

Free Air Under The Diaphragm In Perforated Hollow Viscus In Children: How Consistent Is It?

Chukwubuike Kevin Emeka^{1*}, Igweagu Chukwuma Paulinus² and Anijunsi Livinus Patrick¹

¹Department of Surgery, Enugu State University Teaching Hospital, Enugu, Nigeria.

²Department of Community Medicine, Enugu State University Teaching Hospital, Enugu, Nigeria.

*Correspondence author

Chukwubuike Kevin Emeka

Department of Surgery
Enugu State University Teaching Hospital
Enugu
Nigeria

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Abstract

Background: Hollow viscus perforation constitutes a frequent surgical emergency and this may results in pneumoperitoneum (free intraperitoneal gas). The aim of this study was to evaluate the preoperative radiographs of children who were operated upon for perforated hollow viscus, with regards to air under the diaphragm.

Materials and Methods: This was a retrospective study of children aged 15 years and younger who were managed for perforated hollow viscus at the pediatric surgery unit of a teaching hospital in Enugu, Nigeria. The information extracted included the patients' age, gender, presenting symptoms, duration of symptoms before presentation, time interval between presentation and intervention, intra-operative finding/definitive diagnosis, definitive operative procedure performed, complications of treatment, duration of hospital stay and outcome of treatment.

Results: A total of 204 cases of perforated hollow viscus were managed during the study period. More males were affected. Abdominal pain was a consistent symptom in the patients. Free air under the diaphragm was observed in 62 (30.4%) patients whereas there was no free air under the diaphragm in 142 (69.6%) patients. Typhoid intestinal perforation and wound infection were the most common cause of hollow viscus perforation and post-operative complication respectively. About one-tenth of the patients expired following severe sepsis, renal compromise and anesthesia related complication.

Conclusion: Hollow viscus perforation manifests as free air in the peritoneal cavity (pneumoperitonem) and is usually an indication for surgical abdominal exploration. However, in the present study, only about one-third of the children with confirmed hollow viscus perforation (at surgery) showed pneumoperitoneum in their preoperative chest radiographs.

Keywords: Children, diaphragm, free air, perforated viscus, penumoperitoneum.

Introduction

Hollow viscus perforation constitutes a significant surgical emergency and requires an emergent surgical intervention. The causes of hollow viscus perforation could be secondary to several factors, most commonly inflammation, infection, trauma or obstruction (Sureka et al., 2015). These hollow viscus perforations manifest as pneumoperitoneum (free intraperitoneal gas). Pneumoperitoneum could be defined as the presence of free air/gas in the peritoneal cavity. This free air can ascend upwards to locate under the diaphragm. Radiographs are required for detection of the air under the diaphragm. However, small amounts of free peritoneal air may be missed on x rays and computed tomography (CT) scan is required in such cases (Lee, 2010). The origin of pneumoperitoneum, and subsequently free air under the diaphragm, is the perforation/disruption of the wall of a hollow viscus. The most sensitive

plain radiograph for the detection of free intraperitoneal gas is the erect chest radiograph; chest radiograph shows subdiaphragmatic free gas. Abdominal radiographs showing the diaphragms may also illustrate the air under the diaphragm. In infants and small children, air under the diaphragm may also be shown in thoracoabdominal radiographs. It is important to note that not all cases of pneumoperitoneum indicate perforated abdominal hollow viscus (Gantt et al., 1977). Cases of negative laparotomies have been reported following radiologic evidence of pneumoperitoneum (Tallant et al., 2016). Although, not all cases of air under the diaphragm require surgical intervention, pnemoperitoneum is considered an ominous pathologic sign that requires detailed attention and evaluation. The aim of this study was to evaluate the preoperative radiographs of children who were operated upon for perforated hollow abdominal viscus, with regards to air under the diaphragm.

Materials and Methods

This was a retrospective study of children aged 15 years and younger who were managed for perforated hollow abdominal viscus between January 2015 and December 2019 at the pediatric surgery unit of Enugu State University Teaching Hospital (ESUTH) Enugu, Nigeria. Patients who presented primarily to ESUTH and those referred from peripheral hospitals were recruited into the study. Patients who are older than 15 years of age and those without hollow viscus perforation at surgery were excluded from the study. Only patients with confirmed hollow viscus perforation at surgery were enrolled into the study. ESUTH is a tertiary hospital located in Enugu, South East Nigeria. The hospital serves the whole of Enugu State, which according to the 2016 estimates of the National Population Commission and Nigerian National Bureau of Statistics, has a population of about 4 million people and a population density of 616.0/km². The hospital also receives referrals from its neighboring states. Information was extracted from the case notes, operation notes, operation register and admission-discharge records. The information extracted included the patients' age, gender, presenting symptoms, duration of symptoms before presentation, time interval between presentation and intervention, intra-operative finding/definitive diagnosis, definitive operative procedure performed, complications of treatment, duration of hospital stay and outcome of treatment. Diagnosis of perforated abdominal hollow viscus was made based on surgical and radiological findings. All the patients had chest and abdominal x rays. The intra-operative findings were compared with the chest/abdominal radiographs. The follow-up period was 12 months. Ethical approval was obtained from the ethics and research committee of ESUTH and informed consent was obtained from the patients' caregivers. Statistical Package for Social Science (SPSS) version 21 (manufactured by IBM Corporation Chicago Illinois) was used for data entry and analysis. Data were expressed as percentages, median, mean, and range.

Results

Patients' demographics

A total of 204 cases of perforated hollow viscus were operated upon during the study period. Out of this number, 142 (69.6%) were males and 62 (30.4%) were females. The mean duration of symptoms before presentation was 5 days, range 3-14 days. The median duration from presentation to surgery was 2 days, range 1-4 days. The mean duration of hospitalization was 13 days with a range of 7-21 days.

Presenting symptoms

All the patients had abdominal pain. Bilious vomiting was recorded in 176 (86.3%) patients, constipation occurred in 121 (59.3%) and abdominal distension was present in 52 (25.5%) patients.

Imaging investigations

All the patients had plain abdominal and chest x ray. Free air under the diaphragm was observed in 62 (30.4%) patients whereas no free air under the diaphragm could be seen in 142

(69.6%) patients. Figure 1 and figure 2 show no free air under the diaphragm and free air under the diaphragm respectively, in some of the studied patients who had bowel perforation.



Figure 1: Plain thoracoabdominal radiograph showing no free air under the diaphragm

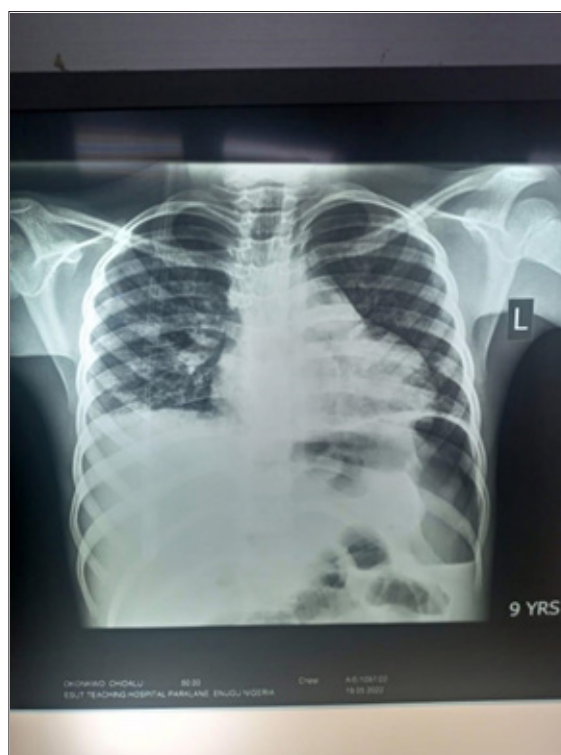


Figure 2: Plain thoracoabdominal radiograph showing free air under the left hemidiaphragm

Intra-operative finding/definitive diagnosis

The intra-operative findings and definitive diagnosis are shown in Table 1.

Intra-operative finding	Number of patients (%)	Definitive diagnosis
Intestinal perforation	144 (70.6)	TIP
Perforated appendix	46 (22.5)	RA
Urinary bladder injury	12 (5.9)	Ruptured bladder
Gastric injury	2 (1.0)	Gastric perforation

Table 1: Intra-operative finding and diagnosis

Complications of treatment

Wound infection happened in 42 (20.6%) patients, residual intra-peritoneal abscess occurred in 11 (5.4%), leak from repair site 5 (2.5%) and burst abdomen in 2 (1%).

Outcome of treatment

One hundred and eighty-five patients (90.7%) made good recovery and were discharged home. However, 19 (9.3%) patients died following severe sepsis, renal compromise and anesthesia related complication.

Discussion

Historically, in August 1915, Hugo Popper first described the radiographic technique of pneumoperitoneum (Eslick et al., 2006). Perforation of abdominal hollow viscus in children is not uncommon and can result from a number of pathologies. The classical sub-diaphragmatic air (free air under the diaphragm) is an obvious radiologic sign of hollow viscus perforation (Abantanga & Wiafe-Addai, 1998). However, this is not present in all the patients. This free air is best seen in erect chest radiographs and may not be very obvious as pneumoperitoneum on supine view (Awolaran, 2015). However, adopting erect position in children in very sick children can be challenging and lateral decubitus views can be adopted when in doubt (Awolaran, 2015). Free air under the diaphragm is seen as an area of lucency under the right or left hemi-diaphragm or at the mid portion of the diaphragm under the central tendon (Cupola sign) (Marshall, 2006). On an erect chest x ray, especially on the right side, as little as 1 ml to 2 mls of air can be seen as air under the diaphragm (Hokama et al., 2009).

In the present study, there was male predominance. This finding is consistent with the report of other research series on pneumoperitoneum (Makki, 2017). The reason for the gender difference is not known but the increased incidence of abdominal surgical emergencies in male children may explain it. The median duration, from onset of symptom to presentation, of 5 days is reflective of the delayed presentation of the patients. The late presentation may be attributed to financial constraints and ignorance of the patients' caregivers. Paucity of parental awareness could also be responsible. It took an average of 2 days to operate on these patients. This is the time interval required to resuscitate, correct dehydration, electrolyte

imbalance and anemia in these patients before surgical intervention. This period of resuscitation and optimization may be prolonged in critically ill patients who present in shock. The duration of hospital stay following surgery may be dependent on the primary pathology, the operative procedure performed and the post-operative course.

Abdominal pain was a consistent symptom in all the patients. The abdominal locations of the hollow viscus may explain the abdominal pain. The pathologies that cause the hollow viscus perforation are intra-abdominal, hence the origin of the abdominal pain. Visceral pain results from distension of hollow viscus (Sengupta, 2009). Stretching of the wall of the abdominal hollow viscus can also give abdominal pain (Mehta, 2016). The pain of perforated hollow viscus is described as acute, of sudden onset and of intense severity. Other symptoms such as bilious vomiting, constipation and abdominal distension may be present depending on the pathology.

In the present study, on imaging, majority of the patients with hollow viscus injury had no air under the diaphragm; only about one-third of the patients showed air under the diaphragm. This is comparable with a study from Ghana that reported that only about 55% of the patients with bowel perforation showed air under the diaphragm (Abantanga & Wiafe-Addai, 1998). However, Sahu et al reported that pneumoperitoneum is indicative of perforation of a hollow viscus in 90 percent of cases (van Gelder et al., 1991). It is pertinent to note that the most common cause of pneumoperitoneum is perforation/ disruption of the wall of a hollow viscus (Sureka, et al., 2015). This is quite significant because a perforated hollow viscus containing air is expected to release air into the peritoneum cavity causing pneumoperitoneum. In fact, there is a surgical dogma that stipulates that perforation of a hollow viscus, indicated by pneumoperitoneum on imaging, mandates abdominal exploration (Shinall et al., 2018). The differences in percentages of the pneumoperitoneum may be accounted for by the quantity of free air released, rate of systemic absorption of the free air and the perforated organ. For instance, in perforated appendix, free air under the diaphragm may be a rare presentation (Cizneli et al., 1990).

Typhoid intestinal perforation was the most perforated viscus in the current series. Chukwubuike et al also reported typhoid intestinal as a common cause of pediatric abdominal surgical emergency involving hollow viscus perforation (Chukwubuike, 2021). Typhoid intestinal perforation is one of the most common surgical complications of typhoid fever and may be associated with significant morbidity and mortality especially in developing countries (Keenan & Hadley, 1984; Ajao, 1982). Typhoid fever, also known as enteric fever, is a common multisystem infection caused by the bacteria *Salmonella enterica* serovar typhi and *Salmonella enterica* serovar paratyphi A and B which are transmitted through feco-oral route (Olori & Ukpoju, 2019). Typhoid causes ulceration of the Peyer's patches at the terminal ileum resulting in the leakage of air and intestinal contents into the peritoneal cavity (Ahmad et al., 2009).

Postoperatively, surgical site infection was most frequent complication. Exposure of the surgical site to the microbes of the intestinal contents may account for the high wound infections and intra-peritoneal pus collections documented in the index study. An infection begins when the balance between bacterial pathogenicity and host resistance is upset (Peterson, 1996). Susceptibility to bacterial infections depends on physiologic and immunologic status of the host and on the virulence of the organism (Peterson, 1996).

In the current study, about one-tenth of the patients expired following complications of anesthesia and sepsis. The anesthetic complications included atelectasis, respiratory arrest and failure to recover from anesthesia. Most of the sepsis occurred from anastomotic leaks and intra-abdominal abscesses. The compromised immune status of the patients may have predisposed to the severity of the sepsis.

Conclusion

Hollow viscus perforation manifests as free air in the peritoneal cavity (pneumoperitonem) and is usually an indication for surgical abdominal exploration. However, in the present study, only about one-third of the children with confirmed hollow viscus perforation (at surgery) showed pneumoperitoneum in their preoperative chest radiographs. Future research will evaluate the predictive factors that may influence the presence or absence of pneumoperitoneum following hollow viscus perforation.

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