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Institut und Poliklinik für Radiologische Diagnostik

Clinical Benefit of Spectral CT

Medical Imaging Convention London ExCel 2018 |

David Maintz

Computed Tomography (CT)

1972: EMI CAT Scanner

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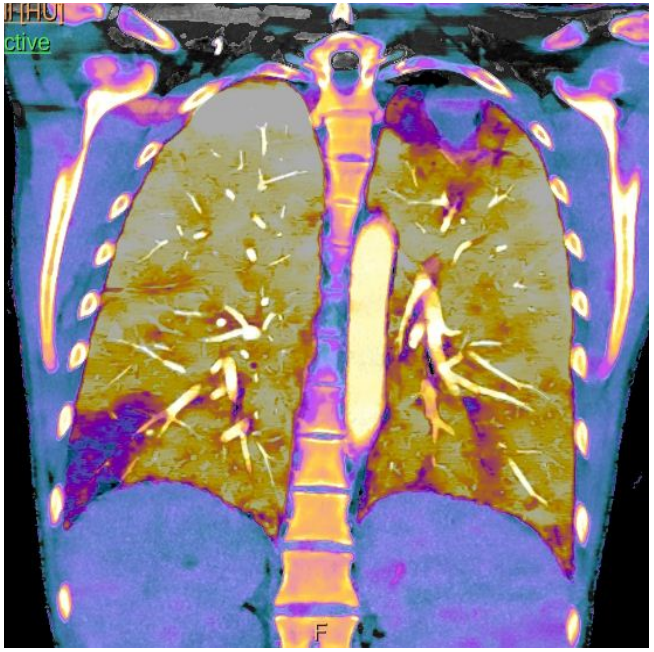
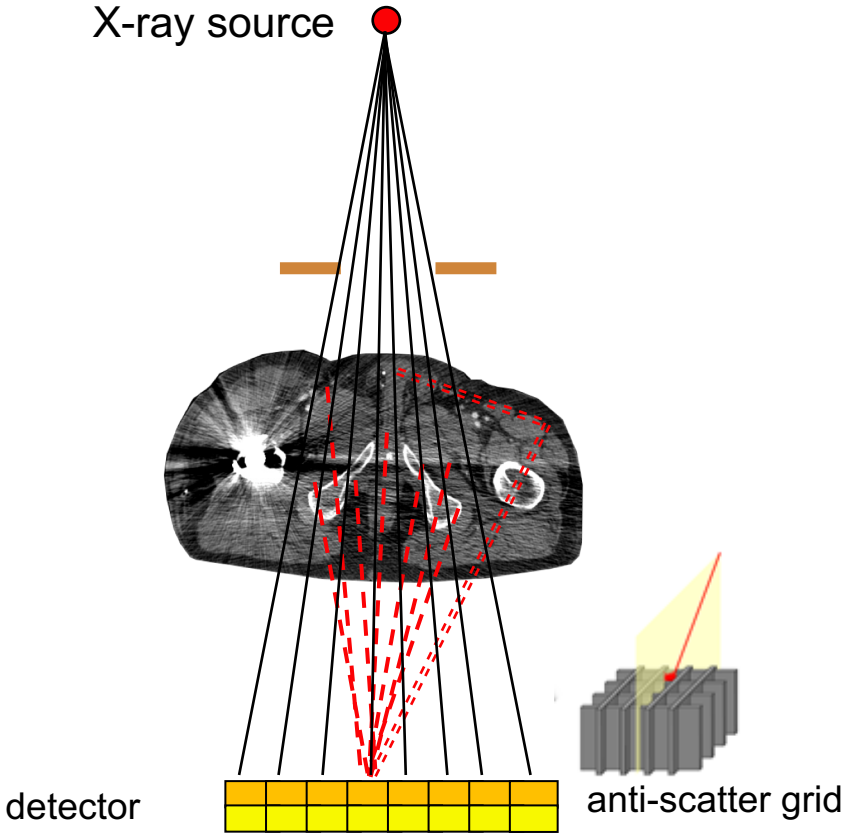
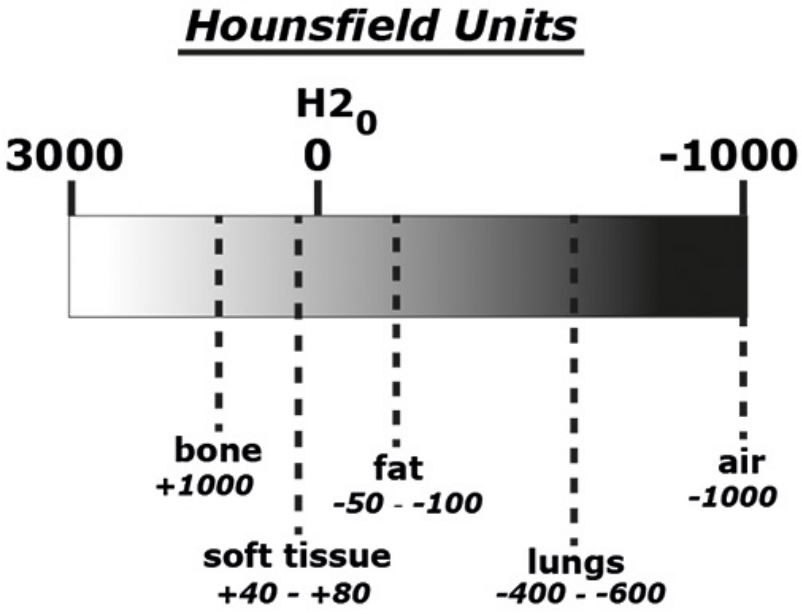
Spectral CT today

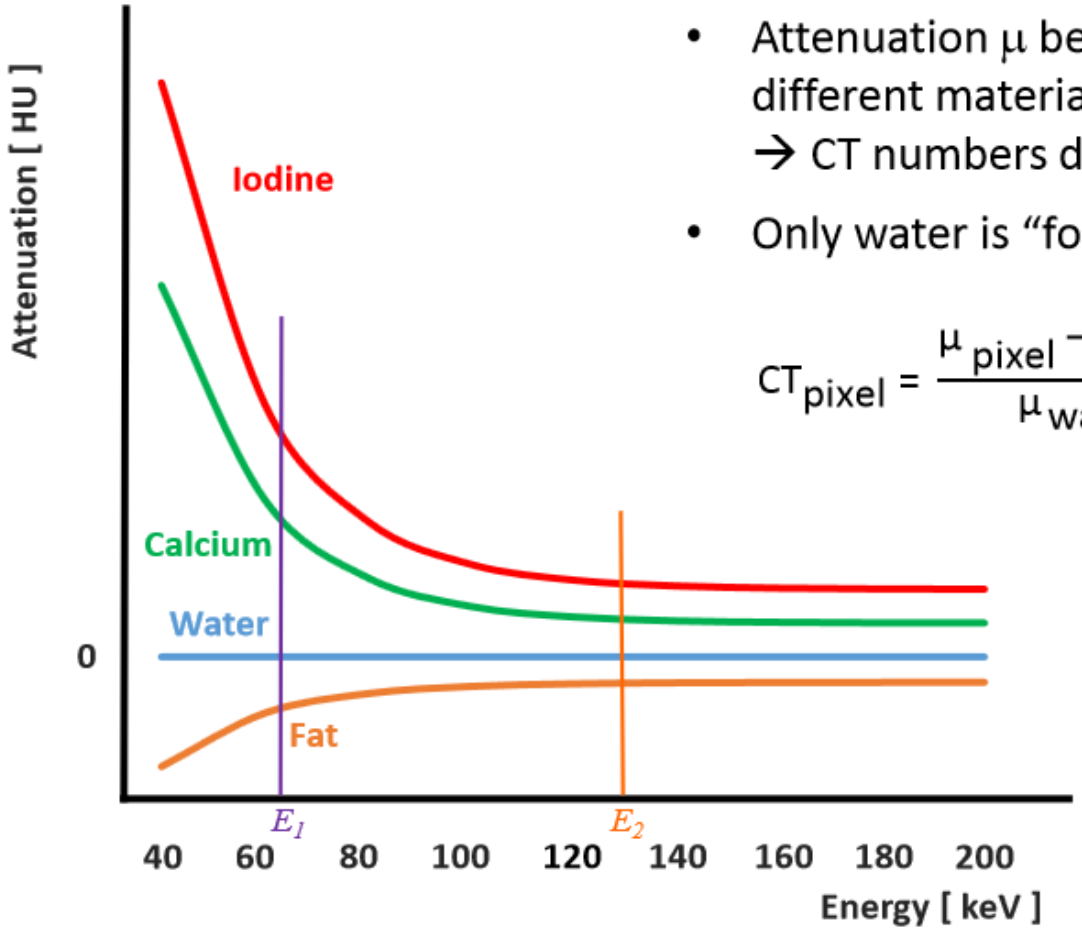


Background CT





Background Spectral CT

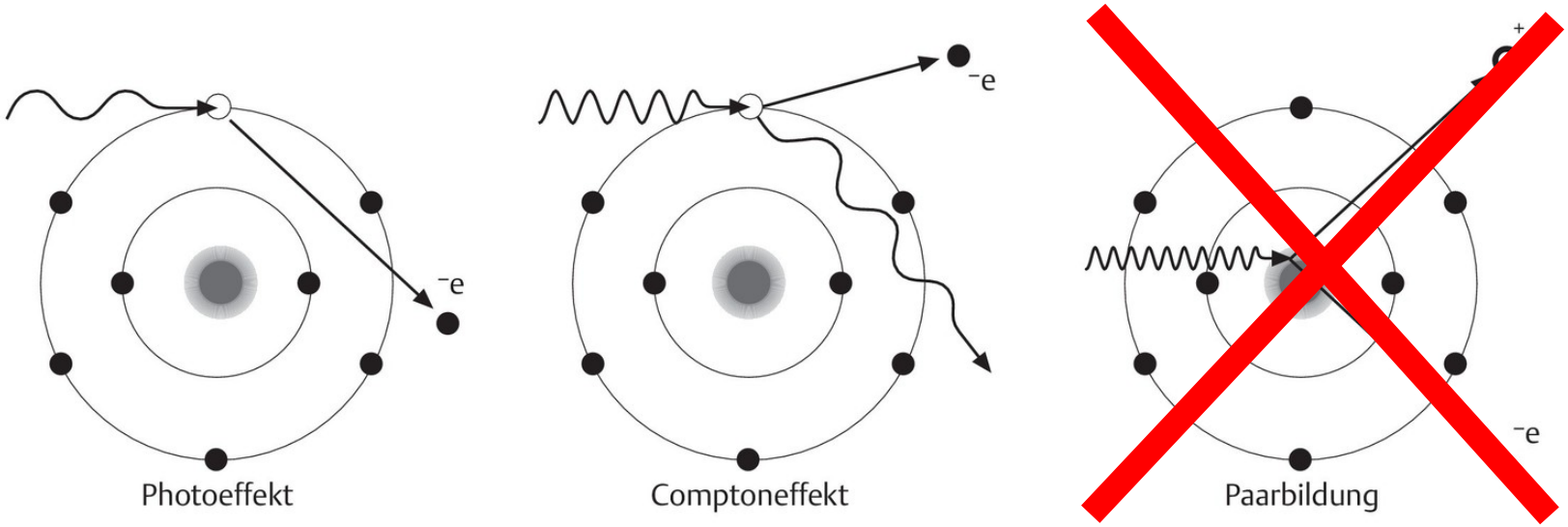


- Attenuation μ behaves differently for different materials at different x-ray energies
  → CT numbers depend on energy
- Only water is "forced" to 0 HU

$$CT_{pixel} = \frac{\mu_{pixel} - \mu_{water}}{\mu_{water}} * 1000\ HU$$

Background Spectral CT

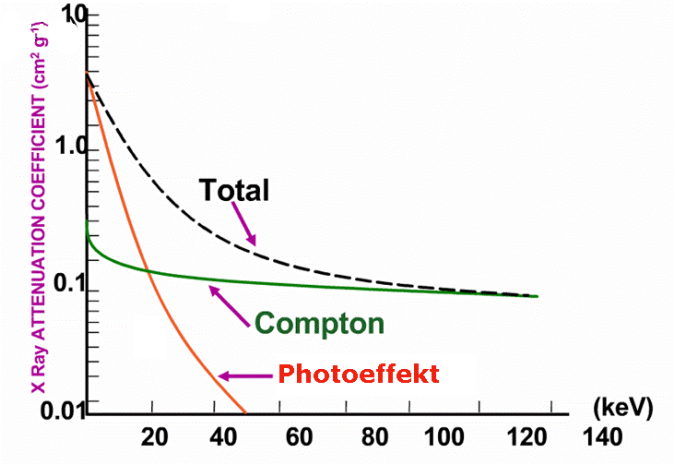
Interaction of photons with matter



Modifiziert aus Schröder U, Schröder B. Wechselwirkung ionisierender Strahlung mit Materie. In: Schröder U, Schröder B, Hrsg. Strahlenschutzkurs für Mediziner. 3. Auflage. 2015. doi:10.1055/b-004-134443

Background Spectral CT

Interaction of photons with matter



$$\mu(E) = a_{photo} \cdot \frac{1}{E^3} + a_{compton} \cdot f_{KN}(E)$$

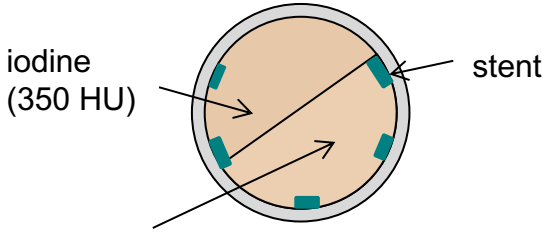
Photo-effect Compton-effect

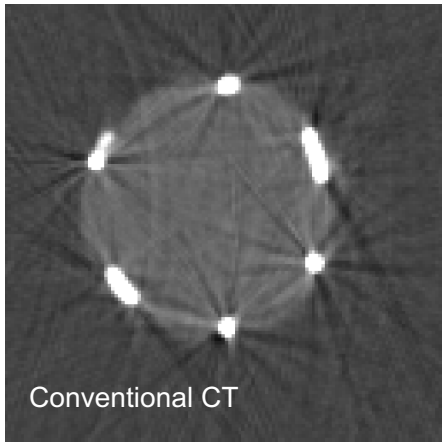
KN: Klein-Nishina Funktion

Background Spectral CT

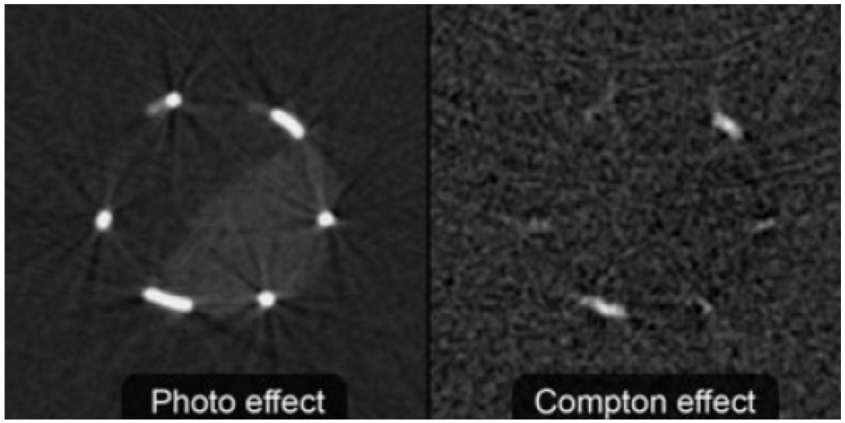
Separation of tissues

simulated calcified plaque in stent





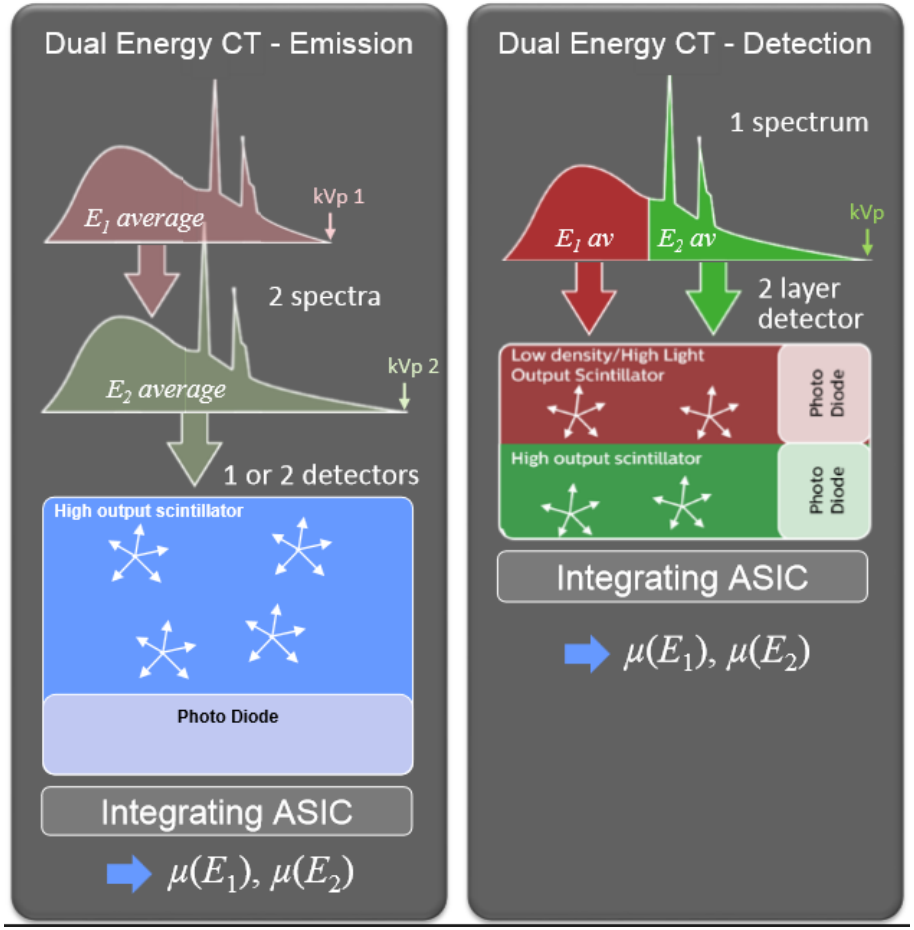
90 kV, 20 mAs

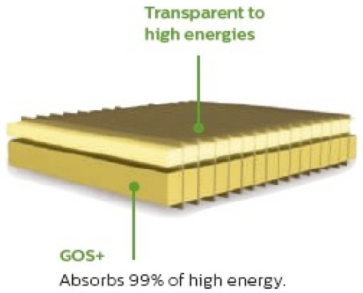


Feuerlein S et al., Radiology. 2008;249(3):1010-6.

Background

Dual-Energy CT



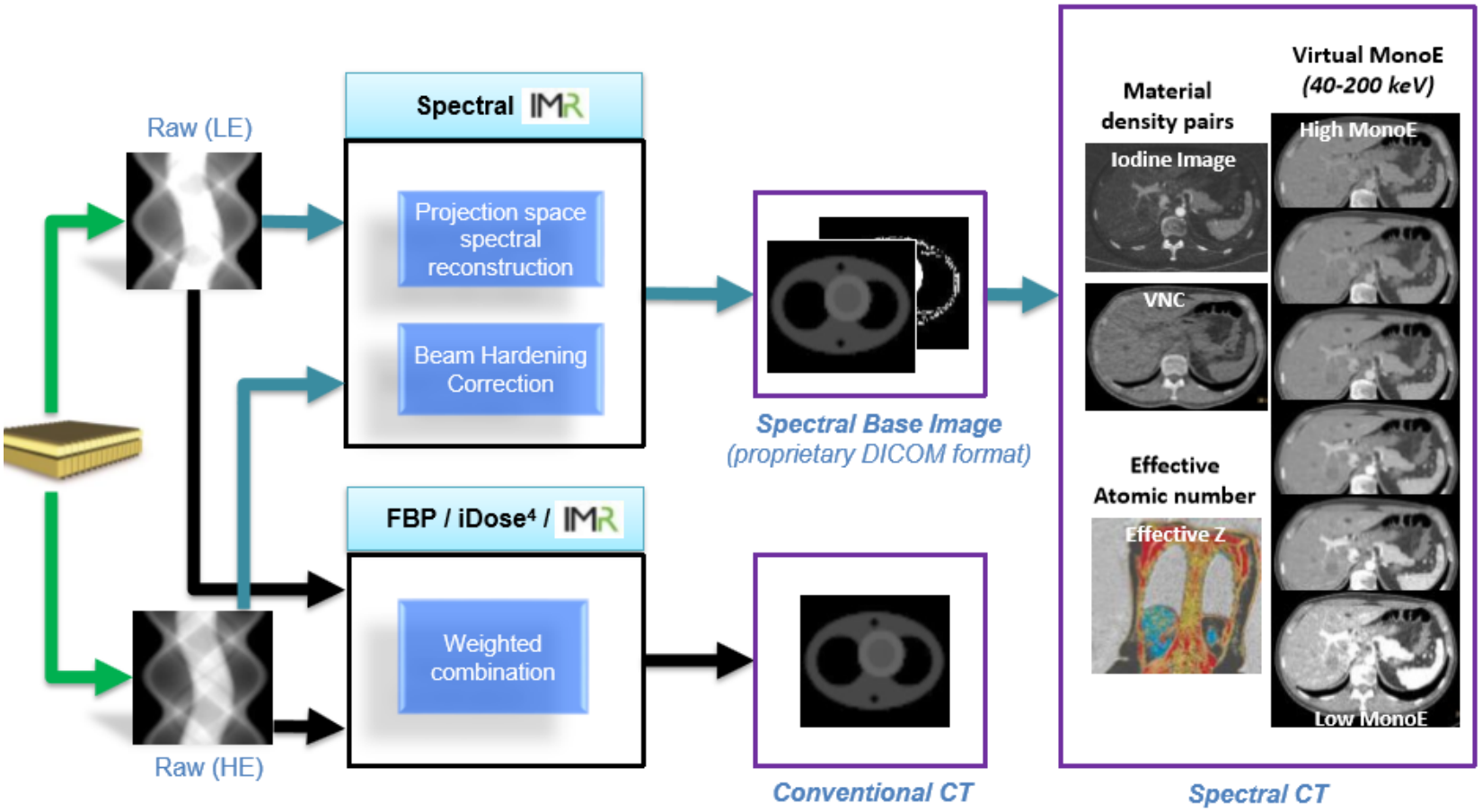


- Simultaneous
- Spatially matched
- Retrospectively available

Philips Healthcare

Background

Dual Layer CT



Philips Healthcare

Potential Categories of Benefits

- Image quality improvement
- Lesion detection improvement
- Lesion characterization improvement
- Radiation dose reduction
- Contrast dose reduction
- Economic benefit

Image Quality

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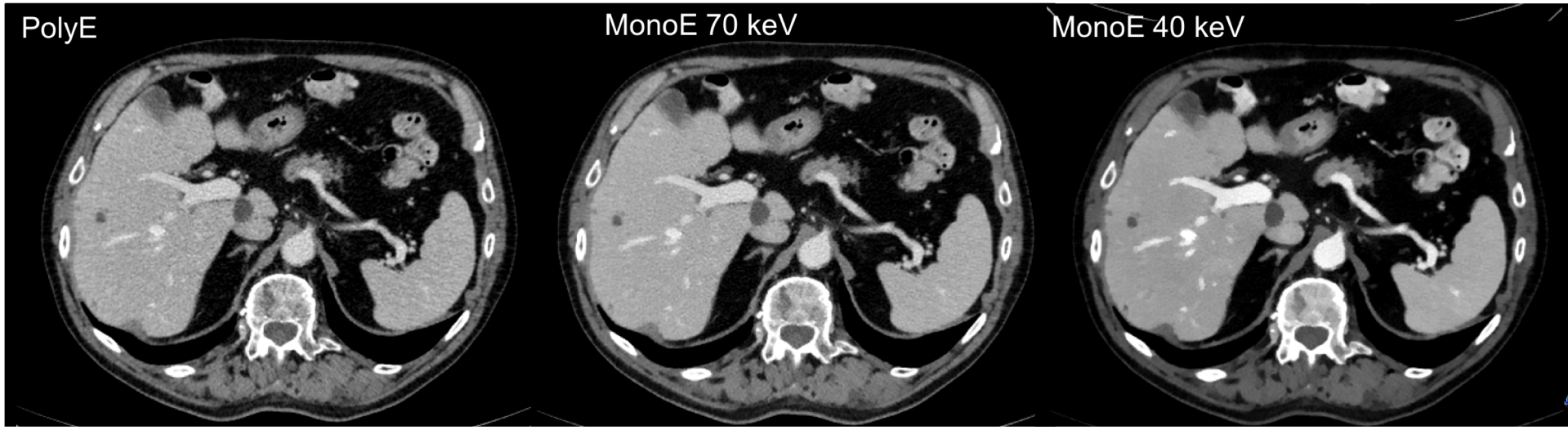
Abdomen: Image Quality

Intra-individual comparison between abdominal virtual mono-energetic spectral and conventional images using a novel spectral detector CT



J. Doerner et al., PLoS One. 2017 Aug 24;12(8):e0183759

J. Doerner et al.: Abdom Radiol (NY). 2017 Jul 4. [Epub ahead of print]

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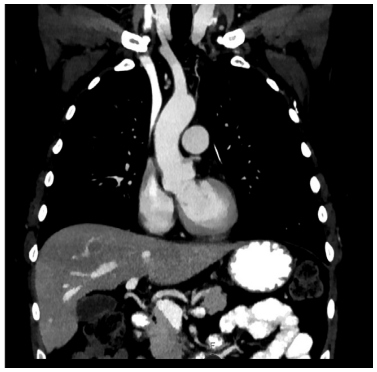
Thorax: Image Quality

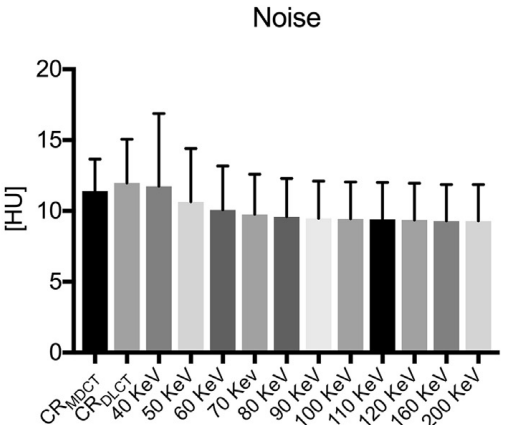
Image quality evaluation of dual-layer spectral detector CT of the chest and comparison with conventional CT imaging

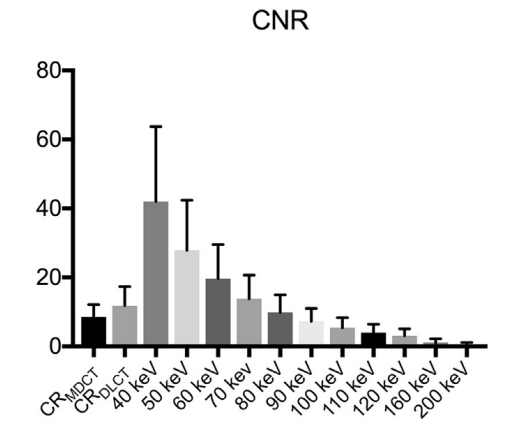
CI

70 keV



40 keV
(adjusted window)





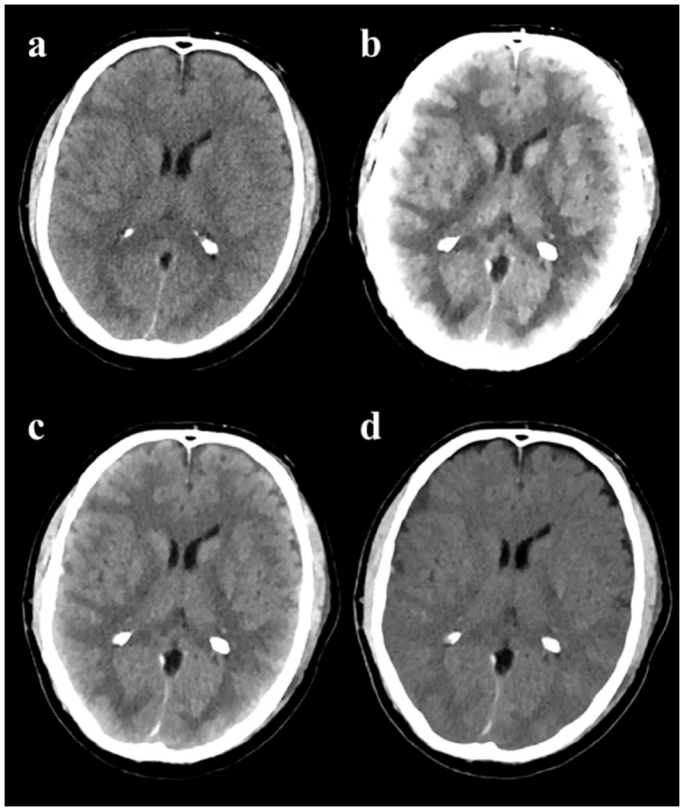
→ MonoE at low keV showed exceptional image quality compared to conventional images

J. Doerner et al.: Eur J Radiol. 2017 Aug;93:52-58.

Brain: Image Quality

Improvement of Image Quality in Unenhanced Dual-Layer CT of the Head

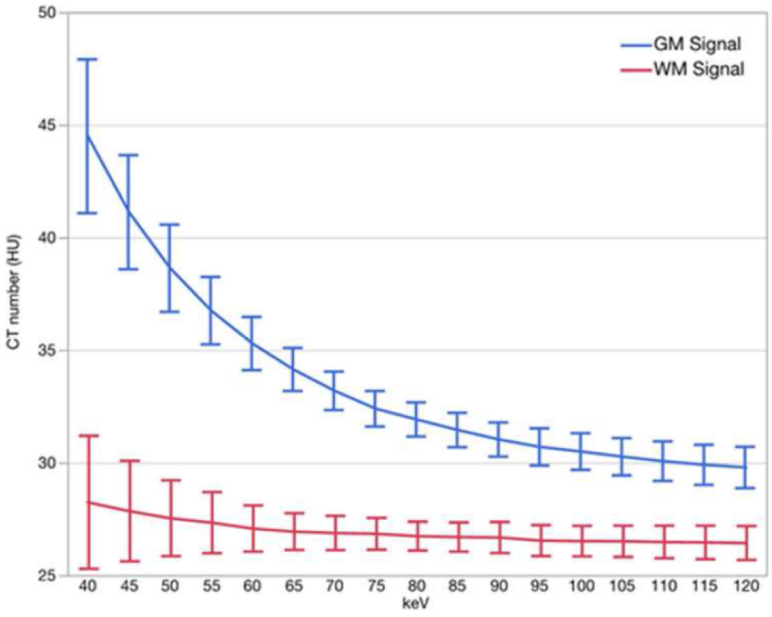
CI



40 keV

65 keV

200 keV



MonoE reconstruction

- Improves image quality
- Enhances gray-white matter contrast

Neuhaus et al., Invest Radiol. 2017 Aug;52(8):470-476

Lesion Detection

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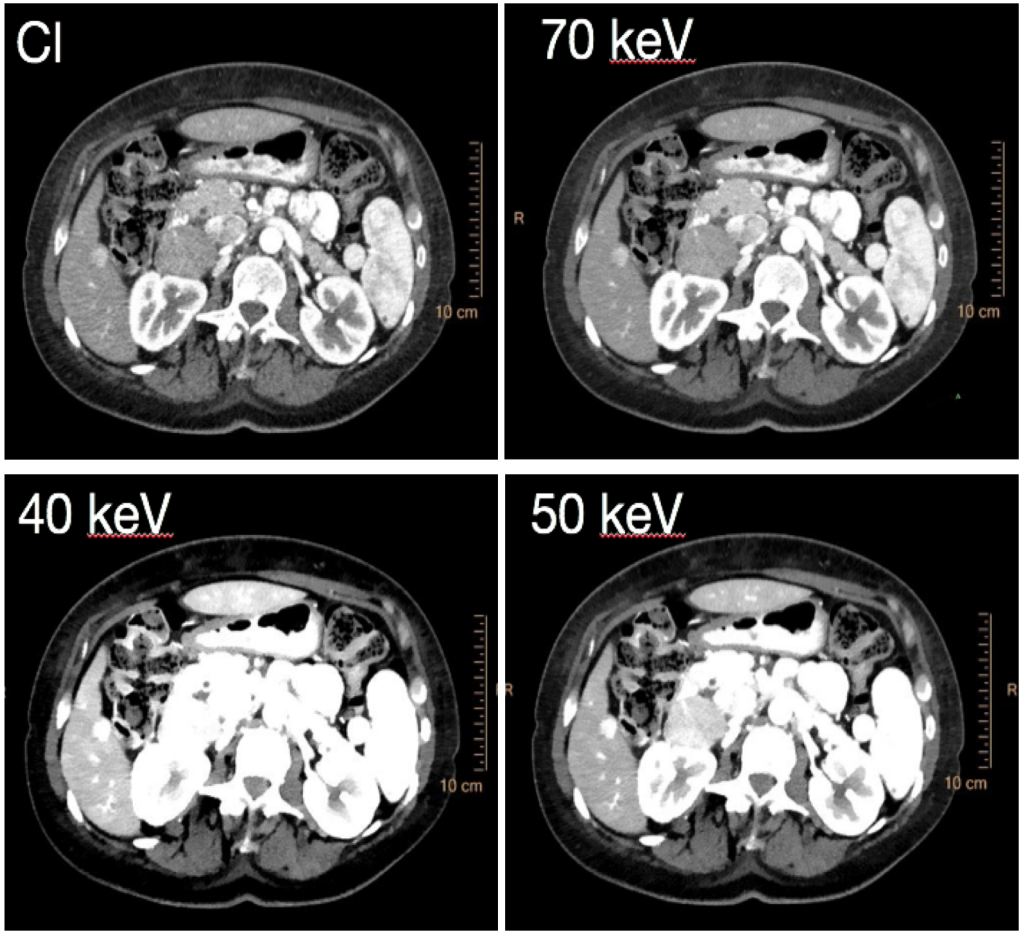
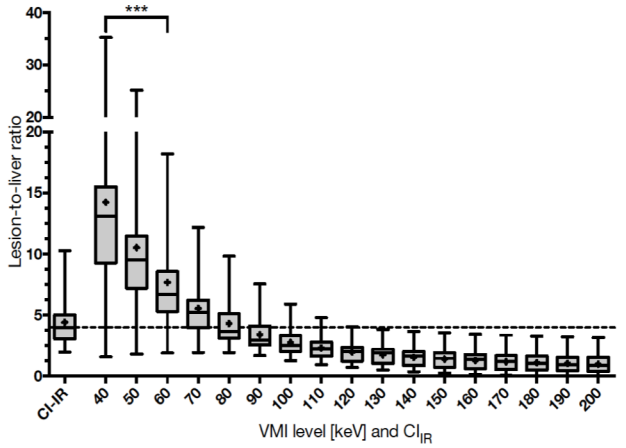
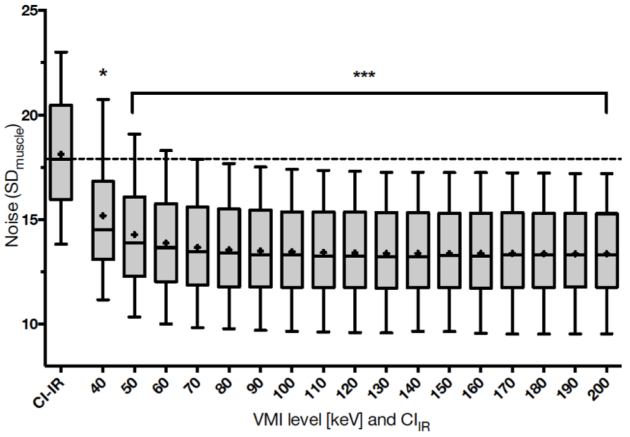
Hypervascular Liver lesions

Assessment of arterially hyper-enhancing liver lesions using virtual monoenergetic images from spectral detector CT



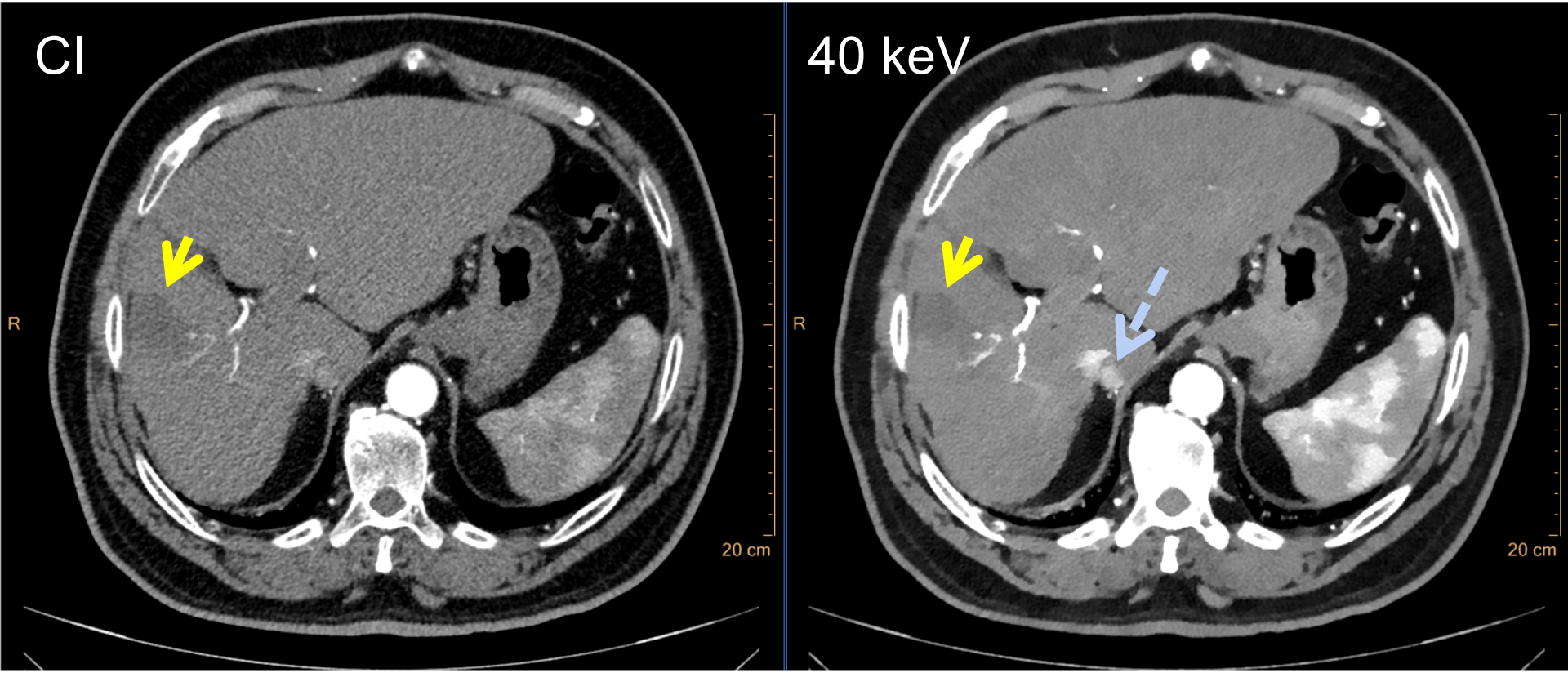




Große Hokamp et al., Abdominal Radiology 2017 accepted

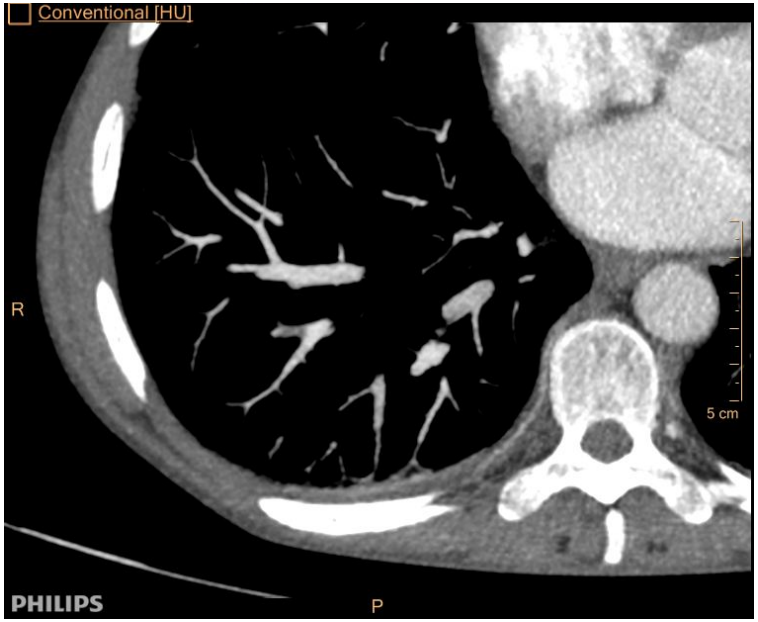
Liver: Lesion Detection: HCC

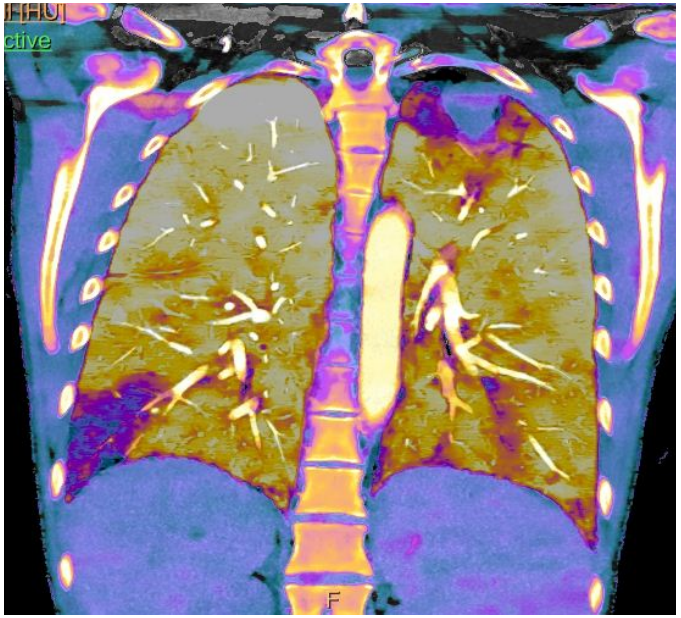
HCC, S/p MWA



Thorax: Pulmonary Vessels

Diagnostic assessment of pulmonary emboli

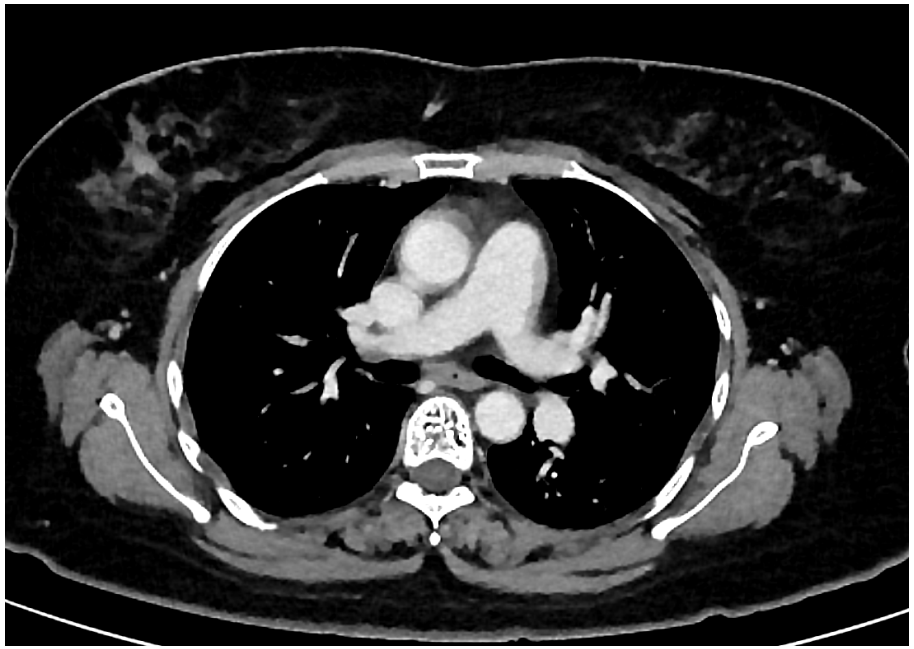




Große Hokamp, N et al., Journal of Computer Assisted Tomography 2018 (accepted for publication)

Breast lesions

53 yo female patient, ovary cancer



Standard IMR

MonoE 40keV

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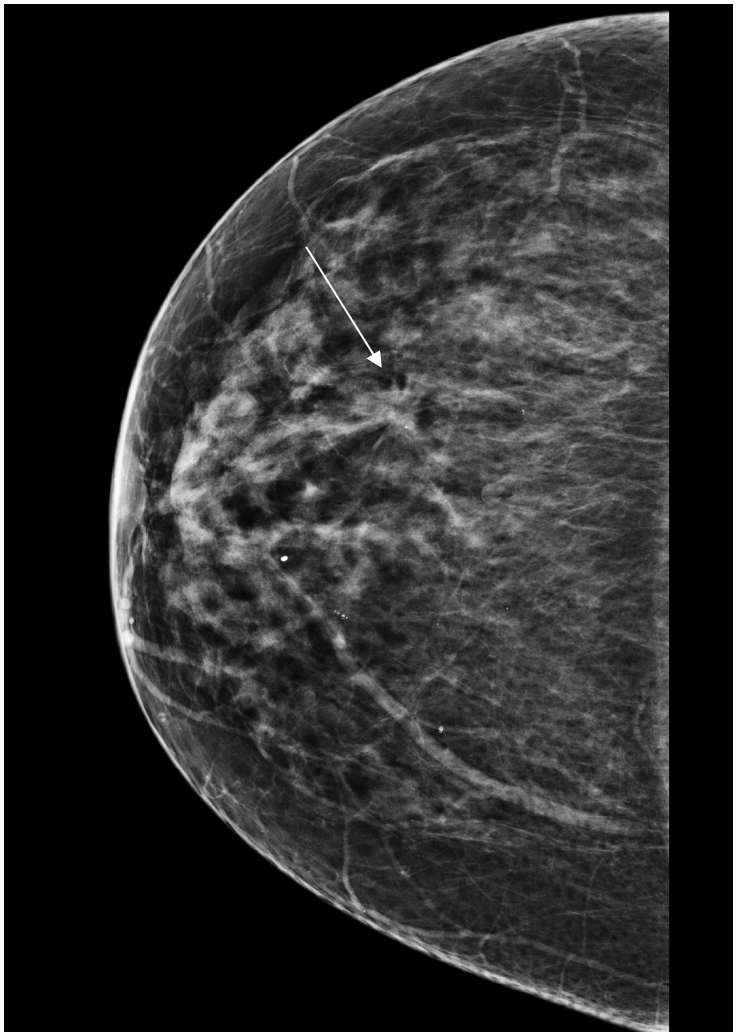
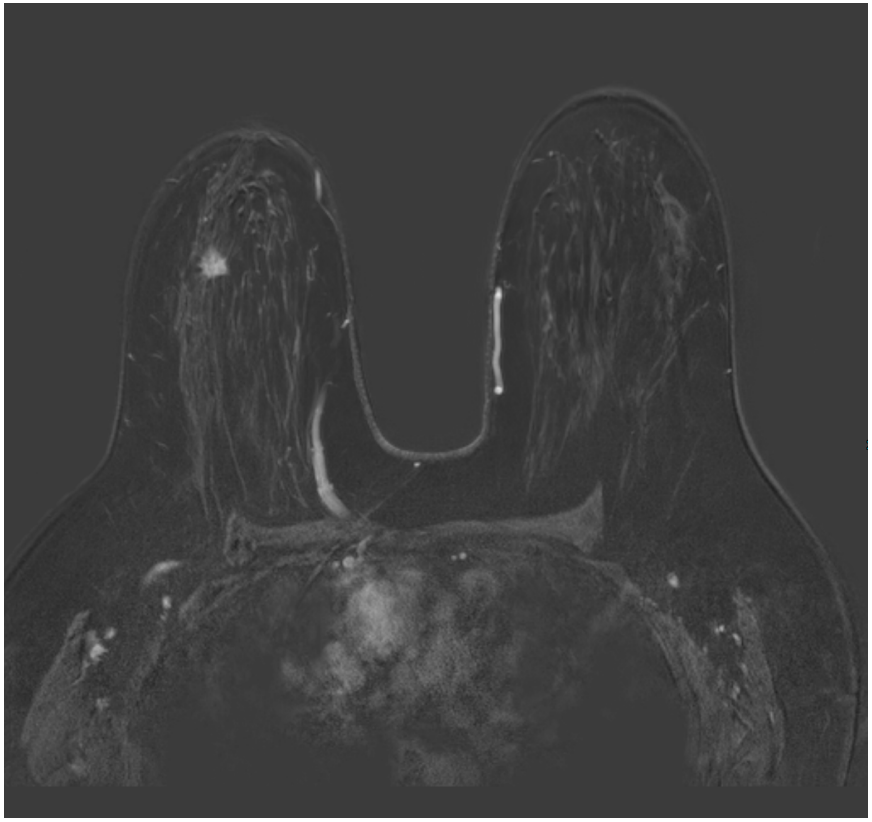
Breast lesions



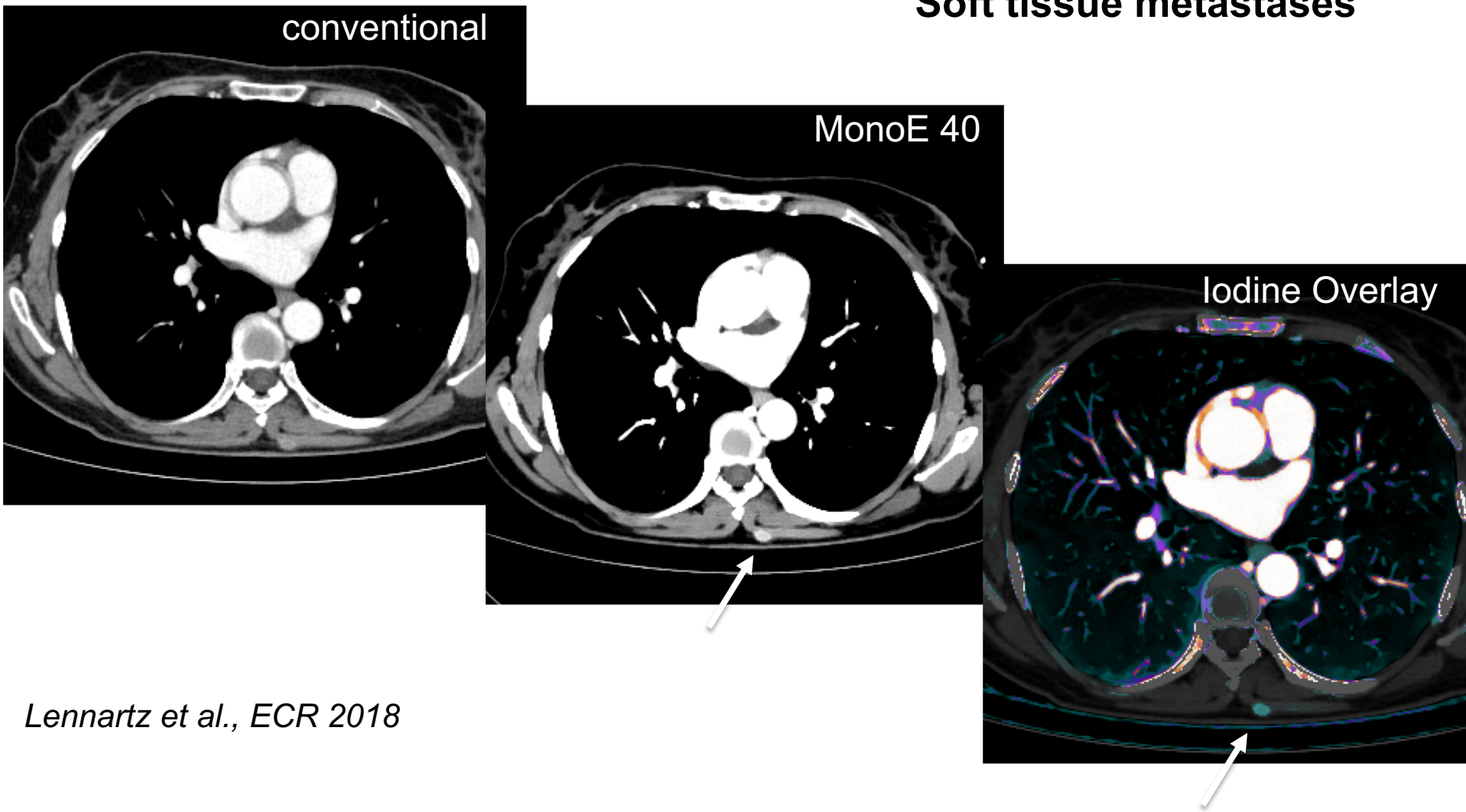
architectural lesion



MRI

Soft tissue

Soft tissue metastases



Lennartz et al., ECR 2018

Lesion characterization

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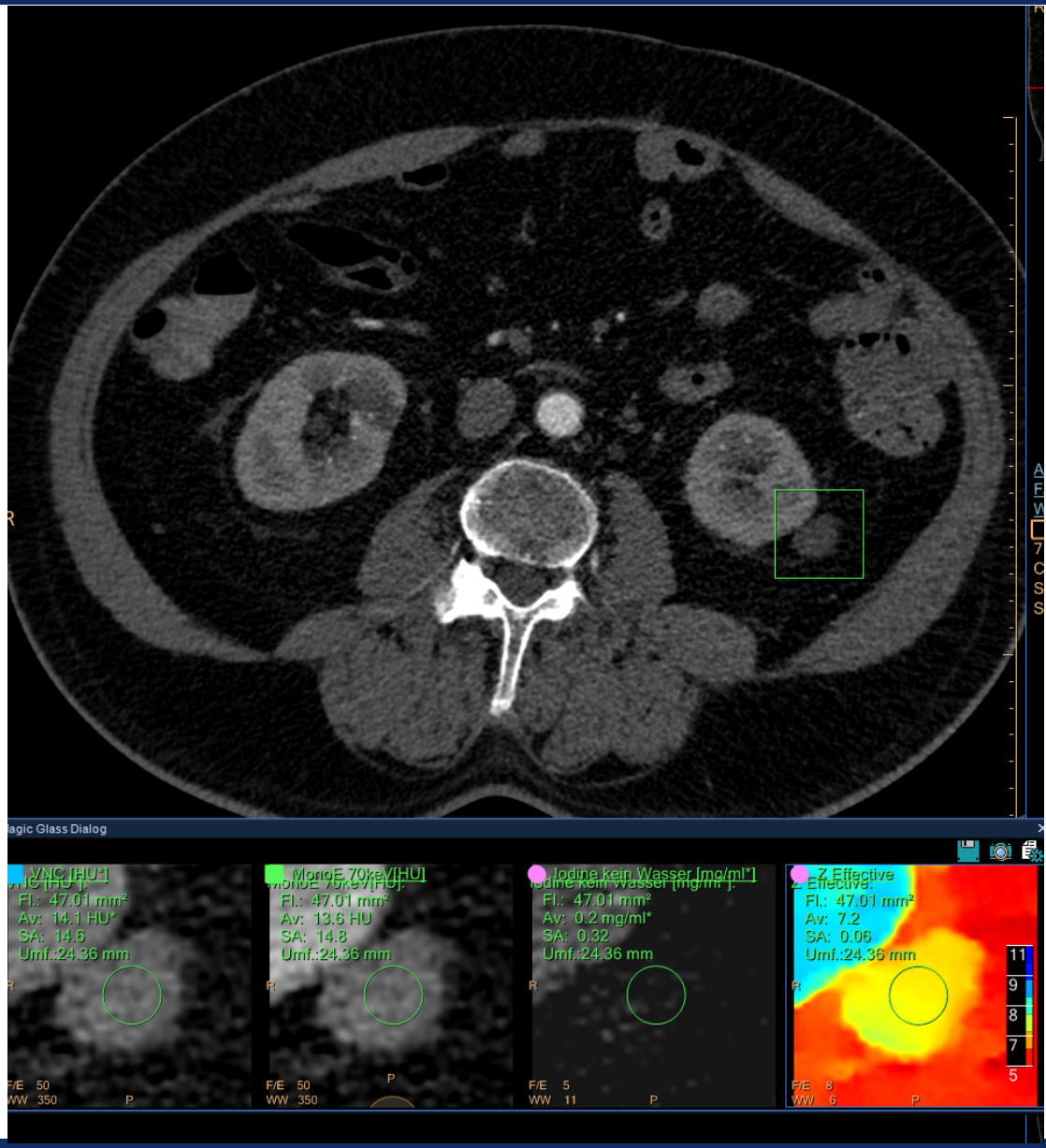
Kidney

Pat. w/ melanoma

cystic renal mass
DD metastasis

>not suspect



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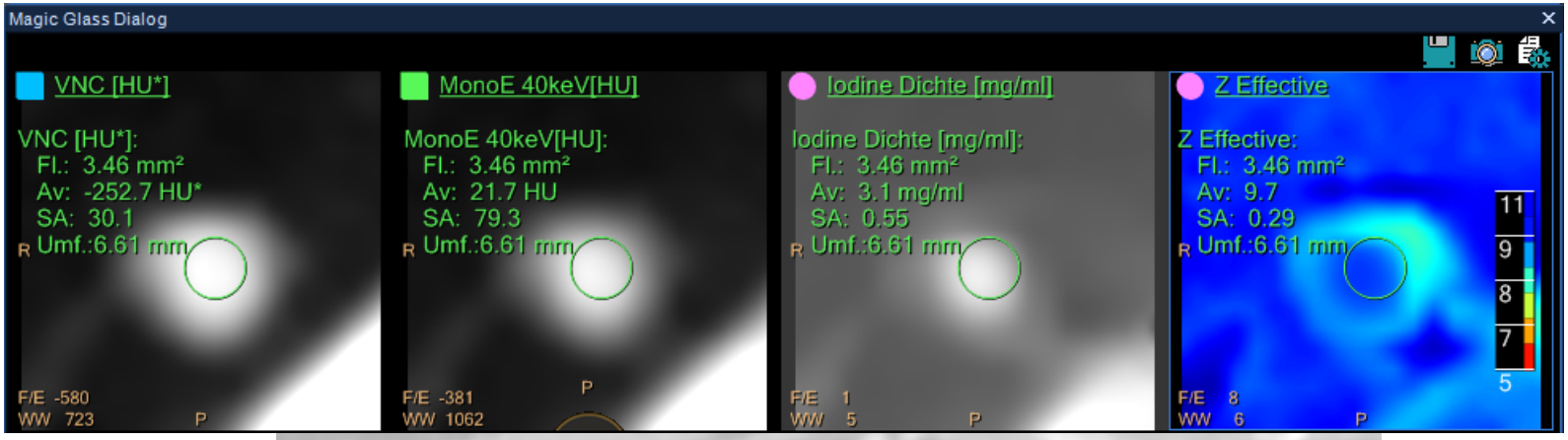
Pulmonary nodules

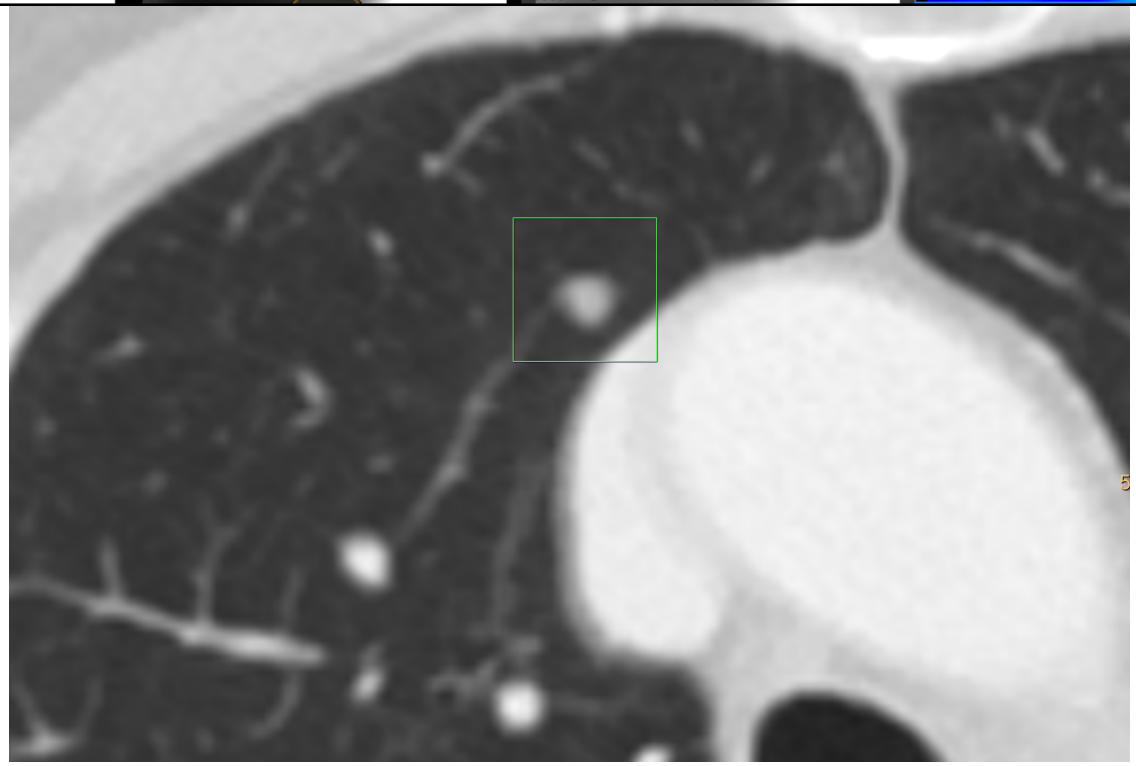


63 yo patient w/ melanoma

pulm. nodule
right upper lobe

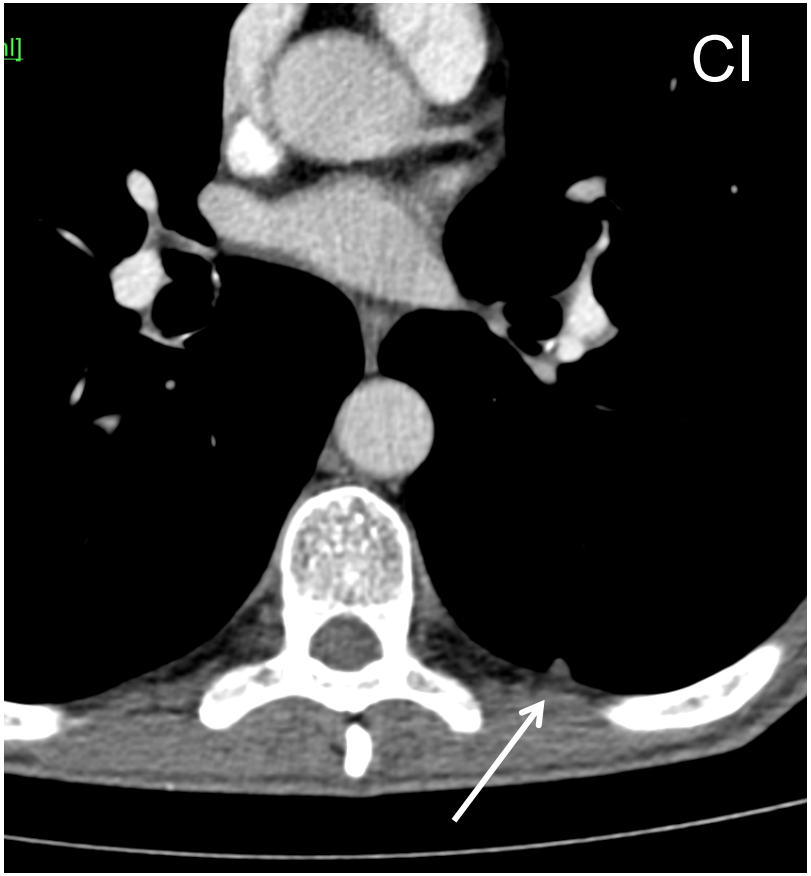
> iodine uptake 3.1 mg/ml

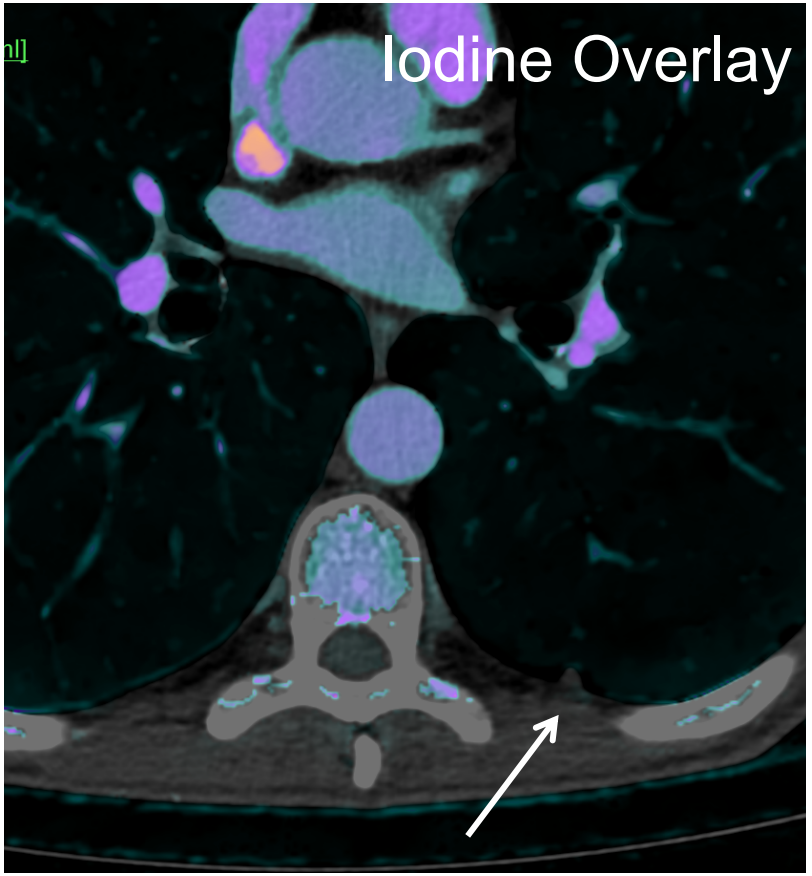
> metastasis likely



Pleura

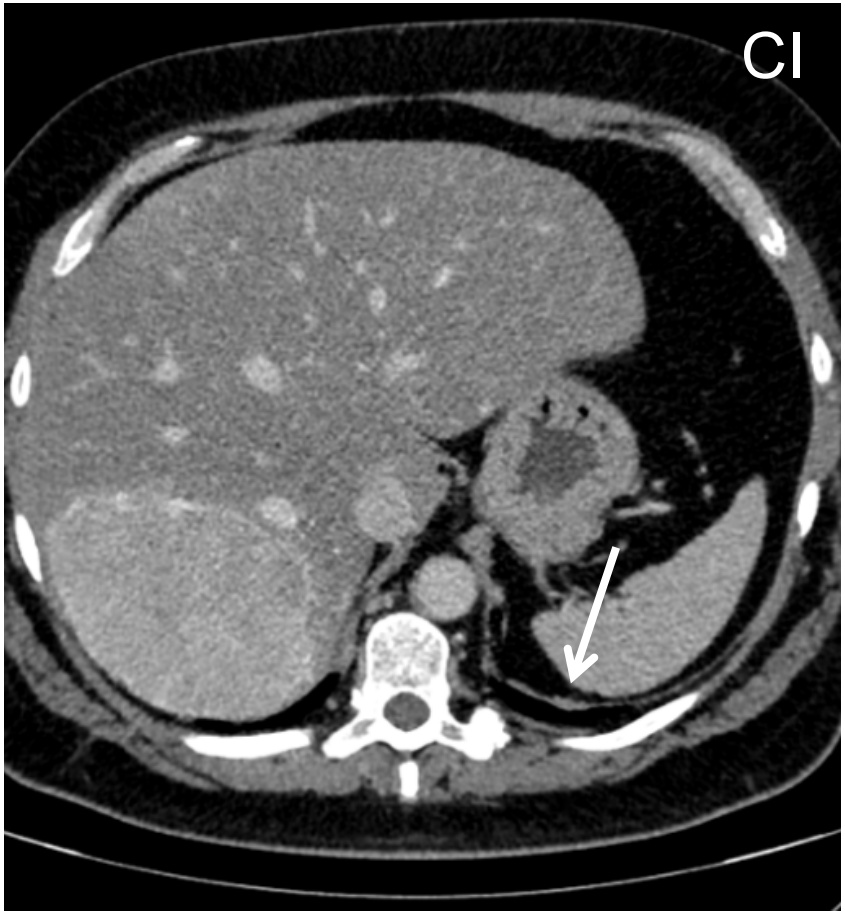
Pleural fibrosis: no Iodine uptake

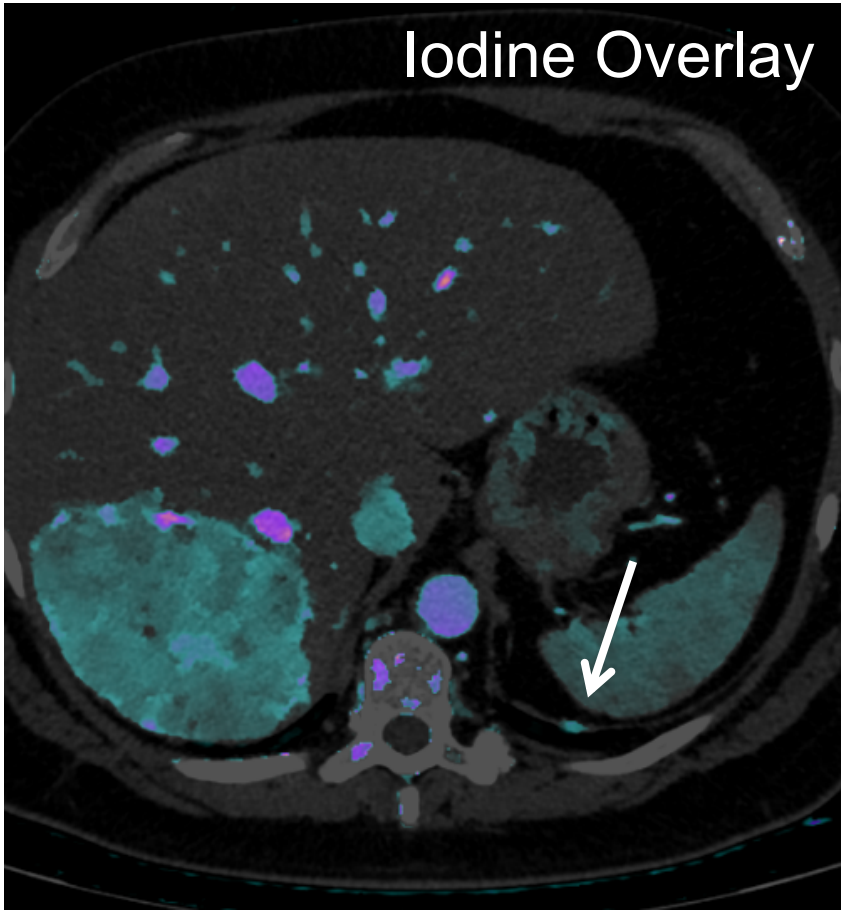




Pleura

Pleural carcinosis: Iodine uptake





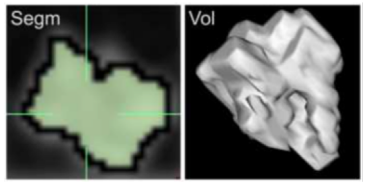
Kidney stones: Characterization

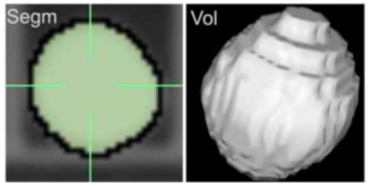
Renal Stone Characterization using Low Dose Protocols

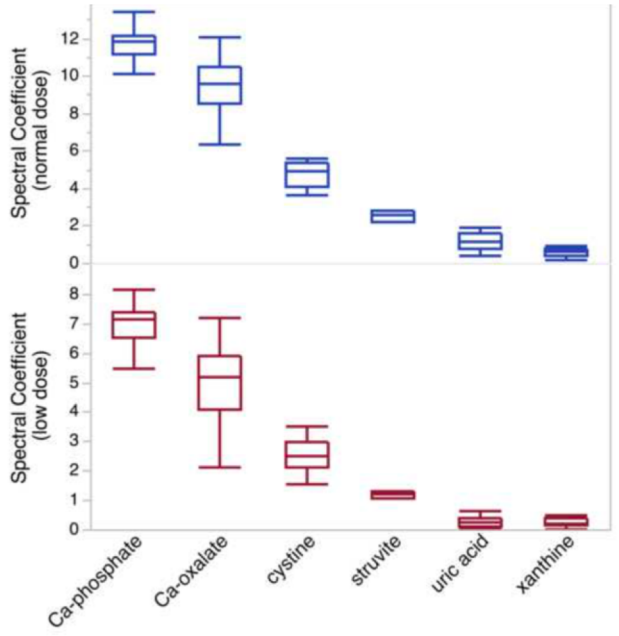
ex vivo study with 154 stones

- Normal dose: $CTDI_{vol}$ 10mGy
- Low dose: $CTDI_{vol}$ 2 mGy
- Semi-automatic segmentation and pixel-by-pixel post-processing

Separation of most stones is possible irrespective of imaging protocol



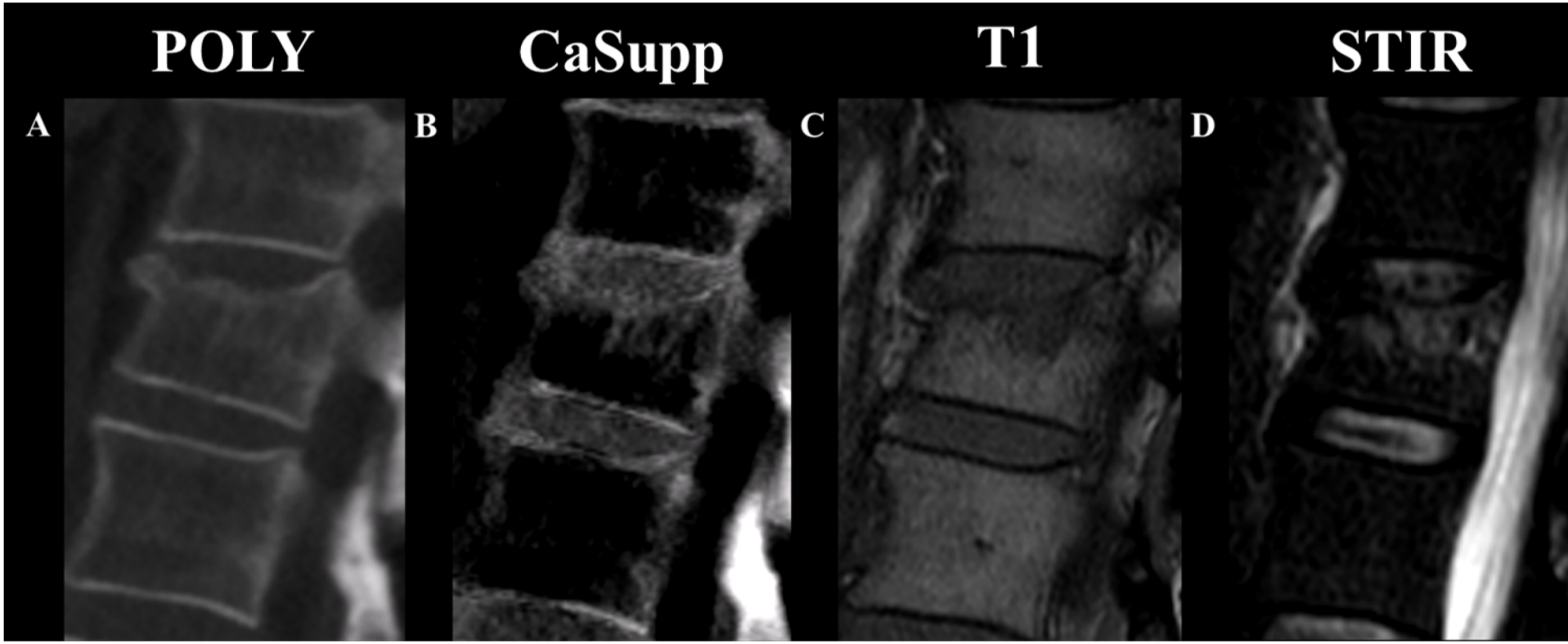




Große Hokamp, N et al. : *Investigative Radiology 2018, in press*

Bone marrow edema

Calcium Suppressed Images (CSI)



- 34 Patients with 57 vertebral fractures
- Sensitivity 87%, Specificity 99% (PPV 95%, NPV 98%, accuracy 97%)

Neuhaus et al., submitted

Reduction of Radiation and Contrast Dose

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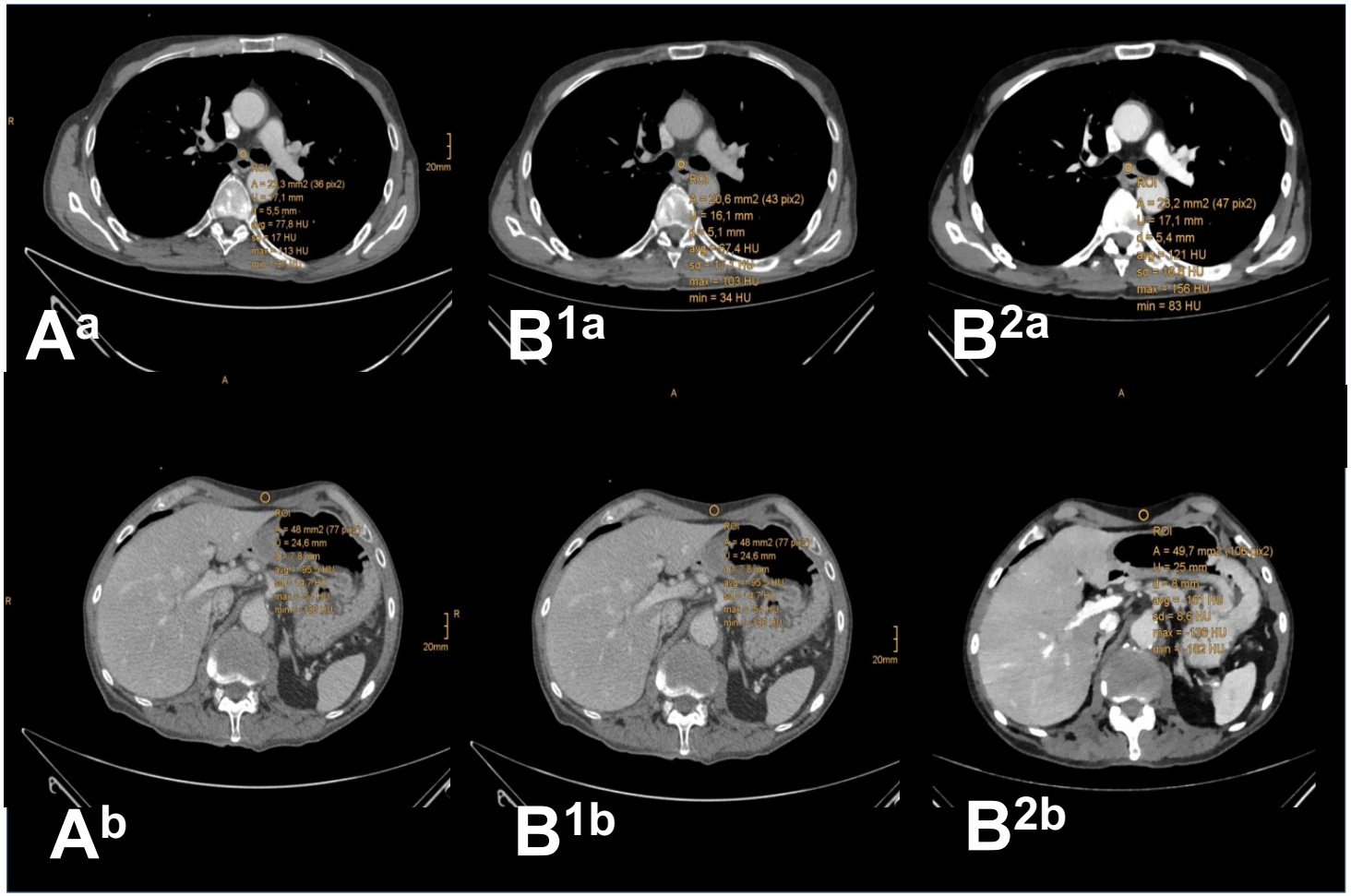
Reduction of radiation (& contrast) dose



Brilliance 6, FBP, 120 kV, 100 mAs, CTDI **6,9 mGy,** **80 ml** Accupaque 350, **CNR 5,3**	IQon, FBP, 120 kV, 35 mAs, CTDI **3,2 mGy,** **40 ml** Accupaque 350, **CNR 4,6**	IQon, monoE 40 keV, 120 kV, 35 mAs, CTDI **3,2 mGy,** **40 ml** Accupaque 350, **CNR 14,1**

T. Hickethier et al., WIP

Economic Benefit

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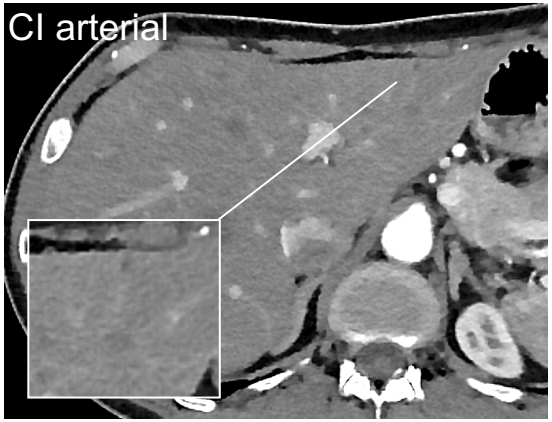
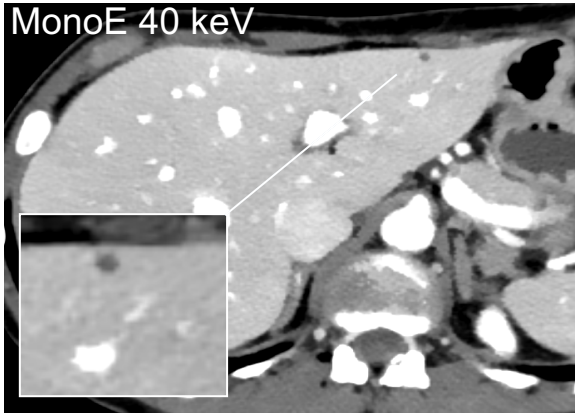
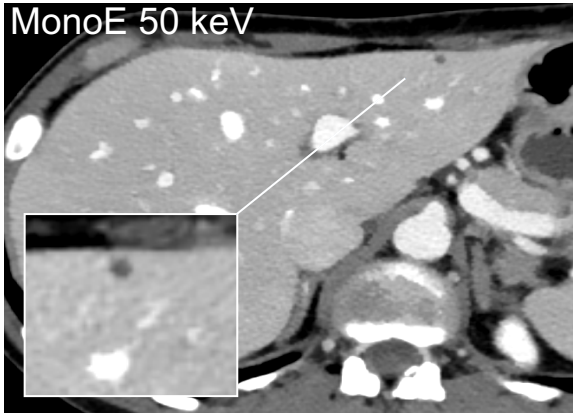
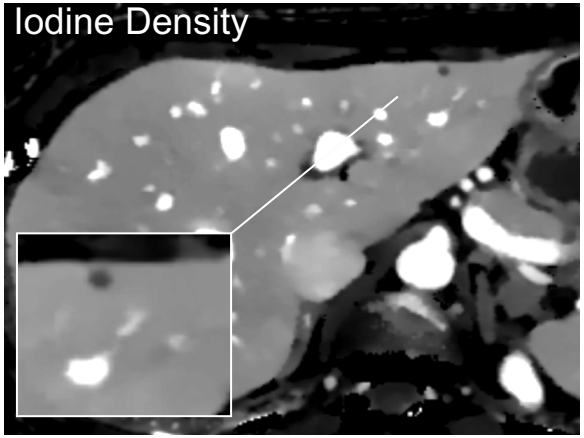
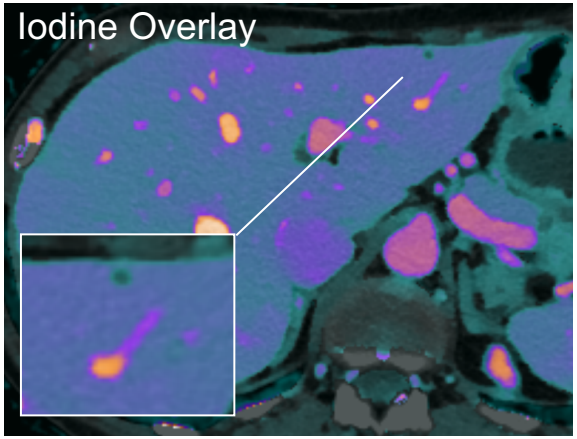
Liver: Diagnostic Confidence











HU = 39
Likert-Score: 2

Iodine = 0.3 mg/ml
Likert-Score: 5

Study on Diagnostic Confidence and Economic Savings

Lesion type	n
FNH	5
Adenoma	4
Hemangioma	27
Cyst	61
HCC	11
Metastasis	29
Cirrhotic nodule	2
	139

Evaluation: benign vs. malignant / most likely diagnosis

1 = no confidence / totally unclear finding

2 = very little confidence / unclear finding

3 = moderate confidence / potential diagnosis

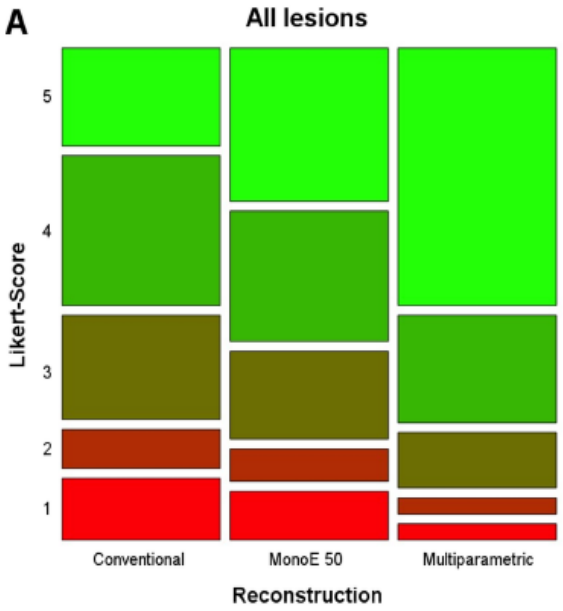
4 = strong confidence / likely diagnosis

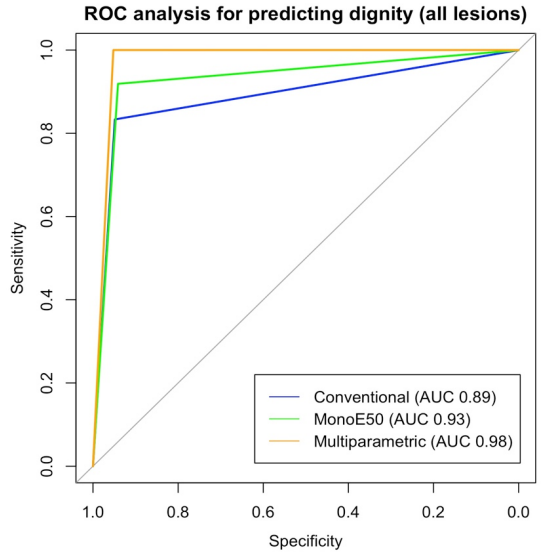
---

5 = absolute confidence / most likely diagnosis

Study on Diagnostic Confidence and Economic Savings

Diagnostic Confidence and Economic Savings





Slebocki et al.: Multiparametric Spectral Detector CT for the assessment of focal liver lesions: evaluation of diagnostic confidence

Study on Diagnostic Confidence and Economic Savings

Economic Analysis

- **112 lesions** w/ score of 1-4 on conventional CT requiring follow-up scanning for confirmation of diagnosis.
- Of these, **52 lesions** changed their confidence rating to 5 on the multi-parametric dataset analysis leading to **reduction in follow-up exams by 46%**.
- **Savings of Euro 89,000 to 116,600** (MRI:US ratio of 50:50 to 75:25).

Potential Categories of Benefits

- Image quality improvement ✓
- Lesion detection improvement ✓
- Lesion characterization improvement ✓
- Radiation dose reduction ✓
- Contrast dose reduction ✓
- Economic benefit ✓

-> better patient care !

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david.maintz@uk-koeln.de