (1%). It is rare to see a comprehensive description of the patients symptoms on the referral request from the ED. Adherence to specific guidelines helps to reduce the request for plain radiographs.

In 1972, plain abdominal radiography (PAR) were the only available diagnostic imaging modality available at the ED.[1] They were ordered for 43% of all presenting patients with abdominal plain.[1] This rate decreased to 30% in 1992 and 21% in 2007 while ultrasound or computerized tomography were requested for 6.8% of patients in 1992 and increased up to 42% in 2007.[1] Smith & Hall[4] performed a structured literature review for 38 original papers concerning the use of PAR's. They concluded that PAR's have a limited role in the ED. Plain abdominal radiography were revealed in 10.4% of cases and some radiographs were requested to avoid criticism.[4]

The Royal College of Radiologists (RCR), the America College of Radiology (ACR), and the Canadian Association of Radiologists (CAR) keep updating their guidelines on radiologic procedures regularly. The number of clinical situations such as abdominal radiography were not indicated but it keeps rising with every new update. The phenomenon of requesting and performing unnecessary x-rays is a particular concern in the evolving affluent Arabian Gulf region where there are multinational expatriate health care providers who may be adopting protective attitudes.

The introduction of CT scan in 1973 revolutionized the cross sectional imaging. Abdominal CT scans are supplemented with oral, rectal, and intravenous contrast media. This renders the examination invasive in nature and of high expanse. Plain abdominal radiography may be used to diagnose intestinal obstruction (**Figures 1A & 1B**), but the exact cause can only be determined by contrast enhanced CT. Radiation exposure to the patient and the environment may statistically increase the cancer risk. Computerized tomography scan of the abdomen delivers an approximately 15 times the dose delivered by radiography. Low dose non-contrast CT is now the commonly used test for the investigation of renal colic.[5] This evades the cost of contrast material, the possibility of allergic reactions, and decreases the cancer risk.

Haller et al[5] compared the performance of PAR's on 222 patients with low dose CT. Patients who had PAR's needed additional imaging in 38% of cases, while those who had low dose CT needed additional imaging in 4% of cases. The low dose CT delivers 4.2 mSv, less than half the radiation dose from the standard contrast enhanced CT. Even when using a 4 detector row multi-slice CT, the result of low dose CT were diagnostic in 59% compared with 20% with PAR's.[5] There is a steady rise of the number of performed CT scan worldwide raising much concern. Fortunately, there is a parallel attention to dose reduction equipment and protocols for each examination.[6] On a study of 10.9 million Australians, 680211 were exposed to CT radiations. There was a significant increased cancer incidence in the exposed group.[6]

Acute appendicitis is the most common surgical emergency. However, negative appendectomy may reach up to 40% in women of child bearing age. Furthermore,

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CT can detect lesions other than appendicitis namely, typhlitis, Crohn's disease, tuberculosis, malignancy, diverticulitis, epiploic appendagitis, and enterocolitis. Negative appendectomy rate during the pre-CT era was 21.5%, which dropped to 10% in the post-CT era.[7] Low dose CT is now advocated for the diagnosis of acute appendicitis, abscess or mass lesions[8] (**Figure 1C**). Graded compressions US technique is a non- invasive quick test without the use of contrast or ionizing radiations. It is however operator dependent.[9] Ultrasound sensitivity varies from 44% to 100%, and specificity varies from 47% to 99%.[9] However, in the elderly with right lower quadrant pain, CT should be performed as cecum malignancy is not uncommon. Colonic diverticulosis is common in western countries affecting 80% of the population after the age of 85 years. Computerized tomography has replaced barium enema because of its ability to demonstrate extra luminal and periodic inflammatory changes or abscess formation. Low dose CT has become the optimal method for diagnosis, grading, and quantification of acute diverticulitis. Radiation dose reduction was 70%. No risk of intravenous contrast reaction. No delay to administer oral contrast (**Figure 1D**).[10] Ultrasound can readily detect gall stones and biliary dilatations, which can cause pancreatitis.[10] Contrast enhanced CT is useful for early detection, classification, and scoring of acute pancreatitis as well as perforated viscous or leaking aneurysms.[10] The MRI is particularly useful for pregnant patients and those requiring repeat examinations. Magnetic resonance imaging (MRI) contrast media are less toxic than CT contrast media.[11]

An upright chest radiograph is the current routine investigation to exclude pneumoperitoneum. A decubitus film is resorted when patient cannot sit or stand. Plain abdominal radiography have a sensitivity

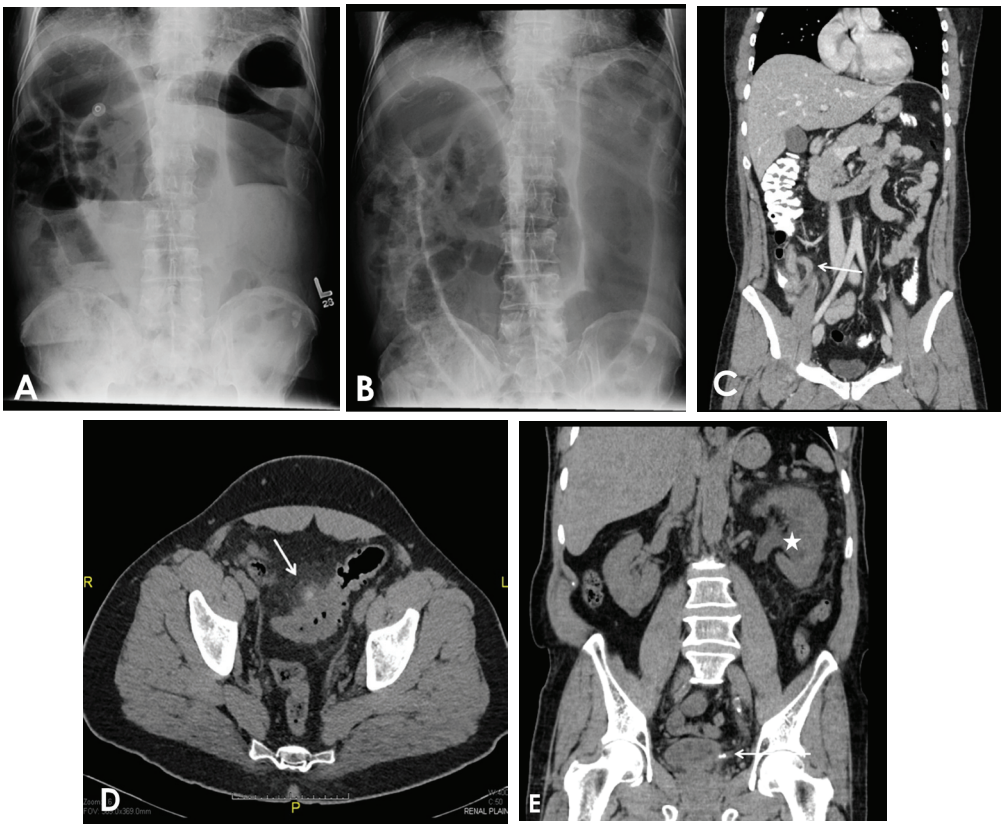

Figure 1 - A photography showing the **A**) erect and **B**) supine abdominal radiograph demonstrating a large bowel distension with large air-fluid level suggestive of distal large bowel obstruction in a 58-year-old male. No evidence of bowel perforation. Sigmoid cancer causing the obstruction was diagnosed by contrast enhanced CT. **C**) An enhanced coronal image of the abdomen and pelvis with oral contrast, demonstrating a thick and inflamed appendix (arrow) with soft tissue stranding suggestive of acute uncomplicated appendicitis. D) CT showed an acutely inflamed sigmoid diverticulum (arrow), with soft tissue stranding in a 35-year-old male with left lower abdominal pain. E) An unenhanced coronal low dose CT scan of the abdomen and pelvis, demonstrating 2 obstructive stones at the distal end of the left ureter (arrow) causing sever left hydronephrosis (star).

of 53% to 89.2% compared with 86% to 100% when CT is used, but adding the CT will add a delay to the operation room.[12] The combination of a supine or decubitus radiographs with an erect chest film may be the only available modalities in hospitals with limited resources.

Acute arterial ischemia requires surgical intervention while venous ischemia may be treated with thrombolytic agents.[3] Therefore, differentiation by triphasic CT is important.[13] In case of the unstable patient with no time for CT, a bed side US scan may help to detect free peritoneal fluid. The ultrasonography of the kidney, ureter, and bladder (KUB) is less sensitive than the low close CT (**Figure 1E**). The old x-ray KUB is now totally redundant.[2] Intravenous urogram is not necessary to diagnose urinary tract stones. Yet another major innovation is evolving, the ultra-low dose CT techniques to address issues of radiation protection against harmful radiation effects on the individual and the environment particularly cancer. The number of performed CT scan is steadily increasing.

The major CT manufactures have come up with ultra-low dose CT using iterative statistical image reconstruction technique to replace the currently used standard back projection techniques namely: ASIR from General Electric, C dose from Philips, ADR from Toshiba, and IRIS from Siemens. A more recent model based iterative reconstruction technique MBIR is reported to bring an approximately 70% radiation dose reduction and a 75% reduction of the image noise as compared with the current low dose CT.[14] However, the reconstruction time is so long hampering daily application particularly at the ED. Like other technologic advances, this delay will eventually be tackled. The guidelines for imaging of acute abdominal pain are continuously updated by the relevant colleges and radiologic societies.[15] Yet, the pace of technologic advances keeps exceeding such revisions.

We conclude with the following simplified facts summary to help the busy front line ED staff in making an appropriate imaging choice promptly. Latest published algorithms are so complex.[15] 1)Where resources are limited and CT is not available, patients presenting with AAP should undergo a supine radiograph with an erect chest film. 2) Where CT is available, the use of PAR's would probably be limited for radiopaque foreign body search and confirmation of fecal impaction in the elderly or the bed ridden. 3) US examination would remain the investigation of choice for the RUQ pain, gynecologic, and pelvic emergencies, acute appendicitis or the search for abscess formation anywhere in the abdomen or pelvis. It is the first line test for the jaundiced patient. In the elderly with suspected appendicitis or RLQ pain, CT is useful since malignancy is not not common. 4) Low dose CT is replacing the use of PAR's and intravenous urograms for all cases of acute renal colic. Low dose CT will certainly be the first test for acute diverticulitis and nonspecific abdominal pain. 5) Contrast enhanced CT is irreplaceable for critical and life threatening conditions such as hollow viscous perforation, leaking aneurysm, bowel ischemia, and severe pancreatitis. Masses causing intestinal obstruction can be readily diagnosed as well as other structural lesions such as adhesions and hernia. 6) Magnetic resonance imaging is of high value as a second line in hepatobiliary and pancreatic disease including magnetic resonance pancreatography (MRCP). It is the safest to use during pregnancy, but not in the first trimester. 7) When the ultra-low dose CT techniques become fully developed and the long reconstruction time is reduced to practical levels, they will take over and play the same old screening role of the PAR's. 8) Every precaution should be taken to avoid the creep phenomenon of CT over utilization or unnecessary repetition, which may increase the cumulative patient and population dose. Strict referral criteria should be agreed on and audited regularly to avoid extra costs and hazards.

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References

1. Gans SL, Stoker J, Boermeester MA. Plain abdominal radiography in acute abdominal pain; past, present, and future. ***Int J Gen Med*** 2012; 5: 525-533.
2. Laméris W, van Randen A, van Es HW, van Heesewijk JPM, van Ramshorst B, Bouma WH, et al. Imaging strategies for detection of urgent conditions in patients with acute abdominal pain: diagnostic accuracy study. ***BMJ*** 2009; 338: b2431.
3. Thoeni RF. Imaging of acute pancreatitis. ***Radiol Clin North Am*** 2015; 53: 1189-1208.
4. Smith JE, Hall EJ. The use of plain abdominal x rays in the emergency department. ***Emerg Med J*** 2009; 26: 160-163.
5. Haller O, Karlsson L, Nyman R. Can low-dose abdominal CT replace abdominal plain film in evaluation of acute abdominal pain? ***Ups J Med Sci*** 2010; 115: 113-120.
6. Mathews JD, Forsythe AV, Brady Z, Butler MW, Goergen SK, Byrnes GB, et al. Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. ***BMJ*** 2013; 346: f2360.

7. Krajewski S, Brown J, Phang PT, Raval M, Brown CJ. Impact of computed tomography of the abdomen on clinical outcomes in patients with acute right lower quadrant pain: a meta-analysis. ***Can J Surg*** 2011; 54: 43-53.
8. Kim K, Kim YH, Kim SY, Kim S, Lee YJ, Kim KP, et al. Low-dose abdominal CT for evaluating suspected appendicitis. ***N Engl J Med*** 2012; 366: 1596-1605.
9. Pinto F, Pinto A, Russo A, Coppolino F, Bracale R, Fonio P, et al. Accuracy of ultrasonography in the diagnosis of acute appendicitis in adult patients: review of the literature. ***Crit Ultrasound J*** 2013; 5 Suppl 1: S2.
10. Shuman WP, Ralls PW, Balfe DM, Bree RL, DiSantis DJ, Glick SN, et al. Imaging evaluation of patients with acute abdominal pain and fever. American College of Radiology. ACR Appropriateness Criteria. ***Radiology*** 2000; 215 Suppl: 209-212.11. Busireddy KK, AlObaidy M, Ramalho M, Kalubowila J, Baodong L, Santagostino I, et al. Pancreatitis-imaging approach. ***World J Gastrointest Pathophysiol*** 2014; 5: 252-270.
12. Solis CV, Chang Y, De Moya MA, Velmahos GC, Fagenholz PJ. Free air on plain film: Do we need a computed tomography too? ***J Emerg Trauma Shock*** 2014; 7: 3-8.
13. Schieda N, Fasih N, Shabana W. Triphasic CT in the diagnosis of acute mesenteric ischaemia. ***Eur Radiol*** 2013; 23: 1891-900.
14. Pickhardt PJ, Lubner MG, Kim DH, Tang J, Ruma JA, del Rio AM, et al. Abdominal CT with model-based iterative reconstruction (MBIR): initial results of a prospective trial comparing ultralow-dose with standard-dose imaging. ***AJR Am J Roentgenol*** 2012; 199: 1266-1274.
15. Gans SL, Pols MA, Stoker J, Boermeester MA, expert steering group. Guideline for the diagnostic pathway in patients with acute abdominal pain. ***Dig Surg*** 2015; 32: 23-31.

Clinical Practice Guidelines

Clinical Practice Guidelines must include a short abstract. There should be an Introduction section addressing the objective in producing the guideline, what the guideline is about and who will benefit from the guideline. It should describe the population, conditions, health care setting and clinical management/diagnostic test. Authors should adequately describe the methods used to collect and analyze evidence, recommendations and validation. If it is adapted, authors should include the source, how, and why it is adapted? The guidelines should include not more than 50 references, 2-4 illustrations/tables, and an algorithm.