

International Symposium on Multidetector Row CT
Jun 20-23, 2016, San Francisco, CA

Low Contrast may be more Harmful than Standard Contrast in TAVR Patients with CKD

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TAVR patients with CKD

Contrast-enhanced imaging may be a risk for patients with CKD → CM volume reduction can reduce this risk

Modern CT-scanners allow for low kVp imaging: increased X-ray absorption in matter (particularly with high Z_{eff} (iodine))

- if mAs can be increased sufficiently (powerful X-ray tube)
- better signal to noise
- can be used to reduce contrast and maintain IQ

Low-kVp CT: automated selection of mA and kVp for 'optimal' signal/noise

The 'optimal' combination of kVp and mAs depends on

- inherent contrast (non-con, bone, liver, ... CTA)
- body size (thickness)

can be calculated from protocol, and from radiograph

The image shows a screenshot of a CT scanner's control interface. On the left, the 'CARE Dose4D' feature is set to 'On'. The 'ff. mAs' is 416 and the 'kV' is 100. The organ characteristic is 'Abdomen'. The CTDIvol (32cm) is 16.43 mGy and the DLP is 396.4 mGy*cm. On the right, a 'Quality ref. mAs' tool is shown with a value of 210 and a 'Ref. kV' of 120. Below this, a 'Dose saving optimized for:' section displays icons for different body parts: a red 'X' over a head, a white leg, a blue liver, and a red kidney. A horizontal scale at the bottom is numbered 1 to 12, with a black square marker positioned at 7.

Low Contrast can be Harmful in TAVR patients with CKD

- when reducing IV contrast, the expected gain of 'iodine signal' by using low kVp is diminished (e.g. if aorta is only 150HU instead of 300HU)
- if mAs is chosen to allow for more noise, the C/N ratio in CTA will suffer accordingly

in addition

- iodine concentration in small vessels / borders is always less than in the center of large vessels
- CTA datasets are not viewed on axial CT images, but on MIPs, or VR, which may augment noise

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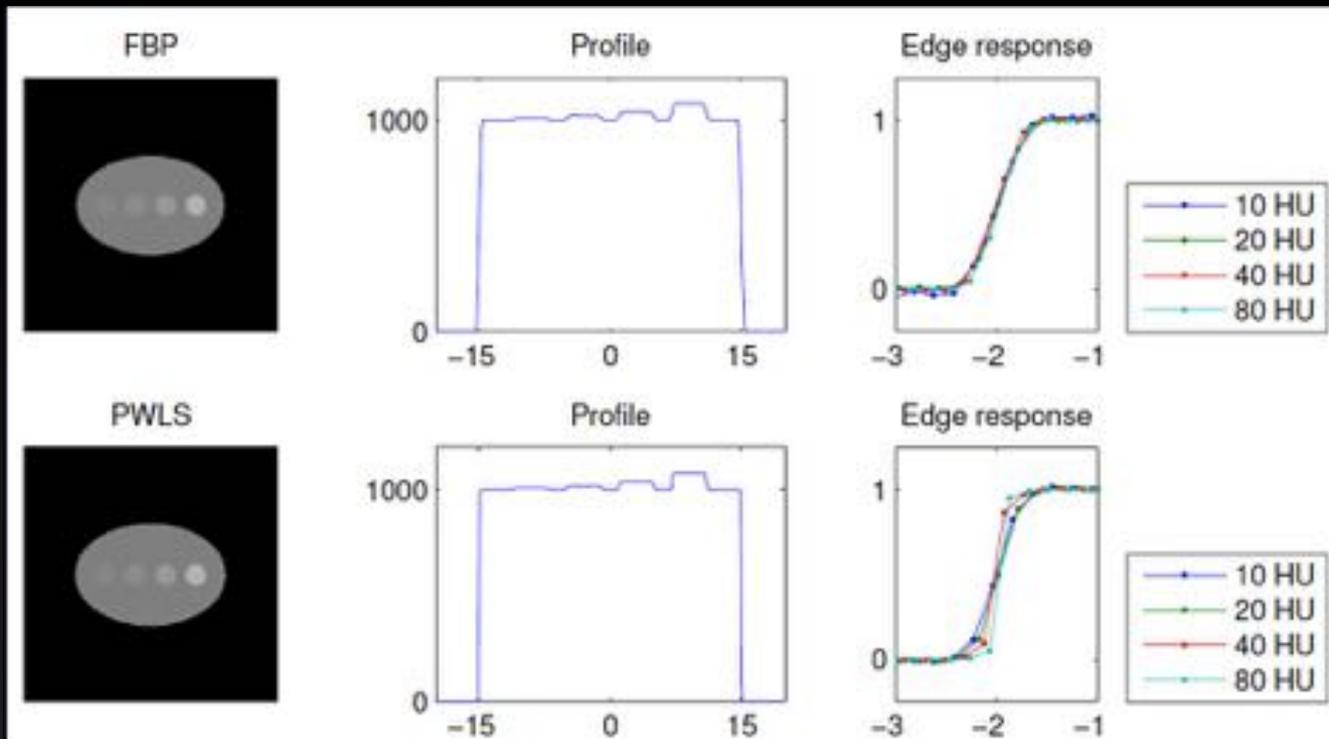
Low Contrast can be Harmful in TAVR patients with CKD

- lower kVp also increases the 'signal' from calcium
- increasing the mAs, particularly at lower kVp, requires large focal spot, and causes focal spot blooming (beyond nominal size), which decreases spatial resolution

in addition

- suspect suboptimal beam hardening correction at lower kVp

Spatial Resolution Characterization



shape of edge response depends on contrast for edge-preserving regularization (courtesy Jeff Fessler)

Low Contrast can be Harmful in TAVR patients with CKD

Can iterative reconstructions help?

- other than FBP, the spatial resolution is not independent of the contrast within an object;
- bright vessels/borders appear sharper, with lower background noise -> ideal for small vessels
- not well opacified vessels may be more blurry, or distorted by 'blotchy' artifacts;

Overall, there are serious potential limitations when attempting to combine low contrast and low kVp

Can low kVp be used to reduce CM?

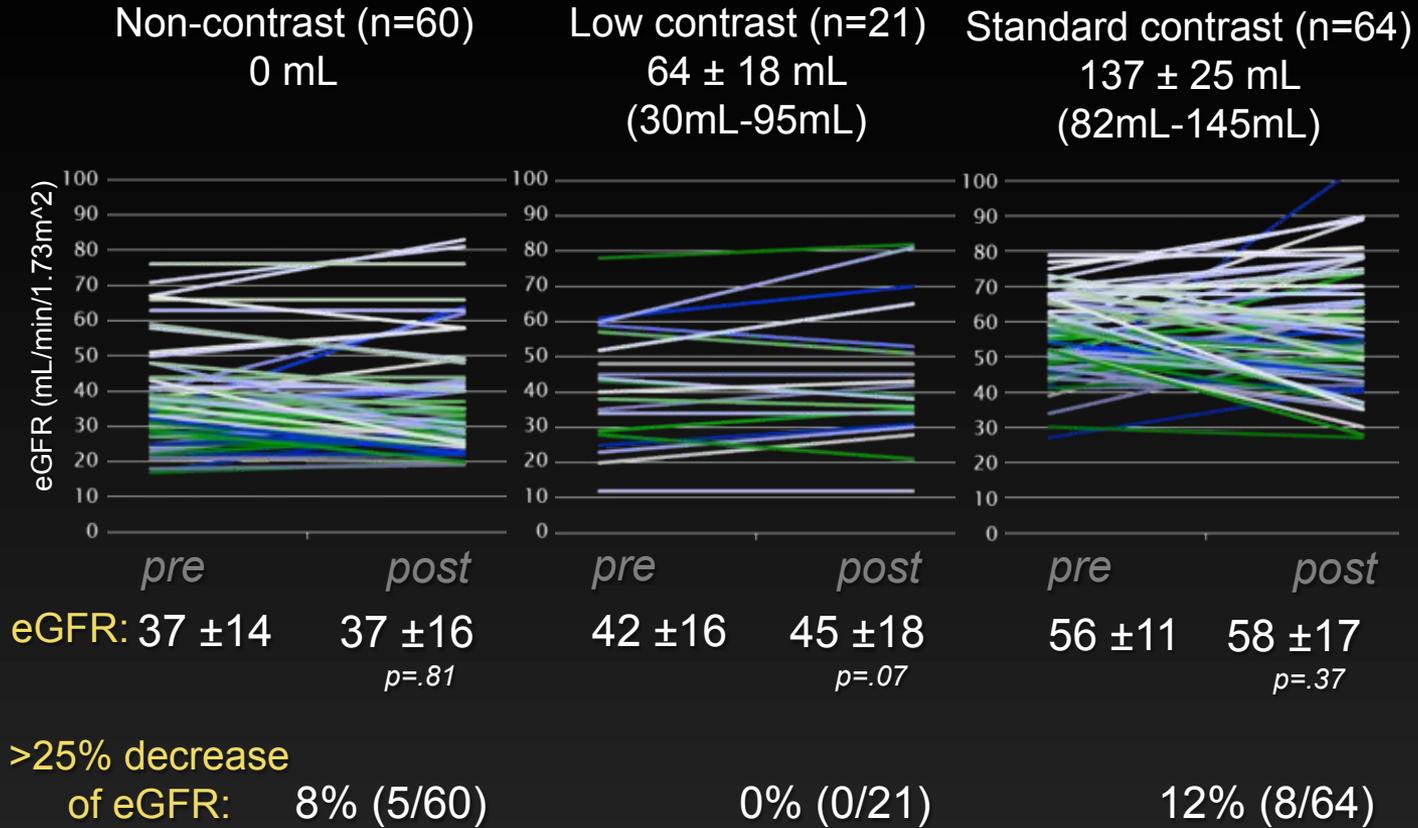
- in principle: lower kVp improves signal/noise ratio
- improved signal/noise ratio can be used to lower iodine concentration (lower CM volume)

predictable

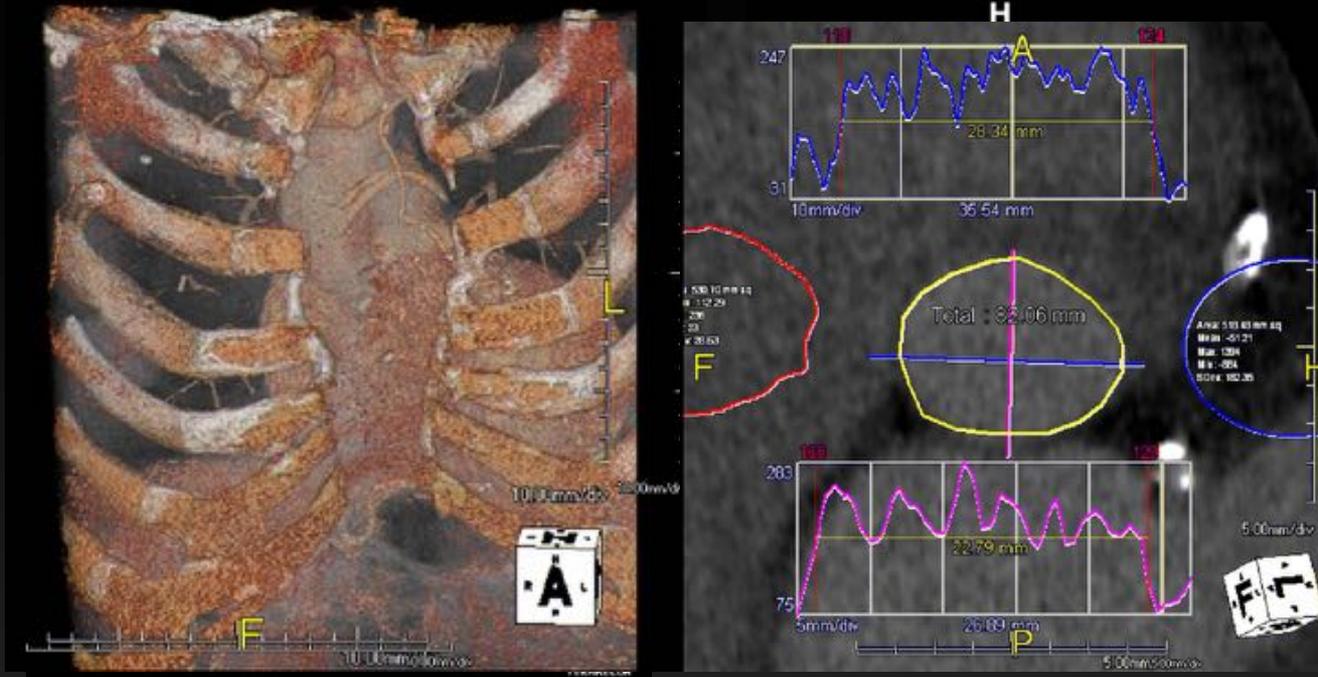
- Implicit assumption: CM is harmful (i.e. reducing contrast will reduce a risk)
- reduced CM opacification does not negatively impact image quality

needs proof

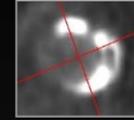
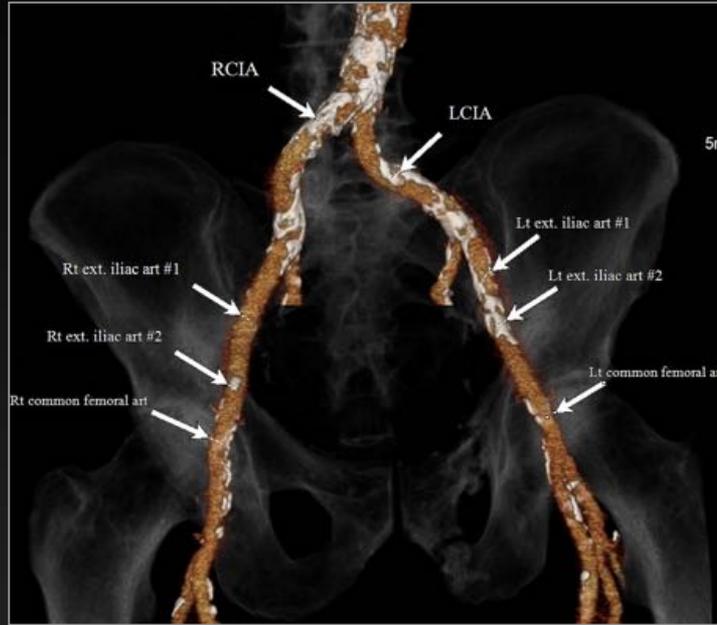
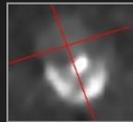
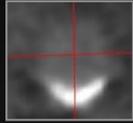
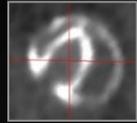
eGFR before and 3-14d after CTA in 145 pts undergoing TAVR



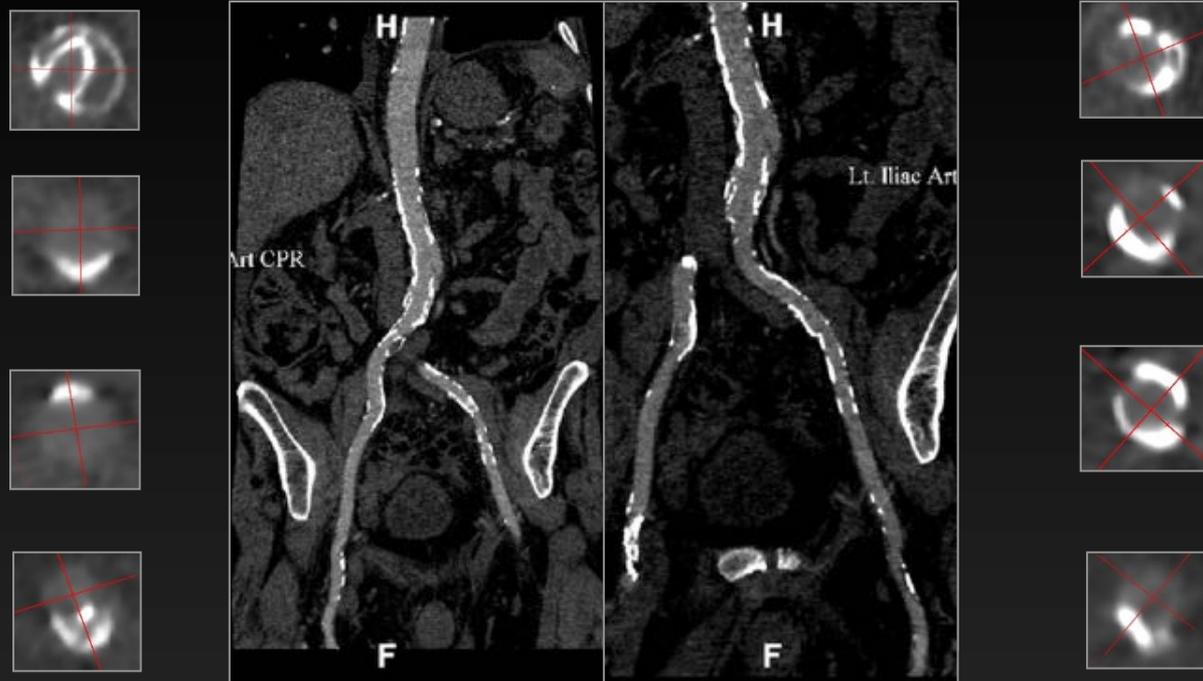
83 y/o man (87kg), evaluated for TAVR



Patient w CKD and history of esophageal cancer:
SCrea 4.0; eGFR 17: 30 mL of IV contrast



Patient w CKD and history of esophageal cancer:
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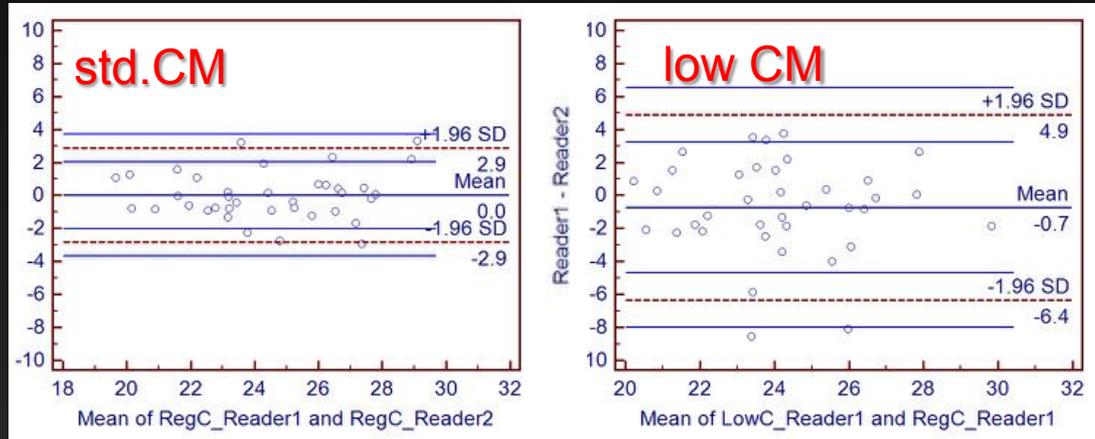
Low Contrast Dose CTA in TAVR

Image Quality: Aortic Root/Annulus

(35 pts./grp., 2 readers)

<u>subjective image quality</u>	<u>std.CM</u>	<u>low-CM</u>
excellent	69 %	50 %
good	30 %	36 %
borderline	1 %	14 %
inadequate	---	---

measurement agreement (annulus)



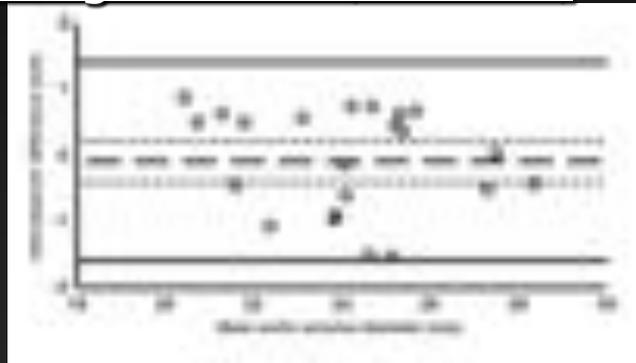
Low CM: Improved IQ and reproducibility with newest CT-scanners?

Bittner et al. Eur Radiol 2016: 40 pts, 30 mL CM, 100kV, 3rd generation DSCT

subjective image quality low-CM

excellent	60 %
good	33 %
borderline	2 %
inadequate	---

measurement agreement (annulus)



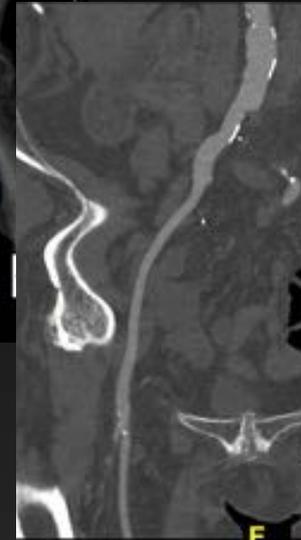
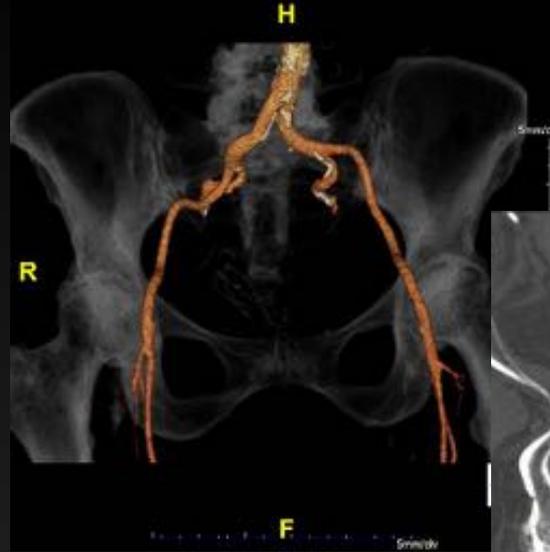
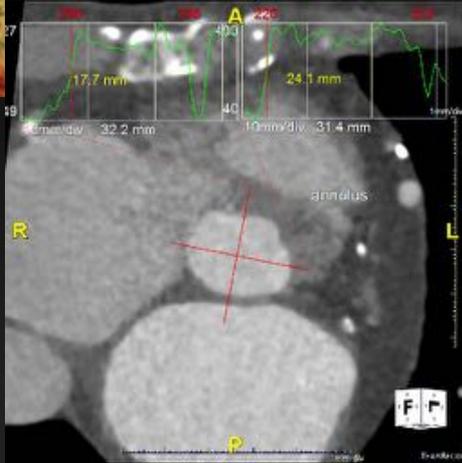
+2 SD 1.41 mm

Mean -0.09 mm

-2 SD -1.59 mm

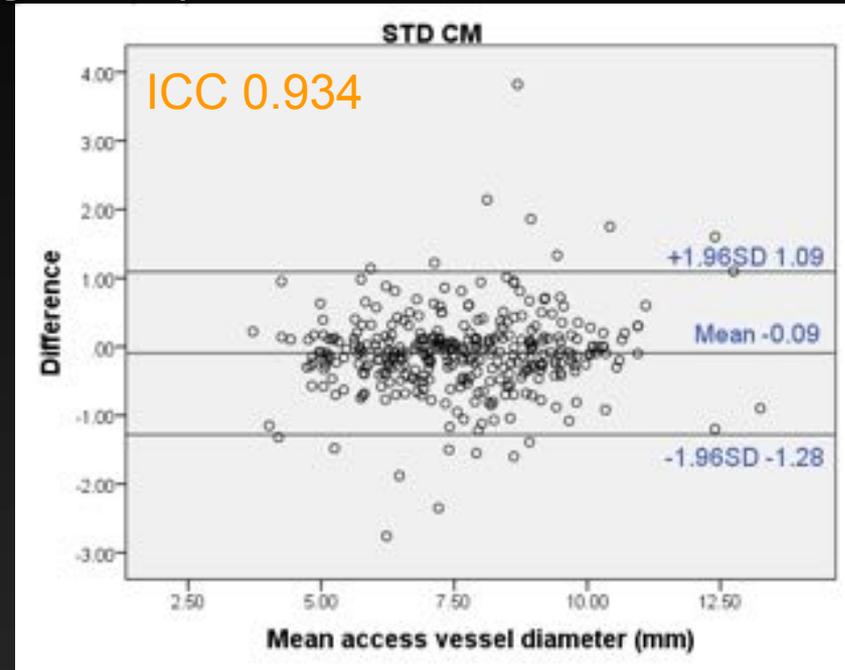
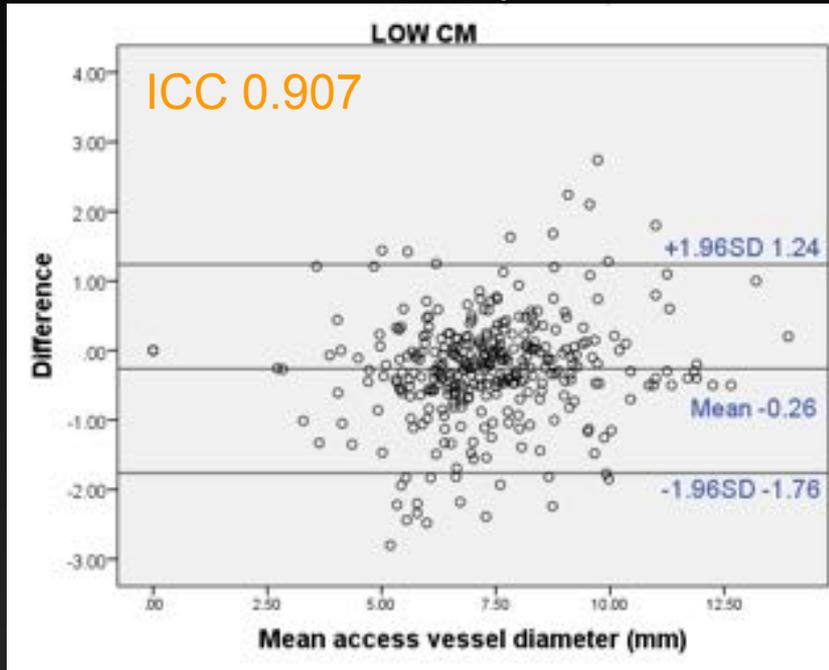
Ultra low CM, Low kVp: may be feasible

88y/o Female 48kg, sCr 2.40, eGFR 20 70 kVp, 20 mL CM



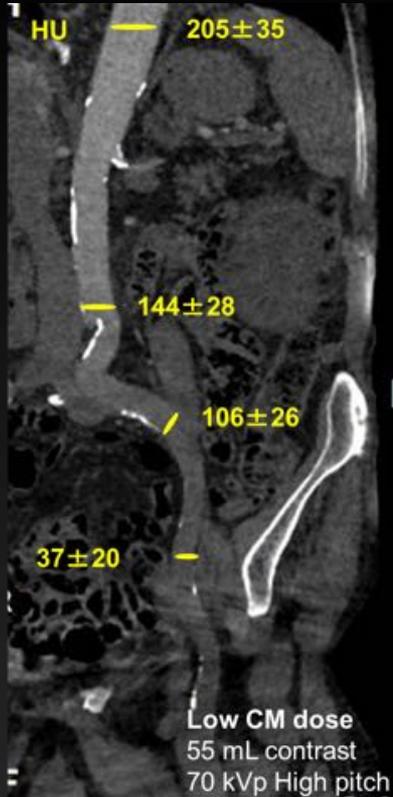
Low kVp, low CM: IQ of access vessels diagnostic using a 3rd generation DSCT?

Preliminary results: interobserver reproducibility ileofemoral measurements (21 pts each group)

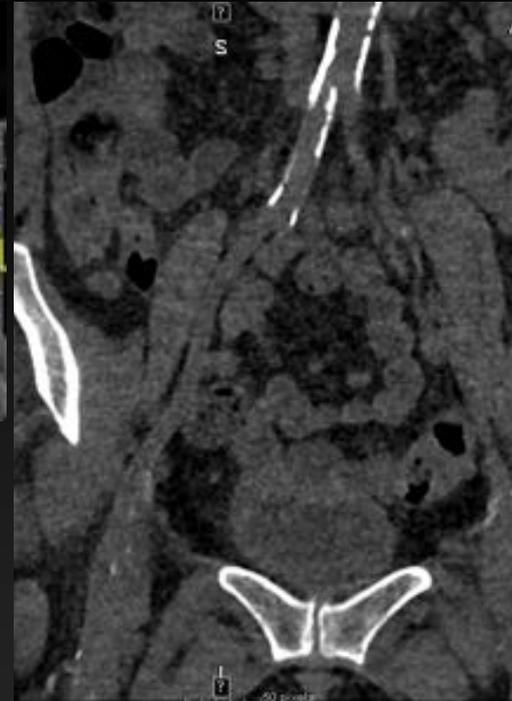


Low kVp, low CM: risks - may still be harmful

CM bolus outrun



CM obstruction



low kVp CTA to reduce CM volume

SUMMARY I

- the gain in s/n with low CM does not compensate for increased noise
→ images are noisier
- higher mAs requires larger focal spot ¹⁾
(even at same nominal FS)
→ images are blurry (spatial resolution)
- lower kVp also increases calcium signal
→ more blooming artifacts

¹⁾ Oh et al., *Eur Radiol* (2014) 24:3010–3016

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SUMMARY II

- Low CM, low kVp CT may be feasible but also has limitations that may be harmful
- Rigorous study design needed to assess effect on image quality and benefit/harm ratio
- Low CM is safe in CKD patients, but does it translate in clinical benefit? (i.e. address renal damage)
- Main risk of CT should not be missing the diagnosis

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Thank you



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CME Question

when using a low contrast dose CTA protocol in patients with chronic kidney disease, arterial enhancement can be improved by:

- A. increasing the kVp
- B. decreasing the kVp
- C. increasing the mAs
- D. decreasing the mAs

correct answer: B

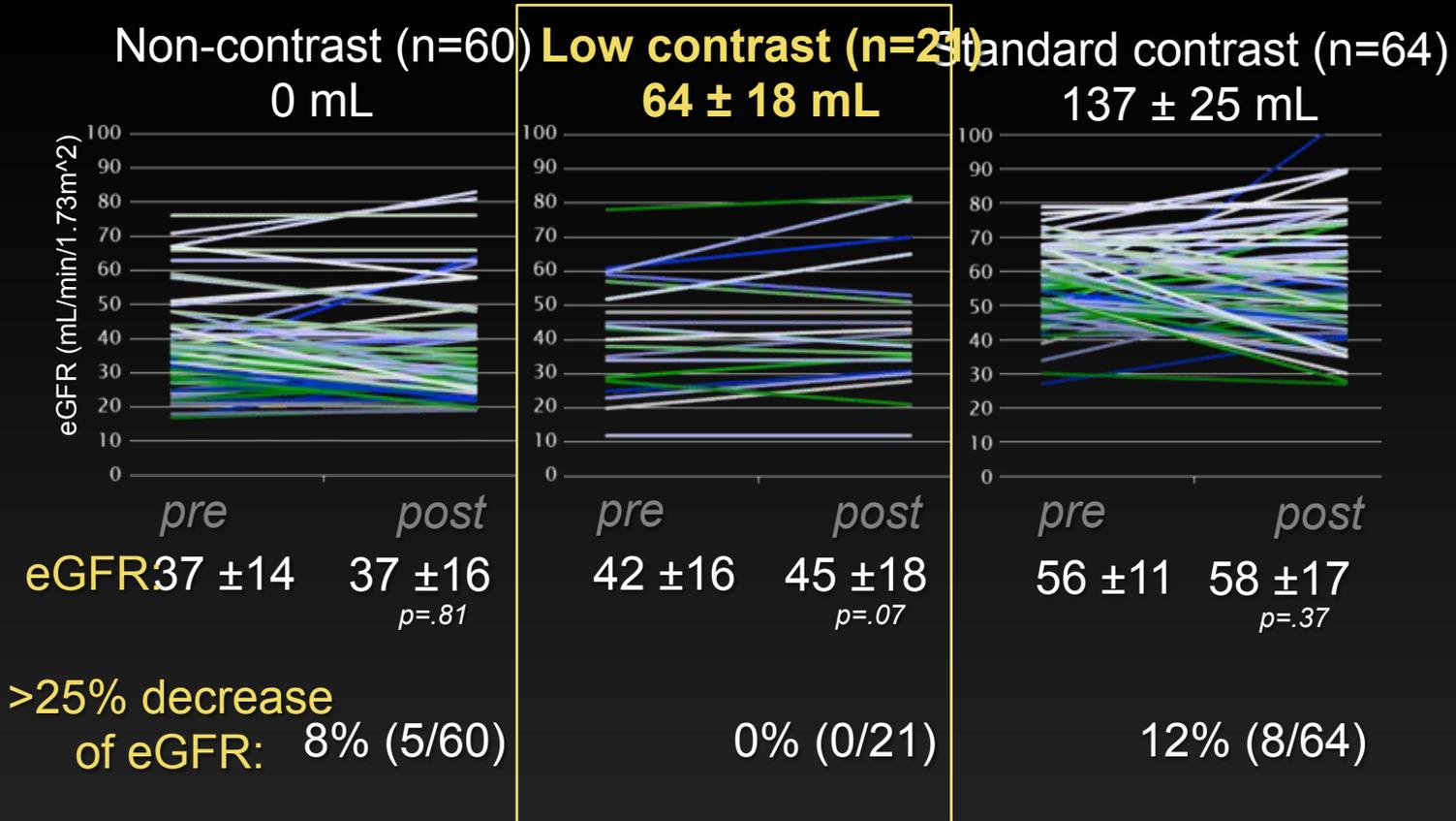
Stanford Approach
CM dosing for patients with CKD
(<60mL/min/1.73m²)

- max volume = eGFR x 2 (for 75kg)
adjust BW = eGFR x 2 x (BW/75)

$$15 \text{ mL/min} \times 2 = 30 \text{ mL contrast}$$
$$30 \text{ mL} \times (92 \text{ kg} / 75 \text{ kg}) = 37 \text{ mL}$$

- low concentration CM (300mg I/mL)
- optimizing scanning parameters (kVp)

eGFR before and 3-14d after CTA in 185 pts undergoing TAVR



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Primum non nocere – First, do no harm

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