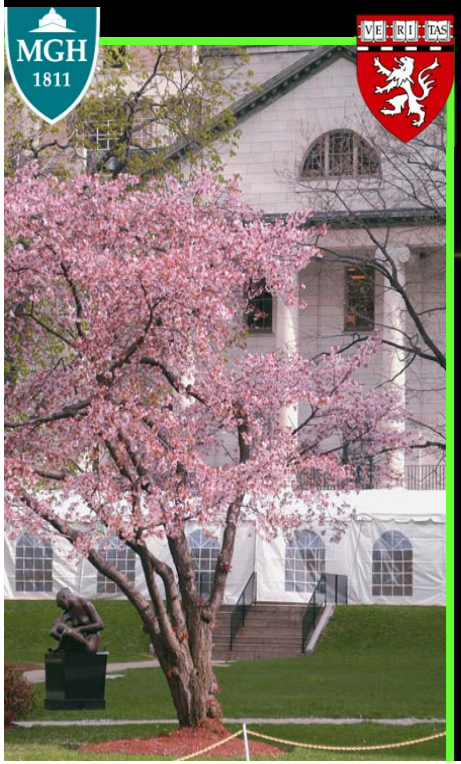
MIT:
RAMETER OPTIMIZATION
NIX, ARIZONA



Specific Principles for Dose Reduction in Chest CT Imaging

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Financial Disclosure

- GE Healthcare:
  - Faculty for Master Course on Radiation

Specific principles

- Compare chest and abdominal doses
- Divide protocols per clinical indications
- Know your specific CT scanners
- Know scan parameters:
  - Nomenclature
  - Effect on dose and image quality
- Specific image reconstruction types

Comparison: Chest CT dose < Abdomen CT

- Routine / general chest CT < abdomen CT
- Lung nodule CT < kidney stone CT
- CT pulmonary embolism < AA Aneurysm
- Fewer multi-phase or pass studies

Time: Feb 15, 2013, 10:44:16
Total DLP: 858.4 mGy*cm
Estimated Dose Savings: 20%

Dose

#	Description	Scan Mode	mAs	kV	CTDIvol [mGy]	DLP [mGy*cm]	Phantom Type[cm]
1	Scout	Surview	0	120	0.10	7.1	16 CM
4	CHEST SUPER D	Helical	92	120	6.78	273.7	32 CM
5	ABP THINS CA F/U	Helical	144	120	10.52	577.6	32 CM

Why Chest CT is better for lower dose….

…..than abdominal CT?

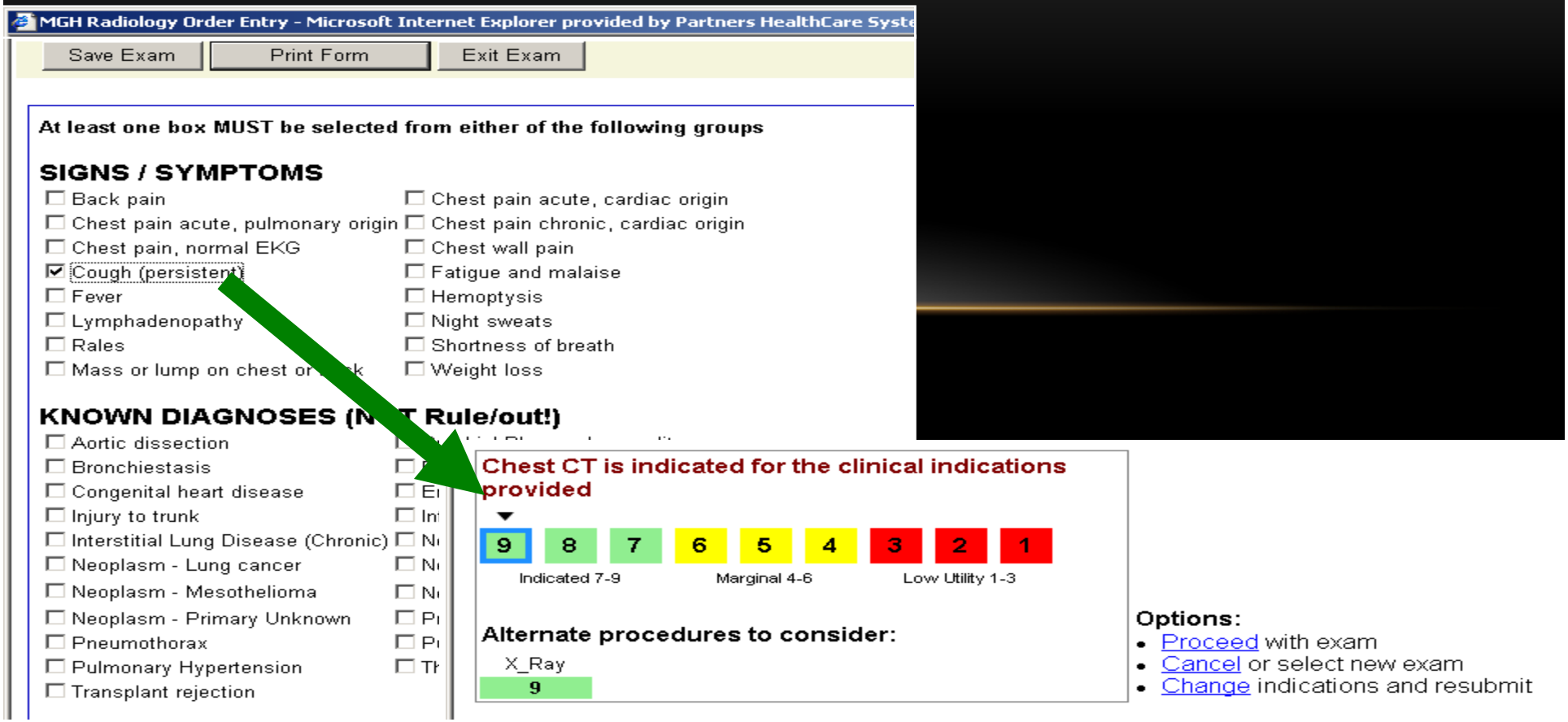
- Air in lungs
  - Higher contrast: allows lower dose
  - Less beam attenuation: lower noise–lower dose

- Mediastinal fat versus blood vessels, heart
  - Higher contrast: allows lower dose

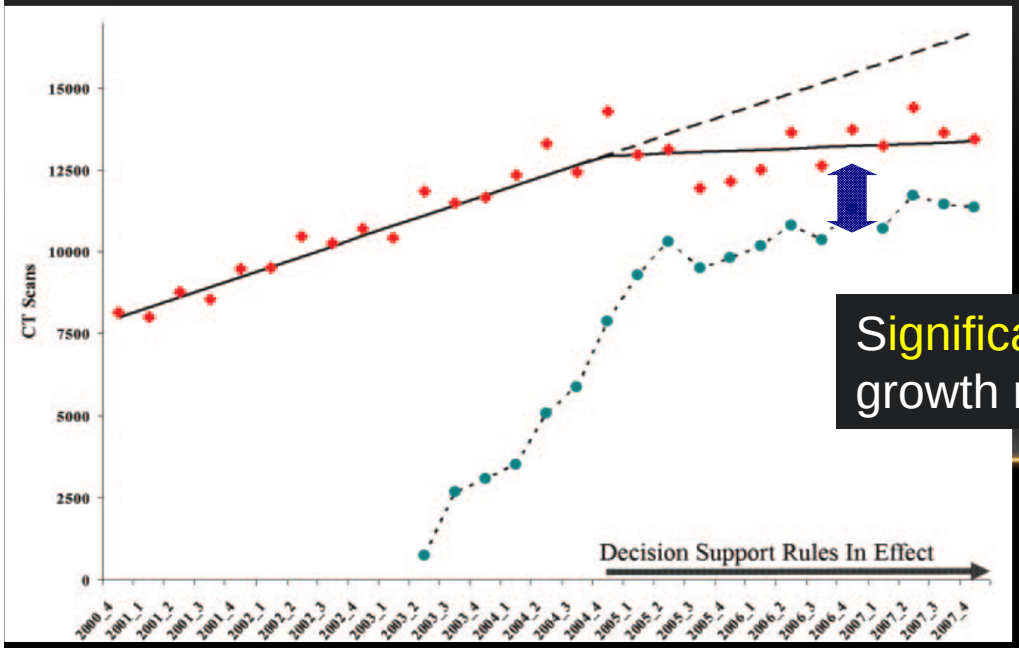
All time winner
for
The BEST
CT dose reduction strategy……..

Appropriateness of clinical indication

Justification: Similar Information from Chest Radiograph



Justified CT: Effect on volume



Significant decrease in CT volume growth and growth rate after DS implementation (*P .001)*

Appropriateness for CT is not an optional scan factor.

Decision support and practice guidelines help optimize

Sistrom et al. Radiology 2009

Indication based protocols help optimize Dose

Chest protocols	Clinical Indications	Specific instructions
Routine chest with IV contrast	Masses, infections, trauma to lungs, mediastinum, pleura	Prone: Pleural effusion Low Dose
Routine chest without contrast	Elevated creatinine for above, Follow-up nodule in pt's with CA	Prone: Pleural effusion Low Dose
Lung nodule follow up	Follow up nodule without known malignancy	Non contrast Low dose
Diffuse lung disease protocol	Sarcoid, bronchiolitis obliterans, ILD, pulmonary fibrosis,	+ Expiratory & Prone images: Limited LD
Pulmonary Embolism	Suspected or known PE	Start from lung bases and not adrenals
Tracheal protocol	Tracheobronchomalacia Tracheal stenosis	+ Inspiratory & expiratory images

Need: Indication driven protocols?

- Certain things are ok at lower dose (lung nodules)
- Others need higher dose (mediastinal LN)

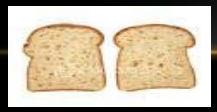
CT Lung nodule FU < Routine Chest CT post contrast

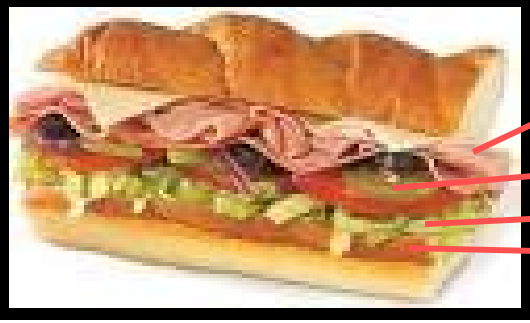
< Routine chest CT Non Contrast

< CT Pulmonary embolism (Thinner)

Know thy scanner



AEC

KV settings and techniques

Iterative reconstruction

Other tips and techniques

Search for the Optimal Blend: The Magic Protocols?

CHEST

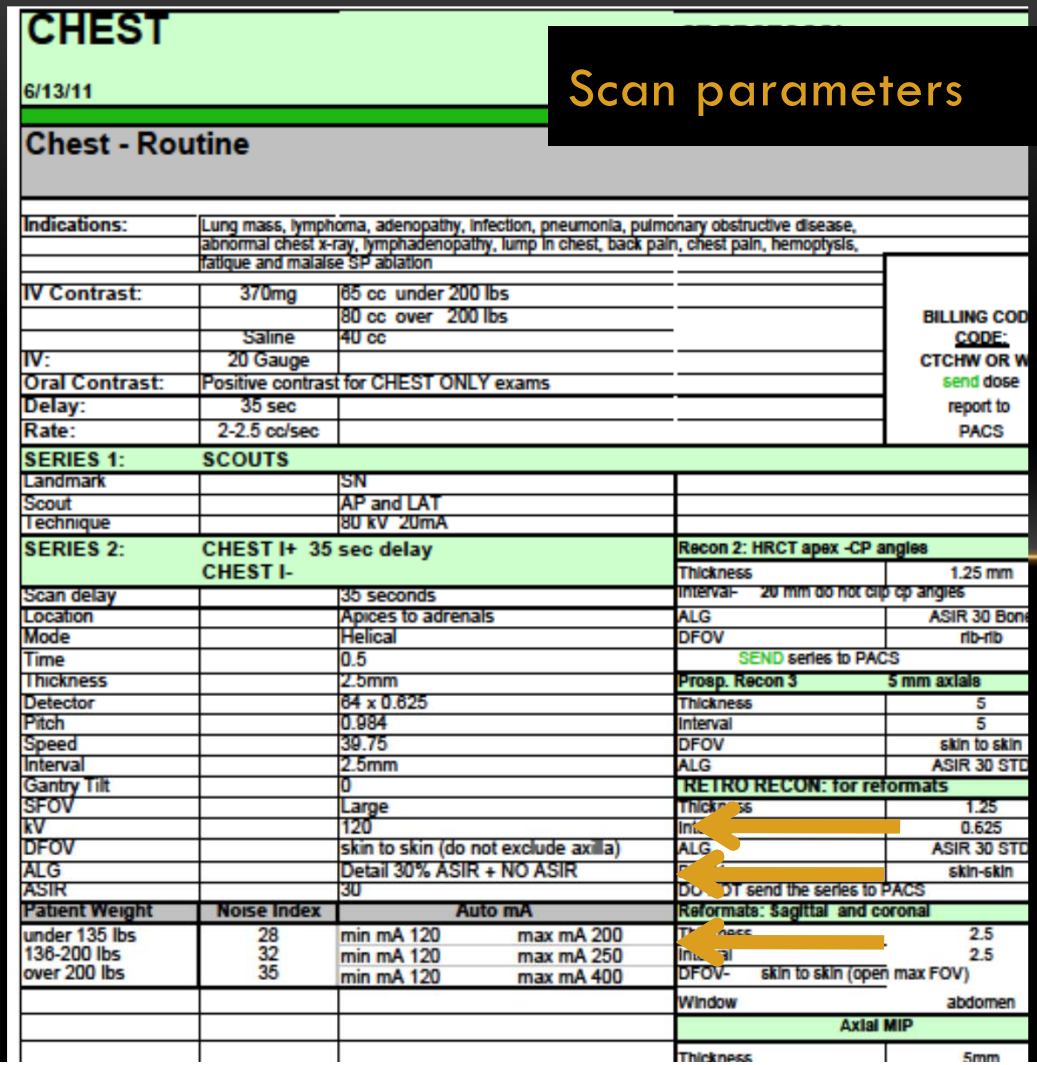
1/19/10

CT PROTOCOL
HD 64 SLICE
GE Scanner

Chest - Routine

Parameter	Value
Scanner	Magique Optimale
Profile	1024 Stealth mode
KV	Scanner determined
mA	Scanner determined
Rotation time	Scanner determined
Slice thickness	0.1 mm, and 5 mm
Reconstruction kernel	Blend Edge sharp, substance soft
Recon Technique	MRT (magical recon technique)
CTDI vol (SSDE)	**0.1 mGy**
DLP	**6.5 mGy.cm**
Est. Effective Dose	**0.1 mSv**

Scan parameters



CHEST

6/13/11

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, fatigue and malaise SP ablation	
IV Contrast:	370mg	65 cc under 200 lbs 80 cc over 200 lbs
	Saline	40 cc
IV:	20 Gauge	
Oral Contrast:	Positive contrast for CHEST ONLY exams	
Delay:	35 sec	
Rate:	2-2.5 cc/sec	

BILLING COD
CODE:
CTCHW OR W
send dose
report to
PACS

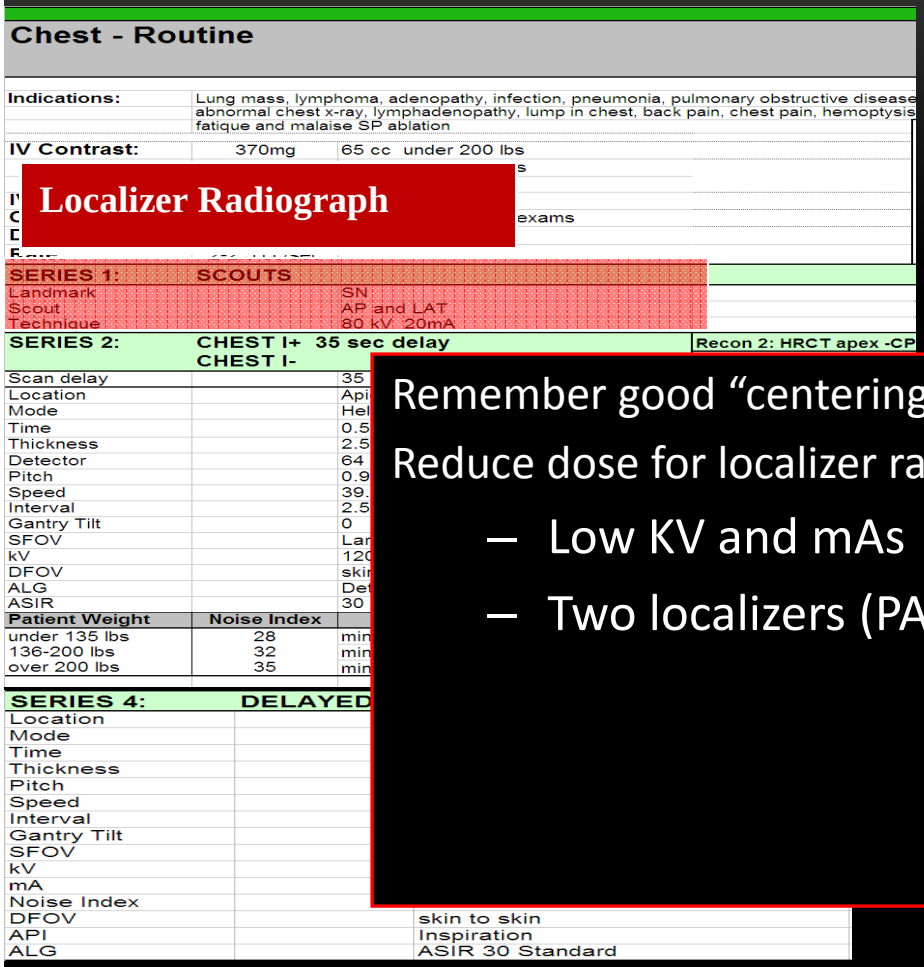
SERIES 1:	**SCOUTS**	
Landmark		SN
Scout		AP and LAT
Technique		80 kV 20mA
SERIES 2:	**CHEST I+ 35 sec delay** **CHEST I-**	
Scan delay		35 seconds
Location		Apices to adrenals
Mode		Helical
Time		0.5
Thickness		2.5mm
Detector		64 x 0.625
Pitch		0.984
Speed		39.75
Interval		2.5mm
Gantry Tilt		0
SFOV		Large
kV		120
DFOV		skin to skin (do not exclude axilla)
ALG		Detail 30% ASIR + NO ASIR
ASIR		30

Patient Weight	Noise Index	Auto mA	
under 135 lbs	28	min mA 120	max mA 200
136-200 lbs	32	min mA 120	max mA 250
over 200 lbs	35	min mA 120	max mA 400

Recon 2: HRCT apex -CP angles	
Thickness	1.25 mm
Interval- 20 mm do not clip cp angles	
ALG	ASIR 30 Bone
DFOV	rib-rib
SEND series to PACS	
Prosp. Recon 3	**5 mm axials**
Thickness	5
Interval	5
DFOV	skin to skin
ALG	ASIR 30 STD
RETRO RECON: for reformats	
Thickness	1.25
Interval	0.625
ALG	ASIR 30 STD
DFOV	skin-skin
DO NOT send the series to PACS	
Reformats: Sagittal and coronal	
Thickness	2.5
Interval	2.5
DFOV- skin to skin (open max FOV)	
Window	abdomen
Axial MIP	
Thickness	5mm

1. Localizer radiograph
2. Helical/axial
3. Tube current
4. AEC
5. Tube voltage
6. Rotation time
7. Table feed/speed
8. Pitch
9. Scan length
10. Detector configuration
11. Slice Thickness
12. Reconstruction technique

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

Localizer Radiograph

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

SERIES 2:	**CHEST I+ 35 sec delay**	Recon 2: HRCT apex -CP
	CHEST I-	
Scan delay		35
Location		Api
Mode		Hel
Time		0.5
Thickness		2.5
Detector		64
Pitch		0.9
Speed		39.
Interval		2.5
Gantry Tilt		0
SFOV		Lar
kV		120
DFOV		ski
ALG		Det
ASIR		30

Patient Weight	Noise Index	
under 135 lbs	28	min
136-200 lbs	32	min
over 200 lbs	35	min

SERIES 4:	**DELAYED**	
Location		
Mode		
Time		
Thickness		
Pitch		
Speed		
Interval		
Gantry Tilt		
SFOV		
kV		
mA		
Noise Index		
DFOV		skin to skin
API		Inspiration
ALG		ASIR 30 Standard

Remember good “centering” = good AEC and quality

Reduce dose for localizer radiograph

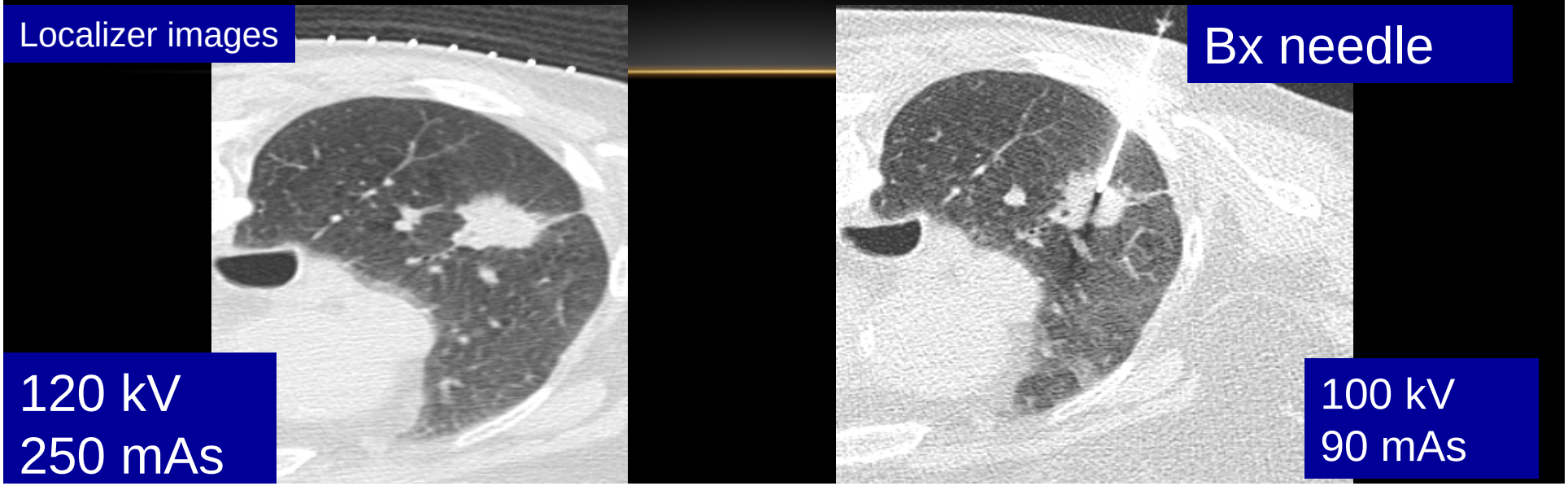
- Low KV and mAs
- Two localizers (PA and lateral better than one)

MISCONCEPTION

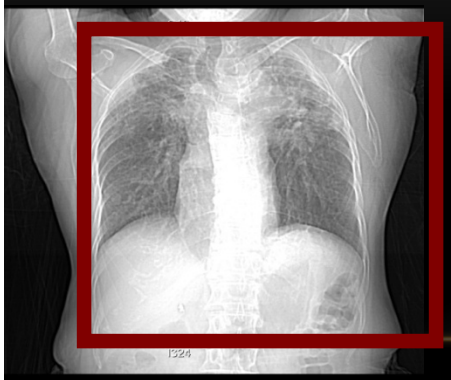
Dose Reduction with Axial Mode

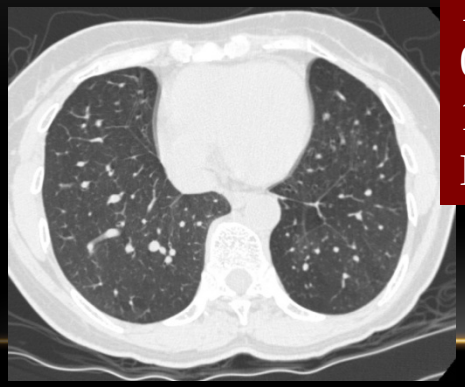
After lesion localization, reduce dose for CT guided Bx

- Axial acquisitions
- Reduce scan length and mA &/or kVp

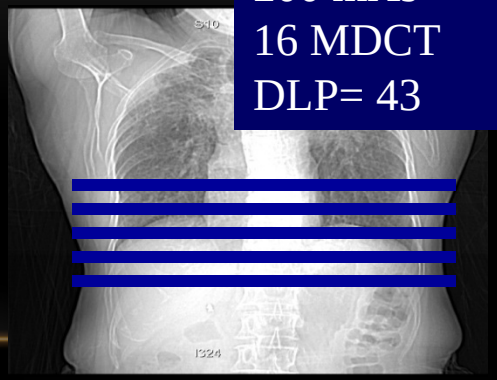


Axial mode over helical in HRCT Lungs

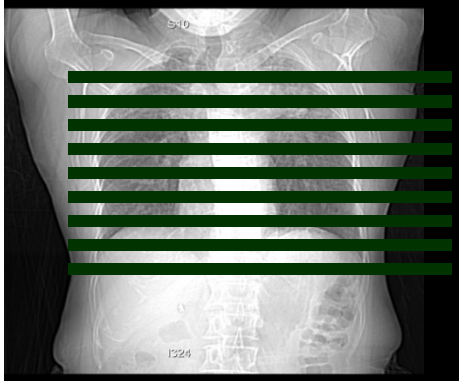


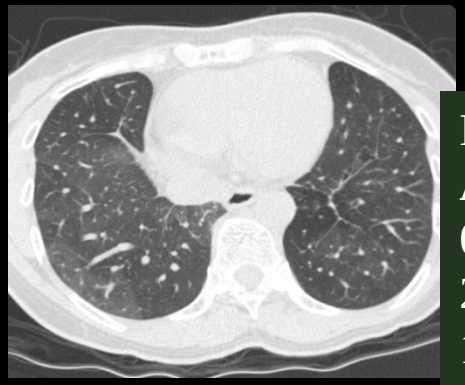


Inspiration
Helical
12.5NI
0.938p
16 MDCT
DLP= 419

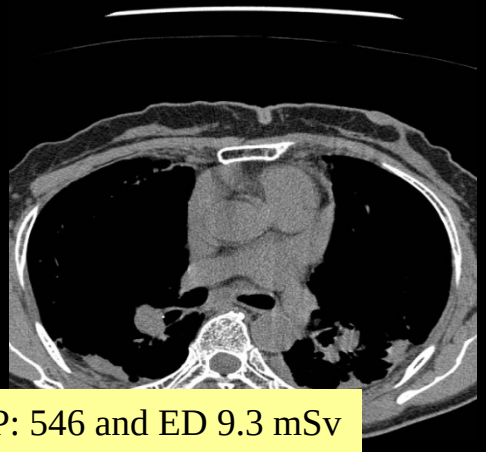


Prone
Axial
0.625/20mm
200 mAs
16 MDCT
DLP= 43



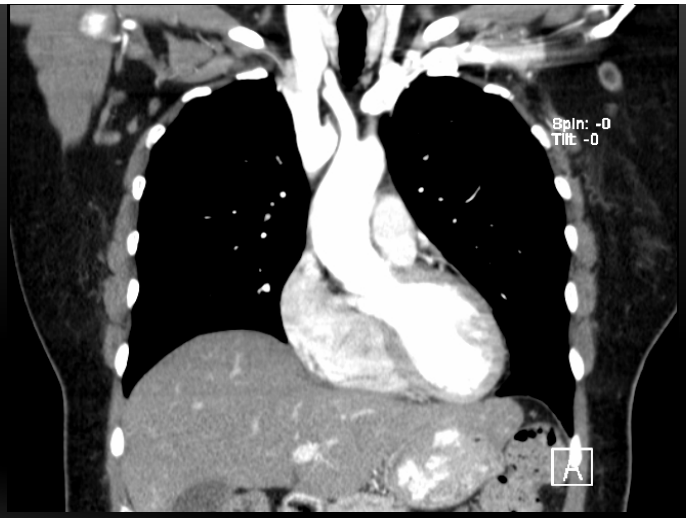


Expiration
AXIAL
0.625/20mm
200mAs
16 MDCT
DLP= 86



Total DLP: 546 and ED 9.3 mSv

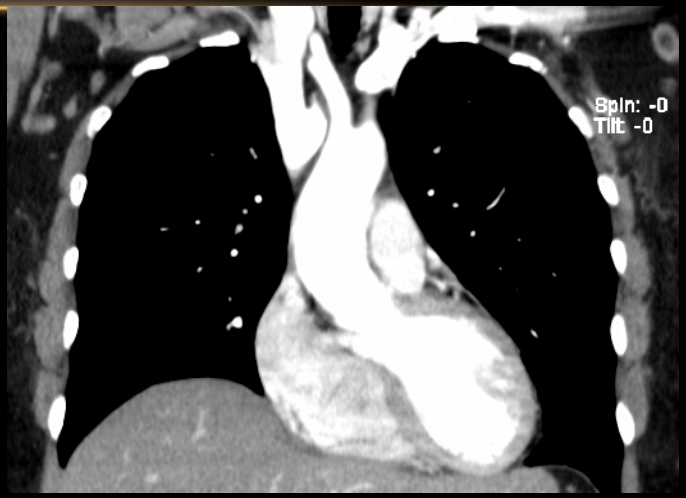
Scan Length



Apex to Adrenals

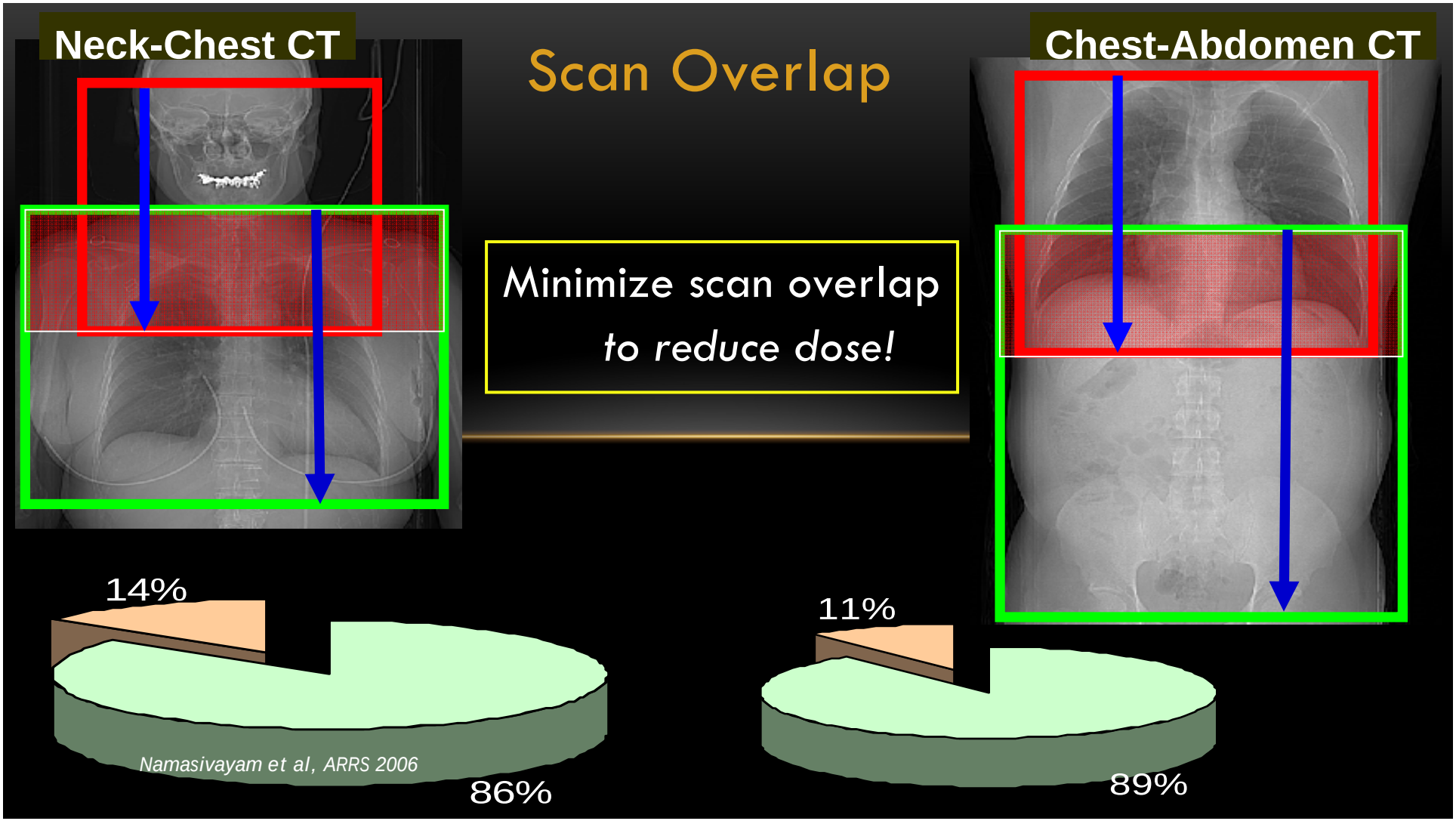
Routine Chest

Apex to Lung Base



Pulmonary Embolism
Lung nodules
Lung Cancer screening
Benign lung disease

Scan Overlap



Tube current: AEC versus Fixed mA

Some indications, like lung nodule FU at low fixed mAs

Most chest CT should be performed with AEC

AEC optimizes dose to patient size

You optimize AEC to clinical indication

Know the quirks, ins and outs of your AEC:

- 80-100 mAs at 120 KV suffices
- Set boundaries for mAs limits

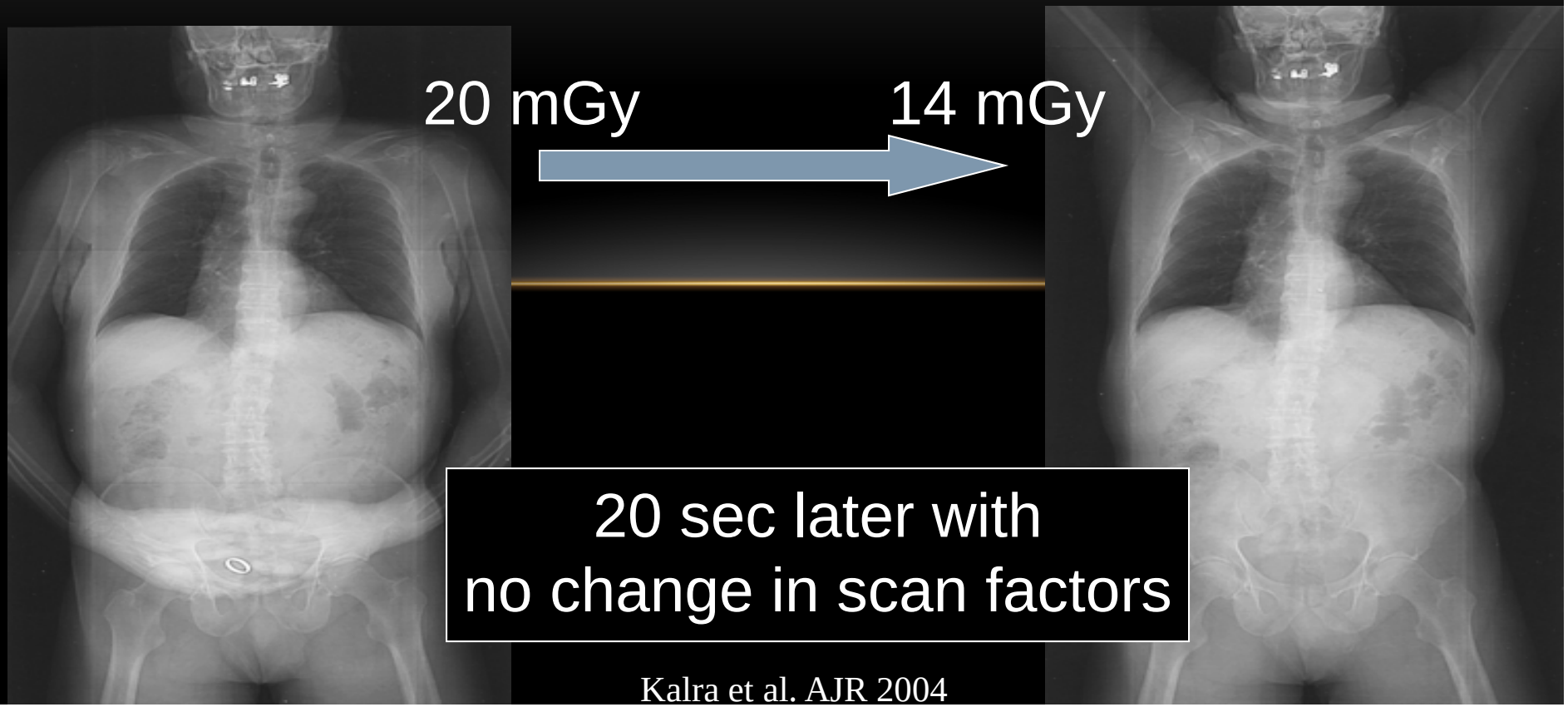
AEC or Fixed mAs

Prefer AEC over fixed mA
Fixed mA can suffices for very low dose CT

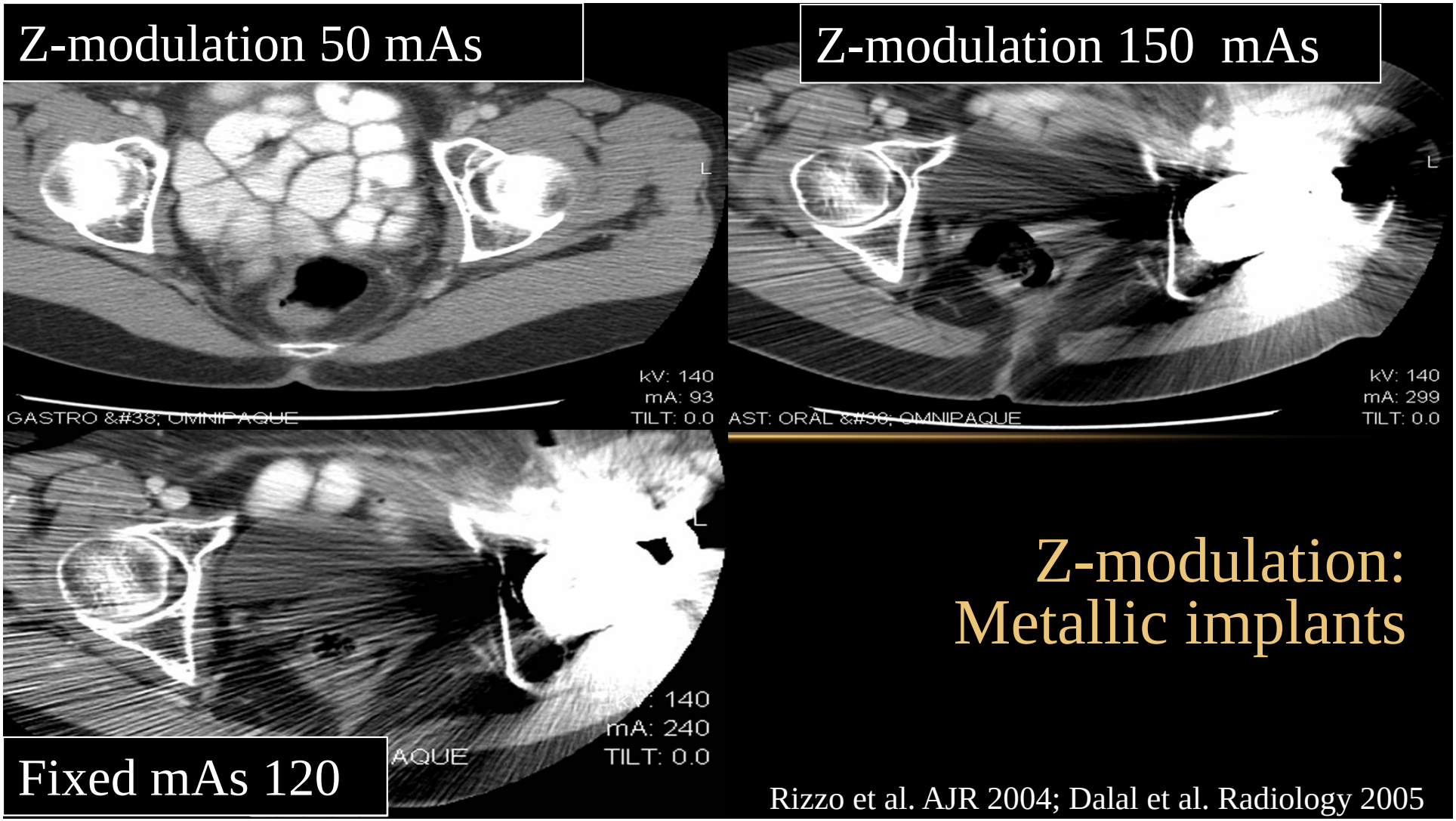
- Minimize mA
  - Pulmonary nodule
  - Pediatric lungs
  - Follow up cystic fibrosis
  - Lung cancer screening
  - DLD – expiration / prone
  - Biopsy
- Controlled mA adjustment
  - Mediastinal abnormalities
  - Lymph node evaluation
  - Large patient ?

AEC: Arms

When possible raise the arms above shoulders



Kalra et al. AJR 2004


Z-modulation 50 mAs
kV: 140
mA: 93
TILT: 0.0
GASTRO & OMNIPAQUE
Z-modulation 150 mAs
kV: 140
mA: 299
TILT: 0.0
AST: ORAL & OMNIPAQUE
mA: 240
TILT: 0.0
Fixed mAs 120
Z-modulation:
Metallic implants
Rizzo et al. AJR 2004; Dalal et al. Radiology 2005

Tube potential (kVp)

Chest CT	*KV*
Infants /children (<50 kg)	80
Adults (50-80+ kg)	80-100-120
Almost never	140

Encourage use of lower kV : Lung nodules FU

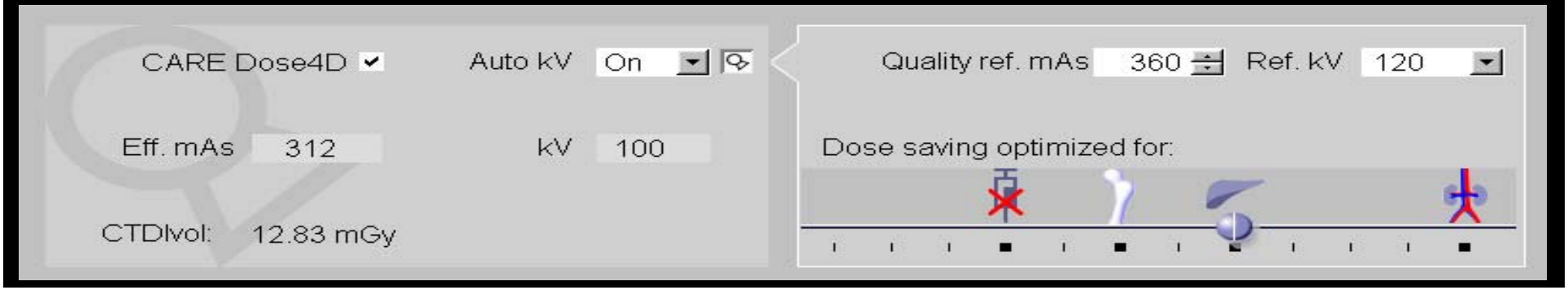
Post contrast chest CT

CT angiography

Automatic kV Selection

- System automatically identifies **optimum kV setting** (CARE kV)**
  - » Body habitus (from planning radiograph)
  - » Exam type (non-contrast, bone, standard contrast, vascular)
  - » System limits (tube current)
- System automatically proposes **kV** and corresponding **mAs** values
- New tube voltage setting **70 kV**

→ neonates, small children



Scan parameters	Values
Scan coverage	Apex to adrenals
Mode	Helical
Time	0.5 second
Recon. thickness	2.5 mm
Detector collimation	64*0.625 mm
KVp	120
Recon. kernel	FBP or h-IRT
Patient Weight	AEC settings
<60 kg	32 NI (100-200)
61-90 kg	35 NI (100-250)
>91 kg	38 NI (100-400)

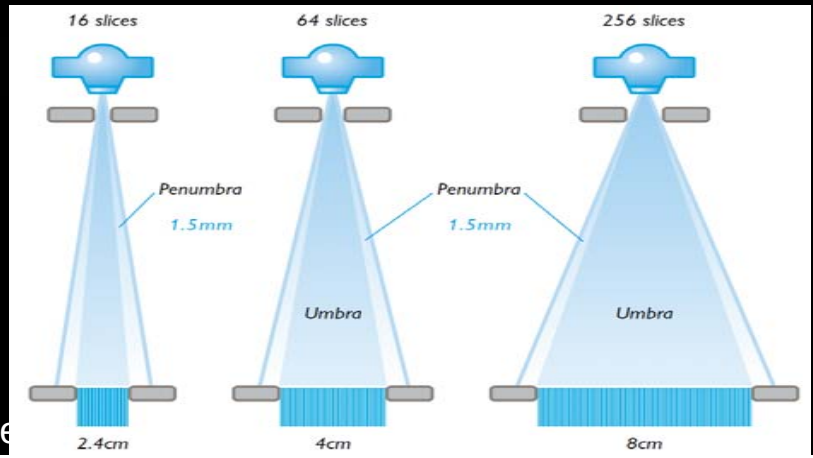
Detector Geometry

Prefer wider beams unless short scan

- Chest: Wider 64 >32 > 16

On 16 slices or lower

- Choice depends on desired slice width
- <1mm: smaller width- less dose efficient
- >1mm: wider width- more dose efficient



CHEST CT PROTOCOL

Scan parameters	Values
Scan coverage	Apices to adrenals
Mode	Helical
Recon. thickness	2.5 mm
Pitch	0.984:1
Speed	40 mm/rotation
KVp	120
Recon. kernel	FBP or h-IRT
Patient Weight	AEC settings
<60 kg	32 NI (100-200)
61-90 kg	35 NI (100-250)
>91 kg	38 NI (100-400)

Pitch

- Scanners adapt mA to keep dose constant irrespective of pitch
- Scan speed and not dose govern pitch
  - Pitch close to 1 suffices

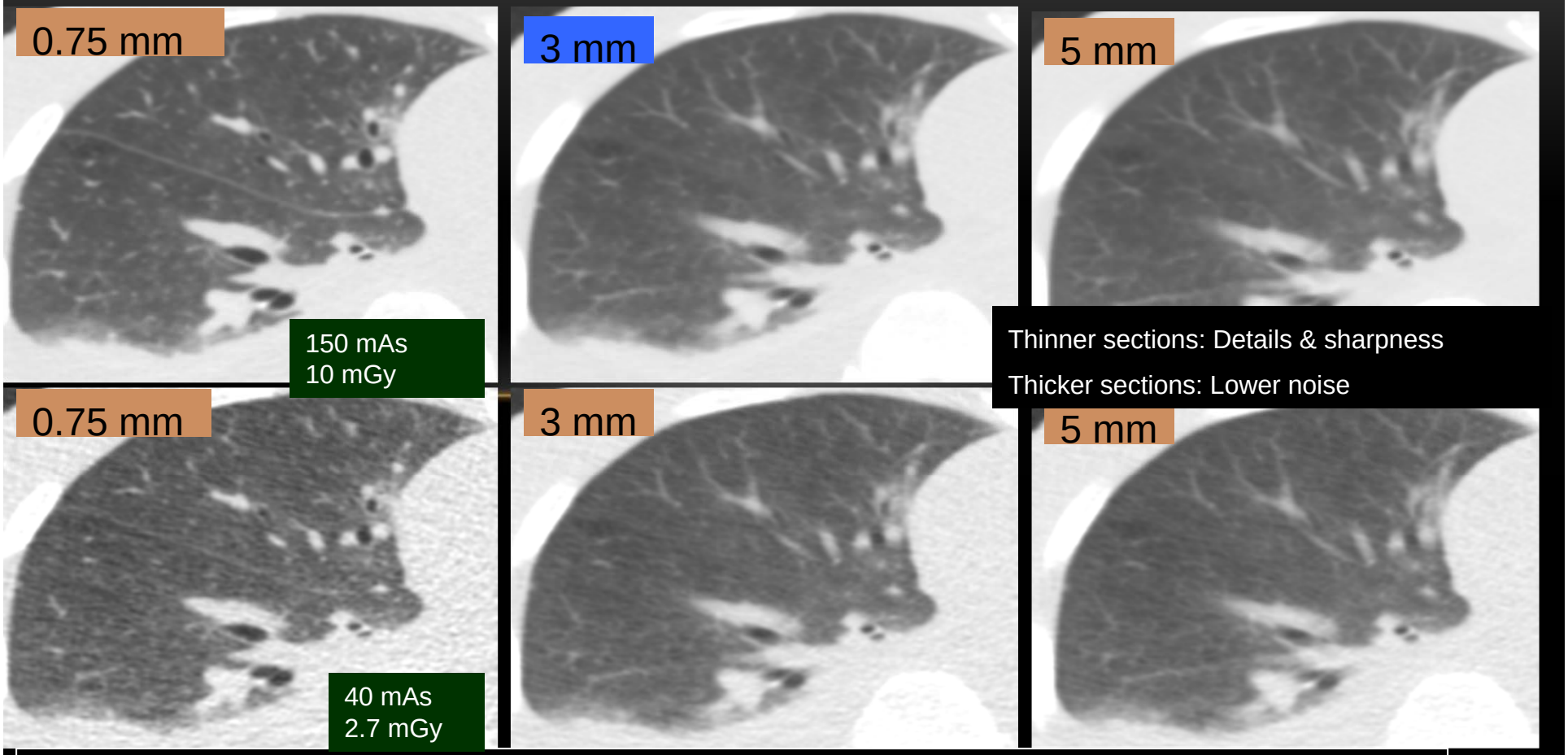
EXCEPTIONS:

- Large patient: lower pitch
- High pitch scanning on DS-CT
  - CTA of heart, Pulmonary A. and V.
  - Pediatric CT chest, spine

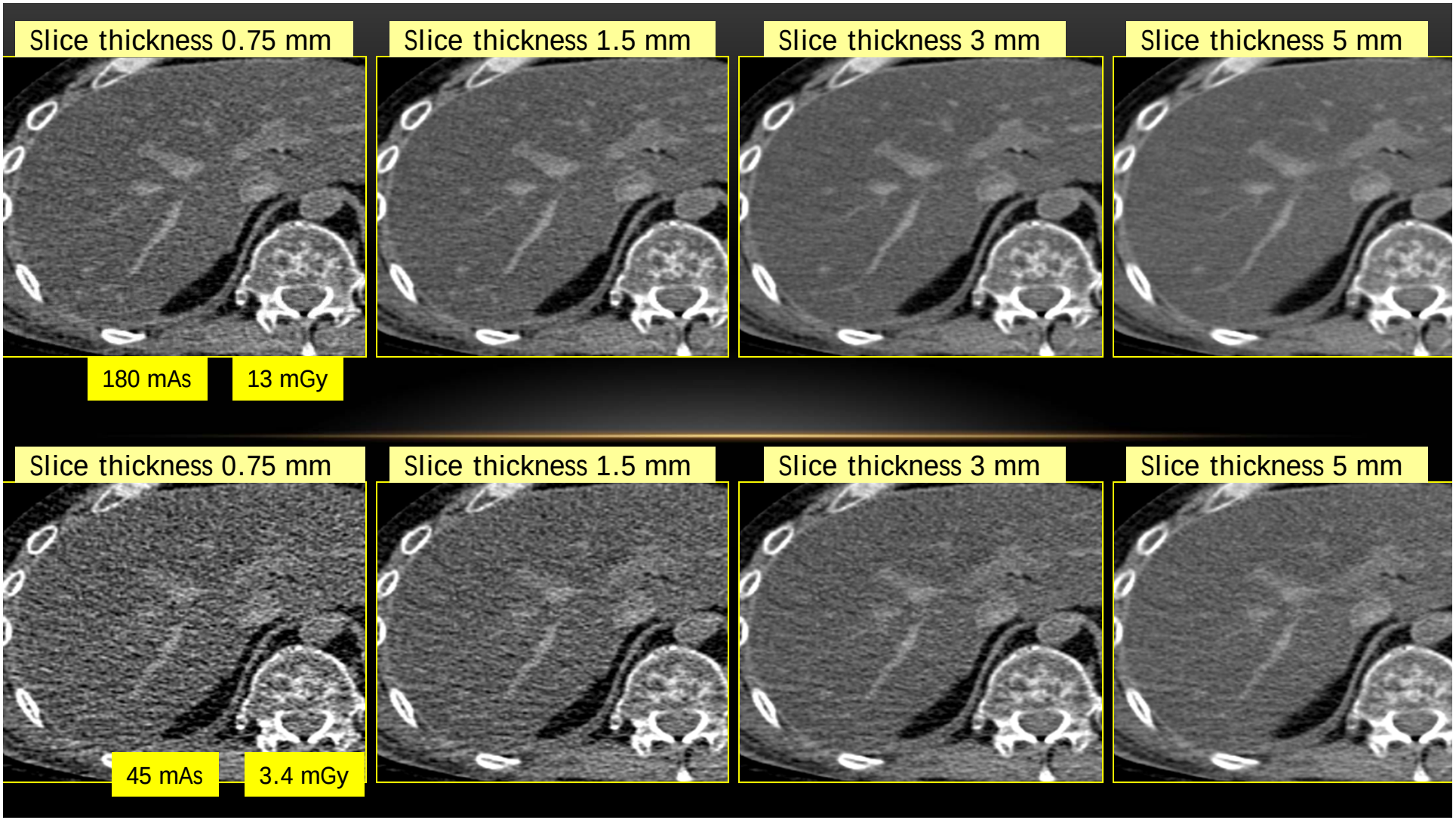
Scan Phases and Section Thickness

- Scan series : Generally 1 series enough
  - No non-contrast CT before post contrast images
  - Diffuse lung Dz: low dose helical or same dose Axial (sequential)
  - Tracheal protocol: Use lower dose overall, esp. expiration
- Slice thickness: Acquire thin, reconstruct thick and MPR
  - Beware of some scanners where prospective slice thickness is linked to mAs with AEC

Chest CT at various image thickness



Acquire thin images but read off the thick images to reduce noise in low dose images.

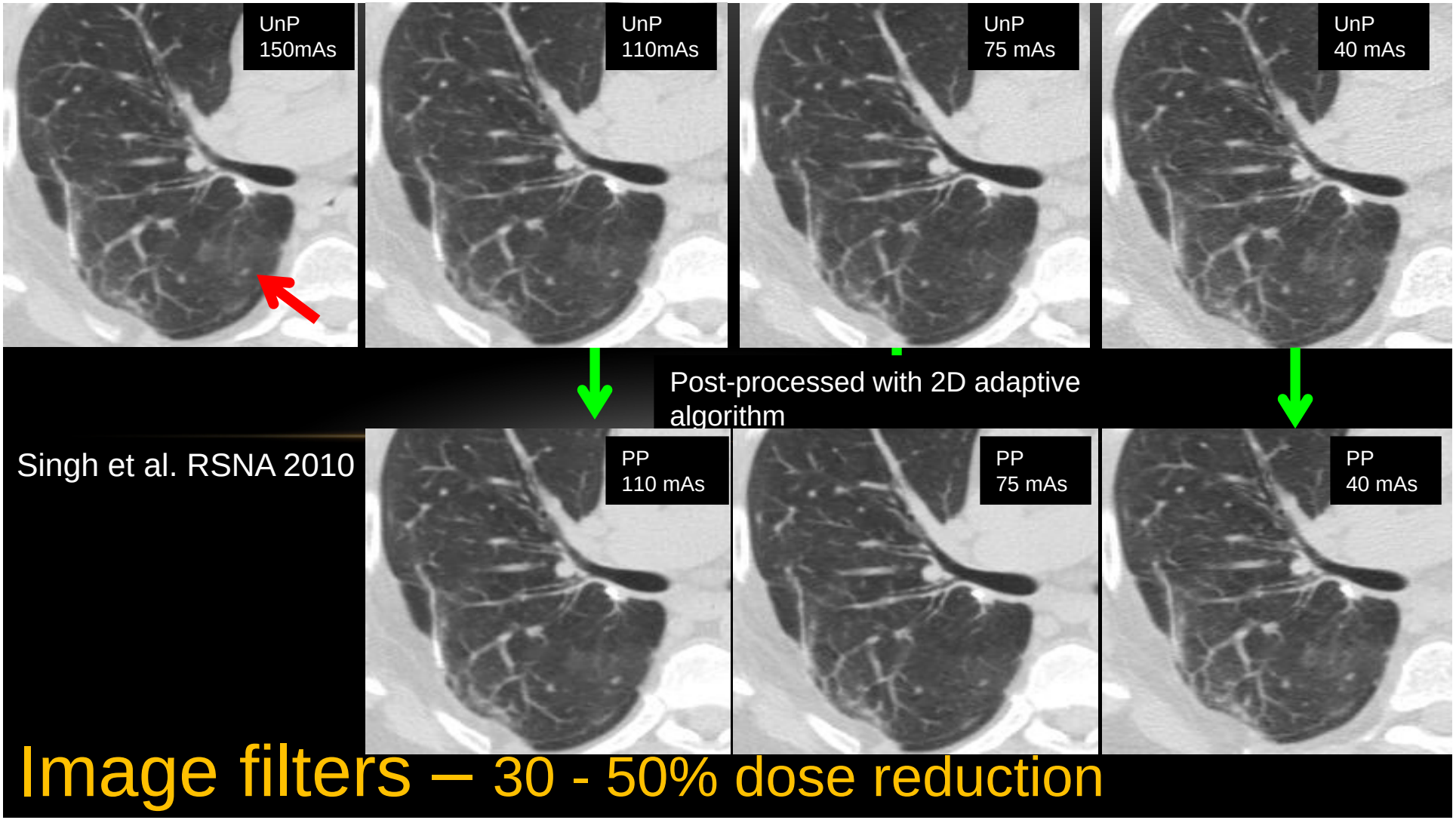

Slice thickness 0.75 mm
Slice thickness 1.5 mm
Slice thickness 3 mm
Slice thickness 5 mm
180 mAs
13 mGy
Slice thickness 0.75 mm
Slice thickness 1.5 mm
Slice thickness 3 mm
Slice thickness 5 mm
45 mAs
3.4 mGy

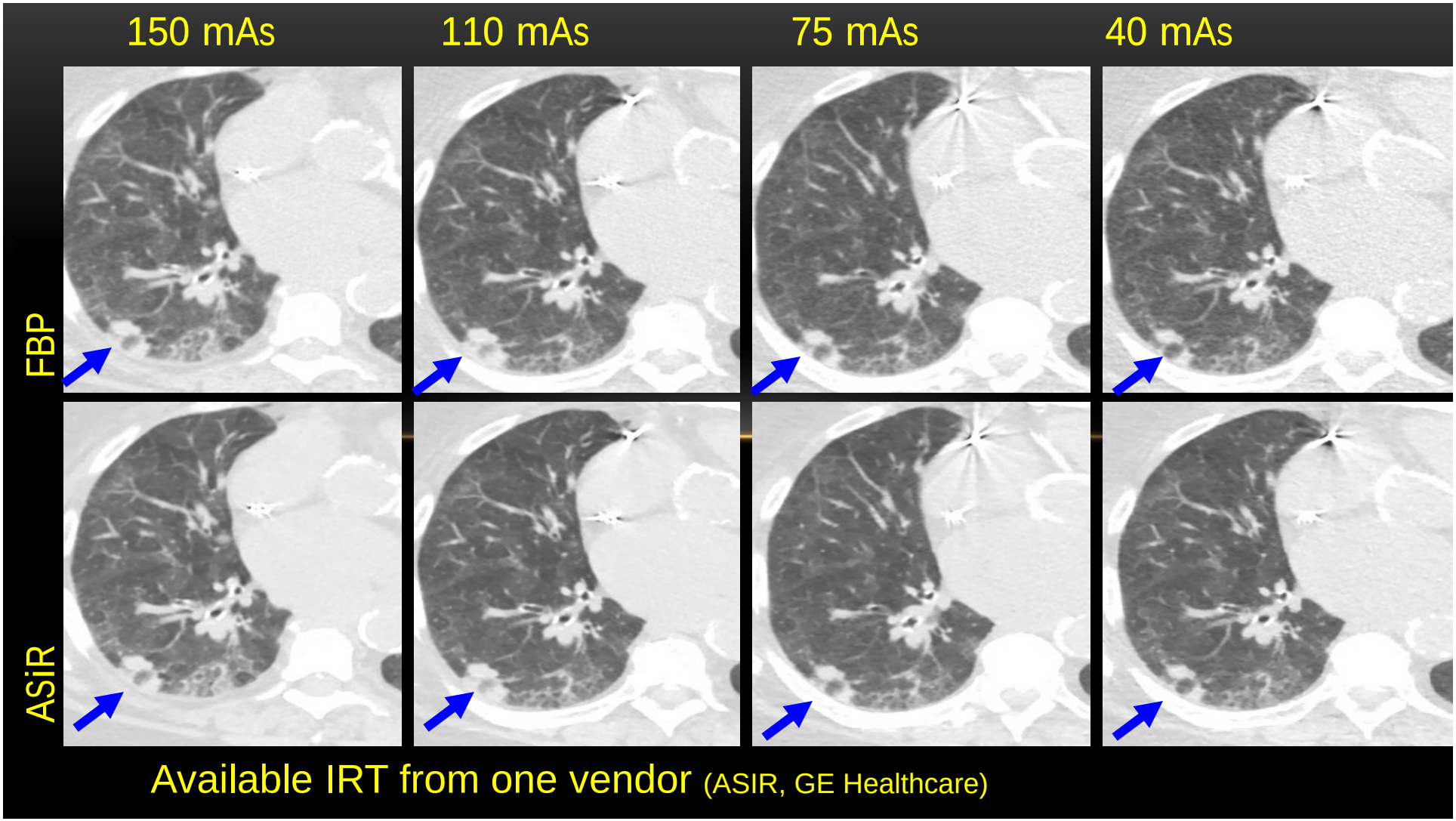
Dose and Reconstruction Algorithms

- FBP reconstruction algorithm
  - Higher image noise
  - Lower artifact suppression
- Newer Iterative Reconstruction algorithm
  - Lowers image noise as well as artifacts
  - Up to 30 - 50% dose reduction

Dose and Reconstruction Technique

- Filtered back projection (FBP)
  - Higher image noise
  - Lower artifact suppression
- Iterative Reconstruction algorithm
  - Lowers image noise as well as artifacts
  - At least 30 - 50% dose reduction: mAs &/ KV reduction
  - Allows lower kV as well (more patients at 80 and 100 kV)


UnP
150mAs
UnP
110mAs
UnP
75 mAs
UnP
40 mAs
Post-processed with 2D adaptive algorithm
Singh et al. RSNA 2010
PP
110 mAs
PP
75 mAs
PP
40 mAs
Image filters – 30 - 50% dose reduction


150 mAs
110 mAs
75 mAs
40 mAs
FBP
ASiR
Available IRT from one vendor (ASIR, GE Healthcare)

Dose summary: Indication driven protocols

Lowest Dose	Intermediate Dose	Routine Chest
Lung nodule follow up	CT pulmonary angiography	Rule out indications
Emphysema		Lung cancer
Lung cancer evaluation		Metastases work up
Bones		Mediastinal LNs
Pleural effusions		Very large patients
Tracheal evaluation		
Bronchiectasis (CF)		
Benign lung disease FU		
Very low mAs	**80-100 kVp: Most patients**	**120 kVp**
	120 kVp: Large patients	**3-8 mGy CTDI Vol**

Summary: Chest CT dose reduction

- Chest CT can be done at substantially lower dose
- Appropriate CT indication comes first for dose reduction
- Appropriate scan protocols come second
- Newer techniques will help cut the dose even further

Questions, Handouts, Concerns or Protocols : E-mail

mkalra@partners.org