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Ultrasound and Computed Tomography in Abdominal and Pelvic Diagnoses

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ABSTRACT

Introduction: the major imaging modalities used in diagnosis of pelvic and abdominal conditions ranged from X-ray, ultrasonography, computed tomography and many more. In each different kind of disorder; a different modality is preferred based on the nature of disease, the patient and the hospital where the management is provided. Some conditions require more than one source of imaging. **Aim of the work:** this study aimed to discuss various abdominal and pelvic pathologies separately to explore the preferred type of imaging modality. **Methodology:** we conducted this review using a comprehensive search of MEDLINE, PubMed and EMBASE from January 1994 to March 2017. The following search terms were used: ultrasound versus CT, acute abdomen imaging, abdominal radiology and pelvic pain diagnosis

Conclusion: various disorders and conditions required different modality of imaging and a health care provider must be well informed of the benefits and risks and be able to weigh in order to make use of the most appropriate imaging technique.

Keywords: ultrasound, computed tomography, acute abdomen, pelvic pain, gynecologic emergency, radiology imaging

INTRODUCTION

Conventional radiography has been substituted by ultrasound (US), computed tomography (CT), and sometimes magnetic resonance imaging (MRI), in the evaluation of acute abdomen.

Although CT is the choice of investigation for the right and left lower quadrant and diffused abdominal pain, US remain the choice of investigation in case of right upper quadrant pain. Ultrasound, CT and MRI all have various advantages and disadvantages over each other and each has its roles, which may not often interchangeable. The risks of ionizing radiation with CT must always be considered, predominantly in young and pregnant patients.

A non-ionizing alternative such as US or MRI should be chosen in those cases if feasible and if it is likely to produce as much diagnostic information. Nevertheless, if justified by understanding the potential benefit outweighing the risk, CT must be performed and the patient can be reassured about the possible future risks [1]. Despite its greater sensitivity, there are at least three difficulties with abdominal CT. The first is that the investigation involves exposing the patient to ionizing radiation, which carries a distinguished, nonetheless theoretical risk of cancer.

With an estimated 2% of future cancers being triggered just by CT scans; clinicians need to decide methods to reduce this exposure. The second issue is that the scanners are costly and not accessible in all medical practice environments, predominantly in developing countries. Lastly, in certain cases, administration of oral and/or rectal contrast is favored, leading to lengthy emergency department (ED) length of stay and when intravenous (IV) contrast is administered, there is a hazard of allergic reaction and nephrotoxicity [2].

Ultrasound has the major benefit of safety due to no ionizing radiation, cost, accessibility and it can be repeated as often as required. However, it is considered as more operator-dependent than the other techniques. MRI also does not use ionizing radiation, even though it has several contraindications such as metallic medical devices like pacemakers and claustrophobia.

It is also comparatively expensive and access is limited, especially to general practitioners. We discussed several abdominal and pelvic pathologies separately to explore the preferred type of imaging modality [1].

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METHODOLOGY

- **Data Sources and Search terms**

We conducted this review using a comprehensive search of MEDLINE, PubMed and EMBASE, from January 1992 to March 2017. The following search terms were used:

- **Data Extraction**

Two reviewers have independently reviewed the studies, abstracted data and disagreements were resolved by consensus. Studies were evaluated for quality and a review protocol was followed throughout.

This study was done after approval of ethical board of King Abdulaziz University.

DISCUSSION

Abdominal Pain

Chronic abdominal pain is a common reason for visit to primary care. It is defined as continuous or intermittent abdominal discomfort for at least six months period. It may occur due to the gastrointestinal tract or adjacent organs, such as the biliary tract and pancreas or may have a gynecological or genitourinary origin. In many cases, chronic abdominal pain is manifestation of a functional syndrome. The major origins of undifferentiated abdominal pain include the functional gastrointestinal disorders including irritable bowel syndrome and functional abdominal pain syndrome. Yet, inflammatory bowel disease, celiac disease and mechanical obstruction may have to be excluded first [3].

In general, clinical localization of cause of pain by the site of the patient's symptoms is unreliable. Nevertheless, there is reasonable association between epigastric pain with gastroduodenal disease, right upper quadrant pain with hepatobiliary disease and suprapubic pain with gynecological causes. It is consequently useful to classify patients by their chief presenting complain, although overlap is possible [2].

Dyspepsia

Dyspepsia is a symptom of complex of epigastric pain or discomfort originating in the upper gastrointestinal tract. It includes acid regurgitation, heartburn, excessive burping or belching, increased abdominal bloating, nausea and early satiety [3]. Diagnostic imaging has little role in the modern investigation of dyspepsia except to exclude, using US, biliary disease as an alternate or concomitant diagnosis or pancreatic disorder if there is clinical suspicion, that is pain radiating to the back, weight loss, jaundice, abnormal liver function, and recent onset of diabetes. CT may be indicated for suspected pancreatic disease.

Red flags that necessitate early evaluation comprise [4]:

- age over 55 years and recent onset of symptoms
- weight loss
- daily constant pain
- non-steroidal anti-inflammatory drug use
- vomiting
- anemia
- a past history of gastric ulcer or gastric surgery
- dysphagia
- gastrointestinal bleeding

In the absence of these red flags, management of dyspepsia is typically with empirical treatment. However, if red flags are present, or if the patient does not respond to empirical treatment, investigation is generally by endoscopy, which makes functional dyspepsia essentially a diagnosis of exclusion [3].

Acute Pancreatitis

Acute pancreatitis is most frequently caused by gallstones or alcohol. The severity of the condition is determined by the degree of multiple organ failure and necrosis of pancreas. The recurrence rate of acute pancreatitis is comparatively high. Acute pancreatitis can be evaluated using US, CT and MRI. CT is the imaging modality of choice in diagnosis and analysis of complications of pancreatitis. The part of US is normally restricted to assess the gall stones because abdominal distension, overlying bowel gas, associated ileus and body habitus can hamper the evaluation of the pancreas using US. Choledocholithiasis is also hardly demonstrated by US [5].

The value of CT is in its ability to foresee prognosis and offers best yield when performed 3-4 days after the onset of symptoms. The evaluation of pancreatic necrosis is best measured by CT (with or without IV contrast) and is shown by low-density areas without enhancement. The CT findings of acute pancreatitis comprise peripancreatic inflammatory changes, surrounding fluid collections, pseudoaneurysms and ascites, thrombosis of the splenic vein or superior mesenteric or portal vein and collection of fluid in intramural and adjacent viscera. In younger patients or patients who are allergic to iodine contrast

agents, finest imaging of the pancreas can be performed with MRI. The most essential sequences for pancreatic evaluation contain T1-weighted gradient echo sequences with fat suppression and dynamic imaging after gadolinium contrast administration. T2-weighted sequences are beneficial for showing the biliary and pancreatic duct anatomy. Image-guided drainage is made by the radiologist for pseudocysts measuring greater than 5 cm and for pancreatic absces [6].

Right Upper Quadrant Pain or Biliary-Type Pain

While most patients with cholelithiasis are asymptomatic, every year over 20 million patients face acute calculous cholecystitis in the United States. The underlying source is an obstruction of the cystic duct of the gall bladder, causing stasis and distension of the gall bladder. Acalculous cholecystitis makes 5%-10% of acute cholecystitis cases and is most frequently encountered in ICU patients [7]. Less than 15% of gallstones are made of calcium which can be seen on plain x-rays. In the occurrence of gall bladder perforation, extraluminal air in the right upper quadrant may be noted. US is the principal imaging modality of choice for the assessment of right upper quadrant pain. In equivocal cases, US can be accompanied by hepatobiliary imino-diacetic acid (HIDA) scan, a test with greater specificity. US results in admirable portrayal of the gall bladder and the biliary ducts, and it will often enough to direct treatment decisions [8].

The findings on US include existence of gall stones, distended gall bladder measuring more than 4.5 cm in the transverse dimension, pericholecystic fluid, wall thickening (> 3 mm), inflammation of the gall bladder, and positive Murphy's sign. Estimation of gall bladder mucosa for sloughing on US is a significant finding of complicated cholecystitis. On CT scan, gas in the wall or lumen and irregularity of the wall can be appreciated in case of gangrenous cholecystitis [9].

Emphysematous cholecystitis is linked with gas-forming bacteria and generally does not have associated gall stones. It is more prevalent in women and patients with diabetes. On US, intraluminal gas displays as non-dependent hyperechoic focus with comet tail artifact. Has greater sensitivity and specificity in indicating the discrepancy between gas and calcification. Infrequently, gall stones may pass from the gall bladder into the bowel lumen, causing mechanical obstruction. Although most stones move without obstruction, about a third of the cases will show gallstone obstruction usually of the terminal ileum. Seldom, the bowel obstruction may happen in the colon, stomach, or duodenum known as Bouveret syndrome [10].

Cholangiography, primarily performed non-invasively with CT cholangiography, or magnetic resonance cholangio-pancreatography (also known as MRCP) are both very precise at determining the cause of biliary obstruction. In young patients MRCP is favored because it does not involve ionizing radiation. If the original US shows alternative pathology to account for symptoms, such as a peri-ampullary or pancreatic mass, then a CT scan and specialist referral are suggested [9].

Intestinal Colic

Colic could be part of a functional syndrome; on the other hand mechanical obstruction due to inflammatory or neoplastic disease may require exclusion. In patients with supposed mechanical recurrent obstruction, clinical evidence and an X-ray that was obtained during an episode of pain can distinguish small and large bowel disease and point to the appropriate investigation. Intestinal obstruction affects the small bowel in two-thirds of the cases. More than 80% of cases of intestinal obstruction are a result of adhesions, hernias, and malignancies. Postoperative adhesions are generally the most common reason of recurrent small bowel obstruction. Nevertheless, further imaging may be essential to exclude other causes such as neoplastic or inflammatory disease (such as Crohn’s disease), particularly if there is no past surgical history. This may take the form of CT enterography, or magnetic resonance enterography [11].

The radiologist's role is to recognize the presence of bowel obstruction, describe the site of obstruction and check for possible strangulation. The plain radiograph findings comprise fluid distended small bowel loops (measuring > 3 cm), multiple air-fluid levels in a typical step-ladder pattern, and presence of gas in the distal bowel. Sporadically, a “string of pearls” sign may be recognized and is caused by confined intraluminal air between valvulae conniventes. Contrast-enhanced CT is the modality of choice in the assessment of small bowel obstruction. It can

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disclose the cause of obstruction and detect both closed-loop obstruction as well as strangulation. CT has a less specificity in the assessment of intestinal ischemia. CT enteroclysis, which is not currently considered the standard of care and investigation, may be beneficial in low-grade small bowel obstruction which is not well identified on conventional CT. A dilated, C- or U-shaped bowel congested loop of the mesentery is distinguished in closed-loop obstruction [3]. Accompanying circumferential wall thickening more than 3 mm and pneumatosis intestinalis should raise worry for strangulation. The small bowel feces sign is the outcome of stasis and may be observed in less than 10% cases of small bowel obstruction. It has high specificity and typically located just proximal to the location of obstruction. Large bowel recurrent or subacute obstructive symptoms need urgent investigation. The type of imaging partly depends on whether the patient can tolerate bowel preparation. Specialist referral is necessary [12].

Suspected Crohn's disease

US is a reasonable initial test for suspected Crohn's disease. What shadows depends on the level of clinical likelihood. If it is low, no further imaging may be obligatory since the negative predictive value of US in this scenario is high. Conversely, if the US is positive, with non-specific results of thickened loops of bowel, or negative but with ongoing clinical suspicion, specialist referral for ileo-colonoscopy is superior to CT or MRI, which may fail to detect early or localized mucosal disease [13].

Succeeding a positive diagnosis of Crohn's disease or a negative colonoscopy, but with persistent clinical suspicion, CT enterography or enteroclysis, or magnetic resonance enterography or enteroclysis are suggested. When Crohn's disease has been beforehand confirmed, these scans are to evaluate the extent and location of disease and the manifestation of complications [14].

Acute Appendicitis

Acute appendicitis is the most prevalent surgical emergency of the abdomen, and there are about 250,000 new cases every year in the United States. The lifetime risk of appendicitis is roughly 8.6% in males while 6.7% in females. In spite of the frequency of the disease, the clinical diagnosis of appendicitis poses a diagnostic challenge. Historically, classic physical findings including pain at McBurney's point or the psoas sign have been understood to make the diagnosis, even though the discriminative power of classic clinical and along with laboratory findings remains minimal. The presence of these signs upsurges the likelihood of appendicitis, though no physical exam finding can effectually diagnose appendicitis [15].

The two most common modalities in use are abdominal helical CT and abdominal US. Both are measured to have acceptable sensitivities, specificities, and positive and negative predictive values; however CT has proved to be superior in several studies. The use of CT has led to a marked reduction in the rate of negative appendectomy, as much as 48% in one study. Compared with clinical and laboratory findings, the addition of CT amplified diagnostic sensitivity from 91.6% to 98.3%. In the United States, CT is presently recommended as the first-line test in the event of suspected appendicitis, and its practice is increasing. CT clearly has its benefits, with sensitivity approaching 100% and the capacity to perform the study in a method that is not operator dependent, and in patients in which US is difficult to accomplish, such as those who are overweight. Nevertheless, the risks of contrast administration, exposure to ionizing radiation, and price are all limiting factors [16].

Although its sensitivity is inferior, US is recognized to be useful in children and pregnant patients, and is the principal modality for these patients based on the American College of Radiology guidelines. Despite the established superiority that CT has over US for the diagnosis of appendicitis, recent studies have advocated for a first-line ultrasound approach with adult patients presenting with probable appendicitis. The message of these studies is the same: the positive predictive value of US is outstanding; if the appendix is envisioned and abnormal, the patient must go to surgery. If the appendix is not seen, then the patient should have a CT. This approach has evidently been shown to be cost effective and safe in children [15].

Renal tract symptoms

Pain from the renal tract may be felt as loin or flank pain. A non-enhanced low-ionising radiation dose CT is suggested if there is a sudden exacerbation of pain to exclude ureteric calculi. For younger patients, the combination of a plain X-ray (which shows kidneys-ureters-bladder, KUB) and

US will rule out renal obstruction, intra-renal calculi and masses. If the pain is referred to the scrotum, a negative US of the scrotum must lead to an US of the whole renal tract. If a renal mass is seen, this must be investigated with a multiphase CT scan [17].

Pelvic Pain

Causes of pelvic or iliac fossa pain comprise Crohn's disease, colonic diverticular disease, and gynecological disease. In reproductive age women, when endometriosis, ovarian, or other adnexal disease is suspected, pelvic US, which includes trans-vaginal US when required, is the investigation of choice. In patients who do not meet the criteria for irritable bowel syndrome or have red flags, the choice of investigation rests on the provisional clinical diagnosis. Diverticular disease is best primarily investigated by CT to look for complications including pericolic inflammation or chronic abscess. Uncomplicated diverticular disease is very common and is usually asymptomatic, and small or moderate sized cancers cannot be excluded on CT, unless it is combined with CT colonography resulting in a very high negative predictive value [1].

Acute Pelvic Inflammatory Disease

In the United States, > 1 million women suffer from pelvic inflammatory disease (PID) yearly and the rate is highest among teenagers. Although *Neisseria gonorrhea* and *Chlamydia trachomatis* are the two most likely microbes, the infection can also be polymicrobial. A single episode of PID is associated with 8% risk of infertility, and the risk increases on second episode with by 20%. The incidence of ectopic pregnancy is also six times higher [18].

The gold standard for the investigation of PID is diagnostic laparoscopy. Yet, in routine clinical practice, imaging by trans-abdominal as well as trans-vaginal US is commonly practiced. US markers of tubal inflammatory disease are dilated, and inflamed fallopian tubes noted as tubular and serpiginous structures inside the adnexa. It may have echo poor or echogenic fluid. The ovaries may be normal or can be hard to differentiate from the complex adnexal lesion. Infrequently, echogenic foci, consistent with air bubbles can be seen. CT and MRI may sporadically be necessary for overall evaluation of the abdomen and pelvis in patients with suspected generalized peritonitis. The CT findings comprise haziness of pelvic fat, loss of pelvic fascial planes, thickening of uterosacral ligaments, and rim-enhancing fluid collections. Image guidance is also beneficial for trans-abdominal, trans-vaginal, and trans-gluteal, drainage of the abscess [19].

Ovarian Torsion

Adnexal torsion is in fact a gynecologic emergency, which is triggered by twisting of the ovary, Fallopian tube, or both along the vascular suspension. Firstly, torsion compromises venous return from the ovary. A larger degree of torsion leads to arterial insufficiency and lastly hemorrhagic infarction. Pregnancy and ovulation induction can predispose to torsion [20].

Transvaginal Doppler US is considered the imaging study of choice and could show enlarged ovary, associated mass or ccyst, and lack of blood flow. The role of CT is to exclude alternate diagnosis. CT and MRI findings consist of Fallopian tube thickening, uterine deviation to the torsed side, thick-walled adnexal cyst, and inflammatory fluid in the Cul-de-Sac [21].

Ectopic Pregnancy

In the United States, ectopic pregnancy is presently the leading cause of pregnancy-related mortality during the first trimester, responsible for 9% of all pregnancy-related deaths. There is a potential for rupture along the extrauterine site, causing massive hemorrhage or even death [22].

Urine pregnancy test, quantitative beta-human chorionic gonadotropin hormone, and trans-vaginal US are habitually used to make a diagnosis of ectopic pregnancy. An embryo in the extrauterine location is the most conclusive evidence of ectopic pregnancy A beta-human chorionic gonadotropin of more than or equal to 1800 mIU/mL (second international standard) is always linked with a recognizable intrauterine gestational sac. An ectopic is presumed in the nonappearance of the intrauterine gestational sac. The findings of ectopic pregnancy comprise biochemical evidence of pregnancy with related complex adnexal mass with amplified flow on color imaging associated with vascularity, and echogenic pelvic fluid demonstrating hemoperitoneum [19].

Request Forms for Imaging

Clinical information on request forms for CT scans must be specific, for example, Abdominal pain is

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unhelpful. Even if a CT scan is recommended, the radiologist will not be able to determine the necessary scanning protocol. For instance, although a request for probable renal colic and a request for suspected mesenteric angina demand an abdominal CT scan, the imaging protocol is fairly different. The former involves a low-radiation dose non-intravenous contrast CT, whereas the latter will often necessitate a multiphase scan (pre-contrast arterial and post-contrast portal venous phase). 'Rule out cancer' is also not supportive on a request form. A normal CT scan does not, however, rule out cancer and may well offer a false sense of security to the patient as well as the doctor [1].

CONCLUSION

Diagnostic imaging is overused in adults with chronic abdominal pain. Even when imaging is required, CT scanning is frequently not the choice of investigation. All imaging investigations should be acceptable when the weighed benefit is greater than the possible adverse effect. Most abdominal and pelvic conditions that demand imaging have different gold standard for proper investigation. The need may also vary based on the patient and the accessibility in the medical institution. Additionally, providing sufficient clinical information to the radiologist is vital to enable the correct modality of imaging, and to allow proper interpretation of the consequence of the test results.

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