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Original article

Post-Surgical Pneumoperitoneum Comparison of Abdominal Ultrasound Findings and Plain Radiography

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Abstract
Pneumoperitoneum refers to the presence of air within the peritoneal cavity and can be divided into two subgroups: surgical pneumoperitoneum (90%) and nonsurgical pneumoperitoneum (10%). Postoperative pneumoperitoneum, a benign and self-limited finding, takes up to 24 days after surgery to resolve. Generally, it resolves within 3-6 days. To determine the sensitivity of ultrasound (USS) in detecting post-surgical pneumoperitoneum and to compare abdominal ultrasonography findings with plain radiography (X-ray), this study is a cross-sectional study carried out at the Radiology Department of Benghazi Medical Center from January 2018 to December 2018. The study included 90 patients aged 15 to 80 years, with a mean age of 37 ± 17.2 years. The types of surgery were as follows: Cholecystectomy (32.2%), Appendectomy (25.7%), Inguinal hernia repair (11%), Segmental sigmoidectomy (5.6%), and Diagnostic laparoscopy (10%). Left hemicolectomy, Splenectomy, ovarian cyst removal, and incisional hernia repair accounted for 2.2% each. Para-umbilical hernia, Hiatus hernia, Colon cancer resection, Sigmoidectomy, choledochoduodenostomy, and umbilical hernia repair accounted for 1.1% each. The timing of X-rays showed that 88.9% were done at the same time as USS and 11.1% were performed 24 hours after USS. Post-surgical pneumoperitoneum was present in 98.6% of cases on USS and X-ray. 12.1% of males and 17.5% of females. The difference was not statistically significant (p-value = 0.494). The study concluded that the sensitivity of USS was superior to abdominal radiography in the diagnosis of pneumoperitoneum.
Keywords: Pneumoperitoneum, Post-Surgical, Ultrasonography, Radiography, Sensitivity.

Introduction

Pneumoperitoneum refers to the presence of air within the peritoneal cavity and can be classified into two main types: surgical pneumoperitoneum, which accounts for about 90% of cases, and nonsurgical pneumoperitoneum, making up the remaining 10% [1]. It most commonly arises from perforated hollow organs, gas-forming intra-abdominal abscesses, or as a result of surgical procedures. Postoperative pneumoperitoneum usually resolves within 3 to 6 days but can sometimes persist for up to 24 days [2]. Diagnosing pneumoperitoneum based on clinical signs and symptoms alone is often unreliable. Abdominal X-rays detect free air in about 55–85% of cases [3-7]. While computed tomography (CT) is considered the gold standard for identifying free intraperitoneal air, it is not practical as a routine screening tool for patients with acute abdominal pain due to its high cost, limited availability in some centers, exposure to significant radiation, and the need to transfer patients for the scan [8,9].

Common symptoms of pneumoperitoneum include abdominal pain, vomiting, abdominal distension, constipation, fever, diarrhea, rapid heartbeat (pulse over 110 beats per minute), low blood pressure (systolic below 100 mmHg), decreased urine output (less than 30 ml per hour), and increased respiratory rate (over 20 breaths per minute) [10]. The exact clinical presentation depends on the site of the perforation. For example, patients with a duodenal ulcer perforation often report a brief history of epigastric pain with generalized tenderness and guarding, sometimes accompanied by a history of NSAID use. Small bowel perforations tend to present with a longer history of fever followed by lower abdominal pain. Appendiceal perforations typically cause pain starting in the right lower abdomen or around the navel, along with fever and vomiting. Interestingly, perforations of the upper gastrointestinal tract are more common in countries like India, while studies from developed nations such as the USA, Greece, and Japan report a higher incidence of perforations in the lower parts of the gastrointestinal tract [11]. The peritoneum is a thin, serous membrane that lines the abdominal cavity. It has parietal and visceral layers [12]. In cases of pneumoperitoneum, gas may be visible next to the peritoneal line or above the liver. Small gas locules may also be visible outside the gut in cases of perforation [13].

An abdominal X-ray can reveal various signs of pneumoperitoneum, including Cupola/Mustache Triangular Sign: A triangular gas pocket between three bowel loops. Middle Umbilical Ligament/Urachus Sign: Visualization of the urachus outlined by gas [14]. The liver and the diaphragm may appear similar to pneumoperitoneum. In this case, an examination with a high-frequency linear probe will show that haustral folds are typically visible. Additionally, if the gas is tracked throughout the abdomen, it will not be continuous with the peritoneal line. Furthermore, a loculated basal pneumothorax may produce a similar appearance, with gas that does not move and obscures the liver. The indications listed below can aid in distinguishing these conditions, even though their clinical presentations are typically unique [15]. With

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patient positioning or probe pressure, free gas may migrate. When it is unclear whether the gas is in the peritoneal cavity or the colon, movement can be observed with patient repositioning. Typically, the patient is reexamined after being rolled into a left lateral decubitus position. Probe pressure can also be used to move large amounts of free gas quickly (provided pain and rigidity do not prevent the maneuver). The gas will "separate" due to the pressure, creating an effect likened to curtains parting or scissors opening [16,17]. Additionally, as the bowel loop folds deeper into the abdomen, gas within the intestine may either move away from the peritoneal line or display the characteristic mucosal folds of the bowel. Peristalsis, or movement synchronized with respiration, can also be observed, indicating that the gas is within a bowel loop. In contrast, the peritoneal line is a continuous, wrinkle-free line that wraps around the abdomen. The presence of gas against the peritoneal line enhances its visibility, particularly when ascites are present [18]. Ultrasound imaging easily detects significant amounts of free gas following a colonic perforation. Small collections of gas outside the colon can result from intra-abdominal or retroperitoneal abscesses, such as those associated with diverticular disease or post-operative conditions. Gas locules from uncomplicated diverticular disease may appear to be outside the bowel lumen, despite the mucosa being visible around the gas. However, this gas will not be as mobile as intraperitoneal gas and will remain superficial to the peritoneal line[19].

Methods

This cross-sectional study was conducted in the Department of Radiology at Benghazi Medical Center over one year, from January to December 2018, and included 90 adult patients who underwent open or laparoscopic laparotomy within the last 10 days; patients below 15 years of age or who had surgery more than 10 days prior were excluded. A thorough review of patients' medical and surgical histories was conducted, demographic data were collected, and radiological exams were performed using a 500 mA X-ray machine (obtaining left lateral decubitus and/or upright chest X-rays depending on the patient's condition). Abdominal ultrasonography was carried out using Phillips linear and convex probes with patients in supine and left lateral decubitus positions within 24 hours post-surgery to detect pneumoperitoneum, though exams could be limited by postoperative tenderness and the ability to change positions, and detecting small amounts of gas was challenging. All findings were documented, data were analyzed with SPSS version 24 using descriptive statistics and the chi-square test (with a p-value <0.05 considered significant), and the study received approval from the Head of the Radiology Department and ethical approval from the hospital's Research and Ethics Committee.

Results

Data were collected through patient history, basic clinical examinations, laboratory tests, and outcome assessments. The information was coded and initially entered into Microsoft Excel for organization. It was then imported into SPSS (version 24) for statistical analysis. Qualitative data were summarized using numbers and percentages. All collected data were systematically prepared and submitted for analysis.

Table 1. Distribution of patients according to age

Age /year	No.	%
≤20	21	23.3
21 30	18	20
31-40	20	22.2
41-50	13	14.4
51-60	8	8.9
>60	10	11.1
Total	90	100

Mean age =37yeas. St. Deviation =17.2years. Median=35years. Minimum age=15 years. Maximum =80 years.

Table 2. Distribution of patients according to sex

Sex	No.	%
Male	33	36.7
Female	57	63.3
Total	90	100

Male: Female ratio 1:1.7

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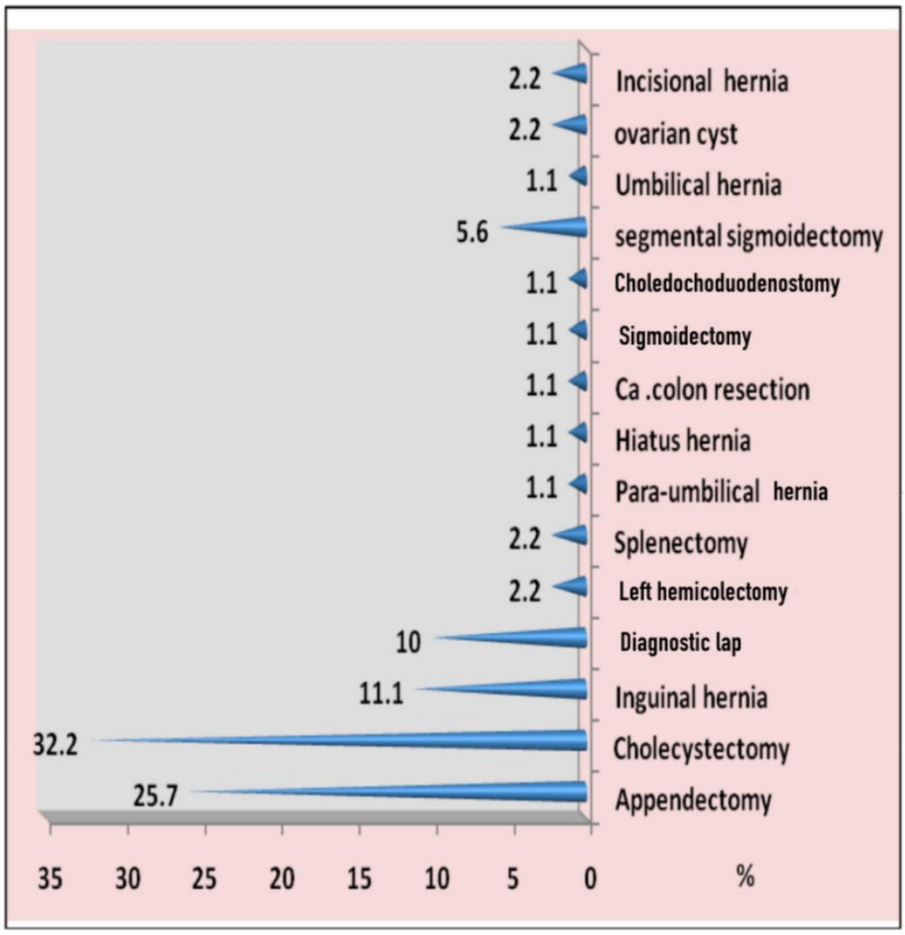

Fig.1. Distribution of patients according to the type of surgery

Table 3. Distribution of patients according to the interval between USS and X-Ray

X-Ray done	No.	%
Same time as USS	80	88.9
After 24Hours of USS	10	11.1
Total	90	100

Table 4. Distribution of patients according to USS results and X-ray results for detecting the post-surgical pneumoperitoneum

Result of USS (Screening test)	Result of X-ray (Gold standard)				Total	
	Present		Absent			
	No.	%	No.	%	No.	%
Present	72	98.6	4	23.5	76	84.4
Absent	1	1.4	13	76.5	14	15.6
Total	73	81.1	17	18.9	90	100

X^2=59.20 df=1 p=0.000(Highly Significant)

Table 5. Distribution of patients according to X-ray results, and X-ray results detecting the post-surgical pneumoperitoneum

Result of X-ray (Gold standard)	Result of USS (Screening test)				Total	
	Present		Absent			
	No	%	No.	%	No.	%
Present	72	94.7	1	7.1	73	81.1
Absent	4	5.3	13	92.9	17	18.9
Total	76	100	14	100	90	100

X^2= 59.205 df=1 p=0.000 (Highly Significant)

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Table 6. The comparison between Ultrasonography and plain radiography in the detection of pneumoperitoneum

Measures	Ultrsonography	Plain radiography
Sensitivity	98.6	94.7
False positive	23.5	7.1
False negative	1.4	5.3
-ve predictive value	92.9	76.5
Specificity	76.5	92.9
+ve predictive value	94 .7	98.6

Table 7. Distribution of patients according to X-ray result and USS results, andsex for detecting the post-surgical pneumoperitoneum

Result of USS (Screening test)	Sex			
	Male		Female	
	No.	%	No.	%
Present	29	87.9	47	82.5
Absent	4	12.1	10	17.5
Total	33	100	57	100

X^2=0.468 df=1 p= 0.494 (Not Significant)

The right image shows the peritoneal stripe sign obscuring the superior aspect of segment 8, with characteristic reverberation artifacts indicating pneumoperitoneum. The left image shows the x-ray findings with a rim of free intraperitoneal air under the right hemidiaphragm.

Fig.2. Comparison of Ultrasound and X-ray Images of post-surgical pneumoperitoneum of the same patient.

The right image shows the peritoneal stripe sign, with characteristic reverberation artifacts indicating pneumoperitoneum. The left image shows the X-ray findings with a free intraperitoneal air under both hemidiaphragms.

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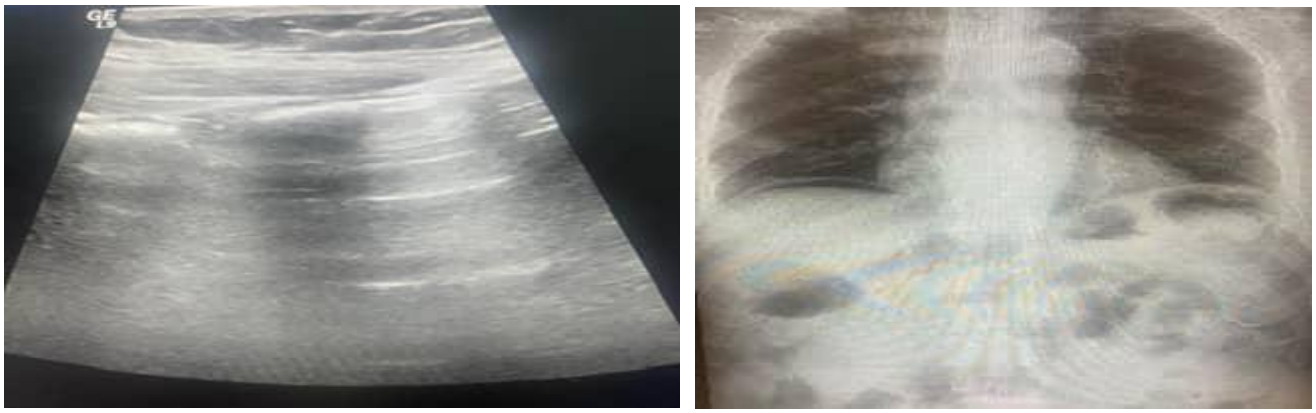

Fig.3. Comparison of Ultrasound and X-ray Images of post-surgical pneumoperitoneum of the same patient

The right image shows reverberation detected in the right hypochondrium scan with a linear probe; the left image shows the X-ray findings with a free intra-peritoneal air under the right hemidiaphragm.

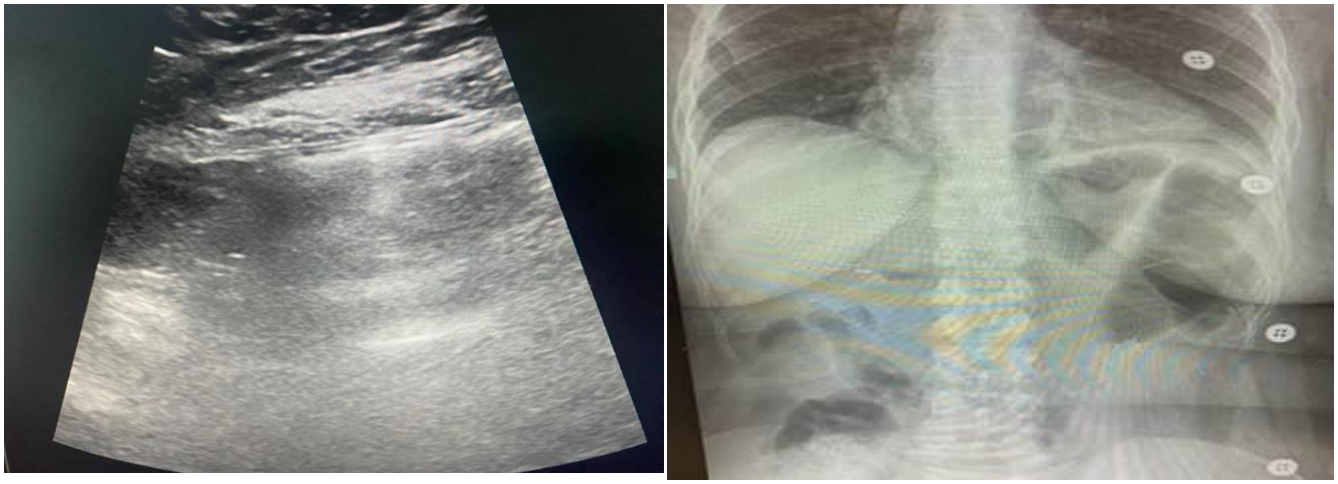

Fig.4. Comparison of Ultrasound and X-ray Images of post-surgical pneumoperitoneum of the same patient

The right image shows reverberation with ring-down artifact starting from the peritoneum detected in the right hypochondrium scan; the left image shows a normal X-ray with no radiological sign of free intraperitoneal air.

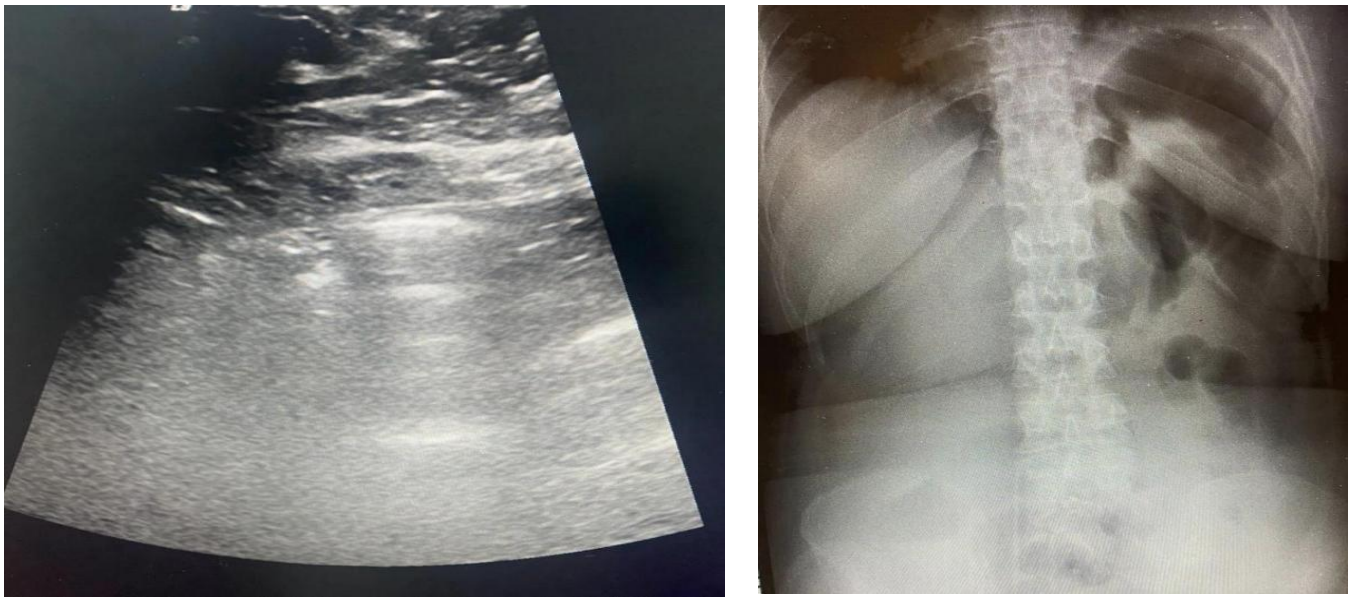

Fig.5. Ultrasound and X-ray images of post-surgical pneumoperitoneum of the same patient.

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The right image shows reverberation with ring-down artifact starting from the peritoneum detected in the right hypochondrium scan; the left image shows a normal X-ray with no radiological sign of free intraperitoneal air.

Discussion

The study included 90 patients aged 15 to 80 years, with a mean age of 37/+ 17.2 years. This finding was similar to another study, the average age was 38.07+/-12.41 years. In this study Male to male-to-female ratio was 1:1.7, females constituted 63.3% of the patients, and 36.7% were male. In another study (73.3%) were females and 8 (26.7%) were males (M: F = 1: 2.75). (2) The type of surgery was cholecystectomy in 32.2%, 25.7% was appendectomy, 11% was inguinal hernia,5.6% was segmental sigmoidectomy, diagnostic lap was 10%, left hemicolectomy, splenectomy, ovarian cyst, and incisional hernia were 2.2% for. Para-umbilical, hiatus hernia, colon resection, sigmoidectomy, choledochoduodenostomy, and umbilical hernia 1.1% each. Another study included 170 patients who had hollow organ perforation, five patients who had perforated appendicitis, and three who had acute cholecystitis. Times of doing X-rays,88.9% at the same time of USS and 11.1% after 24 hours of USS. Post-surgical pneumoperitoneum was present in 98.6% of USS and x-ray,23.5% was present in USS and absent in x-ray,76.5% was absent in both, the difference was statistically significant p-value was 0.0001. Compared to other studies, 27 out of 30 patients with post-surgical pneumoperitoneum (90%) were detected on ultrasonography, while (10%) were not detected (2). If we consider X-ray as the gold standard and USS as a screening test, the results are as follows: 94.7% were present in the X-ray and also detected in the USS, 5.3% were absent in the x-ray and present in the USS, 7.1% were present in the x ray and absent in the USS, and 92.9% were absent in the X-ray And also absent in the USS. The distribution was statistically significant with a p-value of 0.0001. The sensitivity of USS was 98.6% and for X-ray was 94.7%. The false positive rate of USS was 23.5% and 7.1% for X-ray. The false negative rate was 1.4% in USS and 5.3% in. The negative predictive value was 92.9% in USS and 76.5% in X-ray. Specificity was 76.5% in USS and 92.9% in X-ray. .+ve predictive value was 94.7% in USS and 98.6% in x-ray. In other studies, the sensitivity of abdominal USS was 95.5% and the specificity of 81.8%. (20) The sensitivity of abdominal radiography was 72.2%, which was lower than that of abdominal ultrasound. However, the specificity of abdominal radiograph (92.5%) was higher. in another study, it was found that ultrasound has improved sensitivity (90% versus 75%), negative predictive value (36% versus 18%), and accuracy (88% versus 74%) compared to plain radiography. both methods had similar specificity (50%) and positive predictive value (95% versus 93%). (20,21) In this study, post-surgical pneumoperitoneum was found in 9% of males and 82.5% of females, and not found in 12.1% of males and 17.5% of females. The difference was not statistically significant, with a P value of 0.494.

Conclusion

The study concluded that the sensitivity of USS was superior to abdominal radiography in the diagnosis of pneumoperitoneum. As a recommendation, since abdominal USS is more sensitive than plain radiography in diagnosing pneumoperitoneum, it can be recommended as a bedside screening test for pneumoperitoneum.

Conflicts of Interest

no conflicts of interest

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