# Experience with the use of Kyoto anthropomorphic phantoms in CT


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# Anthropomorphic Phantoms Kyoto Kagaku

| Materials | | |
|---|---|---|
| | Soft tissue: | urethane-based resin (specific gravity 1.06) |
| | Synthetic bone: | epoxy resin (specific gravity 1.31) |
| | Skull: | epoxy resin (specific gravity 1.11) |

PBU-60 Whole Body Phantom
165 cm, 50 kg → BMI 18.4 (packing weight 80 kg)

PBU-70 Paediatric Phantom (5y)
110 cm, 20 kg

PH-1 Lungman Phantom
Chest girth 94 cm, 18 kg

PBU-50 Newborn Phantom
53 cm, 3.5 kg

# Same “patient” scanned by same radiographer & Physics at each site

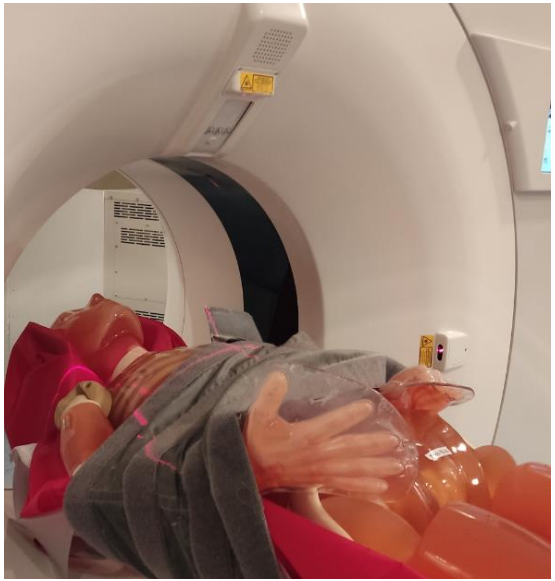
Adult and paed (5y) phantoms on loan from 2nd to 28th May 2024
Lots of activities to experiment with phantoms in Diagnostic CT, General X-ray, Paed X-ray, IR Angio and R/therapy CT

For Diagnostic Radiology
- Philips: iQon (x2), 7500, 7500 Pro
- Siemens: Somatom Definition Edge (x2), Definition Flash
- Canon: One Aquilion Prism

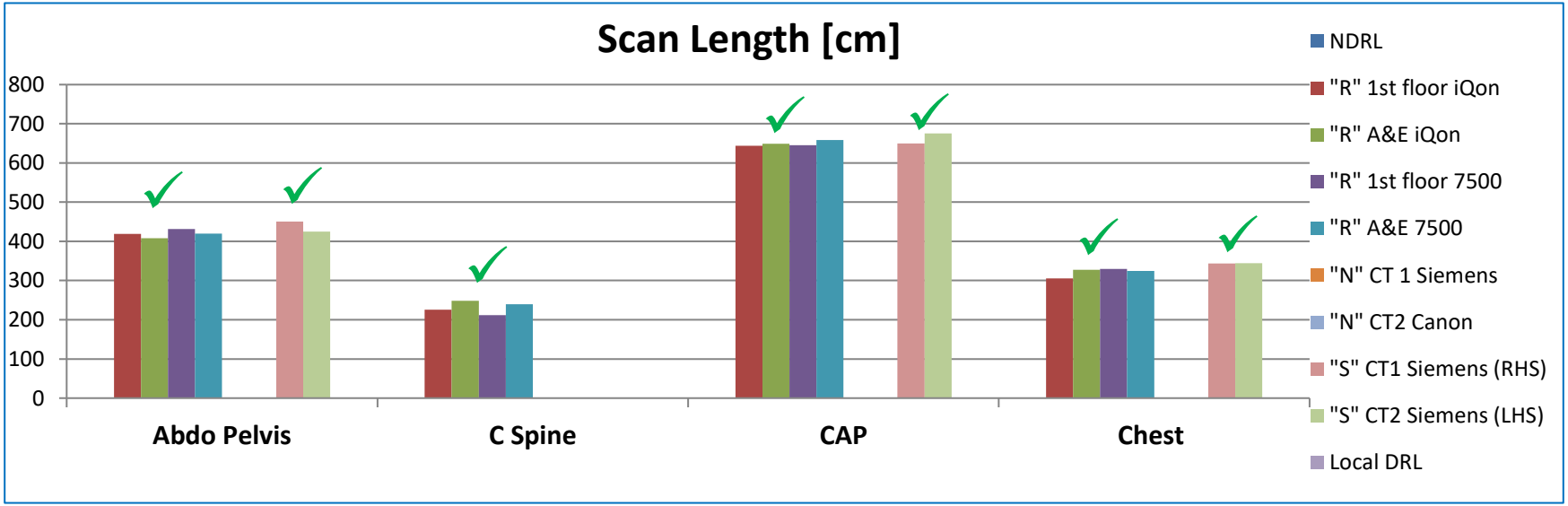
To find out:
- ? How harmonised scans are intra-site and across sites
- ? Optimisation priorities (corroborating with patient dose audits)
- ? Is phantom “realistic”
- ? Useful for showing effects of technique variations (mis-centring, arms up/down)
- ? Practicalities, including handling
- ??? Will it be worth buying

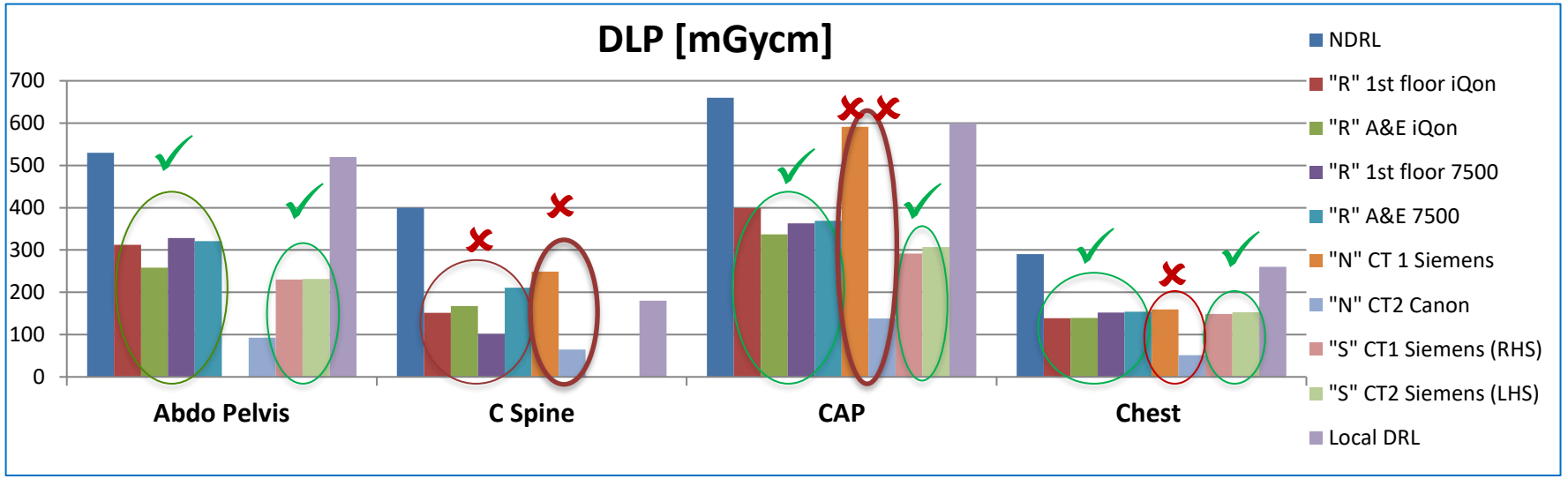
# Adult protocols:

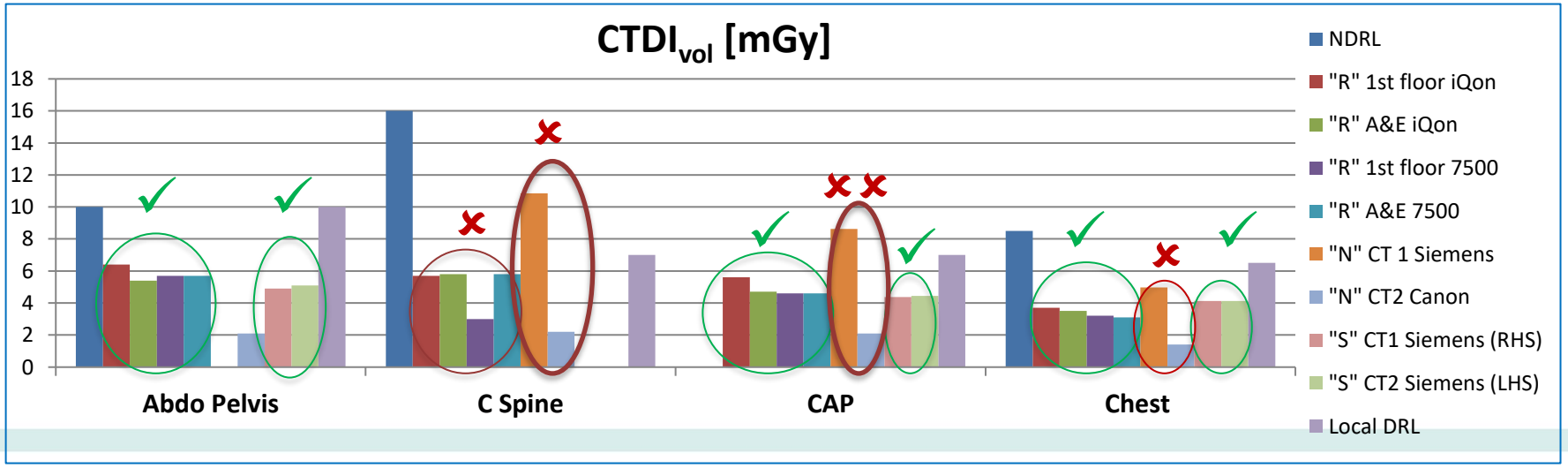
# What did the scanning reveal?



# Scan lengths for body scans – harmonised (same patient)



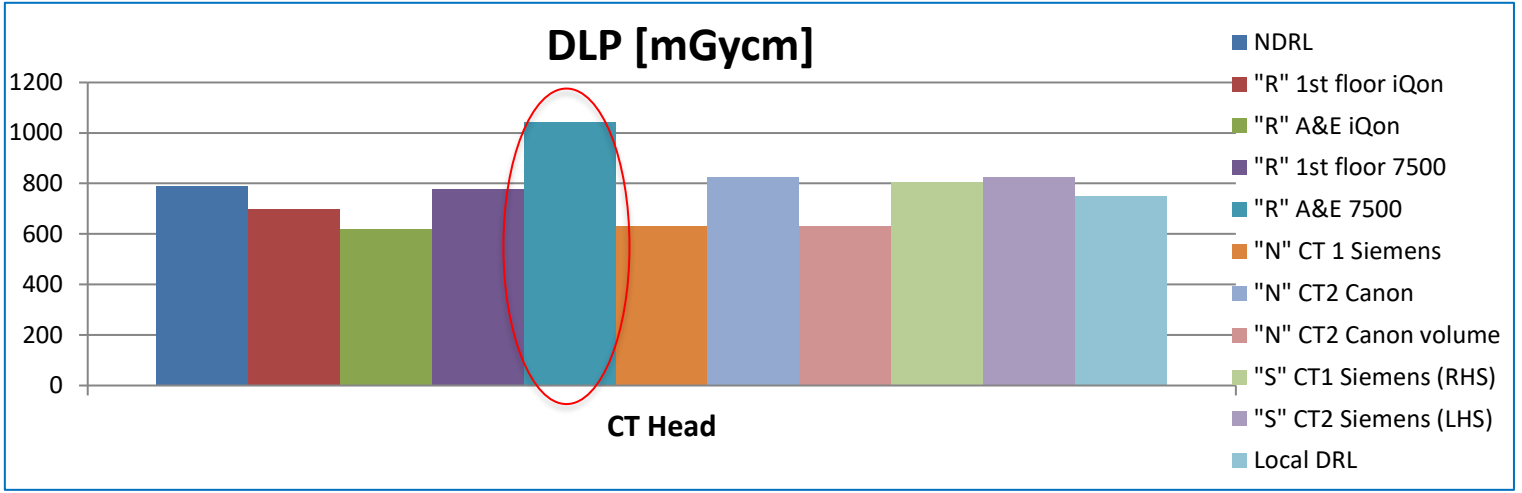

DLP [mGycm]
700
600
500
400
300
200
100
0
Abdo Pelvis
C Spine
CAP
Chest
NDRL
"R" 1st floor iQon
"R" A&E iQon
"R" 1st floor 7500
"R" A&E 7500
"N" CT 1 Siemens
"N" CT2 Canon
"S" CT1 Siemens (RHS)
"S" CT2 Siemens (LHS)
Local DRL

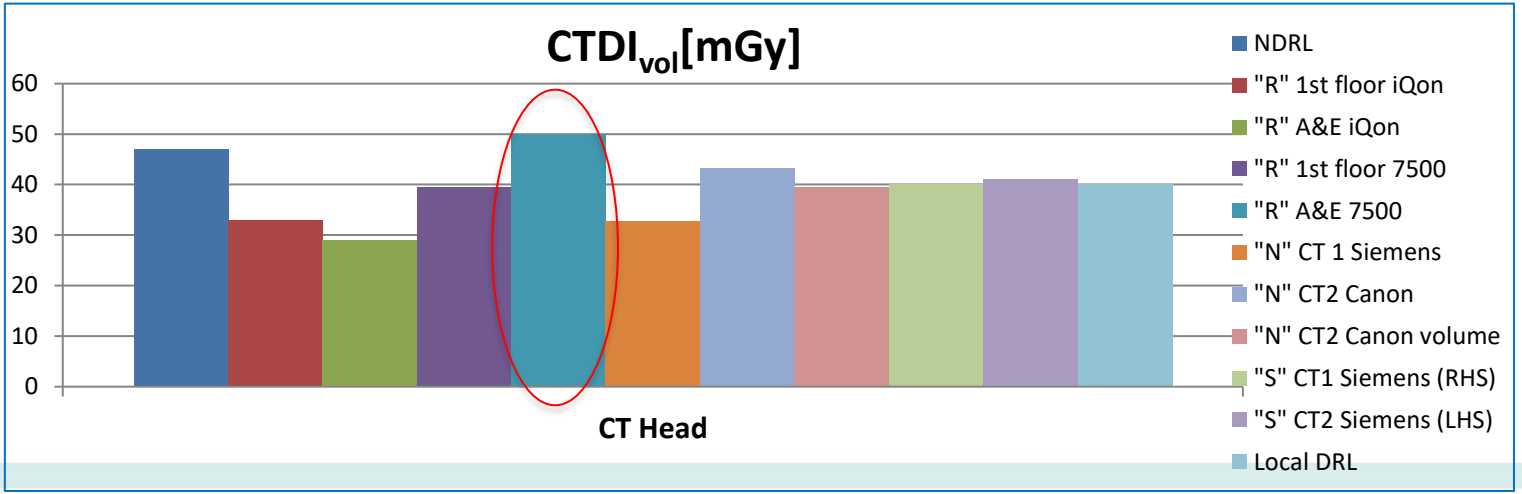

CTDIvol [mGy]
18
16
14
12
10
8
6
4
2
0
Abdo Pelvis
C Spine
CAP
Chest
NDRL
"R" 1st floor iQon
"R" A&E iQon
"R" 1st floor 7500
"R" A&E 7500
"N" CT 1 Siemens
"N" CT2 Canon
"S" CT1 Siemens (RHS)
"S" CT2 Siemens (LHS)
Local DRL

# CT Head – Close to DRL except for 1 AE scanner

Outcome:

Protocol review
- Re-optimisation
- Patient audits



# Interesting case: Hi-res Chest

2 neighbouring scanners at one site have very similar values of DLP, $CTDI_{vol}$ and scan length, but very different kV and mAs

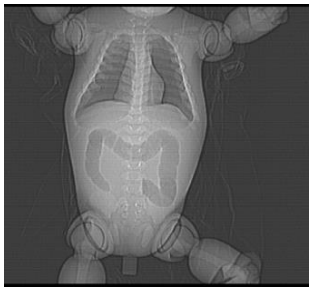
| Scanner | kVp | mAs | $CTDI_{vol}$ [mGy] | DLP [mGycm] |
|---|---|---|---|---|
| SBH CT1 | 120 | 45 | 3.04 | 108.4 |
| SBH CT2 | 100 | 75 | 2.96 | 109.6 |

Which of these gives better image quality?

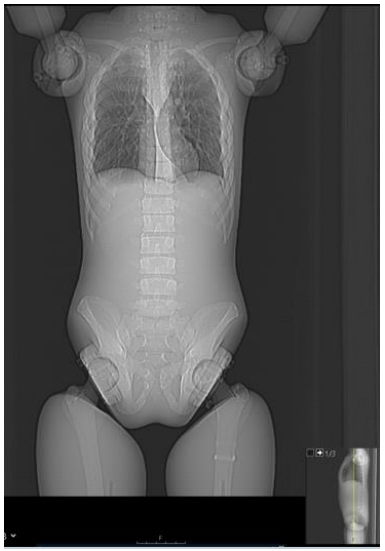
# Paediatric protocols:

# What did the scanning reveal?

# Kyoto paediatric phantoms



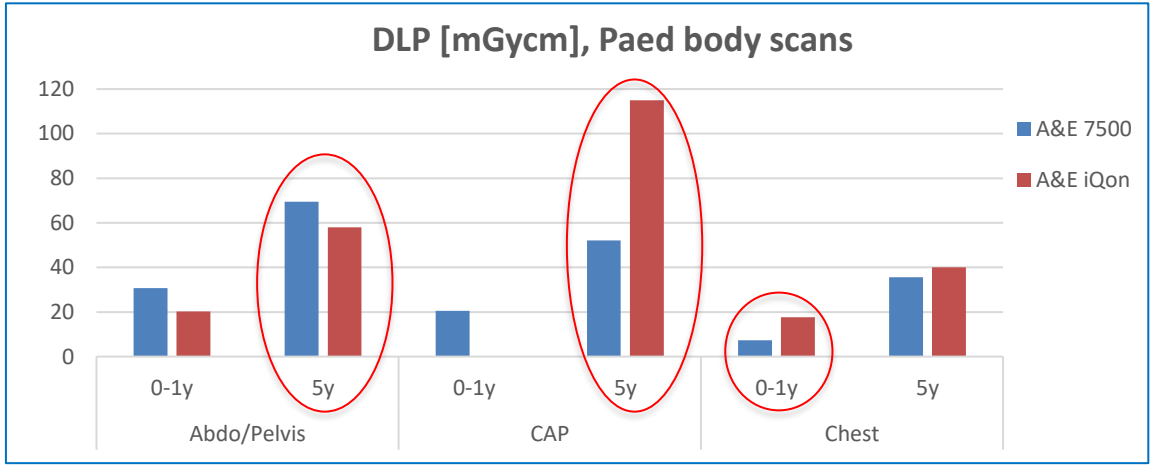
Newborn

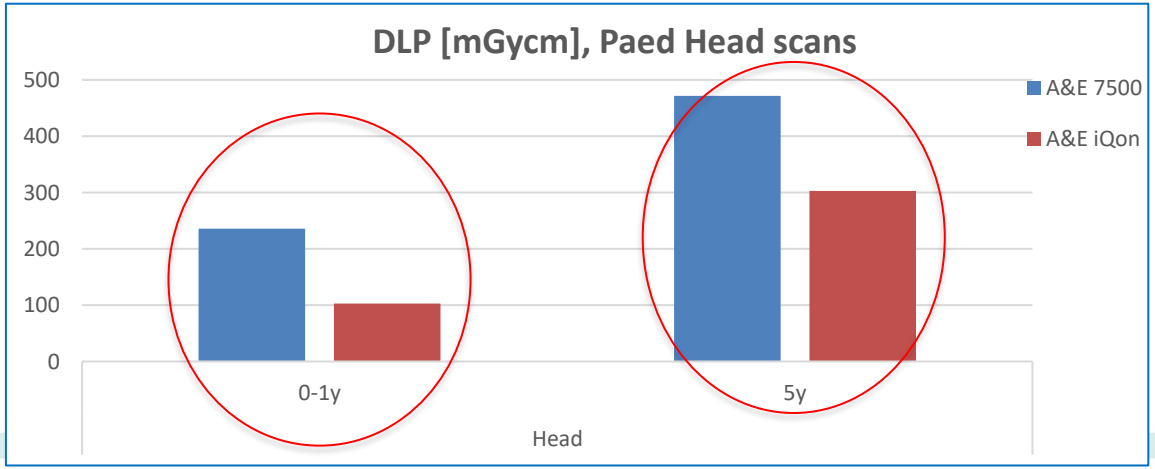


5y old

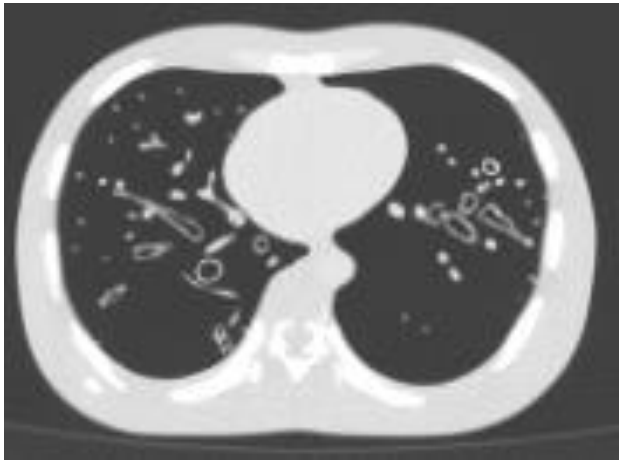
Review of protocols straightaway

- Re-optimisation
- Patient audits following



# How did the images look?



# Phantom versus Patient on same scanner

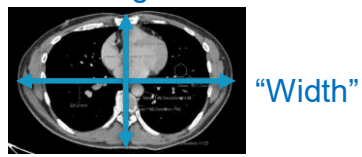
Kyoto: CAP scan 23/05/2024

| Scan Mode | mAs | kV | CTDIvol [mGy] | DLP [mGy*cm] |
|---|---|---|---|---|
| Surview | | 120 | 0.107 | 7.3 |
| Surview | | 120 | 0.107 | 7.3 |
| Helical | 60 | 120 | 4.6 | 363 |

34y ♂: CAP scan 22/05/2024

| Scan Mode | mAs | kV | CTDIvol [mGy] | DLP [mGy*cm] |
|---|---|---|---|---|
| Surview | | 120 | 0.063 | 4.8 |
| Surview | | 120 | 0.063 | 4.8 |
| Helical | 67 | 120 | 6.1 | 411.8 |

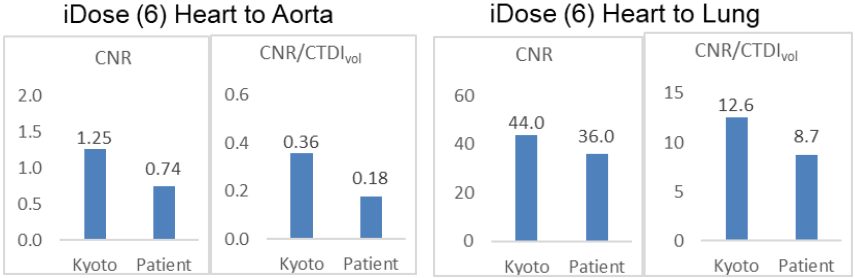
| Body part measurements on axial slice | | Kyoto | Patient |
|---|---|---|---|
| Chest through heart | Width [mm] | 290.3 | 320.3 |
| | Height [mm] | 200.1 | 199.3 |
| Abdo through liver | Width [mm] | 273.8 | 301.3 |
| | Height [mm] | 187.8 | 180.5 |



Contrast-to-noise ratio between 2 tissues

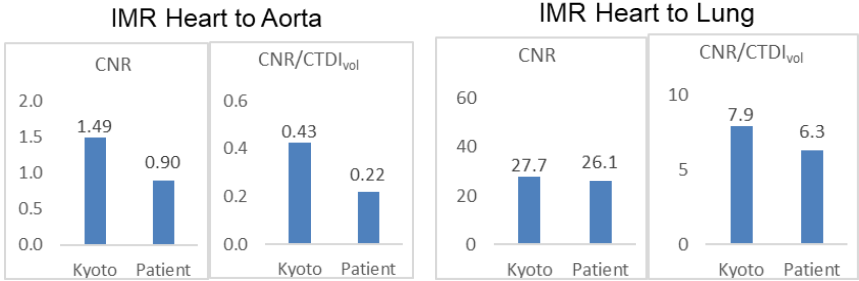
$$CNR = \frac{|m_1 - m_2|}{\sqrt{\frac{\sigma_1^2 + \sigma_2^2}{2}}}$$

CNR per unit dose: $CNR/CTDI_{vol}$





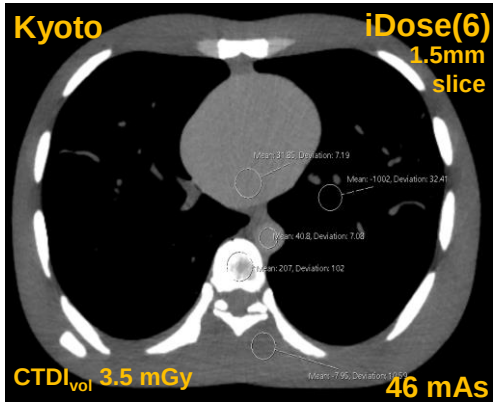


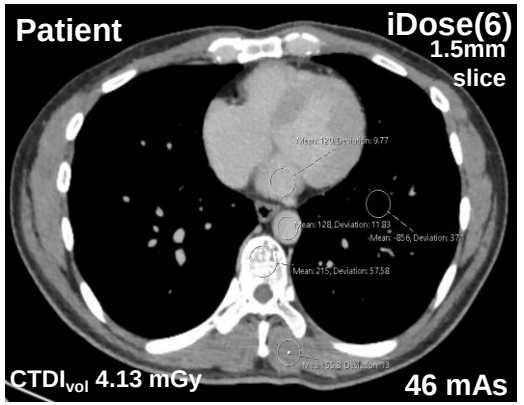


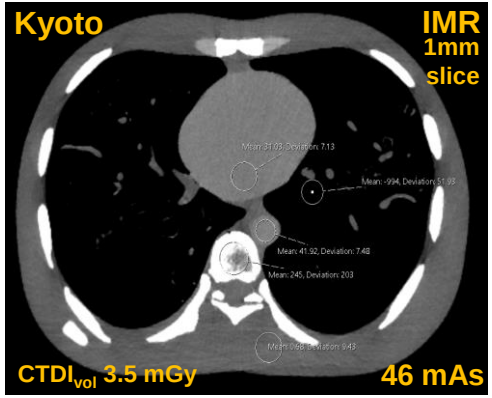


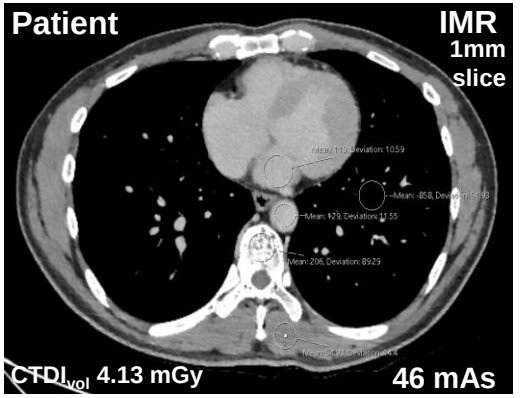


# Philips 7500, Chest, 120 kV



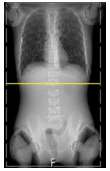



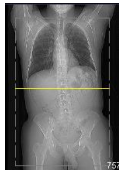



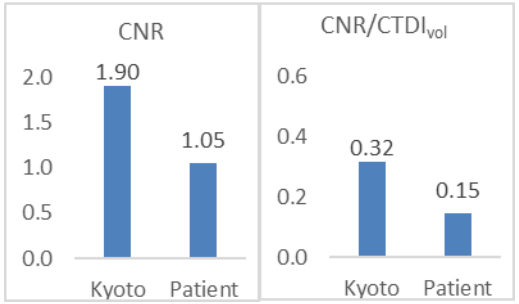

- Kyoto CNR > Patient CNR
- Good match between Kyoto and Patient for Heart to Lung CNR
- For Heart to Lung CNR: IMR better match than iDose (6) – Kyoto CNR/Pt CNR 1.06; CNR/dose ratio 1.25

# Philips 7500, Abdo, 120 kV

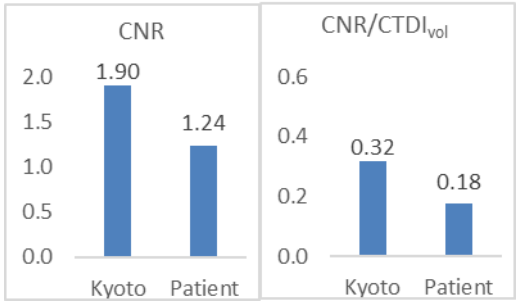


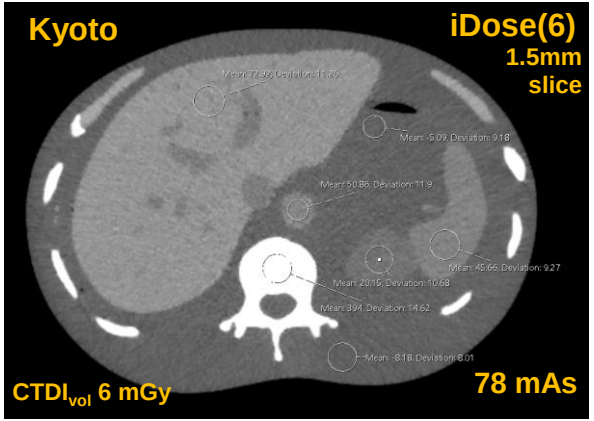


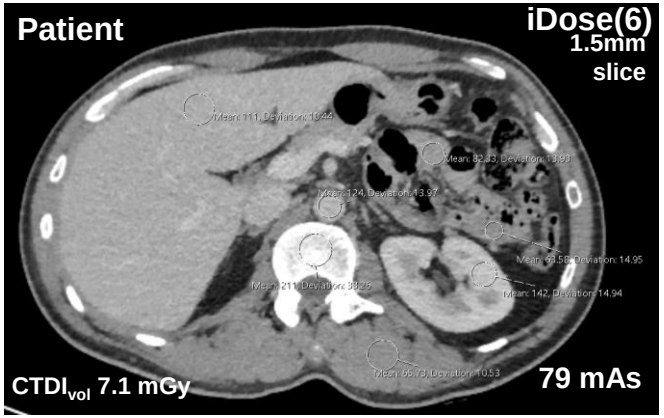
iDose (6) Liver to Aorta

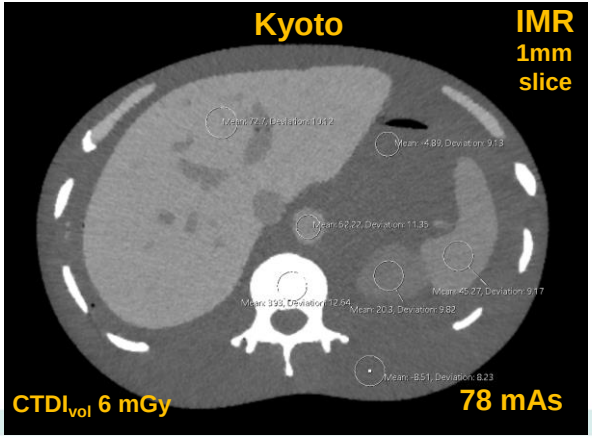


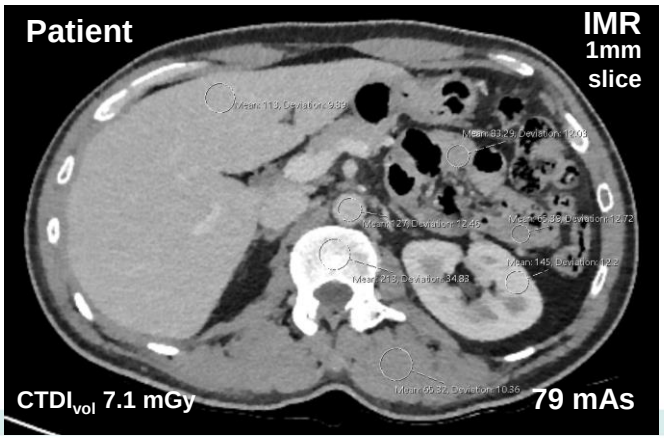

IMR Liver to Aorta




- Kyoto CNR > Patient CNR

# Summary - answering my own questions

? How harmonised scans are intra-site and across sites
- Reasonably so for body scans, except for 1 site

? Optimisation priorities (corroborating with patient dose audits)
- Paediatric body scans, Adult head and C-spine

? Is phantom “realistic”
- Depends: OK for dose optimisation but would need body plate to increase BMI (32, or 40); not so realistic for image optimisation

? Useful for showing effects of technique variations (mis-centring, arms up/down)
- Yes, but bigger effects seen if add body plates

? Practicalities, including handling
- Heavy, storage space, time to assemble/disassemble, but able to cope;
- Need careful annotations/notes on scans when doing a run of experiments

??? Will it be worth buying if resources available
- Yes, I would say, if resources are available

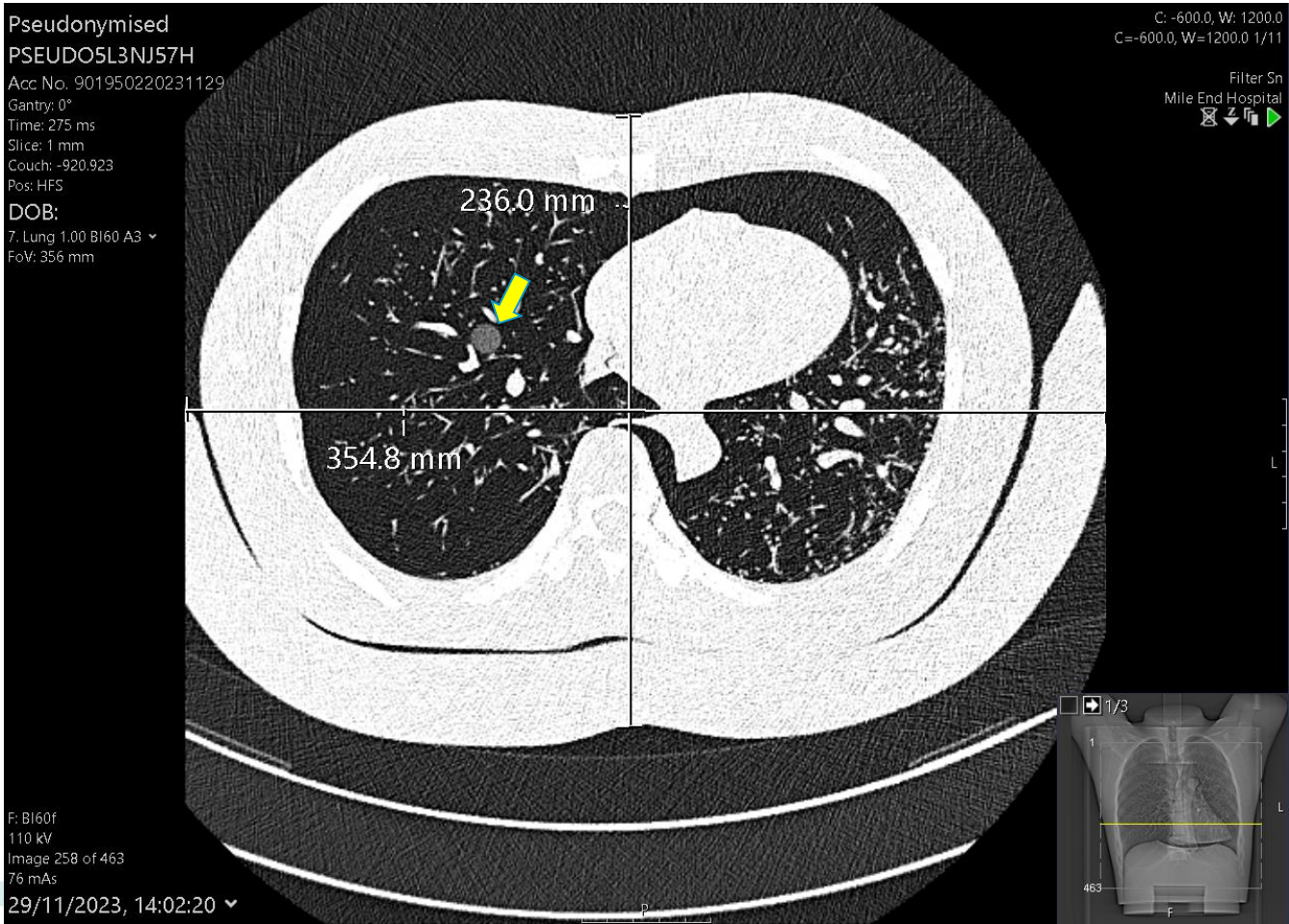
# Bonus:

## Kyoto Lungman Trial (Nov. ‘23)

### For Targeted Lung Health Check Programme


# Phantom with body plate - dimensions more akin to those of a real patient

| DLP [mGycm] | | |
|---|---|---|
| Lungman | LDRL | NDRL |
| 36 (on Sn110 kV, Siemens Go.Top) | 70 | 74 |



# Thank you for listening


## Acknowledgements

To MediScientific and BHRUT for lending us Kyoto phantoms and
To Barts Health Radiation Safety Team and the Imaging departments at the sites involved