How to use abdominal X-rays in preterm infants suspected of developing necrotising enterocolitis

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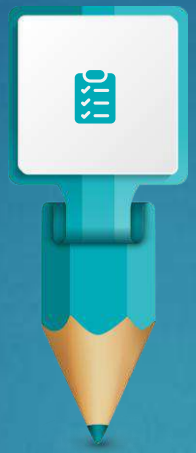
OUTLINE

Introduction



Normal abdominal radiograph in neonates

Definition, Incidence, Etiology and Clinical findings

Radiographic technique

Pathological correlation with radiography

Diagnosis of NEC

Sign of NEC

Conclusion

Introduction

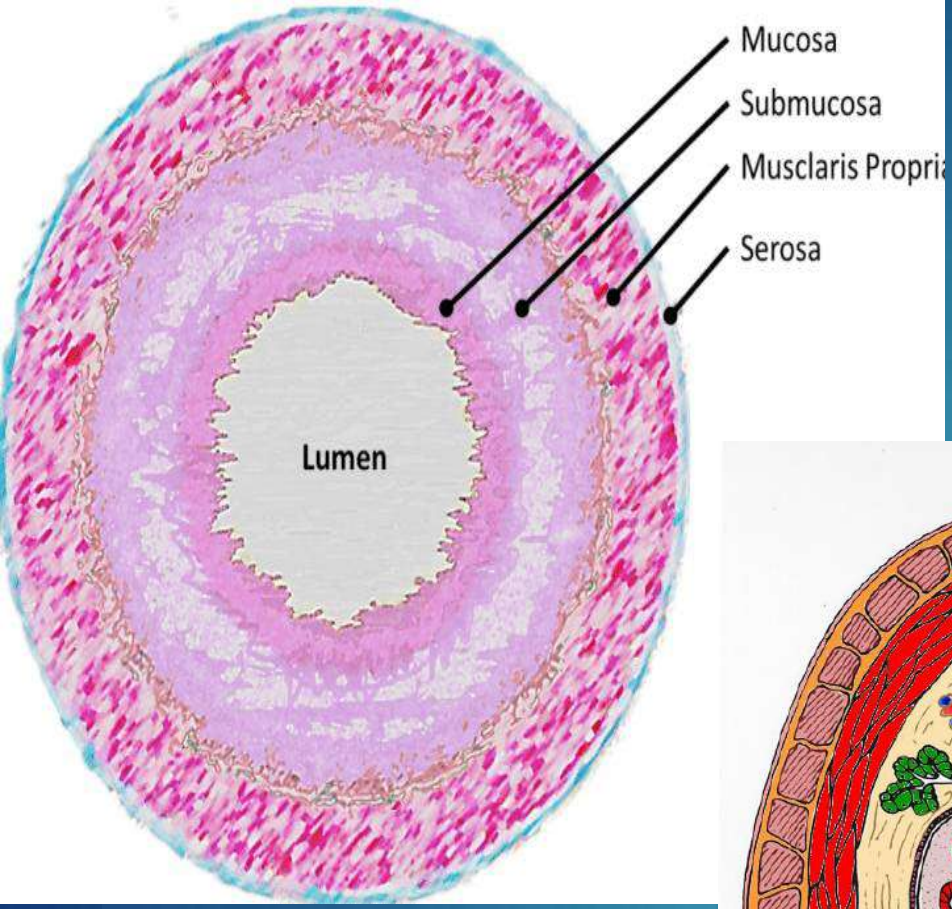
Necrotising enterocolitis (NEC) is a serious life-threatening gastrointestinal disease in the newborn.

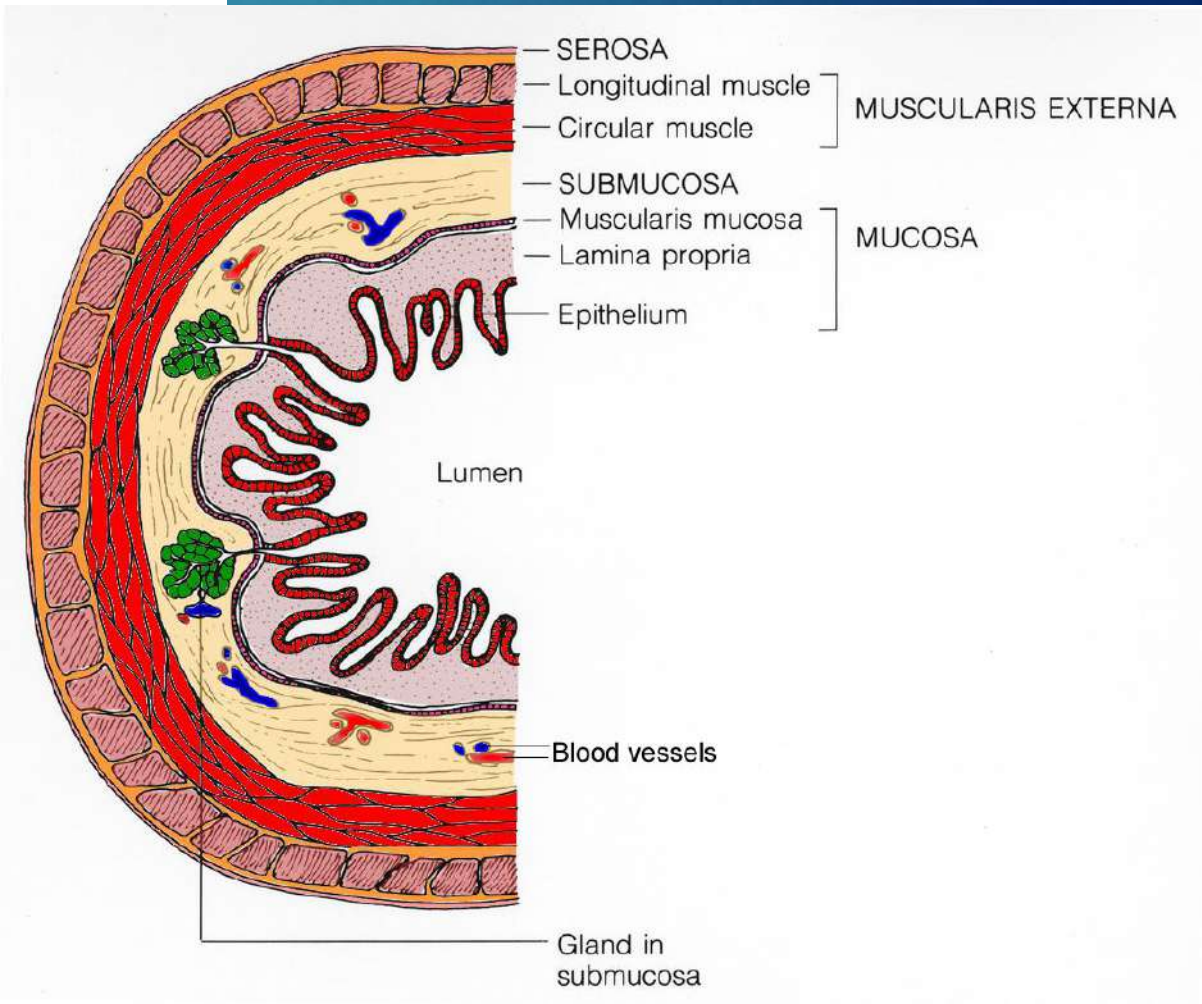
Affecting 1%–5% of neonatal intensive care unit admissions and up to 10% of neonates under 1500g.

The overall mortality rate in NEC is between 20% and 40%, approaching 50% in extremely low birthweight infants, who require surgical treatment of NEC.

Abdominal X-rays (AXRs) are heavily relied on to help establish a diagnosis of NEC

Bowel wall layers



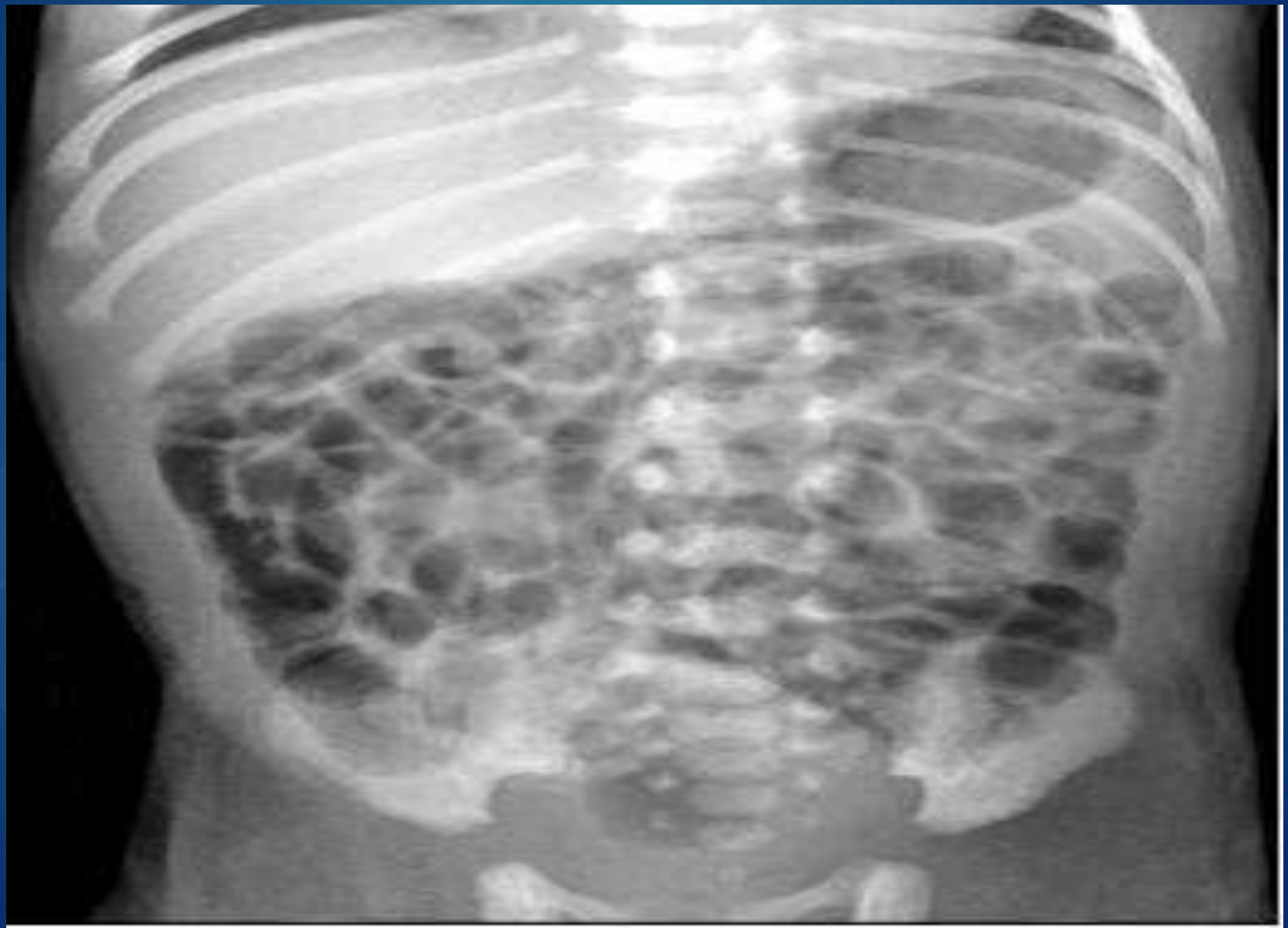


Normal abdominal radiograph in neonates

- ✓ Gas is usually present in the stomach within 10 to 15 minutes after birth.
- ✓ Gas normally reaches the proximal small bowel within an hour and fills most of the small bowel by 6 hours.
- ✓ The large bowel is filled by 12-14 hours, often with the passage of meconium.

- ✓The gas distribution is one of multiple, closely apposed, rounded or polyhedral structures.
- ✓The small and large bowel cannot be distinguished.
- ✓The normal calibre of the bowel loop should be equal to the measurement of either the width of L5 or the distance between the top of L1 to the bottom of L2.

Supine view of a normal neonate. The gas distribution is present throughout the small and large bowel and is one of multiple, closely apposed, rounded or polyhedral structures. The small and large bowel cannot be distinguished

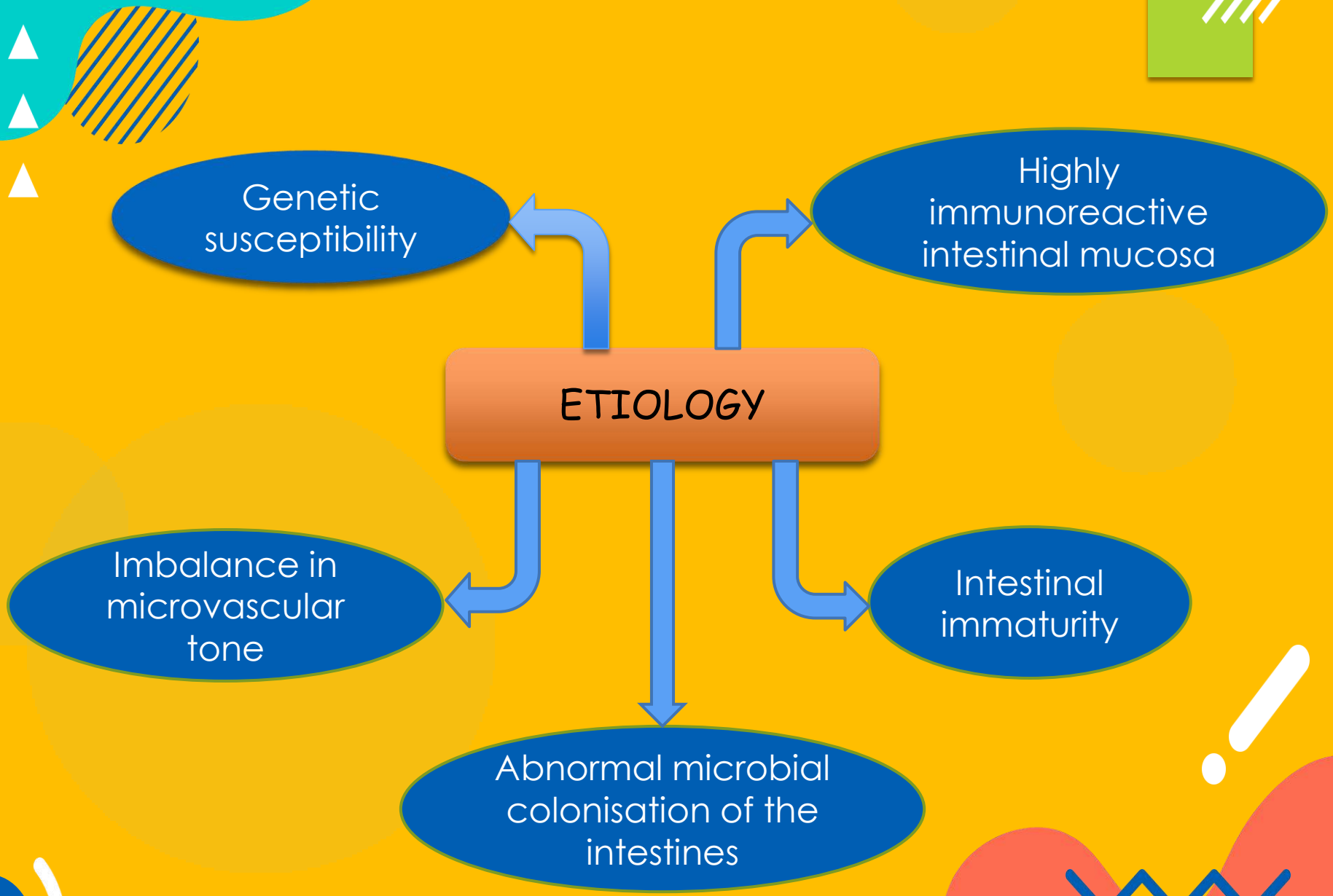


Definition

Necrotizing enterocolitis (NEC) is the most common gastrointestinal condition in premature neonates. It is characterized by inflammation, ischemia, and permeability of the neonatal bowel wall to bacteria. It is potentially life-threatening with significant associated morbidity.

Incidence

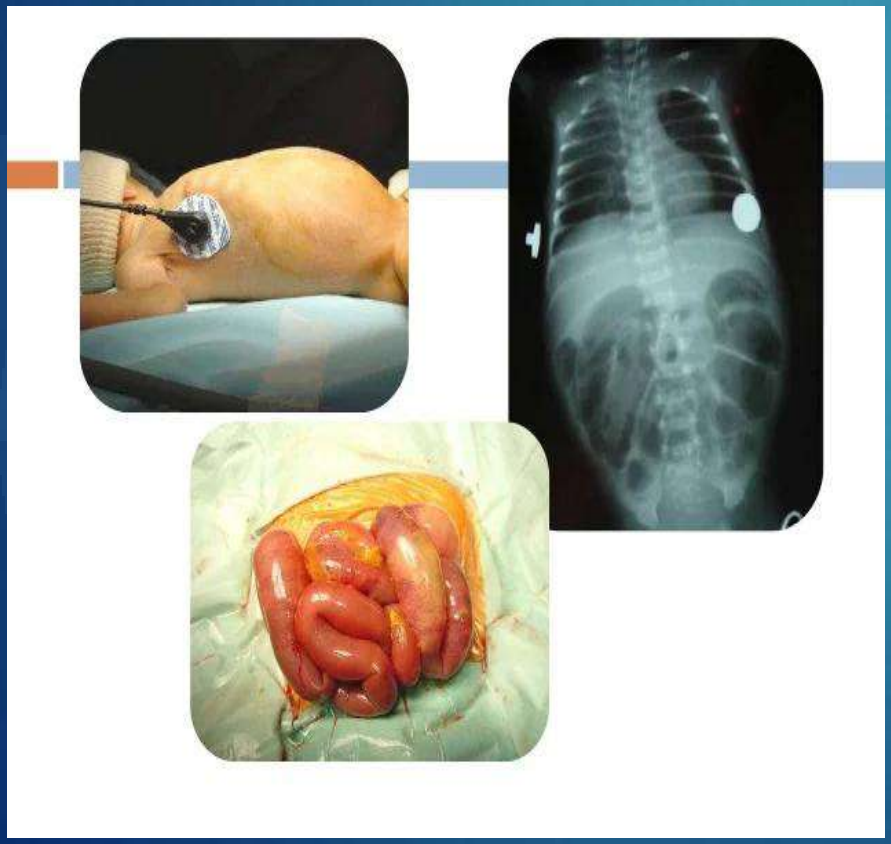
- ✓90% of NEC cases occur in premature babies.
- ✓Up to 10%-15% of NEC cases are found among full-term babies
- ✓The incidence of NEC in babies born at less than 32 weeks of gestational age varies from 2% to 7%
- ✓The frequency of the disease increases with decreasing gestational age at birth and lower birth weight


ETIOLOGY
Genetic susceptibility
Highly immunoreactive intestinal mucosa
Imbalance in microvascular tone
Intestinal immaturity
Abnormal microbial colonisation of the intestines

Clinical findings

- ✓ It usually occurs two weeks or later after birth
- ✓ More common in babies who are fed than not fed
- ✓ Distension, tenderness, vomiting
- ✓ Enhanchement gastric aspirate
- ✓ Ileus, abdominal wall erythema
- ✓ Ascites
- ✓ Bloody stool

Pathological correlation with radiography



- Bacteria
- Penetrate mucosal defence
- Inflammatory cascade
- Intramural gas
- Ischemic
- Necrosis
- Sloughing of the bowel wall occurs → Perforation

- ✓ Many of the radiographic signs of NEC are dependent on the phenomenon of gas-forming organisms → pathological presence.
- ✓ Pneumatosis intestinalis (intramural gas) → pathognomonic radiographic sign of NEC.
- ✓ Pneumoperitoneum is complicated by the fact that only in between one half and three quarters of patients with perforation is free air detectable even on lateral film.

Pathology

Postmortem photograph of bowel involved with severe NEC. The arrows indicate areas of the bowel wall where there has been so much necrosis and sloughing of the mucosa, submucosa, and muscularis that only the serosa is intact.

Diagnosis of NEC

The modified Bell's criteria

- Clinical findings
- Pathophysiological
- Radiological signs
- Classify the severity of the disease

Table 1 Modified Bell's staging criteria (Kliegman and Walsh[7])

Modified Bell's staging	Clinical findings	Radiographic findings	Gastrointestinal findings
Stage I	Apnoea, bradycardia and temperature instability.	Normal gas pattern or mild ileus.	Mild abdominal distension, stool occult blood, gastric residuals.
Stage IIA	Apnoea, bradycardia and temperature instability.	Ileus with dilated bowel loops and focal pneumatosis.	Moderate abdominal distension, haematochezia, absent bowel sounds.
Stage IIB	Metabolic acidosis and thrombocytopaenia.	Widespread pneumatosis, portal venous gas, ascites.	Abdominal tenderness and oedema.
Stage IIIA	Mixed acidosis, coagulopathy, hypotension, oliguria.	Moderate to severely dilated bowel loops, ascites, no free air.	Abdominal wall oedema, erythema and induration.
Stage IIIB	Shock, worsening vital signs and laboratory values.	Pneumoperitoneum.	Bowel perforation.

^ Radiographic Technique

- ✓ A supine anteroposterior film is recommended when NEC is suspected.
- ✓ Further AXRs (6–12 hourly).
- ✓ A lateral decubitus radiograph (right side up) may be useful when perforation is suspected but not clear on plain anteroposterior X-ray.

How to read abdominal X-rays where there is a suspicion of necrotising enterocolitis (NEC)

General information :

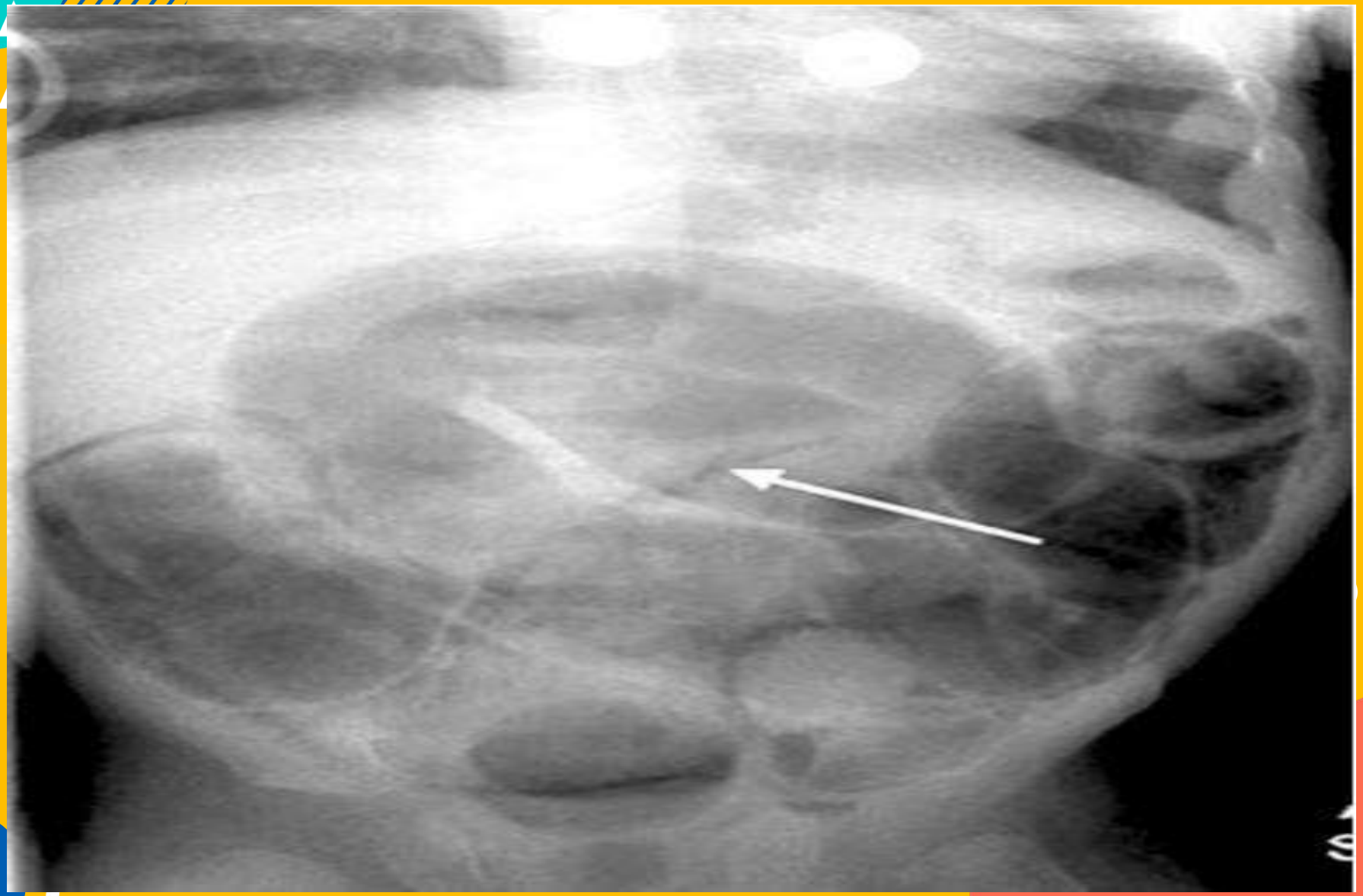
- ✓ Identify : (the patient, date of the film, time of the film).
- ✓ Check the adequacy of the film.
- ✓ Equipment.
- ✓ Chest.
- ✓ Air
- ✓ Soft tissue
- ✓ Bone
- ✓ Abnormal shadows

Signs of NEC

Crescents

- ✓Curvilinear appearance of intramural gas (pathognomonic of NEC).
- ✓Curvilinear lucencies in the bowel wall are due to gas in a subserosal location.
- ✓Crescents are more commonly seen in the right lower quadrant (the terminal ileum and the ascending colon).

Widespread pneumatosis seen as crescents (arrow)



Crescent from pneumatosis

Soap bubble

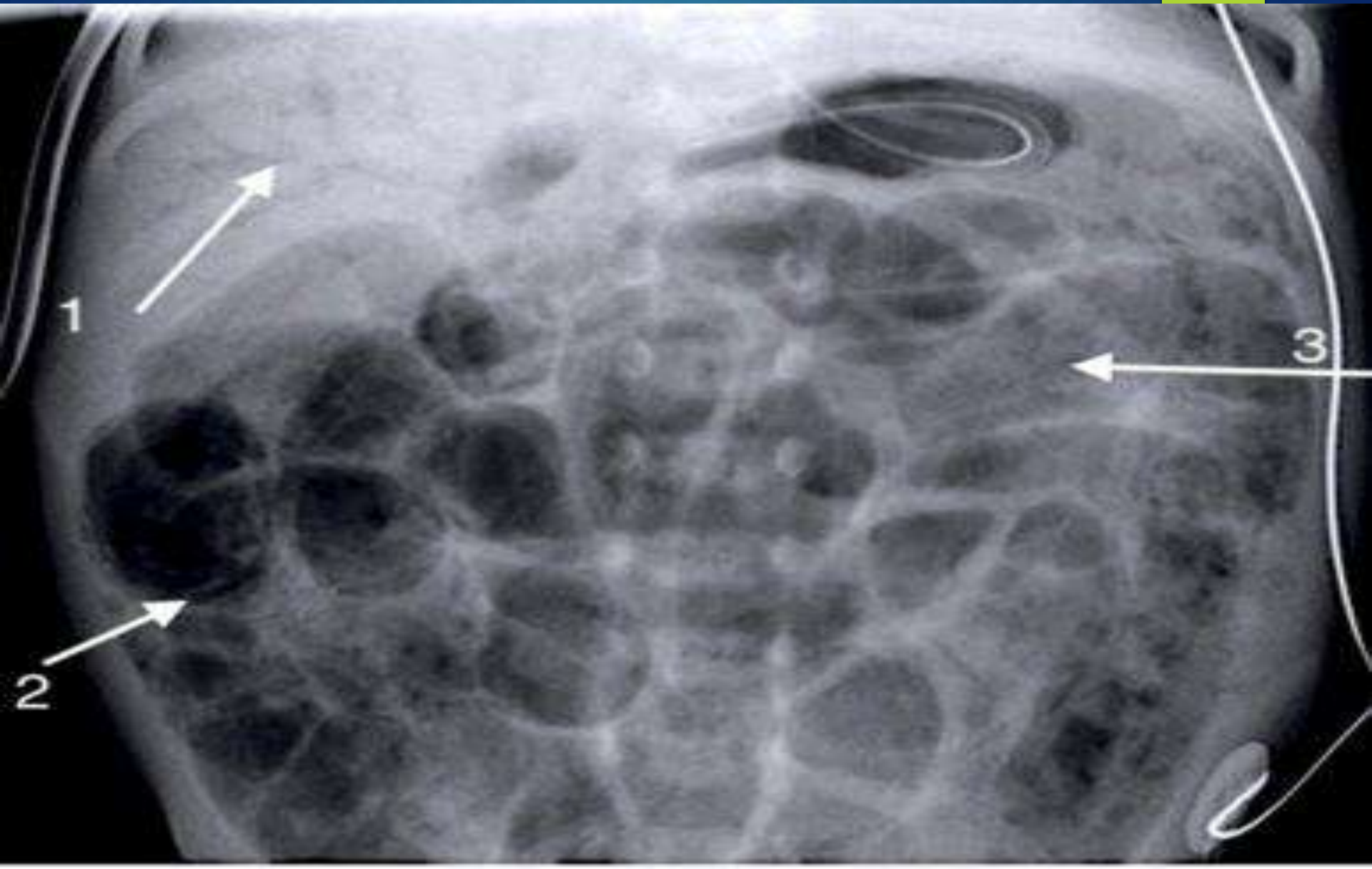
- ✓Symmetrical, small, in linear patterns.
- ✓Soap bubbles are not always specific of NEC.
- ✓The bubbly appearance is due to submucosal gas ‘blebs’
- ✓The bubbly morphology may be confused with stool in a normal colon.

Soap bubble appearance (arrow) persisting at 48 hours into treatment for necrotising enterocolitis. Found to be necrotic ascending colon at laparotomy.

Gas in the portal venous system

- ✓Seen as a shadow on the liver area, like the branching of a tree upwards.
- ✓This is typically appreciated in the periphery of the liver.
- ✓PVG (portal venous gas) may also be seen when a UVC (umbilical venous cateter) is in situ, where there is no prior suspicion of NEC.

Arrow 1 shows the branching tree of the portal venous gas.
Arrow 2 shows the crescents of pneumatosis.
Arrow 3 shows widespread soap bubbling

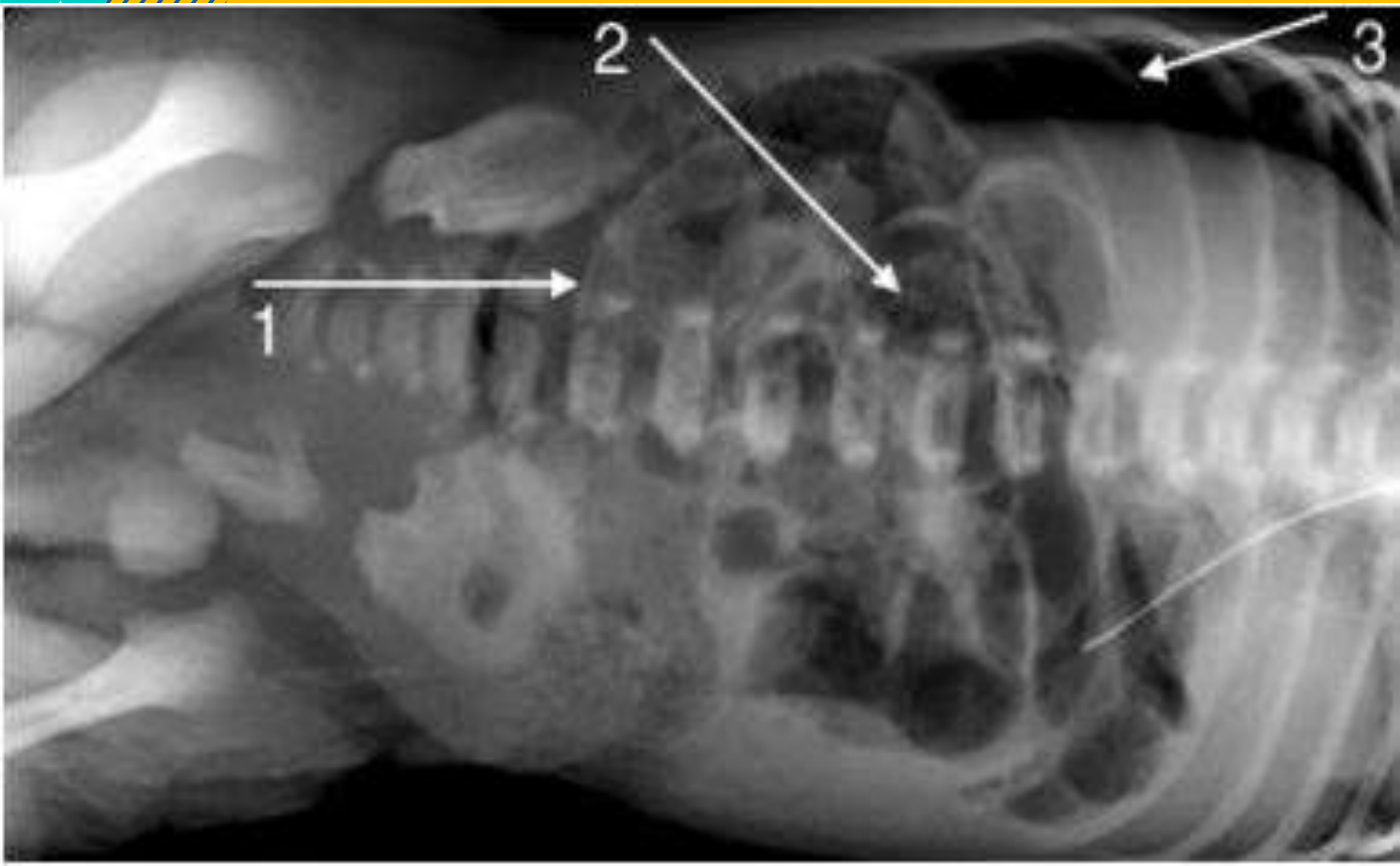


Sign of perforation

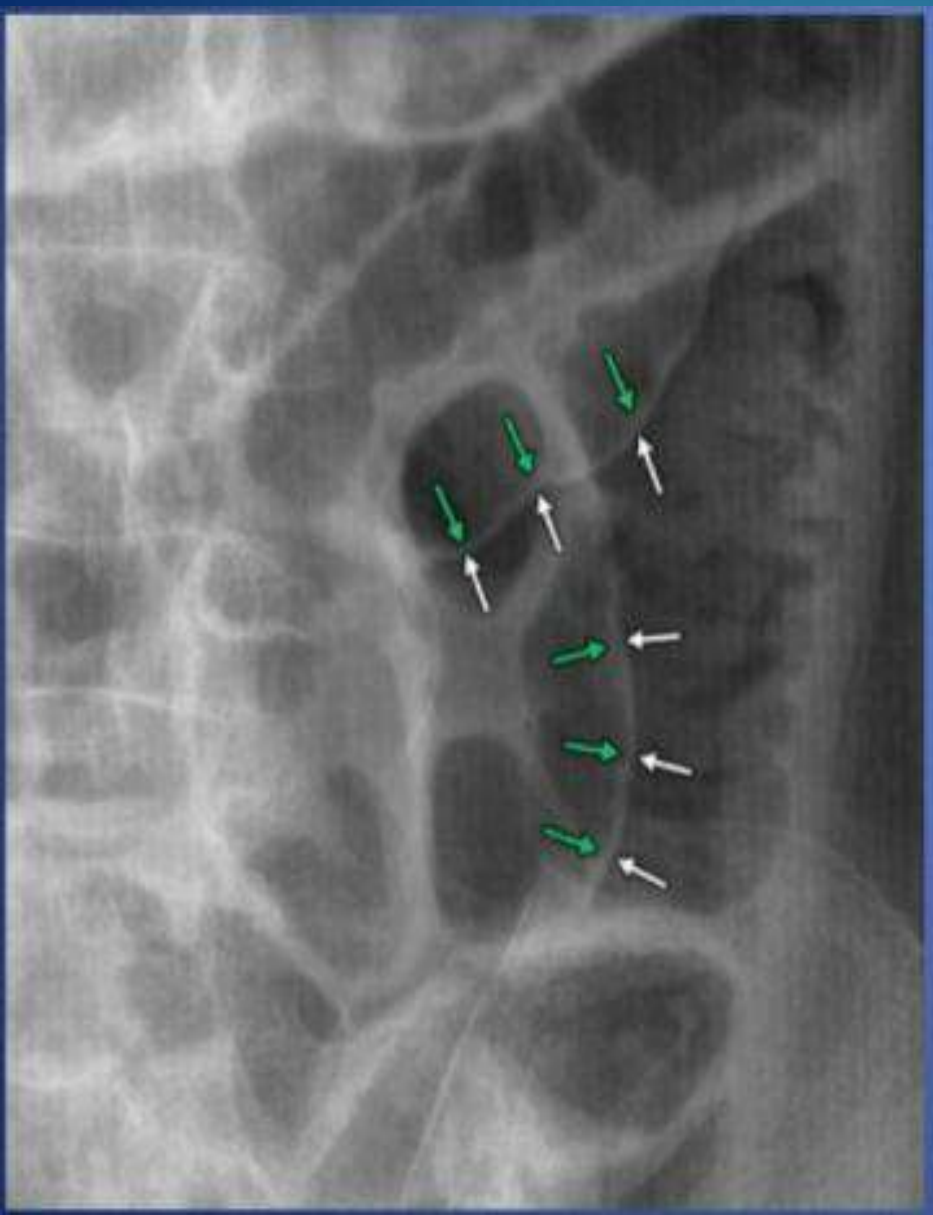
Rigler sign

- ✓A sharp demarcation of the bowel wall (almost like a line drawn with a pencil)
- ✓Usually one of the first signs of perforation and implies that there is air on both sides of the bowel wall.

X-ray taken lying on the left side.
Arrow 1 shows the ‘Rigler sign’. Arrow 2 shows widespread soap bubbling. Arrow 3 shows the solid liver clearly outlined by free intraperitoneal gas when the baby is placed right side up



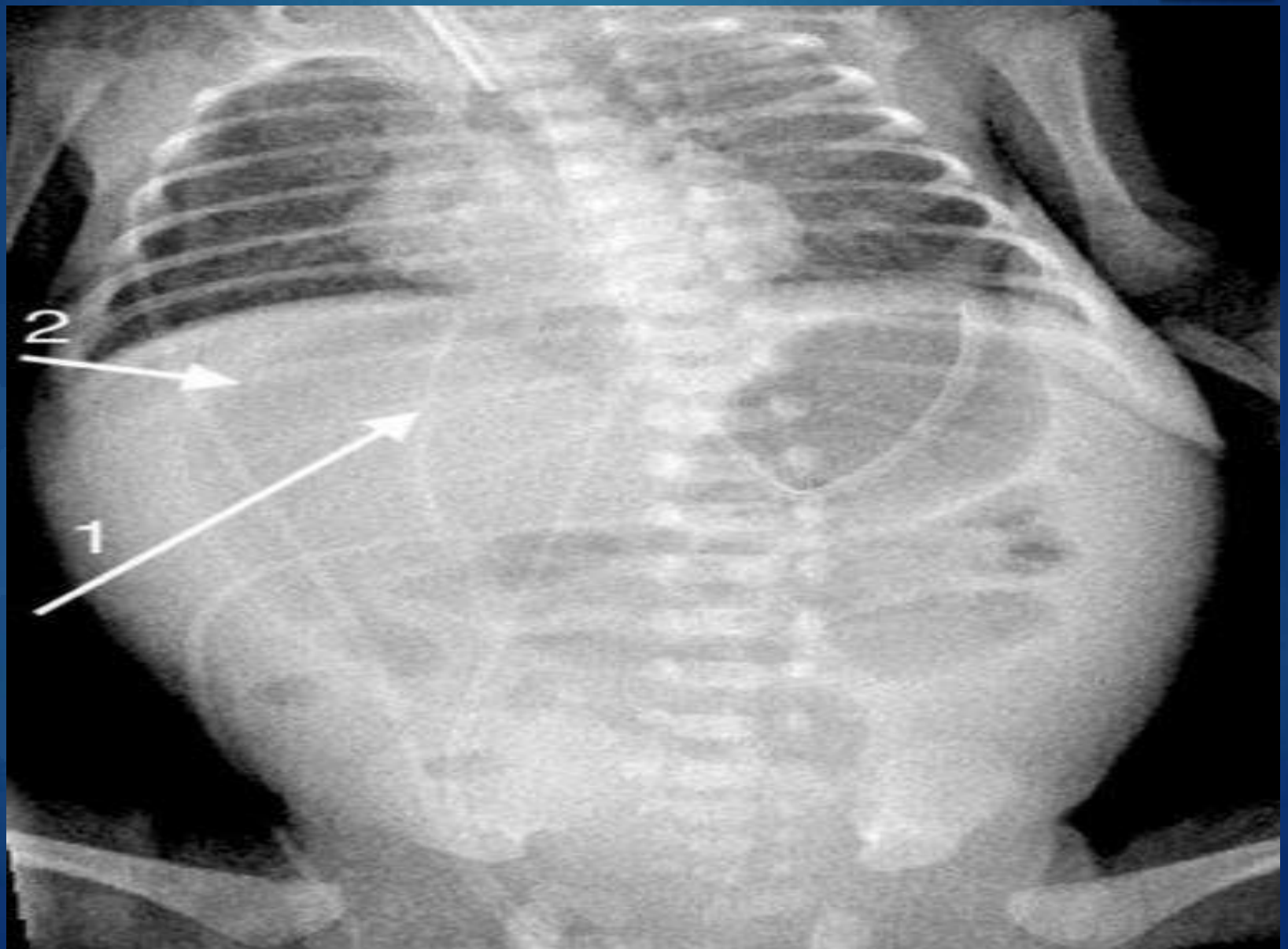
Arrows (Rigler sign) : bowel wall visualised both sides due to intra and extraluminal air



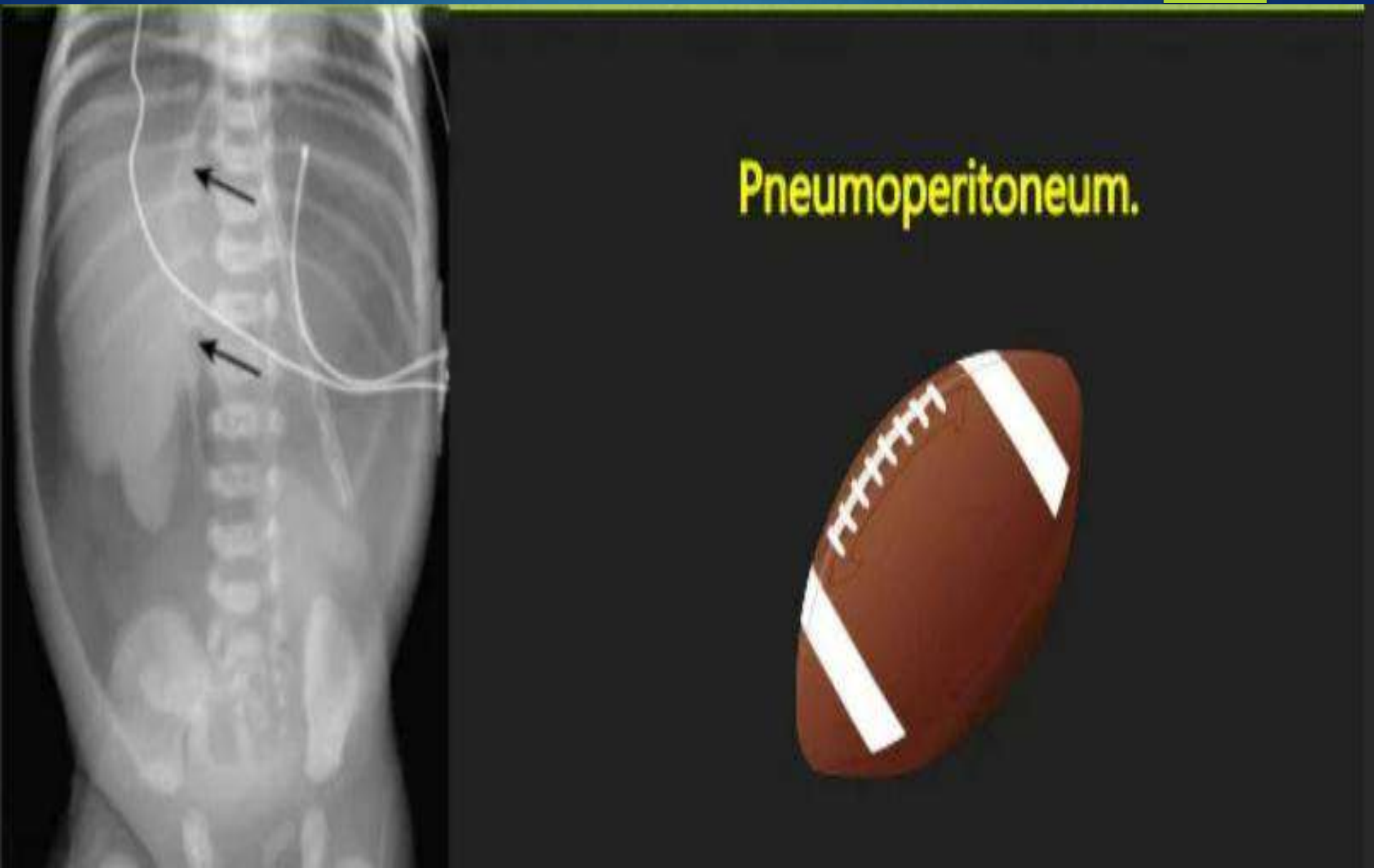
Football sign

- ✓ A large ovoid or circular lucency over the liver or in the central part of the abdomen due to a large amount of free intraperitoneal air.
- ✓ The falciform ligament is outlined due to the air being present on either side of it. This is seen as a faint linear opacity situated longitudinally within the right upper abdomen, representing the seams or laces of an American football.

The ‘football sign’ is demonstrated with gas on either side of the falciform ligament (arrow 1). Arrow 2 shows the lucency over the liver, indicating pneumoperitoneum.



The ‘football sign



Air under the diaphragm

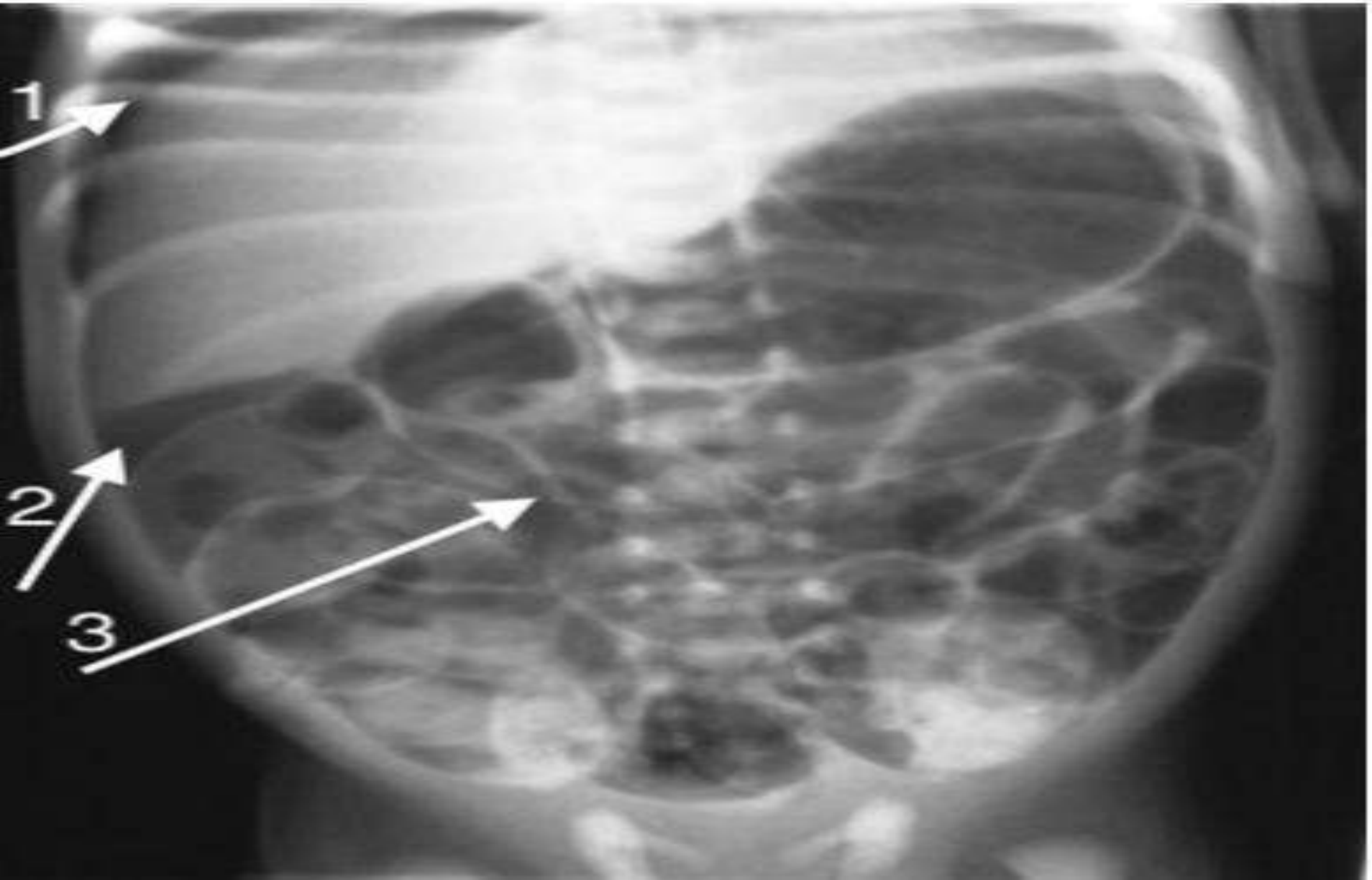
- ✓ Can be seen in an anteroposterior or lateral view.
- ✓ Lateral view, ask for right side up so that the solid liver is clearly outlined by free intraperitoneal gas.

Both arrows show the very subtle difference in radiolucency indicating large gas bubble in front of the liver from perforation

Triangle sign

- ✓ When free air becomes trapped in between loops of bowel, it can give the appearance of triangular shapes.
- ✓ This is also commonly seen under the liver

Arrow 1 shows gas under the diaphragm. Arrow 2 shows a ‘triangle’ under the liver. Arrow 3 points at the ‘Rigler sign’



Lucency over solid abdominal organs

- ✓ Lucency over a solid organ may be indicative of pneumoperitoneum.

Gas in patent processus vaginalis (PPV)

Gas in the PPV can be seen with perforation and may reach down to the scrotum in boys.

Other important signs

Fixed loop

- ✓ The presence of a non-moving.
- ✓ Persistently dilated loop has been reported as a hallmark of impending perforation.
- ✓ It is a radiographic sign that should be interpreted with caution as such loops can normalise with medical treatment.

Persistent pneumatosis

Pneumatosis visible on X-rays beyond 24 hours of institution of therapy may be an indication of severe ischaemia.

Soap bubble appearance (arrow) persisting at 48 hours into treatment for necrotising enterocolitis. Found to be necrotic ascending colon at laparotomy.

Bowel dilatation

- ✓ Bowel dilatation is considered normal in premature babies on invasive and non-invasive ventilation → The normal calibre of the bowel loop should be equal to the measurement of either the width of L5 or the distance between the top of L1 to the bottom of L2.

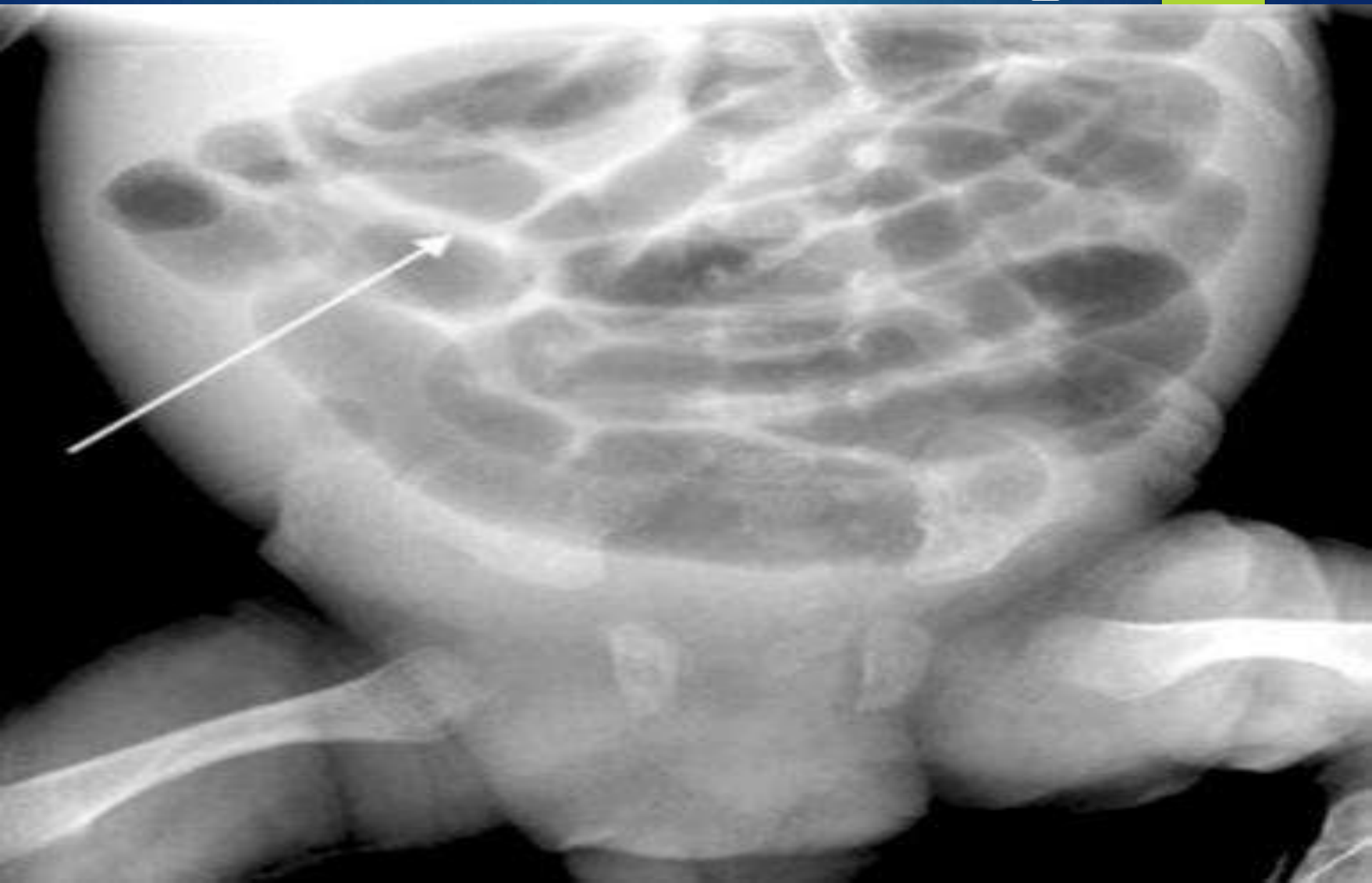
Dilated bowel loops

- ✓ Dilated bowel loops in the centre of the abdomen (described by some surgeons as the ‘flowerpot’ sign)→ implies that there is significant ascites and correlates with a sick baby.
- ✓ Dilated loops surrounding an area of the abdomen that looks radio-opaque (‘inverse flower pot’ sign)

Separation of the bowel loops

- ✓ An increase in peritoneal fluid between the loops.
- ✓ Commonly seen in generalised or systemic sepsis It is often mistaken as ‘thickened bowel wall’

Infant with sepsis (not necrotising enterocolitis). The arrow point to the ‘separation of bowel loops’ by an increase in intraperitoneal fluid



Conclusion

- ✓ AXR remains the modality of choice for diagnosis and follow-up of NEC. Clinical correlation is important.
- ✓ The standardisation of X-ray interpretation aims to avoid cases of misclassified NEC and thereby reduce the number of babies subjected to periods of suspended oral feeding and unnecessary transfers, both of which have an overall negative impact on neurodevelopmental outcomes of preterm babies.
- ✓ Early identification of abnormal signs on X-rays will allow timely institution of medical therapy in cases of NEC.


THANK YOU