IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 11 Ser.2 (November. 2019), PP 57-64
www.iosrjournals.org

A Comparison of the Accuracy of Ultrasound and Computerized Tomography in Acute Abdominal Pain

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Abstract: *Background: Acute abdominal pain is a common chief complaint in patients examined in the emergency department (ED) and can be related to a myriad of diagnoses. Of all patients who present to the ED, 10% have acute abdominal pain. Obtaining a careful medical history and performing a physical examination are the initial diagnostic steps for these patients. On the basis of the results of this clinical evaluation and laboratory investigations, the clinician will consider imaging examinations to help establish the correct diagnosis.*

Aim of Study: *To determine the accuracy of the Ultrasonography and the computed tomography in evaluation of patients presenting with acute abdominal pain and to decide which is superior to other regarding sensitivity and specificity.*

Patient and Methods: *A prospective study was done in the radiological department of Baghdad teaching hospital in Medical city from September 2013 through august 2014, in which 100 consecutive patients presenting with acute abdominal pain for more than 2 h and less than 5 days to the emergency department (ED) of Baghdad teaching hospital. The Ultrasonography examination&Computed Tomographyscan of abdomen and pelvis were done*

Results: *The distribution of patient according to final diagnosis was; Appendicitis (24)patients , Cholecystitis (18)patients, gastrointestinal disorders(18)patients, pancreatitis (10)patients, malignancy (10)patients, Gynecological (10)patients, Obstructive uropathy (10)patients. Regard gender distribution according to diagnosis was : appendicitis 41 % male and 59 % female , cholecystitis 22 % male and 78 % female , gastro intestinal disorder 28 % male and 72 % female , pancreatitis 40 % male and 60 % female , malignancy 70 % male and 30% female , gynecological 100 % female ,obstructive uropathy 70 % male and 30 % females.The Computed Tomography scan was more sensitive (95%)(97%)than Ultrasonography (70%) (70%) in diagnosis of appendicitis and obstructive uropathyrespectively ,while The US was more sensitive(90%) than Computed Tomography scan (80%)sensitivity in diagnosis of gynecological*

Conclusion: *The Computed Tomography scan was more sensitive than US in diagnosis of appendicitis and obstructive uropathy while The Ultrasonography was more sensitive than CT scan in diagnosis of gynecological problems with P value of 0.03.*

Key words: *Ultrasound , Computerized Tomography, Acute Abdominal Pain*

Date of Submission: 24-10-2019 Date of Acceptance: 09-11-2019

I. Introduction

Acute abdominal pain is a common chief complaint in patients examined in the emergency department (ED) and can be related to a myriad of diagnoses.. (1) Acute abdominal pain is defined generally as an intra-abdominal process causing severe abdominal pain develops > 2 hours and < 5 days. Symptoms of pain may be acute (an acute abdomen), subacute or acute on chronic. (2) The term acute abdominal pain to refer to the complete spectrum of acute abdominal pain in patients who are treated in the ED and require imaging. (3) The causes of acute abdominal pain range from life-threatening to benign self-limiting disorders.. (4) Non enhanced CT, US, and conventional radiography are considered less appropriate initial imaging examinations for these patients. (5) Abdominal pain is the most common symptom of appendicitis, US is widely available inexpensive modality with the potential for highly accurate imaging in the patient suspected to have acute appendicitis, and safe for use in children and pregnant women. (6,7,8,9) The addition of color Doppler US also is of benefit in the evaluation of inflammatory conditions of the intestinal tract(10,11,12).Computed Tomography (CT) is highly

accurate and effective cross-sectional imaging technique for diagnosing of acute appendicitis. (13),Acute calculus cholecystitis (14) andAcalculuscholecystitis(15) The evaluation of the patient with suspected gallbladder disease has changed dramatically since the early 1980s. (16,17) Recently several studies have appeared dealing with the role of color Doppler ultrasound in detecting the possible wall hyperemia in acute cholecystitis(18).Severe acute pancreatitis is associated with pancreatic necrosis and may lead to organ failure and/or local complications. (20, 21, 22,23) The development of both pseudocyst and abscess usually requires 4 or more weeks from the initial clinical onset of acute pancreatitis. (24) Pancreatic necrosis is defined as focal or diffuse areas of nonviable pancreatic parenchyma; it usually is associated with peripancreatic fat necrosis. (25) . Gallstones and alcohol abuse are the most common causes of acute pancreatitis,(26, 27, 28, 29) Doppler techniques should be used to assess vascular complications of acute pancreatitis, such as venous thrombosis and pseudoaneurysm formation. (30) Complications of acute pancreatitis, such as pseudocysts, abscess, necrosis, venous thrombosis, pseudoaneurysms, and hemorrhage, can be recognized with CECT. (31,32,33) The prolapsing part of the bowel is described as the intussusceptum while the distal segment of bowel receiving the intussusceptum is described as the intussuscipiens. (34,35) CT has become the modality of choice for assessment of acute abdomen in adults, and thus most frequently images intussusception. (36)

Acute colonic diverticulitis is the second most common cause of acute abdominal pain in the United States annually. (37,38) A sensitivity of 64% for the clinical diagnosis of acute diverticulitis in the ED has been reported that is, one-third of the cases are missed clinically. (39) Diverticulitis-associated abscesses are found at CT in approximately 15% of patients. (40,41)cancer can be missed, Therefore, endoscopy and biopsy are often required to make this differentiation after the clinical symptoms have resolved often after 6 weeks. (42) Bowel obstruction is a relatively frequent cause of acute abdominal pain.

Ultrasound is the name given to high frequency sound waves, over 20000 cycles per second (20 KHz). These waves are inaudible to humans and can be transmitted in beams and are used to scan the tissues of the body. (43)

Computed tomography is a special type of x-ray procedure that involves the indirect measurement of the weakening, or attenuation, of xrays at numerous positions located around the patient being investigated. Typically, images are produced for each 360˚ rotation, permitting a high number of measurement data to be acquired and sufficient dose to be applied. While the scan is being performed, attenuation profiles, also referred to as samples or projections, are obtained. (44)

Aim of study: To determine the accuracy of the Ultrasonography and the computed tomography in evaluation of patients presenting with acute abdominal pain and to decide which is superior to other regarding sensitivity and specificity

Patients and Methods: A prospective study was done in the radiological department of Baghdad teaching hospital in medical city from September 2013 through august 2014, in which 100 consecutive patients presenting with acute abdominal pain for more than 2 h and less than 5 days to the emergency department (ED) of Baghdad teaching hospital refer by treating surgeon to radiological department to be imaged by use US and CT scan imaging after evaluation clinically and by laboratory tests. Patients excluded from the study are: patient who discharged from the ED by the treating physician without any one of diagnostic imaging (ultrasound, CT), patients under 12 years, pregnant women and patients with a blunt or penetrating trauma. All included patients were clinically evaluated in the ED by surgical team after which the patients underwent a full diagnostic protocol. The treating surgeon prospectively recorded patients' characteristics and the findings of clinical history and examination in a case record form. A special designed questionnaire was used to collect information from patients who give us verbal consent. The examination was done using Philips (HD 11XE) with a curved array 3-5 MHz and with linear array 7-11 MHz.no special preparation was done apart from full of the urinary bladder. Longitudinal and transverse scans were obtained for each abdominal organ while the patient in supine position .other positions may need in addition to supine position like left lateral decubitus or erect position to avoid missed any gall bladder stones ,left and right oblique decubitus may be used to overcome gastric and colonic gas that may interfere with visualization of pancrease, left and right anterior oblique position or prone may be used for visualization of kidneys . CT abdomen and pelvis was done for 100 patient were examined by CT scan Philips birillance 64 slice,70 patient receive IV contrast as the other either had elevated urea and creatinine or intolerable for contrast ,no oral or rectal agent were used .no preparation was done only full bladder .the protocol was using 5mm slice thickness ,reconstruction 1mm ,pitch 0.6,KV120 ,mass 250 ,window width 300 ,window level 40. CT scan done in two phases: first non-contrast CT scan of abdomen and pelvic and then with intravenous contrast of 100-150 mL, 350 mg /mL of Iohexol at 2-4 mL/sec infusion rate. The examination was done by two different specialist radiologist one in US unit and other in CT scan unit. Ethical agreement was obtain from Ethical committee in Baghdad college of Medicine

Analysis: The primary analysis was focused on a comparison of the accuracy of ultrasound and CT in detecting common diagnoses in patients with acute abdominal pain, using the final diagnosis as the reference standard.

The sensitivity, specificity, positive and negative predictive values and the accuracy of ultrasound and CT were calculated. Differences in sensitivity and specificity between ultrasound and CT were evaluated with McNemar's test statistic. Differences between ultrasound and CT with regard to predictive values were evaluated with the Chi-squared test statistic. P value is the probability of error (error due to sampling or due to chance). If p value less than 5% (less than 0.05) then the result will be significant. All analysis performed in SPSS 15.0.1 (Statistical package for social science version 15.0.1(SPSS Inc. Chicago, IL, USA)). Sensitivity and specificity are statistical measures of the performance of a binary classification test.

II. Results

Number of patient in our sample was 100 patients, the distribution of patient according to diagnosis was; Appendicitis (24), Cholecystitis (18), Gastrointestinal (18), Pancreatitis (10), Malignancy (10), Gynecological Disorder (10), Obstructive uropathy (10). See fig. 1 . Regard gender distribution according to diagnosis was : appendicitis 41 % male and 59 % female , cholecystitis 22 % male and 78 % female , gastro intestinal disorder 28 % male and 72 % female , pancreatitis 40 % male and 60 % female , malignancy 70 % male and 30% female , gynecological 100 % female , obstructive uropathy 70 % male and 30 % female. Mean age distribution according to diagnosis: Appendicitis (29.6±14.5), cholecystitis (46.7±13.5), gastrointestinal (48.5±16.5), pancreatitis (36±7.3), malignancy (56±13.5), gynecological (31±4.5), obstructiveuropathy (49±7.4). Distribution of gastrointestinal problem according to diagnosis was: Paralytic Ilues 9 cases, Intussusception 3 cases, perforated viscus 3 cases, Obstructed Intestinal Hernia 3 cases. See table 1. Table 1: Frequency of Gastro Intestinal Disorder.

Final Diagnosis N =18 %
Paralytic Ileus 9 50
Intussusception 3 16.6
Perforated Viscus3 16.6
Obstructed Intestinal Hernia 3 16.6

Distribution of gynecological problem according to diagnosis was; 5 cases of ovarian cyst, 2 cases ovarian torsion, and 3 cases of pelvic inflammatory disease. See table 2.

Table 2: Frequency of Gynecological Disorder

Final Diagnosis N=10 %
Ovarian Cyst 5 50
PID 3 30
Ovarian Torsion 2 20

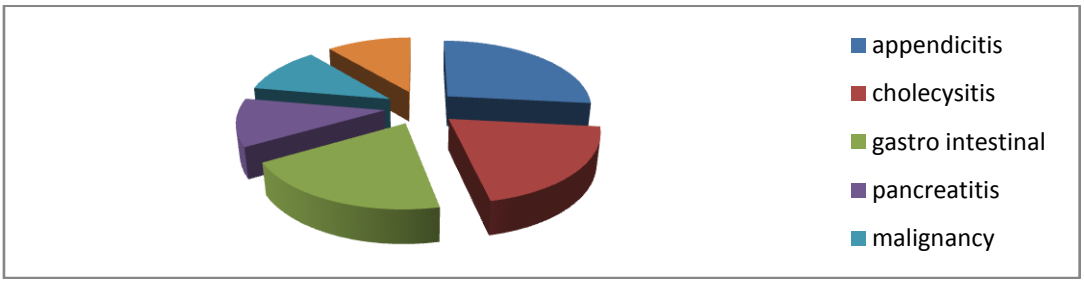

Fig.1: Distribution of patients according to final diagnosis

The Sensitivity of CT scan was higher than US in diagnosis of Appendicitis with P value of 0.02.For gynecological problem the result is different as US has higher Sensitivity than CT scan with P value 0.03. For obstructive uropathy problem the result is same as Appendicitis as CT has higher Sensitivity than US with P value 0.01. For malignancy, pancreatitis, and Gastro intestinal disorder sensitivity of CT was higher than US but the P value was insignificant. In regard to cholecystitis, the result was CT had higher sensitivity than US but also the P value was in significant. See table 3

Table 3: Sensitivity values for US and CT in study sample

Final Diagnosis N=100 Sensitivity US (%) Sensitivity CT (%) P values
Appendicitis 24 70 95 0.02
Cholecystitis18 90 93 0.98
Gastro Intestinal Disorder 18 90 960.50
Pancreatitis 10 70 85 0.11
Malignancy 10 85 90 0.66
Gynecological Disorder 10 90 80 0.03
Obstructive Uropathy10 70 97 0.01

CT has higher specificity than US in diagnosis of malignancy with P value of 0.03. The specificity was the same in diagnosis of pancreatitis, and gynecological problem but the P value was insignificant. The specificity was higher in CT than US in diagnosis of Gastro intestinal disorder, malignancy, and obstructive uropathy problem but the P value was in significant. CT had higher specificity than US in diagnosis of cholecystitis. See table 4

Table 4: Specificity values for US and CT in study sample.

Final Diagnosis	N=100	Specificity US (%)	Specificity CT (%)	P values
Appendicitis	24	8595	0.92	
Cholecystitis18	91	95	0.62	
Gastro Intestinal Disorder	18	90	92	0.57
Pancreatitis	10	100	100	0.87
Malignancy	10	80	90	0.03
Gynecological Disorder	10	90	90	0.41
Obstructive Uropathy	10	70	96	0.12

CT has higher PPV than US in diagnosis of malignancy with P value of 0.02. For the rest diagnosises CT has higher PPV in diagnosis of Appendicitis, cholecystitis, pancreatitis, gynecological, than US but the P value is insignificant. US has higher PPV than CT in obstructive uropathy and Gastro intestinal disorder but also the P value is in significant. See table 5

Table 5: PPV values for US and CT in study sample.

Final Diagnosis	N=100	PPV US (%)	PPV CT (%)	P values
Appendicitis	24	82	85	0.44
Cholecystitis	18	38	48	0.13
Gastro Intestinal Disorder	18	79	71	0.70
Pancreatitis	10	70	86	0.61
Malignancy	10	65	86	0.02
Gynecological Disorder	10	35	53	0.25
Obstructive Uropathy	10	82	70	0.12

PPV: Positive predictive value

NPV was higher in CT than US in diagnosis of Appendicitis and the result was significant. NPV was higher in CT than US in diagnosis of Gastro intestinal disorder, pancreatitis, malignancy and obstructive uropathy but the P value was insignificant. NPV was higher in US than CT in diagnosis of cholecystitis but the P value was insignificant. NPV was the same in gynecological problem but the P value was insignificant. See table 6

Table 6: NPV values for US and CT in study sample.

Final Diagnosis	N=100	NPV US (%)	NPV CT (%)	P values
Appendicitis	24	90	92	0.01
Cholecystitis	18	92	91	0.43
Gastro intestinal disorder	18	96	98	0.69
Pancreatitis	10	96	97	0.06
Malignancy	10	88	90	0.09
Gynecological Disorder	10	97	97	0.27
Obstructive Uropathy	10	81	87	0.18

NPV : Negative predictive value

The CT was more accurate in the diagnosis of most common causes of acute abdominal pain except the gynecological problems where US was more accurate. See table 7.

Table 7: Final table of Sensitivity and Specificity and accuracy of US and US scan

Final Diagnosis	N=100	Sensitivity US (%)	Specificity US (%)	Accuracy of US	Sensitivity CT (%)	Specificity CT (%)	Accuracy of CT
Appendicitis	24	70	85	87%	95	95	93%
Cholecystitis	18	90	91	89%	93	95	92%
GTD	18	90	90	91%	96	92	95%
Pancreatitis	10	70	100	85%	85	100	89%
Malignancy	10	85	80	82%	90	90	89%
GY .D	10	90	90	89%	80	90	85%
O.U	10	70	70	80%	97	96	90%

GIT:Gastro intestinal disorder GY.D:Gynecological disorders O.U :Obstructive uropathy

III. Discussion

In our result we found that CT had higher sensitivity and specificity than US in detection of Appendicitis. Van Randen et al, found that CT had a better test performance than did graded compression US in diagnosing appendicitis. The sensitivity of CT and graded compression US were 91% and 78% respectively .The specificity for CT and graded compression US were 90% and 83% respectivly. Both mean sensitivity and specificity were significantly different between graded compression US and CT. (45) Keyzer et al, found that although US is widely available and inexpensive, its accuracy is dependent on the skill of the operator. It has been reported that when patients suspected of having acute appendicitis are examined by experienced operators, the sensitivity of US is 76% ,specificity is 86%, while CT, conversely, has corresponding values that are all greater than 95% (46)Sivit et al ,mention that, Conventional and helical CT scanning techniques have documented high accuracy (96-98%), sensitivity (96100%), specificity (95-97%), positive predictive value (97-99%), and negative predictive value (88-100%).(47) Saito et al, found that CT had superior sensitivity than US in diagnosis of appendix with 95% and 71% for CT and US respectively. (48) In our result we found that CT had higher sensitivity and specificity than US in detection of Cholecystitis.

Ultrasonography is considered the preferred initial imaging technique for patients who are clinically suspected of having acute calculouscholecystitis because it has the best sensitivity in detection of gallstone of 97% which is the main point against CT that not all stone can be detect by it.(49) Bennett et al ,mention that the Sensitivity, specificity, and accuracy of CT for acute cholecystitis were 91.7%, 99.1%, and 94.3%, respectively, and CT is highly specific for acute gangrenous cholecystitis 96.0% from any other image .The findings with the highest specificity for gangrenous cholecystitis were gas in the wall or lumen (100%), irregular or absent wall (97.6%), and abscess (96.6%). (50) Ralls et al. report that one of the most important advantages of ultrasound over other imaging techniques in the investigation of acute cholecystitis is the ability to assess for a sonographic Murphy sign (pain is provoked by either the transducer or the sonographer's palpation under guidance, in the exact area of the gallbladder) which is a reliable indicator of acute cholecystitis with a sensitivity of 92%. (51) In our result we found that CT had higher sensitivity and specificity than US in detection of Gastro intestinal disorder .Suri et al, compared the efficacy of ultrasound, and CT scan in 32 patients presenting with clinical suspicion of intestinal obstruction, the sensitivity and specificity of ultrasound were 75% for each one, compared with CT scanning at 93% and 100%, respectively. The level of obstruction was correctly predicted in 70% of patients using ultrasound, but in 93% of patients on CT scan. Ultrasound was also inferior to CT for determining the cause of the obstruction (23% versus 87%). Abdominal ultrasonography may be useful for the diagnosis of small bowel obstruction in selected patients. Ultrasound is limited by poor visualization of gas-filled structures.(52) Balthazar et al mention that, the negative predictive value of abdominal CT for excluding strangulation was 95%. (53) Shakil et al, reported that, in high-grade small bowel obstruction, the sensitivity, specificity, and accuracy of CT scan are reported to be 90% to 94%, 96%, and 95%, respectively. (54) Ogata et al, reported that the positive predictive value of a kinetic dilated loop on ultrasound for strangulation was 73%. (55) In our result we found that CT had higher sensitivity than US in detection of Pancreatitis with value of 85% for CT and 70% for US but both have the same specificity of 100%. . In a prospective study of 202 patients, Clavien et al reported a 92% sensitivity and 100% specificity in diagnosing acute pancreatitis via CT.(56) Balthazar et al reported an overall accuracy of 80-90% in the detection of pancreatic necrosis. (57) Block et al, mentioned that the positive predictive value of CT scan for pancreatic necrosis was found to be 92%.

In Rickes study Based on CT findings as the gold standard and the sensitivity, specificity, positive predictive value, and negative predictive value of ultrasound for detecting severe acute pancreatitis based on imaging criteria were, respectively, 82%, 89%, 95% and 67%. (58) In our result we found that CT had higher sensitivity and specificity than US in detection of Malignancy.the sensitivity for US and CT was 85% and 90% respectively .the specificity for US and CT was 80% and 90% with significant p value 0.03. Berland et al consistently indicate that CT is an excellent means of initially staging primary or secondary colorectal tumor. The sensitivity of detecting hepatic metastases has been well documented in the literature, with rates ranging from 85% to 90%. (59) Thompson et al indicate accuracy rates have been reported around 70% for determining local tumor extension. (60) Balthazar et al, CT scanning is particularly useful in staging patients with Dukes stage D lesions, which may lead to changes in surgical planning or preoperative management with Positive predictive value rates have been reported at 100% for CT staging of Dukes D lesions. (61)Rickes et al mention that, for pancreatic carcinoma the real world accuracy of conventional US for diagnosing pancreatic tumors is 70% and sensitivity is 85% and specificity is 90%. (62) Palazzo et al, reported that for CT It has reported to have sensitivity of 92% for diagnosing pancreatic cancer. (63) In our result we found that US had higher sensitivity than CT in detection of gynecological problem with value of 90% and 80% with significant p value 0.03. But both have the same specificity 90%. Stacey et al mention that, transabdominal ultrasonography remains the study of choice in initial evaluation of suspected adnexal masses because it is relatively inexpensive, noninvasive, and widely available. Excellent results of US for detection of adnexal masses have been confirmed

in several studies, which have demonstrated that 97% of ovarian masses may be visualized sonographically, and 93% to 97% of ovarian masses may be characterized by sonographic morphology. (64) Over all CT did not offer significant additional features and did not result in a change in management plan in any of the patients reviewed. Both methods were almost equally efficacious in detecting ovarian cancer cases (65) Study done by Behtash et al ,Transabdominalsonography (TAS) and CT reports of 75 women with adnexal masses (34 malignant, and 41 benign) who were consecutive operated patients at a tertiary gynecology cancer center. For TAS the sensitivity, specificity, positive predictive value and negative predictive value were 91%, 68%, 71% and 90%, respectively. For CT scans the results were 85%, 56 %, 62% and 83%, respectively. The AUC (area under the curve) of sonography assessment to diagnose malignancy was significantly higher than that of CT scan. (66) In our result we found that CT had higher sensitivity and specificity than US in detection of obstructive uropathy .the sensitivity of US and CT was 70% and 97% respectively with significant p value 0.01 .the specificity of US and CT was 70% and 96% . Smith et al mention that, CT has superior sensitivity of 97% and specificity 96% over all other modalities. Greater than 99% of stones, including radiolucent stones, on plain X-ray will be seen on spiral CT scanning. (67) Chen et al reported that, in a study of 100 consecutive patients with flank pain/renal colic, spiral CT scanning was shown to have 96% sensitivity and 99% specificity in detecting ureteric calculi. (68)Sheafor et al, in a prospective study of 44 patients presenting with acute flank pain, non-enhanced helical CT scanning detected 22 of 23 ureteric calculi (sensitivity 96%) compared with 14 of 23 detected on ultrasound examination (sensitivity 61%). Specificity for each technique was 100%. (69) A review by Heidenreich et al. found that studies of unenhanced helical CT showed sensitivity and specificity ranging from 98% to 100% for assessing acute flank pain. This procedure identifies extra urinary causes of flank pain in approximately one-third of patients with acute flank pain. (70).

IV. Conclusions

1. Both ultrasound and CT scan can reliably detect common diagnoses causing acute abdominal pain, so US and CT scan can used on top of clinical and laboratory evaluation.
2. The CT scan was more sensitive than US in diagnosis of appendicitis and obstructive uropathy with P value of 0.02 and 0.01 respectively. The US was more sensitive than CT scan in diagnosis of gynecological problems with P value of 0.03.
3. The CT scan was more specific than US in diagnosis of malignancy with P value of 0.03.
4. The CT scan has higher PPV than US in diagnosis of malignancy with P value of 0.02.
5. The NPV was higher in CT than US in diagnosis of Appendicitis and result was significant with P value of 0.01.
6. The CT was more accurate in the diagnosis of most common causes of acute abdominal pain except the gynecological problems where US was more accurate.

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Dr .AmanyI.Khalel. "A Comparison of the Accuracy of Ultrasound and Computerized Tomography in Acute Abdominal Pain." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 11, 2019, pp 57-64.