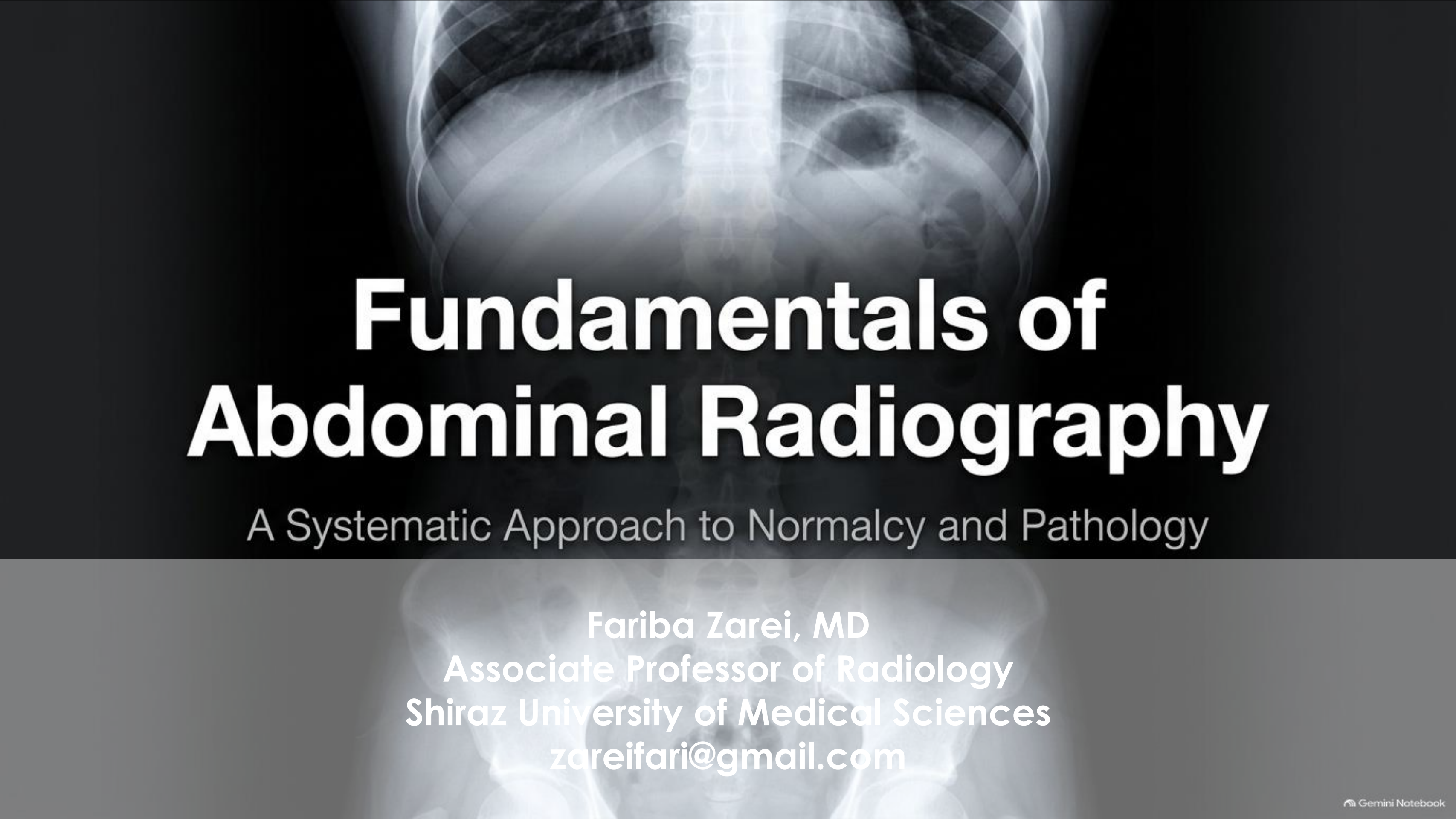


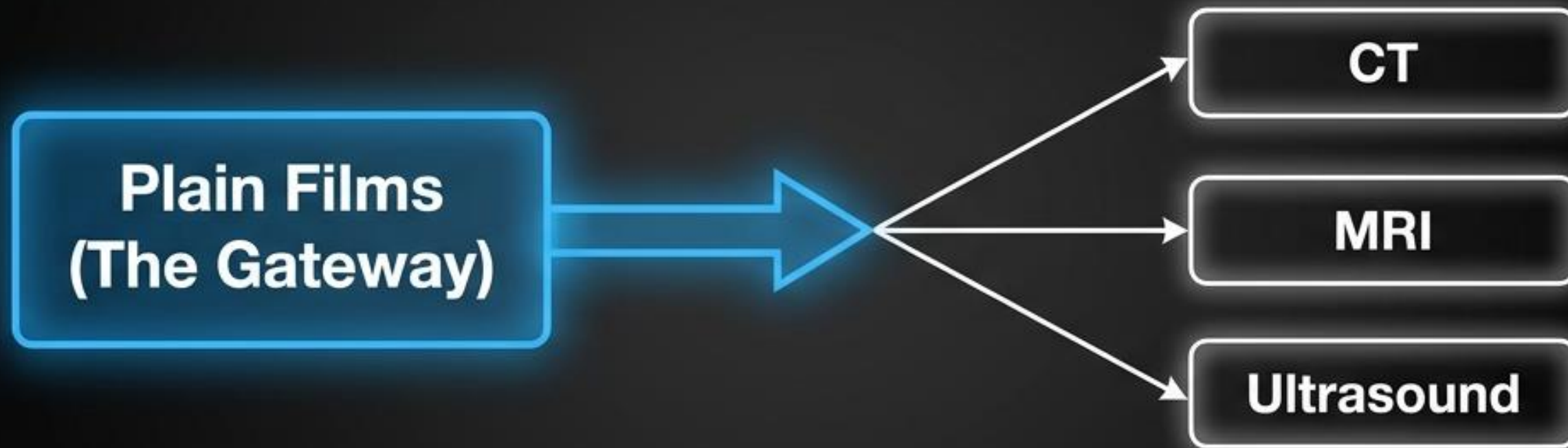


Fundamentals of Abdominal Radiography

A Systematic Approach to Normalcy and Pathology

Fariba Zarei, MD
Associate Professor of Radiology
Shiraz University of Medical Sciences
zareifari@gmail.com

The 4-Step Diagnostic Search Pattern



Plain films remain the routine first step and the standard for following up on other modalities.

1. Overall Gas Pattern	2. Extraluminal Air	3. Abnormal Calcifications	4. Soft-Tissue Masses
Evaluate distension vs. dilation.	Search for free air outside the lumen.	Differentiate pathologic stones from benign aging.	Look for organomegaly via bowel displacement.

The Diagnostic Baseline

The 4 Pillars



Gas



Free Air



Masses



Calcifications

Evaluate 4 things: Gas, Free Air, Masses, Calcifications.

Master the Normal

- Air is always in the stomach and rectosigmoid.
- 2-3 loops of small bowel is normal.

The Acute Series Protocol

- | | |
|--|---|
| • Supine: Overall pattern & masses. | • Prone: Rectosigmoid gas (rule out obstruction). |
| • Upright/Decubitus: Free air & fluid levels. | • Upright Chest: Diaphragmatic free air & effusions. |

The Golden Rule: Plain films are the gateway. To recognize the abnormal, you must first master the appearance of the normal.

Rules of the Central Gas Pattern

The Stomach

Almost always contains air, unless the patient recently vomited or is attached to an NG suction tube.

The Small Bowel

Normally contains a small amount of air in 2–3 loops.

- Normal Diameter: < 2.5 cm (~1 inch, or the size of a US quarter).

Core Principle

Distended = Filled completely to normal size (Normal).

Dilated = Filled beyond normal size (Abnormal).



Evaluating the Large Bowel

Expected Gas

Almost always present in the rectum or sigmoid.

The Dilation Rule of Thumb

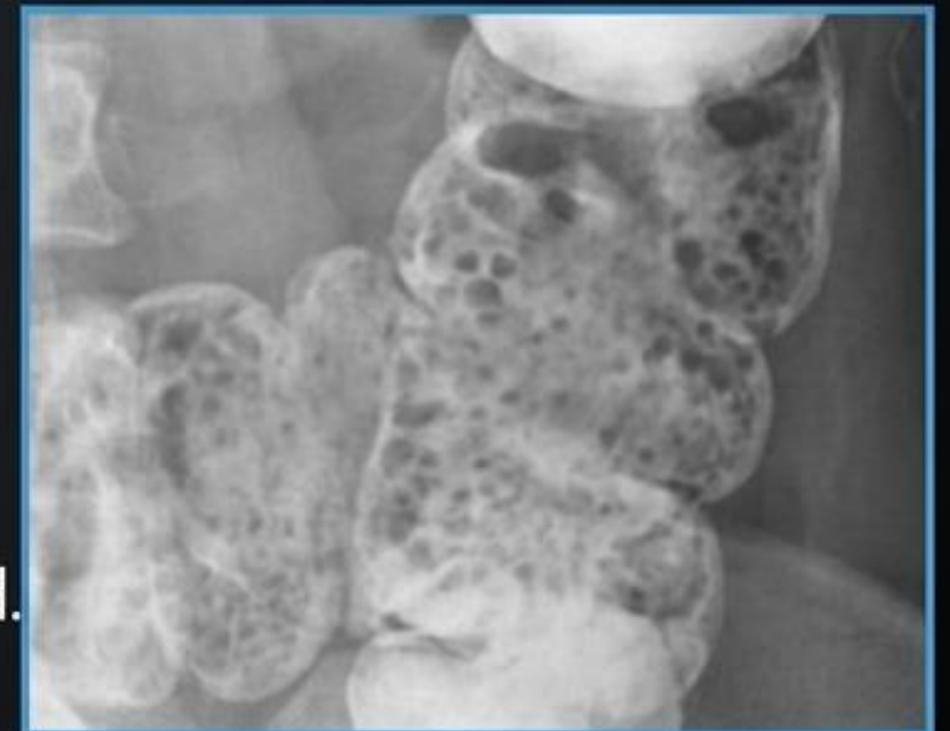
The large bowel can normally distend to the size seen on a barium enema examination. Beyond this, it is considered dilated.

Recognizing Stool

Multiple, small bubbles of gas within a semisolid soft-tissue mass. Identifying stool reliably localizes the large bowel.

Aerophagia Warning

Swallowing large quantities of air produces numerous polygonal, air-containing loops. They are distended and overlapping, but not dilated.

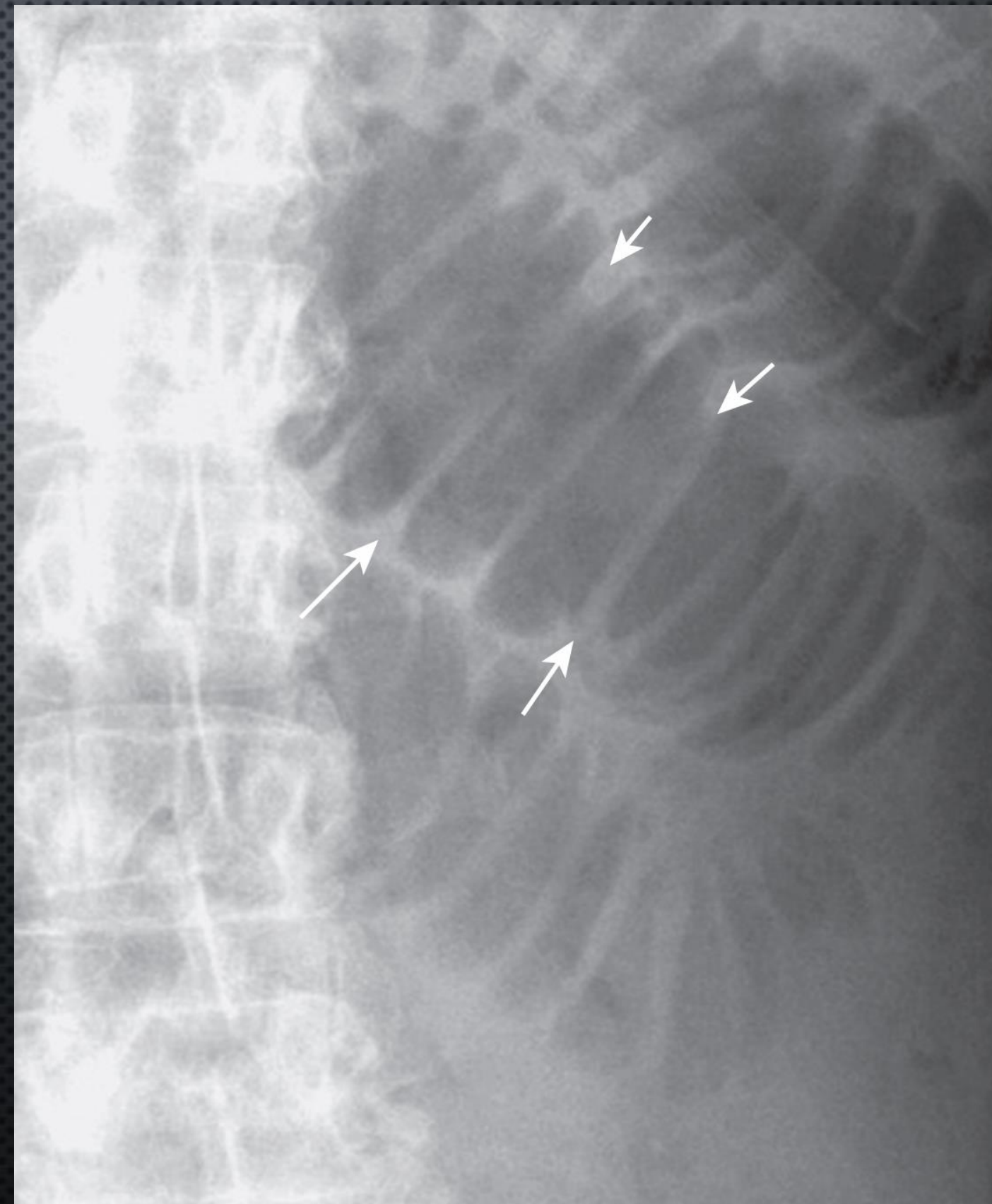
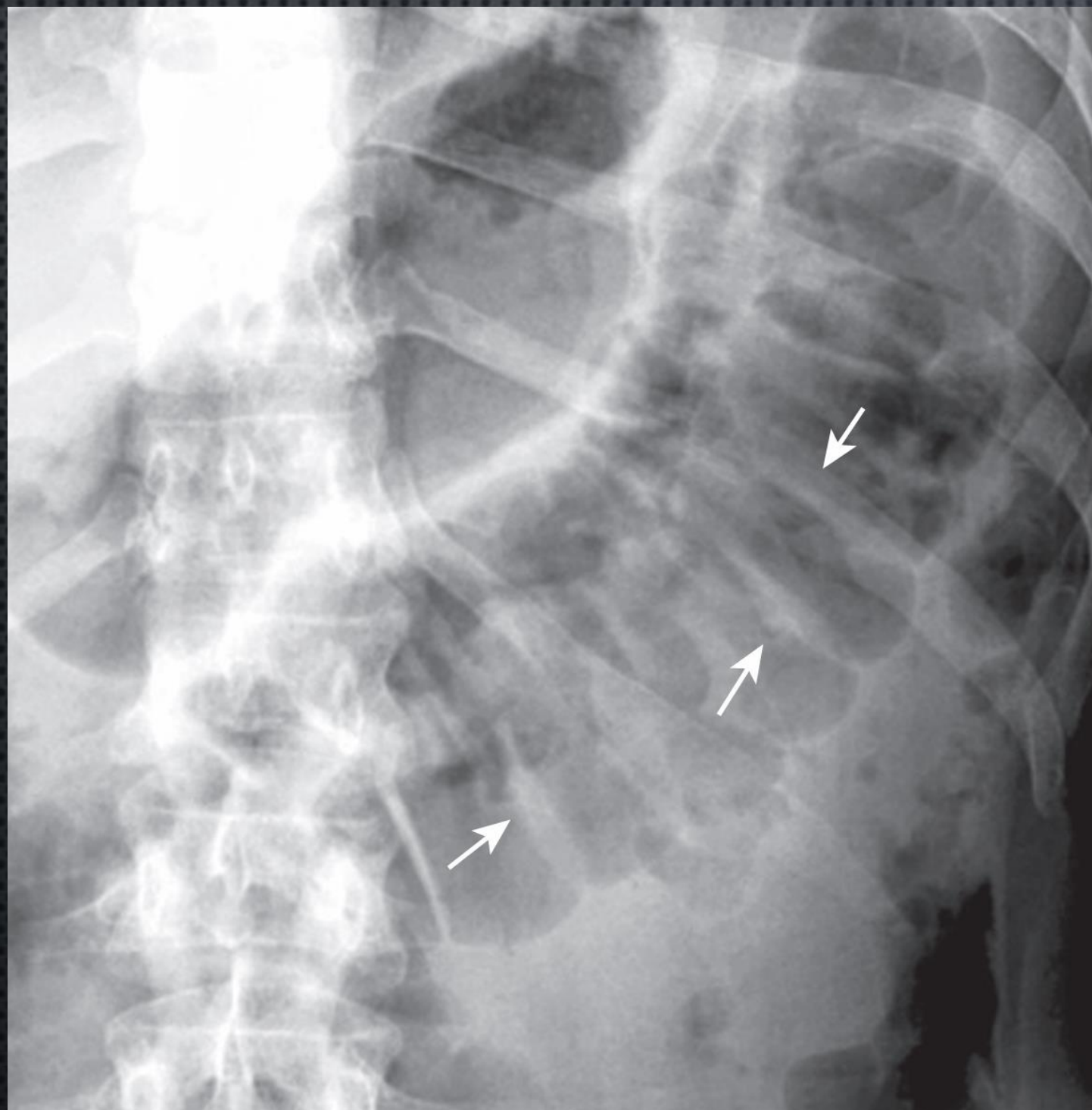


Differentiating Small vs. Large Bowel



	Small Bowel	Large Bowel
Location	Centrally placed	Peripherally placed (except RUQ)
Mucosal Markings	Valvulae conniventes	Haustral markings
Wall-to-Wall Extension	Extend completely across lumen	Do not typically extend completely across
Spacing	Spaced closely together	Spaced widely apart
Maximum Dilated Size	Max ~5 cm	Can dilate to many times small bowel size

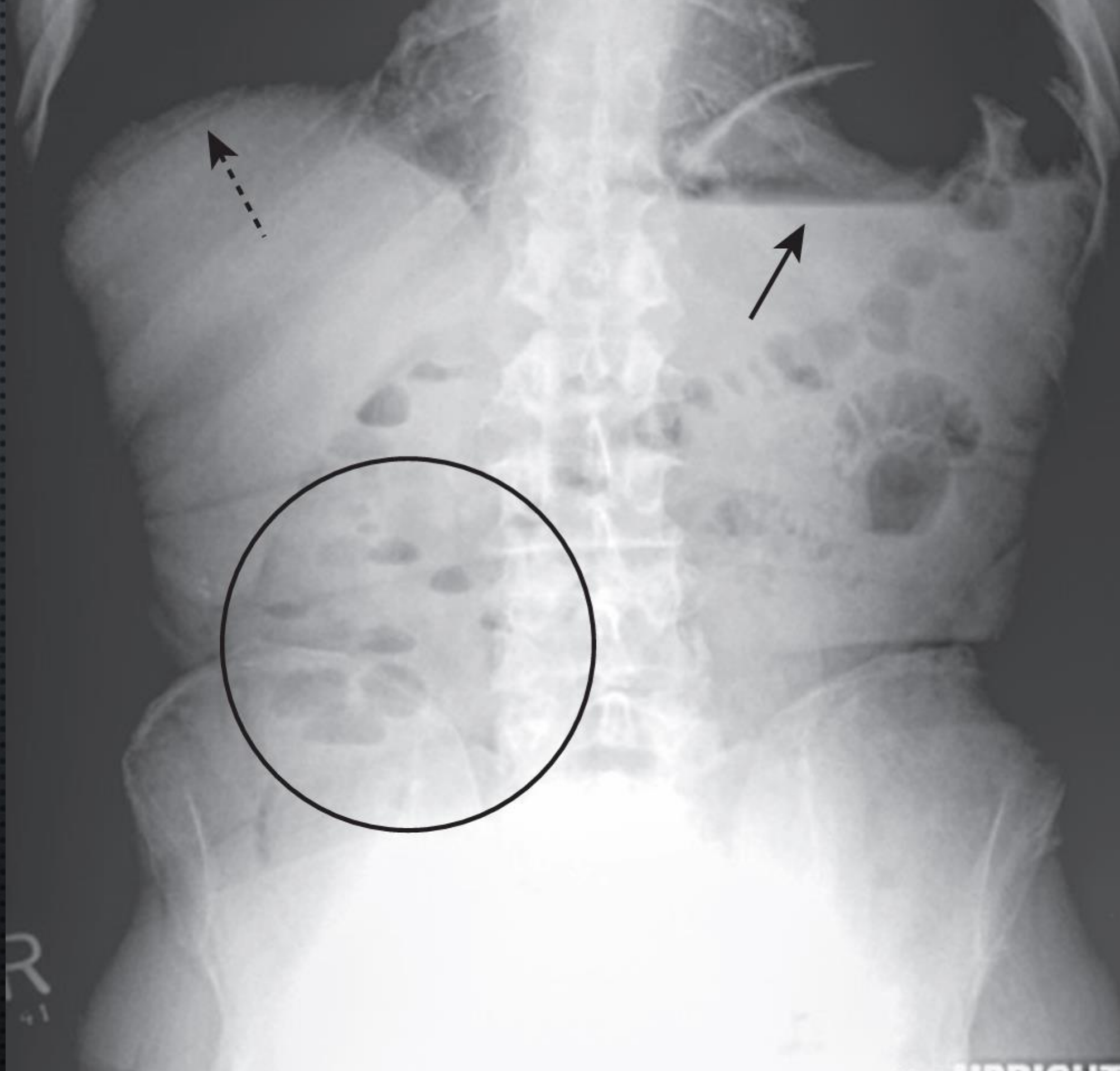




Gravitational Interfaces & Fluid Distribution

The Physics Rule: To see an air-fluid level, you MUST have a horizontal x-ray beam (parallel to the floor). Vertical beams will not show interfaces.

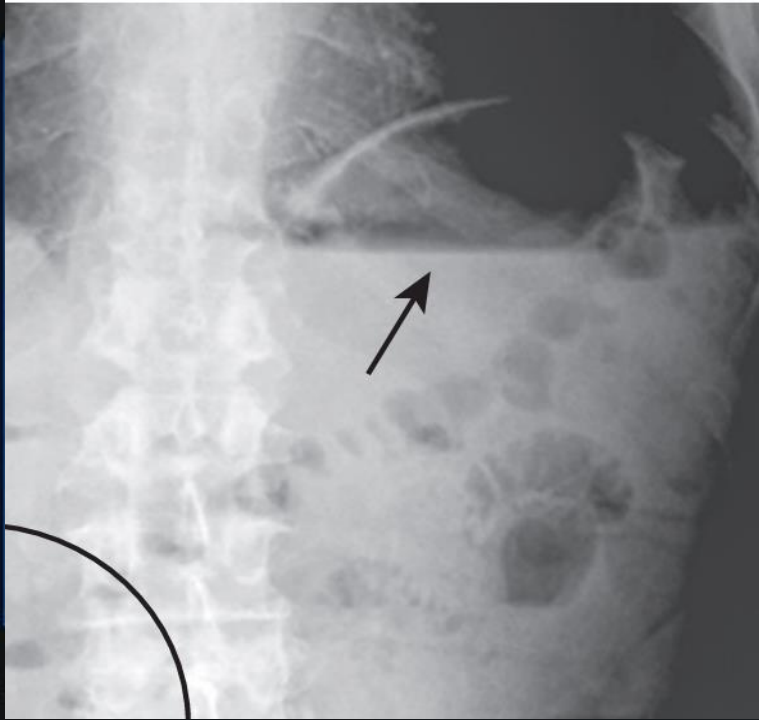
Organ	Normally Contains Gas	Normally has Air/Fluid Levels
Stomach	Yes	Yes, almost always
Small Bowel	Yes, 2-3 loops	Yes
Large Bowel	Yes, esp. rectosigmoid	No - its primary function is removing fluid



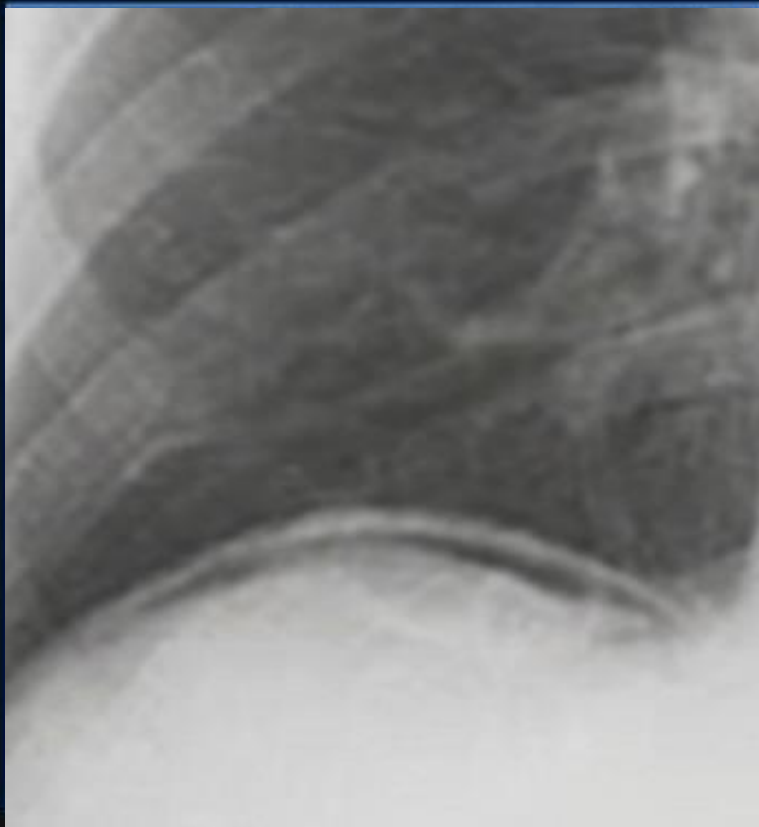
The Acute Abdominal Series Protocol

View	Clinical Purpose	Key Structures Visualized
Supine Abdomen (Scout Film)	General baseline.	Overall bowel gas pattern, calcifications, mass displacement.
Prone Abdomen (or Lateral Rectum)	Differentiating mechanical obstruction.	Gas rising into the rectosigmoid (the highest point of the large bowel when prone).
Upright Abdomen (or L-Lateral Decubitus)	Detecting horizontal air-fluid interfaces.	Air-fluid levels in the bowel, large volumes of free air.
Upright Chest	Identifying extraluminal air and thoracic mimics.	Free air beneath the diaphragm, basilar pneumonia, pleural effusions (e.g., left effusion from pancreatitis).

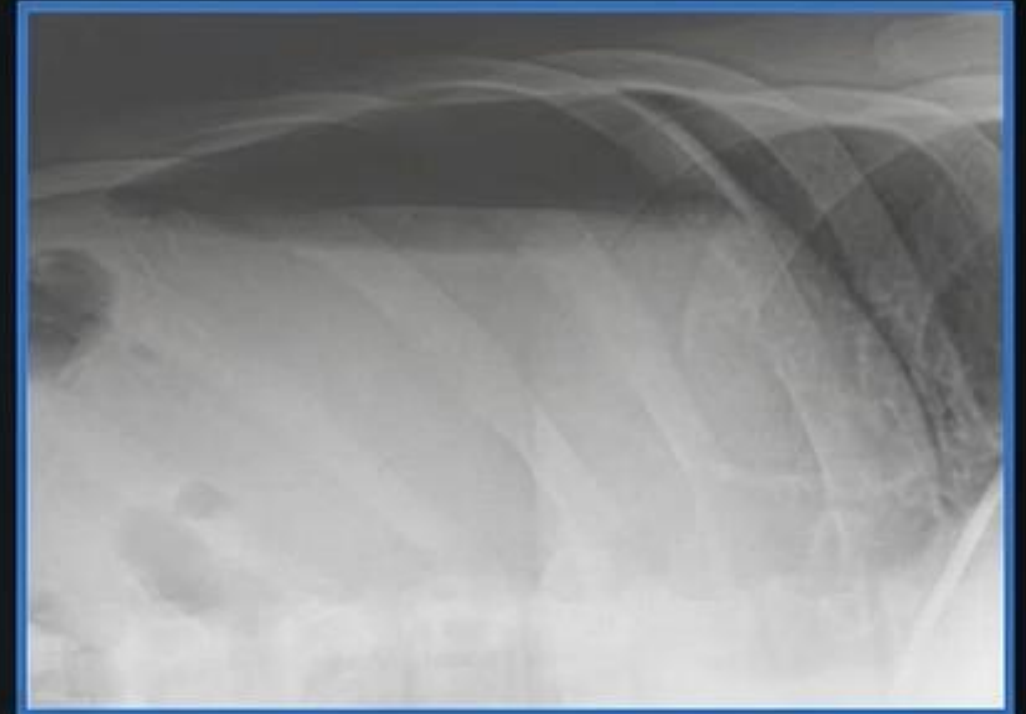
The Hunt for Free Air: Upright & Decubitus



Upright Abdomen: Horizontal beam. Primary goal is identifying free intraperitoneal air and bowel air-fluid levels.



Upright Chest: Horizontal beam. Highly sensitive for free air beneath the diaphragm. Also identifies basal pneumonias (mimics acute abdomen) or pleural effusions (e.g., left effusion = pancreatitis).



The Crucial Substitute (Left Lateral Decubitus)

If the patient cannot stand, lay them on their left side. Free air will rise to the right side, over the liver's outside edge (where there is no bowel gas). If placed right-side down, air mimics the gastric bubble.

The Acute Abdominal Series: Supine & Prone



The Supine View (Scout Film)

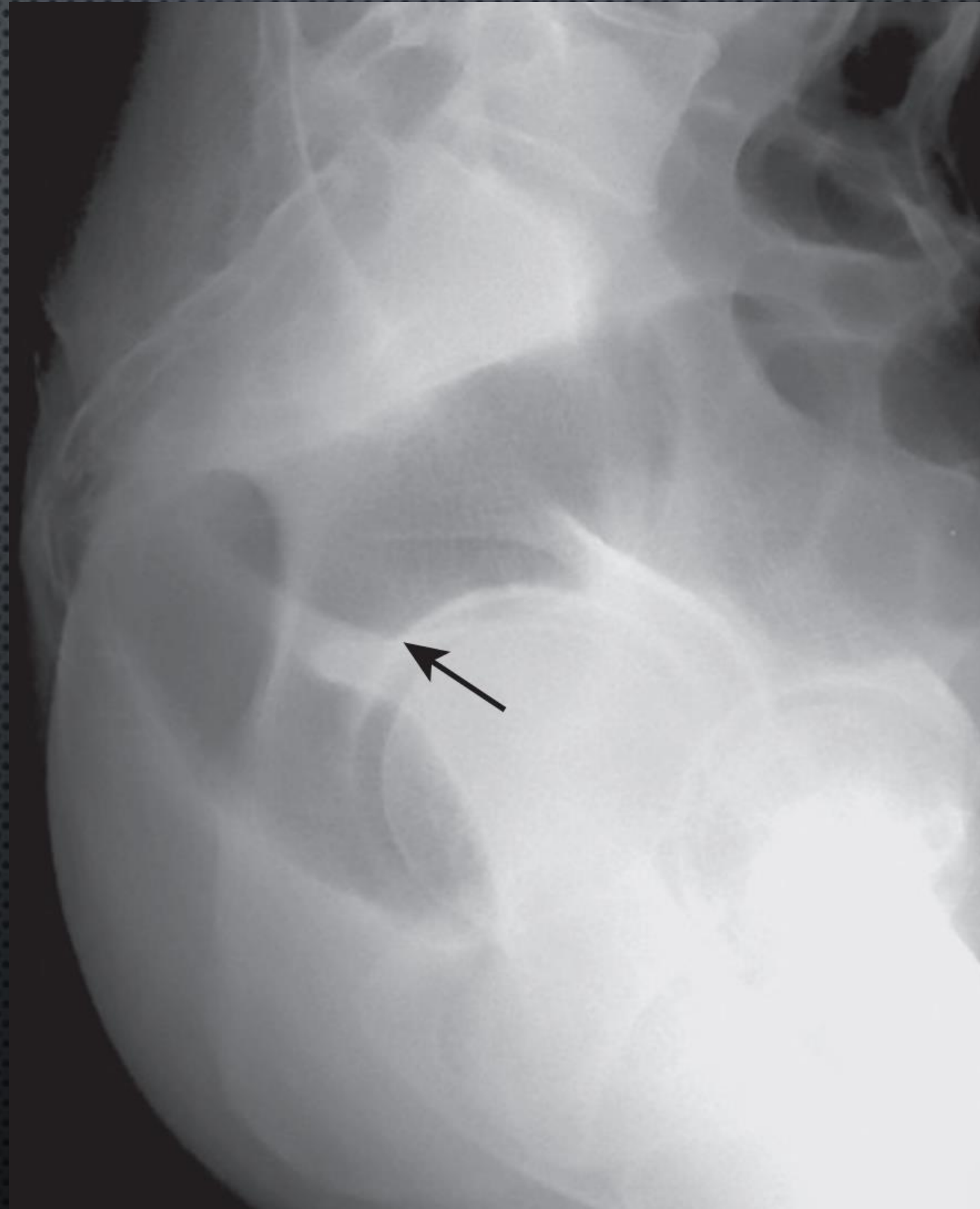
Directed vertically downward. Goal is overall bowel gas pattern, calcifications, and masses. Tolerated by virtually all patients.



The Prone View

Beam directed vertically. Because the rectum and ascending/descending colon are posterior, they become the highest points. Gas rises into the rectosigmoid.

Substitute Note: If a patient cannot lie prone, use a Lateral Rectum view to evaluate rectosigmoid gas for mechanical obstruction.



THE 3 KEY QUESTIONS

Are there dilated loops of small and/or large bowel?

On CT, is there a transition point?

On plain films, is there air in the rectum or sigmoid?

LAWS OF THE GUT

Obstruction occurs



Hyper-peristalsis attempts to clear it



Proximal loops dilate (swallowed air/fluid)



Distal loops evacuate and decompress

DIAGNOSTIC DECISION MATRIX

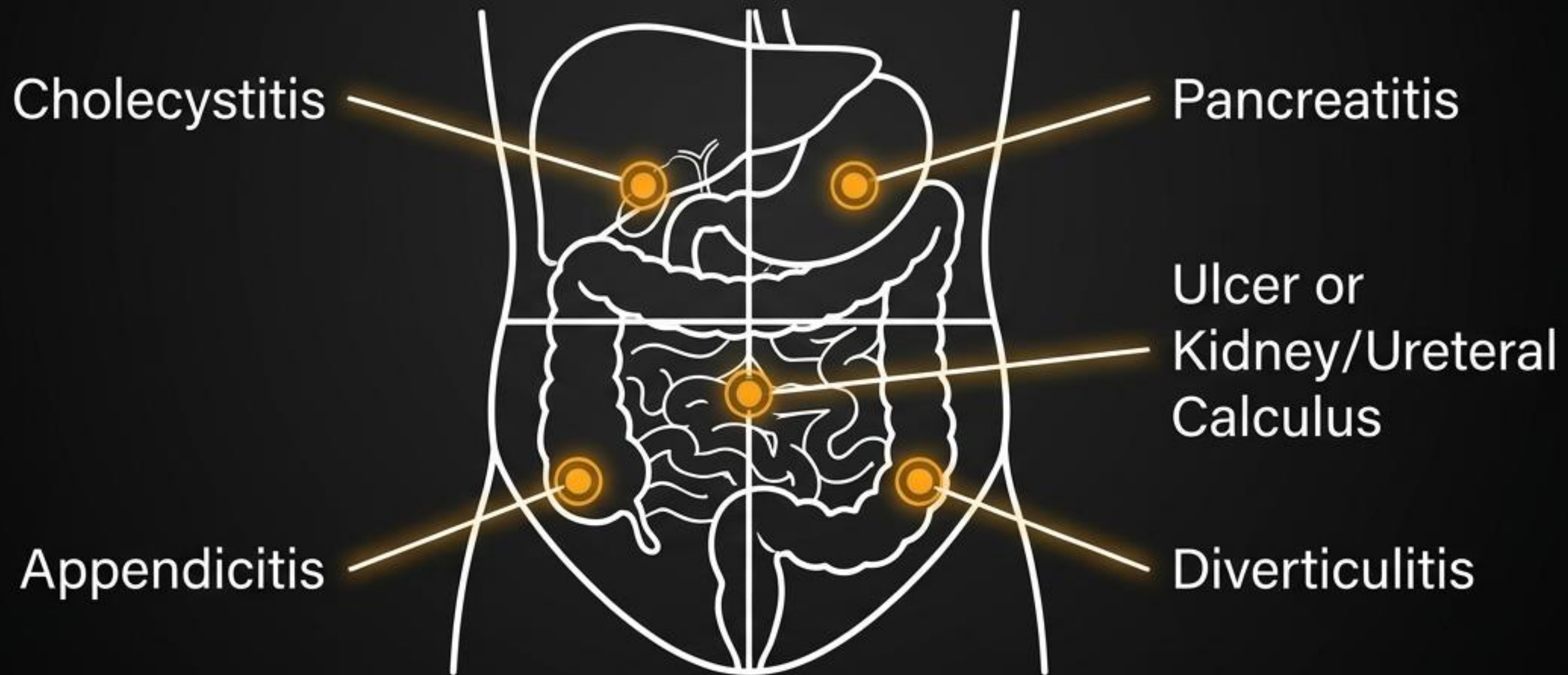
MECHANISM

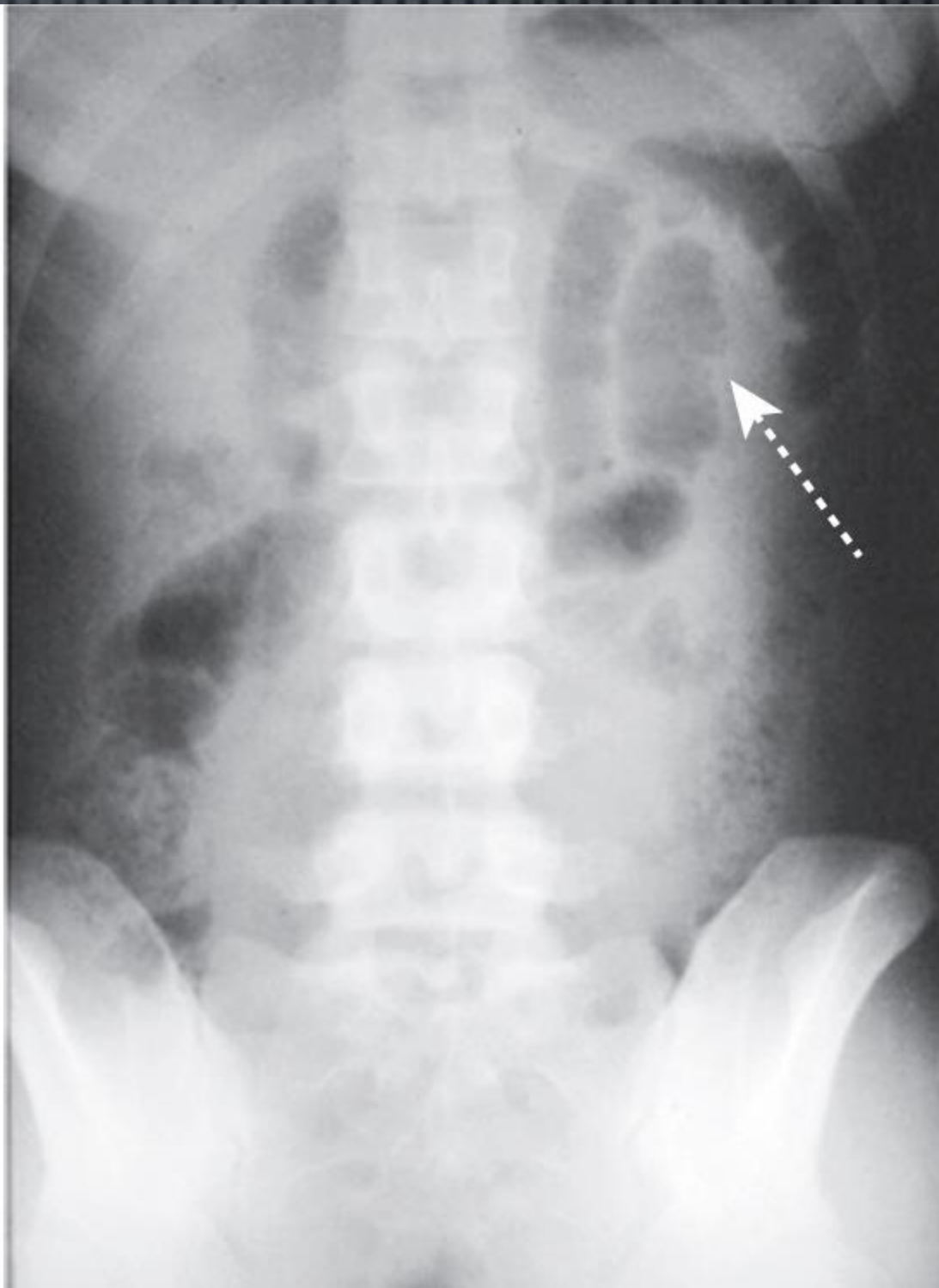
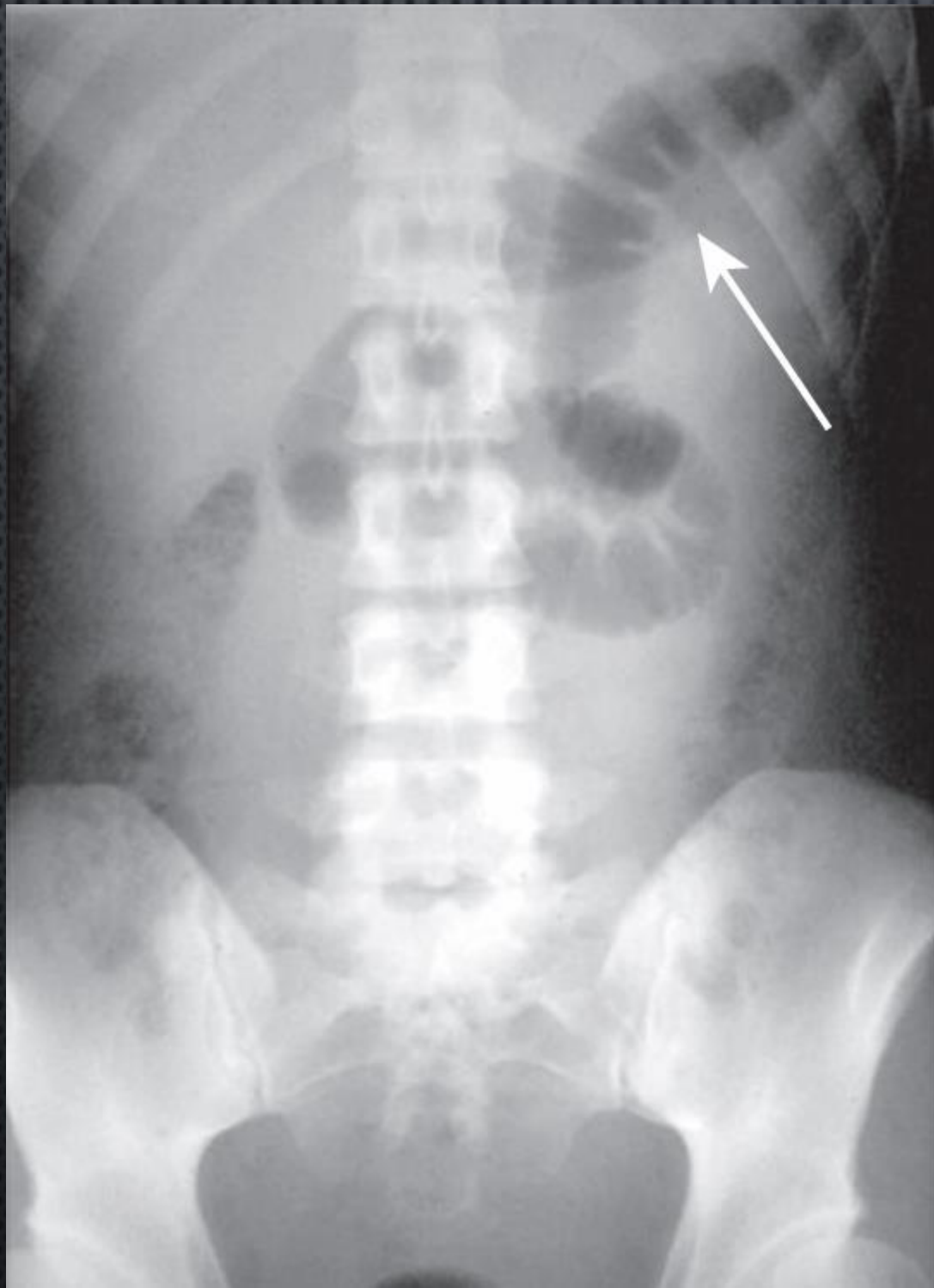
SCOPE

	Localized / Small Bowel	Generalized / Large Bowel
Functional (Local irritation / Loss of peristalsis)	Localized Ileus (Sentinel Loops) 1-2 dilated loops Air in rectum	Generalized Adynamic Ileus Multiple distended loops Air in rectum
Mechanical (Physical blockage)	Small Bowel Obstruction (SBO) Multiple dilated loops NO air in rectum	Large Bowel Obstruction (LBO) Dilated large bowel NO air in rectum

Functional Ileus: Localized (Sentinel Loops)

Focal irritation from an adjacent inflamed organ causes 1-2 small bowel loops to become aperistaltic and dilate. Air still reaches the rectum.





Recognizing Functional Bowel Abnormalities

Localized Ileus (The Sentinel Loop)

Radiographic Finding:

1-2 persistently dilated loops of small bowel.

Pathophysiology:

Indicates an adjacent irritative or inflammatory process. The loop acts as a “sentinel” warning of local disease.

Clinical Correlation:

LUQ loop → Pancreatitis

RLQ loop → Appendicitis

LLQ loop → Diverticulitis

Ogilvie Syndrome (Acute Intestinal Pseudo-obstruction)

Radiographic Finding:

Marked bowel dilatation, almost always confined strictly to the colon.

Pathophysiology:

Loss of peristalsis leading to massive colonic dilation.

Clinical Correlation:

Often occurs in elderly, hospitalized, or bedridden patients on anticholinergic drugs (antidepressants, phenothiazines, narcotics). Treated pharmacologically (e.g., neostigmine).

Functional Ileus: Generalized Adynamic Ileus

1 Pathophysiology

The entire bowel (large and small, often stomach) becomes aperistaltic or hypoperistaltic.

2 Diagnostic Hallmarks

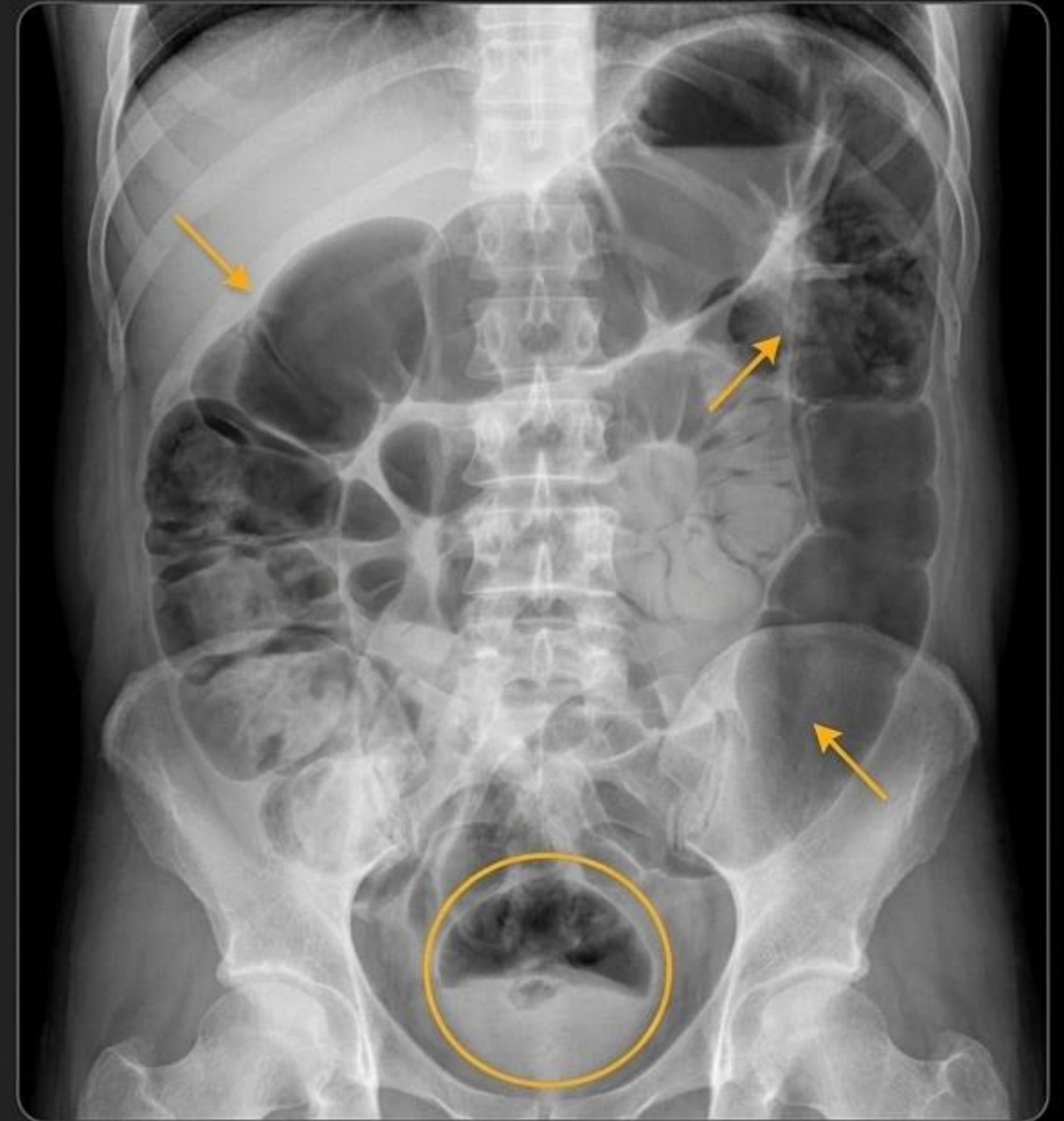
- ✓ Massive dilation of both large and small bowel.
- ✓ Long air-fluid levels.
- ✓ Gas reaches the rectum.
- Crucially, no transition point on CT.

3 Common Causes

Post-operative state (recent abdominal surgery) or severe electrolyte imbalance (e.g., diabetic ketoacidosis).

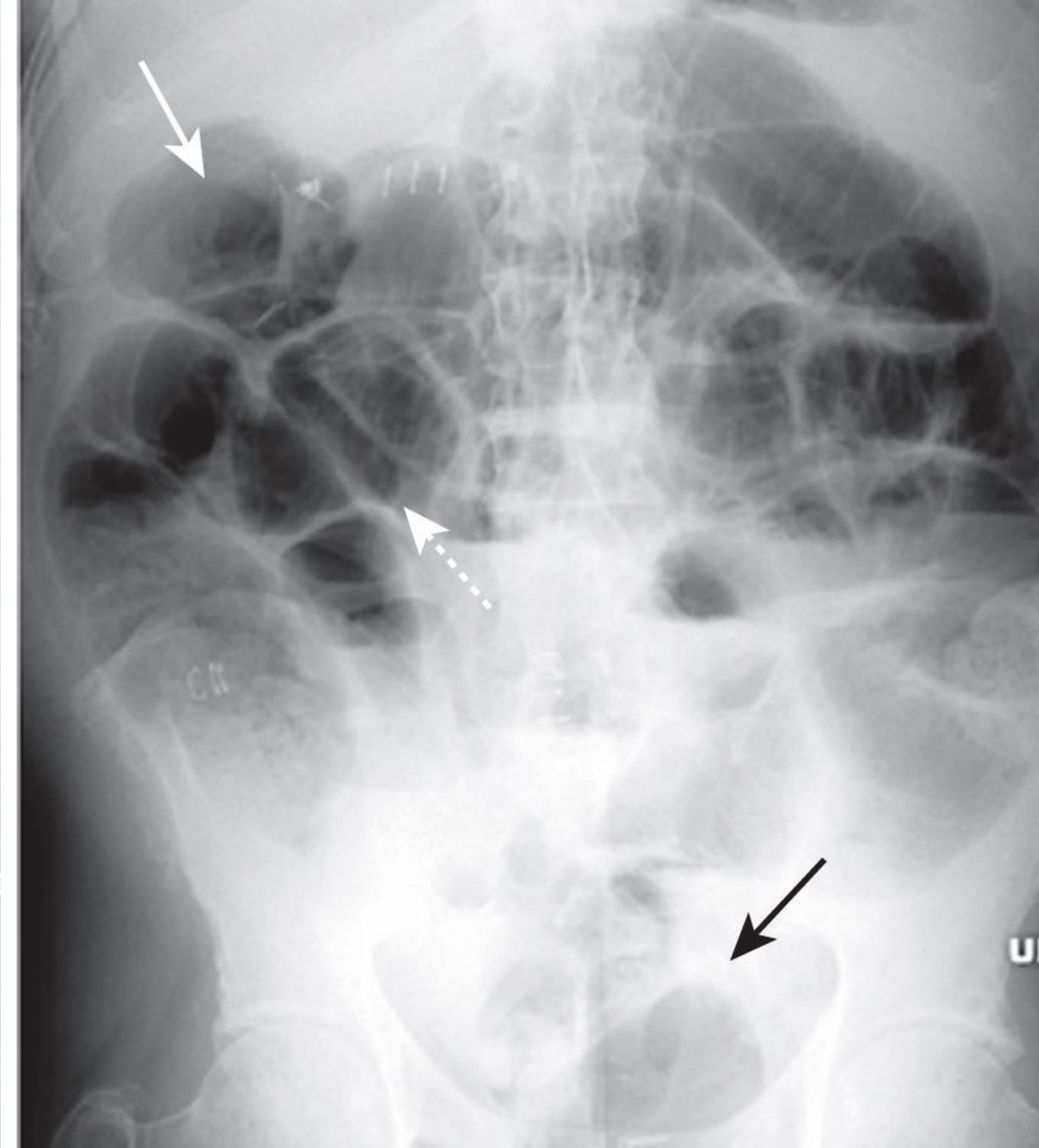
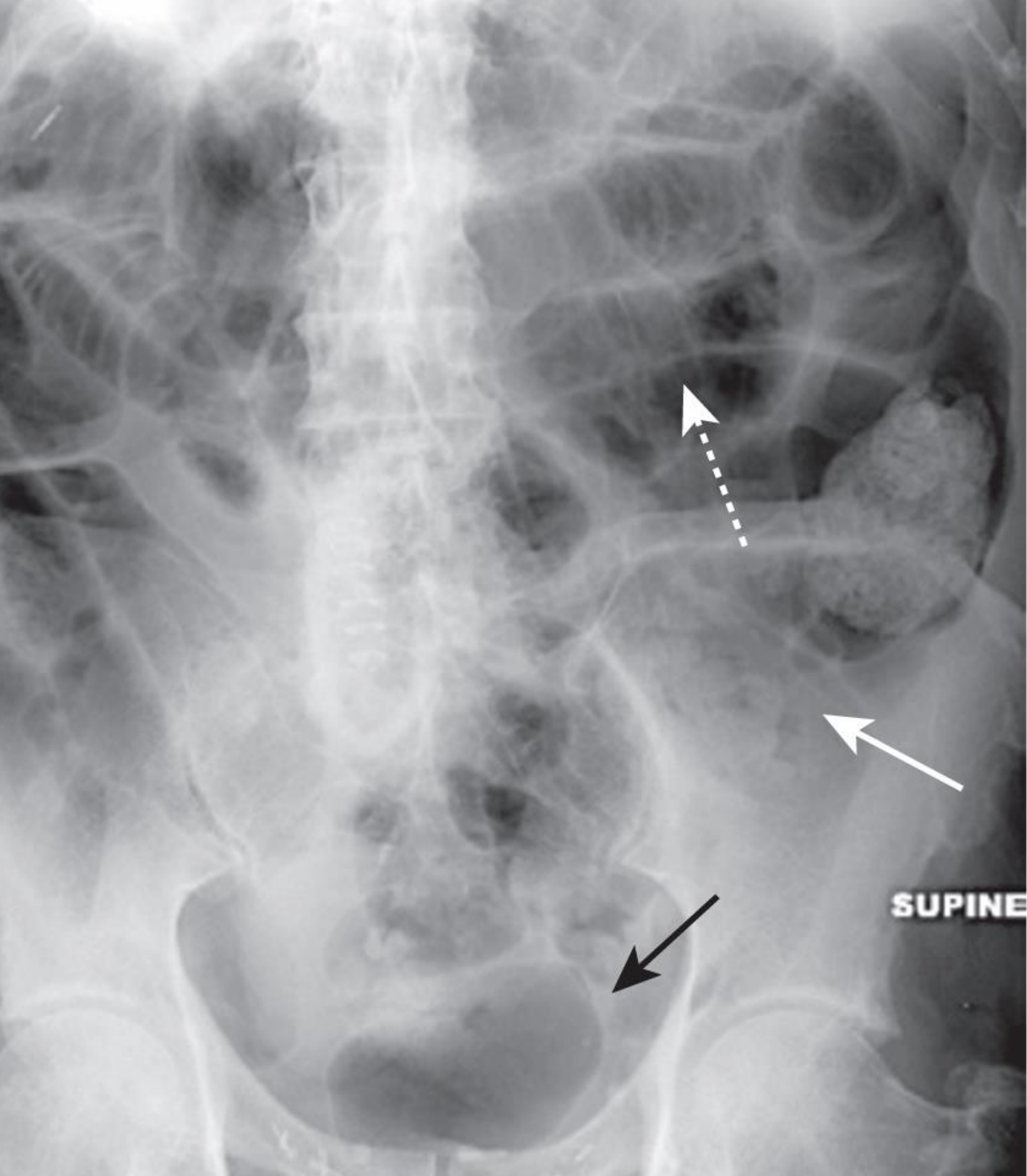
4 Clinical Presentation

Absent or hypoactive bowel sounds.

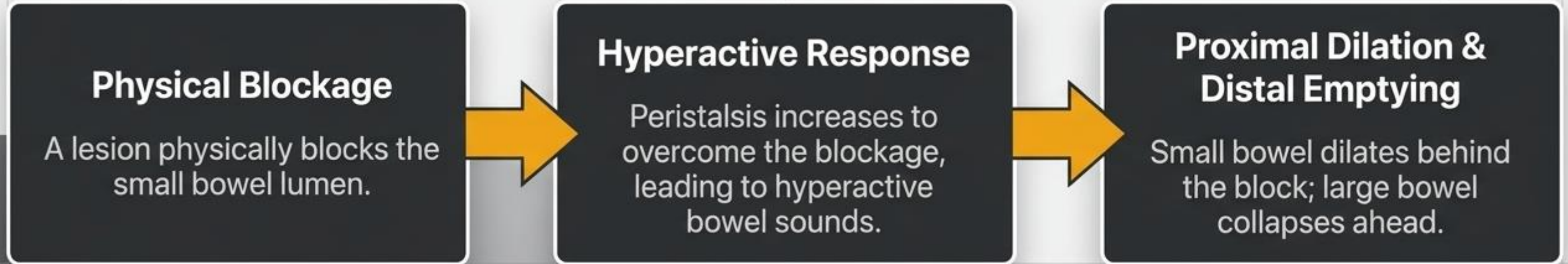


Supine abdominal radiograph demonstrates generalized dilation of both small and large bowel loops without a distinct transition point.





Mechanical Obstruction: Small Bowel (SBO)

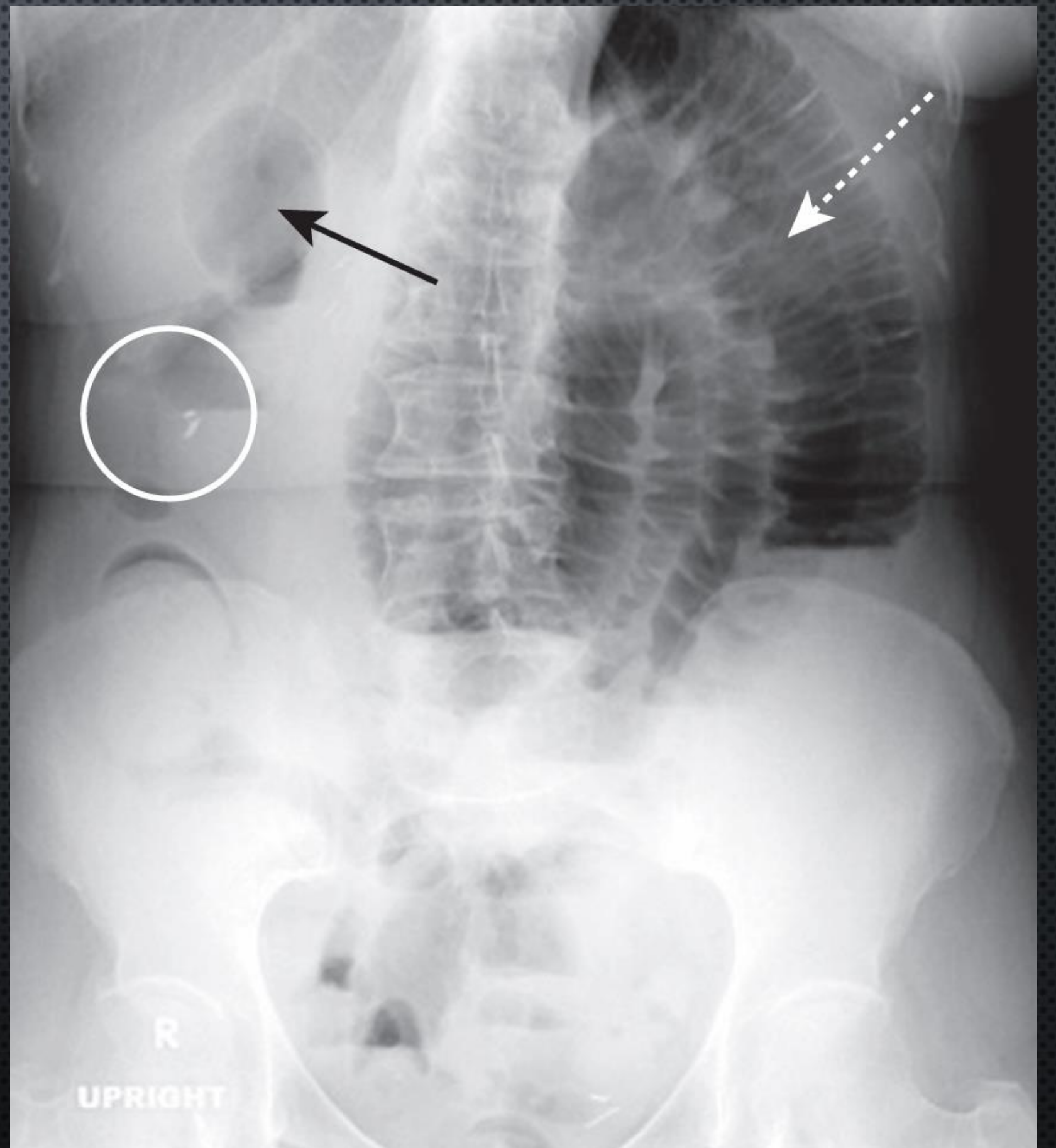
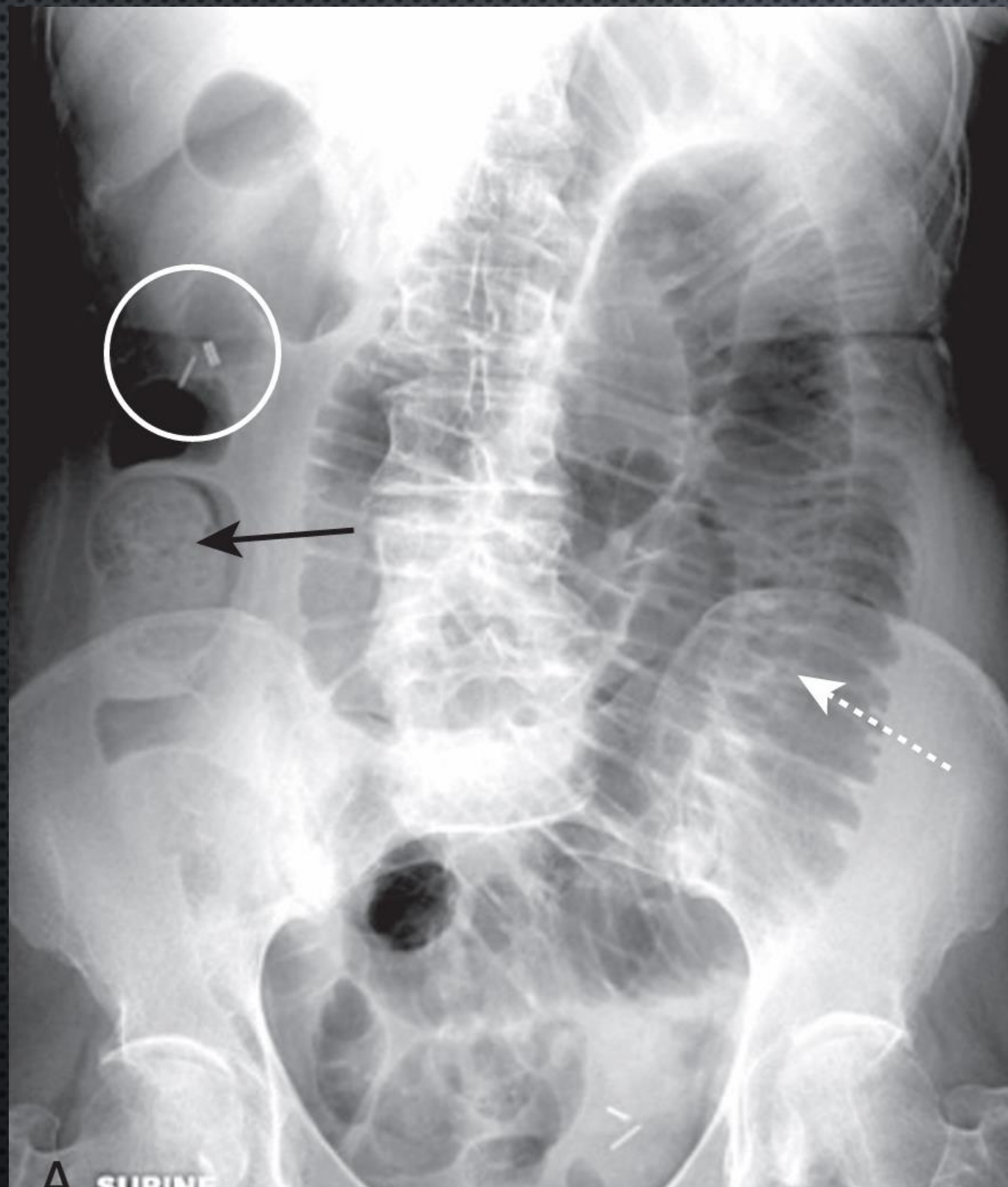


Diagnostic Hallmarks

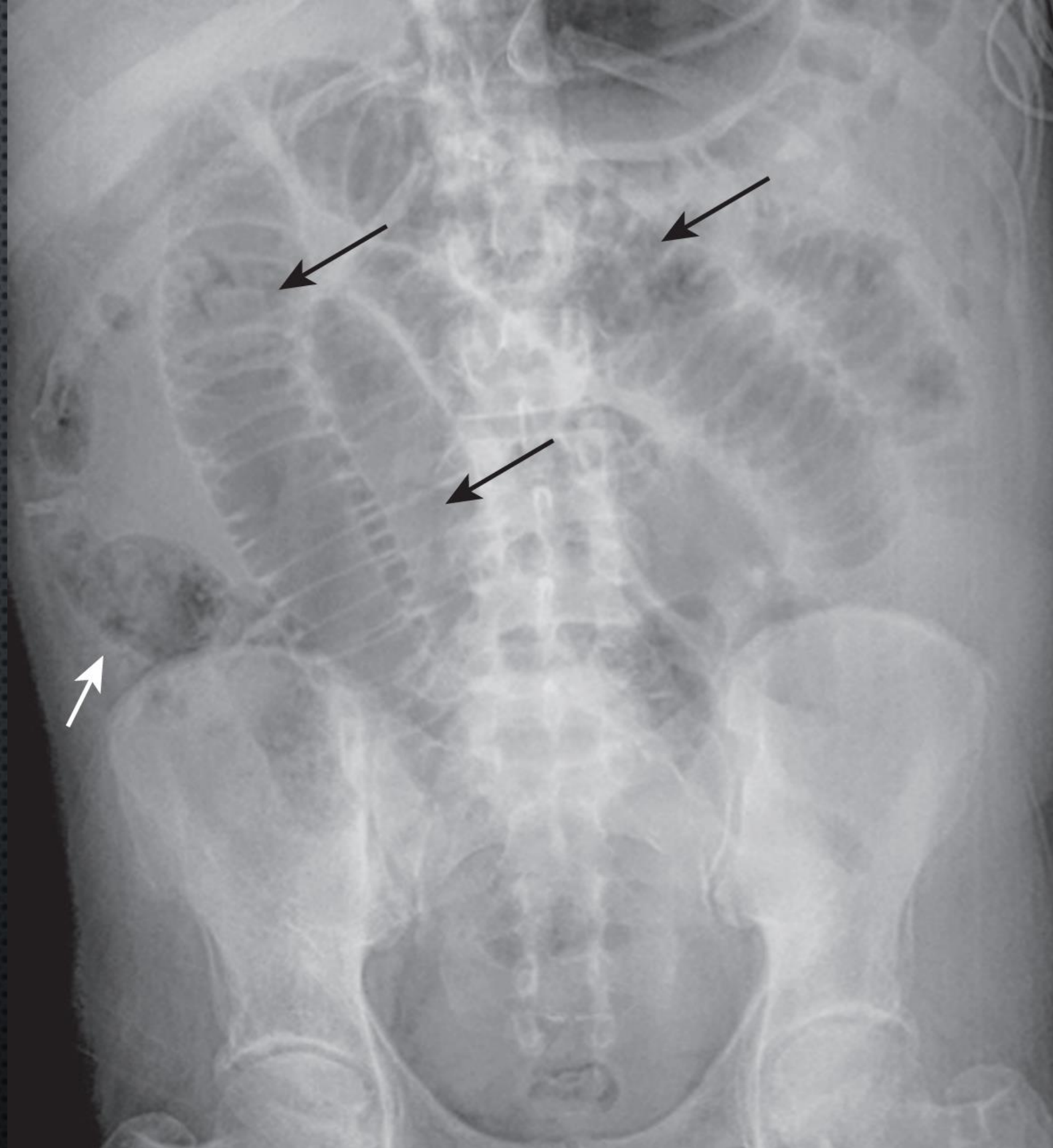
- **Multiple dilated loops** of small bowel (>2.5 cm).
- **Disproportionate dilation:** Massive small bowel, collapsed large bowel.
- **NO AIR** in the rectum or sigmoid.

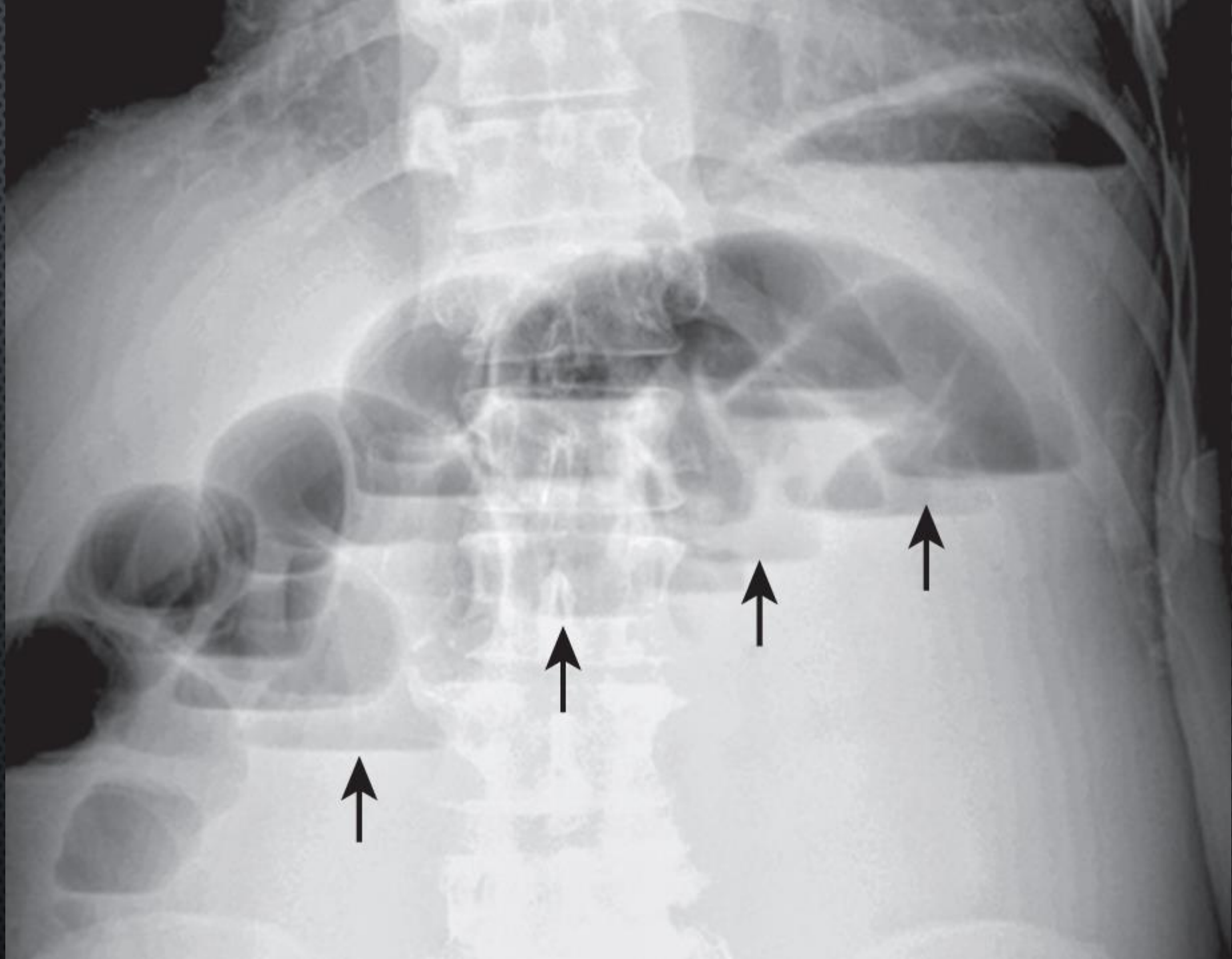
Primary Causes

- Post-surgical adhesions (most common)
- Hernias
- Malignancy
- Intussusception
- Crohn disease









Mechanical Obstruction: Large Bowel (LBO)

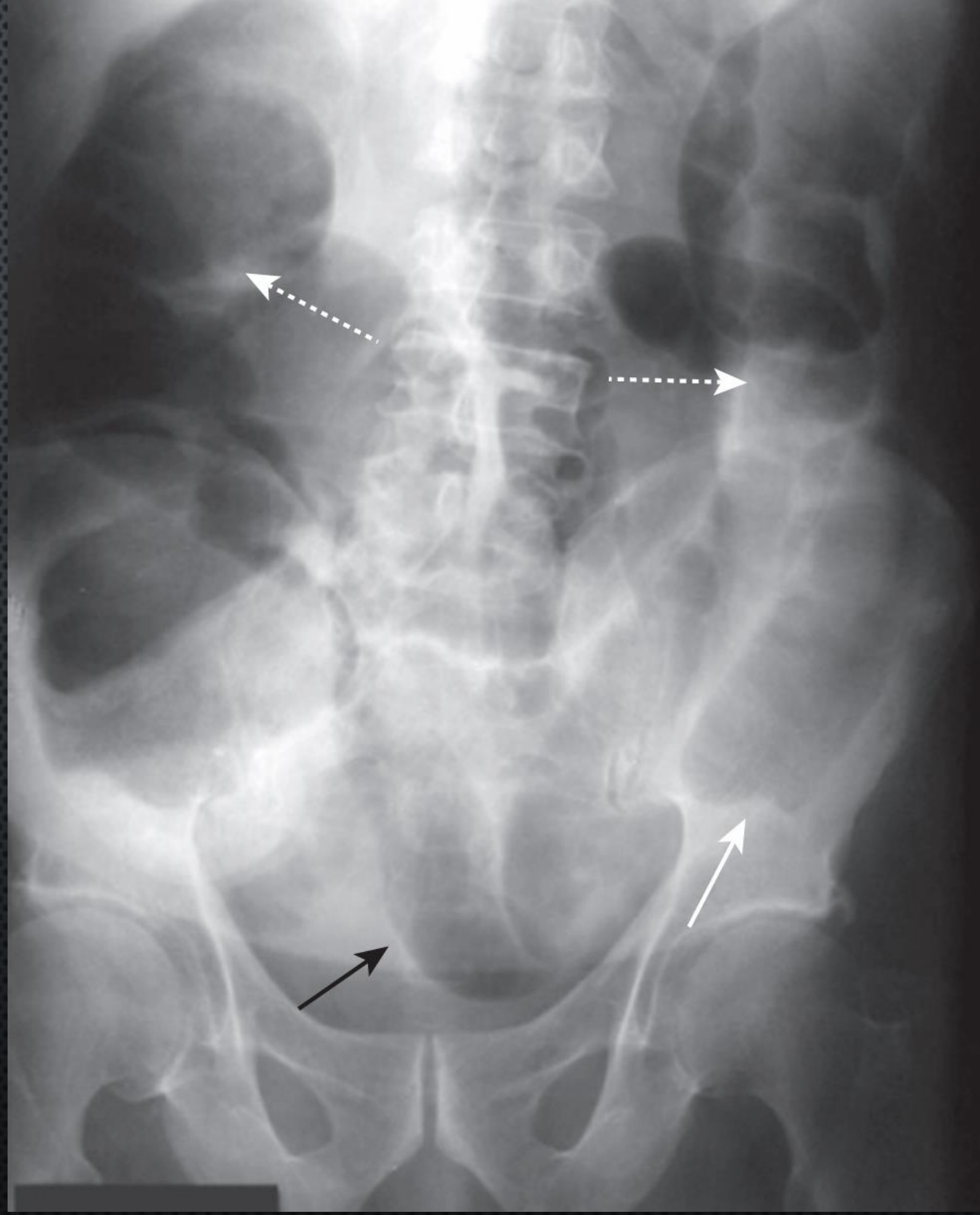
Core Concept: A physical lesion (most commonly a tumor/carcinoma) obstructs the colon. The colon dilates backward from the obstruction.

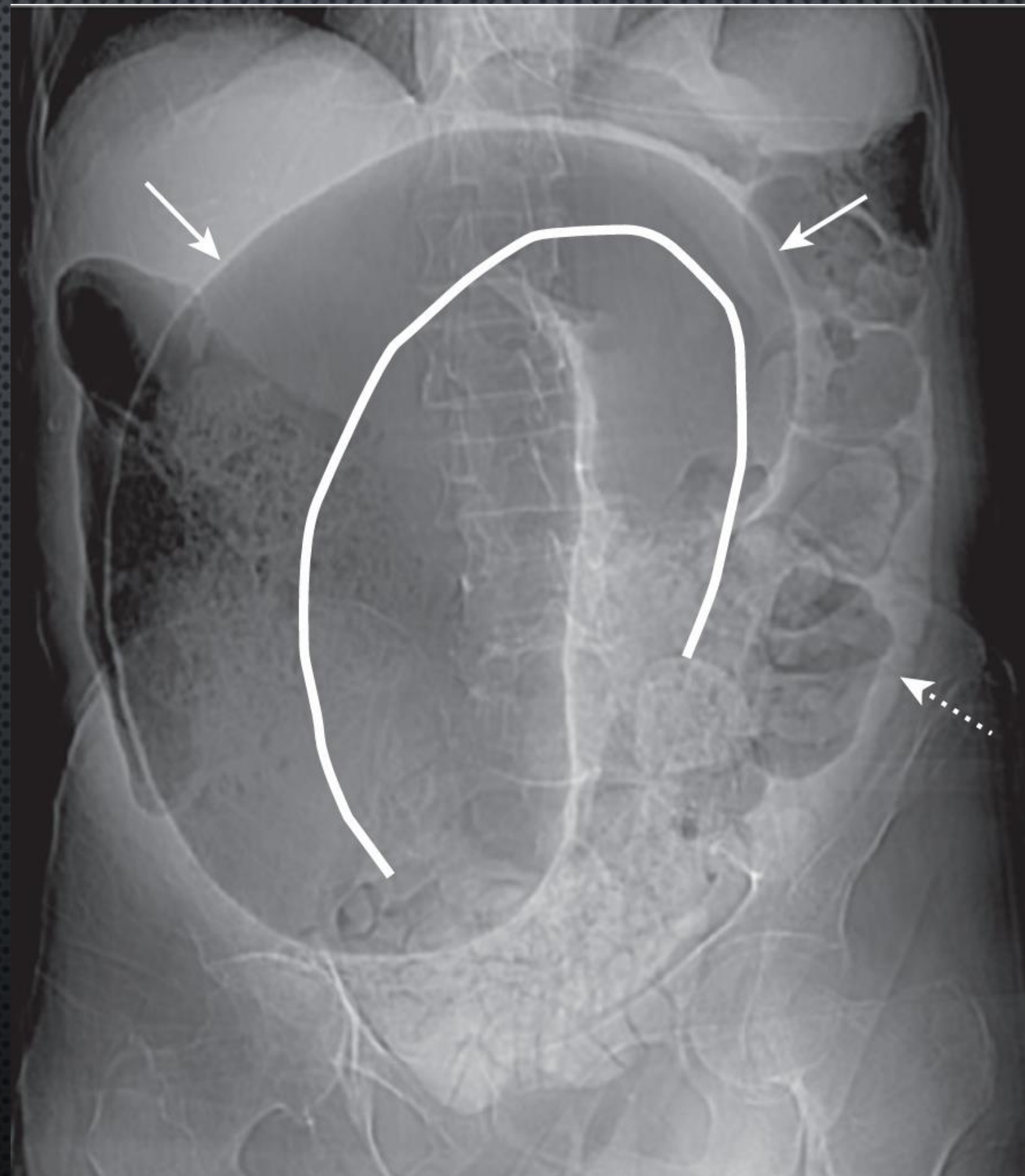
Diagnostic Hallmarks

- ✓ Colon is dilated to the transition point.
- ✓ Small bowel is NOT dilated (unless the ileocecal valve is incompetent).
- ✓ Few or no air-fluid levels (because the large bowel's function is to reabsorb water).
- ✓ Little or no air in the rectum.

Danger Zone

The cecum is often the most dilated segment, regardless of obstruction location.
Rupture danger occurs when cecum diameter exceeds 12 to 15 cm.





Mastering Diagnostic Pitfalls

Pitfall 1: Localized Ileus vs. Early SBO

The Confusion

Both present with a few dilated small bowel loops and air in the colon.

The Resolution

"Early" means 1-2 days of symptoms. Resolve using clinical history, lab findings, and CT to find the underlying inflammatory cause (ileus) vs. an early mechanical block.

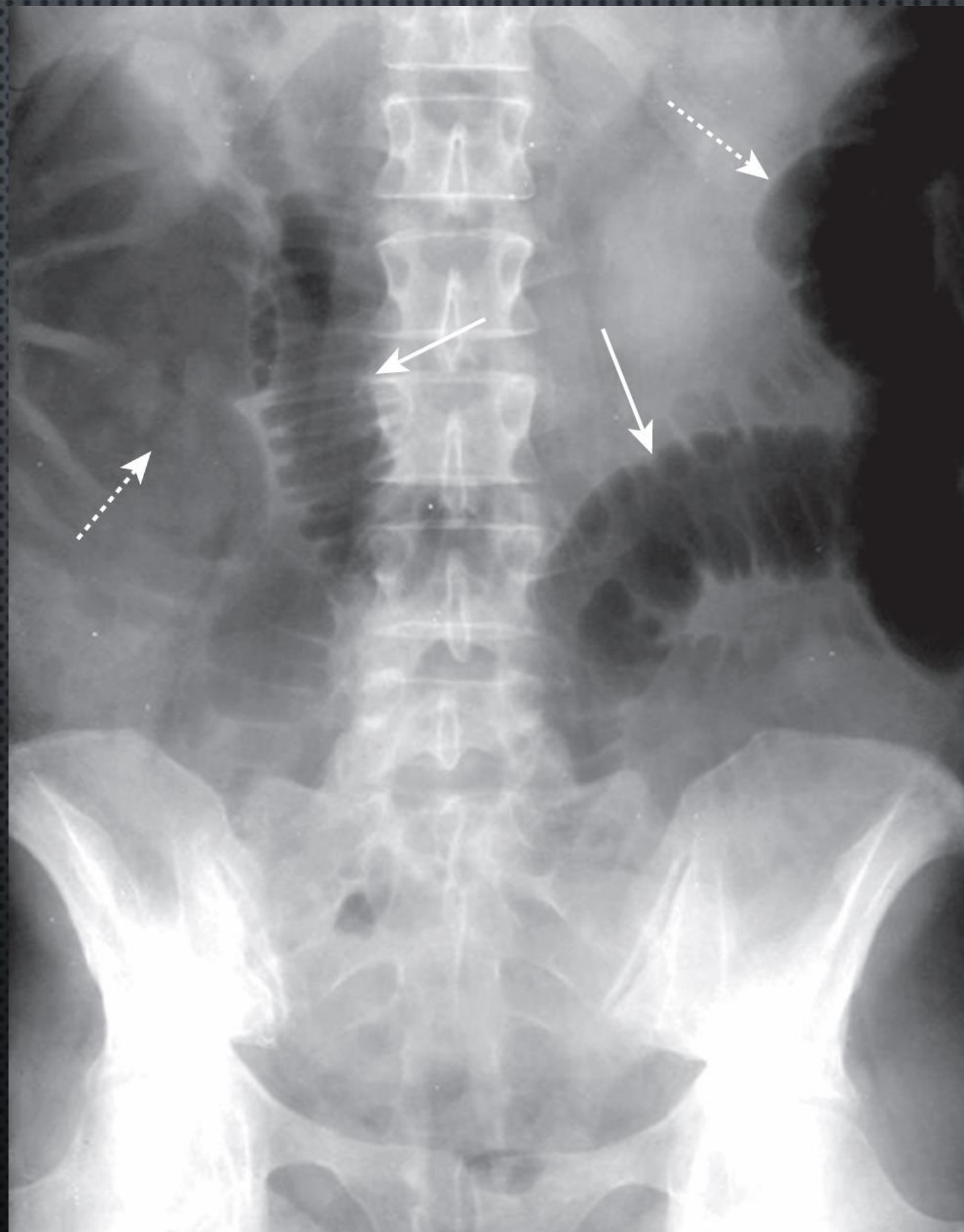
Pitfall 2: LBO Masquerading as SBO

The Confusion

Massive intracolonic pressure forces the ileocecal valve open, decompressing gas backward into the small bowel. X-ray mimics an SBO.

The Resolution

Look for a dilated ascending and descending colon that still contains air. CT scanning provides definitive resolution of the transition point.



Extraluminal Gas in the Abdomen

A Diagnostic Framework for Pattern Recognition



The Rule of Air: Gas belongs strictly within the bowel lumen.

Recognition of extraluminal gas immediately alters the course of treatment.
We will systematically evaluate the four primary spaces of manifestation:



Intraperitoneal Space
[Pneumoperitoneum / Free Air]



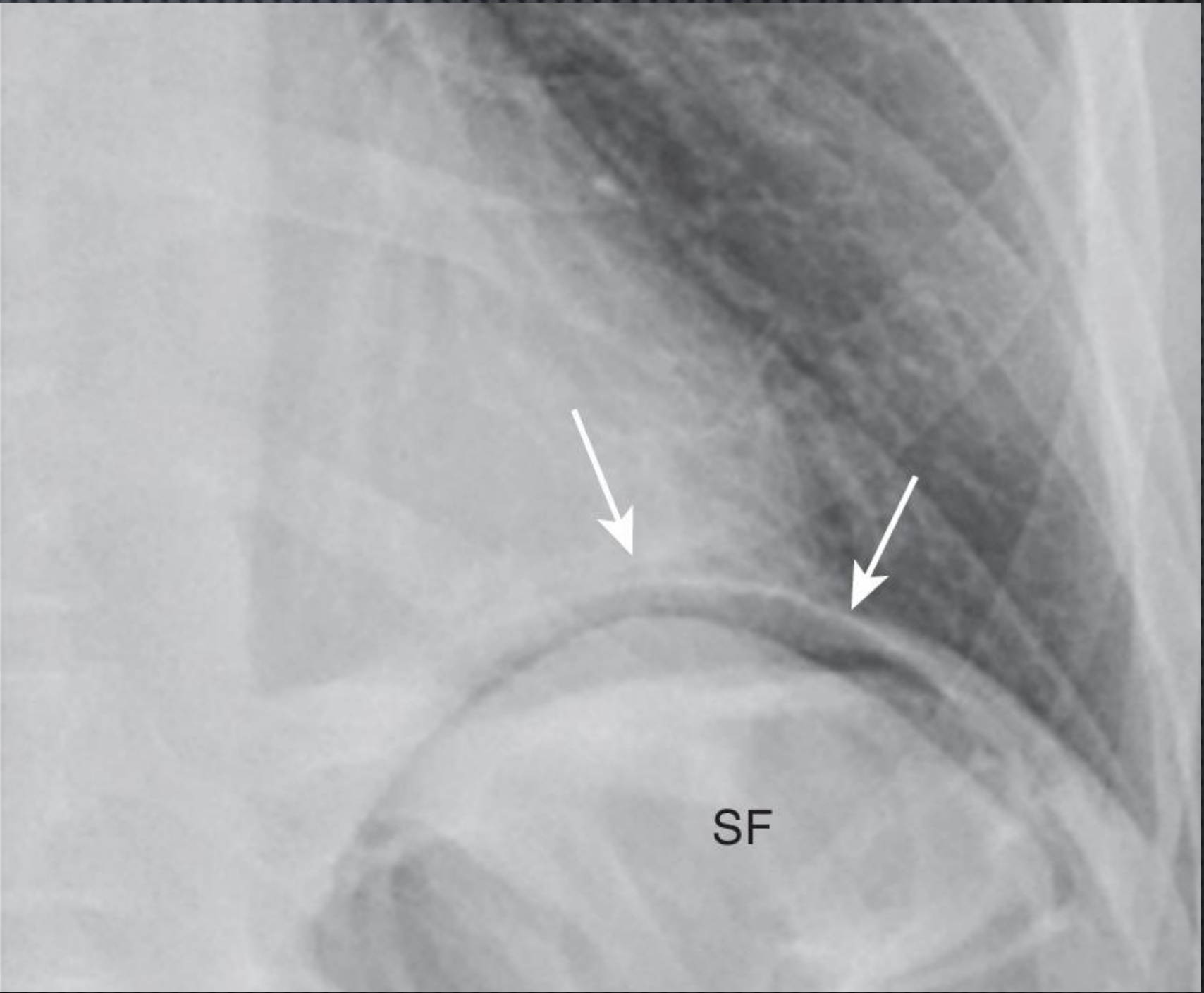
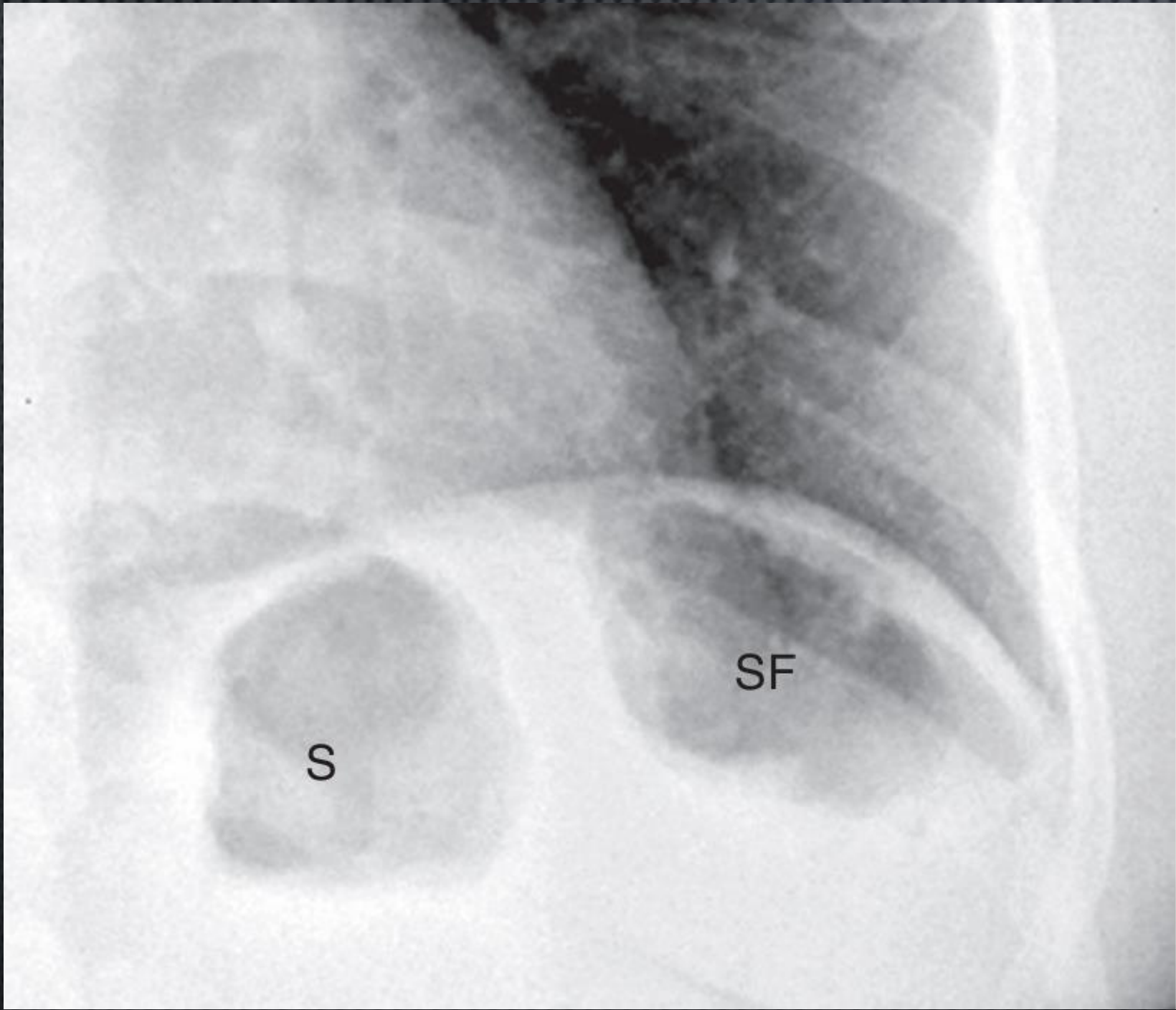
Extraperitoneal Space
[Retroperitoneal Air]



The Bowel Wall
[Pneumatosis Intestinalis]



The Biliary System
[Pneumobilia]



Free air reveals itself as a gravity-dependent crescentic lucency.

The Crescent Sign

Free air rises to the highest part of the abdomen.

In an upright position, it forms a cyan **crescentic lucency** paralleling the undersurface of the diaphragm.

The size of the crescent is roughly proportional to the volume of free air.

Physics & Etiology

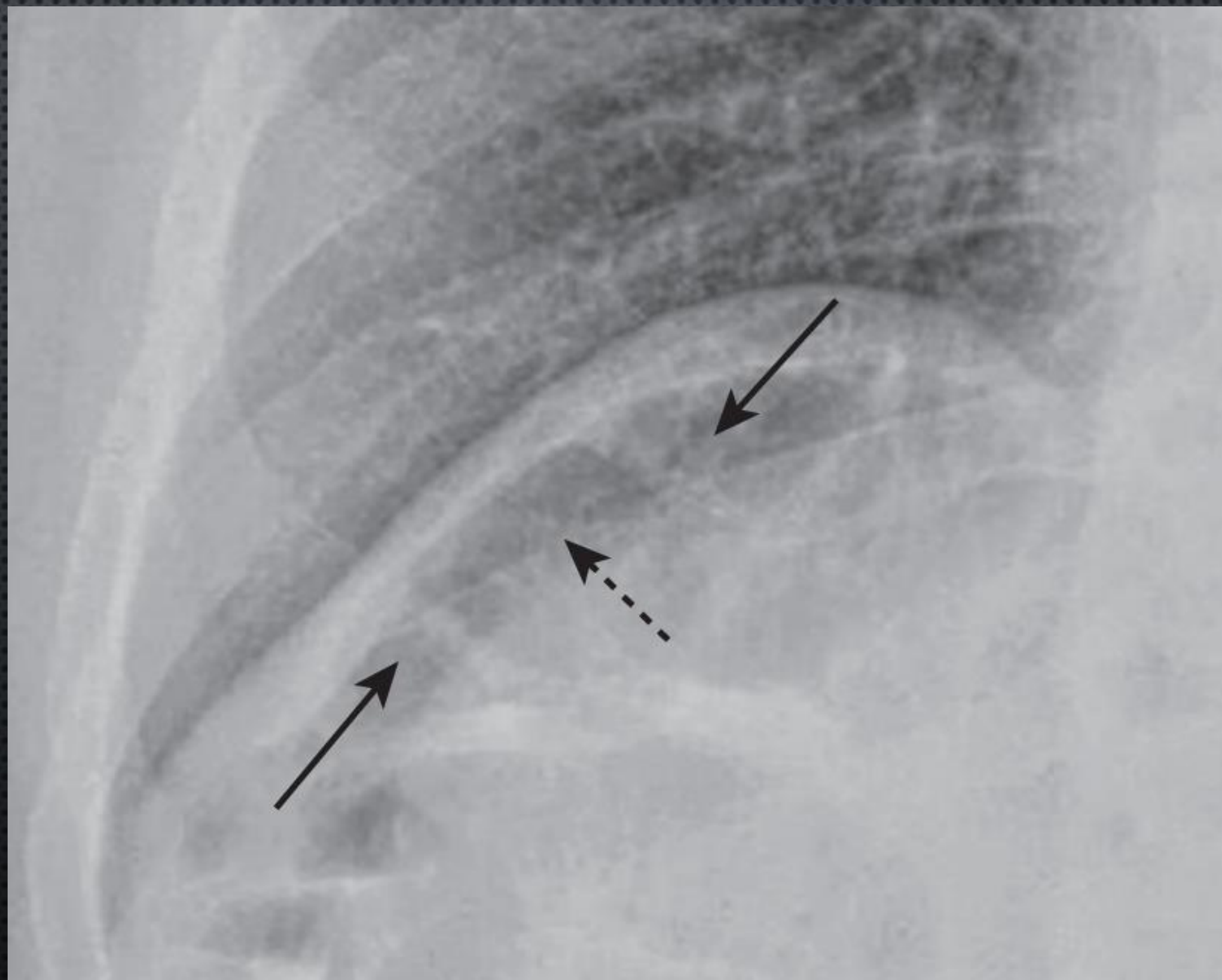
The Horizontal Beam Rule: Small amounts of free air are invisible on supine/prone views. The x-ray beam must be parallel to the floor.

The Decubitus Alternative: If a patient cannot stand, use a Left Lateral Decubitus view. Free air will rise above the outer right edge of the liver. (Right hemidiaphragm is easier to evaluate than the left due to normal stomach/splenic flexure air)

Etiology: Perforated peptic ulcer is the most common cause. Post-operative free air is normal for 5 to 7 days, but must progressively diminish.

Viewport: The Intraperitoneal Space





The Three Signs of Free Intraperitoneal Air

1. Air Beneath the Diaphragm

Requires the patient to be upright or left-lateral decubitus (horizontal x-ray beam). Easiest to see on the right above the soft-tissue density of the liver; the left side is obscured by the stomach bubble and splenic flexure.

2. The Rigler Sign

Visualization of both sides of the bowel wall (requires a large amount of free air).

Diagnostic Pitfall: Beware the "Pseudo-Rigler" sign caused by overlapping loops of dilated small bowel.

3. The Falciform Ligament Sign

Visible on supine films when massive free air crosses the anterior liver. The ligament (containing the remnant umbilical vein) becomes visible as a thin soft-tissue line surrounded by air. (Part of the overarching "Football sign").

Massive pneumoperitoneum illuminates normally invisible structures.

The **Rigler** Sign

Introduction of air into the peritoneal cavity surrounds the bowel on the outside. Result: Both sides of the bowel wall become visible as discrete. Requires a large amount of free air; visible in any position.

Falciform & Football Signs

In a supine patient, massive free air rises anteriorly over the liver, rendering the normally invisible falciform ligament visible. The oval collection of massive air distending the abdomen, bisected by the falciform ligament, creates the Football Sign.

Diagnostic Pitfalls (The Mimics)

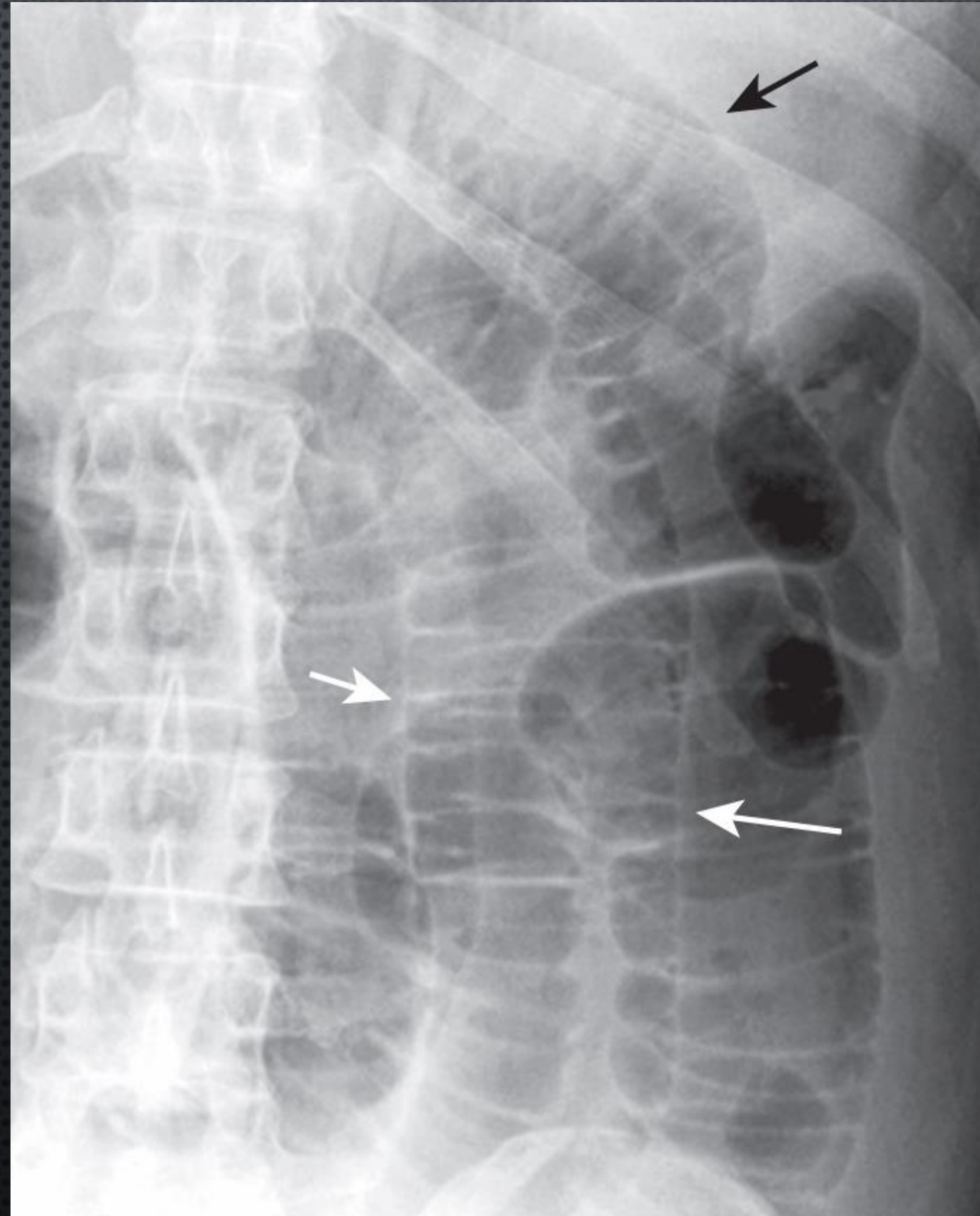
Pseudo-Rigler:

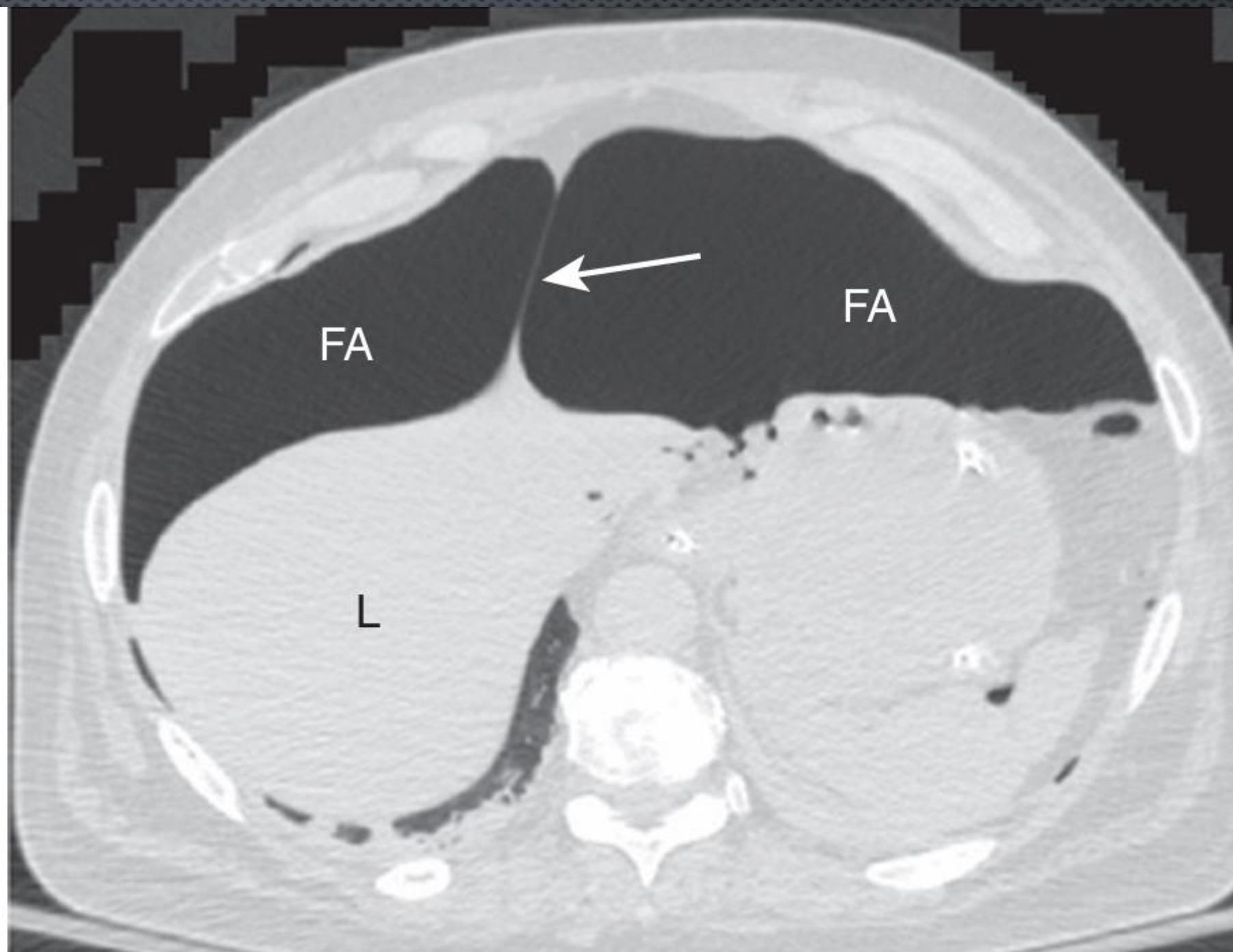
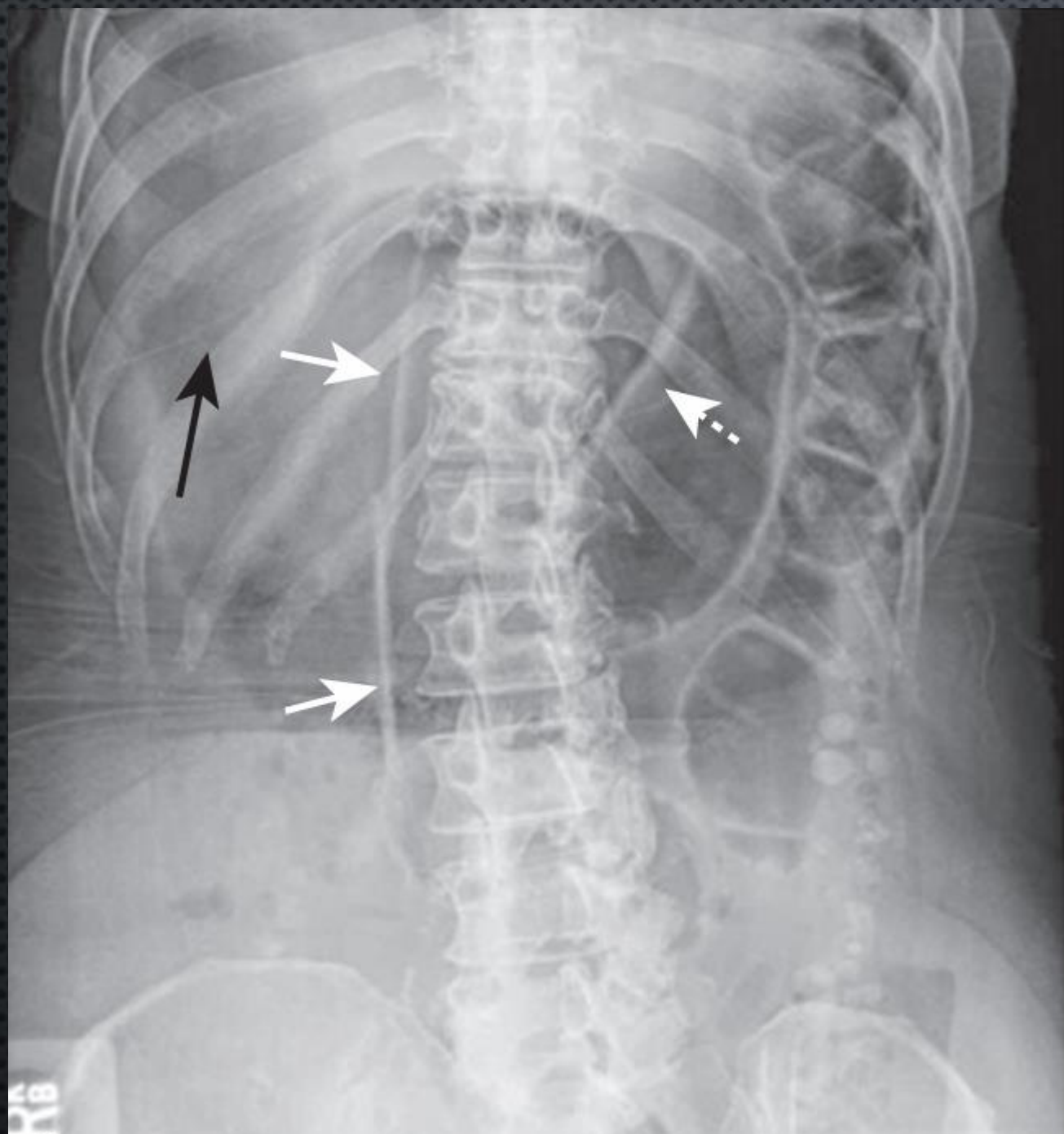
Overlapping loops of dilated small bowel mimicking a visible wall.

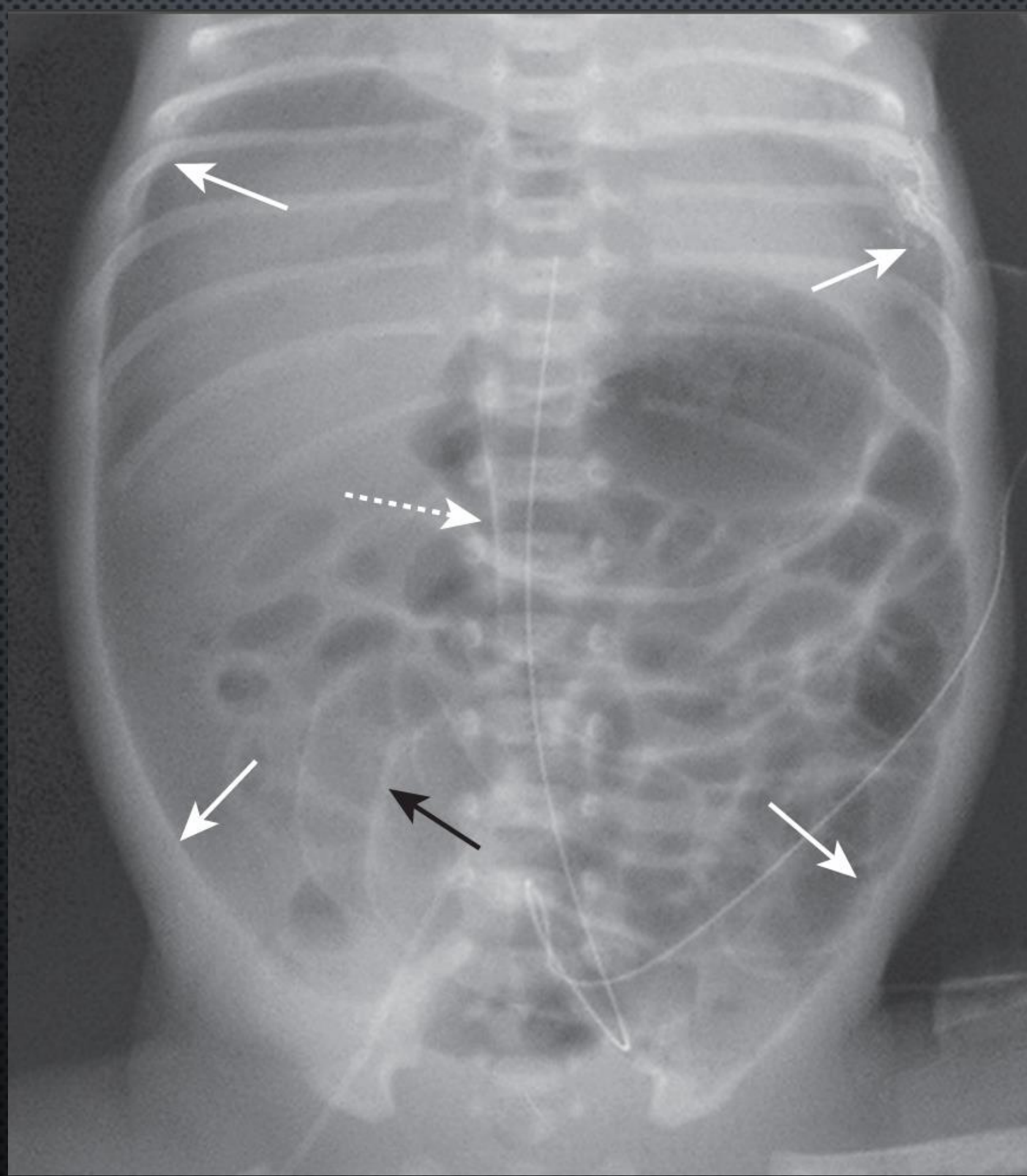
Chilaiditi Sign (kyla-ditty):

Normal colon interposition between the liver and right hemidiaphragm mimicking a crescent. Look for haustral folds to differentiate.









Extraperitoneal air dissects along fascial planes and remains fixed.

Radiographic Signatures

Streaky, linear appearance outlining structures.

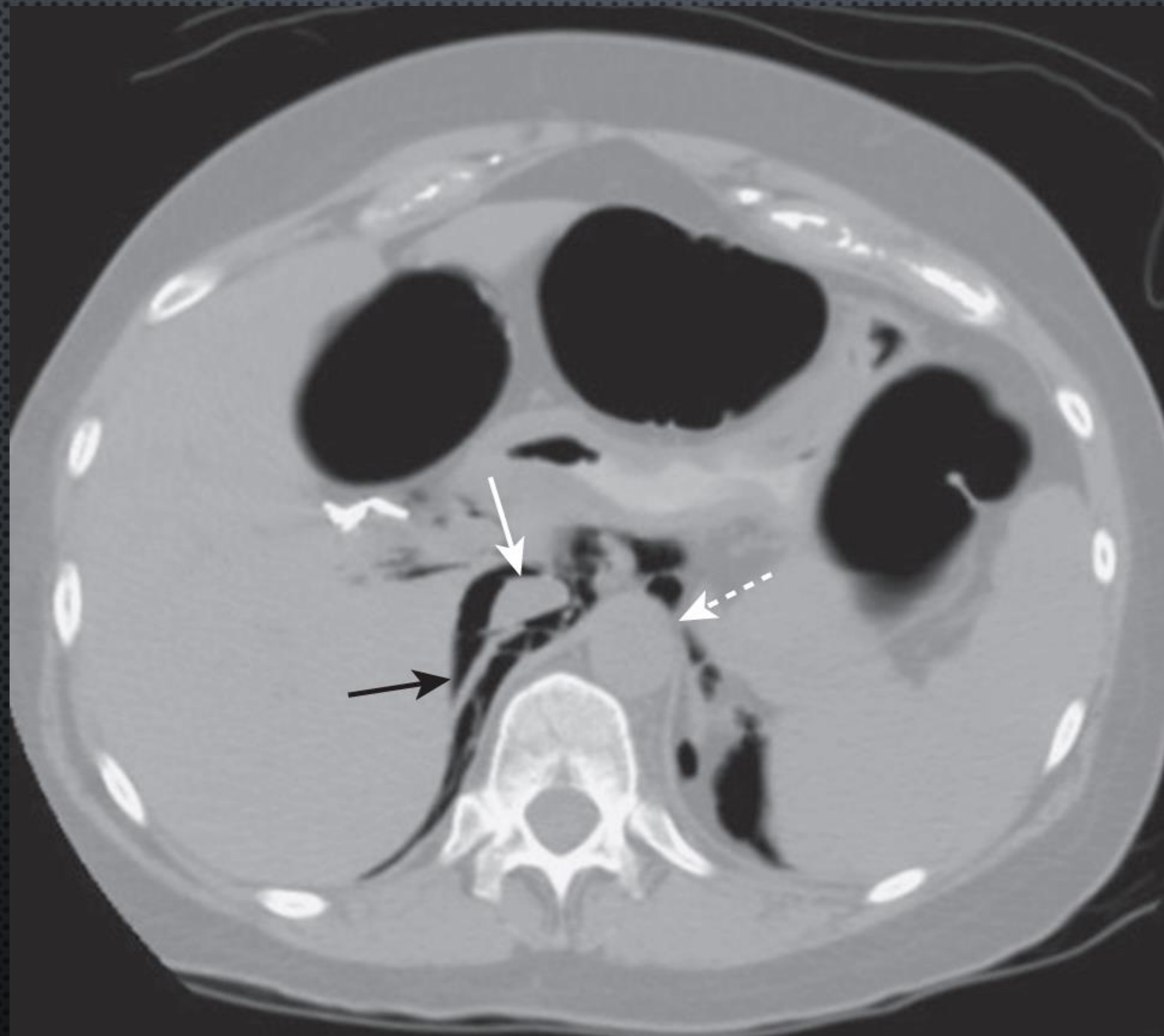
Mottled, blotchy appearance (especially in the anterior pararenal space).

Relatively fixed in position (does not move with patient repositioning, unlike free air).

Anatomical Outlines & Etiology

Anatomical Outlines: Dissects along the psoas muscles, kidneys, ureters, aorta, and IVC. Can extend into the mediastinum (pneumomediastinum).

Etiology: Inflammatory disease (ruptured appendix), ulcerative disease (Crohn's), penetrating trauma, or gas-producing infections (perforated diverticulitis).



Identifying Extraperitoneal Air & Pneumatosis

Extraperitoneal (Retroperitoneal) Air

Appearance: Streaky, linear, or mottled/blotchy radiolucency.

Behavior: Relatively fixed position; does not move freely with patient position changes.

Location: Outlines extraperitoneal structures (psoas muscles, kidneys, aorta). Causes include perforated diverticulitis or trauma.

Pneumatosis Intestinalis (Air in Bowel Wall)

Appearance: Linear radiolucencies seen in profile, paralleling the bowel contour.

Clinical Flag: In infants, this finding is pathognomonic for **Necrotizing Enterocolitis** (most heavily affecting the terminal ileum).

Pneumatosis intestinalis ranges from benign cysts to ominous necrosis

Visualizing the Wall

In Profile: Linear radiolucency whose contour exactly parallels the bowel lumen.

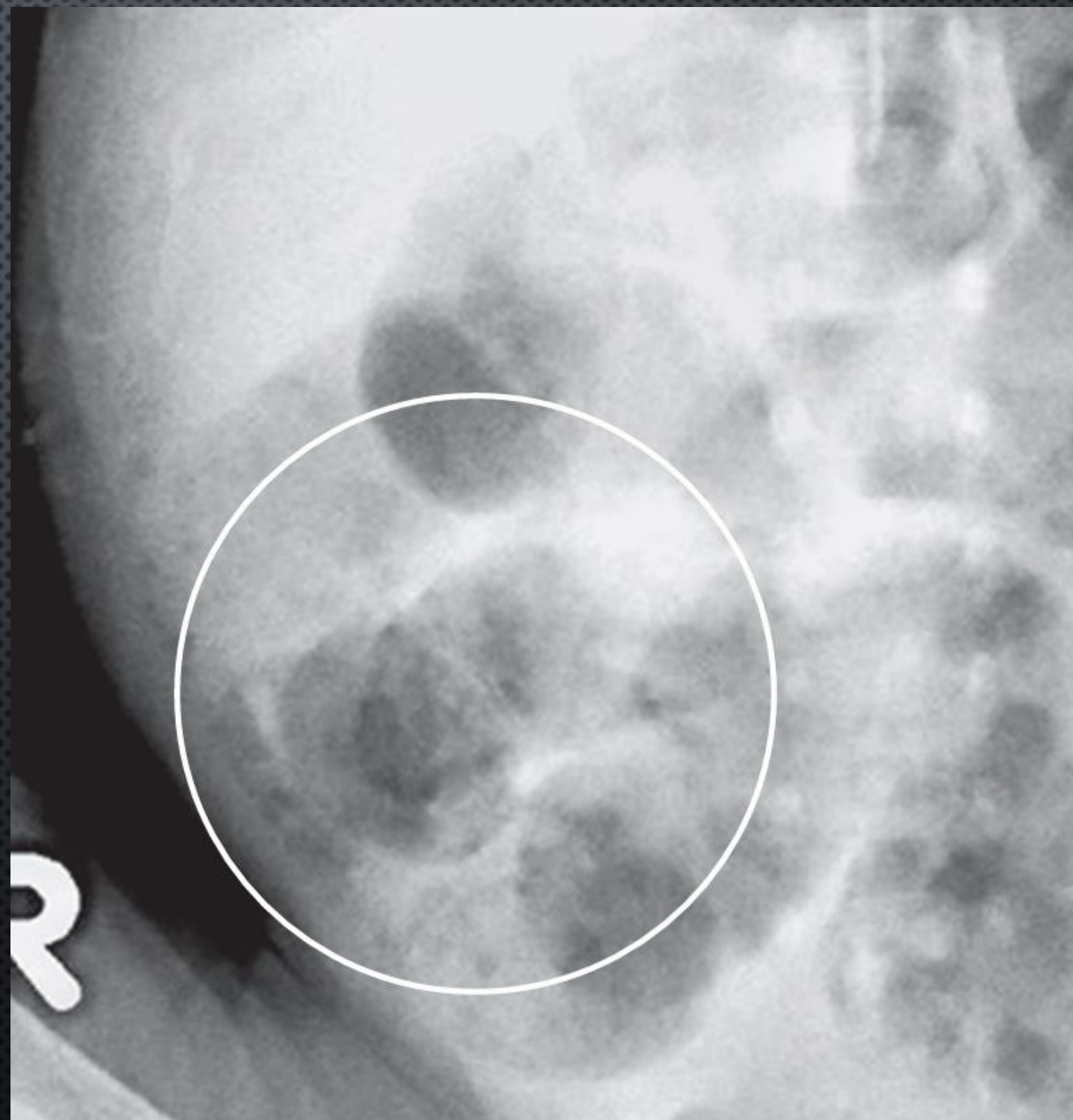
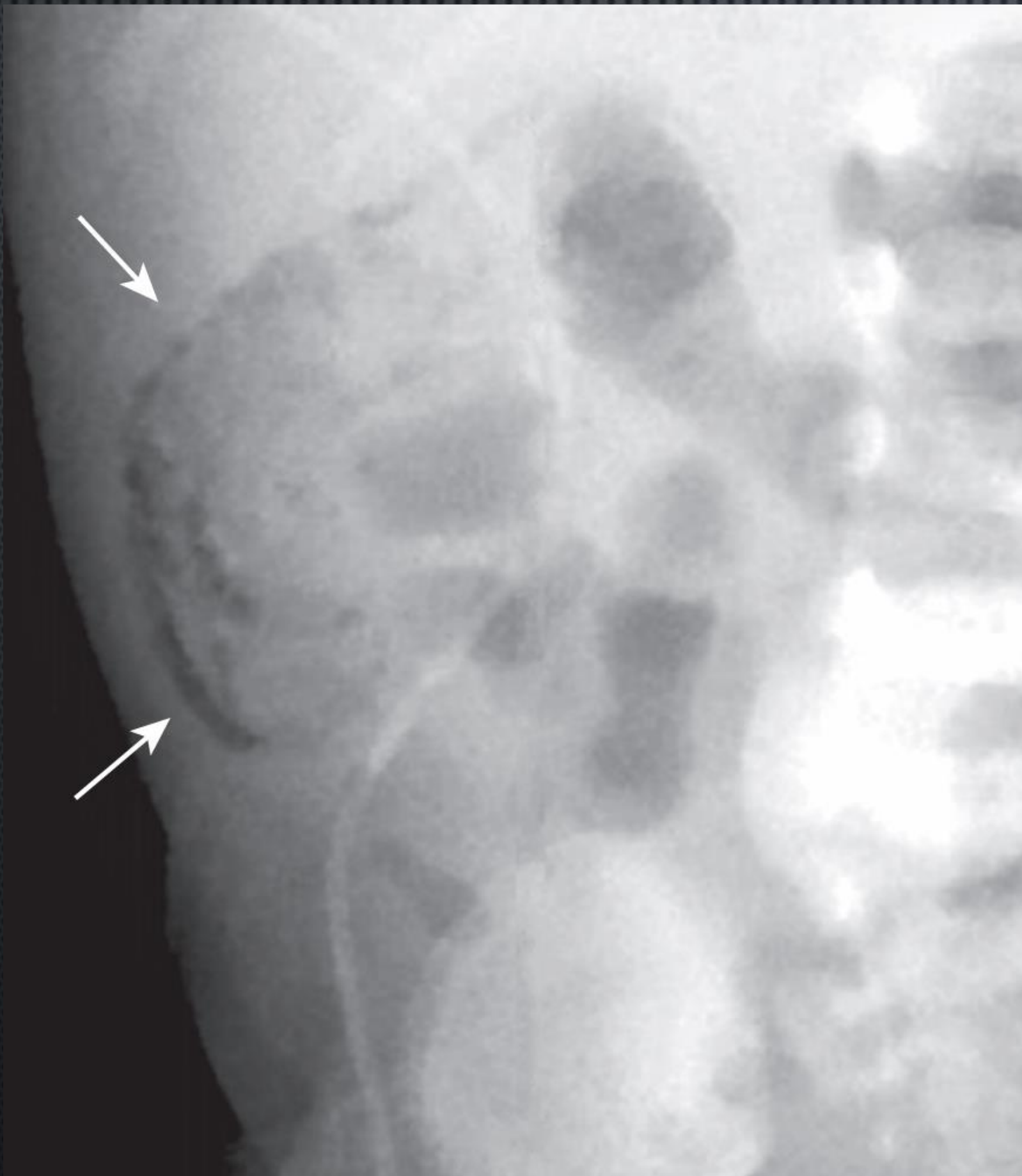
En Face: Mottled appearance resembling gas mixed with feces. Differentiating clue: it occurs in unexpected areas and **does not change over multiple images/positions**.

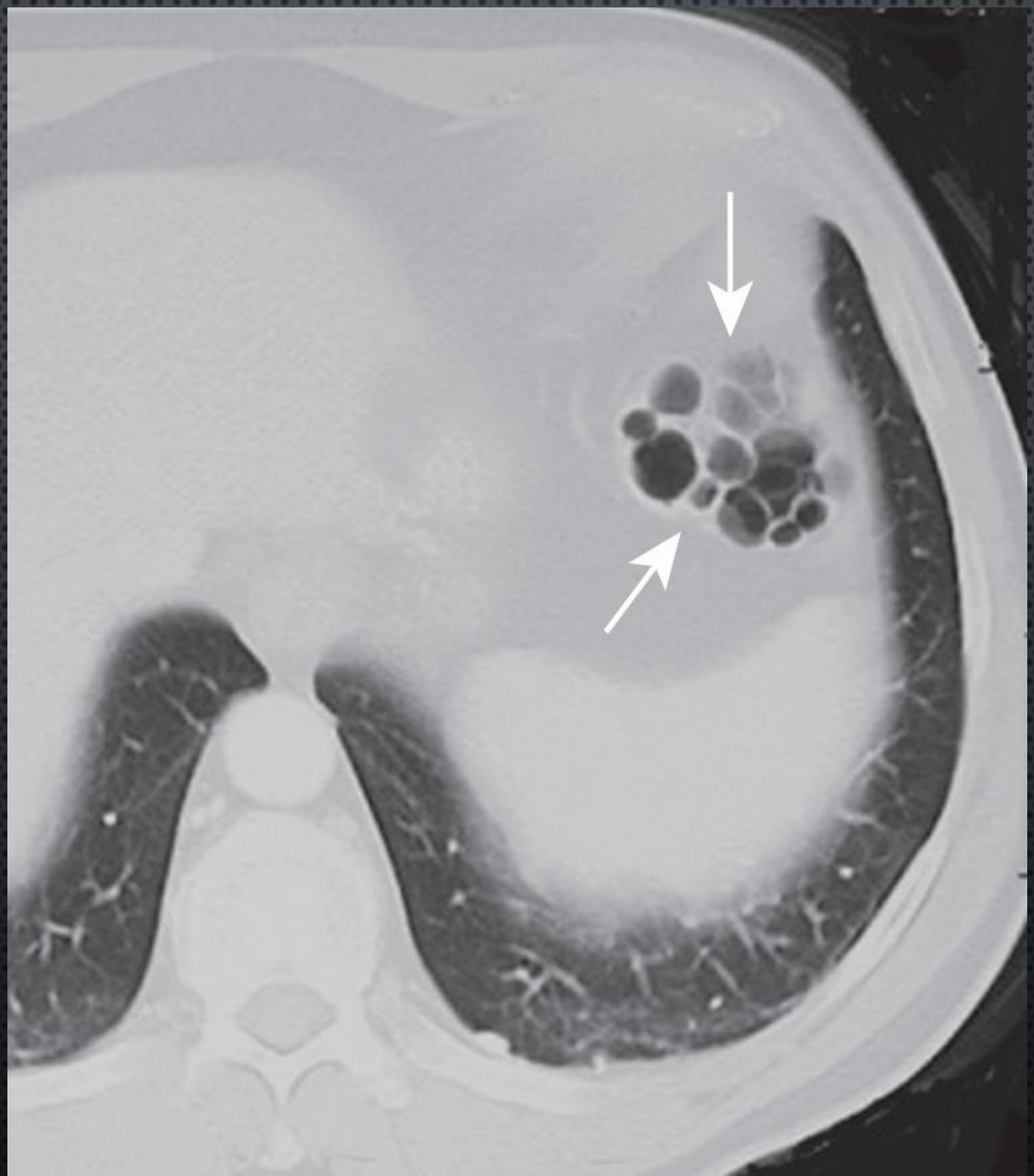
Clinical Significance

Primary (Benign): Pneumatosis cystoides intestinalis. Rare, usually affects the left colon with cyst-like collections.

Secondary (Ominous): Necrosis of the bowel wall. Seen in necrotizing enterocolitis in infants, and ischemic bowel disease in adults.

Complication: Dissection of air into the portal venous system (a highly peripheral branching gas pattern over the liver).





Pneumobilia presents as central branching and often signals a mechanical fistula.

Radiographic Signature: One or two tube-like, branching lucencies overlying the **central portion** of the liver (conforming to major bile ducts).

Benign Causes: Incompetent sphincter of Oddi, or prior surgery (sphincterotomy/choledochoenterostomy).

The Gallstone Ileus Triad: A gallstone erodes through the gallbladder wall into the duodenum, creating a fistula and impacting in the terminal ileum. Look for:

1

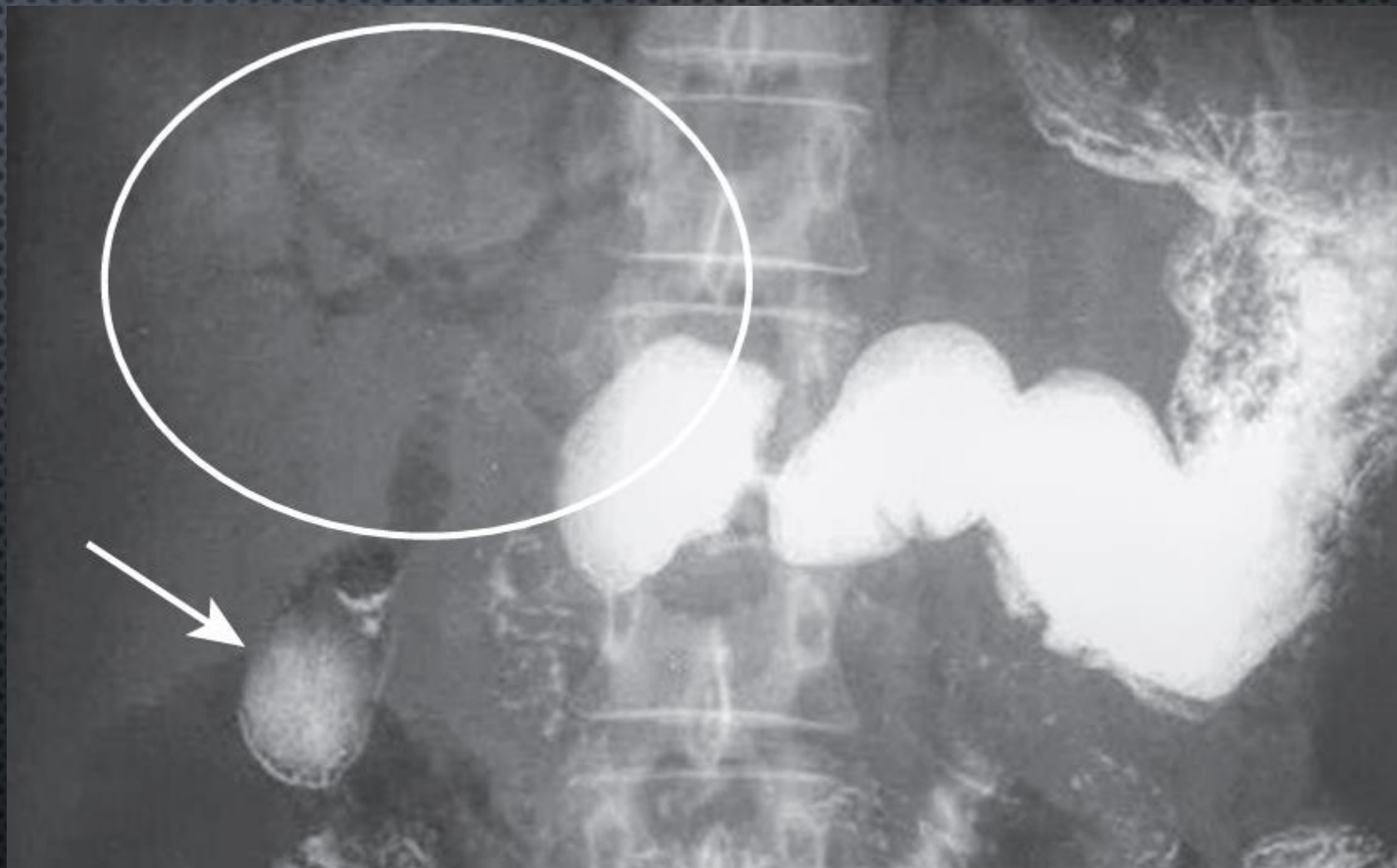
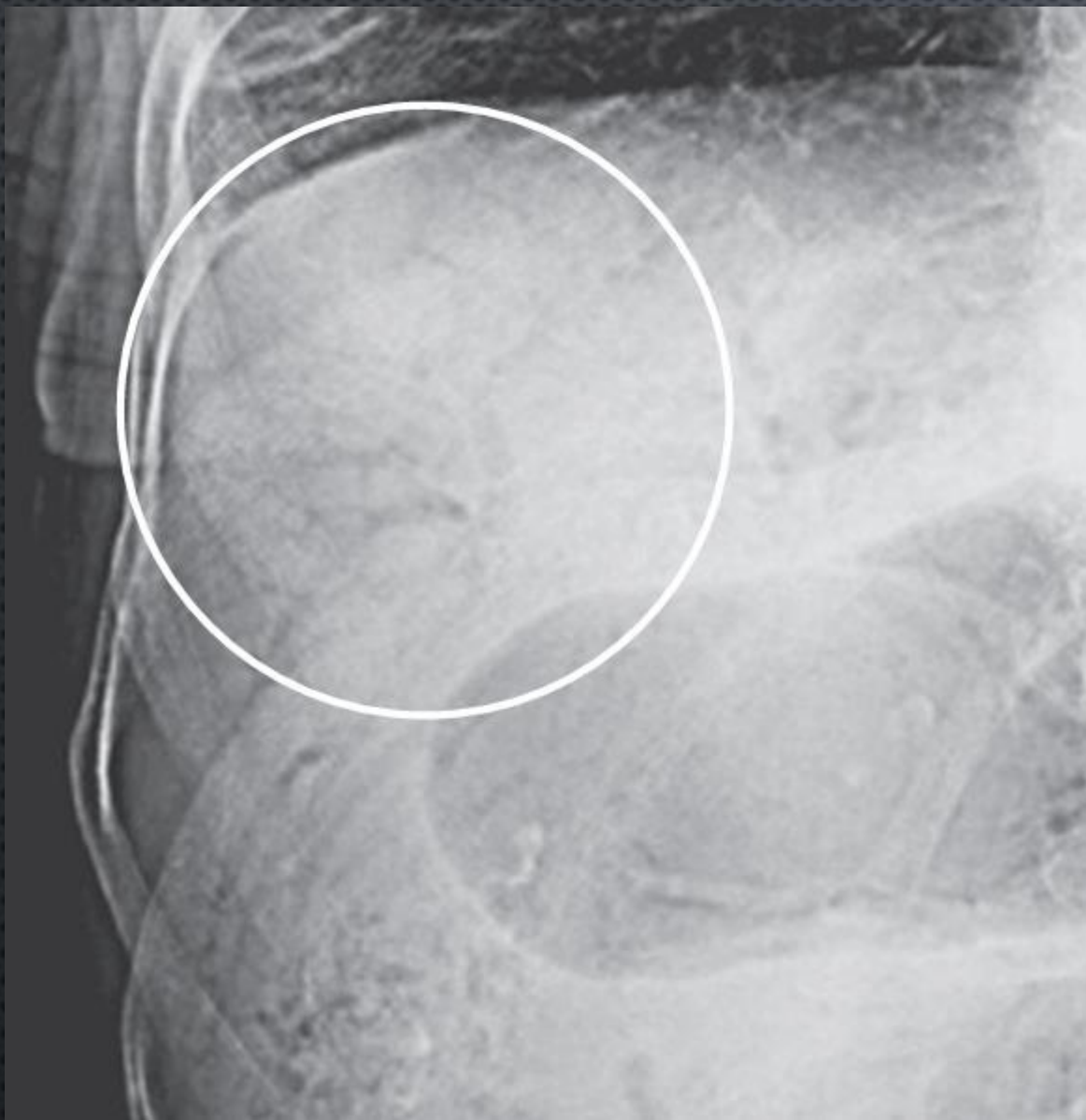
Air in the biliary system
(Pneumobilia).

2

Small bowel obstruction
(Dilated loops).

3

Calcified gallstone in
the bowel.



Differentiating true extraluminal gas from anatomical mimickers.

True Pathology vs. Mimicker	The Differentiating Factor
Free Air (Crescent) vs. Chilaiditi Sign	Presence of colonic haustral folds indicates interposed colon, not free air.
Rigler Sign vs. Pseudo-Rigler	Pseudo-Rigler is caused by overlapping loops of dilated bowel; the wall is not visible where loops do not overlap.
Pneumobilia vs. Portal Venous Gas	Biliary air is central and consists of a few tubular structures. Portal venous gas is highly peripheral and fills innumerable small branching vessels.

The Extraluminal Gas Matrix

Anatomical Space	Key Radiographic Signs	Top Etiologies
Intraperitoneal (Free Air)	Crescent sign, Rigler sign, Falciform/Football signs	Perforated peptic ulcer, trauma, normal 5-7 days post-op.
Extraperitoneal (Retroperitoneal)	Streaky, mottled, fixed in position, outlines structures	Inflammatory (appendicitis), ulcerative (Crohn's), trauma.
Bowel Wall (Pneumatosis)	Linear (profile) or mottled (en face), parallels lumen	Necrotizing enterocolitis, ischemic bowel, obstructing lesions.
Biliary System (Pneumobilia)	Central, tube-like branching over liver	Incompetent sphincter, prior surgery, gallstone ileus.

Diagnostic Maxims for the Reading Room

Maxim 1: Gravity is the primary contrast agent.

Small volumes of free air are invisible on supine views; always demand a horizontal x-ray beam.

Maxim 2: Motion dictates location.

Intraperitoneal air floats and shifts; extraperitoneal air dissects and remains fixed.

Maxim 3: Context defines severity.

Pneumatosis can be a benign incidental cyst or the hallmark of imminent bowel necrosis. Correlate with the clinical state.

Decoding Soft-Tissue Calcifications

A Systematic Approach to Pattern Recognition in Radiology

The Core Principle

Most soft-tissue calcification occurs in tissue that is already abnormal. This is called **Dystrophic Calcification.**



**Pattern of
Calcification**



**Anatomic
Location**



**Pathologic
Diagnosis**



Rim-like



Linear / Track-like



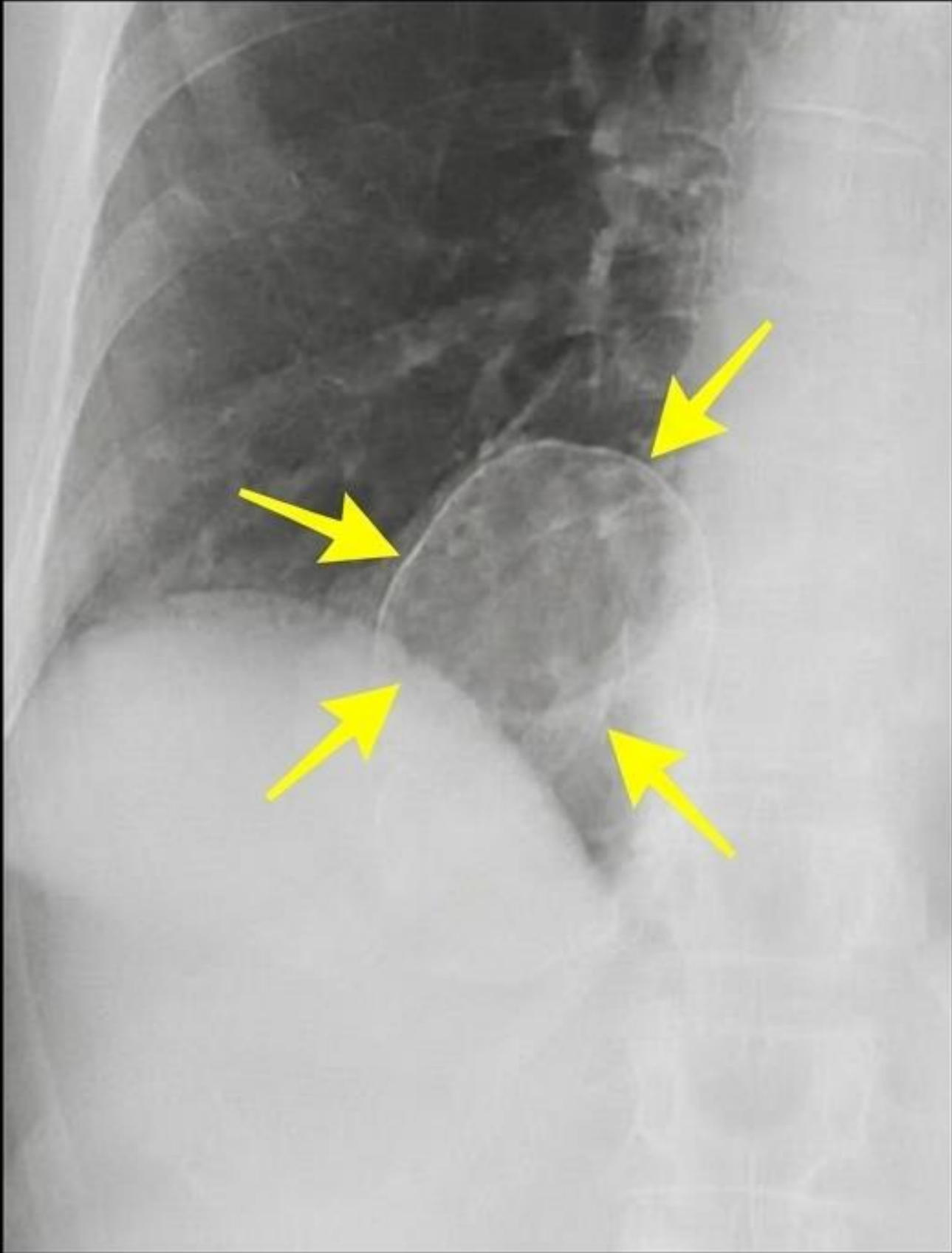
Lamellar



Amorphous / Popcorn



Case 1: The Hollow Viscus



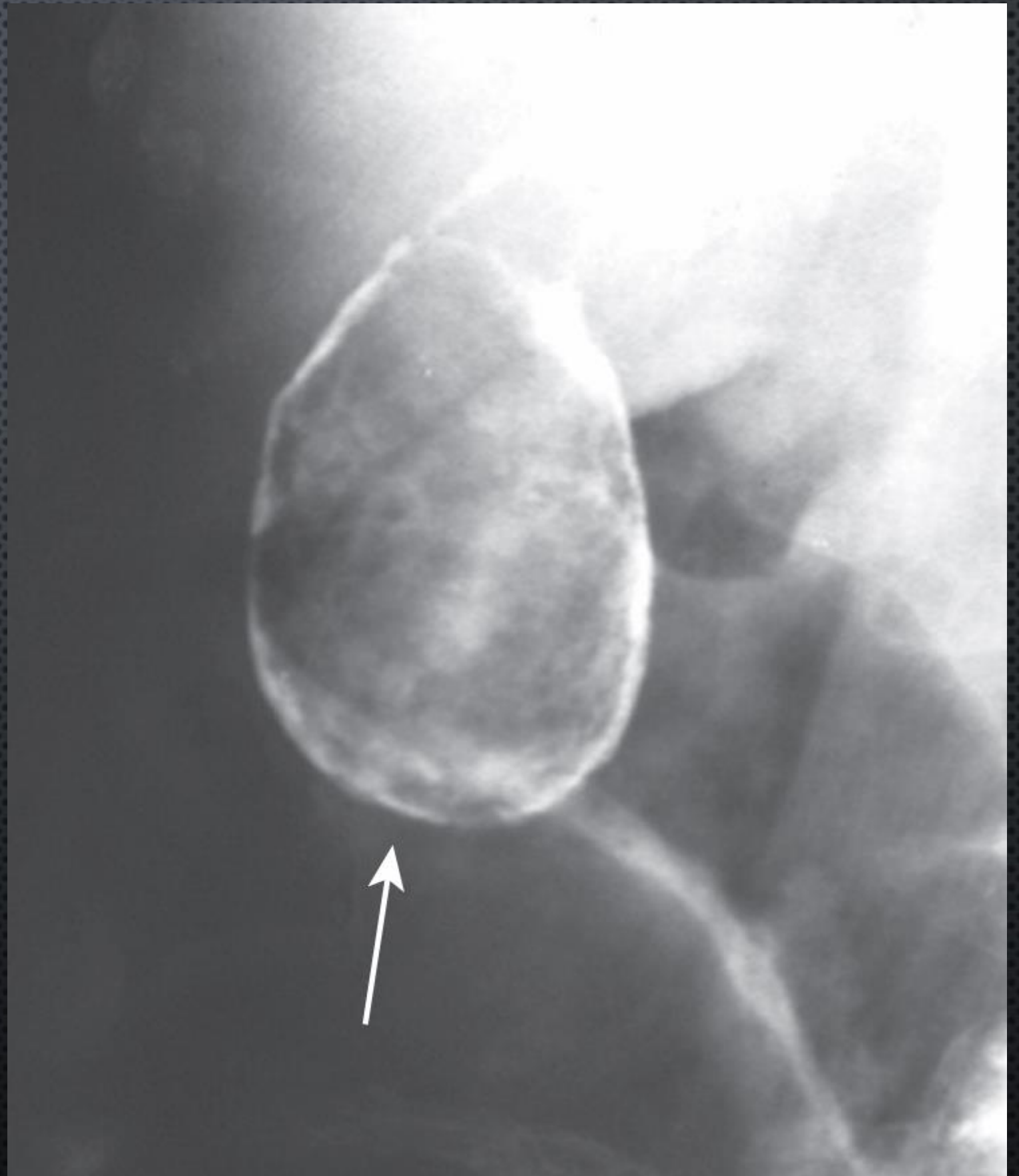
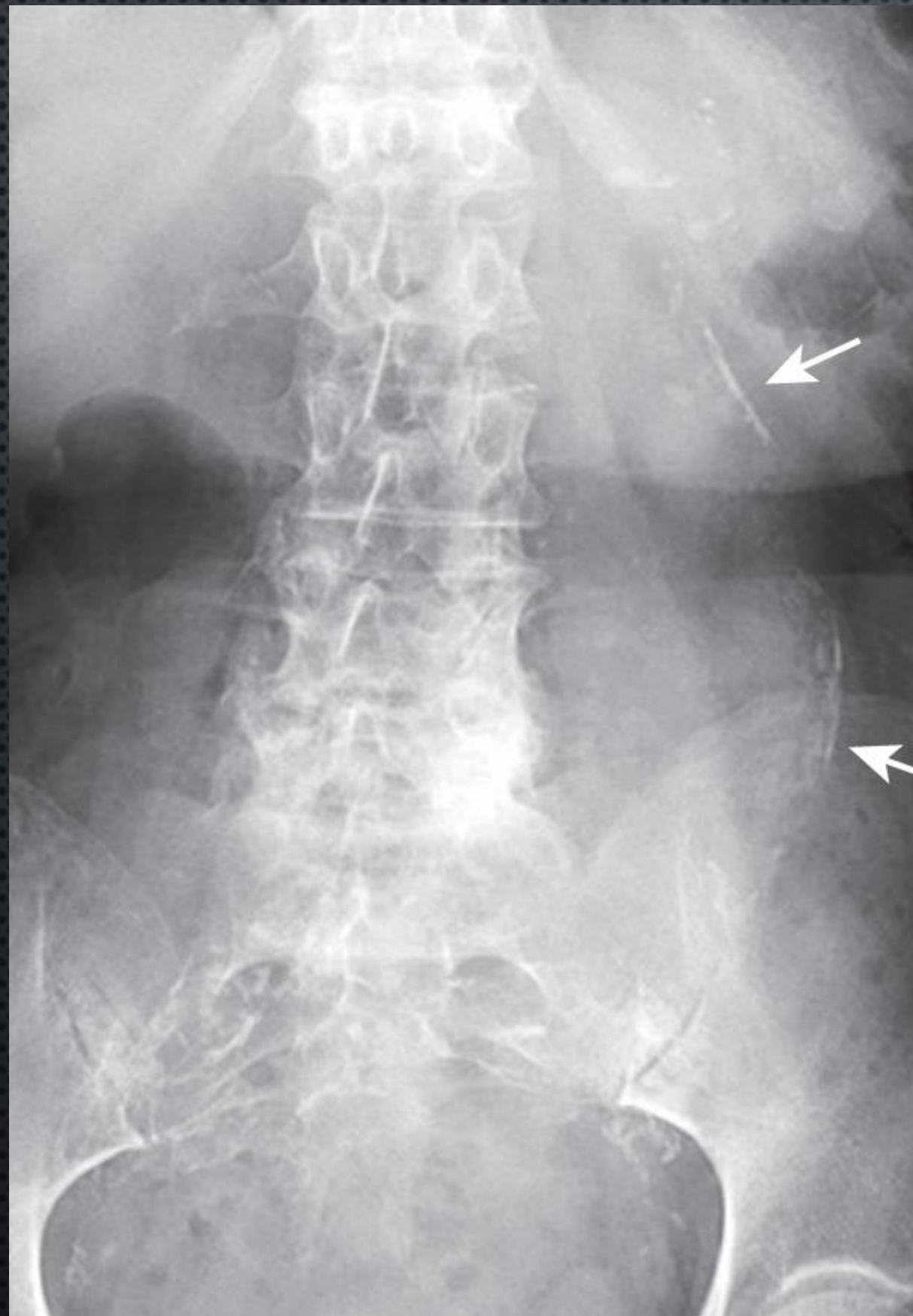
Pattern 1: Rim-Like Calcifications

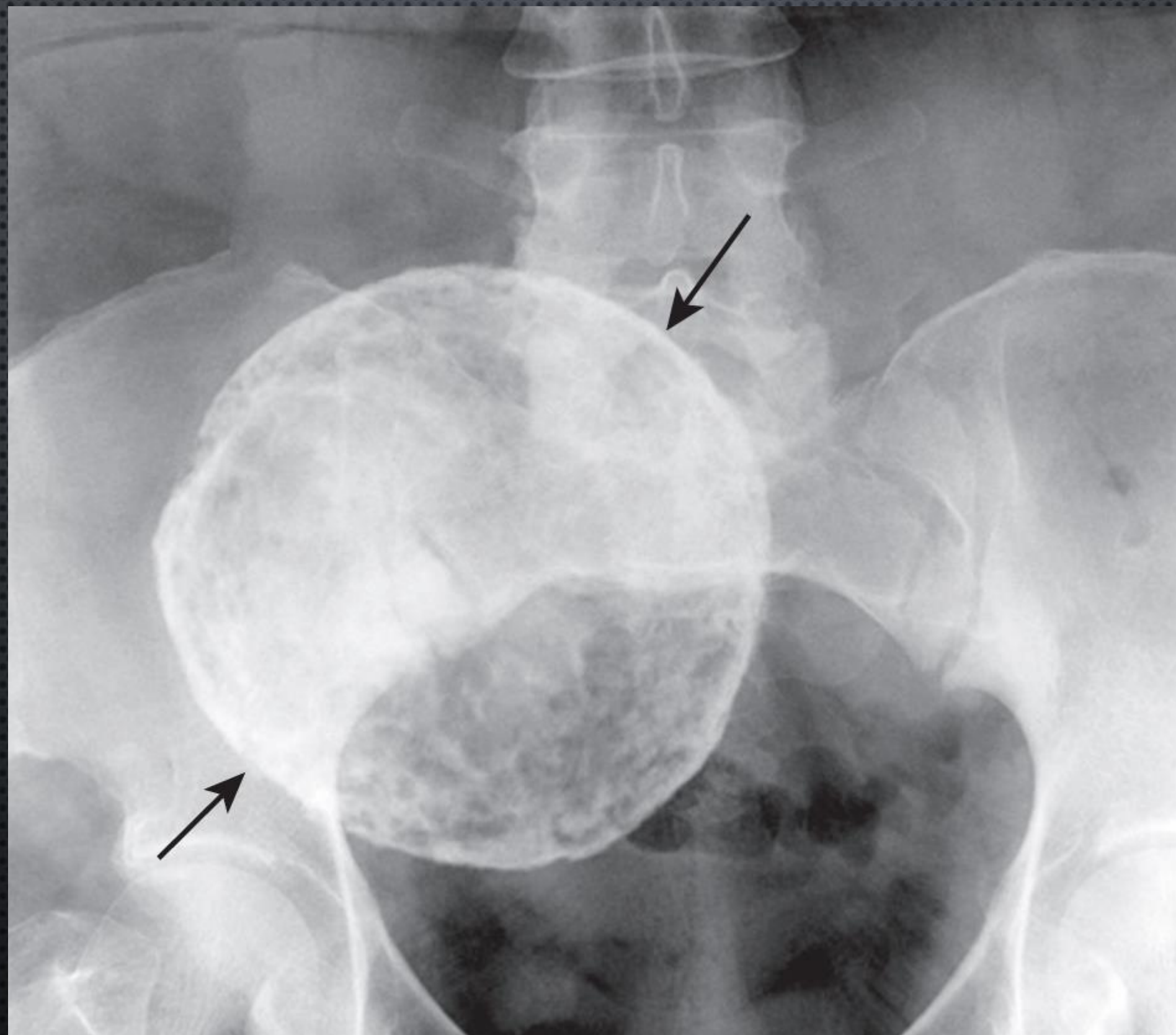
Diagnosis: Calcified Pericardial Cyst

The Equation: Rim-like Pattern + Mediastinal Location (Right-sided) = Pericardial Cyst.

The Rule: Forms in the wall of a hollow viscus (a structure containing fluid, fat, or air enclosed by an outer wall).

Primary Suspects:	Cysts: Renal, splenic, pericardial (usually right-sided, asymptomatic).
	Aneurysms: Aortic (diameter >3cm = aneurysm, common in diabetes), splenic, femoral.
	Saccular Organs: Porcelain gallbladder (indicates chronic stasis, 90% associated with gallstones, potential carcinoma risk).







Pattern 2: Linear or Track-Like Calcifications



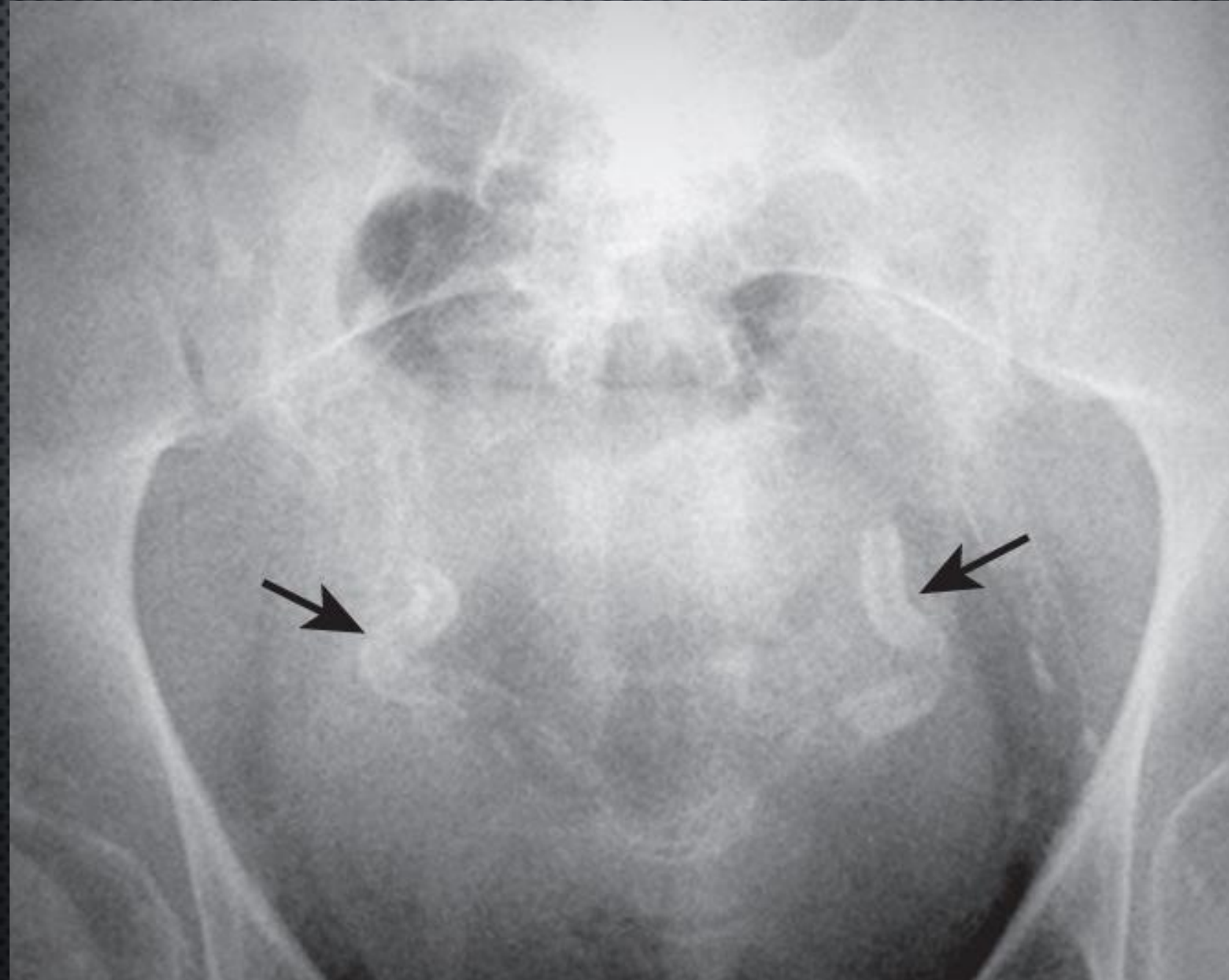
Diagnosis: Calcified Arterial Wall (Femoral Artery)

The Equation: Track-like Pattern + Soft tissue of Thigh = Femoral Artery.

The Rule: Calcification forming in the walls of tubular structures.

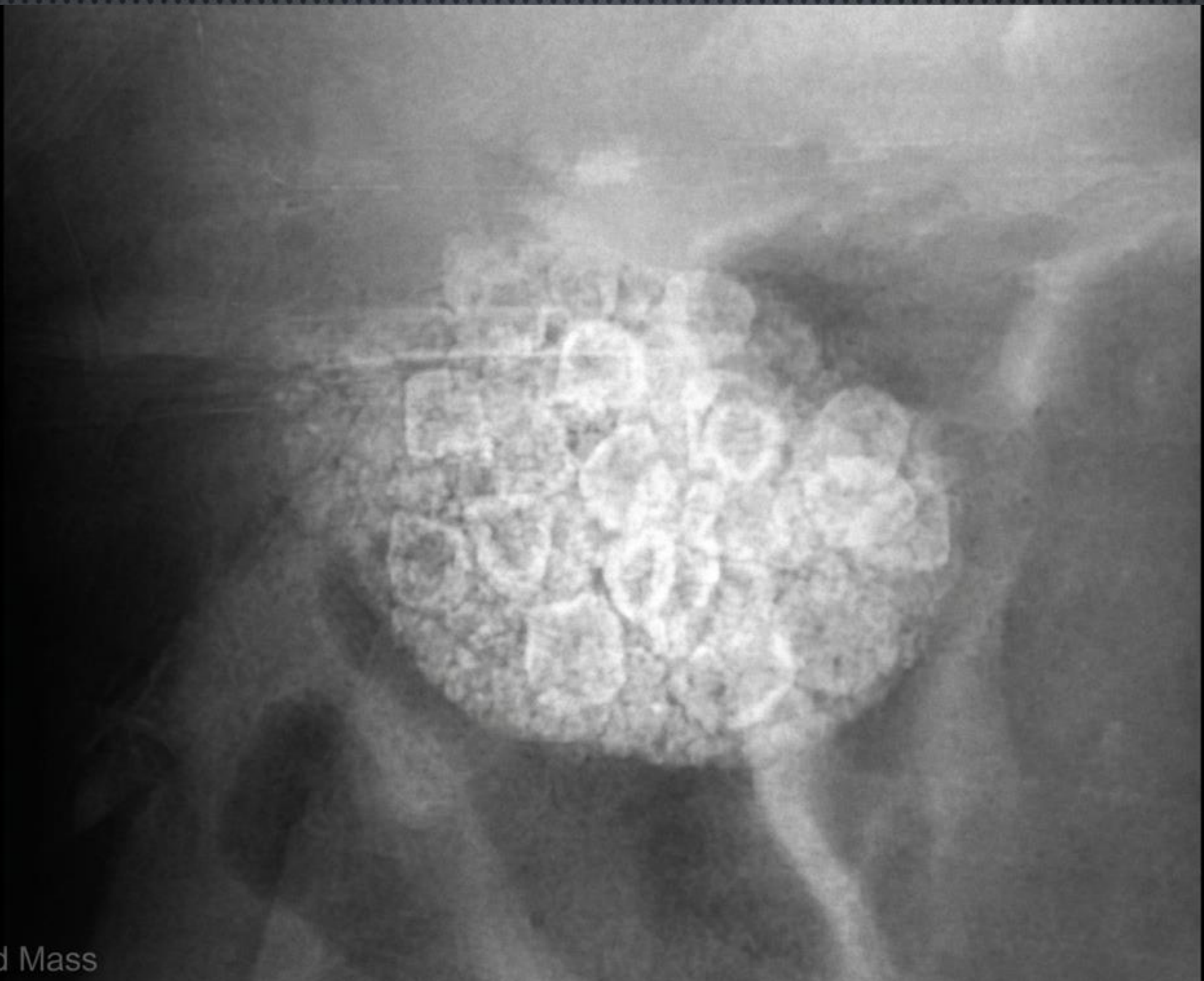
Primary Suspects:	Arteries: Accelerated by atherosclerosis, diabetes, and chronic renal disease. (Note the amputation stump in this case).
	Tubes: Vas deferens (symmetrical, accelerated in diabetes), Fallopian tubes.
	Ureters: Uncommon (seen in schistosomiasis, TB).

Clinical Pearl: The walls of veins do not calcify. Only venous thrombi (phleboliths) calcify in veins.

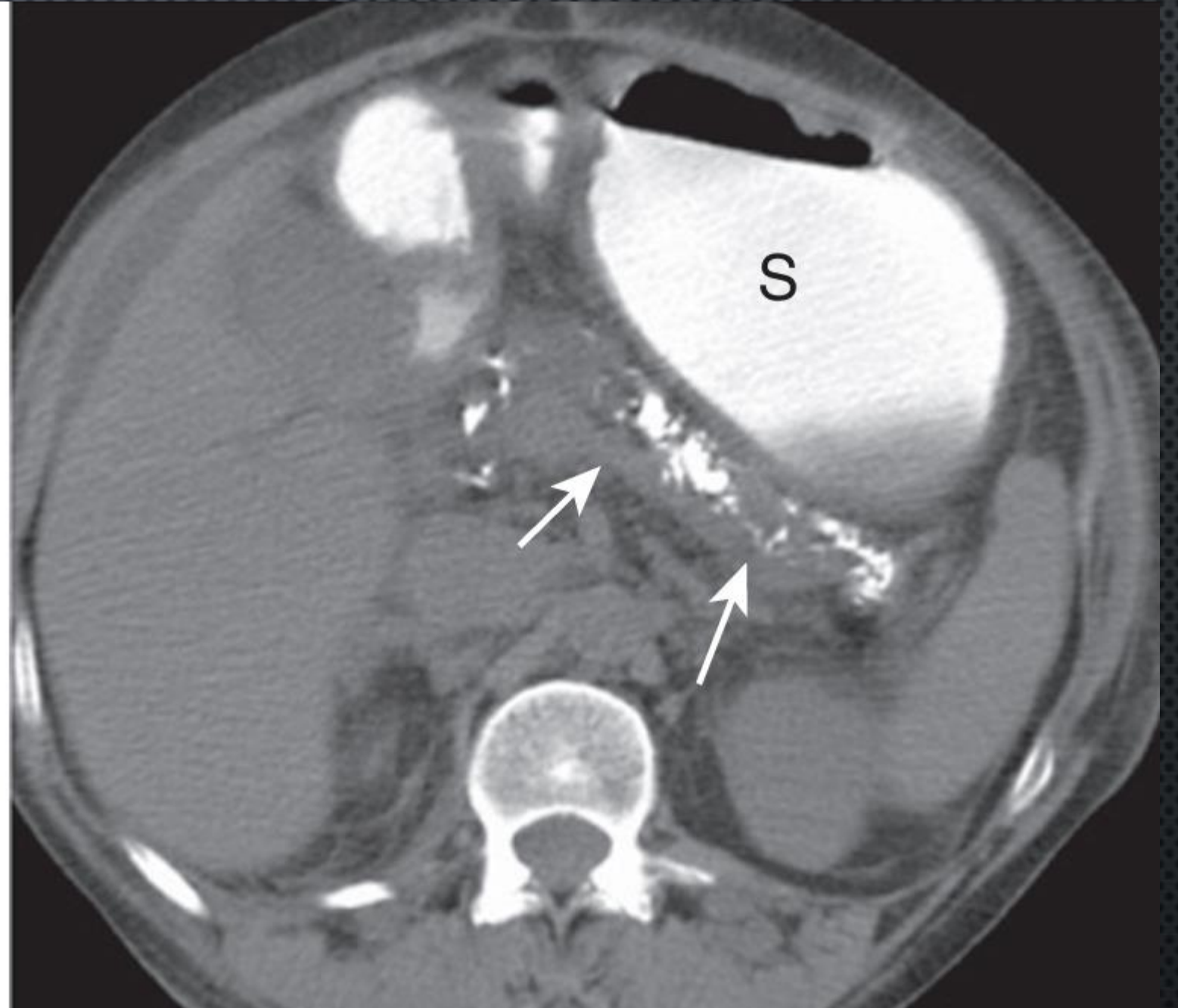
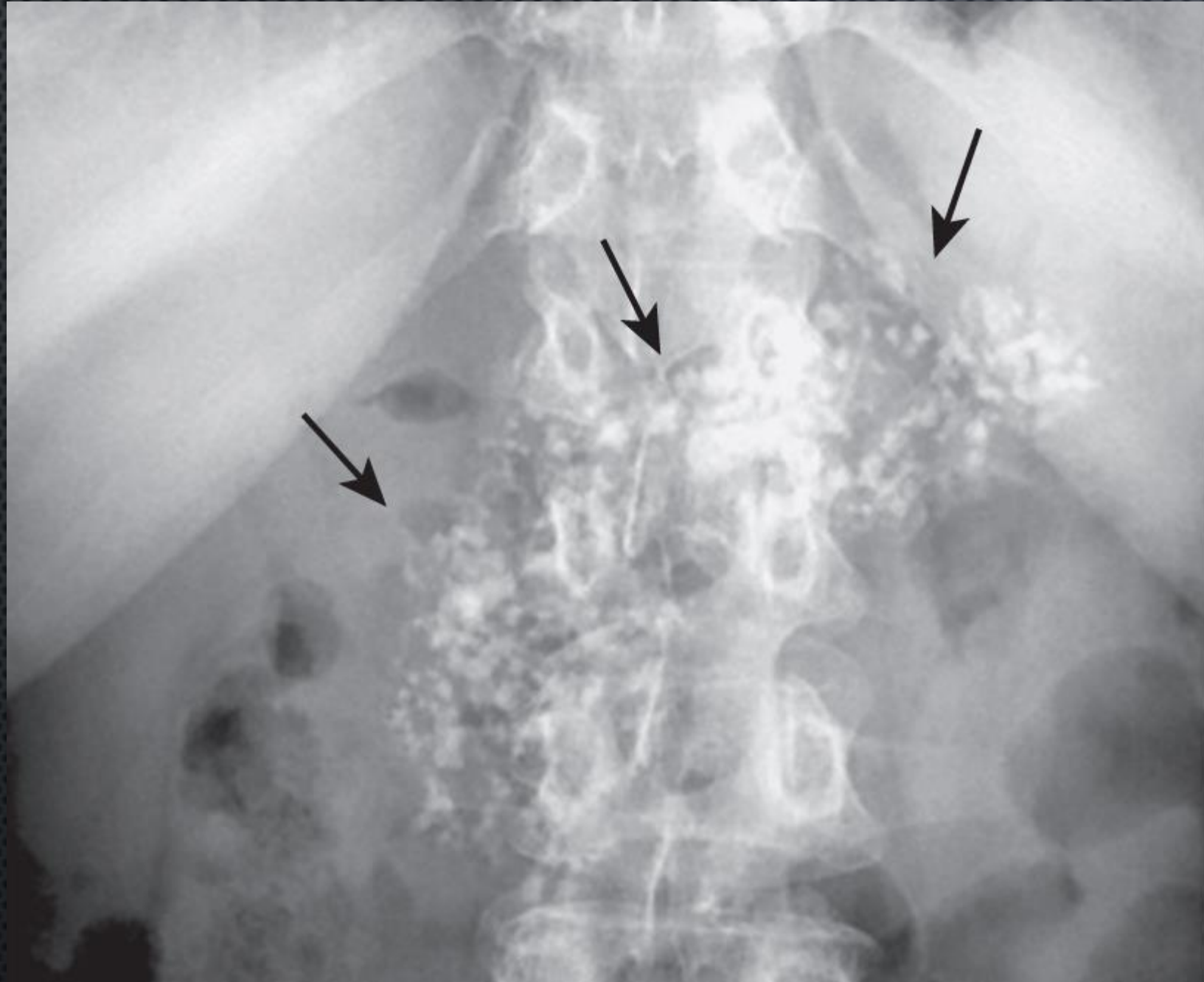


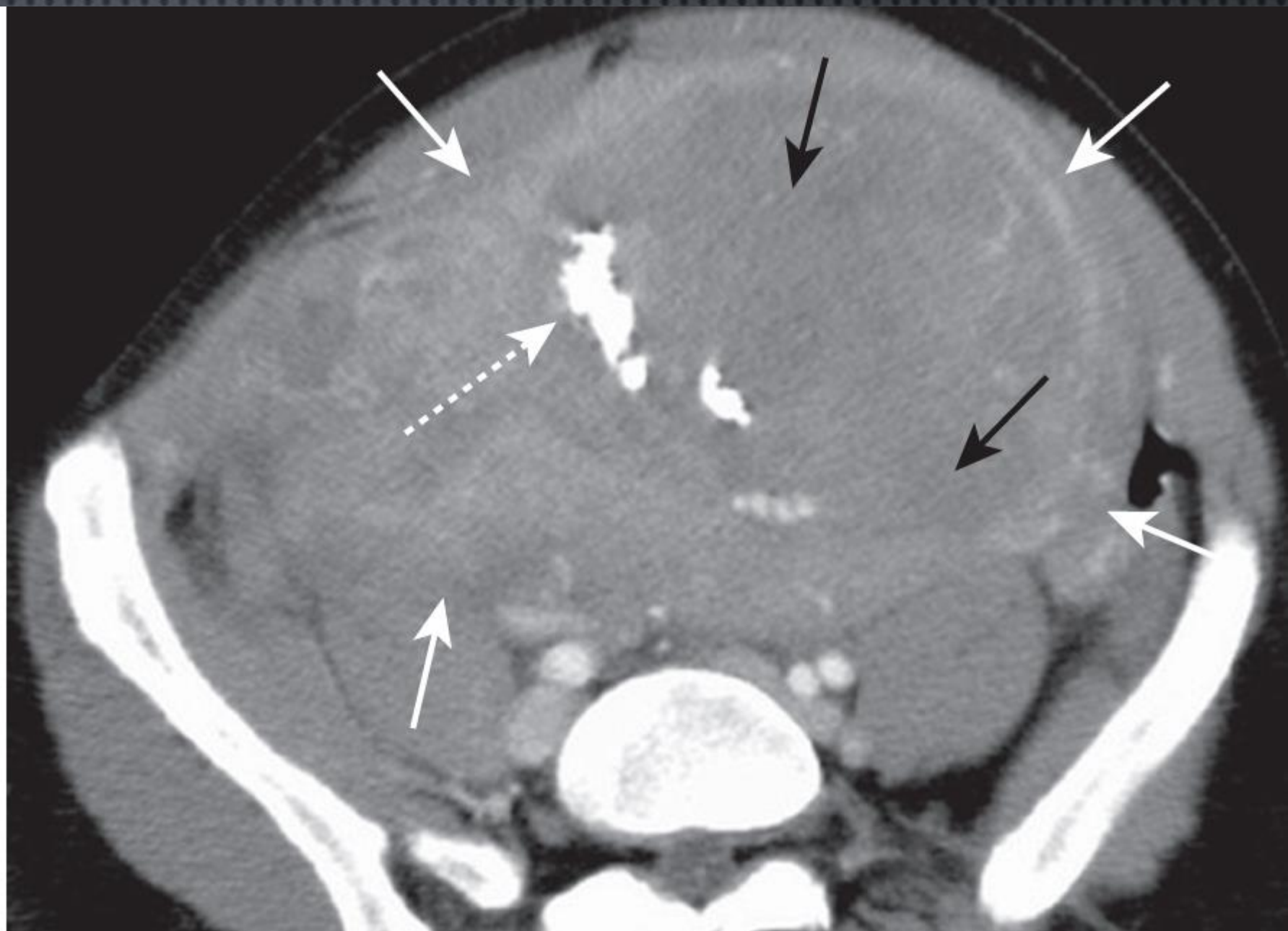


Case 3: The Moving Stone



Case 4: The Solid Mass



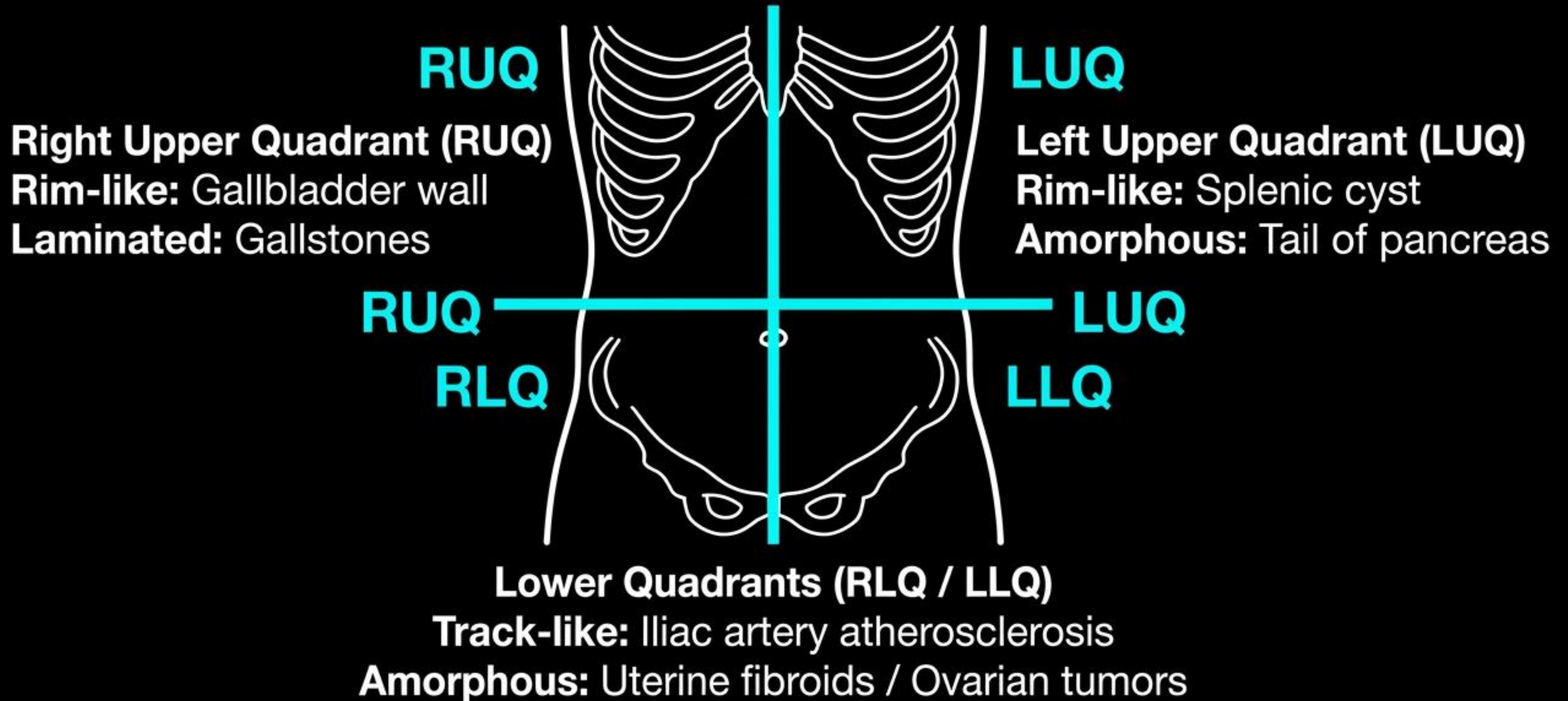




The Structural Taxonomy of Calcification

	Rim-like	Formed in the wall of a hollow viscus	Cysts, aneurysms, gallbladder wall
	Linear / Track	Formed in the walls of tubular structures	Arteries, ureters, vas deferens
	Lamellar	Formed as stones inside a fluid lumen	Renal, gallbladder, and bladder calculi
	Amorphous	Formed inside a solid organ or tumor	Pancreas, uterine fibroids, mucin tumors

The Spatial Matrix



Clinical Takeaways

1

The presence of dystrophic calcification always implies a process that is **subacute** or **chronic**.

2

Identify the **Pattern** to determine the type of structural tissue involved.

3

Identify the **Location** to determine the specific organ of origin.

4

Trust the diagnostic equation:
Pattern + Location = Pathology.

Diagnostic Pitfalls: Benign Calcifications



Phleboliths (Left)

Calcified venous thrombi occurring with increasing age, usually in women's pelvic veins.

Diagnostic Key: They classically possess a lucent center, differentiating them from ureteral calculi.



Calcified Rib Cartilages (Right)

Physiologic process with advancing age.

Diagnostic Key: Amorphous, speckled appearance occurring in an arc sweeping back to the sternum. Do not confuse with renal or gallbladder stones.

The Diagnostic Matrix: Pattern x Location

	RUQ	LUQ	RLQ	LLQ
Rim-like (Wall of hollow viscus/cyst)	Gallbladder wall (chronic infection)	Splenic cyst	Iliac artery aneurysm	Iliac artery aneurysm
Track-like (Wall of a tube)	Hepatic artery (atherosclerosis)	Splenic artery	Iliac artery	Iliac artery
Lamellar (Nidus inside hollow lumen)	Gallstones	Renal stone	Appendicolith	
Amorphous (Inside solid organ/tumor)	Head of pancreas (chronic pancreatitis)	Tail of pancreas	Uterine fibroids / Ovarian tumor	Uterine fibroids / Ovarian tumor

Soft Tissues & Organomegaly



The Physics of Visualization

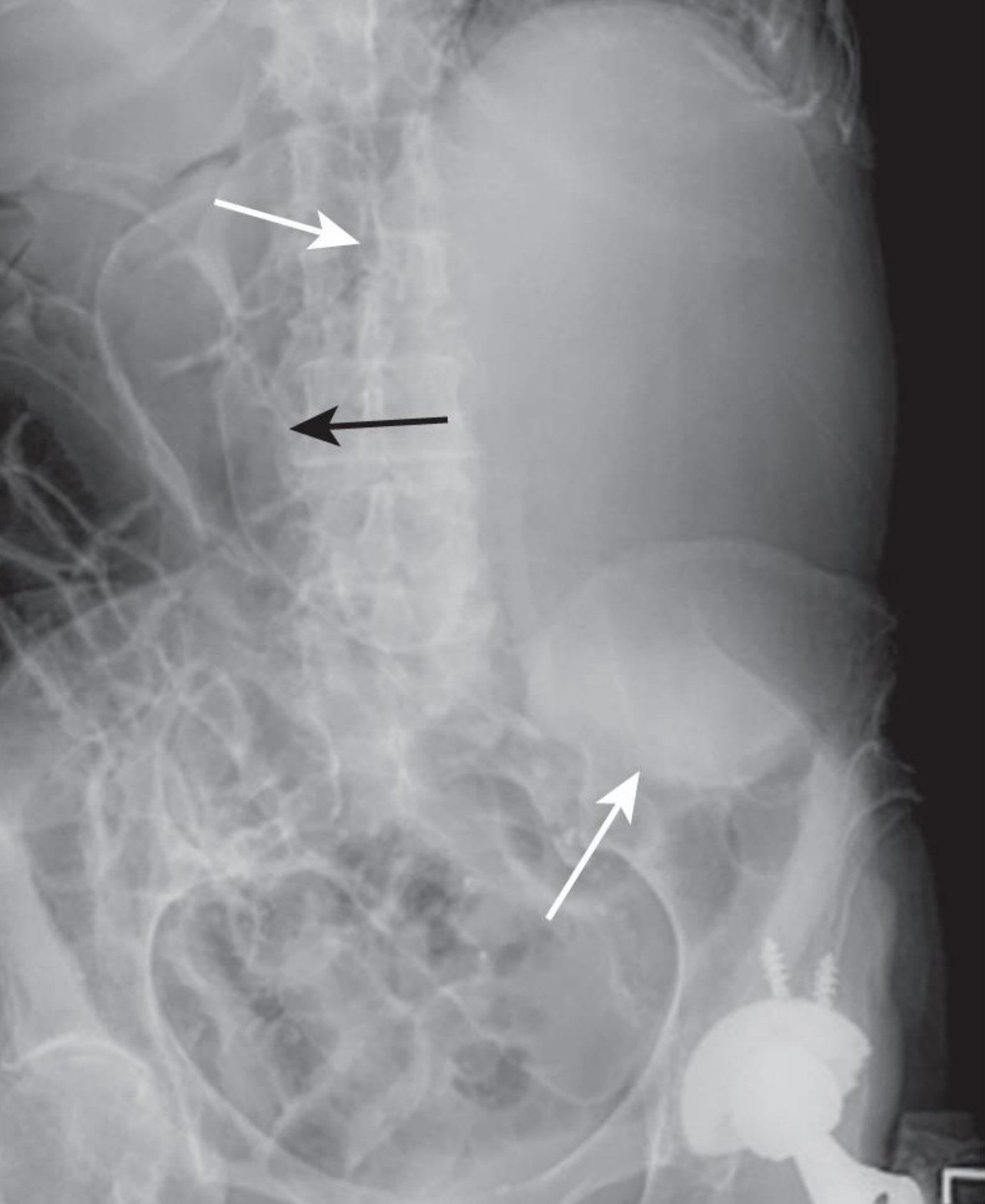
Soft tissues are only directly visible if surrounded by a different density (fat/air). Otherwise, we rely on indirect evidence: the pathologic displacement of bowel gas.

Liver & Spleen Rules

Liver: Hepatomegaly pushes bowel down to the iliac crest and across midline. (Riedel Lobe is a normal tongue-like inferior variant).

Spleen: Normally ~12 cm. Splenomegaly projects below the 12th posterior rib or pushes the stomach bubble across midline.

Psoas Muscle Pearl: Inability to visualize the psoas shadow is not a reliable indicator of retroperitoneal disease.



Organomegaly & The Limits of Plain Film

The Rule of Density

Soft-tissue structures (liver, spleen, kidneys) can only be seen if surrounded by a different density (fat or free air).

The Rule of Displacement

Organomegaly is diagnosed primarily via indirect evidence: the pathologic displacement of air-filled bowel. **Example:** An enlarged liver displaces all bowel from the RUQ down to the iliac crest. An enlarged spleen displaces the stomach bubble across the midline.

Clinical Takeaway

Conventional radiographs remain the ultimate triage and screening tool for gas, free air, and calcifications. However, definitive evaluation of soft-tissue masses and organ dimensions requires advanced modalities (CT, MRI, US).

