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Research Article

Prospective study of comparison between the ultrasonography with the plain radiography in the diagnosis of pneumoperitoneum of hollow viscus perforation

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ABSTRACT

Background: This study was conducted to compare the plain radiography with the abdominal ultrasonography in the detection of pneumoperitoneum in suspected cases of hollow viscus perforation.
Methods: A total number of 60 patients with suspected hollow viscus perforation were studied. All the patients had undergone plain radiography (Erect x-ray abdomen and left lateral decubitus views), ultrasonography and exploratory laparotomy. The investigational findings were compared with that of laparotomy findings. They were compared in terms of their sensitivity, specificity, predictive value of a positive and negative results and their percentage of false positive and false negative results.
Results: Of the 60 patients, who underwent laparotomy, 57 had hollow viscus perforation. Out of 3 non-hollow viscus perforated cases 2 had appendicular perforation and 1 had mesenteric lymphadenitis. In the diagnosis, ultrasonography vs. radiography, their respective parameters were sensitivity (73.7% vs. 80.7%), specificity (66.7% each), predictive value of a positive test (97.7% vs. 97.9%), predictive value of a negative test (11.8% vs. 15.4%), percentage of false negative (26.3% vs. 19.3%) and percentage of false positive (33.3% each).
Conclusion: In detection of pneumoperitoneum plain radiography appears to be more sensitive than ultrasonography with comparable specificity. Ultrasonographic finding of pneumoperitoneum is considered as an added finding.

Keywords: Plain radiography, Ultrasonography, Hollow viscus perforation

INTRODUCTION

Hollow viscus perforation is one of the common surgica[1] causes of acute abdomen. It is usually diagnosed by the evidence of pneumoperitoneum on erect x-ray abdomen /chest x-ray, which is a gold standard.[1] Its sensitivity can be improved even better by left lateral decubitus.[2] Limitation of the radiography is the positioning of the patient for the procedure and also the time duration for the development of the film. Positioning is cumbersome as the patients would be unwell and the movement of the patient would add to the agony. More over the time delay taken for the shifting of the patient to specialized radiological room, where X-rays are taken and their processing would lead to the delay in the surgical management and the radiation exposure associated with it.

CT scan is superior to plain radiography and ultrasonography.[3,4] But the availability, cost effectiveness and more radiation exposure are the limiting factors. Ultrasonography has been proved as the best initial diagnostic procedure in acute abdomen patients.[5,6] Advantages being that it can be done in emergency room with minimal positioning of the patient, immediate reporting and no radiation exposure and added to that it can look into other abnormal conditions. With stress being laid on surgeon operated ultrasonography,[7] which is considered as an extension of clinical examination, it is

of importance to know the ultrasonography role in detection of the pneumoperitoneum. Though ultrasonography has been reported as more sensitive than plain radiography in recent times[8, 9, 10,] it has an inherent drawback of being operator dependent[6] and others have stated that direct evidence of pneumoperitoneum is not as good as plain radiography.[11,12]

Objectives

The main objective of the study was to compare ultrasonography and plain radiography in detection of pneumoperitoneum in suspected cases of hollow viscus perforation. They would be compared in terms of their sensitivity, specificity, positive and negative predictive values, percentage of false negative and false positive.

METHODS

Study Design: This was a comparative prospective clinical investigation of plain radiography and ultrasonography in detection of the pneumoperitoneum in hollow viscus perforation.

Subjects and methods

One year prospective comparative study was conducted in our hospital during July 2009 to June 2010. About 60 patients, who satisfied the inclusion and exclusion criteria, were enrolled into the study after ethical committee clearance.

The inclusion criteria included was that the patient being strongly suspected of hollow viscus perforation, through either of the investigations or clinically and should have to undergo both the investigations and the patients should undergo exploratory laparotomy later so as to confirm the investigational findings. Exclusion criteria being all the patients who for any reason had not undergone laparotomy.

After a detailed and complete physical examination, erect x-ray abdomen, which included the diaphragm, was taken. If it failed to reveal the pneumoperitoneum, they were subjected to left lateral decubitus x-ray. Evidence of pneumoperitoneum was diagnosed by the trained radiologist. The patients were next subjected to ultrasonographic examination by a blinded ultrasonographer, first in the supine position, in the epigastric region, along the anterior abdominal wall next in left lateral decubitus region and in the right hypogastric region for the evidence of pneumoperitoneum, using 3.5MHz curved array transducer (siemens). Positive results were those with pneumoperitoneum evidence and negative for their absence. Ultrasonographic evidence for the pneumoperitoneum was enhancement of the peritoneal stripe associated with dirty shadowing or distal multiple reflection artifacts between the left lobe and the anterior abdominal wall, in supine position and between the right lobe of the liver and the inner thoracic wall and perihepatic region on the right hypogastric region scan[11]

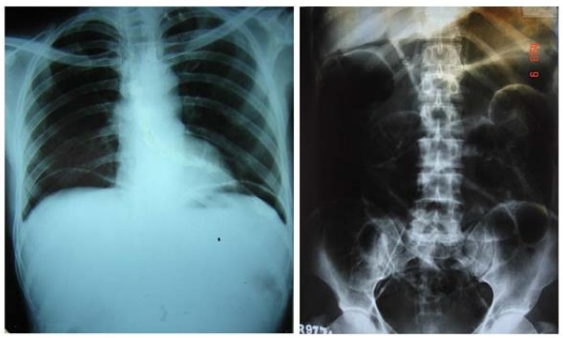
RESULTS

Out of 60 patients, 51 (85%) were male and 9 (15%) were female. Average age being 44 years, youngest being 12 yrs and eldest being 80 yrs. Mean hospital stay was 11 days. There were 2 deaths. All the 60 had undergone exploratory laparotomy, out of which 57 (95%) proved to have hollow viscus perforation. In the remaining 3 (5%), two had appendicular perforation and 1 mesenteric lymphadenitis.

Table 1: Perforated sites.

Duodenum	30
Gastric	13
Ilium	10
Jejunum	2
Caecal	1
Sigmoid	1
Appendicular	2
No perforation	1
Total	60

Plain radiography showed evidence of pneumoperitoneum in 47 patients, out of which one had no perforation. Rest 13 patients were subjected to left lateral decubitus, but did not find any evidence of pneumoperitoneum in our study. Out of these 13 negative radiography findings, 11 had perforation and 2 had no hollow viscus perforation on laparotomy. Ultrasonography had 43 evidence of pneumoperitoneum, out of which 42 proved to have hollow viscus perforation. Out of 17 negative reports, 15 proved to have perforation and in 2 there was no evidence of perforation on laparotomy.



Air under diaphragm *Erect Abdomen showing the delineation of peritoneal reflections and bowel walls*

Figure 1: Plain radiography.

X-ray had a sensitivity of 80.7%, specificity of 66.7%, predictive value of a positive test of 97.9%, predictive value of a negative test of 15.4%, percentage of false negative of 19.3% and percentage of false positive of 33.3%. Ultrasonography had sensitivity of 73.7%, specificity of 66.7%, predictive value of positive test of 97.7%, predictive value of a negative test of 11.8%, percentage of false negative of 26.3% and percentage of false positive of 33.3%.

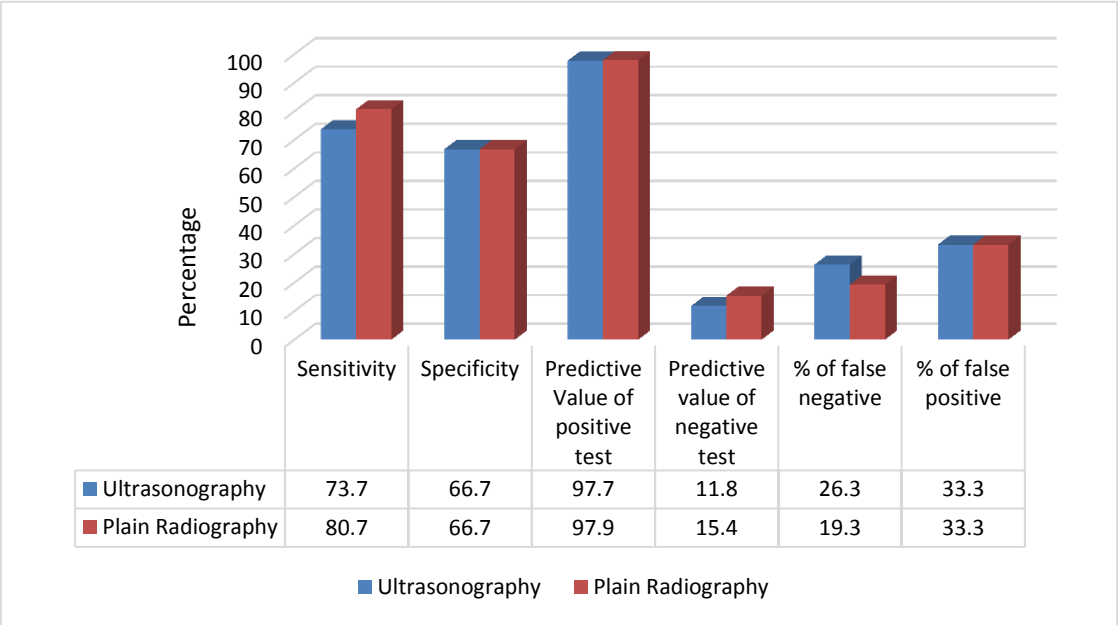


Figure 2: Comparative parameters.

Table 2: Comparative statistics of different studies.

	Present Study		Braccini G et al.[8]		SC Chen et al.[13]		SC Chen et al.[10](2)	
	USG	X-RAY	USG	X-RAY	USG	X-RAY	USG	X-RAY
Sensitivity	73.7	80.7	86	75.7	93	79	92	7
Specificity	66.7	66.7	83.5	89.2	64	64	53	5
Positive Predictive Value	97.7	97.9	87	90.2	97	96	95	94
Negative Predictive Value	11.8	15.4	83.5	76.2	44	21	39	20

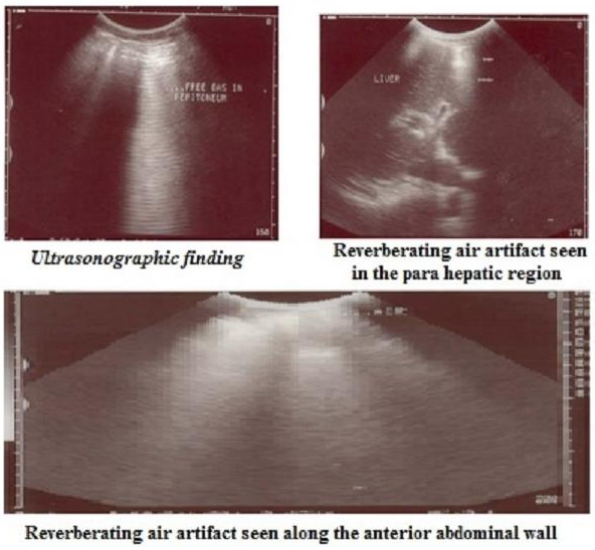


Figure 3: Ultrasonography.

DISCUSSION

Hollow viscus perforation is one of the common surgical emergencies and its detection is usually based on the radiological finding of pneumoperitoneum though recent studies had concluded ultrasonography as more useful.[8,10,13] Their detection in both investigations depends on the quantity of air present in the peritoneal cavity. Seitz and Reising in their experimental study were able to identify 1 ml. of air in the abdomen of an ascites patient with equal certainty.[14] In 1993, Chedha et al[11] in their experimental and clinical study had shown that as little as 5 ml of air could be consistently detected sonographically. Although sonography was found to be more informative than conventional radiology in patients with hollow visceral perforation, they did not find sonography more sensitive than conventional roentgenograms in detecting free intraperitoneal air. In

the study conducted by Miller et al.[1], they were able to detect air less than 1 ml.

Roberto Grassi et al[12] had also found sonographic examination not really useful to identify intraperitoneal free gas. Nevertheless its utility in a diagnostic protocol was high because it could identify the indirect findings of the perforation, such as decreased peristalsis and the presence of free fluid between intestinal loops. In our study, we had sensitivity of radiography of 80.7% which is comparable with their studies but the sensitive of ultrasonography was 73.7% which is quite low. The specificity was 66.7%, which is better. Predictive values of positive test of radiography and the ultrasonography were 97.9% and 97.7%, which are comparably similar to the other studies. In our study we had plain radiography more sensitive than ultrasonography, with equal specificity.

Braccini G et al.[8] did first comparative study. They evaluate ultrasound (US) versus conventional plain (CPF) film radiography in the detection of pneumoperitoneum, 30 patients with postsurgical pneumoperitoneum and a control group of 22 patients were studied using US and CPF. Sonograms and radiograms were obtained while patients were supine and in left lateral decubitus. The two orthogonal plain films of the abdomen were acquired with a horizontal x-ray beam. The epigastric region and right hypochondrium were investigated with ultrasonography. Four experienced, blinded radiologists examined 160 sonograms and 104 radiograms.

SC Chen et al.[13] in 2002 studied 132 patients with suspected hollow organ perforation. All 132 patients received ultrasonography, upright chest radiography and left lateral decubitus abdominal radiography examinations. The diagnostic accuracies of chest and abdominal radiographs for the detection of pneumoperitoneum were compared with corresponding values from ultrasonography. SC Chen et al.[10] in 2002 in another study (study 2) total of 188 patients with suspected hollow organ perforation was studied. All patients had abdominal ultrasonography, upright chest radiography and left lateral decubitus abdominal radiography examinations.

The major studies Braccini G et al.[8], SC Chen et. al.,[13] SC Chen et al.[10] (Study 2) plain radiographic and ultrasonographic parameters have been compared with that of our present study (Table 2).

In the study by SC Chen et al.[13] out of 125 patients who had undergone laparotomy, 121 patients had hollow organ perforation, 3 patients had perforated appendicitis, and one patient had acute cholecystitis. They had suggested that ultrasonography as a useful diagnostic modality when plain radiographs failed to reveal pneumoperitoneum among patients with suspected hollow organ perforation. In the other study by the same authors SC Chen et al.[10] both the modalities were compared in which out of 178 patients 170 hollow organ perforation, five patients had perforated appendicitis and three had acute cholecystitis. Both the study confirmed their results with that of the operative findings and also with that of CT or other investigation like panendoscopy. In contrast with them our study we took surgical finding with which the investigational findings were compared. Since both the study was conducted in the same place their results were high probably due to the expertise in the ultrasonography. In our study the ultrasonography were interpreted by radiologist who were given adequate training with that of the pneumoperitoneum interpretation prior to the start of the study and hence could not be the cause for low results by ultrasonography compared to them. Our study had better specificity probably due to avoidance of misinterpretation with that of the pleura and the overlying rib artefacts. Both of which are known to cause false positive results.

In other study conducted by Chen CH et al.[9] 84 patients with perforated peptic ulcer receiving both upright chest radiography and ultrasonography before laparotomy were studied. Free air was demonstrated in only 46 % upright chest radiographs and 55% by ultrasonography. When both were combined direct sign was demonstrated in 68 % and had concluded that ultrasonography as more sensitive than radiography and the combined methods could increase the overall sensitivity in demonstrating free air. In contrast our study had 80.7 % in surgically proved Radiological positive cases and Ultrasonographic study positive for pneumoperitoneum in 75.43%. In our study we had 82.45 % sensitivity when combined. Since all the parameters were high in our study it did not show any statistically significant increased combined results.

Karahan OI et al.[15] had conducted study to investigate the diagnostic value of a new sonographic technique for the detection of intra abdominal free air. 72 patients with a suspected gastrointestinal tract perforation were included and prospectively evaluated by sonography and abdominal and chest radiography for the detection of intraperitoneal free air. New technique (the scissors maneuver) was used to detect intraperitoneal free air superficial to the liver, the maneuver consisted of applying and then releasing slight pressure onto the abdominal wall with the caudal part of a parasagittaly oriented linear - array probe. 16 patients had a surgically proven gastrointestinal tract perforation causing pneumoperitoneum. Sonography and radiography each showed pneumoperitoneum in 15 patients, with one false negative result for each modality. The sensitivity and specificity values of sonography and radiography were identical, sensitivity was 94% and specificity was 100% for both imaging modalities. The scissors maneuver was positive in all patients with sonographically detected pneumoperitoneum. They had concluded that the sonography as an effective tool in the diagnosis of pneumoperitoneum, with sensitivity and specificity equal to those of radiography. Scissors maneuver may be useful adjunct for improving the diagnostic yield of sonography.

Though our study had low specificity compared with this study it was better than those studies[8, 10, 13] due to the use of this new maneuver in our study.

In the study conducted by Chang - Chien CS et al.[16] abdominal sonography was performed in 283 patients with acute abdominal pain. Of these patients, 10 were diagnosed as having an acute perforated peptic ulcer and 2 were diagnosed as having a sealed off perforated ulcer. The presence of an interference echo with shifting phenomenon is a very strong indication for the presence of free air in the abdominal cavity. Using these criteria, intraperitoneal free air was diagnosed in 9 as comparison to 8 by abdominal and chest radiographs. In our study we adopted this method for the differentiation when there was doubt with that of the rib artefact and found useful.

In the diagnosis of the hollow viscus perforation with that of gastric and colon, we had similar sensitivity of both the investigation, probably because of larger pneumoperitoneum, which they produce[10]. In jejunal and ileal perforation, they had a very low but similar sensitivity of 33.1%, probably due to the low amount of air. In duodenal perforation x-ray showed sensitivity of 90% with that of ultrasonography of 80%. This was probably due to the dilated bowels, which are known to cause difficulty in ultrasonography interpretation. Ultrasonography finding of the pneumoperitoneum is due to the fact that the sound waves initially transmitted from the transducer would get reflected from the junction of the abdominal wall and the air. The reflected waves again get reflected with that of the transducer. This process continues till the initial sound waves progressively get scattered away, casting a dirty shadowing distal to the initial reflected region. Ultrasonography is known to have false positive evidence of reverberating air artefacts due to the presence of overlying rib, air in the costo-phrenic recess (overcome by noting the step pattern) and the intraluminal air (differentiated by the fact that free air can be displaced).[11, 16,17, 18] More over ultrasonography is operator dependent.

In radiography we found air under the diaphragm in the form of a crescent as the most common finding as it was found in all. Rigler's sign/double wall sign (delineation of the bowel wall) in two patients. Falciform sign (visualization of the falciform ligament), the visualization of the umbilical ligament and Foot Ball sign (delineation of the peritoneal cavity) were visualized in one patient each. Hence in plain radiography, air under diaphragm is the most important finding, which should be searched for, which is consistent with studies done by Marija Frkovic et al.[19] who had 92% crescent shaped free air beneath the diaphragm in contrast to our 46%.

CONCLUSION

This study was a prospective clinical investigational study where in two modalities ultrasonography and plain radiography were compared with that of the operative findings. They were compared in terms of their sensitivity, specificity, positive and negative predictive value, percentage of false positive and false negative test. Total of 60 patients were enrolled into the study that satisfied the inclusion and exclusion criteria. X-ray had a sensitivity of 80.7%, specificity of 66.7%, predictive value of a positive test of 97.9%, predictive value of a negative test of 15.4%, percentage of false negative of 19.3%, percentage of false positive of 33.3%. Ultrasonography had sensitivity of 73.7%, specificity of 66.7%, predictive value of positive test of 97.7%, predictive value of a negative test of 11.8%, percentage of false negative of 26.3% and percentage of false positive of 33.3%.

From our study detection of free intra-abdominal air is better with the plain radiography when compared with the ultrasonography. The certainties with which both interpret as to the presence of free air are same. The advantages of x-ray are that it is readily available and its interpretation does not require much expertise. The major drawback is that of the positioning of the patients who are in the peritonitis phase where in their movement would add to agony. To some extent it can be overcome by taking the patient in the left lateral decubitus. Disadvantages being that of the time delay in processing x- ray which can lead to the delay in surgical intervention and other are the radiation exposure which would be undesirable in the pregnant and pediatric patients.

Ultrasonography is also readily available. The scanning can be done in the emergency room with minimal positioning of the patient and no processing delay. It can also detect simultaneously other pathology which would help in ruling out other conditions. But the ultrasonographic interpretation requires expertise in the procedure. It is thus an operator dependent. Hence it cannot be interpreted with the same confidence and certainty by a non expert operator. With recent trends of more stress laid on learning of sonography by surgeons and being it considered as an extension of clinical examination it is fore most that basic knowledge of it is a must for the surgeons. Hence from our study it appears that even though ultrasonography is a valuable tool in the detection of the pneumoperitoneum yet plain radiography has more sensitivity but same specificity. Hence ultrasonographic finding of pneumoperitoneum should be considered as an added finding.

When expert ultrasonographer interprets the presence of free abdominal air it would be sufficient and the patient need not be subjected for further confirmation by radiography as both ultrasonography and plain radiography can detect pneumoperitoneum at the same rate (specificity) and no further information would be obtained. When the expert ultrasonographer is not available and when ultrasonography fails to detect the presence of free intraabdominal air in clinically strongly suspected cases it is better to go for plain radiography for the conformation. Further study can be conducted so as to

add on the secondary findings during the ultrasonographic study of hollow viscus perforation.

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