

The Utility of Gas Under Diaphragm on Radiograph in Patients with Perforated Appendix: A Prospective Observational Study from a Tertiary Care Centre

ASIF ALI AMIR ALI¹, ALI NAWAZ¹, SHAHZORE GUL¹, IMRAN KHAN², SUGHRA PARVEEN³, MUHAMMAD MUSADIQ¹

¹MBBS, PGTSurgery, Jinnah Postgraduate Medical Centre (JPMC), KarachiPakistan

²Assistant ProfessorSurgery, Jinnah Postgraduate Medical Centre (JPMC), KarachiPakistan

³ProfessorSurgery, Jinnah Postgraduate Medical Centre (JPMC), KarachiPakistan

Corresponding Author: Dr. Asif Ali Amir Ali, Email: aakhowaja09@gmail.com, Cell Phone: +923333975004

ABSTRACT

Objective: To evaluate the diagnostic utility of gas under the diaphragm on abdominal radiograph for patients with a perforated appendix.

Study Design: A prospective, observational study

Study Setting and Duration: General Surgery Department, Jinnah Postgraduate Medical Centre, Karachi, Pakistan was conducted between September 2018 to September 2020.

Methodology: All patients with suspected appendicitis, irrespective of gender were included in the study. Patients with age younger than 12 years or older than 60 years were excluded. All findings from the imagings were noted. The plain radiograph was looking for "Gas under diaphragm". All imaging was performed by a radiologist with experience of five years or more. All data were entered into a statistical package for social sciences (SPSS version 24).

Results: The appendix diameter was highly significantly associated with the risk of perforation in patients with appendicitis ($p < 0.001$). Similarly, the patients with a perforated appendix have a higher white blood cell count compared to those without perforation (15.6 ± 5.1 versus 13.2 ± 4.4 ; p -value = 0.002). It was found that out of the 76 patients with perforated appendicitis pneumoperitoneum was positive in 6 (7.8%) patients while out of those with a non-perforated appendix, 8 (10.5%) had gas under the diaphragm.

Conclusion: Gas under the diaphragm on a plain radiograph was detected in only a few cases with perforated appendicitis. Nevertheless, if positive, it warrants immediate abdominal surgery and requires comprehensive investigation.

Keywords: Abdominal Radiography, Appendicitis, Gas under Diaphragm, Perforated Appendicitis, Ruptured Appendicitis, Pneumoperitoneum, Tomography

INTRODUCTION

Annually, there are approximately 250,000 new cases of appendicitis in the United States.¹ In Pakistan, the number of exact new cases are not certain due to unavailability of a central registry. ²Appendicitis is more frequently seen in patients who are young.

Perforated appendicitis is an acute surgical emergency and a serious complication of appendicitis. ² It is a rare complication, although it is quite common with longstanding and untreated appendicitis. It is defined as a hole caused by long standing infection. It is regarded as perforated or ruptured appendicitis.³ At the onset of the rupture, the symptoms of appendicitis are relieved, and the patient feels better, followed by a fatal aftermath. The prognosis is poor with high morbidity and mortality. The most common predisposing factors are male sex, old age, pregnancy, and immunosuppression. ²⁻⁴

Gas under the diaphragm is a common manifestation in patients with peritonitis secondary to a hollow viscus injury such as ileal perforation or a duodenal perforation secondary to tuberculosis or typhoid.⁵⁻⁶ Infrequently, gas under diaphragm can be encountered in association with a ruptured appendix.⁷ It can be seen on an abdominal or a chest X-ray if substantial air is present, however, if the amount of air is insignificant, a CT scan is needed.⁸

It is important to realize that even though rupture of appendix secondary to acute appendicitis is rare, it is a life-threatening condition. ⁹⁻¹⁰

Appendicitis leading to its rupture is rare. The signs and symptoms of such patients may be vague but because it can be fatal, timely diagnosis and treatment are imperative.

METHODOLOGY

A prospective observational study was conducted at the Department of Surgery, Jinnah Postgraduate Medical Centre, Karachi, Pakistan. A non-probability consecutive sampling technique was applied to enroll participants in the study. Before the study, ethical approval was obtained from the institutional review board, JPMC, Karachi. The study continued from September 2018 to September 2020 for a duration of two years.

During the study, all patients with suspected appendicitis, irrespective of gender were included in the study. Patients with age younger than 12 years or older than 60 years were excluded from the study. All patients were asked for their consent of participation. All patients presenting with acute abdomen, nausea, vomiting, fever (99-102 degrees) or raised white blood cell count were suspected for acute appendicitis. Alvarado score was used for diagnosis of appendicitis. Patients with suspected appendicitis underwent plain chest and abdomen radiographs along with computed tomography (CT) Scan with contrast.

All data regarding the patients' age, gender, body mass index, clinical and personal history, and presenting

symptoms were recorded in a predefined proforma. Findings from the imagings for each patient were noted. The plain radiograph was looking for “Gas under diaphragm”. All imaging was performed by a radiologist with an experience of five years or more.

Patients with a non-perforated appendix were treated with open appendectomy with gridiron incision. All perforated appendicitis cases were treated with lower midline incision. The authors planned for exploratory laparotomy midline incision in cases with suspected hollow viscus injury however, found perforated appendix in 6 cases with gas under diaphragm.

All data was entered in a statistical package for social sciences (SPSS version 24). All quantitative variables like patients' age were represented by mean and standard deviation. For all categorical variables, like gender, presence of gas under diaphragm sign, number of patients with perforated appendix among others, frequency and percentages were computed. For assessing the diagnostic utility of the sign “gas under diaphragm”, sensitivity and specificity were determined. For plain radiograph's diagnostic applicability, accuracy, negative predictive value, positive predictive value, were calculated. A p-value of < 0.05 was set as the cut off value for statistical significance.

RESULTS

A total of 152 patients were included in the study. There were 76 patients with perforated appendicitis and 76 patients without perforation. The mean age of patients in perforated appendicitis was 36.3 ± 19.8 years while the age in group with non-perforated appendicitis was 31.9 ± 12.8 years. The appendix diameter was highly significantly associated with the risk of perforation in patients with appendicitis ($p < 0.001$). Similarly, the patients with perforated appendix has a significantly higher white blood cell count compared to those without perforation (15.6 ± 5.1 versus 13.2 ± 4.4 ; p -value = 0.002).

Table 1. Clinical and demographic parameters in study populations

| Variables | Perforated Appendicitis | Non-perforated Appendicitis | p-value |
|---------------------------------------|-------------------------|-----------------------------|---------|
| Patient Age, years (Mean \pm SD) | 36.3 \pm 19.8 | 31.9 \pm 12.8 | 0.106 |
| Gender | | | |
| Male | 55 (72.37%) | 52 (68.42%) | 0.594 |
| Female | 21 (27.63%) | 24 (31.58%) | |
| Appendix diameter, mm (Mean \pm SD) | 14.9 \pm 3.9 | 11.6 \pm 3.5 | <0.001 |
| WBC count, $10^9/L$ (Mean \pm SD) | 15.6 \pm 5.1 | 13.2 \pm 4.4 | 0.002 |

Table 2 demonstrates the presence of “gas under diaphragm” or “” sign on radiograph as an indicator of perforation in patients with appendicitis. It was found that out of the 76 patients with perforated appendicitis pneumoperitoneum was positive in 6 (7.8%) patients while out of those with non-perforated appendix, 8 (10.5%) had gas under diaphragm. The sensitivity and specificity of gas under diaphragm to detect perforated appendicitis were 7.895% and 89.47%.

Table 2. Incidence of Gas under diaphragm in patients with perforated appendicitis

| Gas under diaphragm | Perforated Appendicitis | | Sensitivity, (95% CI) | Specificity, (95% CI) |
|---------------------|-------------------------|--------|------------------------|-------------------------|
| | Present | Absent | | |
| Positive | 6 | 8 | 7.895% (3.66%, 16.17%) | 89.47% (80.58%, 94.57%) |
| Negative | 70 | 68 | | |

The diagnostic accuracy of gas under diaphragm on a plain radiograph was 48.68% with a positive predictive value of 42.86% and a negative predictive value of 49.28% (Table 3).

Table 3. Diagnostic Accuracy of gas under diaphragm as an indicator of perforated appendicitis

| Diagnostic Accuracy | Positive Predictive Value | Negative Predictive Value | Likelihood ratio of a Positive Test | Likelihood ratio of a Negative Test |
|-----------------------|---------------------------|---------------------------|-------------------------------------|-------------------------------------|
| 48.68% (40.87, 56.56) | 42.86% (21.38, 67.41) | 49.28% (41.07, 57.52) | 0.75 (0.01299 - 43.31) | 1.029 (0.9976 - 1.062) |

DISCUSSION

Gas under diaphragm on a radiograph is common in patients with a hollow viscus injury.¹¹⁻¹² The most common causes of gas under diaphragm are peritonitis secondary to typhoid ileal perforation or duodenal perforation. Pneumoperitoneum or gas under diaphragm is a serious condition which requires emergency laparotomy. In the present study, we evaluated the role of gas under diaphragm on the abdominal X ray in diagnosing perforated appendix in our population. We found that there were six cases of perforated appendix that presented as gas under diaphragm on a plain radiograph. The diagnostic accuracy of the sign “gas under diaphragm” to detect perforated appendicitis was only 48.68%, positive predictive value was 42.86%, and a negative predictive value was 49.28%. Whereas, the sensitivity and specificity of gas under

diaphragm to detect perforated appendicitis was only about 7.895% and 89.47%, respectively. This indicates that using “gas under diaphragm” as a diagnostic sign for perforated appendicitis is not as efficient as hypothesized.

Our findings were supported by the study conducted by Jyoti et al., which concluded that Gas under diaphragm was most commonly (94.19%) associated with perforations of the stomach and duodenum, and was uncommon in cases of appendicular perforation (7.69%).¹¹ In the case of a perforated appendix, the omentum and bowel attaches to the appendix, resulting in the release of only a small volume of air and gets trapped within, without escaping into the peritoneal cavity. Thus, the gas may remain undetected in simple radio-graphical investigations. The findings of the research conducted by Kim et al., were consistent with our results. It revealed that a thin rim of gas under the

diaphragm is seen in less than 1% of all perforated appendices.¹²

A study by Kumar et al., was conducted to determine the possible causes of pneumoperitoneum in patients. The study reported that of the patients evaluated, 16% of cases were associated with peptic ulcers, 16% with diverticulitis, 14% with trauma, 14% with malignancy while bowel ischemia and appendicitis were associated with 10% and 6% of cases of pneumoperitoneum respectively.¹³ Research has shown that air can only escape a perforated appendix if the lumen is patent. However, most appendices which are removed are found to be associated with obstruction. Because of the obstruction, luminal air is unable to escape into the peritoneal cavity and cannot be detected on radiographic imaging.¹⁴ This further contributes to the unreliability of gas under diaphragm as a diagnostic measure in perforated appendix.

A large volume of air owing to any cause puts patients at risk of poor intra-abdominal perfusion and must be treated promptly.¹⁵ In short we can conclude that the optimum diagnostic tool for discrimination between non-perforated and perforated appendicitis is computed tomography (CT) scan which can be used in conjunction to other modalities such as ultrasound, MRI, or X-ray.¹⁶⁻¹⁸

Our study has shown the absence of a strong association between gas under the diaphragm as a significant diagnostic factor in perforated appendix. There were certain limitations to our study, which included non-randomized sampling technique and an observational study design. However, the current study still adds to the current literature as there are only limited studies exploring the diagnostic role of "gas under diaphragm" or "pneumoperitoneum" for the diagnosis of perforated appendix.

CONCLUSION

In rare instances, gas under the diaphragm on a plain radiograph can be seen in patients with perforated appendicitis however, it is most commonly seen in patients with peritonitis secondary to a hollow viscus injury. Nevertheless, if positive, it warrants immediate abdominal surgery and requires comprehensive investigation. Further large-scale studies are required to establish any diagnostic importance of gas under diaphragm in patients with suspected appendicitis.

REFERENCES

1. Stringer MD. Acute appendicitis. *Journal of paediatrics and child health*. 2017 Nov;53(11):1071-6.
2. Balogun O, Osinowo A, Afolayan M, Olajide T, Lawal A, Adesanya A. Acute perforated appendicitis in adults: Management and complications in Lagos, Nigeria. *Ann Afr Med [Internet]*. 2019 Jan 1 [cited 2020 Dec 5];18(1):36-41. Available from: /pmc/articles/PMC6380116/?report=abstract
3. Wong CWY, Chung PHY, Lan LCL, Wong KKY. Acute appendicitis presenting as pneumoperitoneum in a teenage boy undergoing chemotherapy. *BMJ Case Rep [Internet]*. 2015 Oct 6 [cited 2020 Dec 5];2015. Available from: /pmc/articles/PMC4600793/?report=abstract
4. Rogers AP, Zens TJ, Leys CM, Nichol PF, Ostlie DJ. A call for a standardized definition of perforated appendicitis. *Journal of pediatric surgery*. 2017 Jan 1;52(1):89-92.
5. Ahangar S, Zaz M, Shah M, Wani SN. Perforated subhepatic appendix presenting as gas under diaphragm. *Indian J Surg*. 2010;72(3):273-4.
6. Nema AA, Darshan JR. A study of surgical approach to typhoid ileal perforation at a tertiary care hospital of South Gujarat, India. *International Surgery Journal*. 2018 Apr 21;5(5):1758-62.
7. Singh S, Satsangi A, Yadavalli SD, Singh B, Patil G. Nontraumatic Small Bowel Perforation: A Review of Demographics, Aetiological Factors, Clinical Presentation, Radiological Findings Along with Hematological and Histopathological Evaluation. *World J Surg Surgical Res*. 2020; 3.:1244.
8. El-Gohary MA, Al Jubouri S. Neonatal appendicitis with perforation: A case report. *J Pediatr Surg Case Reports*. 2014 Jul 1;2(7):353-4.
9. de Wijkerslooth EM, van den Boom AL, Wijnhoven BP. Variation in classification and postoperative management of complex appendicitis: a European survey. *World journal of surgery*. 2019 Feb;43(2):439-46.
10. Howell EC, Dubina ED, Lee SL. Perforation risk in pediatric appendicitis: assessment and management. *Pediatric health, medicine and therapeutics*. 2018;9:135.
11. Bansal J, Jenaw RK, Rao J, Kankaria J, Agrawal NN. Effectiveness of plain radiography in diagnosing hollow viscus perforation: study of 1,723 patients of perforation peritonitis. *Emergency radiology*. 2012 Apr 1;19(2):115-9.
12. Kumar KM. Clinical Profile of patients with duodenal perforation. *International Journal of Surgery*. 2019;3(1):20-3.
13. Kumar A, Muir MT, Cohn SM, Salhanick MA, Lankford DB, Katabathina VS. The etiology of pneumoperitoneum in the 21st century. *Journal of Trauma and Acute Care Surgery*. 2012 Sep 1;73(3):542-8.
14. Dosseh DJ, Ayite AE, Attipou K. Perforated appendicitis-a rare cause of pneumoperitoneum. *South African Medical Journal*. 2007 Nov 14;97(3):186.
15. Das P, Mukherjee R, Pathak D, Gangopadhyay A, Halder S, Singh SK. Tension pneumoperitoneum: a very rare complication of acute gangrenous appendicitis. *The Annals of The Royal College of Surgeons of England*. 2016 Nov;98(8):e197-9.
16. Bom WJ, Bolmers MD, Gans SL, van Rossem CC, van Geloven AA, Bossuyt PM, Stoker J, Boermeester MA. Discriminating complicated from uncomplicated appendicitis by ultrasound imaging, computed tomography or magnetic resonance imaging: systematic review and meta-analysis of diagnostic accuracy. *BJS open*. 2021 Mar;5(2):zraa030.
17. Horrow MM, White DS, Horrow JC. Differentiation of perforated from nonperforated appendicitis at CT. *Radiology*. 2003 Apr;227(1):46-51.
18. Karul M, Berliner C, Keller S, Tsui TY, Yamamura J. Imaging of appendicitis in adults. *Rofo*. 2014 Jun 1;186(6):551-8.