Abdominal CT Protocols: Beyond Vascular Emergencies

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OSLO UNIVERSITY HOSPITAL

Oslo University Hospital, Ullevål/Aker

Radiologists:

Total: 79

Abdominal/Oncology: 32

Residents: 27

Exams per year:

CT: 55.000

MRI: 21.100

Ultrasound: 16.300

Angio: 2.370

Equipment:

CT: 8

MRI: 8

Interventional radiology rooms: 6

Ultrasound rooms: 5

Mobile Ultrasound: 3

Learning Objectives

- Indications for emergency abdominal CT
- Get overview of different abdominal CT protocols
- Exam parameters and their impact

Guidelines:
ACR Appropriateness Criteria

Abdominal pain, no fever

Variant 4: Acute nonlocalized abdominal pain. Not otherwise specified. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	Usually Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Appropriate	O
US abdomen	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography abdomen	May Be Appropriate	☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Nuclear medicine scan gallbladder	Usually Not Appropriate	☢☢
Fluoroscopy upper GI series with small bowel follow-through	Usually Not Appropriate	☢☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢

Abdominal pain, fever

Variant 1: Acute nonlocalized abdominal pain and fever. No recent surgery. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
US abdomen	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
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Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
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Causes of acute abdominal pain

Differential diagnoses

- Abdominal aortic aneurysm
- Acute appendicitis
- Acute cholecystitis
- Acute diverticulitis
- Acute Intestinal ischemia
- Acute pancreatitis
- Acute peptic ulcer
- Acute peritonitis
- Acute pyelonephritis
- Acute ureteric colic
- Adrenal crisis
- Biliary colic
- Bowel obstruction
- Bowel volvulus
- Carcinoid
- Ectopic pregnancy with tubal rupture
- Familial mediterranean fever
- Hemoperitoneum
- Kidney stone
- Ovarian torsion
- Ruptured spleen
- Sicle cell anemia

https://www.ncbi.nlm.nih.gov/books/NBK459328/

Causes of acute abdominal pain

Most frequent

Cause (in decreasing order of frequency)	Number of patients	Frequency (%)
Nonspecific abdominal pain (NSAP)	1,680	31.46
Renal colic	1,665	31.18
Biliary colic/cholecystitis	411	7.70
Appendicitis	203	3.80
Diverticulitis	194	3.63
Urinary tract infection and other urologic pain (i.e., testicular, prostatic)	147	2.75
Gastritis/peptic ulcer	143	2.68
Others	140	2.62
Iatrogenic pain	138	2.58
Gynecologic pain	120	2.25

5 causes ≈ 80%

DOI: 10.21037/atm.2016.09.10; DOI: 10.1016/j.emc.2015.12.008

Diagnostic approach

Appendicitis	CT 93%–95% sensitive if appendix seen
Bowel obstruction	Plain radiograph 71%–77% sensitive; CT 93% sensitive
Cholecystitis	US 91% sensitive, hepatobiliary iminodiacetic acid scan 97% sensitive
Diverticulitis	CT 93%–100% sensitive
Ectopic pregnancy	Transvaginal ultrasound
Mesenteric ischemia	CT angiography 96% sensitive
Pancreatitis	CT 78% sensitive, 86% specific
Perforated viscus	Upright chest radiograph 80% sensitive; CT 87%–98% sensitive
Tubo-ovarian abscess	Transvaginal US preferred imaging
Ovarian torsion	Pelvic US with Doppler flow
Renal/ureteral colic	Noncontrast spiral CT preferred
Ruptured AAA	Bedside US 100% sensitive for enlarged aorta

Abbreviation: US, ultrasound.

What are the choices?

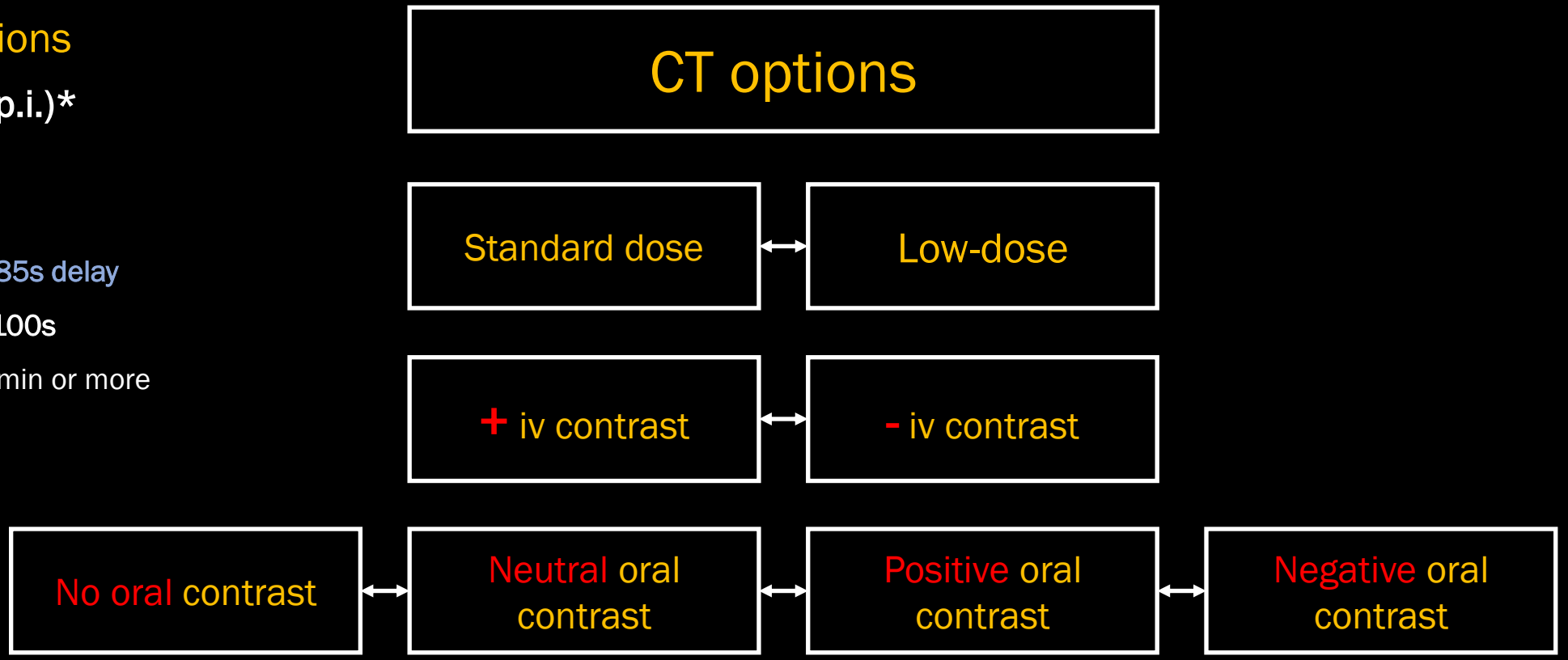
Other Considerations

IV contrast phase (p.i.)*

- Early arterial, 15-20s
- Late arterial, 35-40s
- Porto-venous phase, 85s delay
- Nephrogenic phase, 100s
- Delayed phase, 3-10 min or more

Reconstructions

- Max 2.5-3.0 mm
- Thinn slices?
- Iterative vs AI



* For bolus tracking ≈ 20s shorter

Unenhanced vs enhanced (iv) CT

Unenhanced

Indications:

- **Alternative:**
  Enhanced CT is not available (e.g. impaired renal function, previous adverse reaction)
- **Baseline:**
  Before po or rectal contrast if leakage is suspected, before iv if bleeding is suspected
- **Calculi:**
  Suspected renal or ureteral calculi (low-dose)
- **Control:**
  After intervention or surgery to verify placement of medical equipment or to rule out complications
- **Follow-up exam**
  E.g. po contrast passage

Enhanced

Indication:

Standard approach

iv contrast is usually recommended

Contrast admission

Concentration: 350 mgI/ml (Omnipaque)
Flow: 4 ml/s
Amount: 2 ml/kg.

Minimal contrast uptake of fatty tissue.

Weight	Athlets	Standard	Obese
kg	2.5 ml/kg	2.0 ml/kg	1.5 ml/kg
40-45	110	90	-
46-50	125	100	-
51-55	140	110	80
56-60	150	120	90
61-65	160	130	100
66-70	175	140	110
71-80	200	160	120
81-90	"	180	135
91-100	"	200	150
101-110	"	"	165
111-120	"	"	180
>120	"	"	200

Liver and pancreas:
- min 150 ml
- Flow: 5 ml/s

Kidney function	
GFR ≥ 30	Standard application
GFR < 30	Periprocedural hydration
	Standard: IV NaCl 100 ml/h, 3-400 ml total
	Alternative: 1.4% sodium bicarbonate in 5% dextrose. 250 ml over 1 h
	After: God hydration e.g. NaCl for 4-6 h

Patients with low muscle mass e.g. the elderly:
Contrast amount can be reduced while maintaining good image quality like for “obese” or less

Contrast administration

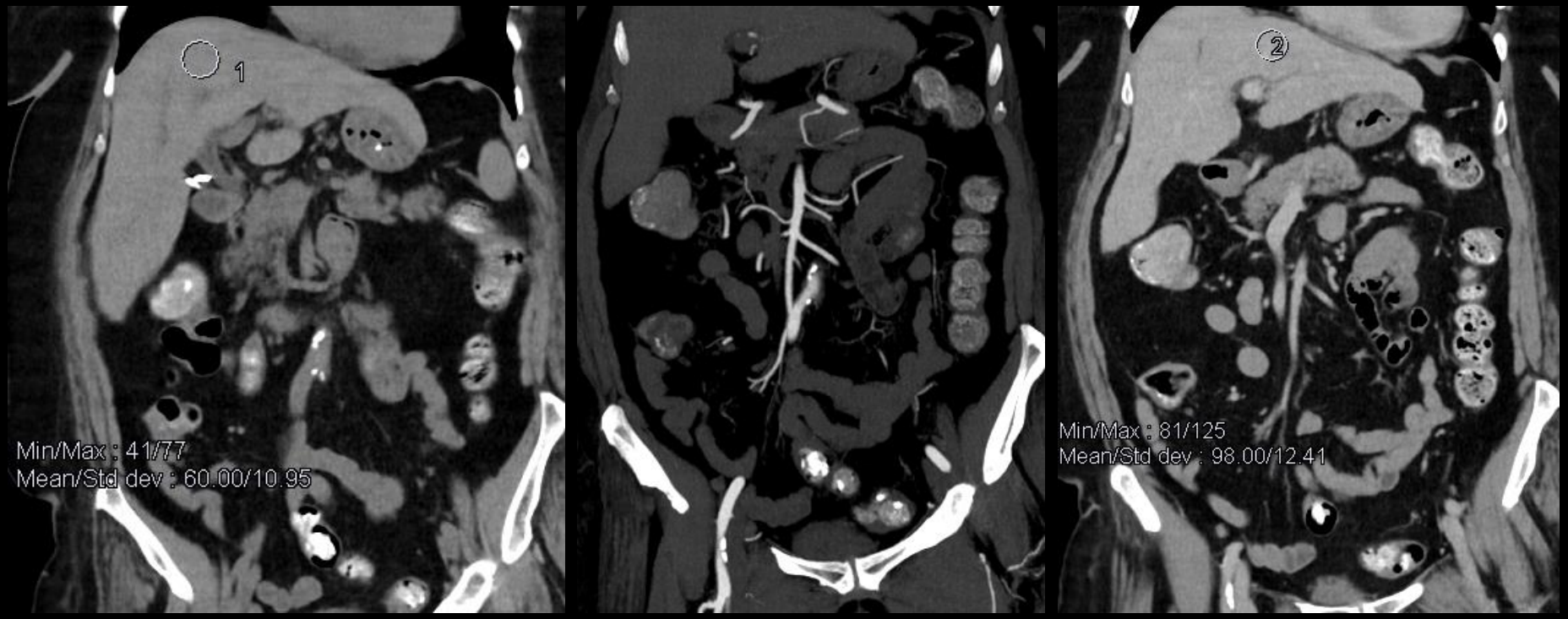
reduced amount – maintained image quality

Clinic:

- 87 years, female
- Severe abdominal pain
- eGFR 21

Referral:

- Intestinal ischemia?
- Mechanic ileus?



Contrast yes/no?

Contrast	Flow
60 ml of 120 ml	4 ml/s

CT without iv contrast

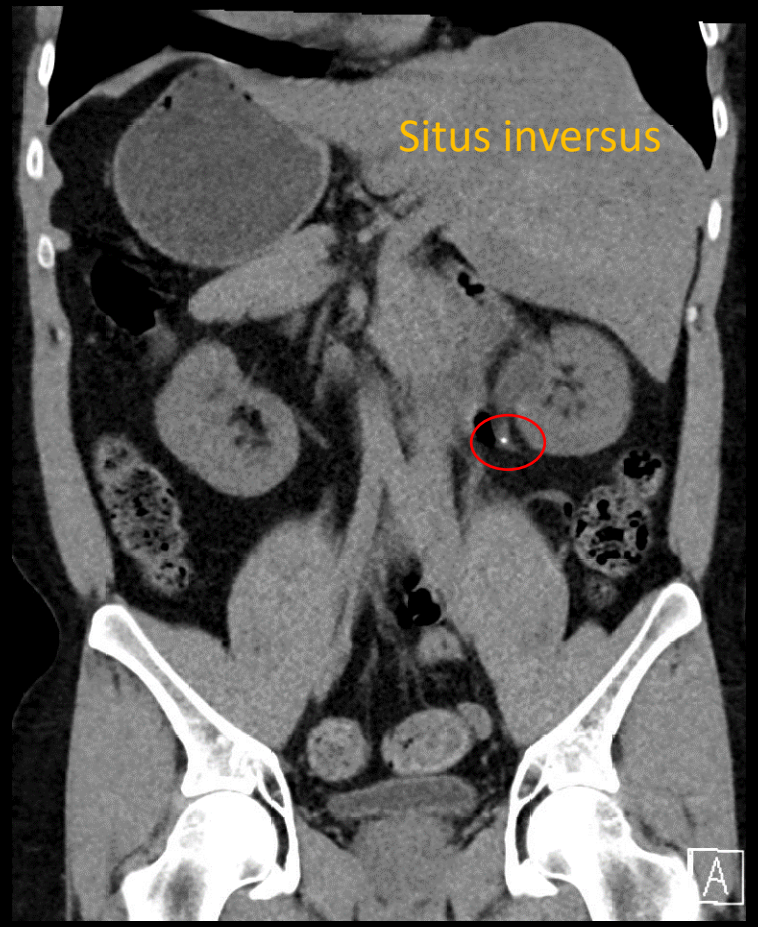
Clinic

- Sudden pain, left side
- Colic like

Low-dose

Renal calculi/stones

Low-dose	Ref. mAs 70, NI 52
Full-dose	Ref. mAs 210, NI 29



DLP 119 mGycm
CTDIvol 2.51 mGy

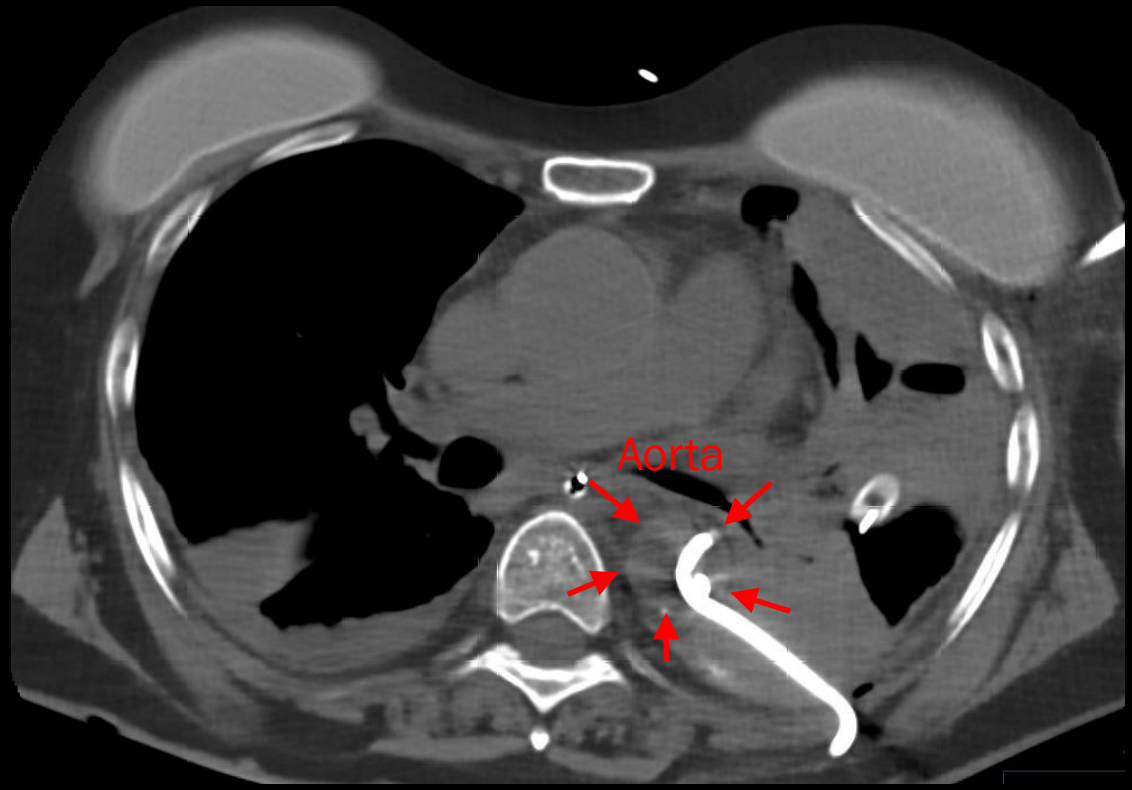
CT without iv contrast

Control after interventional procedure

Unenhanced CT after pleurocentesis

- Difficult procedure at ICU
- Insufficient overview
- Bloody fluids via pigtail catheter.

Low threshold for control CT after procedures!



CT without iv contrast

Control after interventional procedure

Unenhanced CT after pleurocentesis

- Difficult procedure at ICU
- Insufficient overview
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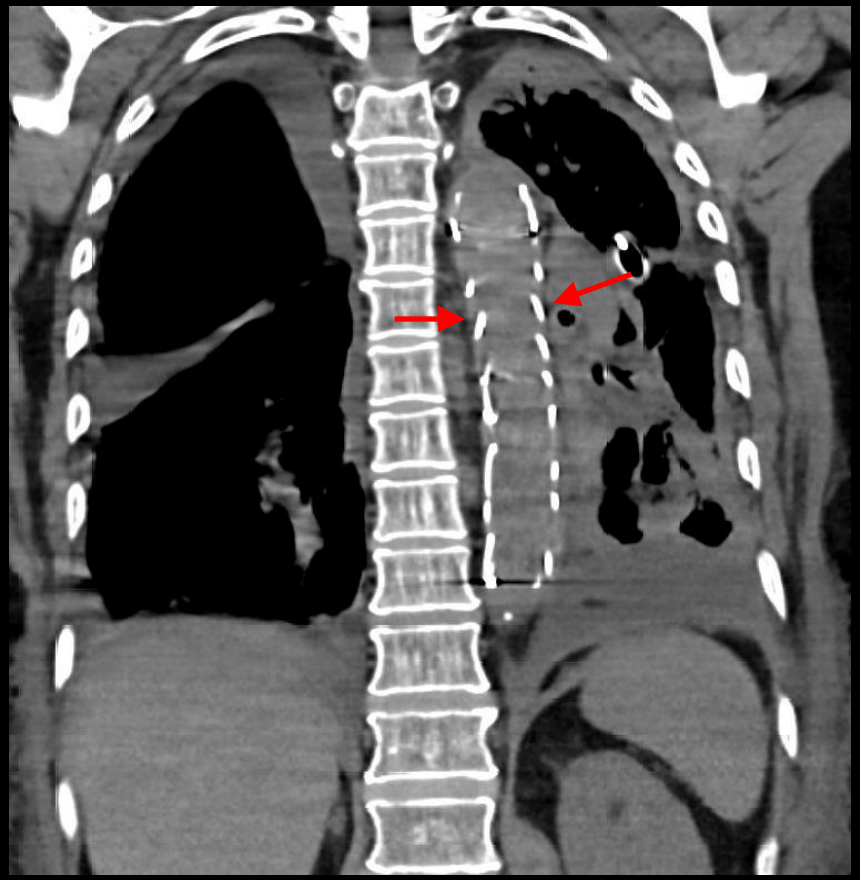
Low threshold for control CT after procedures!

Fast reintervention may be crucial!

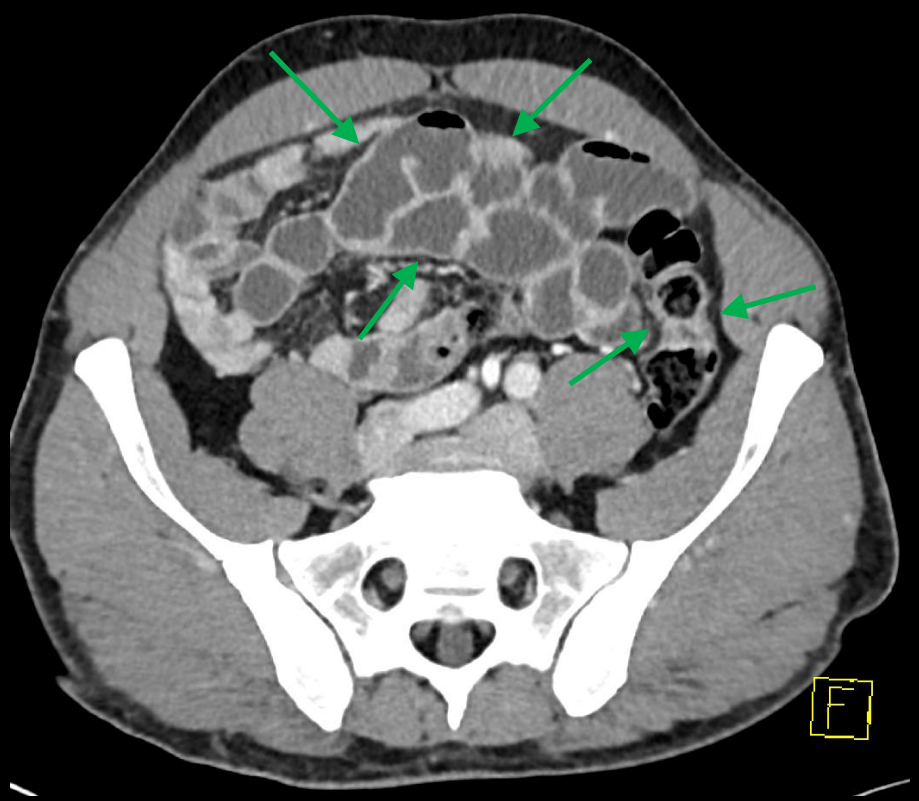


Oral contrast protocols

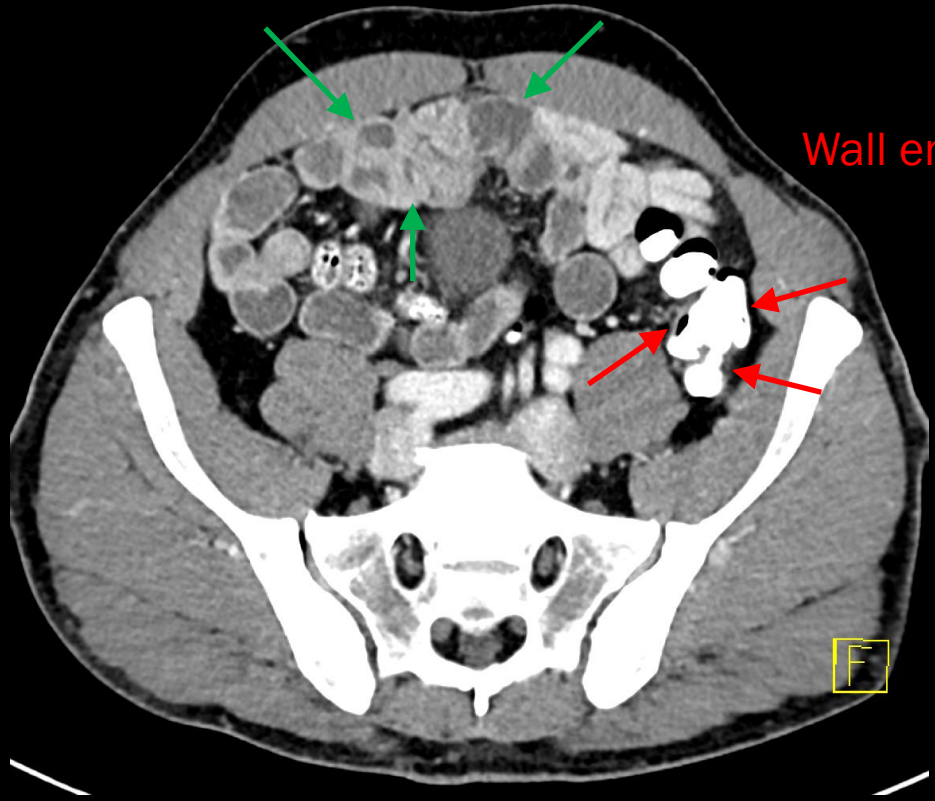
	Acute setting			
	Positive	Neutral	Sorbitol	Laxabon
Concentration	Gastrografin: 370 mgI/ml Omnipaque: 350 mgI/ml	Water (sterile)	Sorbitol 70%	
Solution	1 l water + 30 ml Gast. / 40 ml Omni.	0.75-1.0 l	50 ml Sorb. + 1 l water	2 packages in 2 l water (37°)
Application	Upper abd: 30-40 min before CT Lower abd: 1-2 h before CT	20-40 min 1 h	45 min	1.5-2.0 l Via tube! 50 ml syringe

Oral contrast

Neutral (e.g. water)



Positive (iodine containing)



CT portal venous -oral contrast

Acute small bowel obstruction

Oral contrast in case of suspected small bowel obstruction may not be necessary.

Positive oral contrast may

- delay diagnosis
- increase patient discomfort
- increase the risk of complications, particularly vomiting and aspiration

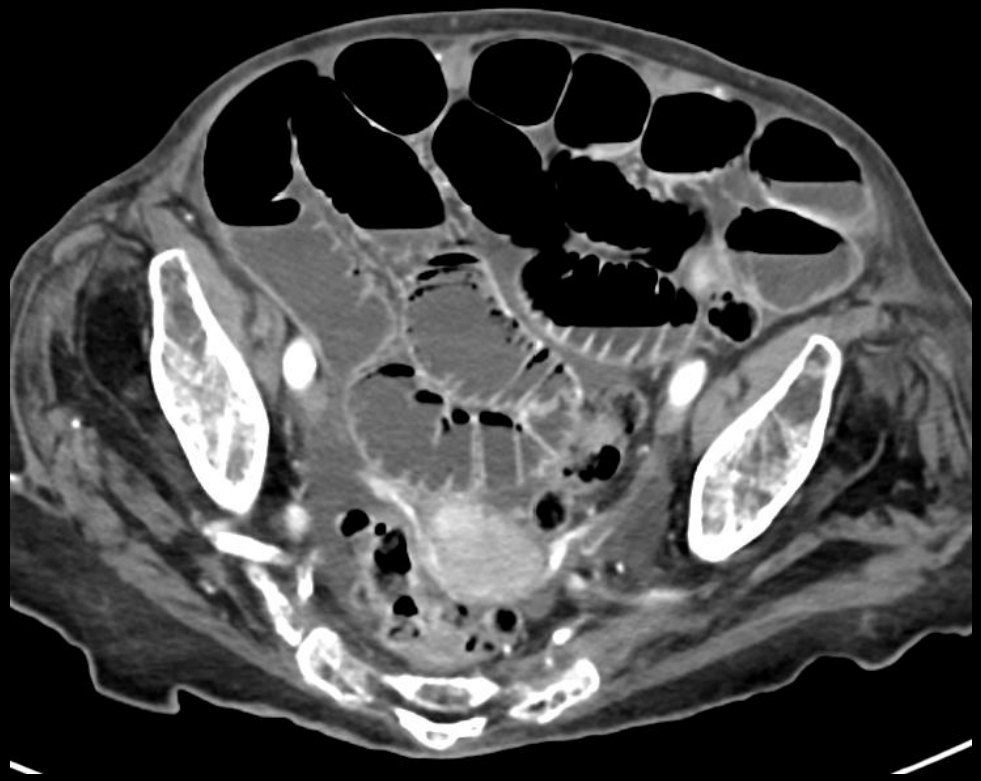
ACR Appropriateness Criteria®

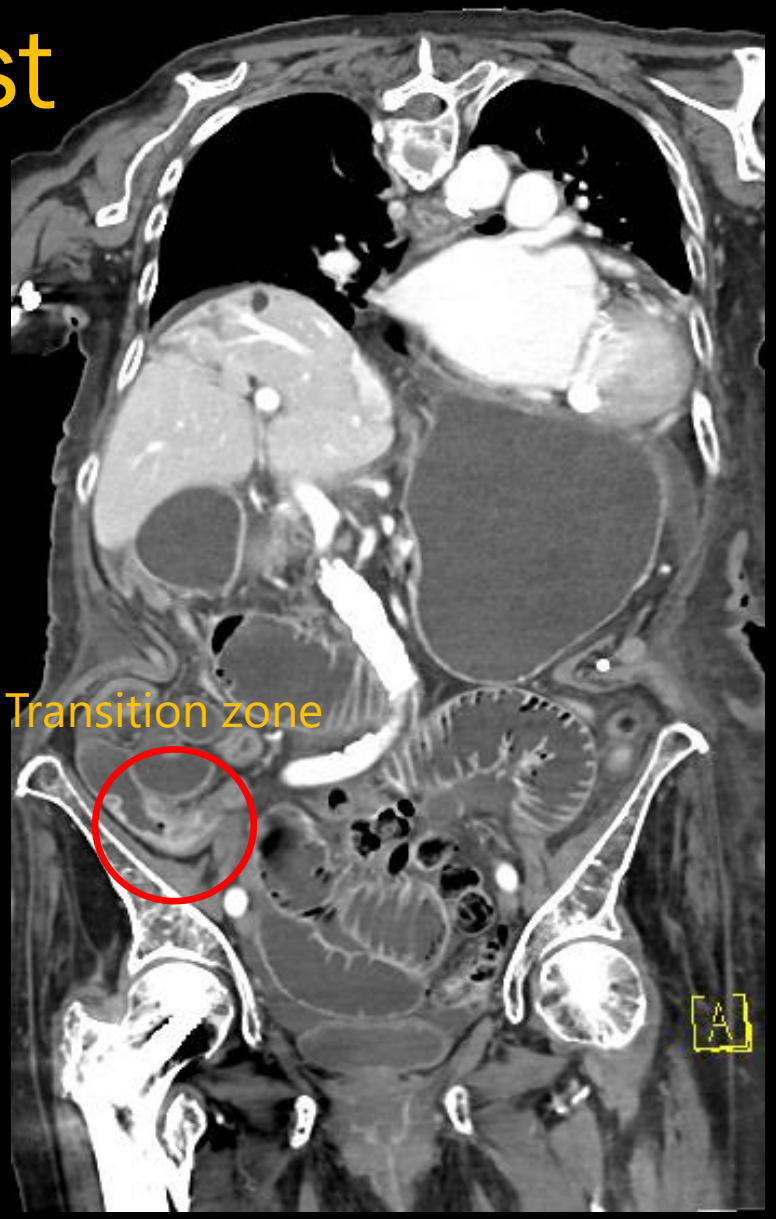
DOI 10.1007/978-3-319-98343-1_49

Stomach already filled with fluids!

CT portal venous -oral contrast

Acute small bowel obstruction





CT passage
subileus/low-grade obstruction

Control after positive oral contrast

- Omnipaque may remain more hyperattenuating e.g. during follow-up of incomplete bowel obstruction
- Prognostic value - non-resolving after 24h indicates need for surgery
- Low-dose follow-up CTs
  - NI 52 / ref. mAs 100
  - 1st follow-up ≥ 4h
  - Doubling of interval for subsequent scans

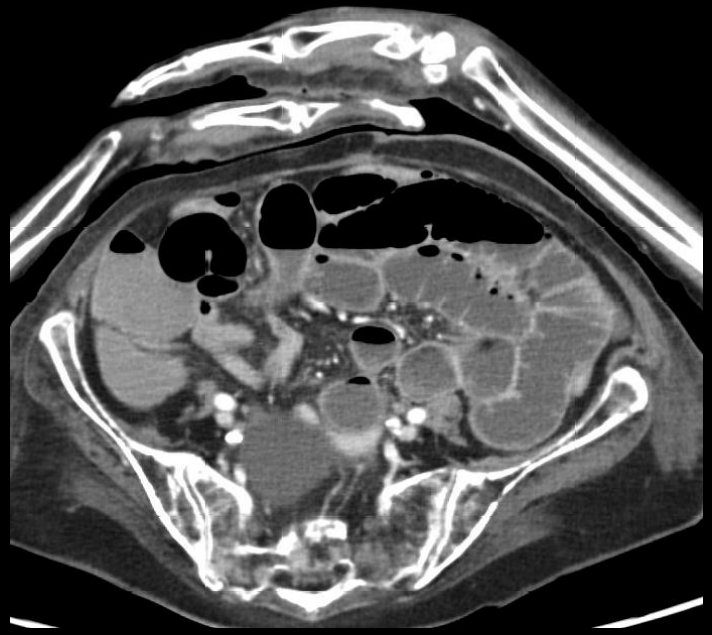
Baseline scan, iv + full dose

Almafreji et al. 2020 doi: 10.7759/cureus.9695
Stordahl et al. 1987 Acta radiologica 1988;29(1):53-56

CT passage

subileus/low-grade obstru

Control after positive oral contrast



Baseline scan, iv, no po contrast, full dose

≈8h later, no passage to colon

≈16h later, passage

Rectal contrast

Protocol

Gastrografin	15 ml / 370 mgI/ml in 500 ml water
Omnipaque	30 ml / 350 mgI/ml in 500 ml water
Amount	250-500 ml or as desired
Application	e.g. via rectal tube

Low-dose
image quality

Clinical information:

- 21 years, female
- Long history with abdominal pain
- Neg. colonoscopy 10 month ago
- Now again acute abdominal pain

Referral:

- Appendicitis?
- Other?

Low-dose protocol - 20% dose

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy*cm)	Phantom cm
Scout					
1	Scout	S0–I555	0.02	0.97	Body 32
1	Scout	S0–I555	0.08	4.71	Body 32
Abd pe					
2	Helical	I19.166–I475.416	2.66	139.15	Body 32
			Total Exam DLP:	144.83	

1/1

Low-dose image quality

TF high 20% of full-dose

TF high 10% of full-dose

Diagnosis: Terminal ileitis

Esophagus
rupture & anastomotic leaks

Protocol - basics

Range:

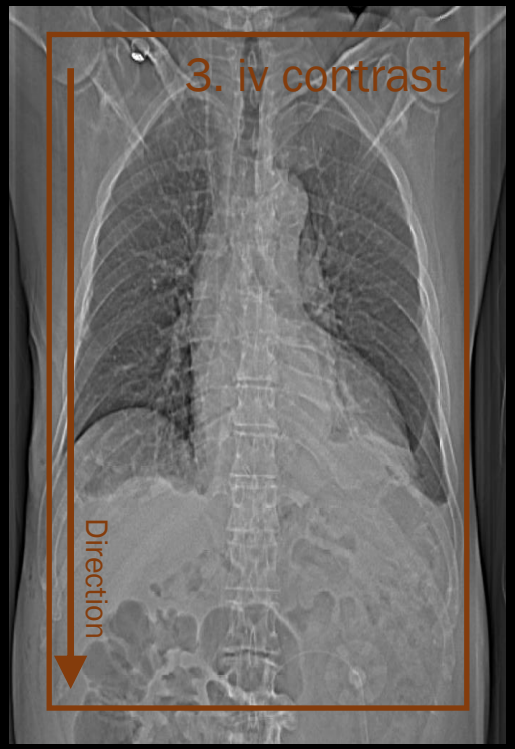
- Stomach to Temporomandibular joint

Scans (supine):

1. Native
2. po contrast
   - Swallow
   - Tube
3. Iv contrast (optional)
   - Portal venous 85s delay
   - Flow 4 ml/s

Ref. mAs 180, NI 29

Ref. mAs 180, NI 29



Ref. mAs 210, NI 29

Esophagus
rupture & anastomotic leaks

Protocol – po contrast

In agreement with radiologist

250 ml water + 25 ml Omnipaque 350 mgl/ml

May use sterile water or NaCl

Swallow:

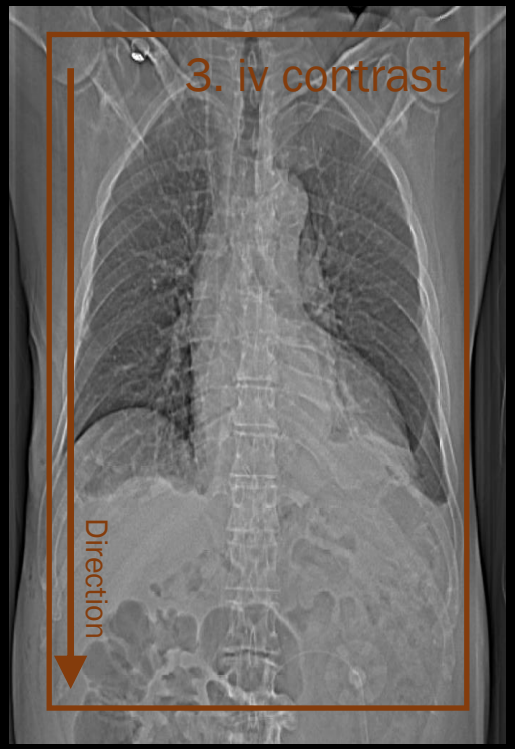
- Scan starts at last swallow

Tube:

- Side wholes?
- May be necessary to retract the tube up above leakage while administering contrast

Ref. mAs 180, NI 29

Ref. mAs 180, NI 29



Ref. mAs 210, NI 29

Esophagus
rupture & anastomotic leaks

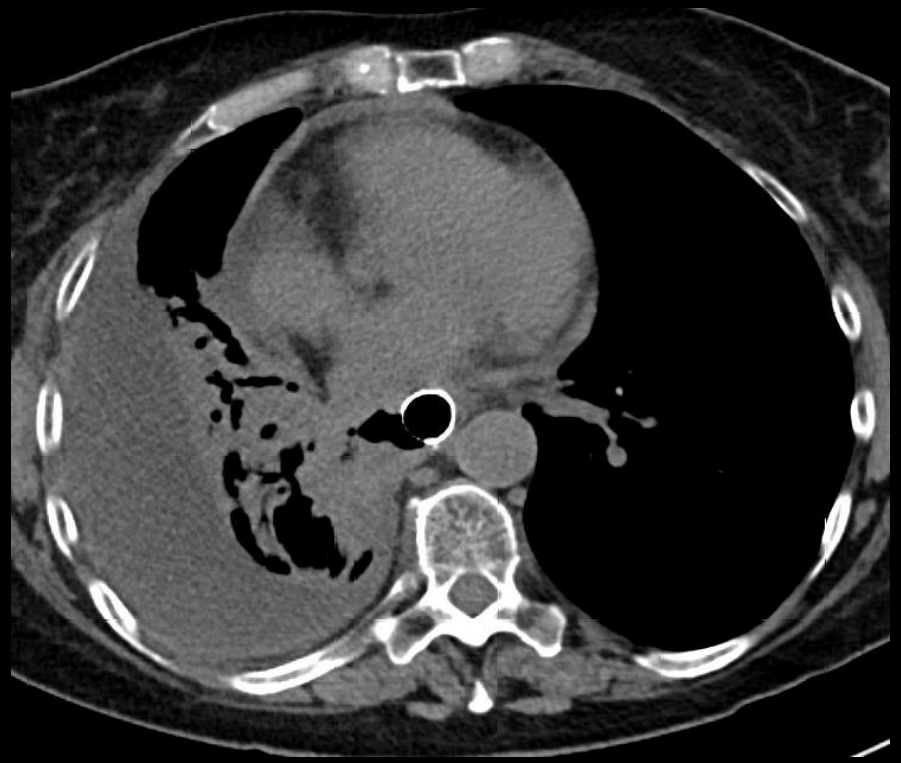
Post-op control

- 59 years, female
- Cancer pulm
- Radiation induced esophagitis with rupture

Post-op control:

- Converting from sponge to stent

Native, unenhanced



Esophagus
rupture & anastomotic leaks

Post-op control

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Post-op control:

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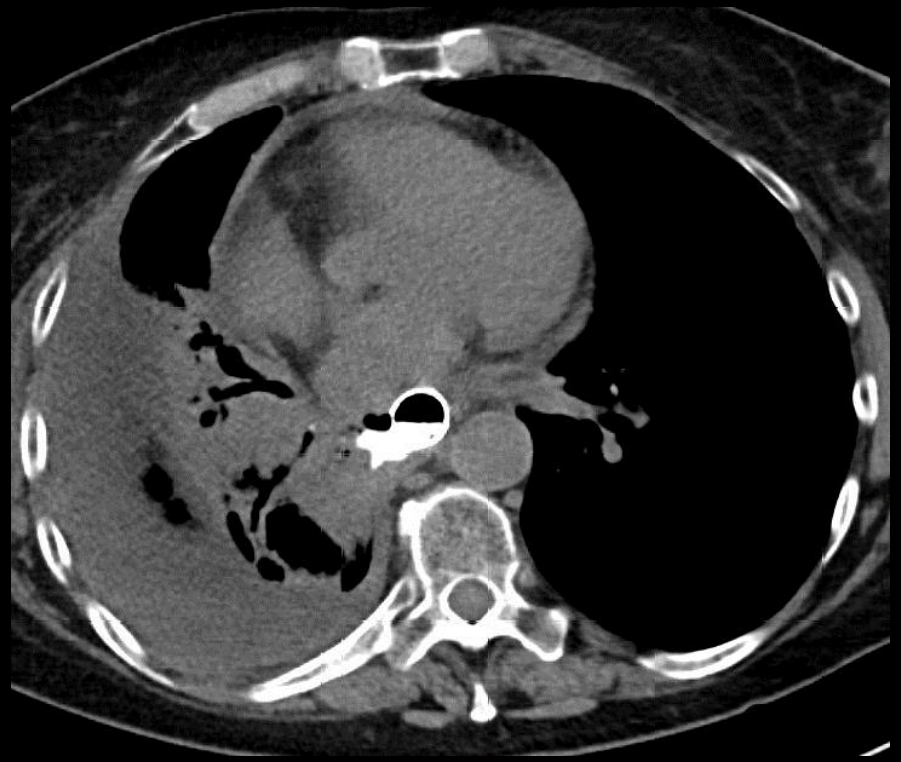
po contrast, swallow



Esophagus
rupture & anastomotic leaks

Post-op control

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- Cancer pulm
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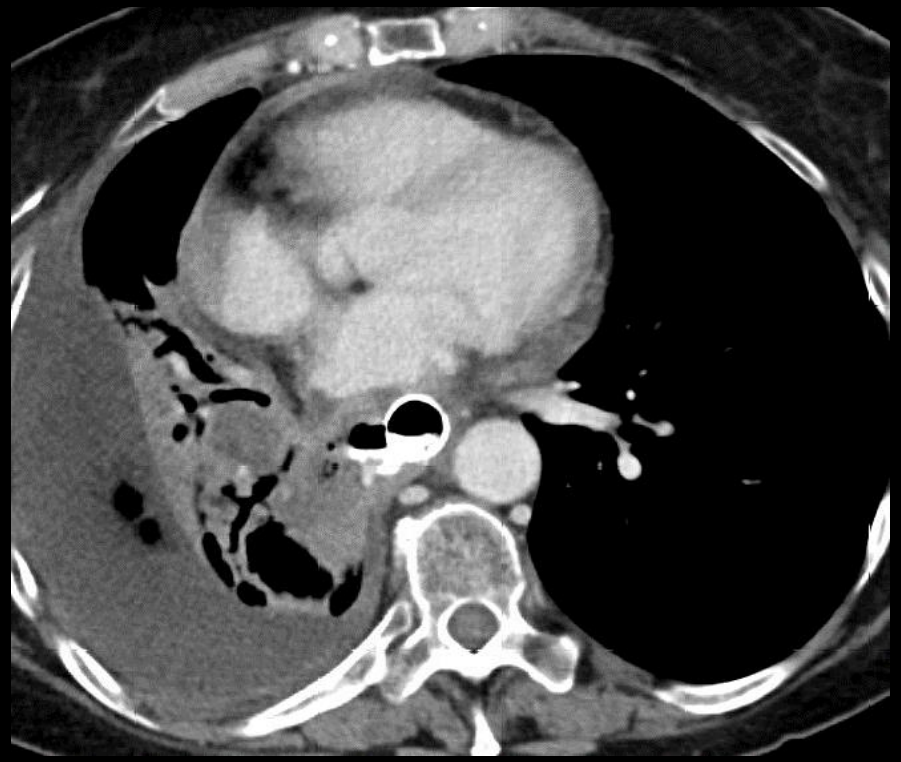
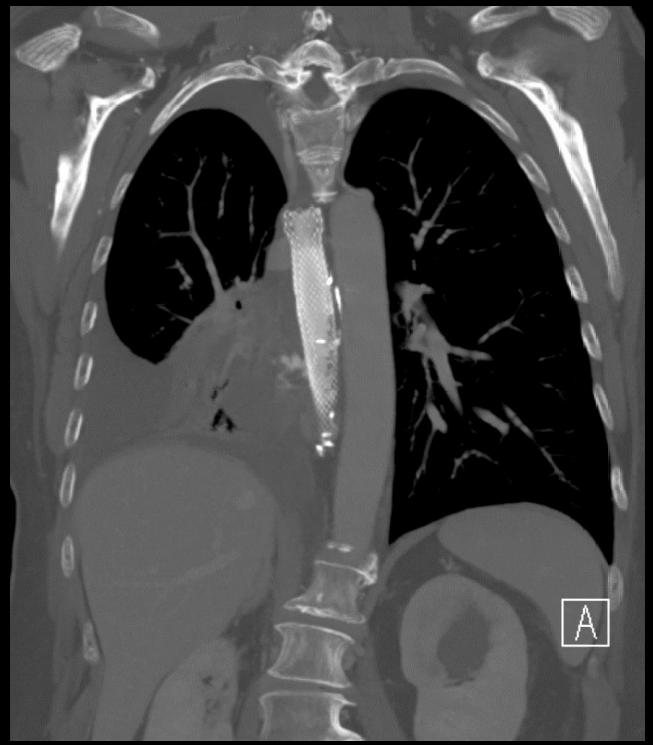
Post-op control:

- Converting from sponge to stent

Diagnosis

po contrast & iv contrast





Esophagus
rupture & anastomotic leaks

Post-op control

- 59 years, female
- Cancer pulm
- Radiation induced esophagitis with rupture

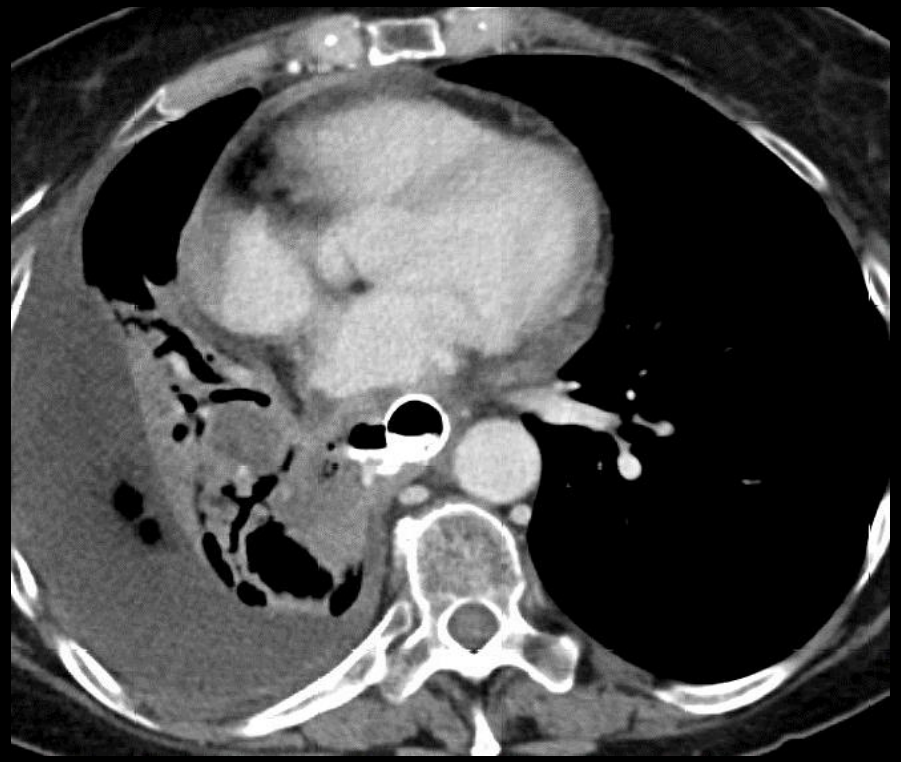
Post-op control:

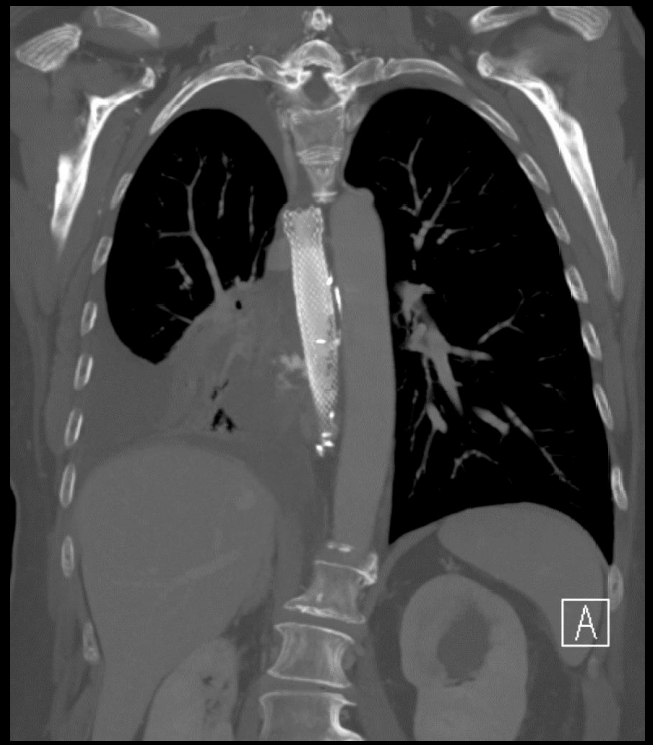
- Converting from sponge to stent

Diagnosis

- Defect covered by stent however still leakage

po contrast & iv contrast





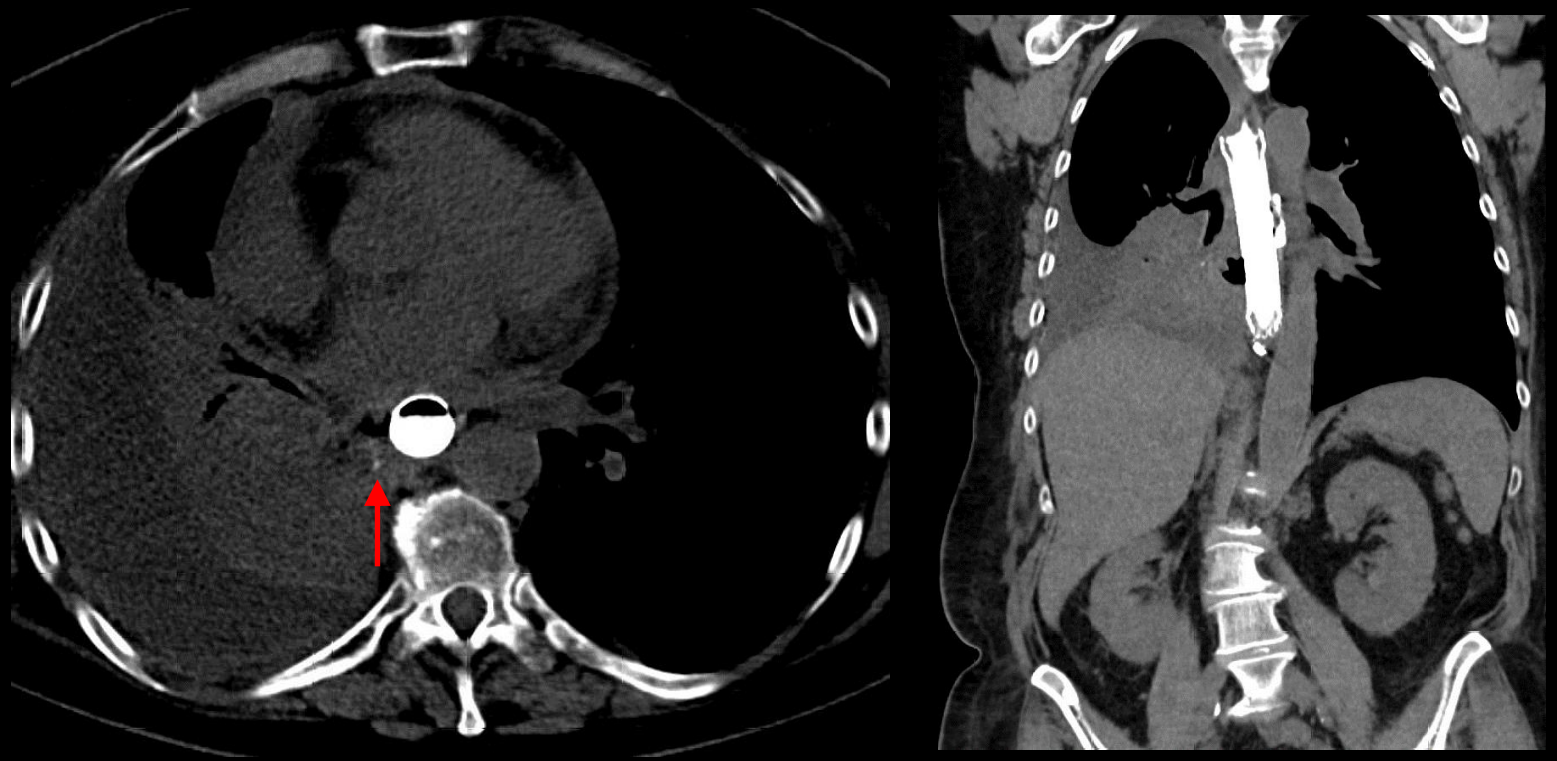
Esophagus
rupture & anastomotic leaks

Post-op control

5 days later:

- Significant improvement
- Just barely visible contrast leakage
- Iv contrast often not necessary on follow-up

5 days later po contrast, iv contrast not necessary



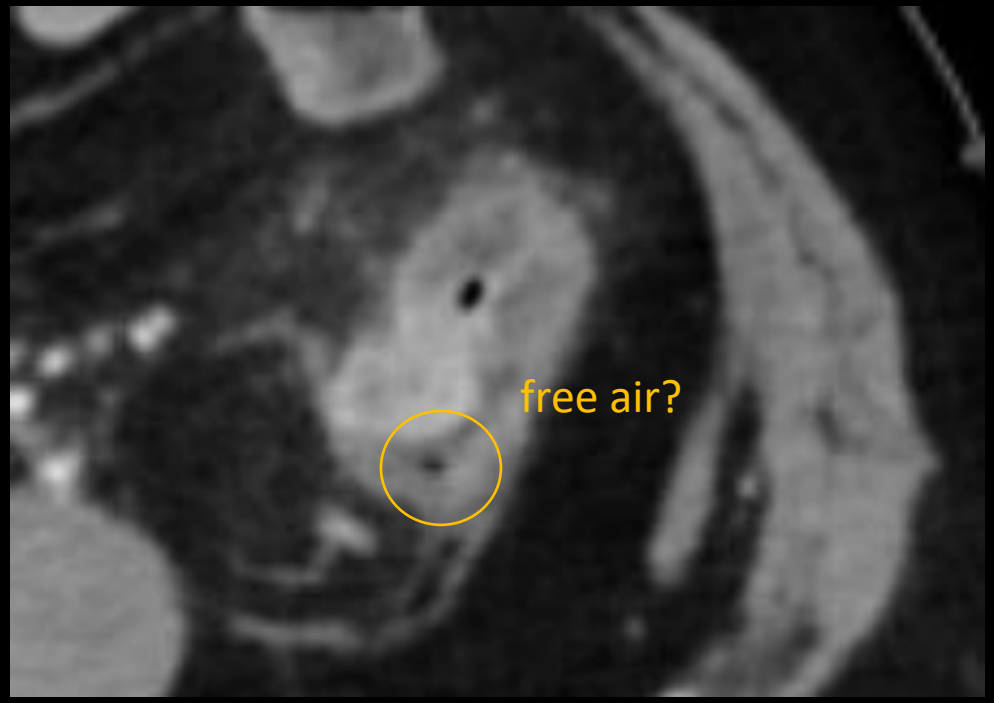
Slice thickness
does it matter?

2.5 mm

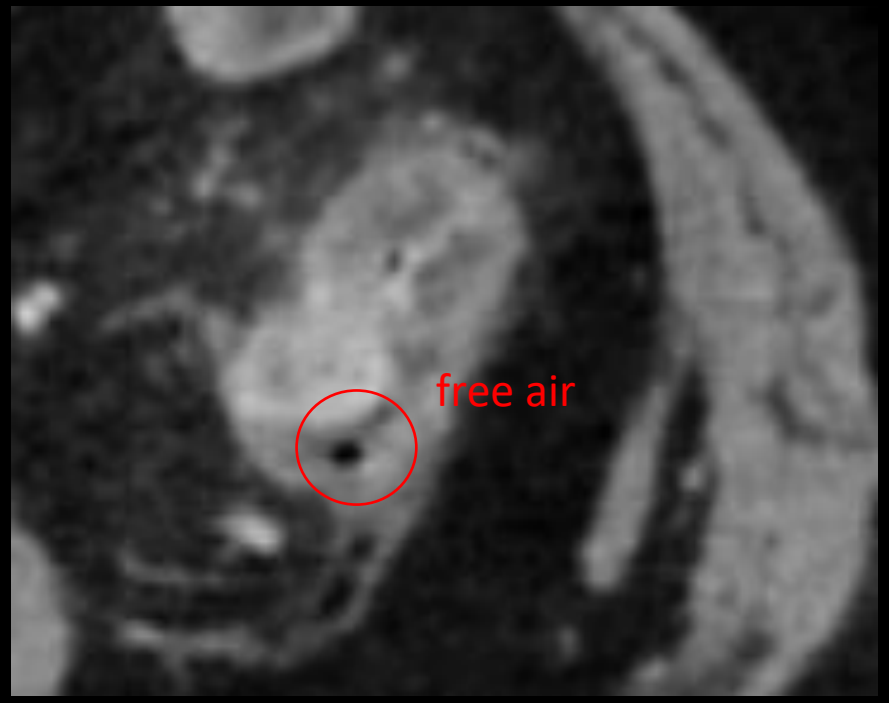
0.625 mm

Slice thickness
does it matter?

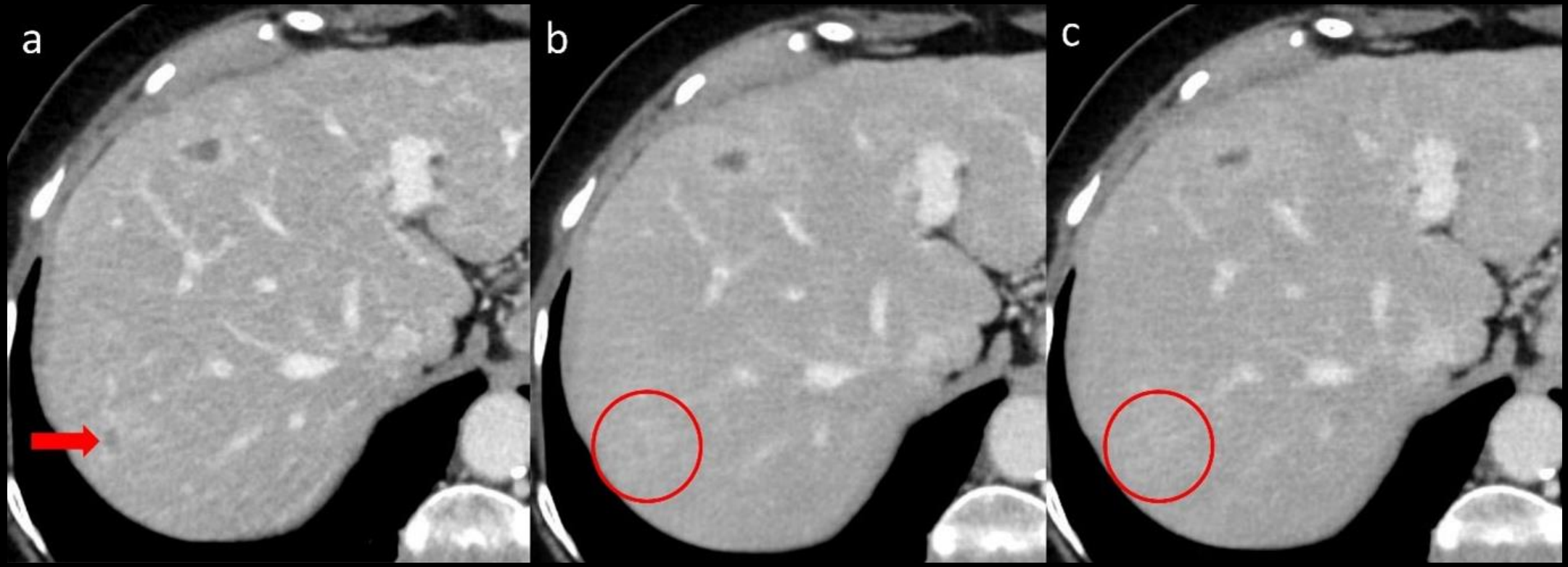
2.5 mm



0.625 mm



Limitations of low-dose
does it matter?



Full dose | 60% dose | 40% dose

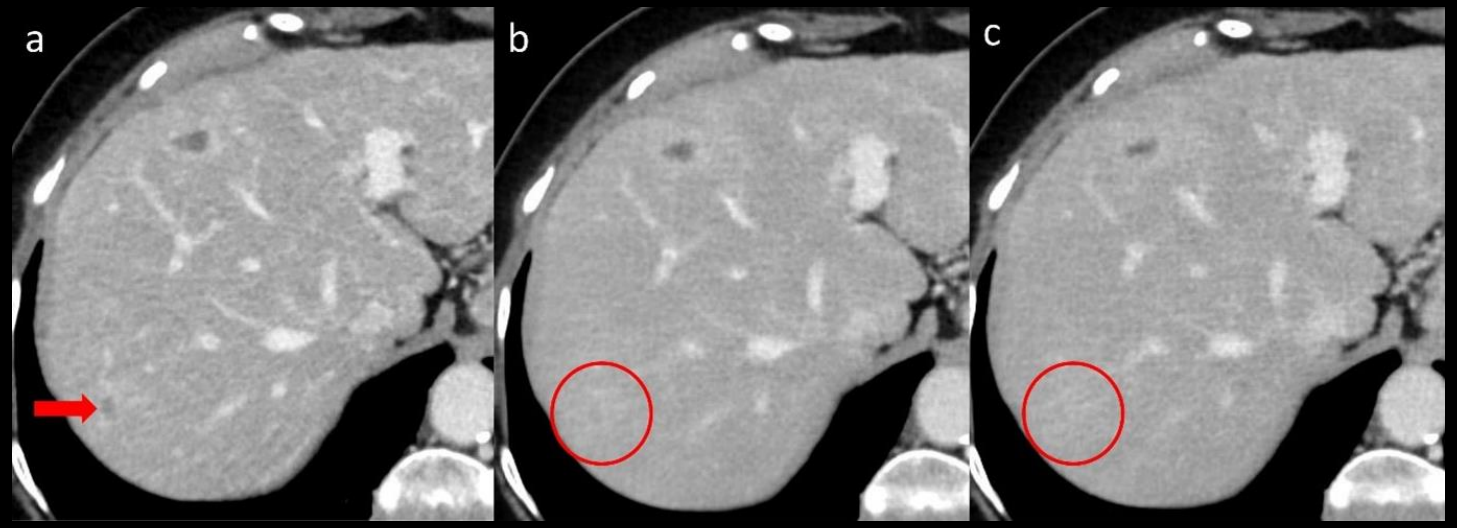
Limitations of low-dose
does it matter?

Limits of dose reductions

The same applies for:

- Contrast amount
- Flow

Similar impact on conspicuity



Full dose 60% dose 40% dose

Conclusion

Appropriate in most acute cases: CT of the abdomen & pelvis with iv contrast

- iv contrast 1.5-2.0 ml/kg
- No po contrast
- Indications po contrast
  - Incomplete ileus - passage
  - Leaks
  - (Collections e.g. abscess)
- Native (no iv contrast)
  - Alternative if iv contraindicated
  - Calculi and foreign bodies (low dose)
  - Passage (low dose)
  - May be sufficient as control after interventional procedures

Thank You!