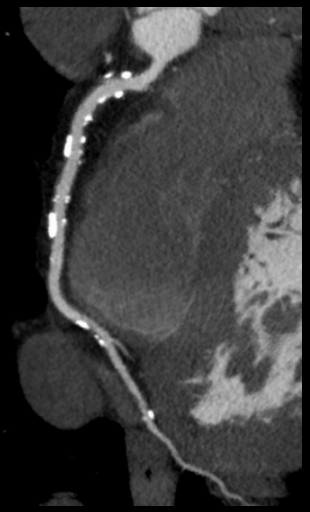
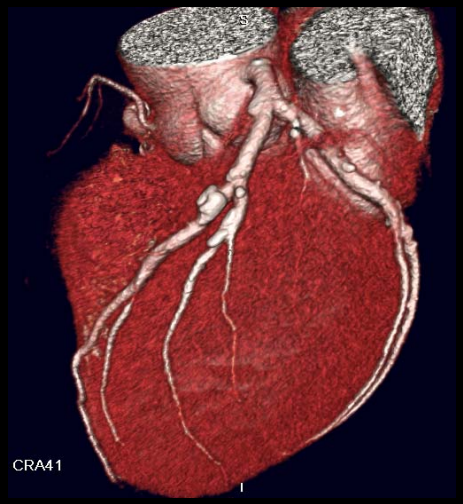
Success Story and Lessons Learned: The Order of Magnitude Reduction in Cardiac CT Dose





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Rybicki Disclosures (2011)

Dr. Rybicki is the recipient of grant support from Toshiba Medical Systems Corporation, Bracco Diagnostics, and Vital Images

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Stephen Ledbetter · Frank P. Castronovo ·
Philip F. Judy · Frank Rybicki

Emerg Radiol (2006) 12: 133-136

Lowering the thyroid dose in screening examinations of the cervical spine

Received: 1 September 2005 005 / Published online: 16 December 2005

Abstract The first objective of this study was to test the hypothesis that a lower-dose (14.1 mGy thyroid dose) protocol for helical c of the entire cervical spine chnical adequacy and diagno rd-dose protocol (26.0 mGy tl

The second objective was to estimate the excess thyroid cancer mortality for three cervical spine screening proto-cols.

.8 mGy
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hasizes
eferring
clinical

etry

Table 1 Estimates of excess thyroid cancer mortality per 100,000 patients for three cervical spine screening examinations stratified by age and sex

35	60.6	48.6	32.9	26.4	4.2	3.4
45	30.4	26.0	16.5	14.1	2.1	1.8
55	10.9	11.7	5.9	6.3	0.7	0.8
65	1.8	4.2	1.0	2.3	0.1	0.3

Three principles in lowering radiation dose

- Decrease the exposure time
- Decrease the exposure per unit time
- Efficiently use exposure data

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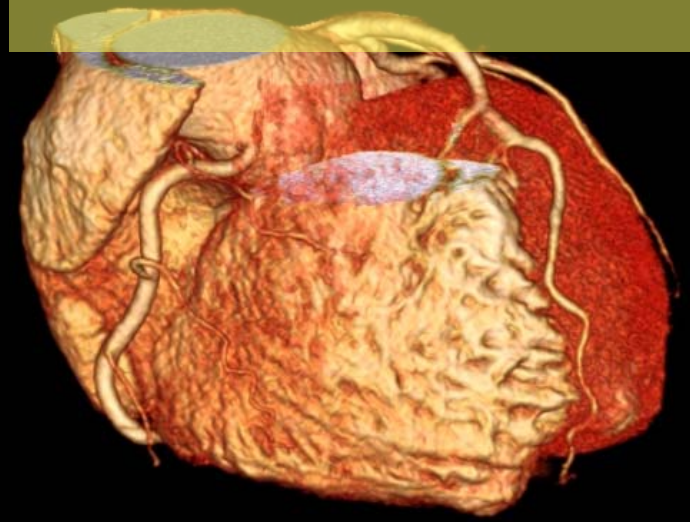
64 Slice Helical

64 Slice

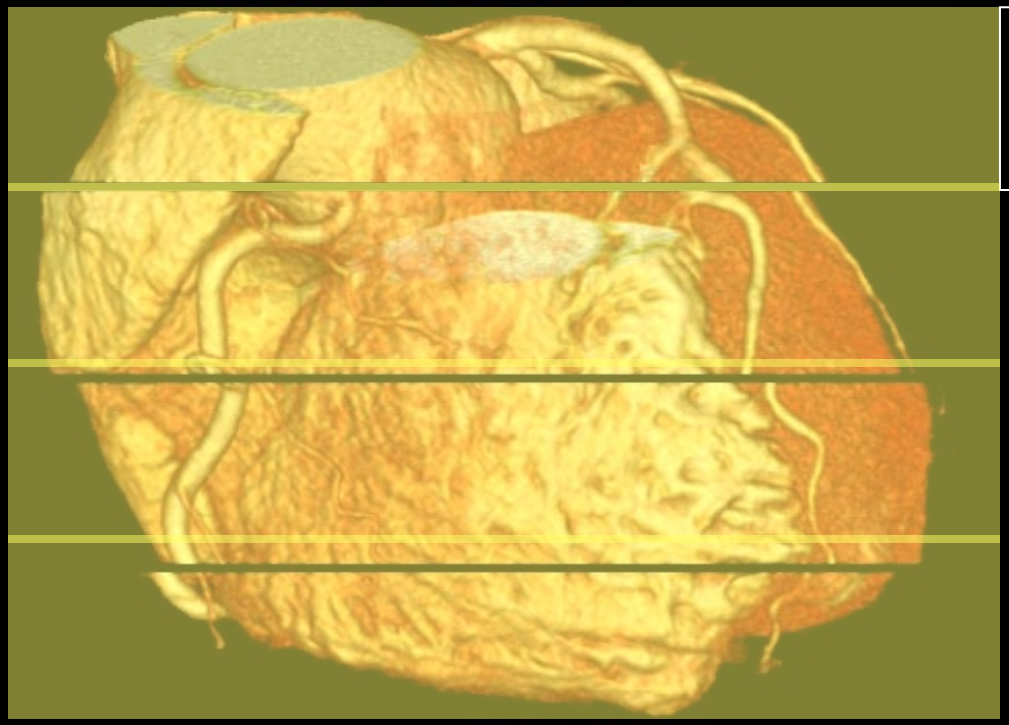


Exposure

~15 mSv

Hausleiter J, Meyer T, Hermann F, et al. JAMA 301(5): 500-507, 2009

Prospective ECG gating – multi R-R

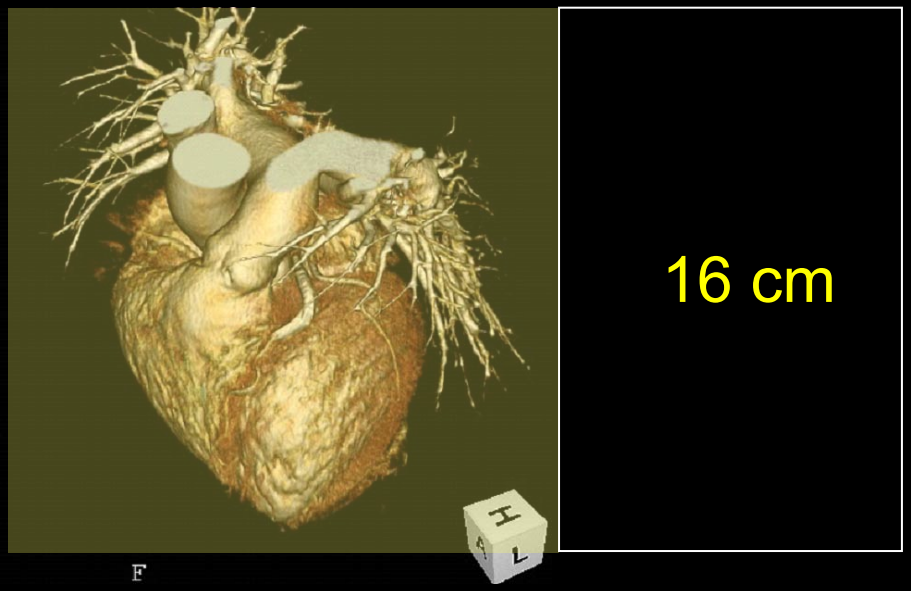


64 Detector

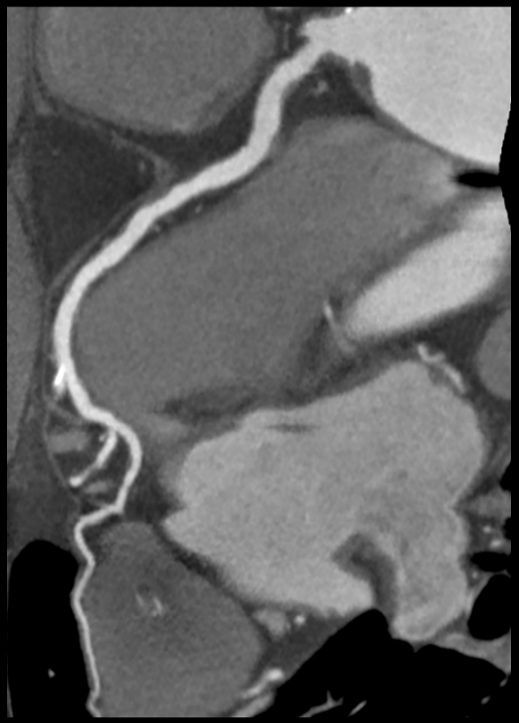
- No functional information

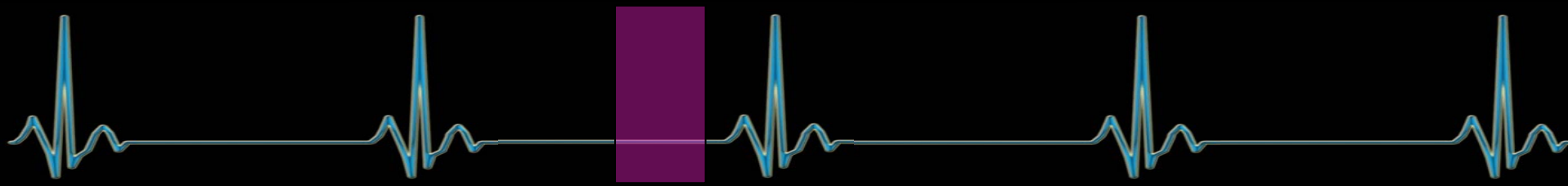
Earls JP, Berman EL, Urban BA, et al. Radiology 2008;246:742–53

Prospective ECG gating – Single R-R, method 1



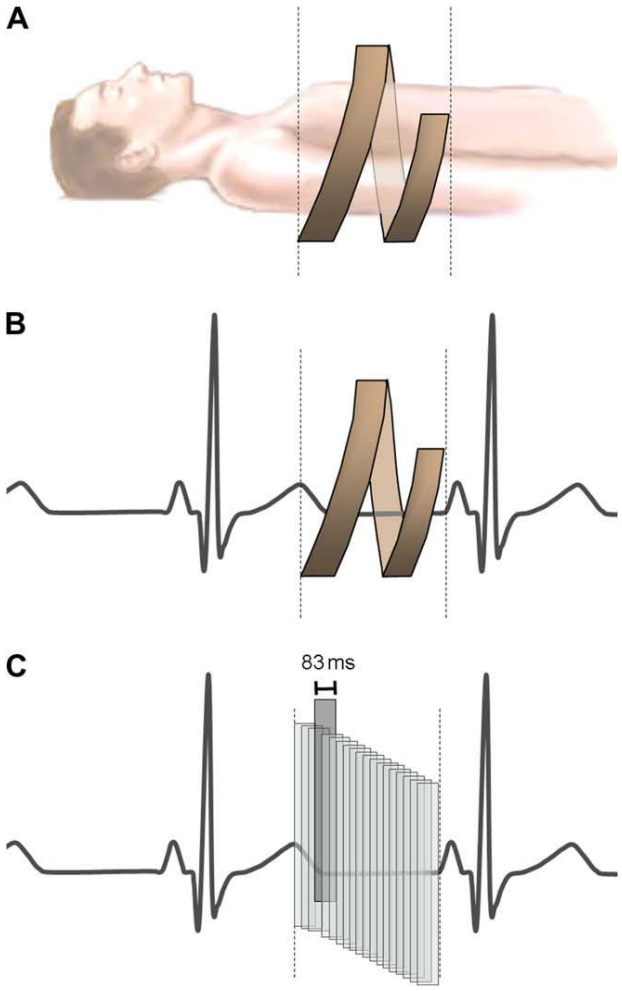
16 cm





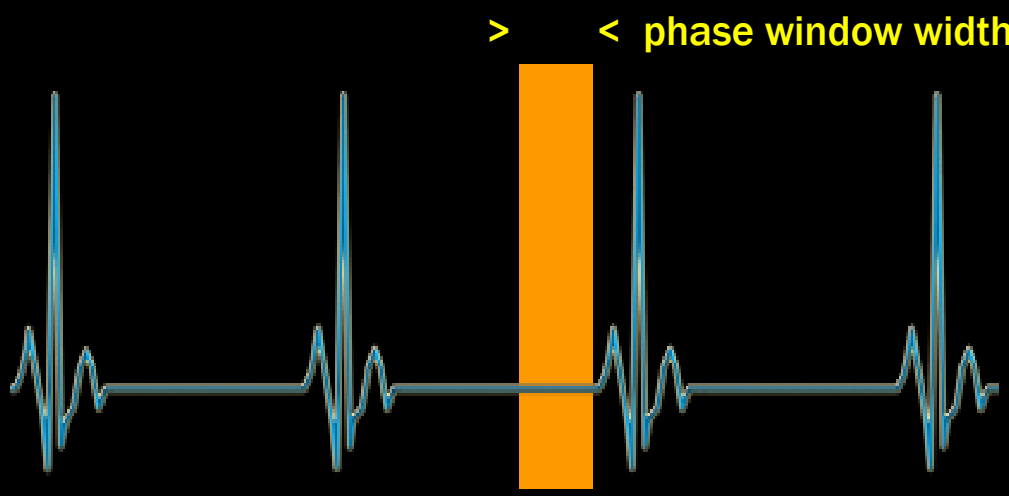
Rybicki FJ, Otero H, Steigner ML et al. Int J of Cardiovascular Imaging 24:535-46, 2008

Prospective ECG gating – Single R-R, method 2



Achenbach S, Marwan M, Schepis T et al. J Cardiovascular CT 3:117-21, 2009

Lowering the exposure within each R-R



Width	RCA	LAD	LCX	All 3
1%	70	87	91	65
10%	96	97	99	93
20%	97	98	99	93
35%	100	100	100	100

15 mSv

↓

3 mSv

Steigner ML, Otero HJ, Cai T et al. International Journal of Cardiovascular Imaging 25: 85-90, 2009

Three principles in lowering radiation dose

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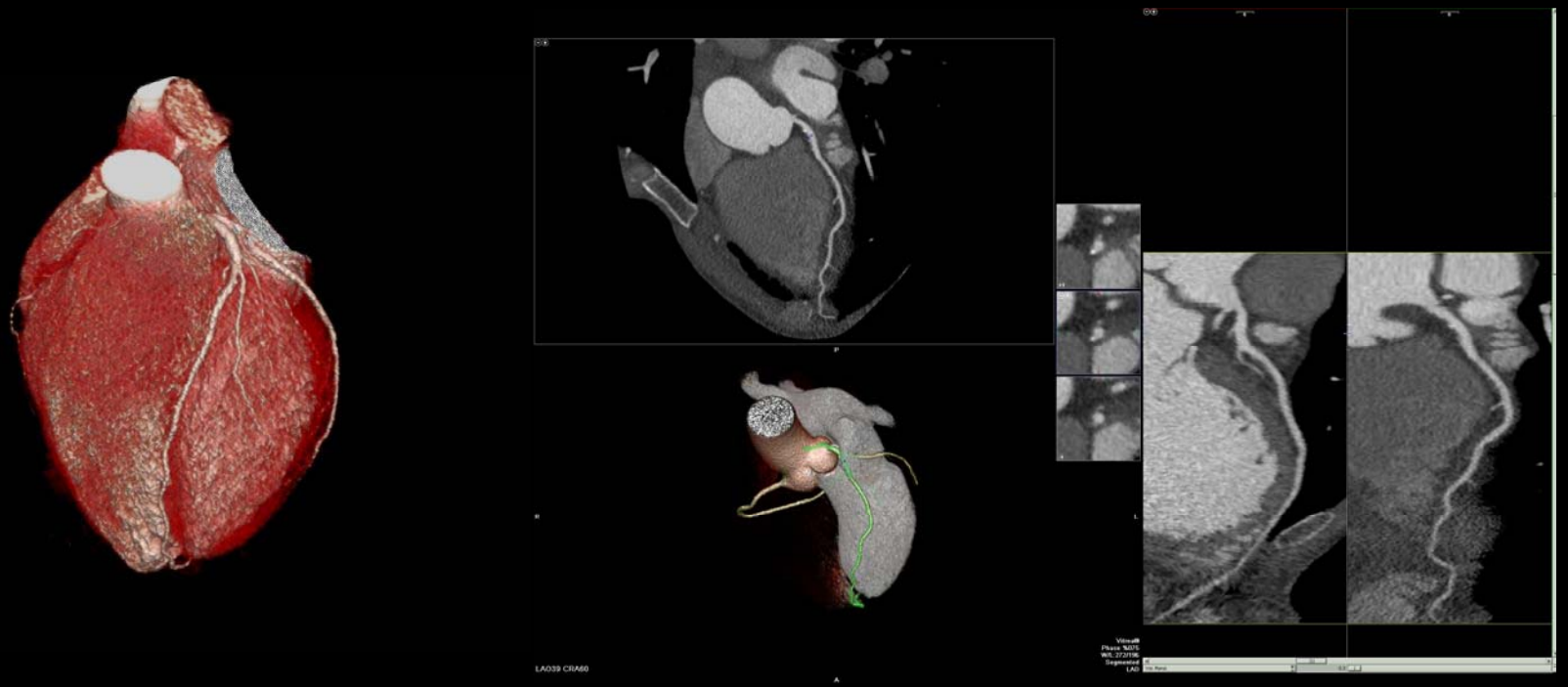
Decisions made by the scanner: adjustments to individual body habitus

x - y tube current modulation: more photons in the lateral than in the AP direction

z tube current modulation: more photons in the shoulders and pelvis than in lung

... not universally used for cardiac imaging

Decisions made by the imager: 100 kV imaging



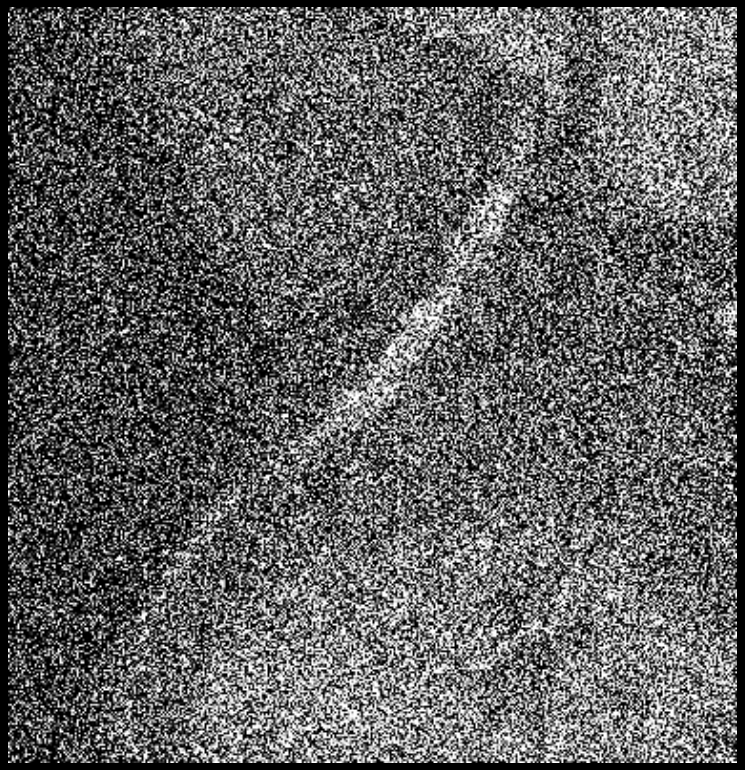
1.6 mSv

Really lowering the # of Photons Per Unit time

12 month old
0.05 mSv

Courtesy of Armed Police Forces Center, Beijing, China

Step on the “dose breaks” carefully



Reference image

Reduced-Dose CT: Effect on Reader Evaluation in Detection of Pulmonary Embolism

John D. MacKenzie[1,2]
Javier Nazario-Larrieu[1,3]
Tianxi Cai[4]
M. Stephen Ledbetter[1]
Maria Alejandra Duran-Mendicuti[1]
Philip F. Judy[1]
Frank J. Rybicki[1]

MacKenzie JD, Nazario-Larrieu J, Cai T, et al.

OBJECTIVE. The purpose of this study was to evaluate the effect of reduction in radiation dose on CT detection of pulmonary embolism.

SUBJECTS AND METHODS. Emergency department patients were evaluated for pulmonary embolism with standard and simulated reduced-dose CT angiography. Simulated lower-dose CT angiograms obtained at 90, 45, 22, and 10 mAs_{eff} were reconstructed by mathematical addition of noise to the standard dose (180 mAs_{eff}) data from the images of 18 patients with and 20 patients without pulmonary embolism. Four radiologists blinded to the study parameters separately interpreted each CT angiogram. Dose trends for subjective measures (diagnostic certainty, image quality, and perceived technical limitations) were evaluated, test characteristics for the detection of pulmonary embolism were computed, and clot burden was

CONCLUSION. Reduction in dose for CT angiography in the detection of pulmonary embolism has a significant adverse effect on readers' subjective assessment of diagnostic confidence and image quality. Detection of pulmonary embolism also decreases as the tube current dose is reduced.

significantly. The sensitivity was 0.94 (lower bound of 0.95 CI, 0.92), specificity, 0.99 (lower bound of 0.95 CI, 0.98); positive predictive value, 0.95 (lower bound of 0.95 CI, 0.92); and negative predictive value, 0.99 (lower bound of 0.95 CI, 0.97). All patients had a low to moderate clot burden.

CONCLUSION. Reduction in dose for CT angiography in the detection of pulmonary embolism has a significant adverse effect on readers' subjective assessment of diagnostic confidence and image quality. Detection of pulmonary embolism also decreases as the tube current dose is reduced.

Keywords: CT, CT angiography, pulmonary artery, pulmonary embolism, radiation dosage

DOI:10.2214/AJR.07.2686

Lesson #1

Use minimum necessary radiation

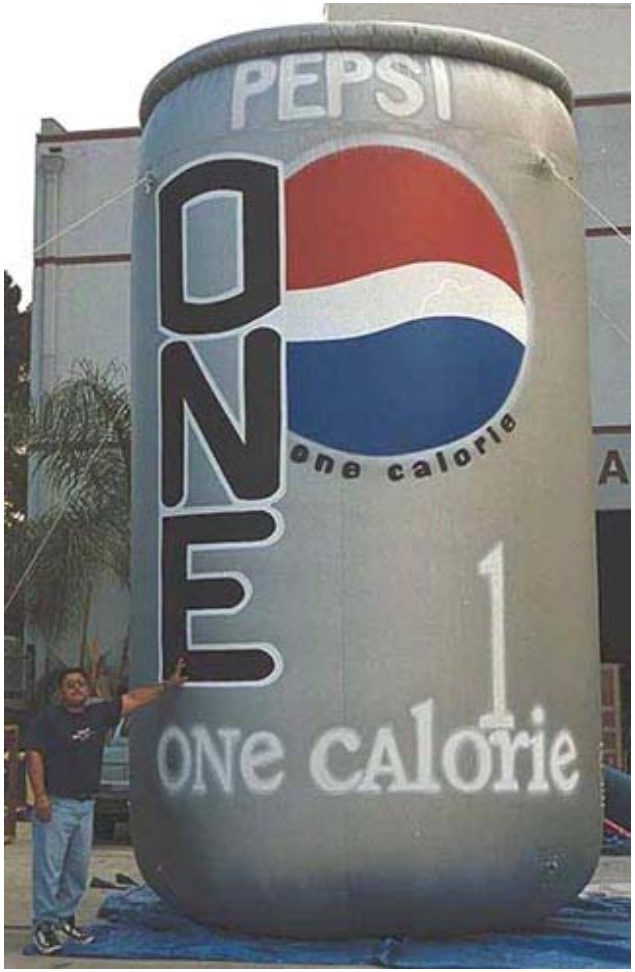
to provide clinically relevant information

for accurate interpretation

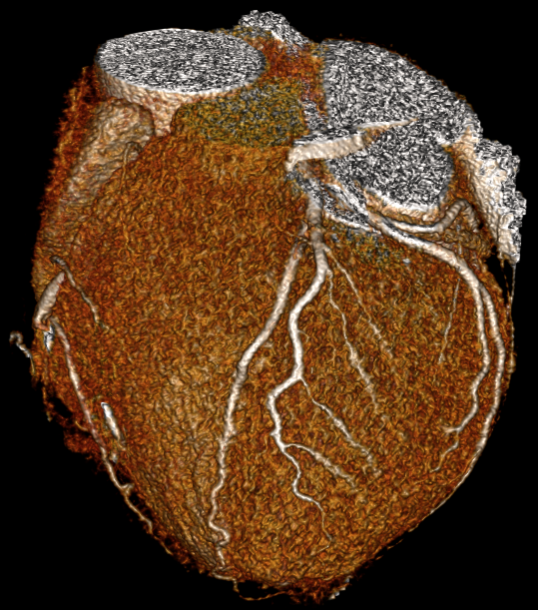
1 mSv charges

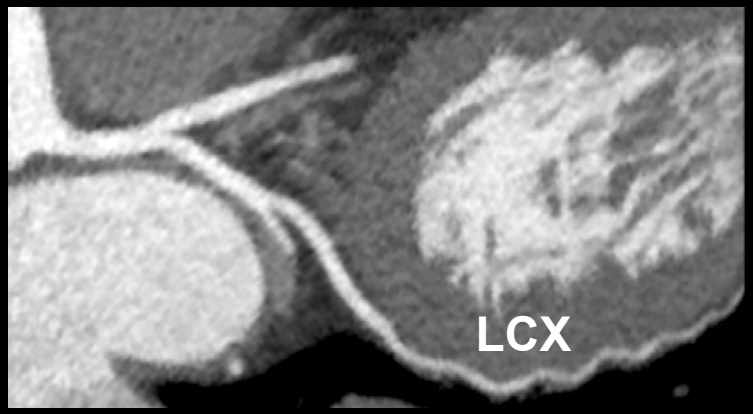
* Mean dose reduction of 7.1 to 1.0 mSv

* 95% of all doses < 1.0 mSv



0.7 mSv





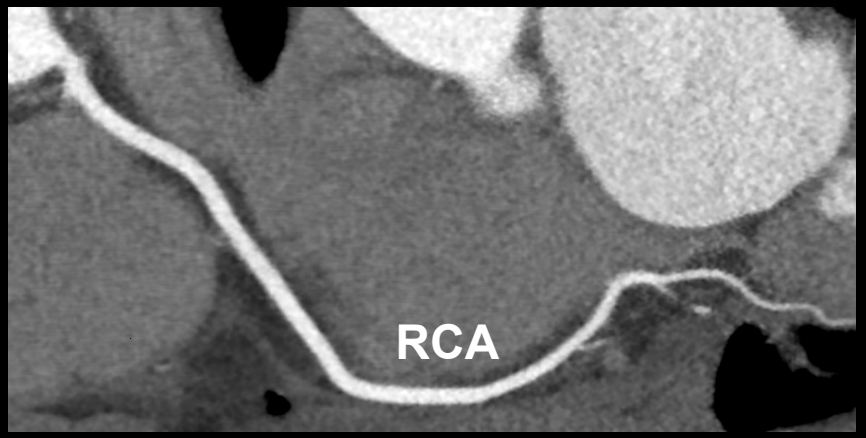
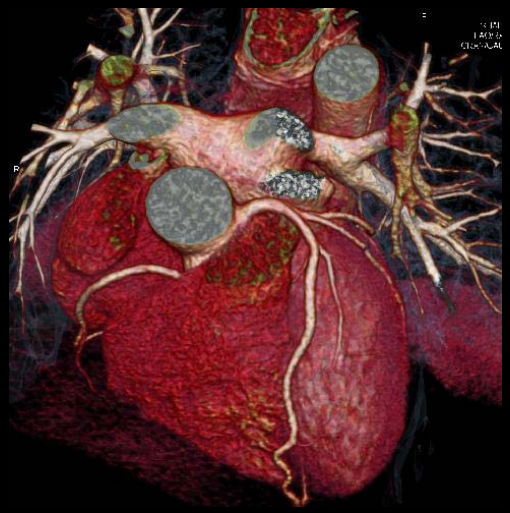
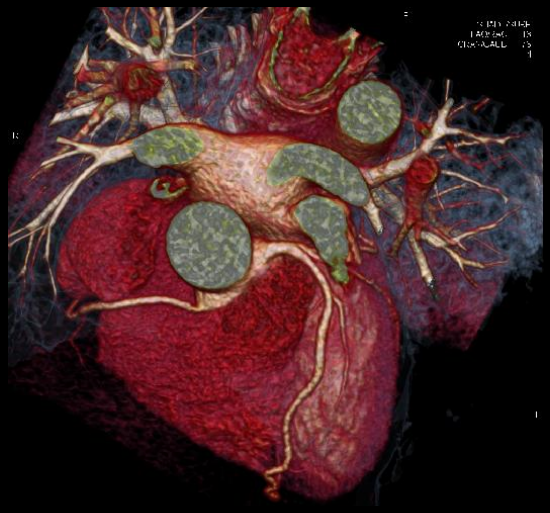


Image Courtesy Marcus Chen and Andrew Arai

80 kV, 300 mAs





0.36 mSv

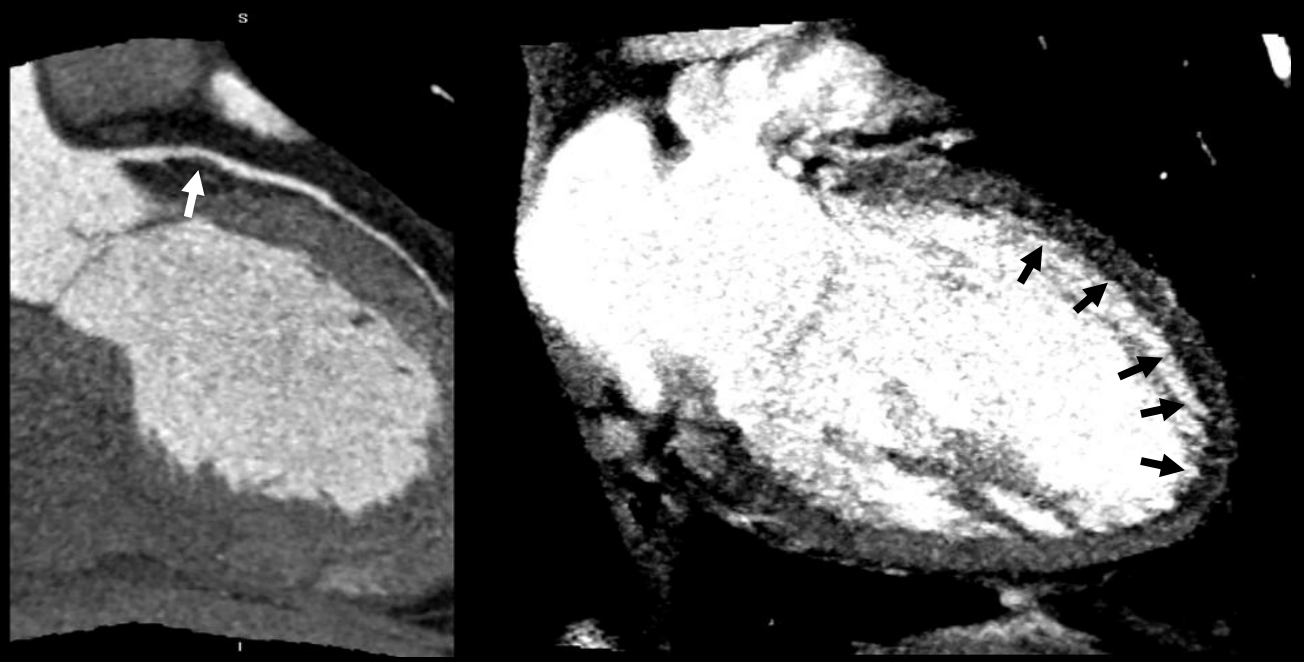
Courtesy of Sir Run Run Shaw University HongKong / HongKong, China

How much radiation is it “worth” to get perfusion data out of your CT scanner?

Myocardial Perfusion

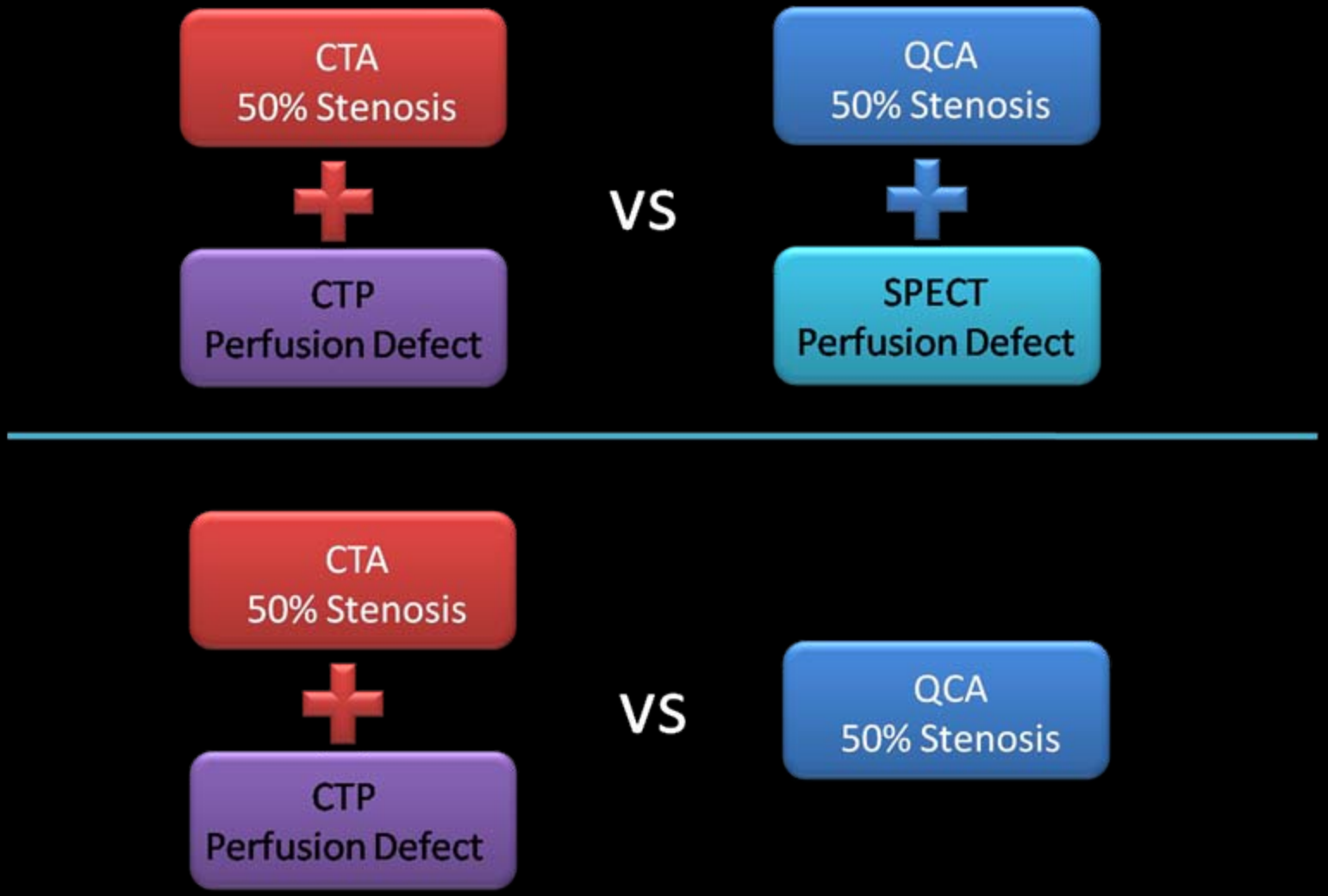
57 yo woman with hypertension and hyperlipidemia complaining of atypical chest pain

adenosine stress CT perfusion imaging



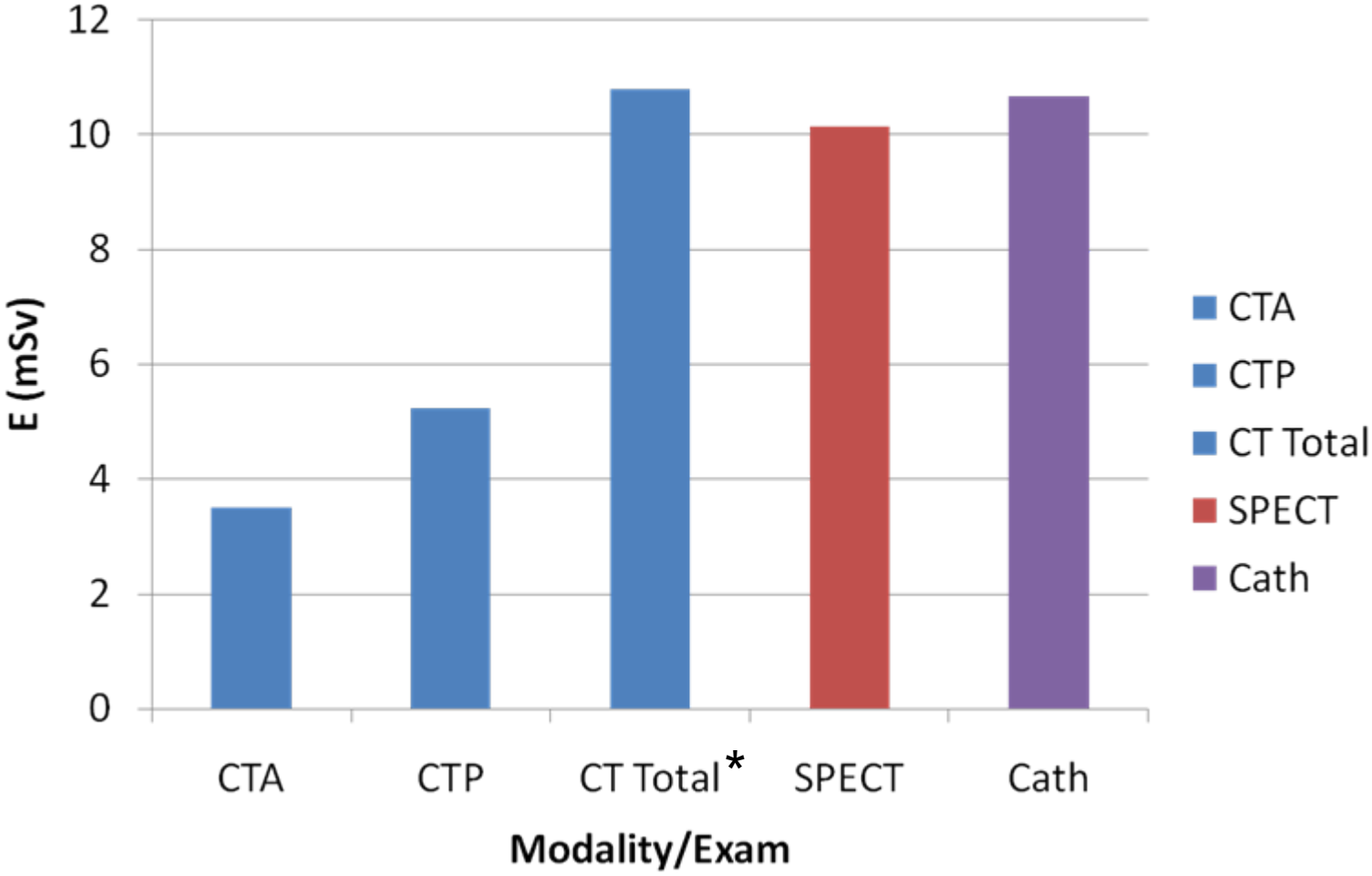
Courtesy of Richard T. George and Joao A.C. Lima, Johns Hopkins University, Division of Cardiology

Core320 Hypotheses



Core320

Effective dose by modality

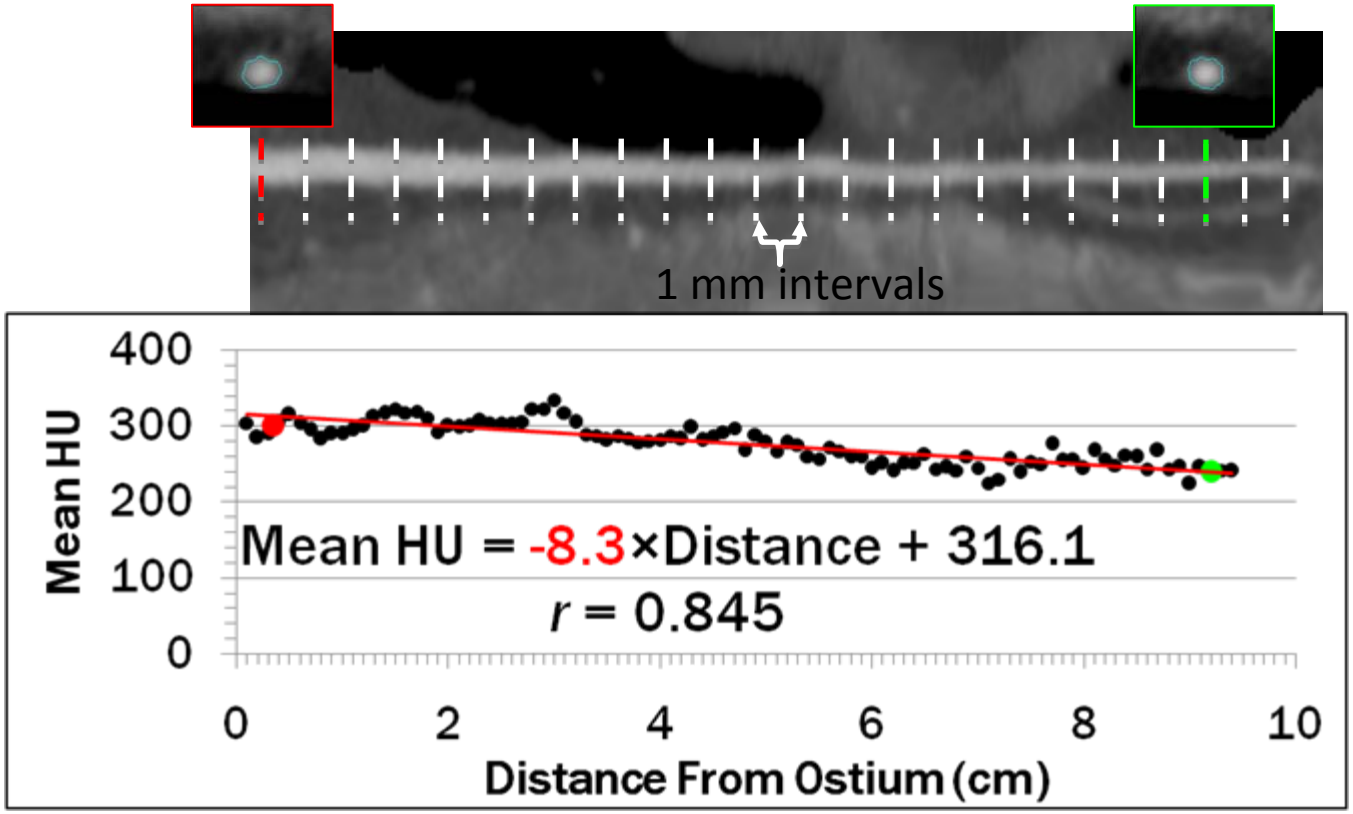


* Includes calcium score, localizers, bolus tracking

Lesson #2

Capitalize on all information that uses no extra radiation

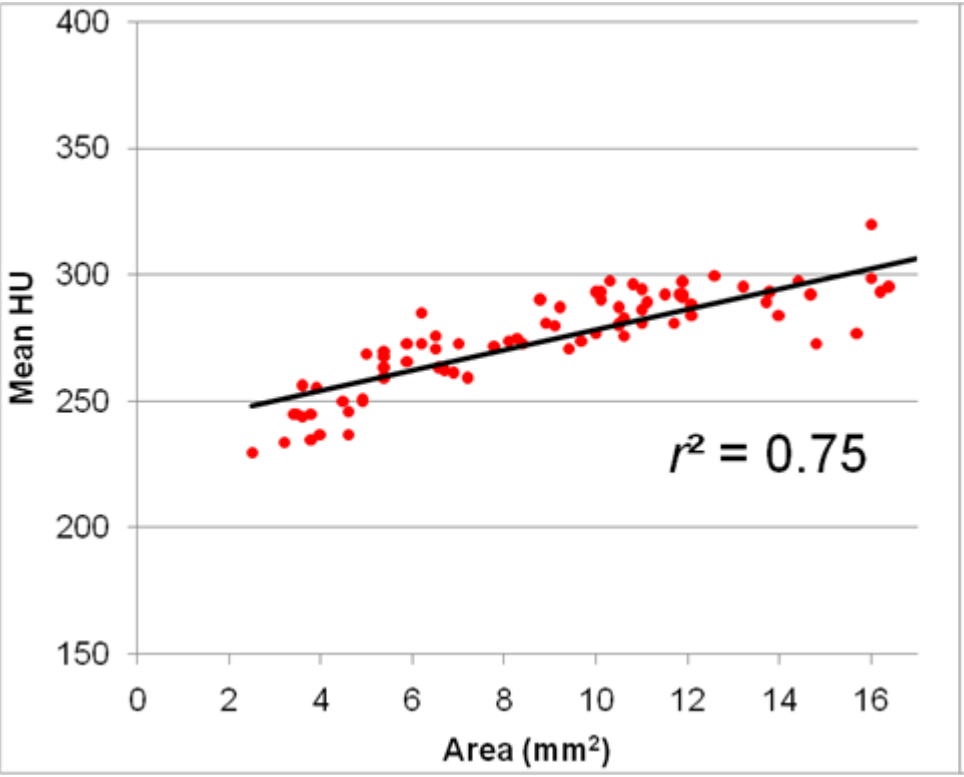
Contrast Opacification Gradients



Steigner ML, Mitsouras D, Whitmore AG et al, Circulation: CV Imaging 2010; 3(2):179-186

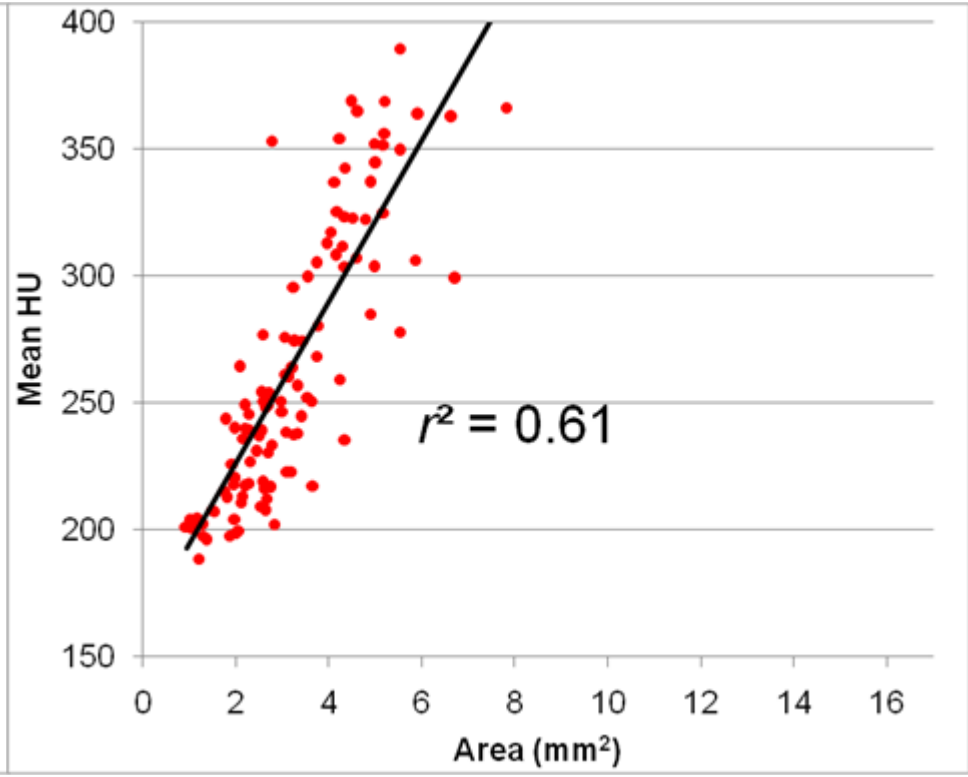
Lumen Area Gradients: NI vs Stenosis

Patient without CAD



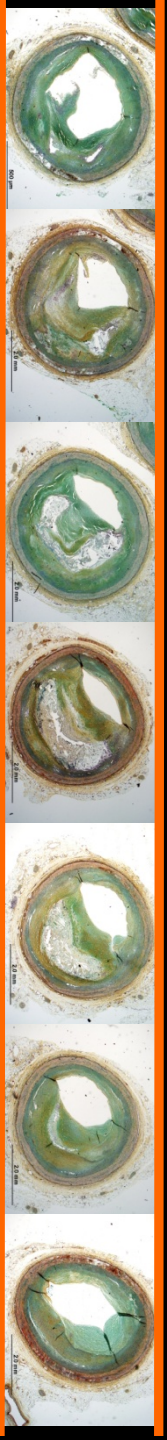
Slope = 4.0 decrease in HU per mm^2 decrease in lumen area

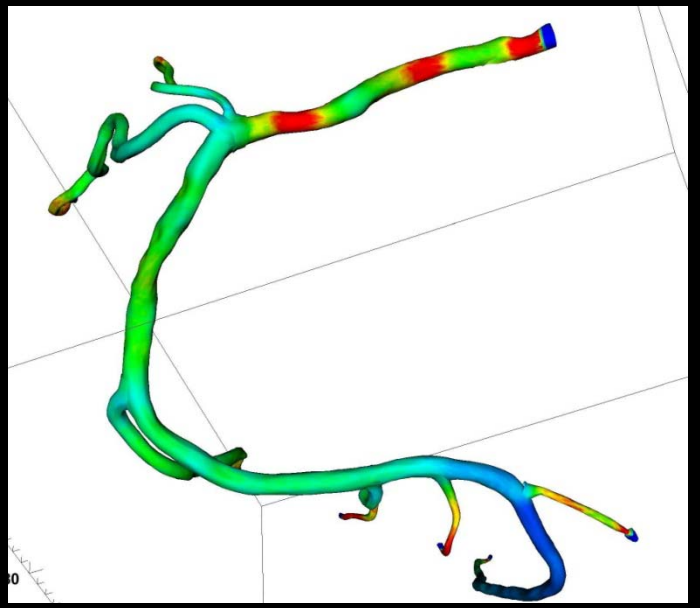
LAD ≥50% stenosis

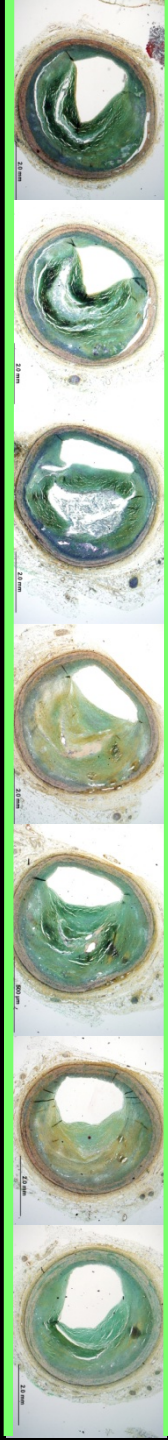


Slope = 31.8 decrease in HU per mm^2 decrease in lumen area

Kumamaru KK, Mitsouras D, Cheung CWS, et al. Manuscript in Review







Steigner ML, Hoffmann U, Mitsouras D, et al. Pilot data from Partners Radiology 2010 award

Three principles in lowering radiation dose

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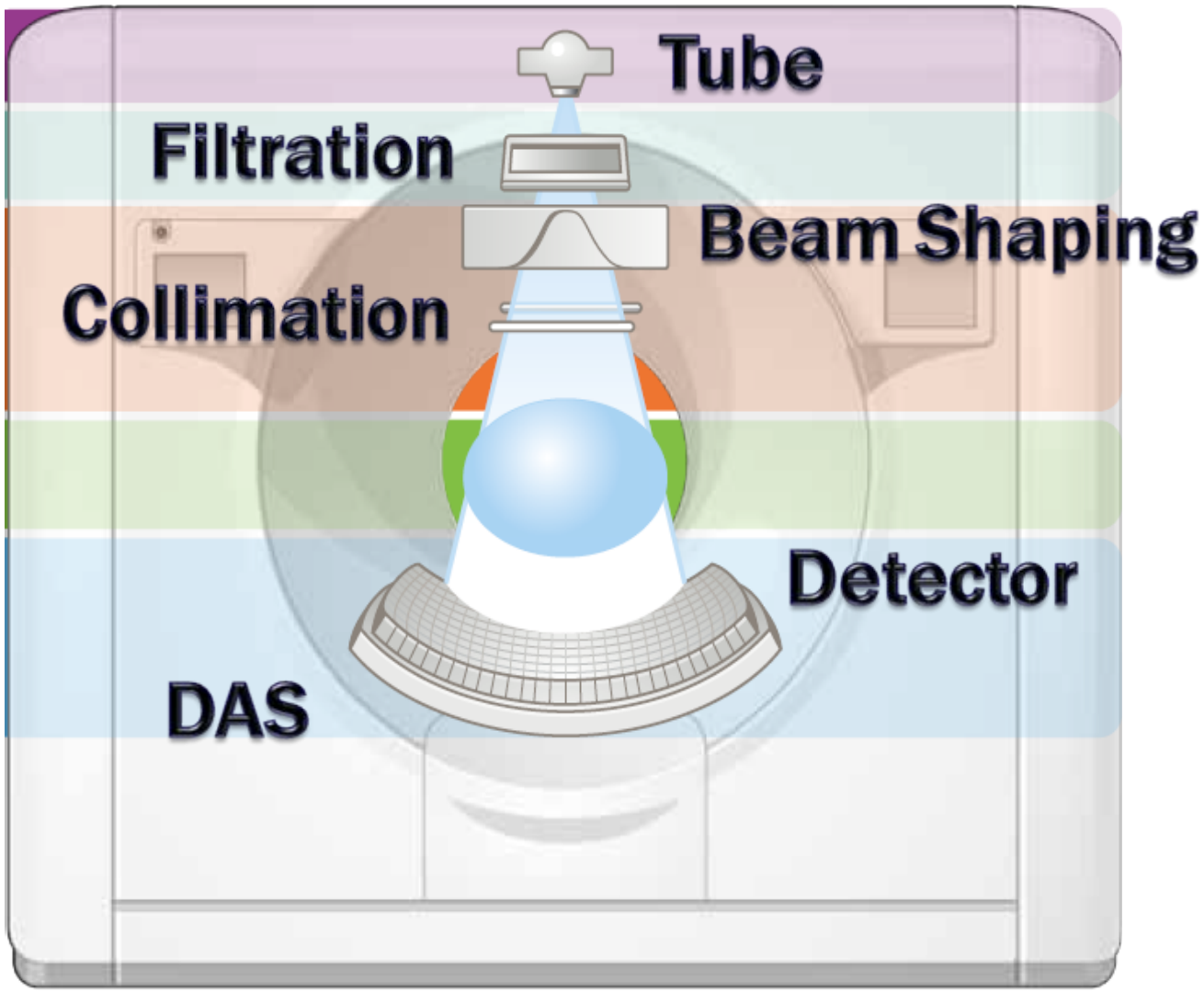
Hardware optimization



Slide Courtesy Mark Olszewski

Software optimization: Iterative Reconstruction

Measured Projection Data

Calibrations, corrections, adaptive noise reduction, log-conversion

Seed

Analytic Reconstruction

Image estimate

Correction data based on differences and noise model

Forward projection

Back-projection

Image Update

No

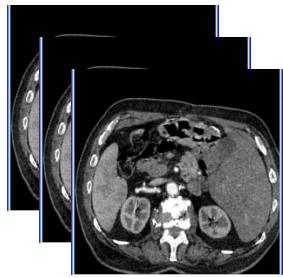
Yes

Good Enough?

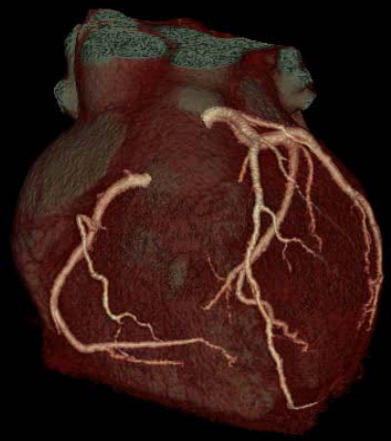
Data Fidelity

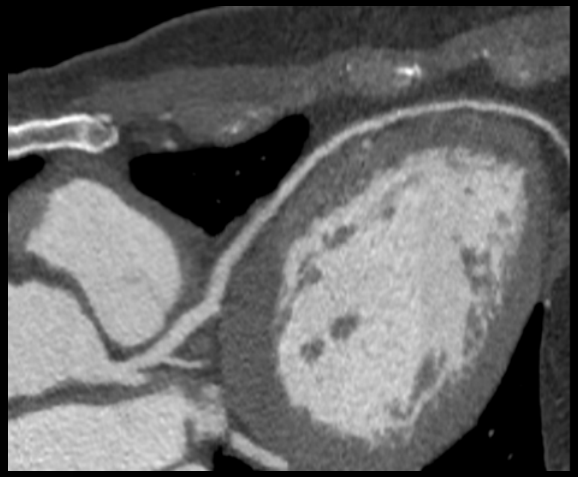
Adaptive Noise Reduction

Regularization



Slide Courtesy Rich Mather





0.75mSv

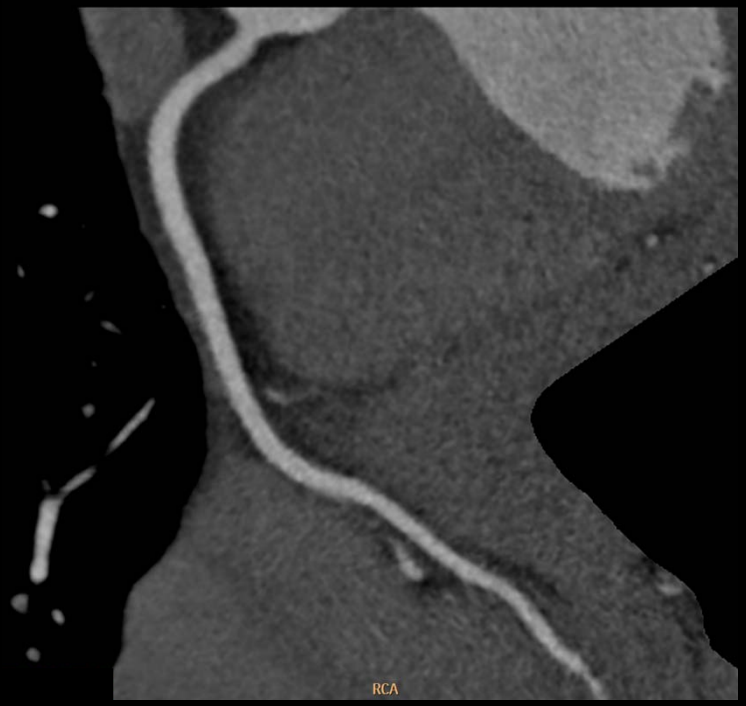
Images courtesy Jonathan Leipsic St. Paul. Vancouver Canada

0.5mSv

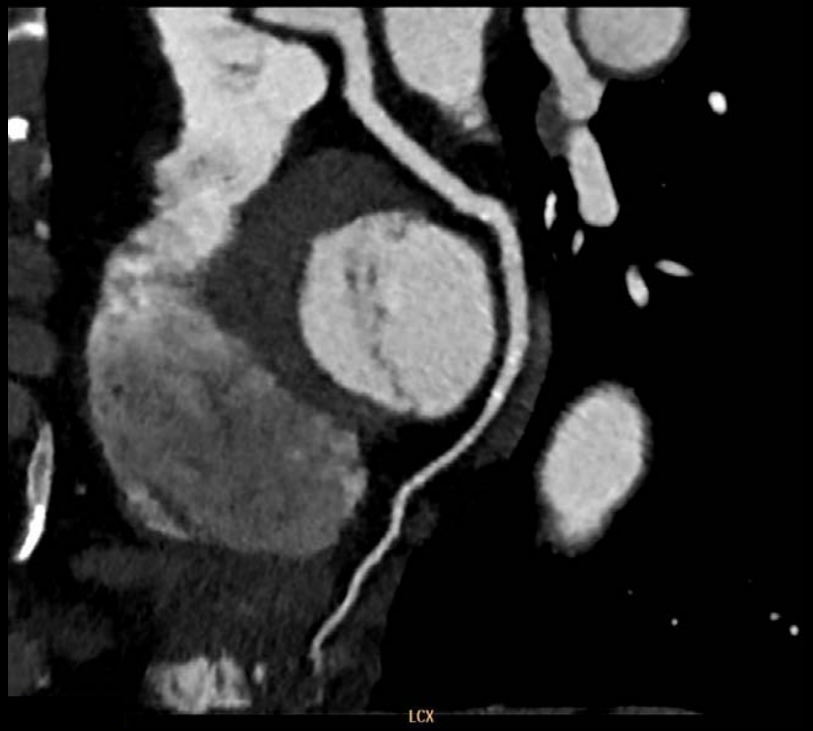
Images Courtesy Jay Earls

Leipsic J, LaBounty TM, Heilbron B et al. AJR 195:655-660 (2010)

Iterative reconstruction: 0.9 mSv



CMPR of RCA



CMPR of LCX

Images Courtesy Guy Weigold

Conclusions

Use minimum necessary *radiation*

to provide clinically relevant *information*

for accurate *interpretation*

Conclusions

Capitalize on all the information that uses no extra radiation

Conclusions

Cardiac CT dose reduction has been a success story. However, we must continue to make intelligent, educated choices regarding radiation dose considerations to provide the best possible patient care.