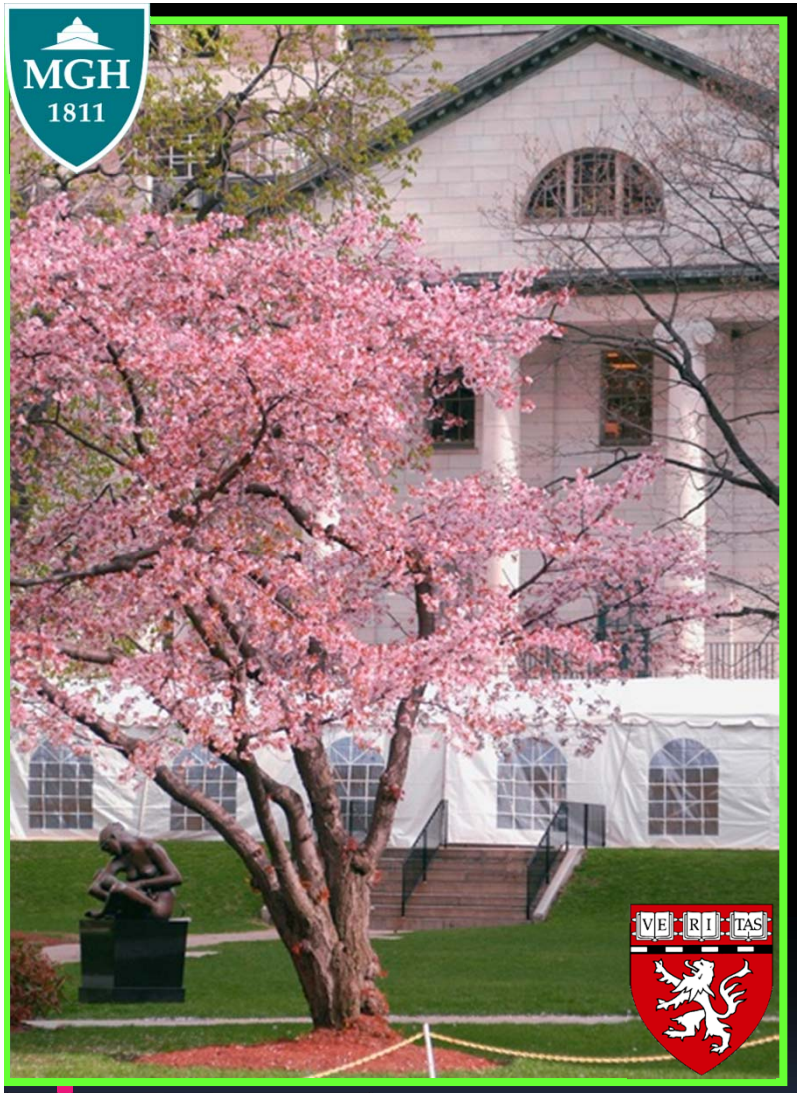

2nd AAPM Summit on CT Dose:
October 2011

BODY CT: WHAT IS A GOOD CT EXAM?

Mannudeep K. Kalra, MD

Webster Center for Advanced Research and Education in Radiation

Massachusetts General Hospital and Harvard Medical School

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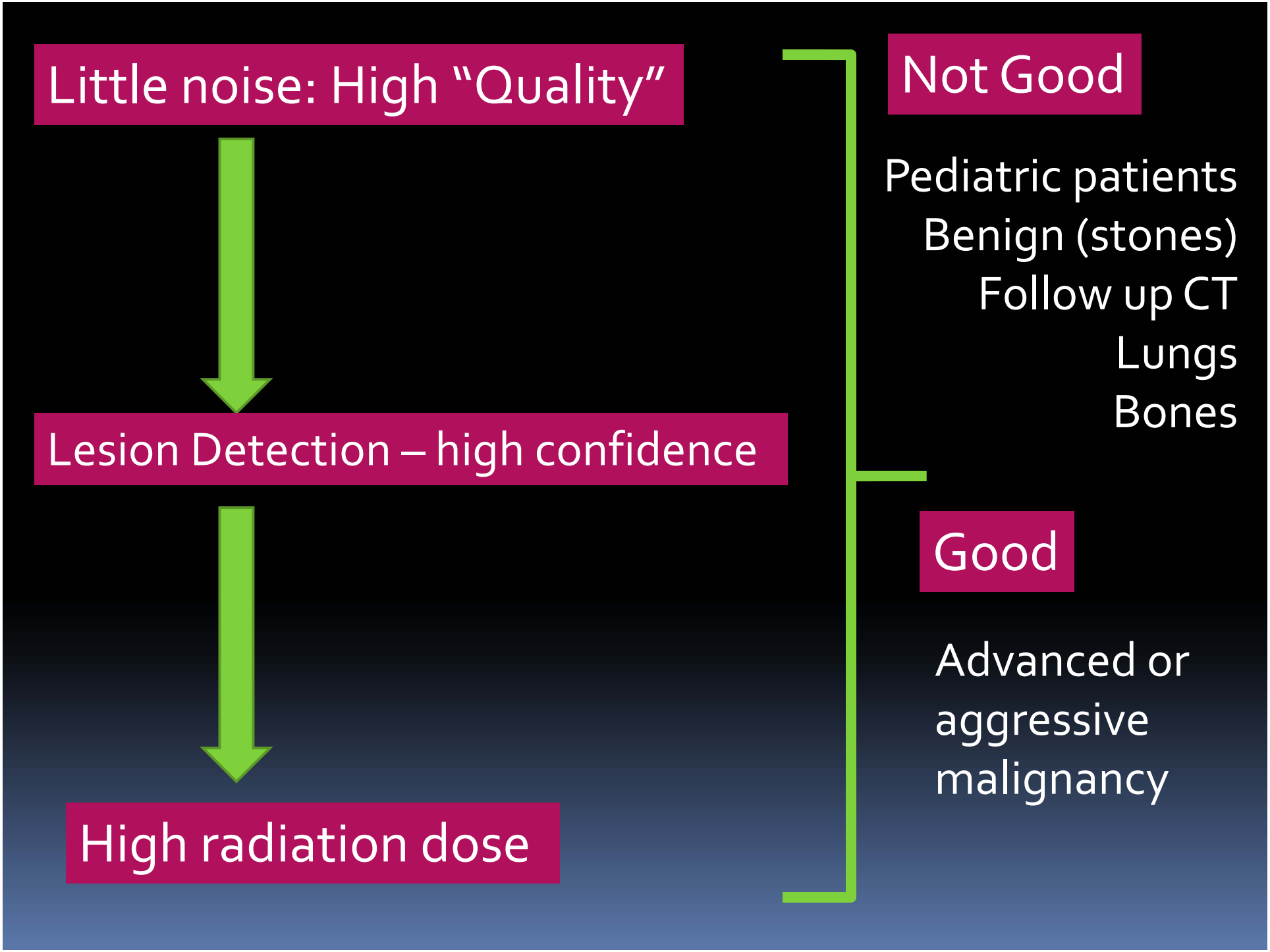
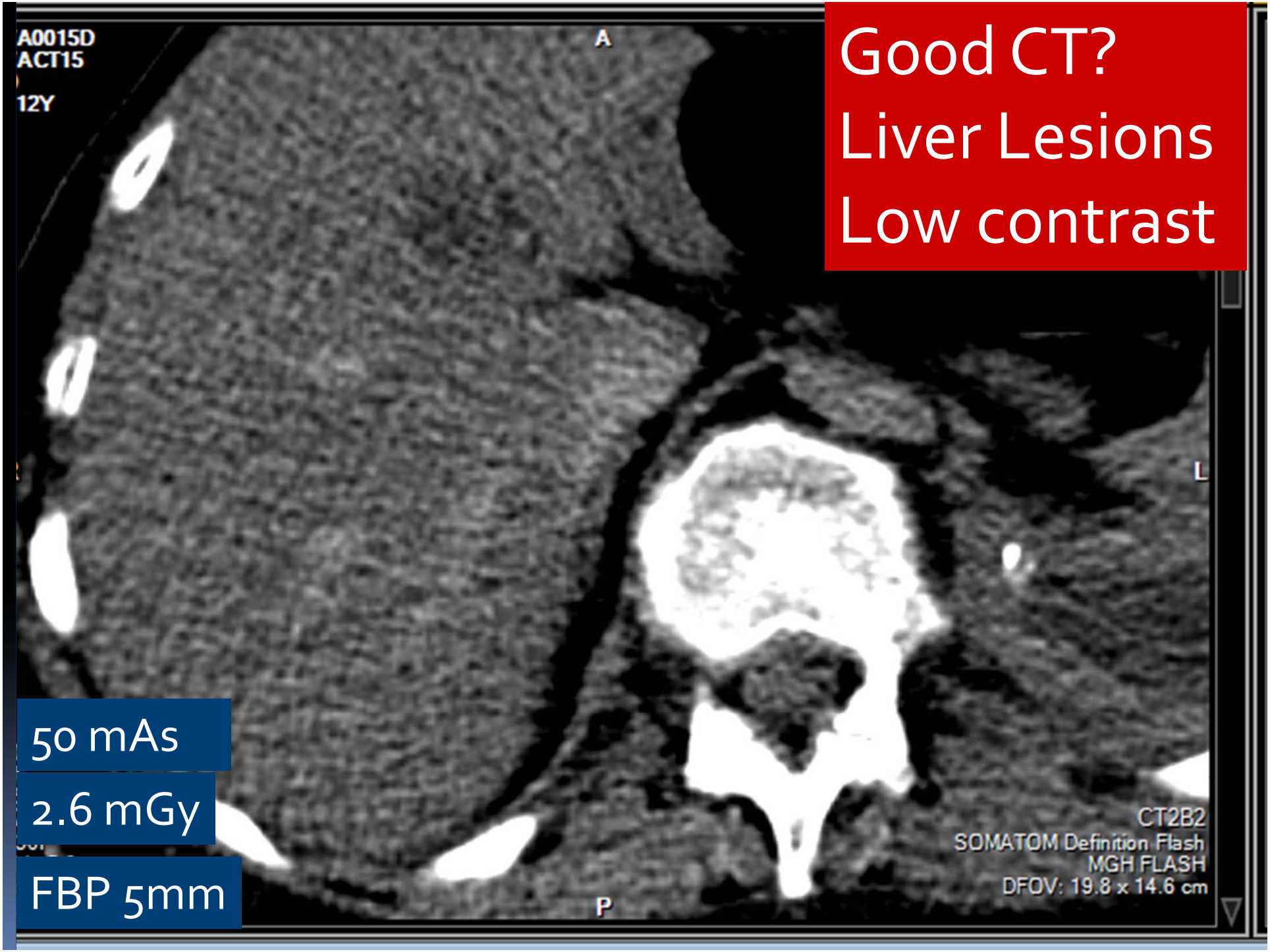
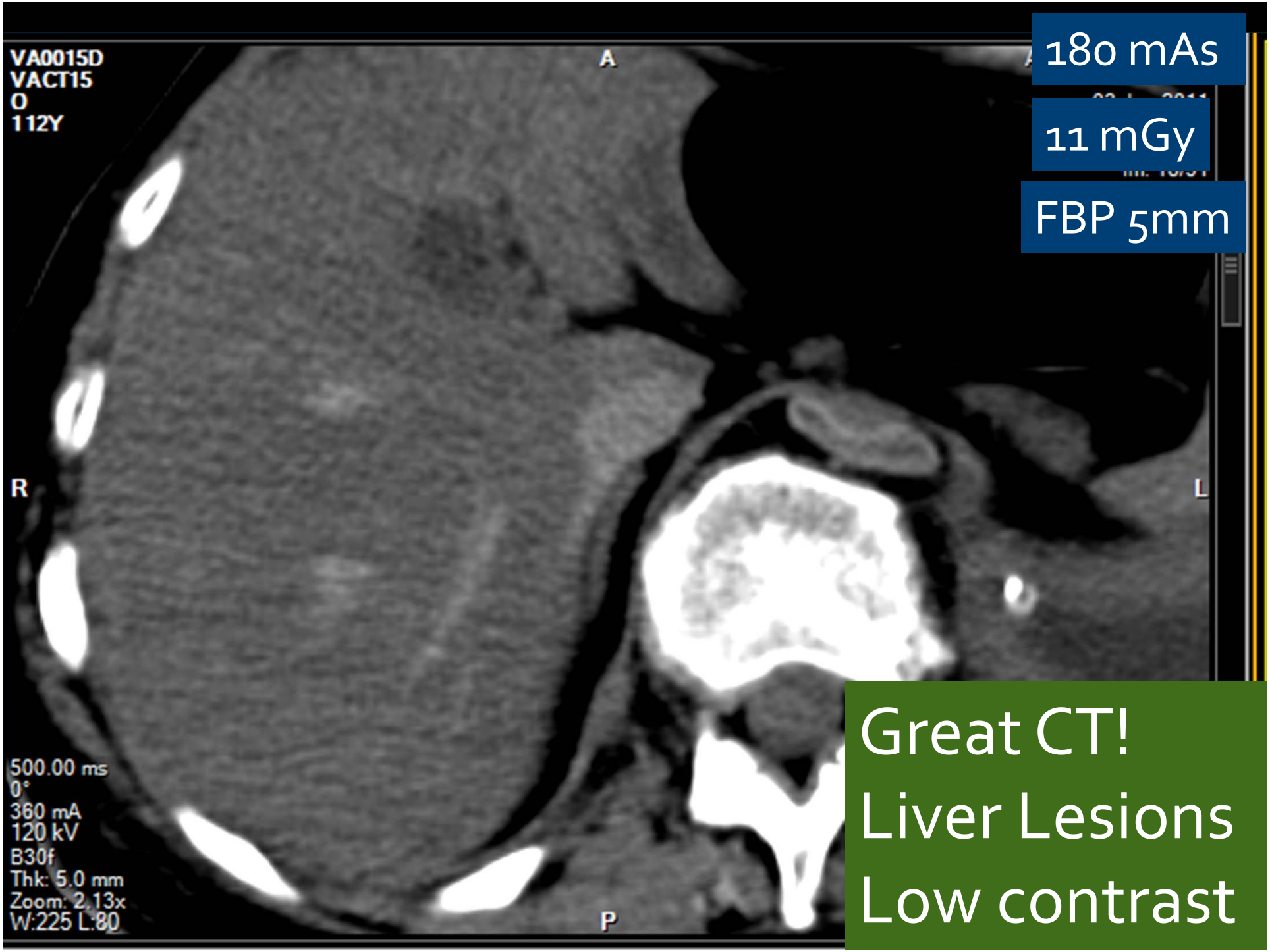
Body CT: What is a good CT exam?

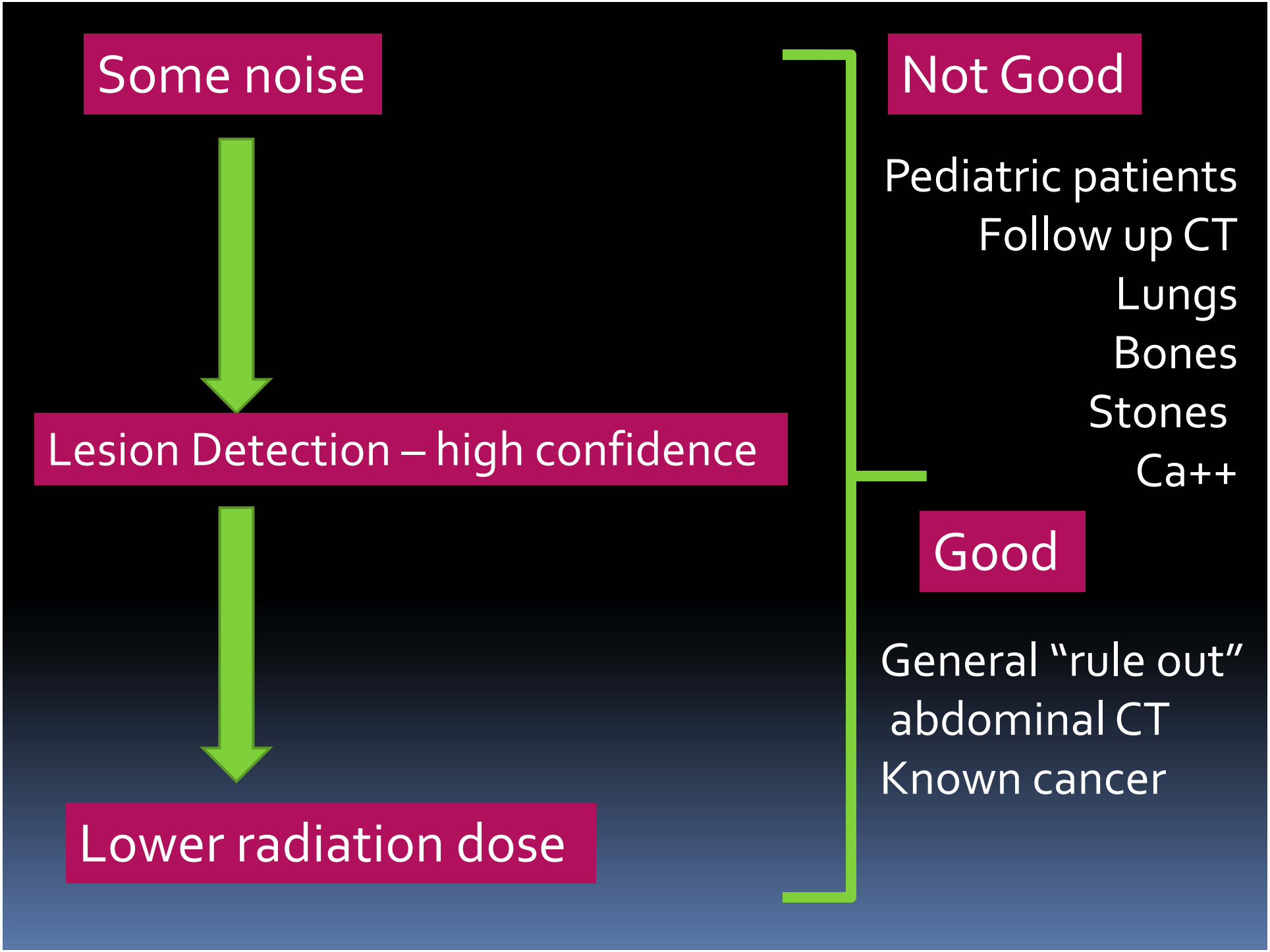
- Is not the lowest dose CT the best CT exam?
- Can I really see everything on lowest dose CT ?

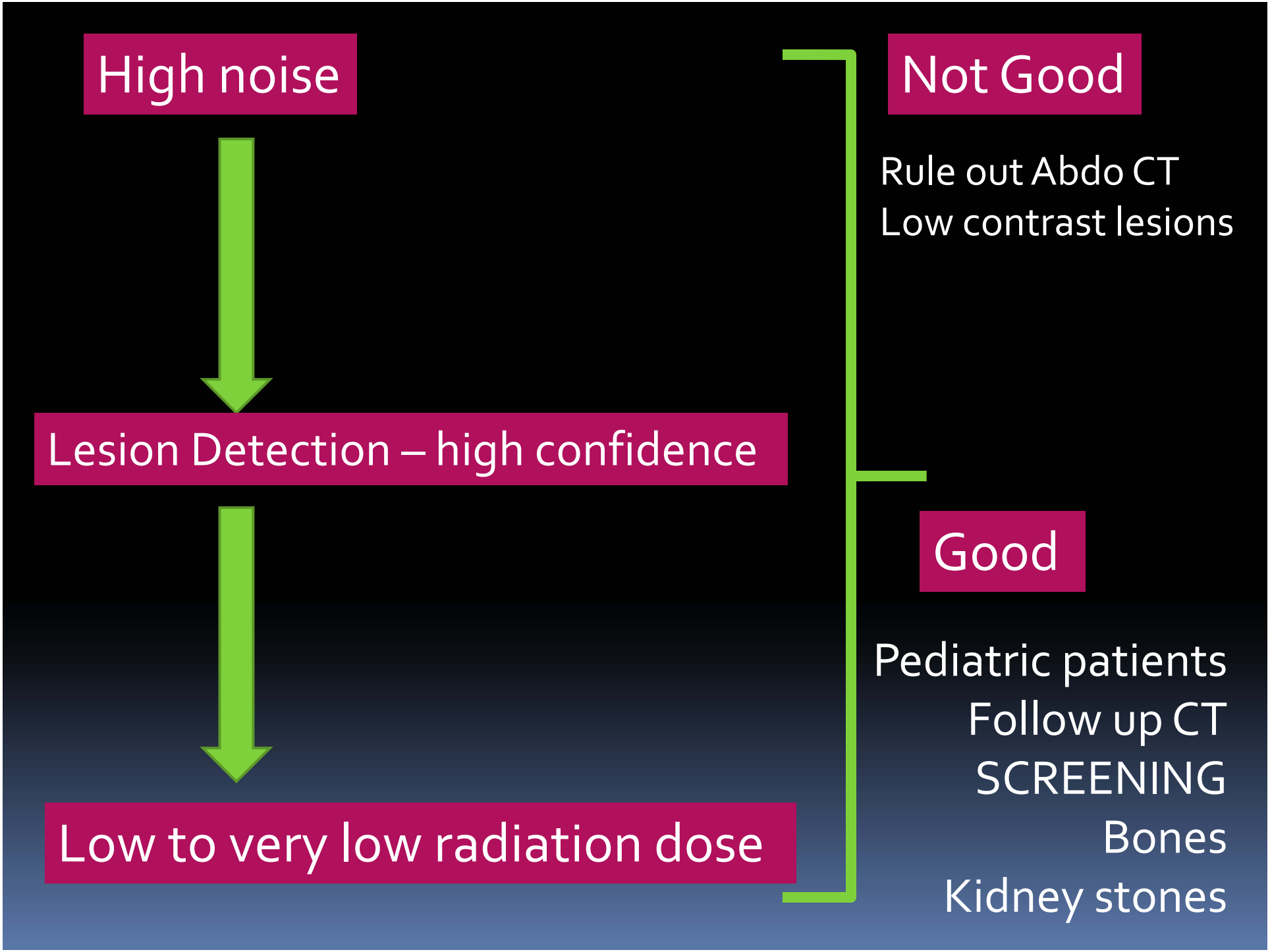
- I can see many things on many low dose CT exams
  - Good exams
- But I can not see somethings on some low dose CT
  - Bad exams
- Not all low dose CT are good CT exams!? Damn!
  - Some times they are good! Some times they are bad!

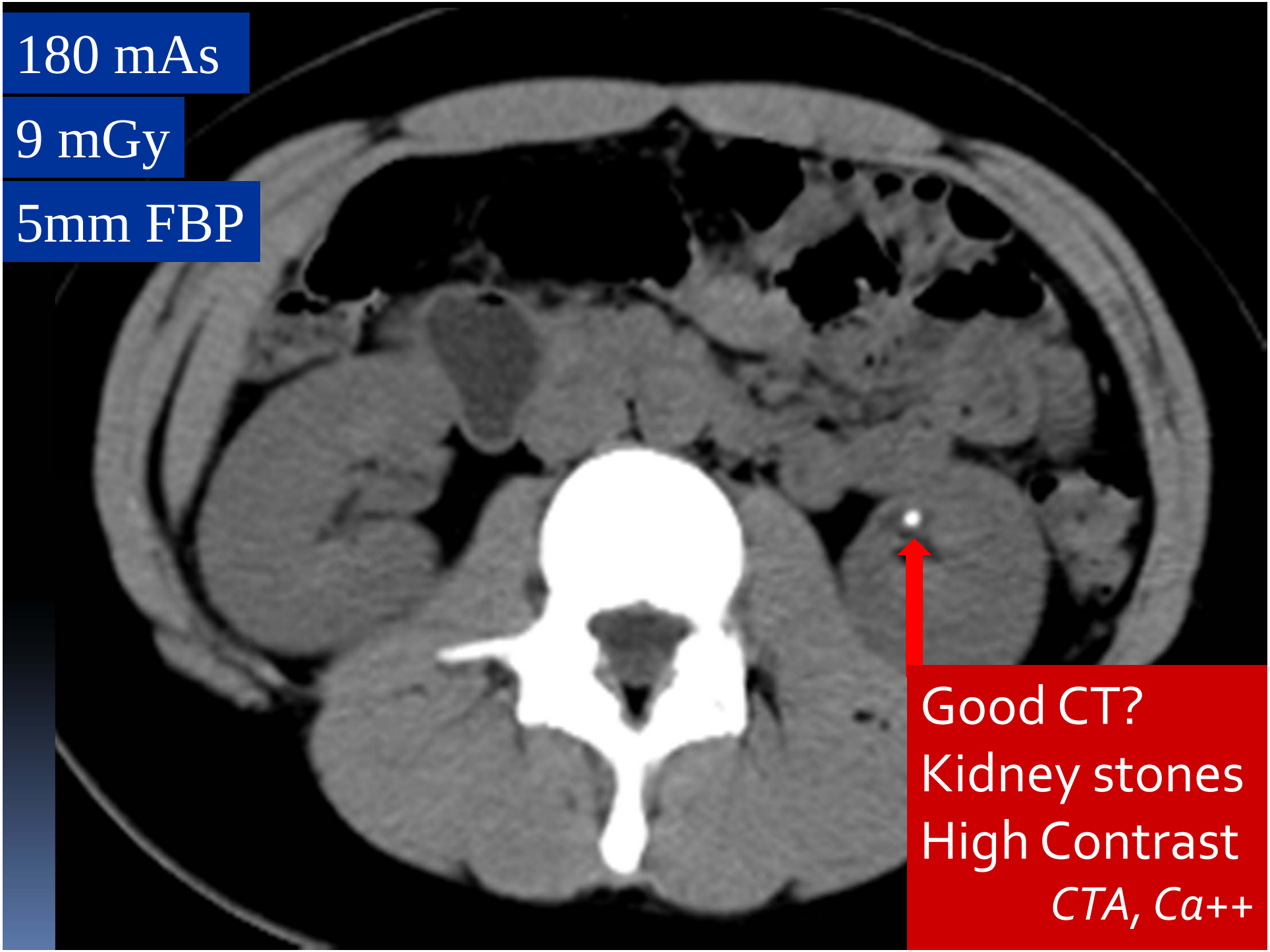

Little noise: High "Quality"
Lesion Detection – high confidence
High radiation dose
Not Good
Pediatric patients
Benign (stones)
Follow up CT
Lungs
Bones
Good
Advanced or aggressive malignancy

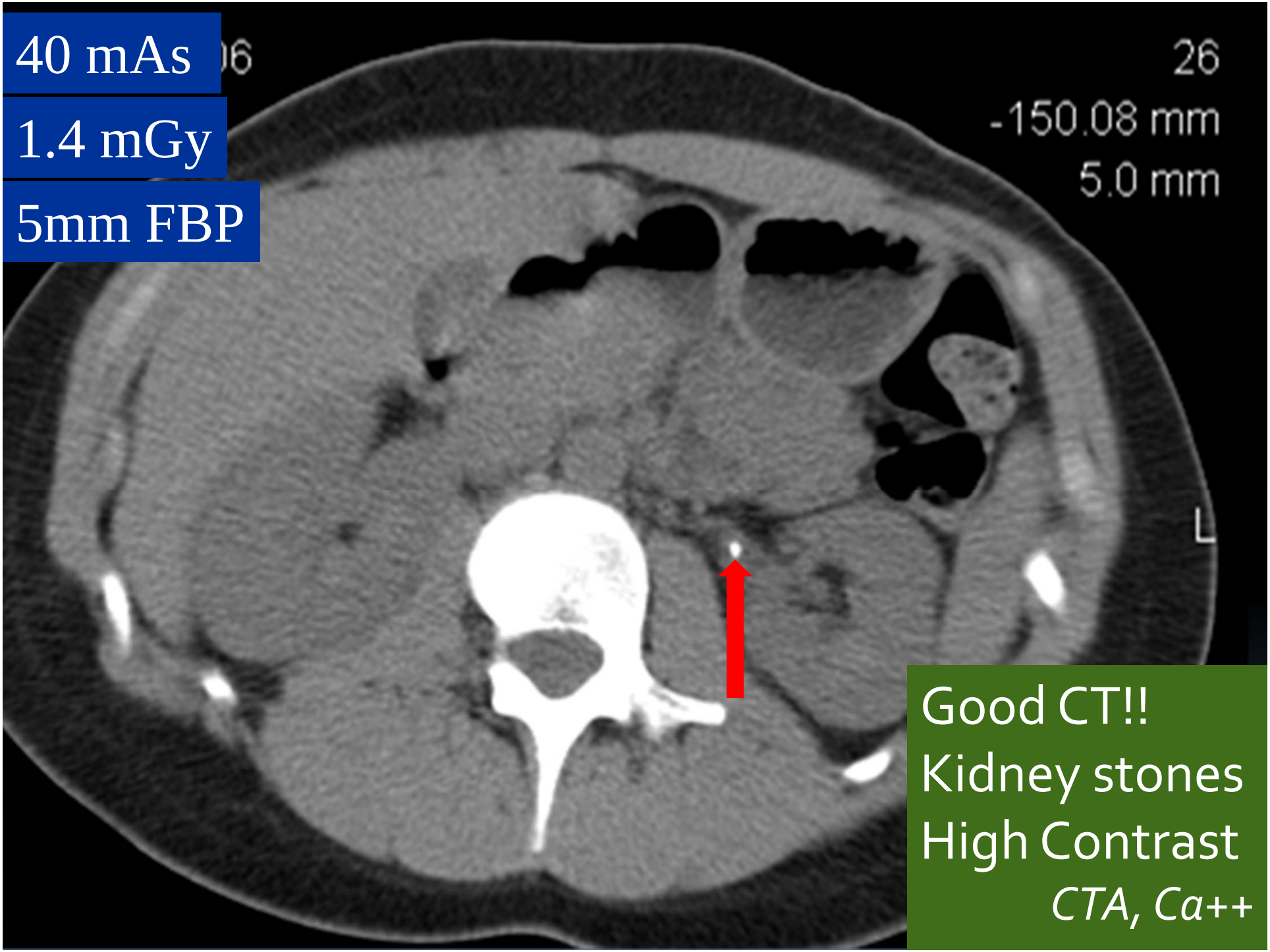

A0015D
ACT15
12Y
A
L
P
CT2B2
SOMATOM Definition Flash
MGH FLASH
DFOV: 19.8 x 14.6 cm
Good CT?
Liver Lesions
Low contrast
50 mAs
2.6 mGy
FBP 5mm


VA0015D
VACT15
O
112Y
A
R
L
P
500.00 ms
0°
360 mA
120 kV
B30f
Thk: 5.0 mm
Zoom: 2.13x
W:225 L:80
180 mAs
11 mGy
FBP 5mm
Great CT!
Liver Lesions
Low contrast


Some noise
Lesion Detection – high confidence
Lower radiation dose
Not Good
Pediatric patients
Follow up CT
Lungs
Bones
Stones
Ca++
Good
General "rule out"
abdominal CT
Known cancer

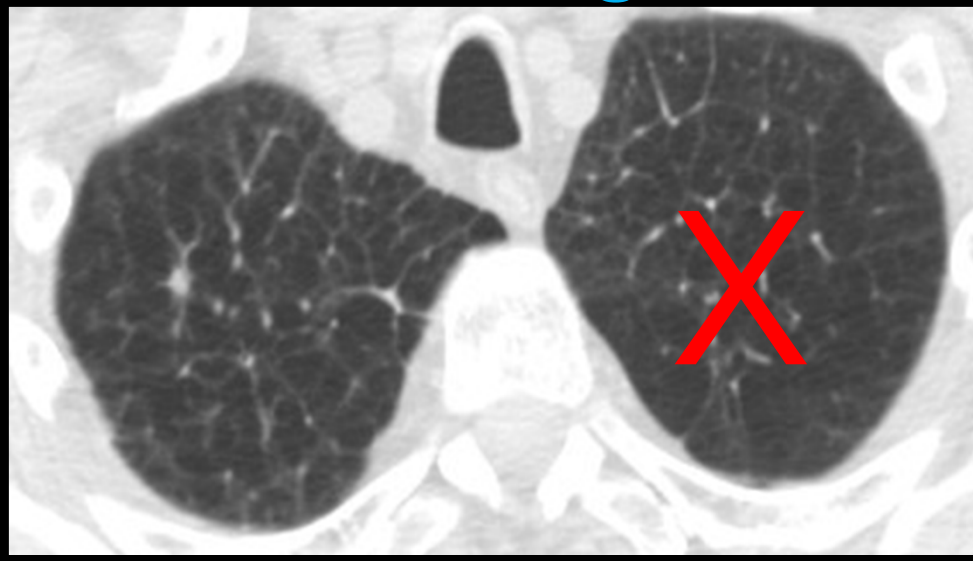

High noise
Lesion Detection – high confidence
Low to very low radiation dose
Not Good
Rule out Abdo CT
Low contrast lesions
Good
Pediatric patients
Follow up CT
SCREENING
Bones
Kidney stones


180 mAs
9 mGy
5mm FBP
Good CT?
Kidney stones
High Contrast
CTA, Ca++

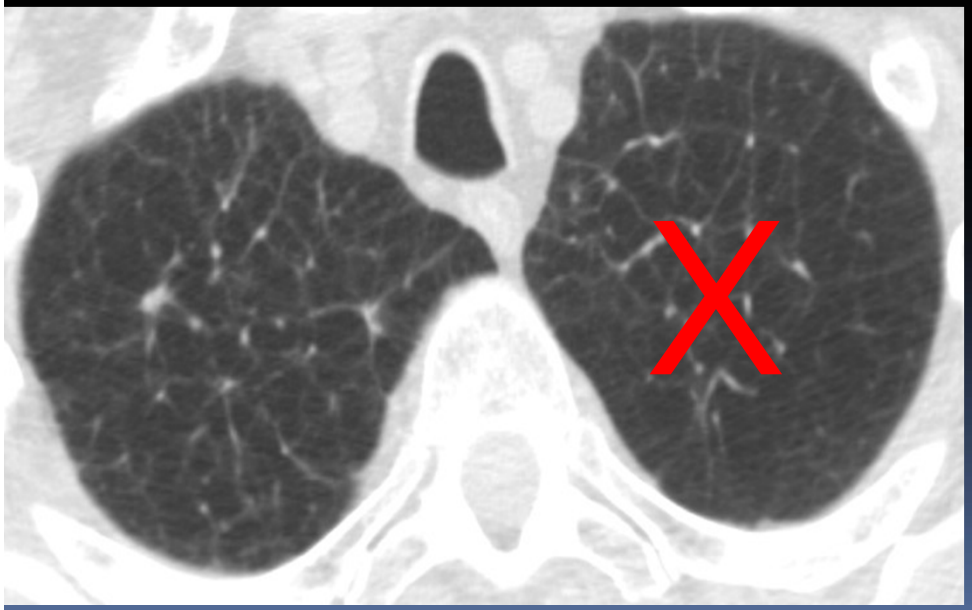

40 mAs
1.4 mGy
5mm FBP
26
-150.08 mm
5.0 mm
L
Good CT!!
Kidney stones
High Contrast
CTA, Ca++

Good CT for lung cancer screening

150 mAs



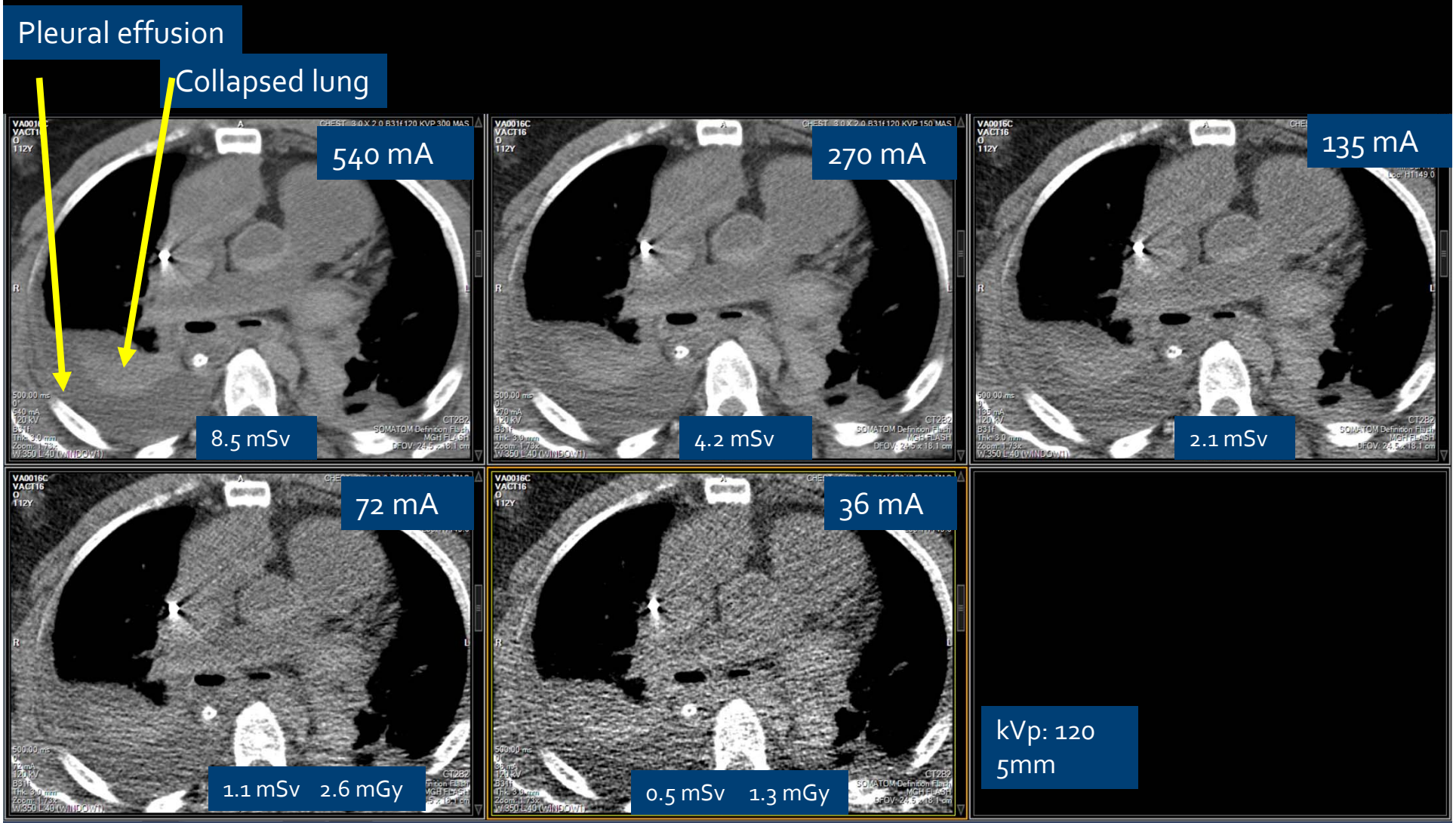
110 mAs



75 mAs

40 mAs 1.4 mGy

chest CT at various tube current levels



What is a Good body CT Exam?

- Justified: Ensuring that CT is the right test

- Interpretable: Tailoring CT for specific indications

- ALARA: Adapting Dose to patient size or age

Characters of Good CT exam

- Appropriate scan indication
- Lack of motion artifacts: Movements, Breathing
- IV access with contrast injection technique
- Appropriate localizer radiographs: Coverage: AEC
- Transverse CT images
  - Scan range
  - # Scan series
  - Scan parameters

Attributes of Good Body CT

- Indication based scan protocols for each body region

Chest CT

- Routine chest
- CT PE
- Lung nodule FU
- Cancer screening
- Diffuse lung Dz
- Tracheal protocol

Abdominal CT

- Routine abdomen
- Kidney stone
- CT colonography
- CT urography
- Dual phase liver
- CT enterography

Good CT requires Good Instructions

- Aim: To minimize wasteful repeats from motion
- Emphasize when practical
  - Please do not move during CT exam unless Emergent
  - Demonstrate breathing or breath hold instructions
- Know what to do when patient can not co-operate
  - Change protocol: Faster scanning or Faster scanner
  - Different scanner:
    - Broader (> = 64 MDCT)
    - Faster (high pitch, speed, or DSCT)

Contrast Injection Technique

- Aim:
  - Minimize repeats from poor contrast
  - Have good CNR esp. CT angiography
- Good CNR also implies greater tolerance to low dose
  - Good "specified" IV access
  - Contrast type, injection rate, and volume
  - Contrast-to-scan delay: Prefer bolus testing or tracking

Good CT Localizers

Chest - Routine

Indications:	Lung mass, lymphoma, adenopathy, infection, pneumonia, pulmonary obstructive disease abnormal chest x-ray, lymphadenopathy, lump in chest, back pain, chest pain, hemoptysis fatique and malaise SP ablation	
IV Contrast:	370mg	65 cc under 200 lbs
Rate:	2-2.5 cc/sec	

Localizer Radiograph

SERIES 1:	**SCOUTS**
Landmark	SN
Scout	AP and LAT
Technique	80 kV 20mA

SERIES 2:	**CH**
Scan delay	
Location	
Mode	
Time	
Thickness	
Detector	
Pitch	
Speed	
Interval	
Gantry Tilt	
SFOV	
kV	
DFOV	
ALG	
ASIR	

Patient Weight	**N**
under 135 lbs	
136-200 lbs	
over 200 lbs	

SERIES 4:	**D**
Location	
Mode	
Time	0.5
Thickness	5 mm
Pitch	1.375
Speed	55
Interval	5 mm (limit to area of effusion)
Gantry Tilt	0
SFOV	Large
kV	100
mA	100
Noise Index	N/A
DFOV	skin to skin
API	Inspiration
ALG	ASIR 30 Standard

Remember good “centering” = good AEC and quality

Reduce dose for localizer radiograph

- 80 kVp
- Lower mA (20-40 sufficient)
- Localizer with good centering requisite for

Good CT Exam: Scanning protocols

- After Indications, adapt Dose to Patient Size
  - Tube Current:
    - Prefer AEC over fixed mA for most body CT
    - Some AEC techniques need adjustment to size
    - Can use fixed mA for very low dose CT protocols
    - Some AEC techniques require adjustment for weight
  - Kilovoltage selection: Automated or user-determined
- Pitch: Except for DSCT, specific desired quality

Good CT Exam: Scanning protocols

- Scan series
  - Must be minimum required
  - When multiple- dose should not be multiple folds higher
- Scan length: Targeted and focused
- Beam collimation: Per slice thickness and scan length
- Fast gantry rotation speed to minimize motion
- Reconstruction kernel
  - Softer: thinner slices (cardiac CT or CTA) or lower dose
  - Sharper: Bones and Lungs

Good CT Exam: Notification Values

CT Scan Region (of each individual scan in an examination)	CTDIvol Notification Value (mGy)
Adult Head	80
Adult Torso	50
Pediatric Head	
<2 years old	50
2 – 5 years old	60
Pediatric Torso	
<10 years old (16-cm phantom)[a]	25
<10 years old (32-cm phantom)[b]	10
Brain Perfusion (examination that repeatedly scans the same anatomic level to measure the flow of contrast media through the anatomy)	600
Cardiac	
Retrospectively gated (spiral)	150
Prospectively gated (sequential)	50

Good Body CT

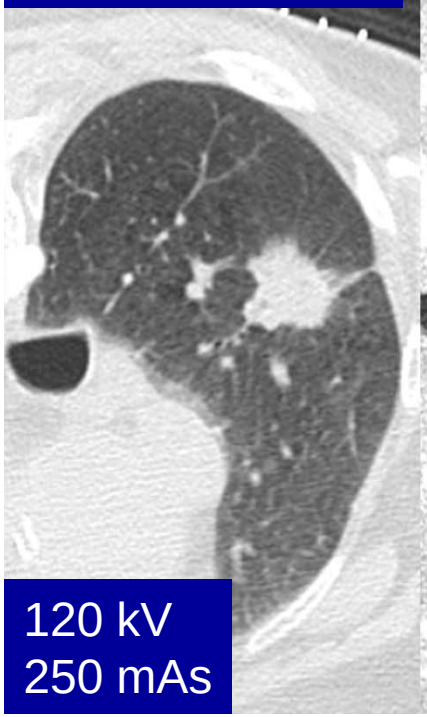
- Chest CT doses < Abdomen CT doses
- Indication based dose reduction
  - Stone protocol < Routine or Rule out abdominal CT dose
  - Lung nodule < Routine or Rule out chest CT dose
- Smaller patient < Medium size < large patient doses

Good CT for Biopsy - Axial and Length

After lesion localization, reduce dose for CT guided Bx

- Axial acquisitions
- Reduce scan length and mA and kVp

Localizer images



120 kV
250 mAs

Bx needle

100 kV
88 mAs

Subsequent scans at 1-2 mGy

Total mAs 3228 Total DLP 475

	Scan	kV	mAs / ref.	CTDIvol	DLP
Patient Position H-PR					
Topogram	1	[illegible]			
LOCALIZER	2	120	250 / 200	17.03	194
Biopsy	8	[illegible]	[illegible]	[illegible]	27
Biopsy	9	100	101	3.96	11
Biopsy	10	100	95	3.72	11
Biopsy	11	100	236	9.25	27
Biopsy	12	100	98	3.84	11
Biopsy	13	100	96	3.76	11
Biopsy	14	100	99	3.88	11
Biopsy	15	100	99	3.88	11
Biopsy	16	100	101	3.96	11
Biopsy	17	100	101	3.96	11
Biopsy	18	100	98	3.84	11
Biopsy	19	100	95	3.72	11
Biopsy	20	100	102	4.00	12

Good CT: Limit scan length for Multi-pass CT

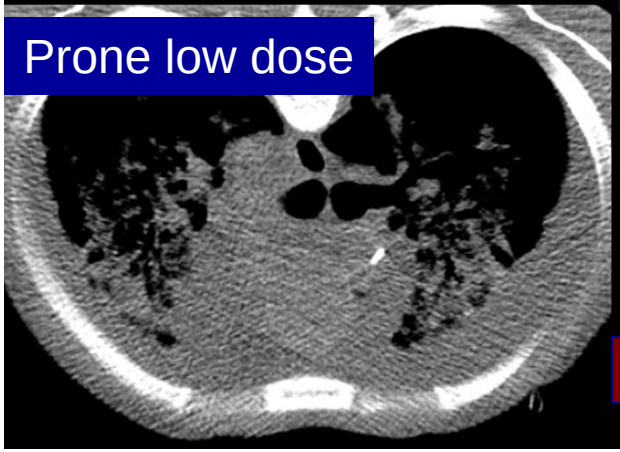
For multiple series exams

E.g. check for loculated effusions

- Limit scan length, reduce kV and mA

Standard dose supine

Prone low dose



Standard dose supine series:
Entire chest, 120 kVp, 160 mAs

Low dose prone images:
Small scan length, 80 kVp, 50 mAs (<1 mGy)

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
Standard dose		122.750-1377.750	17.81	681.21	Body 32
4	Scout	-	-	-	-
Prone low dose		187.000-1337.000	0.85	24.87	Body 32
				Total Exam DLP:	706.08

Good PE CT: shorter Scan Length

PE protocol
Apices to adrenal

PE protocol
Apices to lung bases

Total mAs 6574 Total DLP 912

	Scan	kV	mAs / ref.	CTDIvol	DLP
Patient Position F-SP					
Topogram	1	120			
PreMonitoring	2	120	60	12.13	12
I.V. Bolus					
Monitoring	3	120	60	36.40	35
PE CHEST	6	120	210 / 240	14.20	455

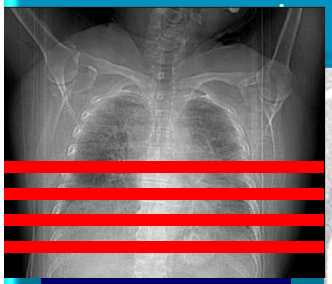
Good CT: Diffuse lung disease
Helical vs Axial Mode

Scan parameters	Values
Scan coverage	Apices to adrenals
Mode	**Helical**
Time	0.5 second
Recon. thickness	1 mm
KVp	120
Recon. kernel	FBP or h-IRT
	AEC settings

Helical: Most CT

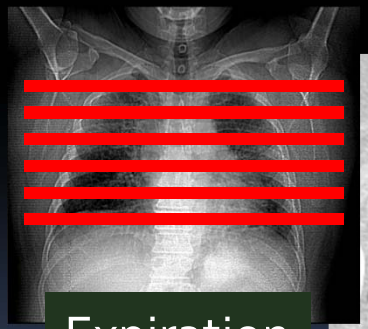
Axial: Diffuse lung Dz

Prospective EKG triggering



Prone
AXIAL
DLP = 43

Inspiration
Helical
DLP = 419



Expiration
AXIAL
DLP = 86

Total DLP: 546 and ED 9.3 mSv

Good CT for Lung findings: Low Dose

540 mA

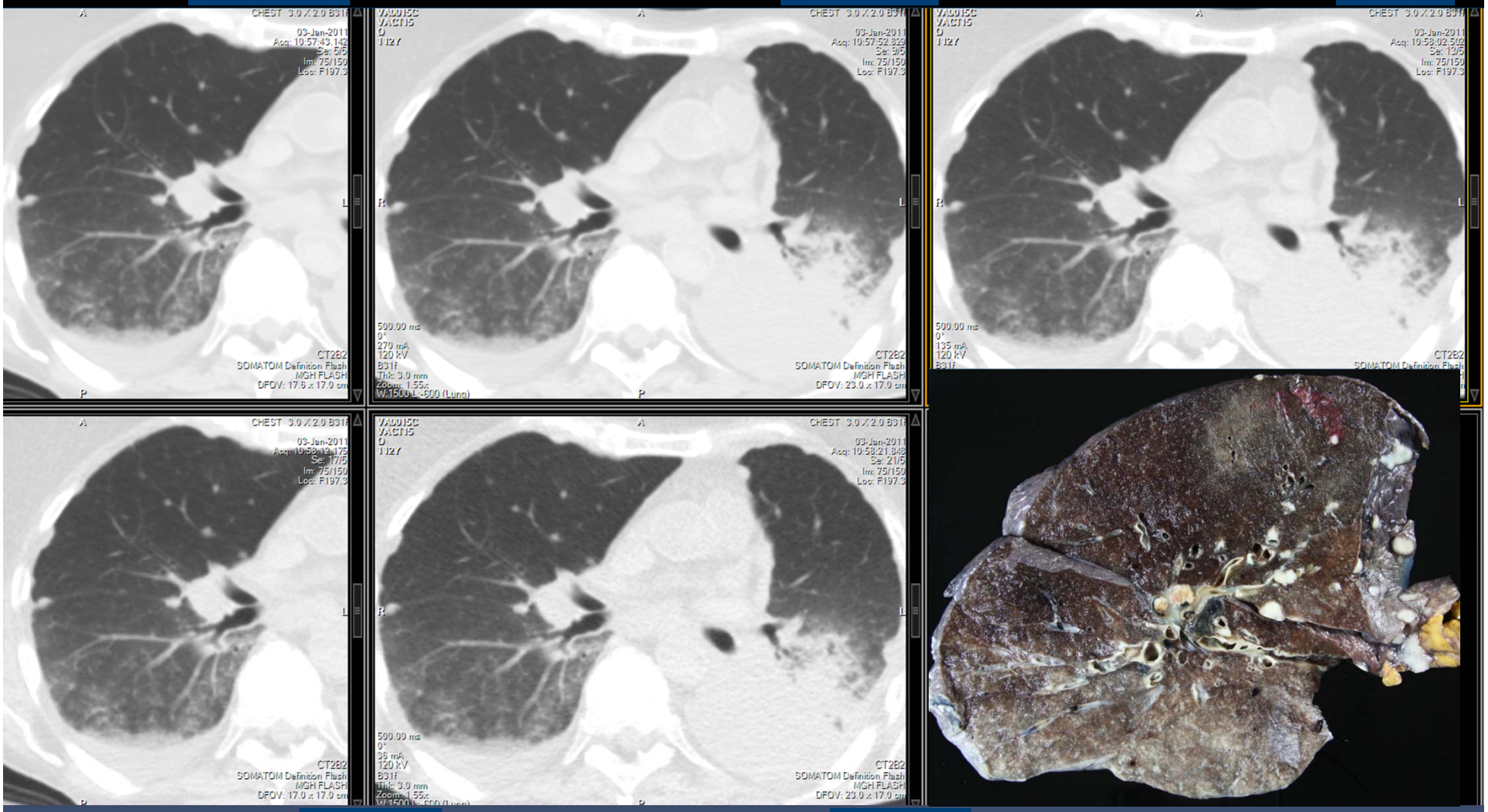
20.2 mGy

270 mA

10.1 mGy

135 mA

5 mGy

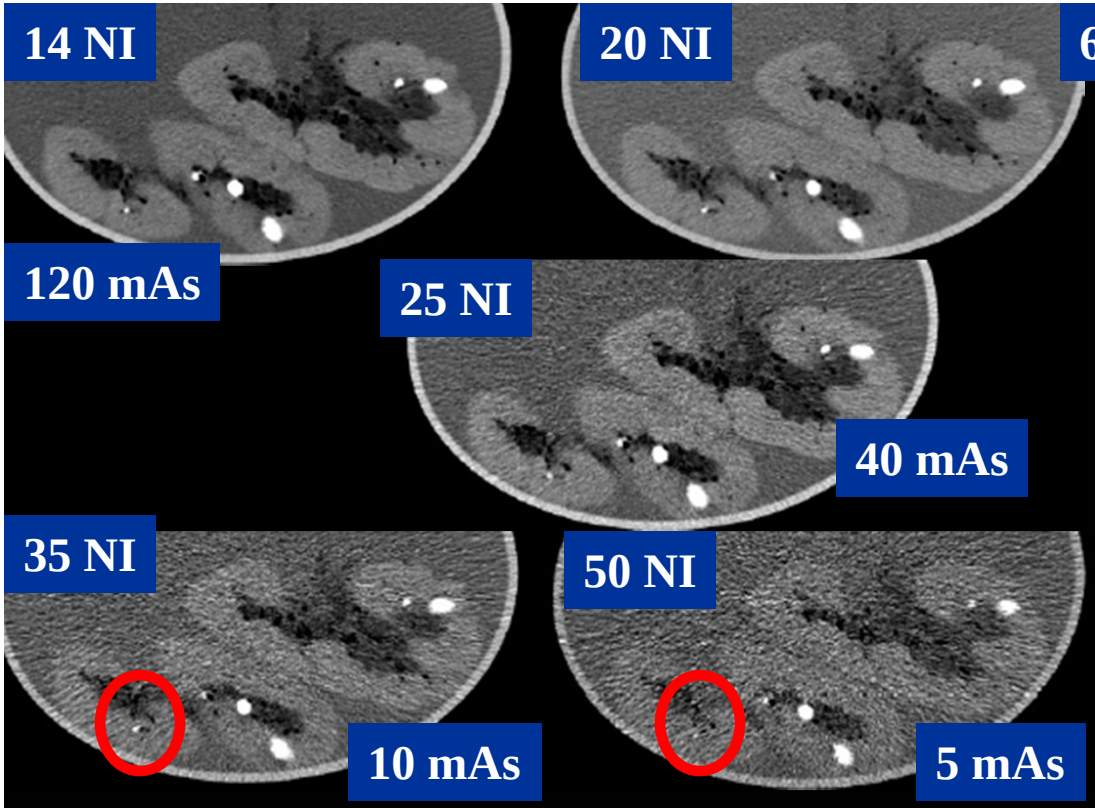


72 mA

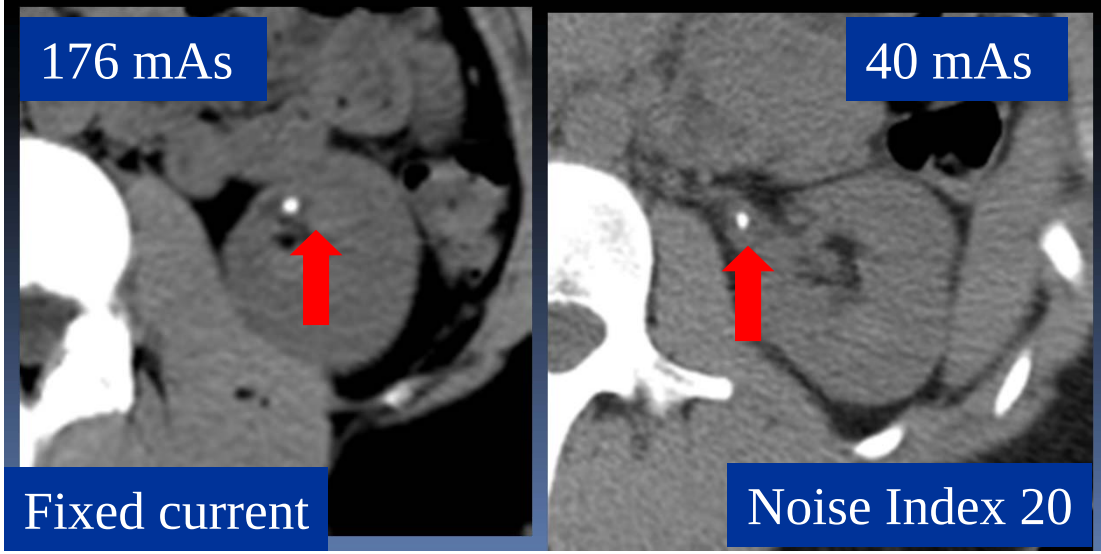
2.7 mGy

36 mA

1.3 mGy



Good body CT:
Low-dose kidney stone



Effective Dose:
1.5mSv
66% reduction

Kalra et al. Radiology 2005

633 mA

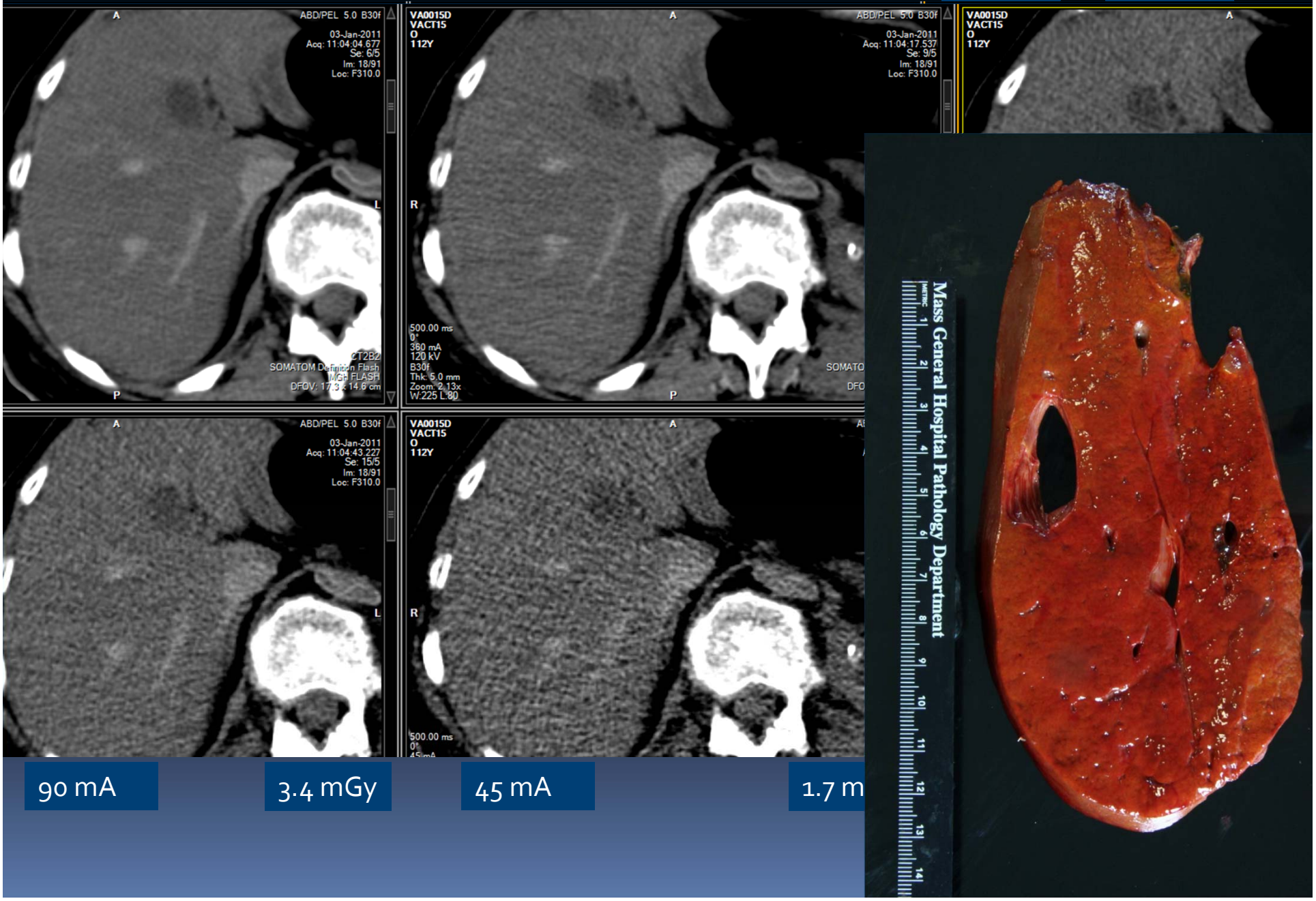
23.7 mGy

360 mA

13.5 mGy

180 mA

6.8 mGy



90 mA

3.4 mGy

45 mA

1.7 m

Low Dose CT Colonography

Detector Configuration	64*0.625
Beam Pitch	1.35: 1
Table Speed (mm/rotation)	55
Gantry Rotation Time (second)	0.5
Tube Potential (kVp)	120
Tube Current (mA)	50 supine 100 prone
Slice Thick/Recon Interval (mm)	2.5/1.25

CT Colonography (100 mA, 120 kVp) in 78-kg woman demonstrates sessile polyp (arrow) in sigmoid colon

Filtered back projection

Advantages

- Faster reconstruction
- Less costly equipment

Disadvantages

- Higher image noise
- More streak artifacts as well as beam hardening
- Does not consider attenuation and scatter

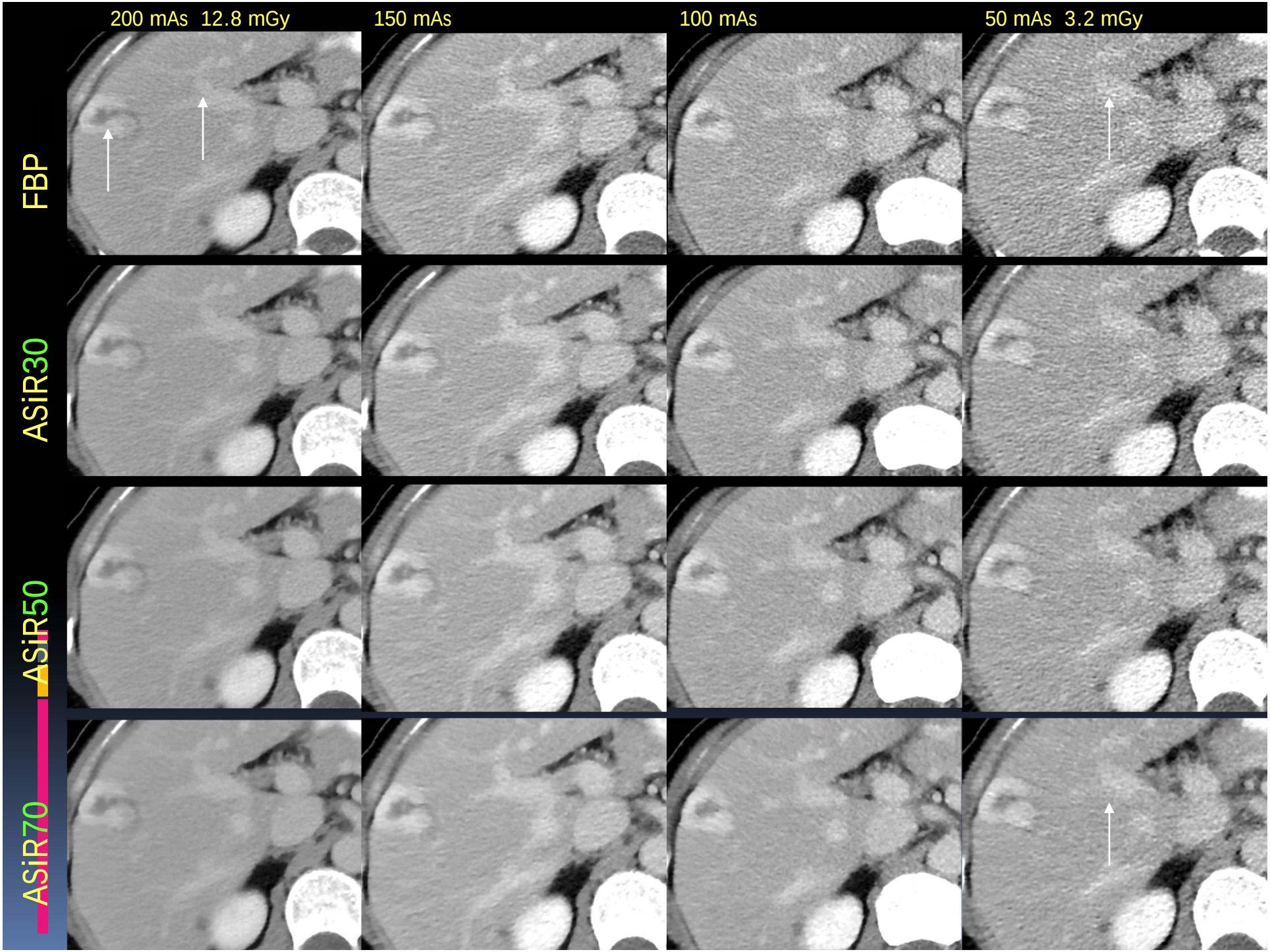
Iterative Reconstruction tech.

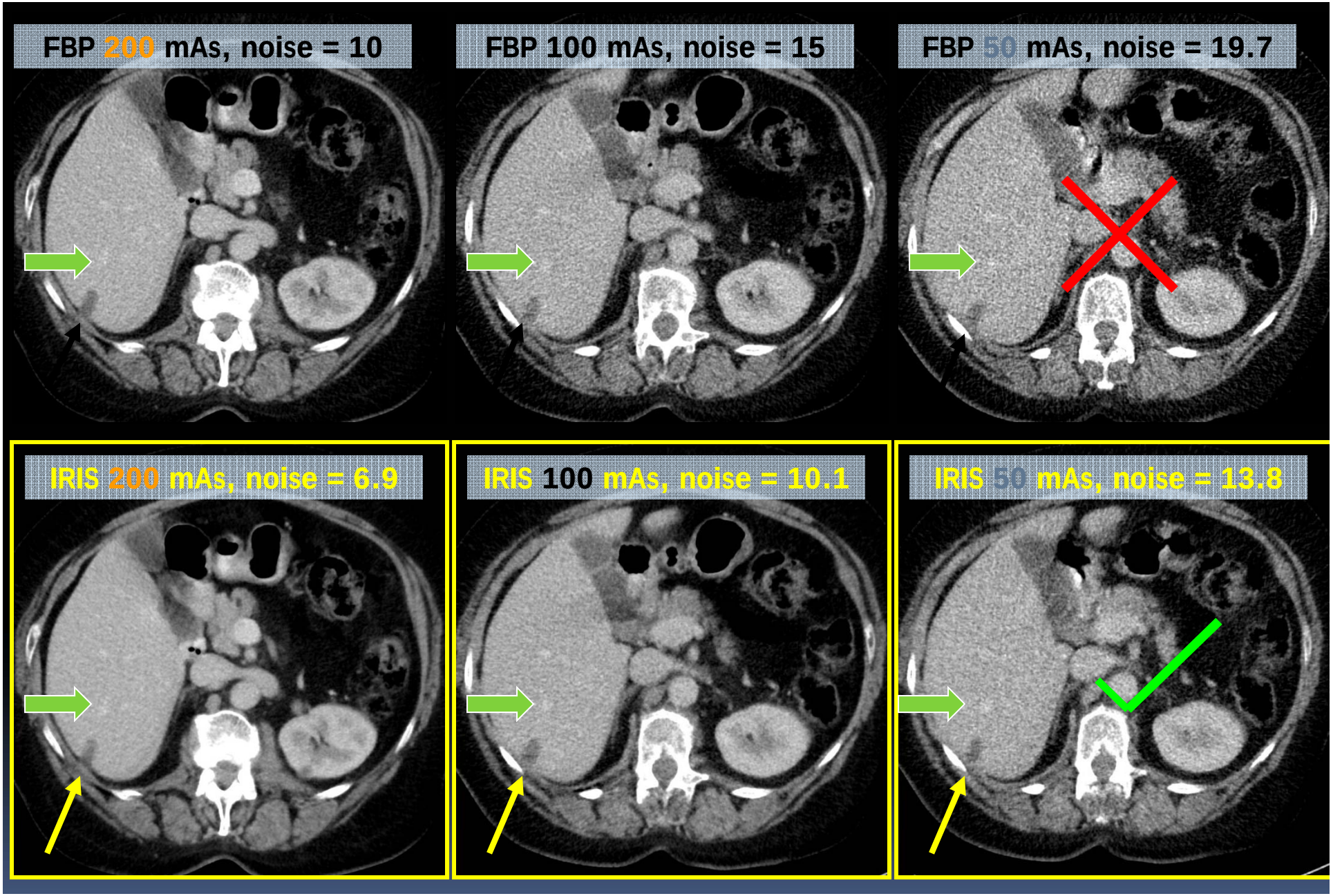
- Advantages:
  - Lower image noise
  - Reduce radiation dose
  - Almost same recon time
  - Considers scatter effect
  - Computationally more accurate
- Disadvantages:
  - Need faster and robust computers
  - Extra cost for upgrade

Types of iterative reconstructions

Available Techniques

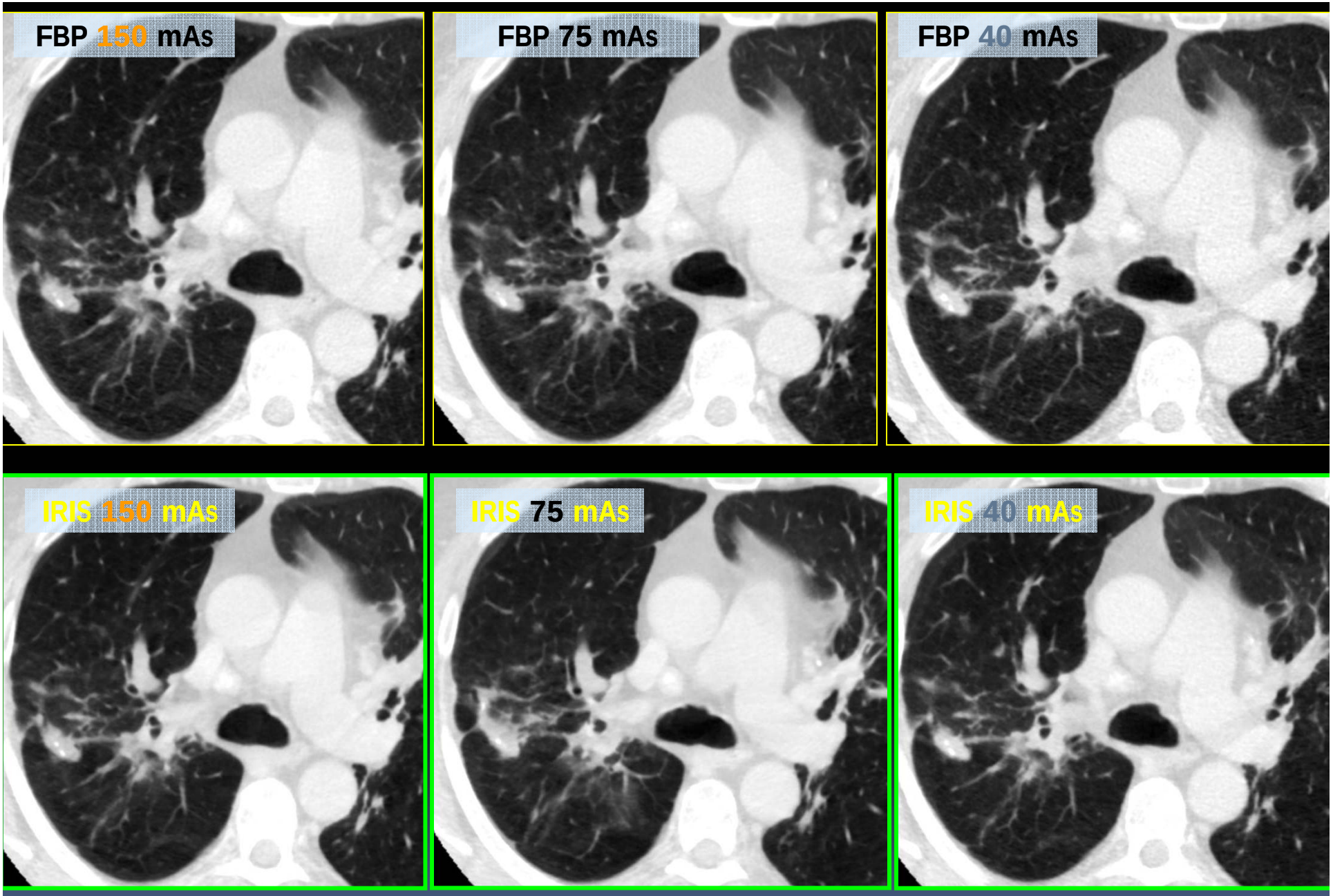
- Adaptive Statistical Iterative Reconstruction (ASIR) (GE Healthcare)
- Iterative Reconstruction in Image Space (IRIS) (Siemens Healthcare)
- Model Based Iterative Reconstruction (MBIR) (GE Healthcare)
- Model Based Algebraic Iteration (MBAI) (© HH Pien, Mass General)
- iDose (Philips Medical Solutions)
- Adaptive Iterative dose reduction (AIDR) (Toshiba Medical Systems)


200 mAs 12.8 mGy
150 mAs
100 mAs
50 mAs 3.2 mGy
FBP
ASiR30
ASiR50
ASiR70



Abdominal CT acquired at 3 different radiation doses with informed consent.

IRIS images were acceptable at 50 mAs but FBP images were unacceptable at 50 mAs.



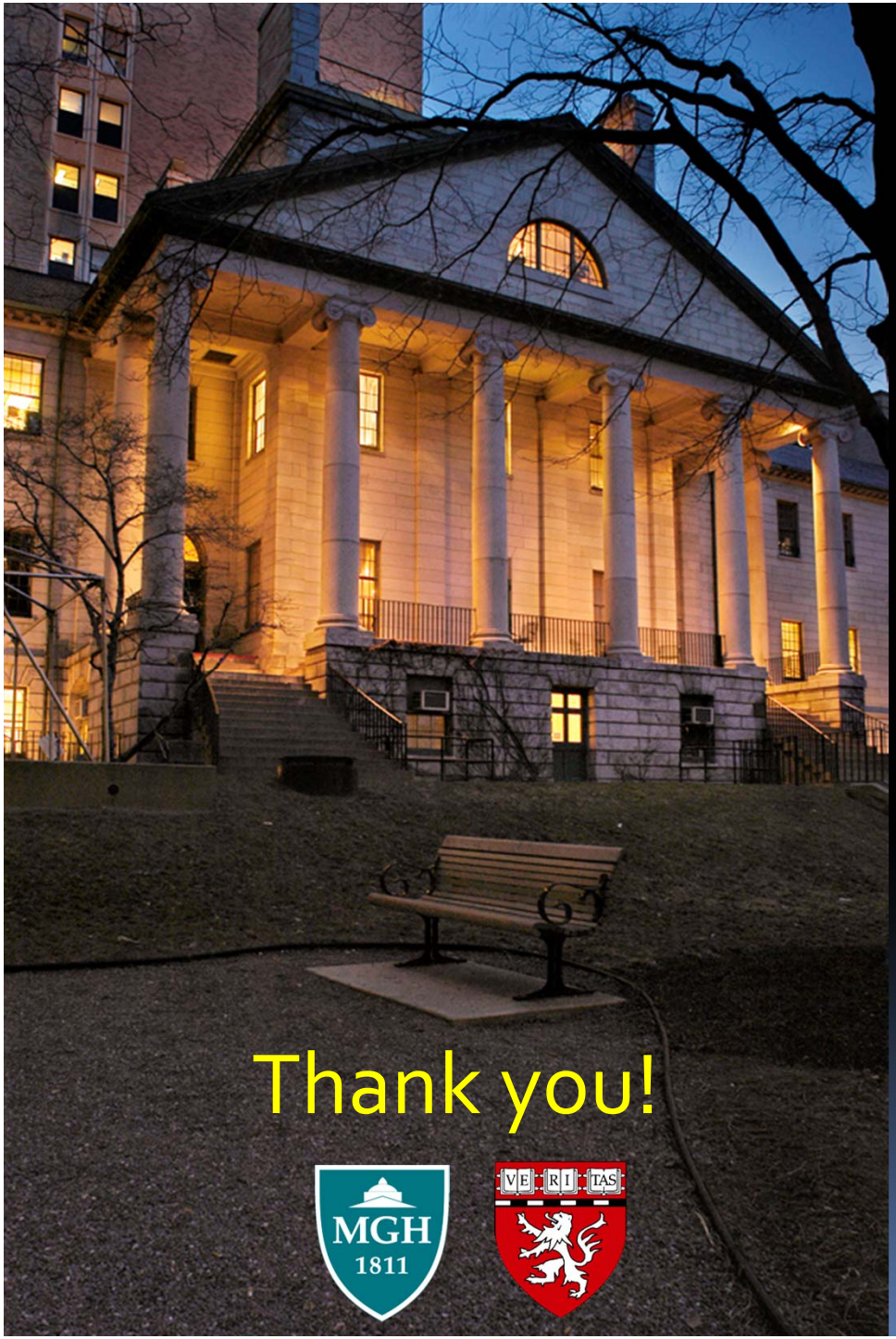
Chest CT acquired at 3 different radiation doses with informed consent.

IRIS images are superior to FBP at all mAs levels.

Good Body CT: How Do You Get it?

-  Cynthia McCollough or Dianna Cody…

- Understand CTDI and DLP
- Compare CTDI and DLP with RDL (eg. ACR)
- Reduce if necessary: Small Steps – recognize effect
- Increase if necessary: Small Steps
- Stratify CT protocols per indications
- Each protocol with AEC or patient size modifications



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Contact information:
mkalra@partners.org