ORIGINAL ARTICLE

Postsurgical Pneumoperitoneum – Comparison of Abdominal Ultrasound Findings with Plain Radiography

Abdul Ghaffar, Tariq Saeed Siddiqui, Haseeb Haider* and Hanif Khatri

ABSTRACT

Objective: To compare abdominal ultrasonography findings with plain radiography in the detection of postsurgical pneumoperitoneum.

Study Design: Cross-sectional, observational.

Place and Duration of Study: Radiology Department, PNS Shifa Hospital, Karachi, from October, 2005 to April, 2006.

Methodology: Thirty patients of either gender who underwent laparotomies were included in the study. Patients were examined with plain radiography and abdominal ultrasound to detect postsurgical pneumoperitoneum within 24 hours of surgery. Upright chest radiography and left lateral decubitus views of abdomen were used to detect free air. McNemar test was applied to compute relationship between sonographic and radiographic findings.

Results: Among 30 patients, 22 (73.3%) were females and 8 (26.7%) were males (M: F = 1: 2.75). Average age was 38.07 ± 12.41 years. Out of 30 patients of postsurgical pneumoperitoneum, 27 (90%) were detected on ultrasonography while 3 (10%) were not detected. On plain X-rays, 4 patients were observed in group-I (no free air) and 26 in group-II (1-10 mm thickness). Significant ($p<0.001$) relationship was observed between the two findings.

Conclusion: Since both modalities can diagnose pneumoperitoneum reliably, ultrasonography can be a useful alternative imaging modality for the detection of pneumoperitoneum.

Key words: *Pneumoperitoneum. Ultrasonography. Perforation. Postsurgical. Radiography.*

INTRODUCTION

Pneumoperitoneum most commonly results from perforated hollow organ viscus, surgical procedures or a gas-forming intra-abdominal abscess. Postoperative pneumoperitoneum may take upto 24 days to resolve. Usually it resolves within 3-6 days.

Upright chest radiography, using a horizontal X-rays beam is the standard method in the detection of pneumoperitoneum.[1,2] Plain radiography can demonstrate 55-85% of patients with pneum-operitoneum.[3,4] However, diagnosis based on this method has practical limitations since many patients are too sick or debilitated to stand for chest radiographic examinations and in pregnant ladies, radiation exposure might be a problem.[5,6] A Left Lateral Decubitus (LLD) abdominal radiograph may also be used to demonstrate pneumoperitoneum. Incorporating LLD abdominal radiography may improve the sensitivity to detect pneumoperitoneum. Ultrasonography (US) is a rapidly expanding modality in our country and has been widely used in the evaluation of the patient with an acute abdomen.[7,8] Many patients will undergo ultrasonography as their initial investigation. Detection of pneumoperitoneum on sonography in patients with an acute abdomen is an important sign of a perforated viscus.[9] Evaluation of the peritoneum is often neglected during abdominal and pelvic US due to unfamiliarity with the common US features of pneumoperitoneum in a patient with suspected hollow viscus perforation.

Although US should not be used to exclude the diagnosis of pneumoperitoneum, its identification is an extremely important finding. It was hypothesized that there is no marked difference between abdominal ultrasound and plain radiography findings in the detection of postsurgical pneumoperitoneum.

The objective of this study was to compare abdominal ultrasonography findings with plain radiography in the detection of postsurgical pneumoperitoneum.

METHODOLOGY

It was a cross-sectional study, conducted in the Department of Radiology in collaboration with Surgical Department at PNS Shifa, in Karachi, Pakistan from October 2005 to April 2006.

Thirty patients of either gender, aged 15-60 years, who underwent laparotomy, were included in the study. Patients who were stable postoperatively were included and patients below 15 years and above 60 years were excluded from the study. A 500 MAs X-ray machine Model KXO-12 was used for radiological examination.

Department of Diagnostic Radiology, PNS Shifa Hospital, Karachi.

** Department of General Surgery, PNS Shifa Hospital, Karachi.*

***Correspondence:** Brig. Abdul Ghaffar, Classified Radiologist, Military Hospital, Rawalpindi.*
E-mail: aghaffarpk@hotmail.com

Received November 30, 2007; accepted May 21, 2008.

Left lateral decubitus and upright chest radiographs were taken in cases fulfilling the inclusion criteria. Ultrasound abdomen was performed on Toshiba Nemio ultrasound machine using 3.5 and 5.0 MHz convex and 7.5 MHz linear transducers on real time scanners. Ultrasound scans were done with patient lying in supine and left lateral positions.

Informed consent was taken from all the patients before surgery to be included in the study. Selected patients from wards were shifted to radiology department on first postoperative day, within 24 hours of the opening of peritoneum. Either left lateral decubitus and upright chest radiograph or only one of them was taken depending upon the patient's general condition and morbidity. Grouping was done on the basis of air thickness on plain radiography. Thickness was measured with ordinary scale at maximum point of thickness on plain radiograph. Based upon plain radiographic findings, the cases were divided into following four groups: group 1: no free air seen, group 2: free air of less than 10 mm thickness, group 3: free air of 10-30 mm thickness and group 4: free air of more than 30 mm thickness. Ultrasound was performed with 3.5, 5.0 MHz convex and 7.5 MHz linear transducers on real time scanners. The transducer was placed longitudinally and transversely on the anterior abdominal wall of the right upper quadrant with the patient supine. The patient was re-examined through the intercostals space in the left lateral decubitus position. Axial, oblique and coronal scans were also performed across the intercostals space at the mid-axillary line during inspiration and expiration to differentiate between pulmonary air and pneumoperitoneum. Shifting phenomenon, shifting of the interference echo pattern following displacement of air in the peritoneal cavity on changing posture and visible peristalsis were used to differentiate between intraluminal air and pneumoperitoneum. Sonographic appearance of the peritoneal interface with gas artifacts distal to the pockets of free air was also documented. After ultrasound and radiological examination, patients were shifted back to wards. Relevant features were recorded on proforma and SPSS-10.0 was used for statistical analysis. Ultrasonographic and radiographic findings were presented by frequencies and percentages. McNemar test for paired qualitative data (plain radiograph and ultrasound findings) to assess the relationship was applied in order to test the hypothesis at $p < 0.05$ level of significance.

RESULTS

Among the 30 patients, 22 (73.3%) were females and 8 (26.7%) were males with 1: 2.75 male to female ratio. Average age of the patients was 38.07 ± 12.41 (ranging from 17 to 56 years).

Out of 30 patients, free air was detected by sonography in 27 (90%) patients with both convex (Figure 1) and linear probes (Figure 2). Free air was detected more easily with linear than with convex probes due to superior near field resolution. In all these patients, air was detected in the right upper quadrant anterior to liver surface and right para median epigastric region. In 3 (10%) patients, free air was not detected. On plain X-rays, 4 patients were observed in group-I (no free air), 3 (10%) were negative with no free air on ultrasound examination but in one patient, free air was detected on ultrasound examination. All those 3 patients were obese. Twenty-six (86.67%) patients on plain X-rays were categorized in group-II (1-10 mm thickness, Figure 3) and in all these patients, free air was detected. As the general condition of the patients was reasonably stable, therefore, both the upright chest and left lateral decubitus radiograph were done in all the 30 patients. Both views demonstrated similar results.

Figure 1: Sonogram (convex probe 5 MHz) showing pneumoperitoneum, seen as an echogenic line with posterior ring-down or reverberation artefact.

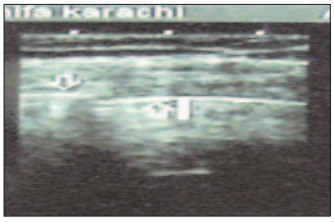

Figure 2: Sonogram (linear probe 7.5 MHz) shows free air (open arrow pointing upward) between anterior abdominal wall and the liver whereas open arrow pointing downward is showing air in the lungs.

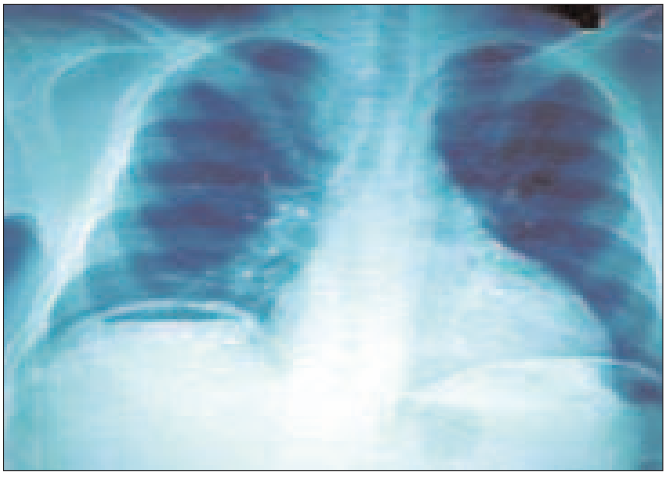

Figure 3: Erect X-ray chest showing free air under the right hemidiaphragm.

Data showed significant relationship between plain x-ray and ultrasound findings in detection of free air ($p < 0.001$). Out of 15 patients of age ≤ 35 years, free air on ultrasonography was detected in 14 (93.3%) patients while in only one (6.67%) patient, free air was not detected. On the other hand, out of 15 patients,

aged > 35 years, free air was detected in 13 (86.7%) patients and in 2 (13.3%) patients, free air was not detected. In 8 male patients, free air was detected in all 100% patients.

DISCUSSION

Erect chest radiographic examinations for determination of pneumoperitoneum have certain practical limitations. Radiographs are taken with portable X-rays machines and proper positioning of the patient is difficult. If erect radiograph is not possible due to some reasons then diagnosis of pneumoperitoneum on supine film of abdomen, without consulting a radiologist, can be very difficult. Free air is missed on upright posteroanterior radiographs in 20-62 per cent cases.[10,11] Ultrasound is a safe, relatively inexpensive, ionizing radiation-free and readily accessible imaging tool for investigation of many peritoneal and intra-peritoneal diseases.[12-17] It is particularly valuable in patients for whom radiation is a major concern. These patients include children, pregnant women and individuals of reproductive age.

CT is the gold standard for the detection of pneumoperitoneum.[18,19] It was not utilized in this study due to increased dose of radiation delivered and higher cost. Role of sonography in terms of sensitivity, specificity, positive predictive value and negative predictive value can be calculated by including CT. In this study, due to this limitation, only comparison between plain X-rays and sonography was made.

In this study, free intra-peritoneal air was detected through ultrasonography in 90%. The 3 patients in whom free air was not detected were females. One common factor which was observed in all the 3 patients was obesity. This was the main factor for disbalanced female to male ratio in this study. Difficulty has been reported in identifying peritoneal stripe in obese patients.[20,21] Majority of patients with free peritoneal air are acutely ill (due to perforated hollow viscus) and require diagnostic imaging modality which is quicker to perform. US examination takes longer time to scrutinize epigastrium and right upper quadrants for the presence of free air as compared to plain X-rays. In this study, it took 20-25 minutes to reach diagnosis. Time factor is mainly dependent upon the operator's skill and experience.

Ultrasonography has the additional advantage of detecting other findings associated with pneumoperitoneum that were not found on the plain X-rays.[9,12] Lee *et al.* reported 5 patients who presented with acute abdominal symptoms and identified the site of perforation in 4 out of 5 patients. It, however, remains operator-dependent;[20] for an independent ultrasonographer to perform ultrasonography and interpret the results with accuracy, for which adequate training is required. In this study, all the cases were postoperative and sonography revealed evidence of intervention. US machines are readily available in most centres but experienced radiologists are not available for 24 hours of the day; therefore, it is inevitable that ultrasonography is performed by other trained physicians.[22] In most of the centres in our setup, X-rays machines and radiographers are available for 24 hours to perform plain X-rays and signs of free air are usually interpreted easily on erect chest and LLD films.

On plain X-rays, 4 patients were observed in group-I (No free air). Twenty-six (86.67%) patients on plain X-rays were categorized in group-II (1-10 mm thickness) and in all these patients, free air was detected (Table I). 'Woodring JH' and 'Stapakis JC' reported that free air can be missed, on upright posteroanterior radiographs in 20-62 per cent cases.[10]

CONCLUSION

Since both modalities can diagnose pneumoperitoneum reliably, ultrasonography can be a useful alternative imaging modality for the detection of pneumoperitoneum.

REFERENCES

1. Markowitz SK, Ziter FM Jr. The lateral chest film and pneumoperitoneum. *Ann Emerg Med* 1986; **15**:425-7.
2. Miller RE, Nelson SW. The roentgenologic demonstration of tiny amounts of free intraperitoneal gas: experimental and clinical studies. *Am J Roentgenol Radium Ther Nuci Med* 1971; **112**:574-85.
3. Maull KI, Reath DB. Pneumogastrography in the diagnosis of perforated peptic ulcer. *Am J Surg* 1984; **148**:340-5.
4. Roh JJ, Thompson JS, Harned RK, Hodgson PE. Value of pneumoperitoneum in the diagnosis of visceral perforation. *Am J Surg* 1983; **146**:830-3.
5. Levine MS, Scheiner JD, Rubesin SE, Laufer I, Herlinger H. Diagnosis of pneumoperitoneum on supine abdominal radiographs. *AJR Am J Roentgenol* 1991; **156**: 731-5.
6. Shaffer HA Jr. Perforation and obstruction of the gastrointestinal tract. Assessment by conventional radiology. *Radiol Clin North Am* 1992; **30**:405-26.
7. Chen SC, Chen KM, Wang SM, Chang KJ. Abdominal sonography screening of clinically diagnosed or suspected appendicitis before surgery. *World J Surg* 1998; **22**:449-52.
8. Chen SC, Lin FY, Hsieh YS, Chen WJ. Accuracy of ultrasonography in the diagnosis of peritonitis compared with the clinical impression of the surgeon. *Arch Surg* 2000; **135**:170-3.
9. Lee DH, Lim JH, Ko YT, Yoon Y. Sonographic detection of pneumoperitoneum in patients with acute abdomen. *AJR Am J Roentgenol* 1990; **154**:107-9.
10. Woodring JH, Heiser MJ. Detection of pneumoperitoneum on chest radiographs: comparison of upright lateral and posteroanterior projections. *AJR Am J Roentgenol* 1995; **165**:45-7.
11. Stapakis JC, Thickman D. Diagnosis of pneumoperitoneum: abdominal CT vs. upright chest film. *J Comput Assist Tomogr* 1992; **16**:713-6.
12. Hanbidge AE, Lynch D, Wilson SR. US of the peritoneum. *Radiographics* 2003; **23**:663-84.

13. Braccini G, Lamacchia M, Boraschi P, Bertellotti L, Marruci A, Goletti O, *et al.* Ultrasound versus plain film in the detection of pneumoperitoneum. *Abdom Imaging* 1996; **21**:404-12.
14. Ogata M, Mateer JR, Condon RE. Prospective evaluation of abdominal sonography for the diagnosis of bowel obstruction. *Ann Surg* 1996; **223**:237-41.
15. Romano WM, Platt JF. Ultrasound of the abdomen. *Crit Care Clin* 1994; **10**: 297-319.
16. Hernandez JA, Swischuk LE, Angel CA, Chung D, Chandler R, Lee S. Imaging of acute appendicitis: US as the primary imaging modality. *Pediatr Radiol* 2005; **35**:392-5.
17. Chadha D, Kedar RP, Malde HM. Sonographic detection of pneumoperitoneum: an experimental and clinical study. *Australas Radiol* 1993; **37**:182-5.
18. Lee FT Jr, Leahy-Gross KM, Hammond TG, Wakeen MJ, Zimmerman SW. Pneumoperitoneum in peritoneal dialysis patients: significance of diagnosis by CT. *J Comput Assist Tomogr* 1994; **18**: 439-42.
19. Earls JP, Dachman AH, Colon E, Garrett MG, Molloy M. Prevalence and duration of postoperative pneumoperitoneum: sensitivity of CT vs. left lateral decubitus radiography. *AJR Am J Roentgenol* 1993; **161**:781-5.
20. Muradali D, Wilson S, Burns PN, Shapiro H, Hope-Simpson D. A specific sign of pneumoperitoneum on sonography: enhancement of the peritoneal stripe. *AJR Am J Roentgenol* 1999; **173**:1257-62.
21. Asrani A. Sonographic diagnosis of pneumoperitoneum using the 'enhancement of the peritoneal stripe sign.' A prospective study. *Emerg Radiol* 2007; **14**:29-39.
22. Williams RJ, Windsor AC, Rosin RD, Mann DV, Crofton M. Ultrasound scanning of the acute abdomen by surgeons in training. *Ann R Coll Surg Engl* 1994; **76**: 228-33.