Impact of Computed vs. Digital Radiography and Radiation Dose on Image Quality of Chest X-Rays in Neonates using a dedicated Neonatal Phantom

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ESPR European Society of Paediatric Radiology

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Disclosures

Friedrich Wanninger is an employee of Agfa-Gevaert HealthCare GmbH, Munich, Germany.

Nothing to disclose for the other authors.

Background

One study[1] compared CR needle and DR CsI but otherwise there is not much evidence, in particular regarding dose parameters and image quality for Digital Radiography

Digital Radiography technique is convenient in daily practice due to ultra short processing time, but Computed Radiography has significantly higher spatial resolution (100 µm pixel in CR needle vs. 148 µm pixel in DR CsI)

Objectives

Is there a difference in neonatal chest X-Ray between CR needle and DR CsI detectors?

Which dose and parameters are needed for good image quality?

Methods – Phantom 1

- **Technical measurements [no image post-processing]:**
  - ➢ Contrast-Detail Phantom, evaluated by automated software

Acquisition parameters

Voltage	Current · Time	Filter
66 kV	0.50 mAs	2.5 mm Al
70 kV	1.00 mAs	3.5 mm Al + 0.1 mm Cu
	1.50 mAs	3.5 mm Al + 0.2 mm Cu
	2.00 mAs	

Methods – Phantom 2

- **Clinical images [with image post-processing]:**
  - ➢ Neonatal Phantom, 112 images, with different kV, mAs, and filter settings:
    - evaluated by 3 radiologists, using ratings 1 to 5 in a Visual Grading Analysis[1] [13 criteria]
    - AI-supported quantitative data measurement after manual registration [24 segments]

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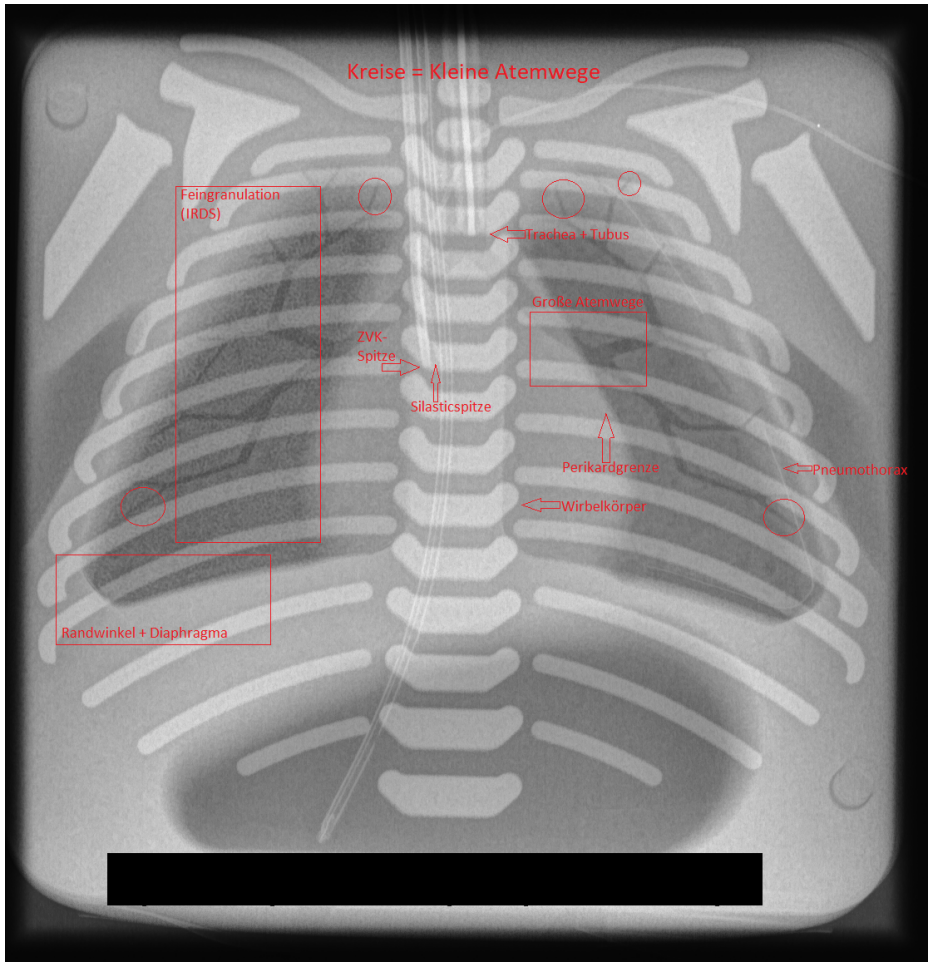
Our characteristics:
- IRDS (right lung)
- Pneumothorax (left lung)
- Endotracheal tube
- CVC
- Silastic-CVC
- NG tube

Acquisition parameters

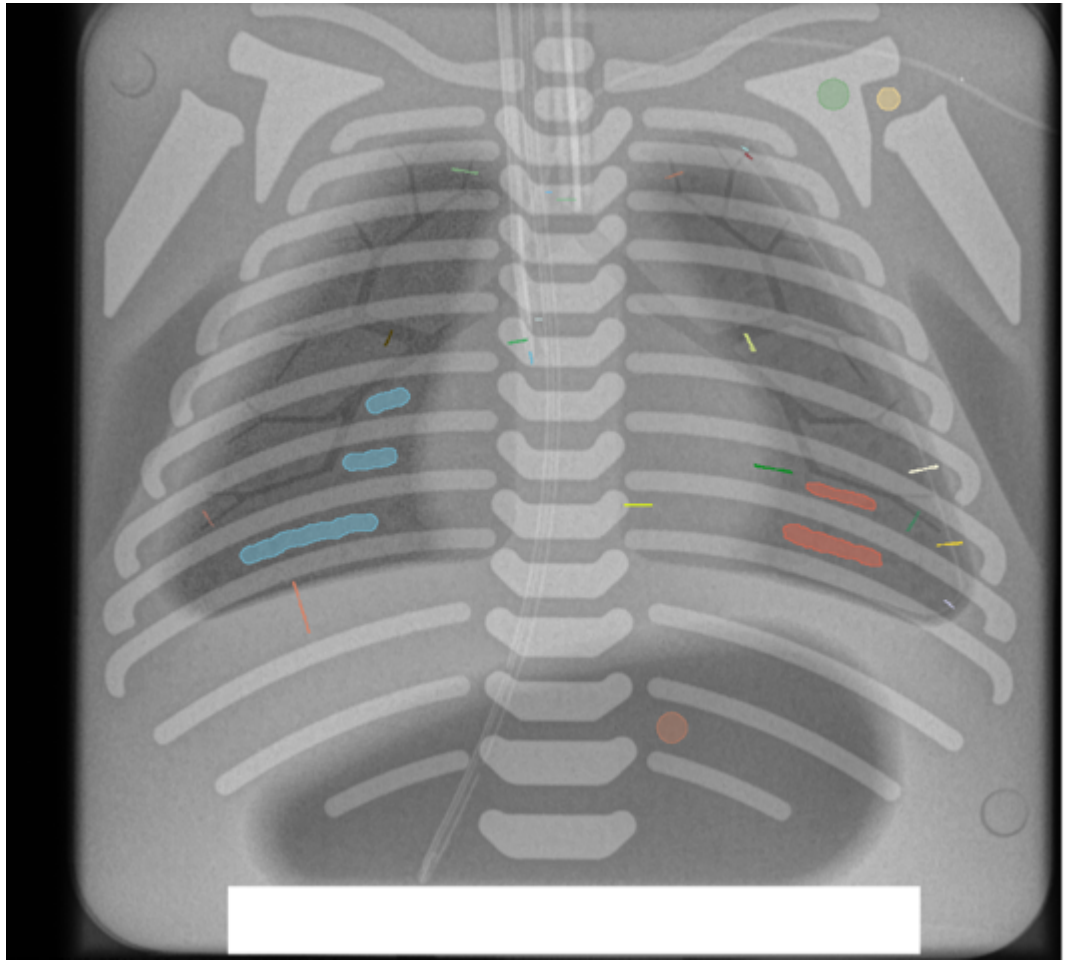
Voltage	Current · Time	Filter
57 kV	0.50 mAs	2.5 mm Al
60 kV	0.63 mAs	3.5 mm Al + 0.1 mm Cu
66 kV	0.80 mAs	
77 kV	1.00 mAs	
	1.25 mAs	
	1.60 mAs	
	2.00 mAs	

Methods – Features evaluation

Radiologists: Visual Grading Analysis



AI-supported measurements: Profile curves and ROIs



Methods – Dose calculation

Based on Dose Area Product values, we calculated Effective Dose (IRCP 103 standard) and organ doses based on published conversion tables[2].

Surface of the neonatal phantom: 100 cm^2

Results – Contrast-Detail Phantom, two different voltages

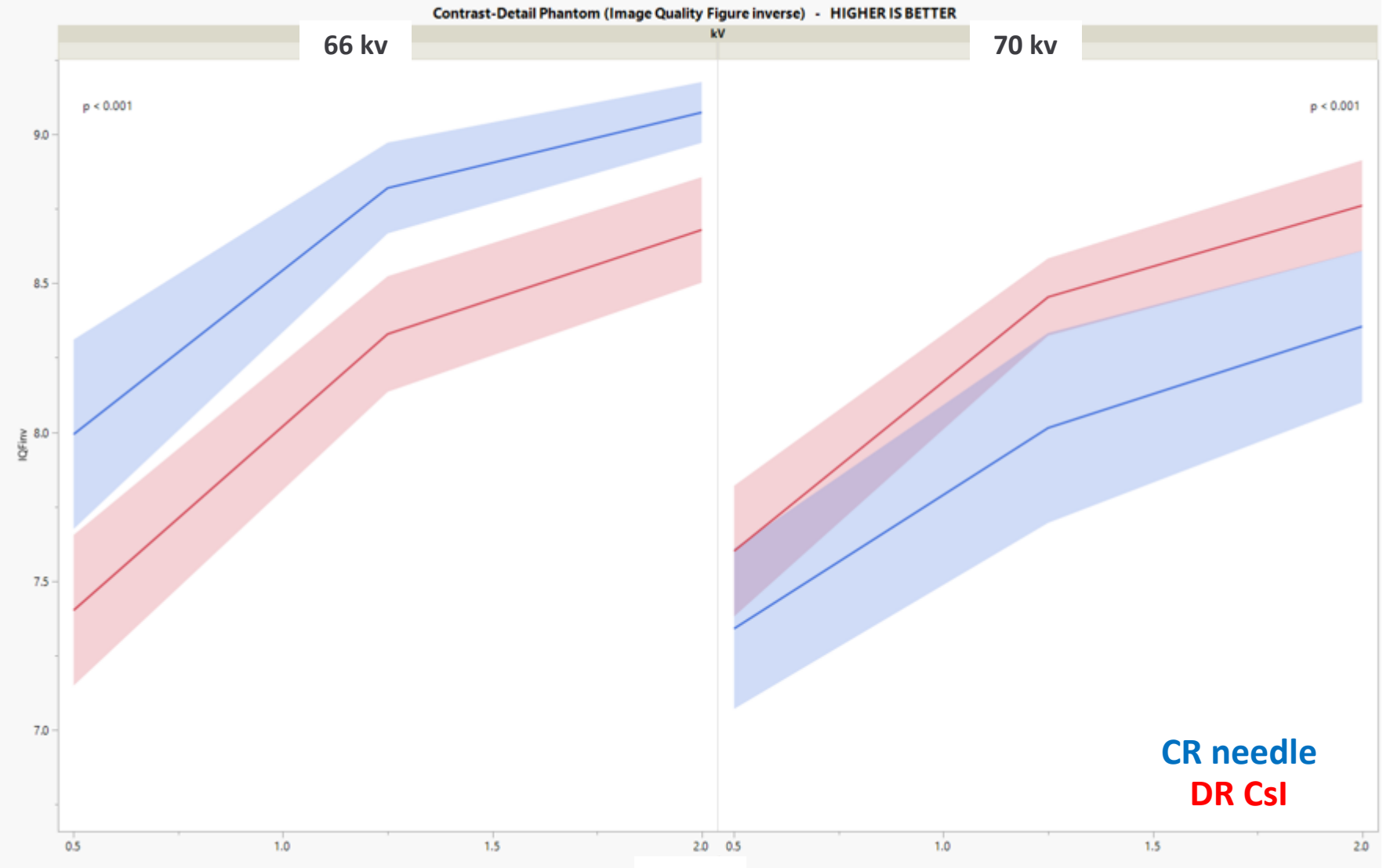


Image Quality

mAs

3 missing CR values at 70 kV

Results – Neonatal Phantom, Visual Grading Analysis Score

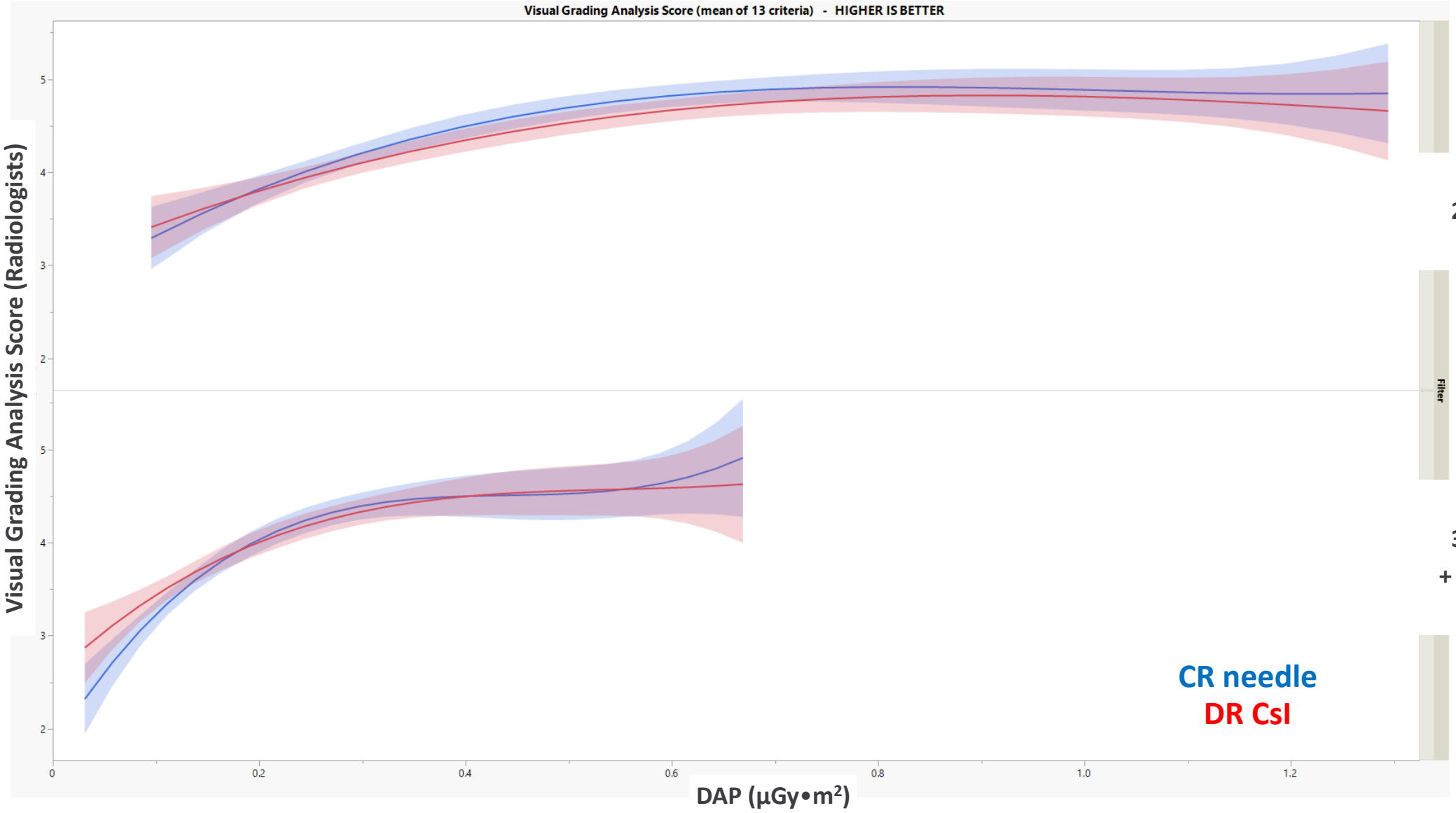
High Inter-Reader and Intra-Reader agreement (determined by Intraclass Correlation Coefficient):

- Inter-Reader: 0.85 [95% CI: 0.71 - 0.91]
- Intra-Reader: 0.90 [0.65 - 0.97]; 0.91 [0.66 - 0.98]; 0.95 [0.79 - 0.99].

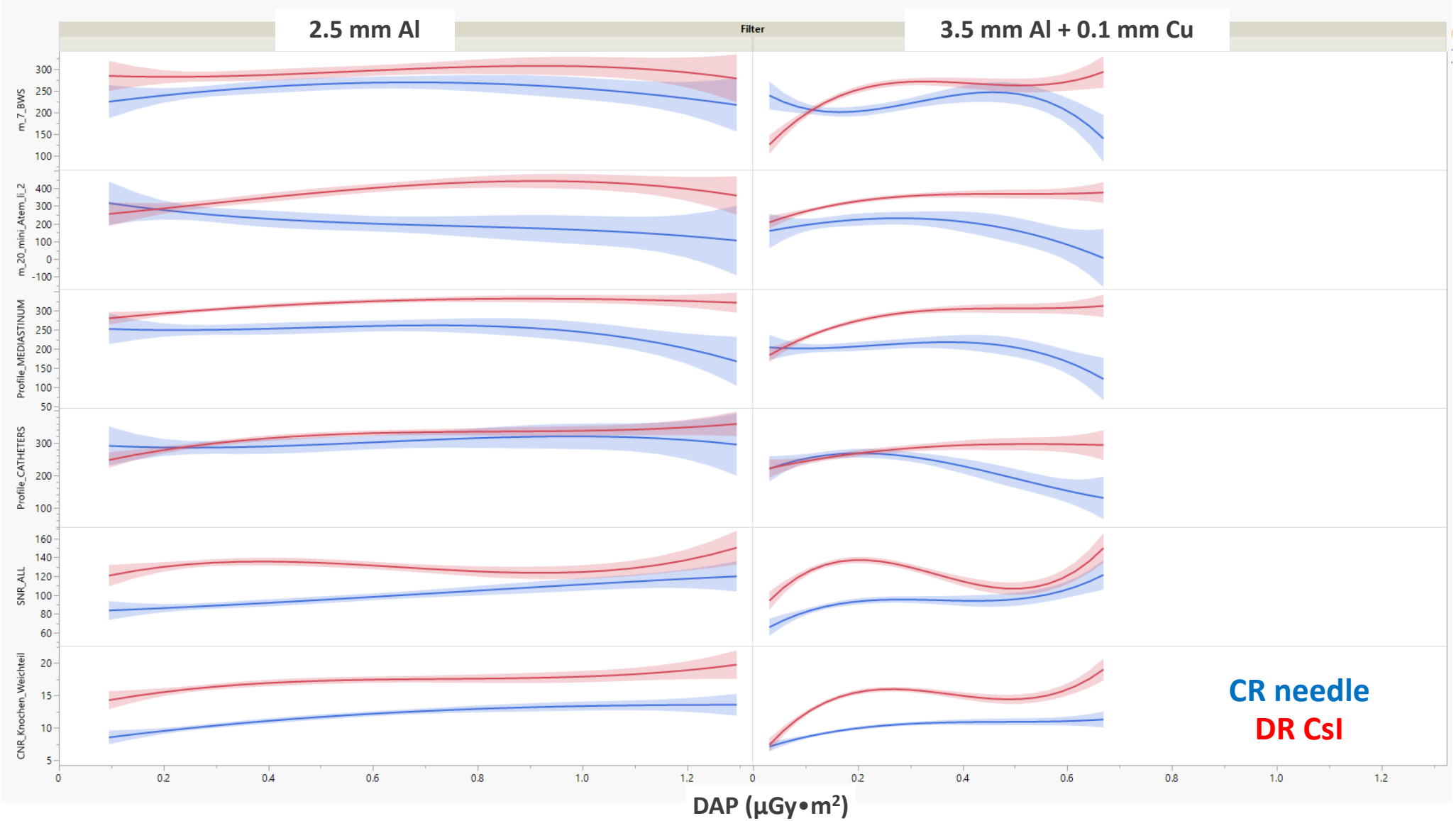
Ordinal Logistic Regression:

- No statistically significant difference ($p = 0.63$) in Image Quality-VGAS at the same DAP levels between CR needle and DR CsI detectors.
- No statistically significant difference ($p = 0.44$) in Image Quality-VGAS at the same DAP levels between standard pediatric filtering (3.5 mm Al + 0.1 mm Cu) and minimal filtering (2.5 mm Al).
- Dose Area Product has a significant effect on Image Quality-VGAS ($p < 0.001$).

Results – Neonatal Phantom, Visual Grading Analysis Score



Results – Neonatal Phantom, AI-supported quantitative data (example)



Correlation between Visual Grading and AI-supported quantitative results

24 ROIs and profile curves, evaluation of AI-supported quantitative data by Spearman's correlation to Visual Grading:

- Contrast-to-Noise-Ratio of bone vs. soft tissue has a correlation to Visual Grading ≥ 0.50 for both detectors

- 3 other segments have a correlation to Visual Grading ≥ 0.50 for one detector
    - Signal-to-Noise-Ratio of bone
    - Profile curve of pericardium-to-lung
    - Profile curve of a very small airway-to-air in the top left lung

- 13 other segments have a correlation to Visual Grading < 0.50 for both detectors

- 7 profile curves could not be evaluated due to either AI inability to generate data or no clear profile

Dose levels and image aquisition parameters

Based on Visual Grading Analysis Score of the Lungs (mean of IRDS, pneumothorax, small airways)

- **Parameters for "good" image quality of chest X-ray in neonates with total filter of 3.5 mm Al + 0.1 mm Cu:**

kV	mAs	Effective Dose (IRCP 103)	Lung Dose	Dose Area Product
57	1.60	0.010 mSv	0.017 mSv	2.3 mGy•cm^2
60	1.60	0.012 mSv	0.019 mSv	2.6 mGy•cm^2
66	1.25	0.012 mSv	0.021 mSv	2.6 mGy•cm^2
77	0.80	0.012 mSv	0.019 mSv	2.3 mGy•cm^2

Summary

Contrast-Detail Phantom [no image post-processing]:

- Highest Image Quality at 66 kV using CR, no kV-dependency when using DR in the rage of 66 to 70 kV

Neonatal Phantom [with image post-processing], evaluated by Radiologists:

- At same dose, no difference between CR needle and DR CsI
- At same dose, no difference between standard pediatric filter (3.5 mm Al + 0.1 mm Cu) and minimal filter (2.5 mm Al)

Neonatal Phantom [with image post-processing], AI-supported quantitative evaluation:

- Analysis by CNR has good correlation to Visual Grading, while profile curves and SNR have low to moderate correlation

Among our image acquisition parameters, we found the lowest dose to image quality compromise when using 57 kV, 1.60 mAs, and filter of 3.5 mm Al + 0.1 mm Cu, but also for other parameters, as shown.

References

[1] Smet MH, Breysem L, Mussen E, Bosmans H, Marshall NW, Cockmartin L. Visual grading analysis of digital neonatal chest phantom X-ray images: Impact of detector type, dose and image processing on image quality. Eur Radiol. 2018;28(7):2951-2959.

[2] Seidenbusch M., Rösenberger V., Schneider K., Imaging Practice and Radiation Protection in Pediatric Radiology, Cham, Switzerland, Springer Nature Switzerland, 2019-2020

Thank you for listening