GAS PATTERNS IN ACUTE ABDOMEN-REVISITED: A PICTORIAL ESSAY

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ABSTRACT

INTRODUCTION

Acute abdomen is defined as the clinical condition in which the patient presents with acute severe abdominal symptoms within a period of 24 hours and where emergency medical or surgical intervention is required. A plain radiograph of the abdomen is often the first line of investigation in patients presenting with an acute abdomen, in spite of advances in other promising modalities like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). It is important to be familiar with gas patterns to narrow down on the differential diagnoses and to make a correct diagnosis. Here we present a pictorial essay of the spectrum of gas patterns on plain radiograms.

KEYWORDS

Plain Radiogram, Gas Patterns, Acute Abdomen, Volvulus.

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INTRODUCTION: Acute abdomen is a term frequently used to describe the acute abdominal pain in a subgroup of patients who are seriously ill and have abdominal tenderness and rigidity. [1] About 4–5% of the patients presenting to the Emergency Department present with acute abdomen. [2] X-rays are still considered the first line imaging modality in evaluating a patient presenting to the emergency room with acute abdomen. Our aim is to describe the radiological findings of the common conditions presenting with acute abdominal pain based on the pattern of distribution of bowel gas. [3]

DISCUSSION: Gas in the abdomen is in abundance and is well imaged by X-rays. Familiarity with gas patterns is very important to make the correct diagnosis. The location and amount of bowel gas is equally important. Based on the location of intra-abdominal gas, we classify the gas patterns as:

1. Gas within the lumen- which could be normal, increased or decreased.
2. Gas in the walls of the Gastro-Intestinal Tract (GIT).
3. Gas present outside the GIT lumen in the peritoneal or retroperitoneal space.
4. Gas present outside the GIT within vessels or in solid organs.

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Normal Gas Pattern: When assessing an abdominal radiogram, the following should be noted:

a. Aerated lung tissue should be seen above the diaphragms.
b. No air translucency is to be seen immediately below the domes of diaphragms.
c. Ideally the rectal air bubble should be demonstrated in the radiogram.
d. Normally air-fluid levels can be seen in the stomach, duodenal cap and in the right iliac fossa.
e. Pro-peritoneal fat lines are seen as a translucent shadow longitudinally along the flank [Fig. 1].
f. Neonates demonstrate a normal "mosaic pattern" of abdominal gas.

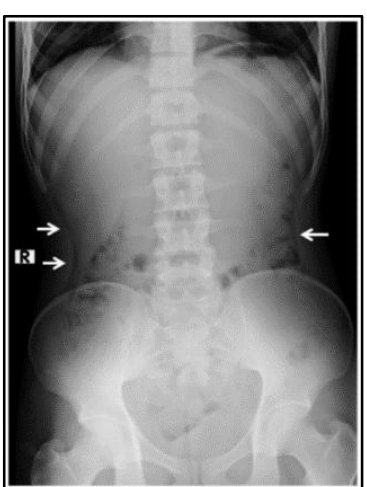

Fig. 1: Normal Abdomen

Fig. 1: Plain X-ray Erect Abdomen shows normal gastric air bubble and few normal air-fluid levels in the small bowel and rectal gas shadow. Observe the properitoneal fat stripe (arrows) which is to be seen normally in all patients.

Increased Intra-Luminal Air in Paediatric Patients: The most common causes of bowel obstruction in infants are bands, malrotations, atresias, meconium plugs and intussusceptions. These children present with excessive vomiting. Malrotations are frequently associated with Ladd's bands [Fig. 2A]. Ladd's bands are bands of peritoneal fibrous tissue which extend from the caecum to the sub-hepatic region, posterior peritoneum or abdominal wall, and lead to compression of the 2nd or 3rd duodenal portions. [4] In such cases, the stomach is grossly distended with a dilated duodenum. The right flank is devoid of bowel loops and all the bowel loops are seen on the left side of abdomen. A barium study will show a dilated stomach and duodenum with abrupt cut off, and all the bowel loops would be placed on the left side. [Fig. 2B]

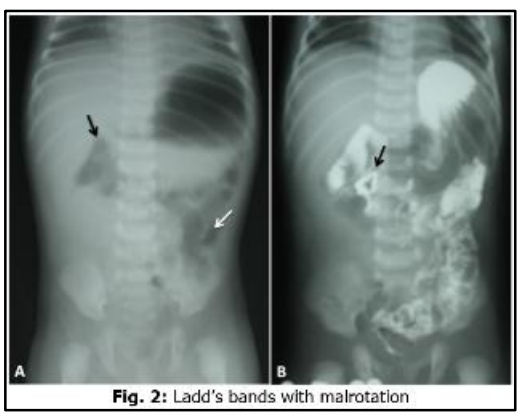

Fig. 2: Ladd's bands with malrotation

Fig. 2: (A). Plain X-ray Erect Abdomen shows dilated gas filled stomach and duodenum with abrupt cut off (black arrow). All the bowel loops are placed on the left side (white arrow). (B). Barium meal follow through study confirms the findings.

Bowel atresia is a congenital abnormality wherein there is severe narrowing or complete absence of a portion of the bowel which is generally thought to be secondary to an intra-uterine vascular insult. [5] The child typically presents at birth with bilious vomiting. A 'double bubble sign' is seen in a duodenal atresia [Fig. 3] and a 'triple bubble sign' is seen in a jejunal atresia. In ileal atresia, the small bowel loops are grossly dilated with absent rectal air bubble [Fig. 4A]. A water soluble contrast enema study will show an underdeveloped colon termed as micro colon [Fig. 4B].

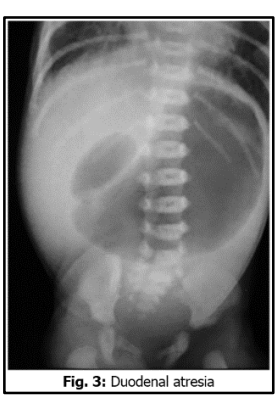
Fig. 3: Duodenal atresia

Fig. 3: A plain X-ray supine abdomen shows 'double bubble sign' with paucity of bowel gas distally.

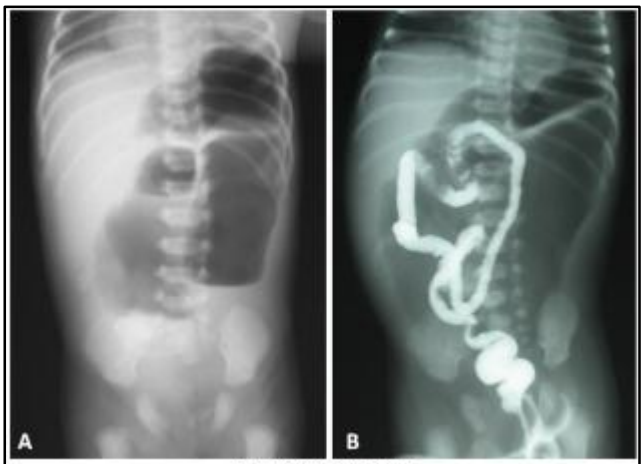

Fig. 4: Ileal Atresia

Fig. 4: (A) Plain X-ray Erect Abdomen shows a grossly dilated ileal loop with paucity of bowel loops distally. Note that the rectal air bubble is absent. (B). Water soluble contrast enema shows a small and narrow colon, typically termed as micro colon.

Large bowel atresia is relatively less common and the child presents with vomiting and non-passage of meconium. The colon proximal to the point of atresia is often massively dilated, and a mottled pattern of gas and faeces may be identified. [Fig. 5]

Fig. 5: Colonic Atresia

Fig. 5: (A). Plain X-ray Abdomen lateral view in a case of colonic atresia at the level of splenic flexure shows grossly dilated proximal large bowel loops with absence of rectal air bubble. (B). Water soluble contrast enema shows a small and narrow distal colon with abrupt cut off at the splenic flexure (arrow).

Meconium ileus occurs due to ileal obstruction in a new-born secondary to an abnormally thick and impacted meconium. It can present as intestinal obstruction or perforation, wherein it leads to meconium peritonitis. Plain radiograms show an abnormally dilated small bowel loops proximal to the site of impaction [Fig.6]. The admixture of gas with meconium may give rise to a soap bubble appearance. [6]

Fig. 6: (A) Plain X-ray Erect Abdomen shows moderately dilated small bowel loops with air-fluid levels in the mid abdomen and paucity of bowel loops distally. There is also pneumoperitoneum suggested by free air under the domes of diaphragm. Further, there is loss of properitoneal fat plane s which suggests peritonitis.

Necrotizing enterocolitis develops two to three days following birth and is more common in premature neonates. Plain radiogram reveals asymmetrically dilated bowel loops with loss of normal mosaic pattern, bowel wall oedema and sometimes pneumoperitoneum. [Fig. 7]

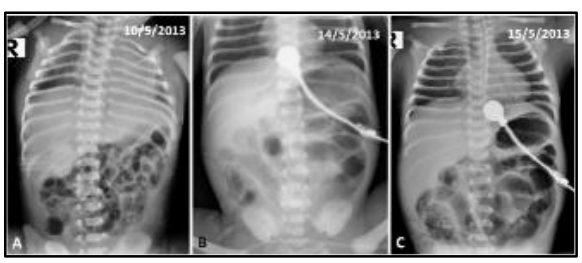

Fig. 7: Necrotizing Enterocolitis

Fig. 7: Supine abdominal radiograms show changing bowel patterns from normal mosaic pattern (A) to dilated parallel oriented bowel loops (B). Return of normal mosaic pattern (C).

Intussusception is another common cause of small bowel obstruction in older children. On plain radiogram, a crescentic gas shadow is visualized with or without proximal dilatation of bowel loops. [Fig. 8]

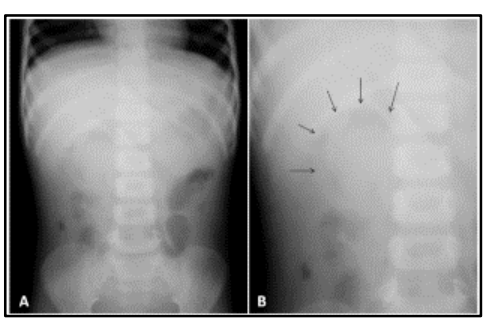

Fig. 8: Intussusception

Fig. 8: Plain X-ray Erect Abdomen shows a pincer shaped translucent shadow in the right hypochondrium (arrows).

Gastric volvulus is of two types-organoaxial, wherein the stomach rotates along its long axis and the greater curvature is seen above the lesser curvature; and mesenteroaxial, wherein the stomach rotates along its short axis. Here the gastric antrum is displaced above the gastro-oesophageal junction. Plain radiogram shows a massively dilated stomach with air-fluid level in the left upper quadrant. A Barium meal may be necessary to confirm the diagnosis. [Fig. 9]

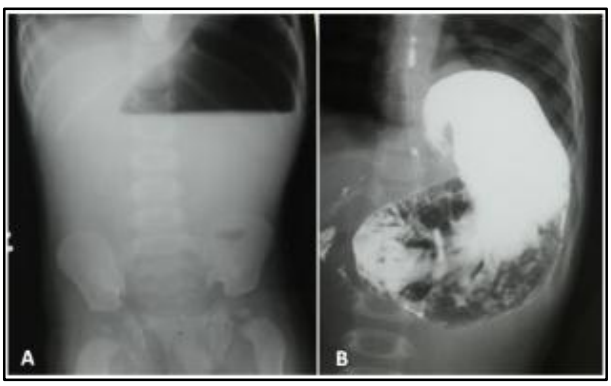

Fig. 9: Gastric Volvulus

Fig. 9: (A). X-ray Erect Abdomen shows grossly dilated fluid-filled stomach. (B). Barium study confirming the gastro-oesophageal junction (black arrow) is at a lower level in relation to the gastric antrum (white arrows).

Midgut volvulus occurs when the small bowel twists along its mesentery and is commonly associated with malrotation. It is usually not a diagnosis of plain radiogram. A barium study reveals a classical cork screw appearance of the small bowel. [Fig. 10]

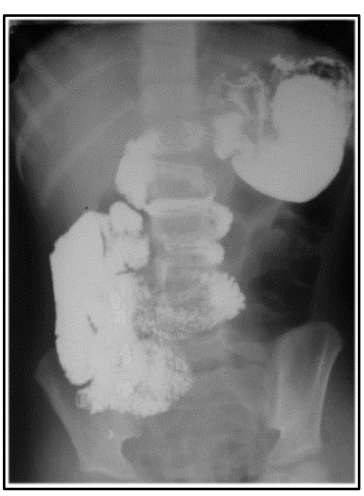

Fig. 10: Midgut volvulus with malrotation

Fig. 10: Barium series shows cork screw appearance of midgut with proximal jejunal loops seen on right side

Increased Intra-Luminal Air In Adult Patients: The commonest causes for intestinal obstruction in an adult are adhesions, volvulus and bands. Plain abdominal radiogram is a valuable initial radiographic examination in differentiating small bowel obstruction from ileus.[7] A Plain

radiogram reveals multiple air-fluid levels arranged in a 'step ladder pattern' [Fig. 11A]. Paucity of air-fluid levels may indicate either proximal bowel obstruction or an early phase of obstruction where the bowel loops are fluid filled, whereas multiple air-fluid levels indicate a distal point of obstruction. Air trapped amidst the oedematous valvulae connivantes gives a 'stacked coin appearance' [Fig. 11B]. Plain abdominal radiogram is a valuable initial radiographic examination in differentiating small bowel obstruction from paralytic ileus. In paralytic ileus, both small and large bowel loops are dilated with presence of rectal gas shadow.

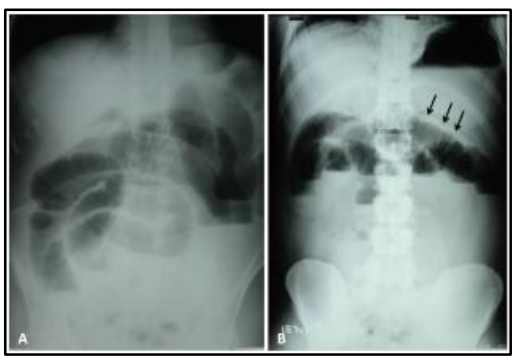

Fig. 11: Small Intestinal Obstruction

Fig. 11: (A). Plain Xray Erect Abdomen shows dilated small bowel loops with multiple air-fluid levels in a step-ladder pattern. (B). Small bowel obstruction in another patient shows similarly dilated small bowel loops with air-fluid levels and oedematous valvulae connivantes giving a stacked coin appearance (arrows)

A sigmoid volvulus will be seen as a 'U' shaped dilated large bowel loop with ahaustral margins, termed as the 'coffee bean sign' whose apex lies above 10th thoracic vertebra, and may show liver & left flank overlap sign [Fig. 12]. Convergence sign i.e. three lines converge into the pelvis on the left side is an important diagnostic finding, along with an air: fluid level ratio of 2:1.[8]

Fig. 12: Sigmoid Volvulus

Fig. 12: (A) Plain X-ray erect abdomen shows a grossly dilated loop of sigmoid colon devoid of haustrations with its apex reaching the left hypochondrium up to the T8 vertebral level.

In contrast, a caecal volvulus usually shows haustral pattern with its long axis extending from the right lower quadrant with its apex at the epigastrium or left upper quadrant and typically does not cross T10. Identification of an attached gas filled appendix confirms the diagnosis of caecal volvulus. [8]

Localized Increased Intra-Luminal Air: Localized bowel dilatation or sentinel loop or localised ileus suggests local inflammation. This is due to paralysis of the myenteric plexus of nerves.

Intestinal ascariasis can also be a cause of localized obstruction [Fig. 13].

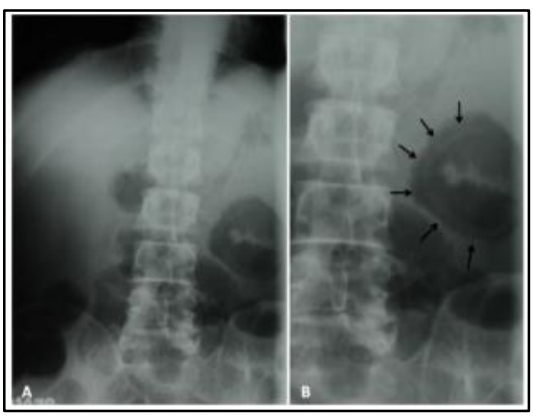

Fig. 13: Ascaris worm delineated in a dilated small bowel

Fig. 13: Plain supine radiogram shows an ascaris worm (arrows) within the dilated small bowel loop.

Localised dilated small bowel loop in the left flank may be seen in acute pancreatitis involving the tail of pancreas. Dilated large bowel without faecal matter and abrupt cut off of the descending colon called 'colon cut off' sign also suggests pancreatitis. [Fig.14]

Fig. 14: Acute Pancreatitis

Fig. 14: Plain X-ray Erect Abdomen shows abrupt cut-off of proximal transverse colon and distal descending colon giving 'colon cut off sign' (arrows).

Decreased intra-luminal air in adult patients: Gasless abdomen i.e. near total decreased air in the abdomen suggests Acute pancreatitis. [Fig. 15]

Fig. 15: Acute Pancreatitis

Fig. 15: Plain X-ray erect abdomen shows total decreased air in the abdomen giving the appearance of 'gasless abdomen' suggesting pancreatitis

Air within the walls of GIT: Presence of air in the walls of GIT is termed as intramural air or pneumatosis intestinalis, which itself is not a disease, but rather an important sign. In some cases, this is an incidental finding whereas in others, it portends a life-threatening intra-abdominal condition as in a case of bowel gangrene. [Fig. 16].

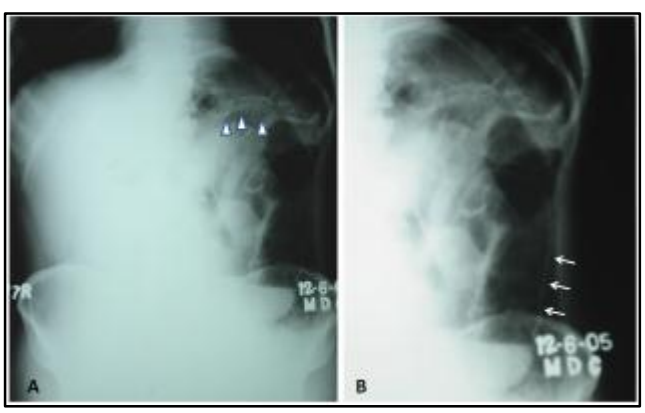

Fig. 16: Pneumatosis Intestinalis

Fig. 16: Plain X-ray erect abdomen shows serrated margins of a small bowel wall in-profile view (arrows); and lacy pattern in en-face view (arrow heads)

Air outside the GIT lumen, in the peritoneal space: Free air outside the lumen of GIT is termed as pneumoperitoneum, the commonest non-iatrogenic cause being hollow viscus perforation [Fig. 17]. The quantity of air seen under the domes of diaphragm depends on the site of perforation and amount of fluid in the lumen. Delineation of both walls of bowel is termed as Rigler's sign. The signs of pneumoperitoneum on a radiogram are enlisted in Table-1.

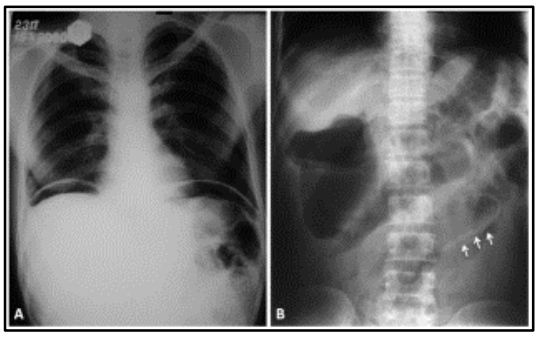

Fig. 17: Pneumoperitoneum

Fig. 17: (A). Plain X-ray Erect Abdomen demonstrates a crescentic lucency under both domes of diaphragm suggesting free peritoneal air. (B). Plain X-ray supine Abdomen demonstrates Rigler's sign, wherein both sides of the bowel wall are clearly seen (white arrows)

Air outside the GIT lumen, in the retroperitoneal space: Pneumoretroperitoneum could extend from the scrotum [Fig.18], diverticular perforation or retroperitoneal appendix or rarely an intraperitoneal hollow viscus can perforate into the intramesenteric space and then track air to the retroperitoneal spaces. Sometimes air can become loculated at a site as seen in this case of appendicular perforation [Fig. 19].

Fig. 18: Pneumoretroperitoneum

Fig. 18: A. Air in the retroperitoneal spaces (arrows). B. Air in the scrotal sac.

Fig. 19: Appendicular Perforation

Fig. 19: Plain radiogram Erect Abdomen shows mottled translucency in the right paracolic region (arrows).

Air outside the GIT, within tubular (Non-vascular & Vascular) structures: Air in the biliary channels is termed as pneumobilia. Tubular, branching air in the region of liver could be due to pneumobilia, air in the portal radicles or hepatic veins. The differentiation between these is extremely important as both the aetiology and management differ. Air in the biliary tree is situated towards the centre of liver shadow and shows branching pattern [Fig. 20], whereas air in the portal radicles are branching translucencies situated more peripherally [Fig. 21A]. Air in the hepatic veins appear as centrally placed branching translucencies but directed cranially and converging towards the spine [Fig. 21B].

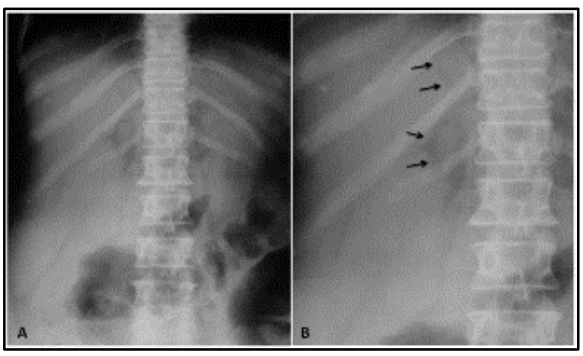

Fig. 20: Pneumobilia

Fig. 20: Centrally placed branching linear tubular translucency in the liver shadow, suggesting air in the biliary tree (arrows).

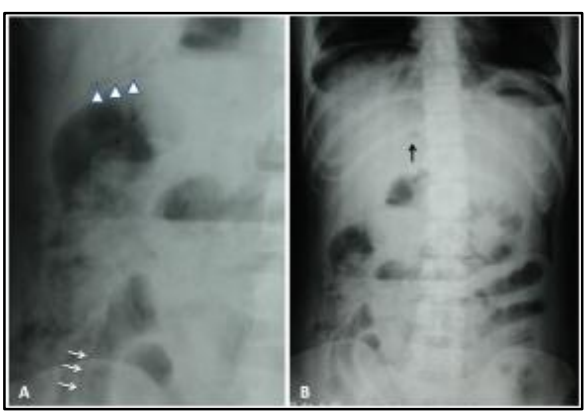

Fig. 21: Pneumoperitoneum with portal venous and hepatic venous air

Fig. 21: Plain X-ray Erect Abdomen in a patient of mesenteric ischaemia shows air in the portal radicals (arrow heads), middle hepatic vein (black arrow), intramural air (white arrows) and free air under the right dome of diaphragm.

Air outside the GIT, within solid organs: Air in solid abdominal organs like liver and kidney could be due to infections. One of the most common causes of air in the liver is secondary to abscesses due to gas forming organisms [Fig. 22] or post-interventional changes in an abscess. The common cause of air in the kidneys is emphysematous pyelonephritis. On supine radiograms, the renal shadow is seen to have a mottled appearance and on erect radiograms, it may show air-fluid levels [Fig. 23].

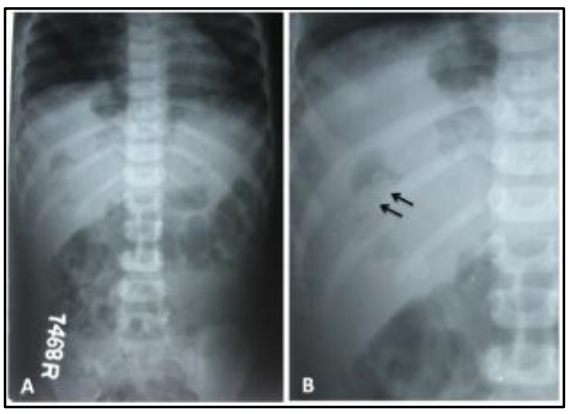

Fig. 22: Multiple hepatic abscesses with worms

Fig. 22: Plain radiogram supine Abdomen shows multiple translucencies within the liver shadow, with one of them showing ascaris worms within (arrows).

Fig. 23: Emphysematous pyelonephritis

Fig. 23: Plain radiogram of Erect Abdomen shows mottled lucencies in the right renal area and delineation of the pelvicalyceal system and proximal ureter by air.

CONCLUSION: To conclude, gas patterns are best identified on plain radiograms. Though there is a tendency to order an Ultrasound or CT examination, a plain abdomen and chest radiograms still have a very important role as they reflect a great quantum of information. In acute abdomen, a thorough knowledge of gas patterns will help to identify the aetiology. A simple abdominal radiogram thus should be read with a great deal of suspicion in a clinically demanding case.

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