Radiological diagnosis of pneumoperitoneum in children with typhoid intestinal perforation

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Abstract

**Background:** Typhoid fever is a severe systemic illness caused by the gram-negative bacillus Salmonella typhi and transmitted by the faecal-oral route. This study sought to determine the value of plain abdominal and chest radiographs in detecting pneumoperitoneum in children with typhoid intestinal perforation (TIP).

**Methods:** A retrospective review of plain abdominal and chest radiographs of children who had surgery for TIP between June 2009 and December 2011 in our unit. All the films were reviewed by the same radiologist who was blinded to the intraoperative findings, for the presence or absence of various signs of pneumoperitoneum. Data were collected on a structured questionnaire and analysed using SPSS version 15.0.

**Results:** Radiographs of 54 children were reviewed. Their ages ranged from 3 years to 13 years (median 7 years). Thirty-three of them were boys and 21 were girls (male-to-female ratio 1.57:1). Pneumoperitoneum was detected in 47 patients (87%). In the erect abdominothoracic films, air under the right hemidiaphragm was detected in 16 of 41 cases (39%), and extraluminal or intraperitoneal air–fluid levels in 31 of 41 cases (75.6%). In the supine abdominal films, the commonest sign of pneumoperitoneum was the right upper quadrant gas sign (23 of 50 cases; 46%).

**Conclusions:** A careful interpretation of plain abdominal and chest radiographs in the child suspected to have TIP, would lead to more accurate diagnosis of pneumoperitoneum.

**Keywords:** pneumoperitoneum, typhoid intestinal perforation, radiographs, children, air–fluid levels

Introduction

Typhoid fever is a septicemic illness caused by the gram-negative bacillus *Salmonella typhi*, and constitutes a major public health challenge in developing countries.1,2 It is estimated that perforation of the intestine occurs in 2% to 4% of all cases of typhoid fever, and that this is the cause of mortality in about 25% to 40% of patients afflicted with this disease.3 Once perforation has occurred, the resultant peritoneal contamination and peritonitis will depend on the duration, number, location, and size of perforation.4 Perforation is heralded by exacerbation of abdominal pain association with tenderness, rigidity, and guarding, most pronounced over the right iliac fossa; experience and a high index of suspicion may however be required for some patients in a
severe toxic state, and for children under 5 years, in whom these signs may be obscured, with resultant delays in diagnosis and institution of appropriate treatment.4,5

Since the early part of the 20th century, erect or left lateral decubitus films of the abdomen have been shown to be valuable for the detection of pneumoperitoneum in patients with suspected perforation of the gut.6–8 In clinical practice, however, many patients with an acute abdomen are too sick or debilitated to stand erect or lie on their side for the time necessary to permit air to migrate to the least dependent portion of the peritoneal cavity, such that supine abdominal radiographs may be the only films feasible.7,8 Signs indicating the presence of pneumoperitoneum are based on direct identification of peritoneal ligaments and other structure which are only visible when outlined by air.8,9

This study was aimed at determining the value of plain abdominal and chest radiographs in detecting pneumoperitoneum in children presenting with typhoid intestinal perforation in our hospital.

**Methods**

We retrospectively reviewed the plain abdominal and chest radiographs of children who were admitted into our ward and had surgery for typhoid intestinal perforation between June 2009 and December 2011. All the films were retrieved from our archives and were reviewed by the same radiologist who was blinded to the intraoperative findings. The films were evaluated for the presence or absence of various signs of pneumoperitoneum. In all there were 41 erect abdomino-thoracic films, 50 supine abdominal films, 5 left lateral decubitus films, 16 erect chest films, and 10 supine chest films.

Data were collected on a structured questionnaire and analysed using SPSS version 15.0. Descriptive statistics were computed for continuous variables, while proportions were used for categorical variables. The study was approved by the research and ethics committee of our hospital.

**Results**

A summary of the results is as depicted in Table 1.

**Radiological signs on erect abdomino-thoracic films**

*Air under right hemidiaphragm:* This is visualised as a radiolucent area separating the right hemidiaphragm above from the dome of the liver below (Figure 1). This was present in 16 of the 41 erect abdominothoracic films (39%).

*Air under left hemidiaphragm:* Here, a radiolucent area is seen separating the left hemidiaphragm above from the fundus of the stomach below. This was seen in 11 of the 41 of the erect abdominothoracic films (26.8%).
Extraluminal or intraperitoneal air–fluid levels: This appears as an air–fluid interface between a radiolucent region of intraperitoneal gas collection above and a radio-opaque region of intraperitoneal fluid collection below (Figure 2). This was noted in 31 (75.6%) of the erect abdominothoracic films.

Figure 1: Erect abdominothoracic radiograph showing air under the right hemidiaphragm (arrow)

Figure 2: Erect abdominothoracic radiograph showing massive intraperitoneal air and fluid collection with an air–fluid interface (arrows)

Figure 3: Supine abdominal radiograph showing right upper quadrant gas sign (arrow)

Figure 4: Supine abdominal radiograph showing: A. Air in fissure of ligamentum teres sign; B. Rigler’s sign; C. Triangle sign D. Liver edge silhouette sign.
Radiological signs on supine abdominal films

Right upper quadrant gas sign: This appears as a radiolucent pocket (localised gas) in the right upper quadrant.\textsuperscript{7,10} This was visualised in 23 of the 50 supine abdominal films (46\%) (Figure 3).

Liver edge silhouette sign: This is visualised as a lucent crescentic area against the liver edge.\textsuperscript{10} It was seen in 12 (24\%) of the supine abdominal films (Figure 4).

Air in fissure of ligamentum teres sign: This appears radiographically as a vertically oriented, sharply defined, slit-like or oblong area of hyperlucency found about 2.5 to 4 cm right of the vertebral border, between the tenth to twelfth ribs.\textsuperscript{10} This was seen in 22 (44\%) of the supine abdominal films (Figure 4).

Triangle sign: This appears as a sharply defined triangular area of lucency, extraluminal in location.\textsuperscript{10} It was visualised in 2 (4\%) of the supine abdominal films (Figure 4).

Falciform ligament sign: Here, gas outlines the falciform ligament, which is radiographically apparent as a vertical band of soft tissue parallel to the right border of the spine.\textsuperscript{7,10} This sign was seen in 9 of the 50 supine abdominal films (18\%) (Figure 5).

Football sign: Radiographically, this appears as a huge oval shadow outlining the periphery of the peritoneal cavity.\textsuperscript{7,10} This was visualised in 12 (24\%) of the supine abdominal films (Figure 5).

Other signs: The inverted V sign (gas outlining the lateral umbilical ligaments),\textsuperscript{7,10} and the anterosuperior oval sign (single or multiple avoid lucent areas, usually over the medial aspect of the liver),\textsuperscript{10} were not seen in any of the supine abdominal films.
Table 1: Summary of radiographic findings in 54 cases of pneumoperitoneum in children, resulting from typhoid intestinal perforation

| Sign                                           | No. of cases | No. of films | %  |
|------------------------------------------------|--------------|--------------|----|
| **Erect abdomino-thoracic films**              |              |              |    |
| Air under right hemidiaphragm                   | 16           | 41           | 39 |
| Air under left hemidiaphragm                    | 11           | 41           | 26.8 |
| Extraluminal/intraperitoneal air–fluid levels   | 31           | 41           | 75.6 |
| **Supine abdominal films**                      |              |              |    |
| Right upper quadrant gas sign                   | 23           | 50           | 46 |
| Liver edge silhouette sign                      | 12           | 50           | 24 |
| Air in fissure of ligamentum teres sign         | 22           | 50           | 44 |
| Rigler’s sign                                   | 16           | 50           | 32 |
| Triangle sign                                   | 2            | 50           | 4  |
| Falciform ligament sign                         | 9            | 50           | 18 |
| Football sign                                   | 12           | 50           | 24 |
| Inverted V sign                                 | 0            | 50           | 0  |
| Antero-superior oval                            | 0            | 50           | 0  |

**Discussion**

Typhoid fever is a severe systemic illness transmitted by the faecal–oral route. After ingestion in food or water, *S. typhi* travels to the stomach, from where it goes to the small intestine, adheres to the mucosal cells, invades the mucosa and is subsequently transported across the intestinal
Serotonergic innervation of the ileocecal valve: Its role in the pathogenesis of acute gynecologic pelvic pain

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Gynecologic Pelvic Pain

Introduction

Acute gynecologic pelvic pain is a distressing and frequent problem in women. While the initial assessment of this symptom can often be straightforward, its management can be more challenging. This paper focuses on the serotonergic innervation of the ileocecal valve (ICV) and its role in the pathogenesis of acute gynecologic pelvic pain.

The ICV is a crucial anatomic structure located at the distal ileum and proximal colon that controls the transition of chyme from the ileum to the colon. Its function is essential for the smooth passage of food through the digestive tract. The ICV is innervated by a complex network of nerves, including the enteric nervous system, which plays a significant role in its control.

Serotonergic Innervation

Serotonin (5-HT) is a neurotransmitter that is synthesized and stored in mast cells and enterochromaffin cells throughout the digestive tract. It plays a crucial role in the regulation of gut motility and is involved in the control of gut inflammation. The serotonergic innervation of the ICV is an important component of this regulatory mechanism.

Pathogenesis

Acute gynecologic pelvic pain can be caused by a variety of conditions, including endometriosis, uterine fibroids, and acute appendicitis. The pain can be diffuse or localized, and its etiology is often multifactorial. The serotonergic innervation of the ICV can contribute to the pathogenesis of acute gynecologic pelvic pain in several ways.

1. Gut Inflammation: Serotonin released from mast cells or enterochromaffin cells can contribute to the local inflammatory response, which can lead to increased motility and pain.

2. Gut Motility: Serotonin can affect gut motility by stimulating the release of acetylcholine from enteric neurons, leading to increased peristalsis and possible pain.

3. Neurogenic Pain: Serotonin can act as a neurotransmitter in the central nervous system, contributing to the pain sensation.

Conclusion

The serotonergic innervation of the ICV is a critical component of the gut's regulatory mechanisms. Understanding its role in the pathogenesis of acute gynecologic pelvic pain can lead to improved diagnostic and therapeutic approaches. Further research is needed to fully ascertain the mechanisms involved and to develop targeted therapies for this distressing condition.
In contrast to other forms of small bowel perforation which produce little free intraperitoneal gas because of the paucity of gas in the small intestine at the time of perforation, the small intestine is distended with gas prior to perforation in typhoid fever, leading to massive pneumoperitoneum upon intestinal perforation. Small intestinal dilatation and a large amount of free intraperitoneal gas was common among our patients (Figure 6). Although subdiaphragmatic gas on an erect chest or abdominal radiograph usually indicates the presence of a gastrointestinal perforation, this sign is present in only 60-80% of cases. Due to the mobility of the gas in the peritoneal cavity, it will only be possible to determine that a perforation exists and not to localize the perforation to any particular part of the gastrointestinal tract. Unless a considerable amount of free air is present in the abdomen, supine abdominal radiographs are generally thought to have limited value in diagnosing pneumoperitoneum. Although the erect chest radiograph and lateral decubitus views are far more sensitive at detecting pneumoperitoneum than a plain supine film, frequently only a supine abdominal radiograph may be available for examination especially in critically ill patients such as the child with typhoid intestinal perforation.

In this study, combining the radiographic signs of pneumoperitoneum from both erect abdomino-thoracic radiographs and supine abdominal radiographs, pneumoperitoneum was detected in 87% of children with typhoid intestinal perforation. Earlier studies in adults with intestinal perforation resulting from typhoid fever have shown that pneumoperitoneum could be detected in between 50%-80% of the patients' erect abdominal thoracic radiographs.

In our study, the most common sign of pneumoperitoneum seen on supine abdominal radiographs was the right upper-quadrant gas sign (46%). This is an agreement with the findings of some workers who believe that it is probably the single best sign of pneumoperitoneum on supine films. The second most frequent sign of pneumoperitoneum on supine abdominal radiographs in our study was “air in fissures of ligamentum teres sign” (44%), which is at variance with the findings of Levine et al., in which the Rigler’s sign which also occurred in 32% of their cases was the second most frequent. The large volume of intraperitoneal fluid collection in some of our typhoid intestinal perforation patients could have made it difficult to visualise the Rigler’s sign in which the wall of the intestine is defined when air is present both in the lumen and outside the lumen of the bowel. With regards to the right upper-quadrant gas sign, it has been said that the linear collections represent gas in the right sub-hepatic space, whereas the triangular collections represent gas in the posterior recess of the right sub-hepatic space, just medial and inferior to the eleventh rib, in an area known as the Rutherford Morrison pouch or the hepatorenal fossa.

Given that small intestinal dilatation is a fairly frequent finding in perforated and non-perforated typhoid fever patients, its presence on plain abdominal radiographs may help distinguish this disease form other abdominal conditions.

A major limitation of this study is that preoperative diagnosis of typhoid intestinal perforation was primarily based on clinical features of a history of fever followed by abdominal pain, distension and tenderness. It was supplemented by radiological findings of pneumoperitoneum and intra-operative findings of an oval perforation disposed longitudinally on the anti-mesenteric border of the jejunum or ileum or between the taenia coli in the colon, as well as an acutely inflamed and oedematous intestine with intra-peritoneal soiling. Blood cultures for S. typhi were not done in any of the patients due to the non-availability of this procedure in our laboratory.
Conclusions

Our study has shown that the combination of different types of plain abdominal and thoracic radiographs improves the detection of pneumoperitoneum in children with typhoid intestinal perforation.

It is however worthy of note that although the radiographic detection of pneumoperitoneum remains a reliable sign of bowel perforation, its absence does not invalidate the diagnosis.

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