

Pneumoperitoneum: Signs on Supine Abdominal Radiograph

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ABSTRACT

Pneumoperitoneum is a term describing intraperitoneal, extraluminal air. Although it can be seen in either benign or serious condition, most represent lethal situation. Prompt diagnosis and prompt treatment are keys to save patients' lives. Plain radiograph is the first-lined imaging modality for diagnosis of pneumoperitoneum. Small amount of free air can be easily seen beneath diaphragmatic domes on upright film. Unfortunately, sick patients could undergo only supine films which need more attention during interpretation. Physicians should be familiar with signs of pneumoperitoneum on supine abdominal radiograph and able to interpret this critical condition accurately.

Key words : Pneumoperitoneum, abdominal radiograph

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Radiographic appearances of pneumoperitoneum on supine film can be grouped in four anatomical areas: upper abdomen, midabdomen, lower abdomen and extra-abdominal intraperitoneal air (Table 1). Pneumoperitoneal signs in upper abdomen are subdivided into right upper quadrant, paramedian and left upper quadrant free air.

Large amount of free air at right upper quadrant is easily detected by falciform ligament sign, ligamentum teres sign or diaphragmatic muscle slip sign. Falciform ligament sign, one of the most well-known sign of pneumoperitoneum, represents large amount of free air outlining both sides of falciform ligament. It is seen as a slightly curved, vertical, linear opacity locating just right of midline. Ligamentum teres sign describes an oblique band of soft tissue density extend-

ing from umbilicus to inferior hepatic border. This sign is seen when extrahepatic segment of ligamentum teres is outlined by pneumoperitoneum⁽¹⁾. Caudally-joined falciform ligament and ligamentum teres can be seen at the umbilical level. Diaphragmatic muscle slip sign or leaping dolphins sign is recently documented by Cho KC, *et al.*⁽²⁾ It is detected at right upper quadrant superimposed with superior hepatic shadow, caused by free air outlining the muscle slips of costal portion of diaphragm. It is seen as two to four elongated, parallel, curving bands of linear opacity which converge superomedially.

Small amount of free air at right upper quadrant is more difficult to interpret. These signs comprise of lucent liver sign, anterior-superior bubble sign, Morison's pouch-doge's cap sign, ligamentum teres

Table 1 Signs of pneumoperitoneum on supine abdominal radiograph [adapted from Baker SR and Cho KC. The abdominal plain film with correlative imaging, 2nd ed. New Jersey: Appleton & Lange, 1999:96 (8)].

I. Upper abdomen
A. Right upper quadrant
- Large amount
1. Falciform ligament sign
2. Ligamentum teres sign
3. Diaphragmatic muscle slip sign
- Small amount
1. Lucent liver sign
2. Anterior-superior bubble sign
3. Morison's pouch-doge's cap sign
4. Ligamentum teres fissure sign
5. Hepatic edge sign
6. Visible gallbladder sign
B. Paramedian
1. Lesser sac gas
2. Cupola sign
3. Visible lower cardiac border sign
C. Left upper quadrant: left-sided pneumoperitoneum
II. Midabdomen
1. Rigler's sign
2. Football sign
3. Triangle sign
4. Pneumoomentum
5. Pneumomesocolon
6. Visible transverse mesocolon
7. Visible small bowel mesentery
III. Lower abdomen
1. Urachus sign
2. Medial umbilical fold sign
3. Lateral umbilical fold sign
4. Inverted "V" sign
5. Pneumoscrotum
6. Isolated lower abdominal free air
IV. Extra-abdominal intraperitoneal air
1. Free air in hiatal hernia sac
2. Free air in ventral hernia sac

fissure sign, hepatic edge sign and visible gallbladder sign. Lucent liver sign is called when a collection of free intraperitoneal air located anterior to liver and caused decrease of hepatic density on supine radiograph. This sign is easily overlooked if lack of awareness of this condition. Anterior-superior bubble sign means single or multiple anteriorly-located bubbles of

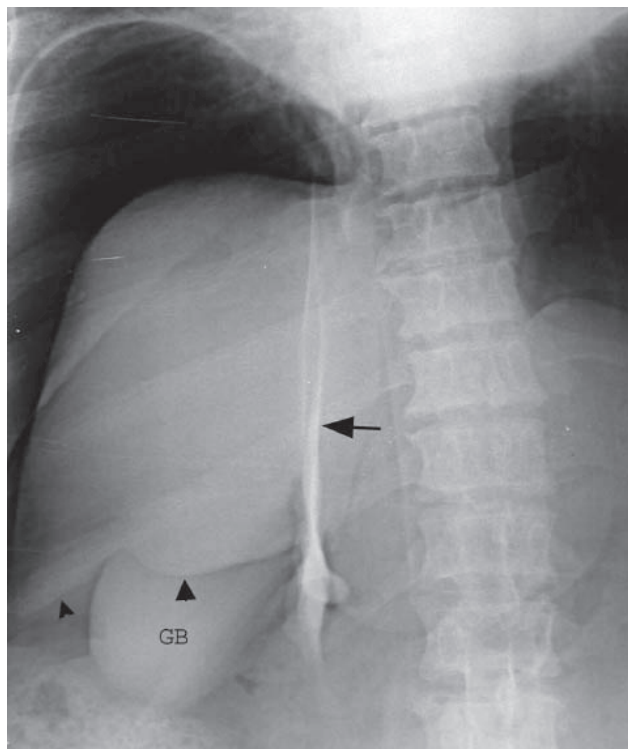


Figure 1 Plain abdominal radiograph reveals massive pneumoperitoneum. The falciform ligament (arrow), hepatic edge (arrowheads) and gallbladder (GB) are outlined by intraperitoneal air

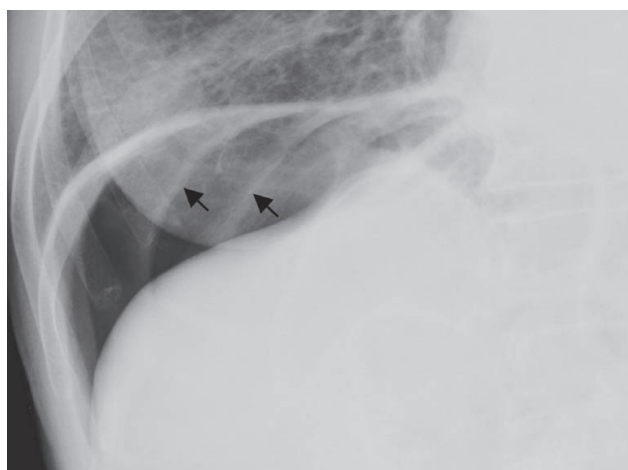


Figure 2 Diaphragmatic muscle slip sign is seen as a few elongated, parallel, curving bands of linear opacity at right upper quadrant (arrows).

free air at right upper quadrant. These are usually detected just below the diaphragmatic dome. If free air collects in Morison's pouch interposed between posterior hepatic edge and anterior aspect of right kidney, it is named as a Doge's cap sign. Its typical appearance is a triangular radiolucency paralleling to right 11th rib. Ligamentum teres fissure sign⁽³⁾ represents

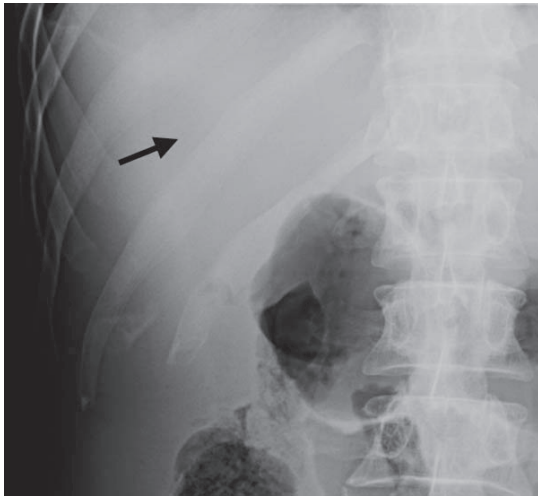


Figure 3 The supine abdominal radiograph demonstrates lucent liver sign (arrow)

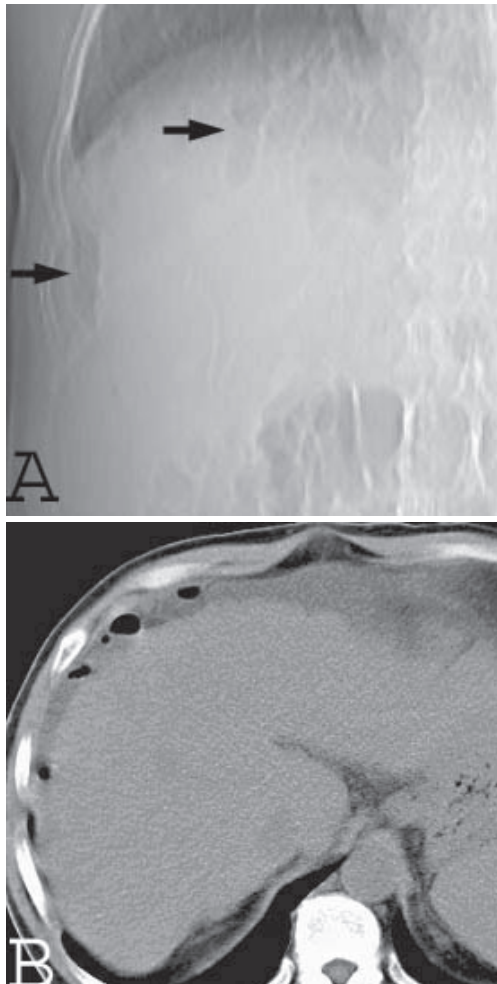


Figure 4 Anterior-superior bubble sign

- A. The scout film of CT abdomen shows a few bubbles of free air at right upper quadrant (arrows)
- B. CT abdomen reveals anteriorly-located bubbles of free air floating in perihepatic fluid.

small amount of free air which is confined to fissure for ligamentum teres within the liver. It appears as a vertical slit-like lucency in hepatic region (whereas ligamentum teres sign seen as a linear opacity of extrahepatic portion of ligamentum teres outlined by free intraperitoneal air). A collection of free air inferior to liver causing lower hepatic margin and extrahepatic part of gallbladder be more visible is termed as hepatic edge sign and visible gallbladder sign, respectively.

Signs of free intraperitoneal air at paramedian upper abdomen include lesser sac gas, cupola sign, and visible lower cardiac border sign. Lesser sac gas is free air in lesser sac shown as a homogenous lucency area crossing the midline. The most common cause of an isolated lesser sac gas is posterior perforation of a gastric or duodenal ulcer⁽⁴⁾. Cupola sign is visualized when middle leaf of central tendon of diaphragm outlined by intraperitoneal air. It is visualized as a transverse line of lucency crossing the midline underneath the heart. Visible lower cardiac border sign may be seen together with cupola sign. It is caused by free intraperitoneal air outlining lower cardiac border. Besides the right upper abdominal and paramedian free air, pneumoperitoneum at left upper quadrant must not be neglected. Isolated left-sided pneumoperitoneum can be occasionally seen especially in patients with preexisting adhesion bands.

There are many signs of pneumoperitoneum de-



Figure 5 Morison's pouch-dog's cap sign is seen as a triangular radiolucency at right upper quadrant (arrow)

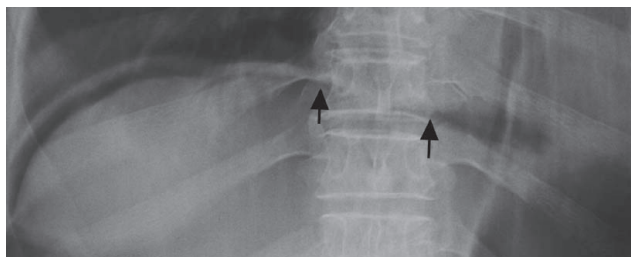


Figure 6 Cupola sign is demonstrated as a transverse radiolucent line crossing midline underneath the heart (arrows).

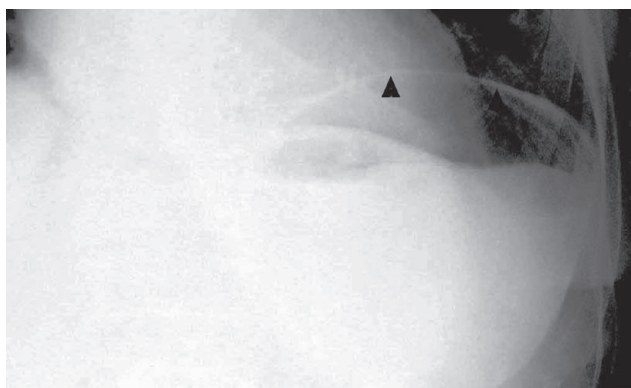


Figure 7 Left-sided pneumoperitoneum is seen as free intraperitoneal air at left upper quadrant outlined the left hemidiaphragm (arrowhead).



Figure 8 Rigler's sign. The supine abdominal radiograph reveals free intraperitoneal air outlining the outer wall of bowels. The thickness of bowel wall could be well demonstrated from extraluminal-intraperitoneal air and normally-visualized intraluminal air.

tected at midabdomen. The most frequently-seen sign of pneumoperitoneum on supine radiograph is Rigler's sign, also called as bas-relief sign or double wall sign. This sign is detected in moderate to massive pneumoperitoneum which outlines serosal surface of bowel. Detection of Rigler's sign alone should be carefully interpreted. Attached loops of distended bowels are commonly misinterpreted as positive Rigler's sign. Football sign, a large oval lucency with a shape of an American football, is frequently found in massive pneumoperitoneum in infants. This sign is presented in only 2% of adults with pneumoperitoneum⁽⁵⁾. Triangle sign is a triangular lucency which bordered by two loops of bowels and nearby parietal peritoneum. The pneumo-omentum and pneumomesocolon are uncommonly seen. Rarely, the transverse mesocolon and root of small bowel mesentery can be visualized in massive pneumoperitoneum as opaque bands in the midabdomen⁽⁶⁾.

Many signs of pneumoperitoneum at lower abdomen were described. Their names depend on the name of ligaments outlined by free intraperitoneal air.

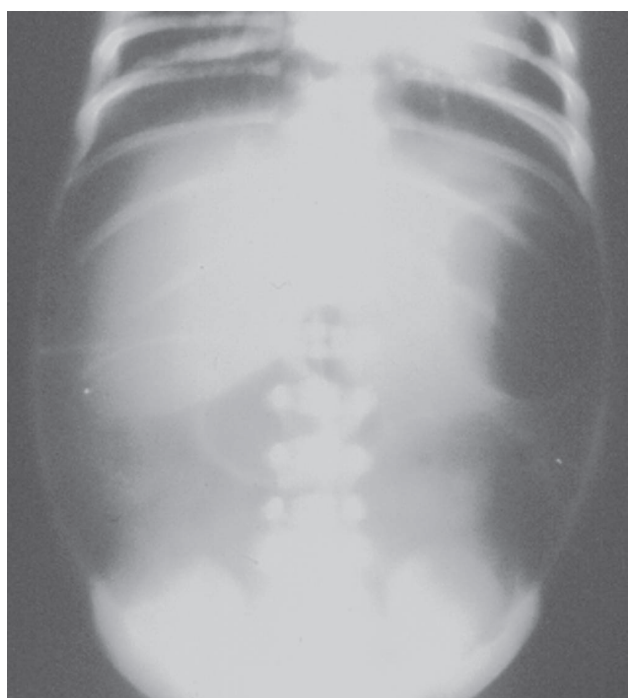


Figure 9 Football sign. There is a large oval lucency with a shape of an American football of massive pneumoperitoneum on supine abdominal radiograph.

Urachus sign is a midline, elongated opacity band, extending from bladder dome to the umbilicus. Visualization of medial and lateral umbilical ligaments is termed as medial and lateral umbilical folds, respectively. These ligaments are paired structures. When both right and left ligaments are outlined by pneumoperitoneum, the inverted "V" sign is called. In infants, the inverted çVé sign is produced by a pair of medial umbilical ligaments which contain obliterated umbilical arteries⁽⁷⁾. In adults, this sign is created by a pair of lateral umbilical ligaments which enclose the inferior epigastric vessels. In some circumstance, free air extends into scrotal sac via an open processus vaginalis and causes pneumoscrotum. The last sign of lower abdominal free air is probably the most sensitive but least specific sign, termed as isolated lower abdominal free air. This sign is seen as a single, well-defined lucency in lower abdomen. It can be differentiated from normal bowel segment by the absence of valvulae conniventes or haustra. Rarely, extra-abdominal intraperitoneal air may be seen in hiatal hernia sac or ventral hernia sac.

In conclusion, familiarity of pneumoperitoneal signs on supine abdominal radiograph is useful especially in sick patients who can not be filmed in upright position. However, accurate interpretation of these

findings can not be obtained if no clinical correlation. In addition, benign causes of pneumoperitoneum should be ruled out to avoid unnecessary surgery.

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