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Original Article

Comparative Study of Ultrasonography with Plain Radiography in the Diagnosis of Pneumoperitoneum

Raja Shekhar[1], Satyam Guntupalli[2], Padmanabh S Inamdar[3]

[1]Senior Resident, Department of Surgery, Mamata Medical College and Hospital, Khammam, Telangana, India, [2]Associate Professor, Department of Surgery, Mamata Medical College and Hospital, Khammam, Telangana, India, [3]Associate Professor, Department of Surgery, Mamata Medical College and Hospital, Khammam, Telangana, India

Abstract

Introduction: Pneumoperitoneum results most commonly results from a perforated hollow viscus. Although several reports have documented the detection of free intraperitoneal air in patients with acute abdominal disorders, the relative sensitivity and specificity of ultrasonography and plain radiography remains unclear. The aim of this study was to compare ultrasonography with plain radiography in the detection of pneumoperitoneum in suspected cases of hollow viscus perforation.

Materials and Methods: This prospective comparative study was conducted on 60 patients in our institute from November 2013 to September 2015. Patients suspected of hollow viscus perforation, undergoing both investigations and exploratory laparotomy were included in this study.

Results: Out of the 60 patients, 56 had perforation on laparotomy. Plain radiography showed evidence of pneumoperitoneum in 48 patients, out of which one had no perforation with a sensitivity and specificity of 83.92% and 75%. Ultrasonography showed evidence of pneumoperitoneum in 42 cases, out of which 41 cases were proved to have hollow viscus perforation on laparotomy with a sensitivity and specificity of 73.2% and 75%.

Conclusion: From this study, it appears that even though ultrasonography is a valuable tool in the detection of the pneumoperitoneum yet plain radiography has more sensitivity. Hence, the ultrasonographic finding of pneumoperitoneum should be considered as an added finding.

Keywords: Pneumoperitonium, Ultrasonography, Plain radiography

INTRODUCTION

Pneumoperitoneum results most commonly from a perforated hollow viscus. Plain radiography of the chest and abdomen using a horizontal X-ray beam is a standard method for the detection of pneumoperitoneum.[1] The presence of free intraperitoneal gas on a routine radiograph usually indicates bowel perforation. Experimental studies have shown that as little as 1 ml of gas can be detected below the right hemidiaphragm on properly exposed erect chest radiographs. A left lateral decubitus film can also be used in the detection of small amounts of free air that may be interposed between the free edge of the liver and the lateral wall of the peritoneal cavity.[2]

However, plain radiography has the inherent disadvantage that the presence and extent of abnormal lucency may not accurately reveal the extent of pneumoperitoneum. Many patients with an acute abdomen or acute trauma are too sick or debilitated to stand up for erect chest radiographic examinations.[1] Computed tomography scan is superior to plain radiography and ultrasonography.[3] However, the availability, cost effectiveness and more radiation exposure are the limiting factors.[3,4]

Ultrasonography has emerged as an alternative initial diagnostic procedure in patients with an acute abdomen.

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Corresponding Author: Satyam Guntupalli, Department of Surgery, Mamata Medical College and Hospital, Khammam, Telangana - 507 002 India. Phone: +91-9160814653. E-mail: satyamguntupalli@gmail.com

Advantages being that it can be done in an emergency room with the minimal positioning of the patient, immediate reporting, and no radiation exposure and added to that it can look into other abnormal conditions.[1,5] Nevertheless, this exam has its own pitfalls. It is strongly operator dependent; some machines have low-quality images that may not be able to detect intraperitoneal free air; sonography is also difficult in obese patients and with those having subcutaneous emphysema.[6]

Although several reports have documented the detection of free intraperitoneal air in patients with acute abdominal disorders, the relative sensitivity and specificity of ultrasonography remain unclear. The aim of this study was to compare ultrasonography with plain radiography in the detection of pneumoperitoneum suspected cases of hollow viscus perforation.

MATERIALS AND METHODS

This prospective comparative study was conducted on 60 patients in our institute from November 2013 to September 2015. Patients suspected of hollow viscus perforation, undergoing both investigations and exploratory laparotomy were included in this study.

Methods

After a detailed and complete physical examination, erect abdominal radiography, 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 consultant radiologist.

The patients were next subjected to ultrasonographic examination by a blinded ultrasonographer, first in the supine position, in the epigastric region, along with the anterior abdominal wall; next in left lateral decubitus region in the right hypogastric region for the evidence of pneumoperitoneum, using 3.5 MHz curved array transducer (Siemens). Ultrasonographic evidence for the pneumoperitoneum was enhancement of the peritoneal stripe associated with dirty shadowing or distal multiple reflection artifacts between the left lobe of liver 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.[7]

Statistical Analysis

All the data were collected and tabulated. Statistical analysis in terms of sensitivity, specificity, positive predictive value, negative predictive value, percentage of false negative, and percentage of false positive was calculated for both the modalities.

RESULTS

In this study, the average age was found to be 48.26 years (8-75 years). Out of 60 patients, 49 (81.66%) were male, and 11 (18.33%) were female with a male to female ratio of 4.4:1. Gastric perforation was seen in 29 cases (48.3%), followed by duodenal perforation (20%), and then ileal perforation (15%). In 9 cases perforation was noted in jejunum, colon and appendix and no perforation was noted in Table 1.

Radiological Signs on Plain Radiography

In radiography, in this study it was 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 (delineation of the bowel) was seen in two patients. Falciform sign (visualization of the falciform ligament), the visualization of the umbilical ligament and football sign (delineation of the peritoneal cavity) was seen in one patient each. The radiological signs and their incidence in this study were shown in Table 2.

Plain Radiography Findings

Plain radiography showed evidence of pneumoperitoneum in 48 patients, out of which one had no perforation. Rest 12 patients were subjected to left lateral decubitus but did not find any evidence of pneumoperitoneum. Out of these 12 negative radiography findings, 9 had perforation, and 3 had no hollow viscus perforation during laparotomy. Out of the 56 cases with hollow viscus perforation, 47 were correctly identified on x-ray as having pneumoperitoneum with a sensitivity of 83.92%. 4 cases were not having hollow viscus perforation on laparotomy and out of these, 3 cases were correctly identified on X-ray as not having pneumoperitoneum. This accounted to the specificity of

Table 1: Age distribution

Age distribution	Number of patients *n*=60 (%)
<20	5 (8.3)
21-30	5 (8.3)
31-40	9 (15)
41-50	11 (18.3)
51-60	22 (36.6)
61-70	6 (10)
>70	2 (3.3)

Table 2: Incidence of various radiological signs seen in this study

Various radiological signs seen in this study	
Crescent sign	47
Rigler's sign	2
Falciform sign	1
Football sign	1
Umbilical sign	1

plain X-ray as 75% with a positive predictive value of 97.91% and negative predictive value of 25%.

Ultrasonography showed evidence of pneumoperitoneum in 42 cases, out of which 41 cases were proved to have hollow viscus perforation on laparotomy. Out of 18 negative reports, 15 patients had perforation, and in 3 there was no evidence of perforation with a sensitivity of 73.21%, specificity of 75%, positive predictive value of 97.61%, and negative predictive value of 16.66% (Table 3).

DISCUSSION

In this study, most common site of perforation was stomach which was noted in 29 cases (48.33%) followed by duodenum (20%) followed by ileal perforation (15%). In a study conducted by Afridi *et al*.,[7] duodenum accounted for the most common site of perforation (43.6%) followed by ileum (37.6%) followed by colon (8.9%). The previous history of peptic ulcer might be the reason for the increased incidence of perforation in stomach in this study. Perforations in proximal gastrointestinal tract were more commonly observed in our study as compared to perforations in distal gastrointestinal tract[8] in the case of developed countries such as United States[9] and Japan.[10] This might be due to increased incidence of Helicobacter pylori infection in stomach in Indian population compared to western countries (Table 4).

According to Chen *et al*.,[11] sensitivity of plain radiography was 79% whereas the sensitivity of ultrasonography in their study was 93%. The sensitivity of plain radiography of this study was comparable to the other studies, whereas the sensitivity of ultrasonography in other studies was higher when compared to this study. In this study, the ultrasonographic findings were interpreted by consultant. Ultrasonographers who were given adequate training with that of the pneumoperitoneum interpretation before the start of the study and hence could not be the cause for low results compared to them.

The specificity of plain radiography in this study was 75% which was similar to that of ultrasonography (75%). The specificity of both investigations in the study by Ibtesam and Shadydy[3] was 50%. The specificities of both plain radiography and ultrasonography were higher (75%) in this study when compared to other studies. This better specificity of ultrasonography in this study might probably be due to the avoidance of misinterpretation with that of the pleura and overlying rib artifacts, both of which are known to cause false positive results.

To prevent the echo pattern visible in the pleural-diaphragmatic recess from being misinterpreted for free air, modification of the patient position from supine to left lateral during the examination is essential because it permits confirmation of the origin of the interference echo pattern. The presence of an interference echo with shifting phenomenon was useful as a strong indicator for the presence of free air in the abdominal cavity.

To confirm the air was intra-abdominal but not in the overlying air-filled lung, views in both expiration and inspiration were obtained as done in the studies by Lee *et al*.[12] and Chang-Chien *et al*.[13] This technique aids one to differentiate free gas within the peritoneal cavity and air in the lung.

In expiration, the free air was seen superficial to the liver, however, this was not proven to be within the abdominal cavity. On inspiration, the inflated lung was seen traversing down in front of the gas collection, thus proving its intra-abdominal location. This is described as the "interface echo pattern" and shifting phenomenon (Figure 1).

Table 3: Comparative parameters

Statistical test	Plain radiography	Ultrasonography
Sensitivity	83.92	73.21
Specificity	75	75
Positive predictive value	97.91	97.61
Negative predictive value	25	16.66

Table 4: Comparative analysis of site of perforation

Site of perforation	Afridi *et al*.[7]%	Present study (%)
Gastric	2.3	48.33
Duodenum	43.6	20
Jejunum	3.3	5
Ileum	37.6	15
Appendix	5	5
Colon	8.9	5
No perforation	0	1.6

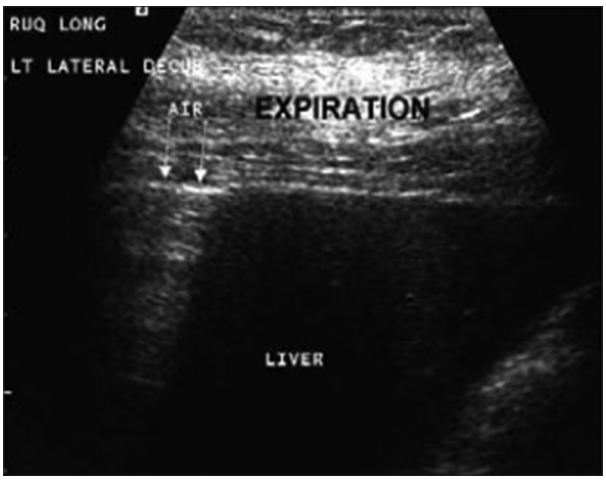

Figure 1: Reverberation from free air anterior to the liver – "interface echo pattern"

Table 5: Comparative analysis of variables of plain radiography and ultrasonography

Statistical test	Present study	Chen *et al*.[11]	Chen *et al*.[16] (2)	Ibtesam and Shadydy[3]	Romero and Castaño[14]
Sensitivity					
Plain radiography	83.92	79	78	75	78
Ultrasonography	73.2	93	92	90	92
Specificity					
Plain radiography	75	64	53	50	53
Ultrasonography	75	64	53	50	53
Positive predictive value					
Plain radiography	97.9	96	94	93	94
Ultrasonography	97.6	53	65	95	95
Negative predictive value					
Plain radiography	25	21	20	18	20
Ultrasonography	16.6	50	39	36	39

The values of plain radiography and ultrasonography were 93% and 95%, respectively, in the study by Ibtesam and Shadydy,[3] whereas in the study by Romero and Castaño,[14] the values were 94% and 95%, respectively. These were almost similar to this study. The positive predictive values were higher could be due to the use of newer technique "scissors maneuver" in this study, which was described by Karaha *et al*.[15]

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 parasagittally oriented linear – array probe.

The negative predictive value of the plain radiography in this study was 25% which was better when compared to the negative predictive value of ultrasonography, which was 16.66%. The negative predictive value of plain radiography in the study by Chen *et al*.[11] was 21% in one study and 20% in second study,[16] which were low when compared to the negative predictive values of ultrasonography, which were 50% and 39%, respectively, in both studies.

Absence of pneumoperitoneum, in some cases of hollow viscus perforation covered by peritoneum, can be a result of insufficient amount of air leak to be detected on roentgenogram. Delayed presentation to the hospital during where escaped gas may get absorbed (as post-surgical pneumoperitoneum will resolve within 2 days in 2/3 of cases and within 5 days in 97% cases when assessed by serial abdominal radiography), obliteration of subdiaphragmatic space by a pathological process, adhesions, the plugging of the perforation by food or redundant mucosa, sealing of the perforation by omentum or peritoneum before the escape of sufficient amount of intraluminal gas which could be demonstrated by radiological method (Table 5).

Similar to study conducted by Prasad *et al*.,[17] we can propose that ultrasonography can be a useful alternative imaging modality for the detection of pneumoperitoneum in patients who are ill and cannot stand, and in whom the ultrasonography confirms the presence of intraperitoneal free air, it is not necessary to subject them again to plain radiography. Free intra-abdominal air detection is operator dependable and can be difficult even for an experienced ultrasound operator. It is important to stress that ultrasound usually rules in and does not rule out a bowel perforation which indicates that a negative study does not exclude a bowel perforation.

CONCLUSION

From this study, detection of free intra-abdominal air is more sensitive with plain radiography than with ultrasonography. With the advantage of detecting other intra-abdominal pathology, ultrasonography can be useful adjunct to plain X-ray in cases suspected of pneumoperitoneum.

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