



UNIVERSITY of  
**BRADFORD**

Faculty of Health Studies

# Hands up if you need a chest CT!

Gareth Iball<sup>1</sup>, Helen Adamson<sup>1</sup>, Helena Cvjetan<sup>2</sup>

1: University of Bradford

2: University of Birmingham

# Agenda

- Importance of arm positioning for body CT scans
- Study aims
- Methods for dose and image quality assessment
- Results: image quality, displayed dose, organ dose
- Implications for practice

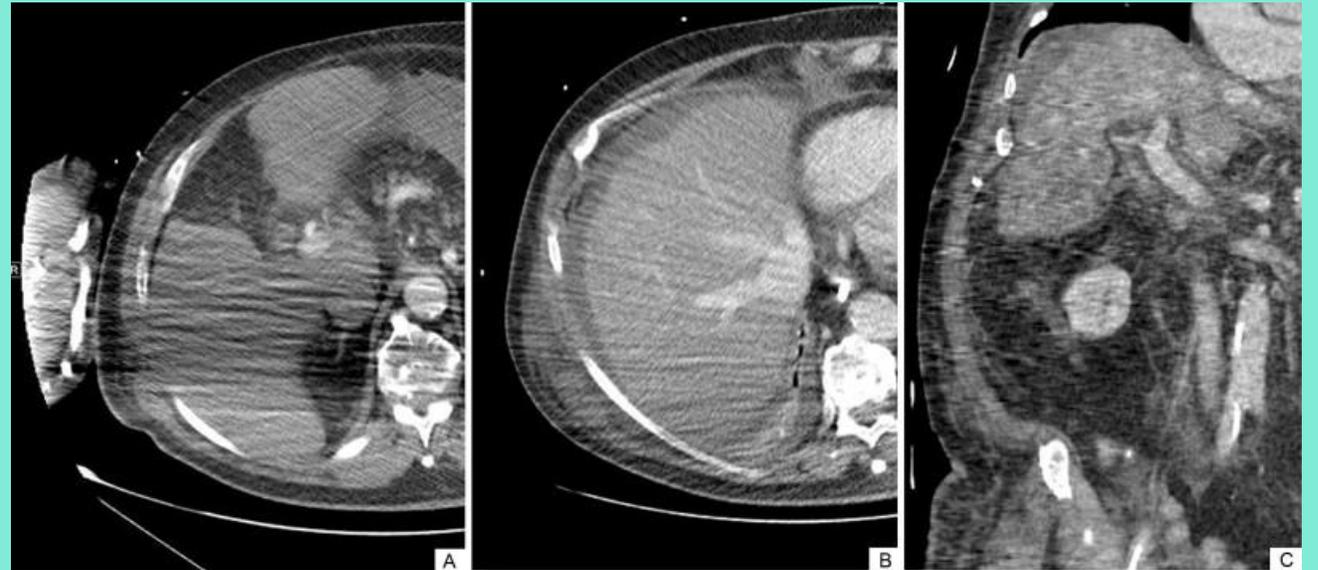


# Normal arm position for chest CT

Both arms above head

Reduces beam hardening  
artefacts (Kahn et al. 2014, Speelman  
et al. 2019, Kawashima et al. 2020)

Arms down increases overall  
dose when AEC used (Buchhave et  
al. 2024, Liu et al. 2014, Graef et al. 2020)



Kahn J, Grupp U, Maurer M, How does arm positioning of polytraumatized patients in the initial computed tomography (CT) affect image quality and diagnostic accuracy?, *European Journal of Radiology*, Volume 83, Issue 1, 2014, Pages e67-e71, <https://doi.org/10.1016/j.ejrad.2013.10.002>.

*“Both arms should be raised above the head. This is sometimes not possible and may result in streak artefacts across the image.*

*To avoid or reduce this the following options, or a combination of them, may compensate:*

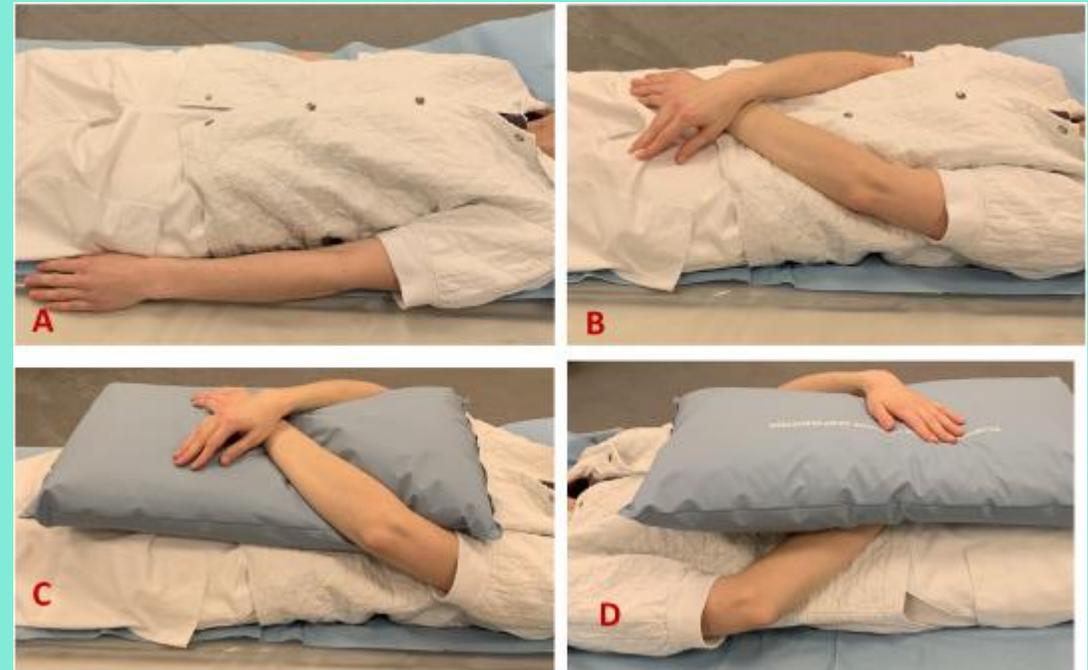
- *Raise one arm if possible*
- *Increase exposure*
- *Change the algorithm to soft rather than standard to reduce noise on the image”*

Clinical CT: Techniques and Practice. Ed Suzanne Henwood



# What if the patient can't get arms up?

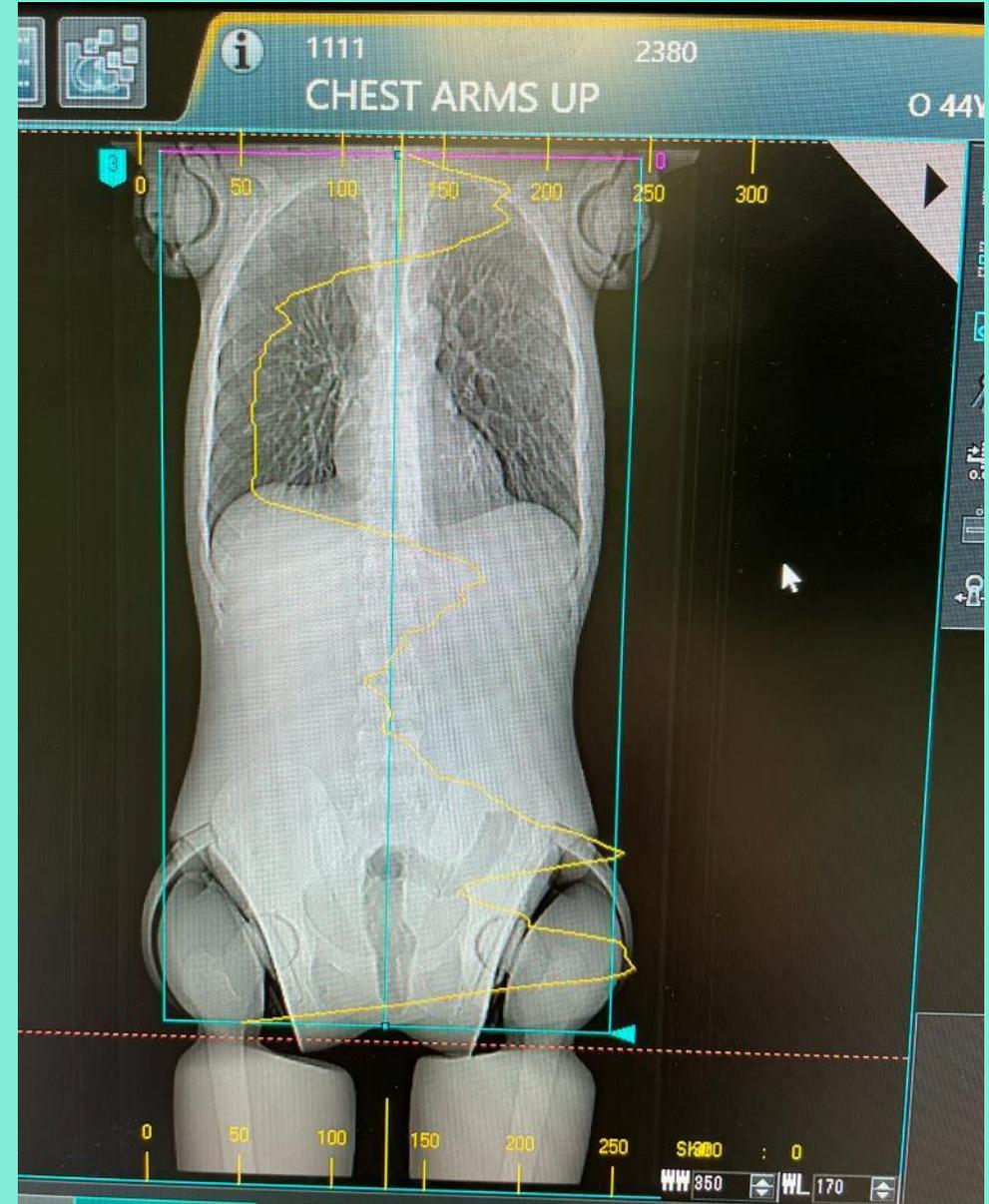
- Range of options available
  - Arms by side
  - Arms on front
  - +/- use of supports
  - position patient lower in gantry
- All would have dose & image quality effects
- Buchhave et al (2024) investigated effect on displayed dose and image noise for a small range of arm positions



Buchhave E.Ø. , Rasmussen C.D., Lentz R., Frederiksen E.H., Kipp J.O., Leftes M.Ø., Effect of arm position on image quality and radiation dose during thorax and abdomen computed tomography scans, Radiography, Volume 30, Issue 4,2024, <https://doi.org/10.1016/j.radi.2024.04.015>.

# Aims of study

- To evaluate the effect of variable arm positioning on:
  - scanner displayed dose
  - organ dose
  - image quality (global noise level)



# Methods

- Kyoto Kagaku PBU 60 body phantom
- FujiFilm Scenaria View Focus Edition CT
- AEC system (Intelli EC) is constant noise but adapted at extremes of patient size
- Range of patient positioning aids used



# Scan protocol

Tube voltage (kV)	120
Intelli EC settings	sd= 12, 2.5mm, IPV Abdomen Lv3, 25-600mA
Detector configuration	40mm (0.625x64)
Pitch	0.83
Rotation time (s)	0.5
Patient position	Feet first supine
Scan direction	Out (chest → pelvis)
Image thickness / increment (mm)	2.5 / 2.5
Reconstruction settings	IPV Abdomen Lv 3

# Methods

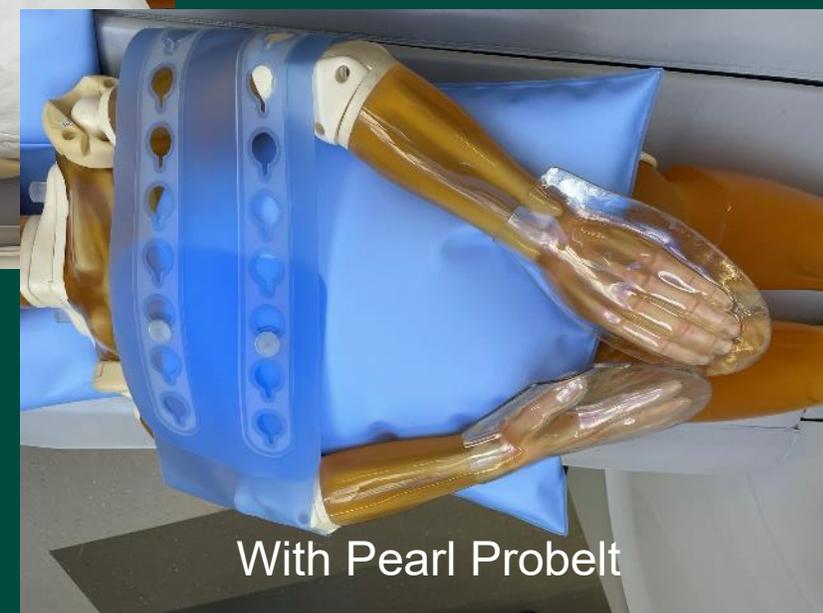
- For each arm position:
- AP & LAT scannograms
- Subsequent single-volume CAP scan
- Scanner displayed doses recorded
  
- z-axis locations of key organs identified from scan images
  
- In house python code to extract mA values, water equivalent diameter (WED) (McCollough et al. 2014) and global noise level (GNL) (Christianson et al. 2015)



# Arm positions used

- Both arms up
- One up, one down
- One up, one across front
- One up, one across front on pillow
- One down, one across front
- One down, one across front on pillow
- Both down
- Both across front
- Both across front with pillow
- Both across front with Pearl Probelt\*
- Both across chest

\*Pearl Probelt Thorax - <https://www.pearl-technology.ch/probelt-thorax>

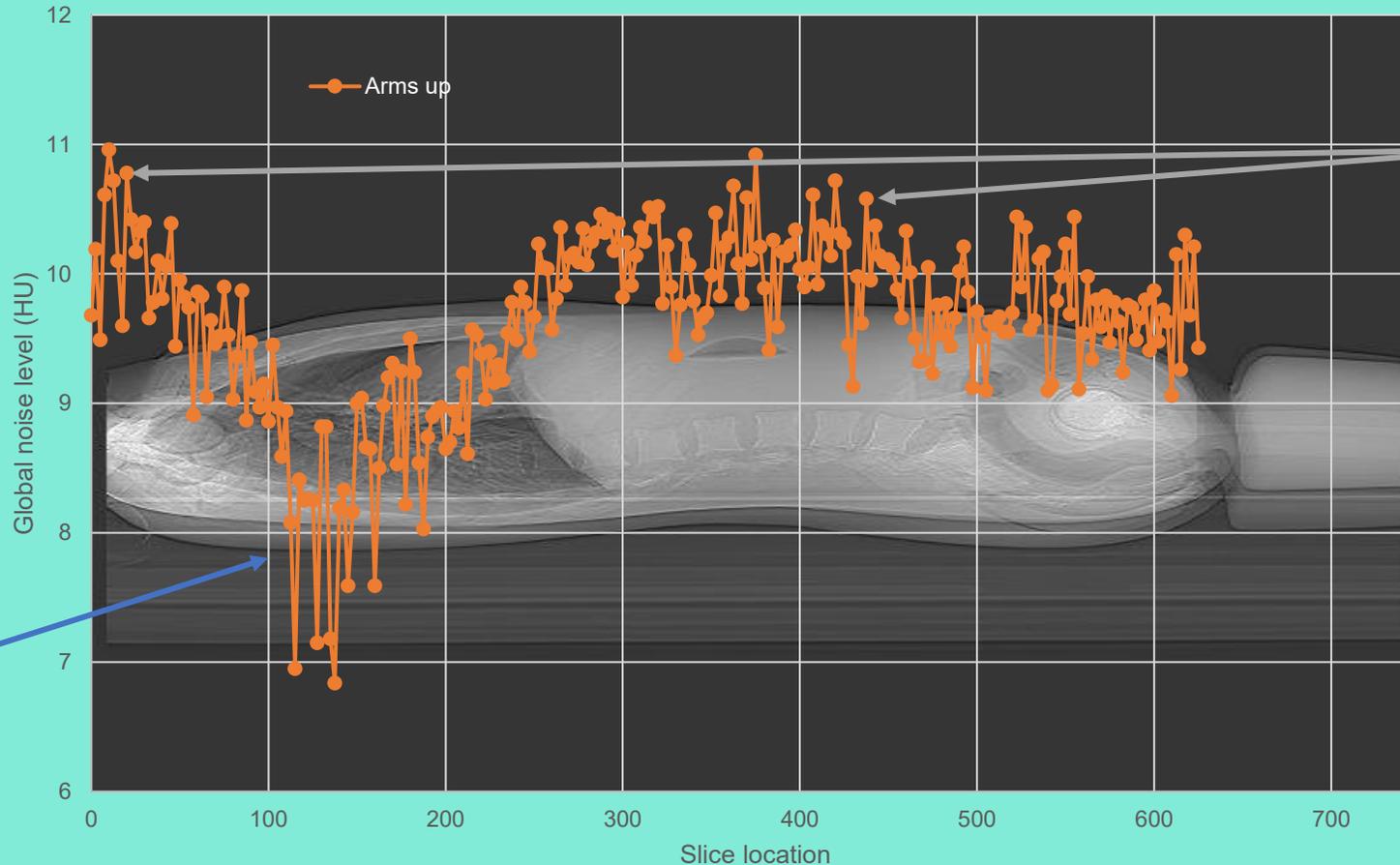


# Organ doses

Average mA in slices  
containing an organ  
used as surrogate of  
organ dose

Tissue / organ	Weighting factor ( $W_T$ )	Include / exclude?
Bladder	0.04	Include
Bone marrow (red)	0.12	Include
Bone surface	0.01	Exclude
Breast	0.12	Include
Colon	0.12	Include
Gonads	0.08	Include
Liver	0.04	Include
Lung	0.12	Include
Oesophagus	0.04	Include
Skin	0.01	Exclude
Stomach	0.12	Include
Thyroid	0.04	Include

# Results – GNL for arms up scan



Lowest noise  
in least  
attenuating  
region

Highest noise  
in most  
attenuating  
regions

Intelli EC  
functioning as  
it should

# Results – GNL for all scans

Artefact severity not specifically assessed...

Arm position	GNL (HU)	% change in GNL
Both up	9.62	-
One up, one down	9.86	2.5
One up, one on front	10.02	4.2
One up, one on pillow	9.78	1.7
One down, one on front	9.73	1.1
One down, one on pillow	10.06	4.6
Both down	10.11	5.1
Both on front	9.73	1.1
Both on pillow	9.54	-0.8
With Pearl Probelt	9.42	-2.1
Both across chest	9.57	-0.5

GNL variation throughout scans showed same trend as for arms up

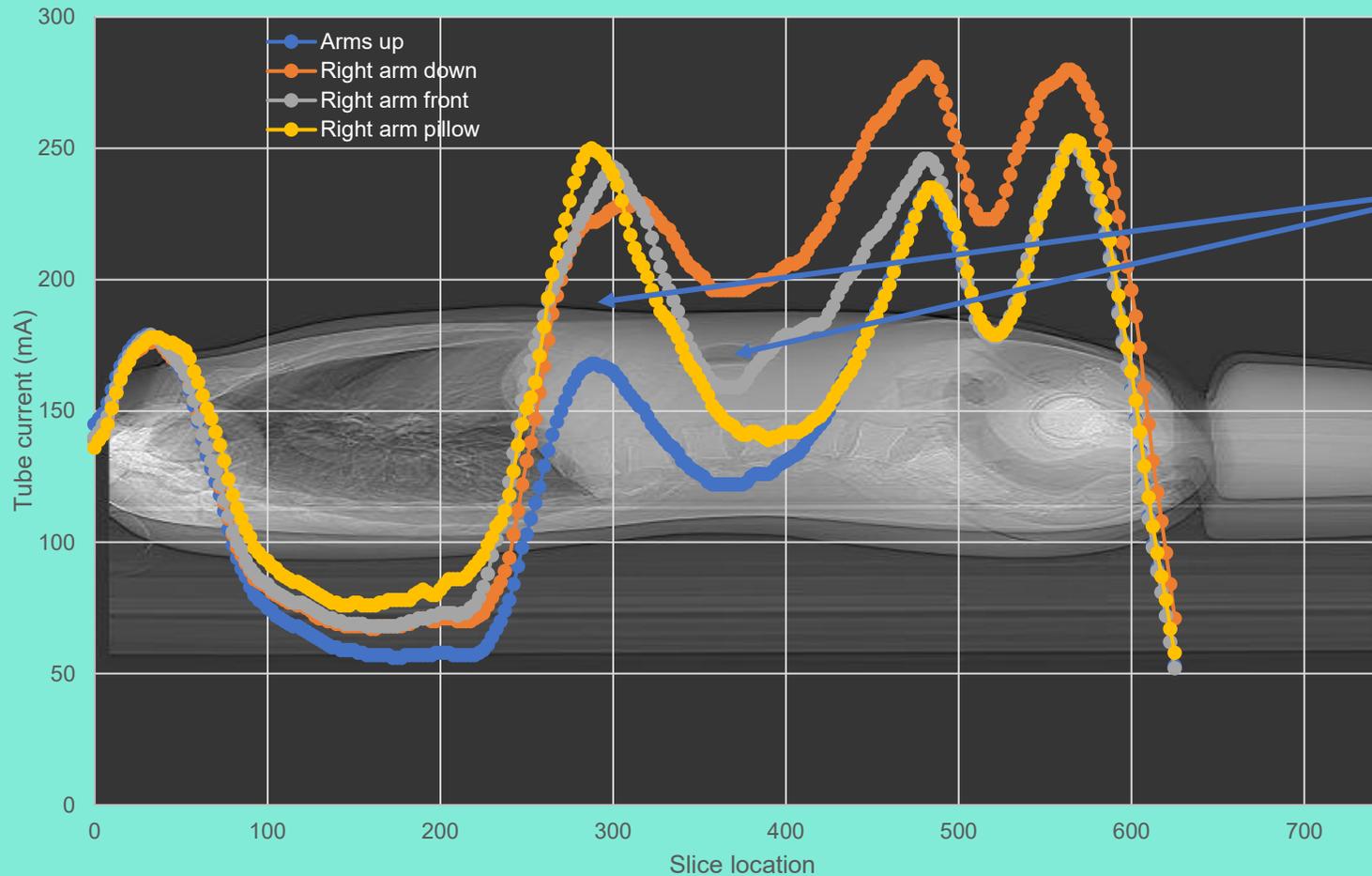
GNL values within 5% of arms up scan – Intelli EC adjusting mA to maintain noise level

Observed dose changes are those required to maintain image quality

# Displayed dose metrics

Arm position	CTDIvol (mGy)	DLP (mGycm)	% change CTDIvol	% change DLP
Both up	7.0	452.4	-	-
One up, one down	8.8	569.7	25.7	25.9
One up, one on front	8.1	522.8	15.7	15.6
One up, one on pillow	7.9	512.7	12.9	13.3
One down, one on front	10.6	687.0	51.4	51.9
One down, one on pillow	10.7	693.7	52.9	53.3
Both down	10.8	703.8	54.3	55.6
Both on front	9.8	636.7	40.0	40.7
Both on pillow	10.3	670.3	47.1	48.2
With Pearl Probelt	10	650.2	42.9	43.7
Both across chest	8.5	553.0	21.4	22.2

# mA variation throughout scan



Up to 50% increase in mAs in parts of abdomen

Need to consider organ doses

# Organ dose changes (%) – $W_T = 0.12$

	Breast	Bone marrow	Colon	Lung	Stomach
One up, one down	15.8	26.4	27.8	14.8	59.6
One up, one on front	18.1	15.9	8.0	19.8	35.6
One up, one on pillow	32.9	13.7	1.5	27.3	24.5
One down, one on front	84.2	55.2	39.6	62.7	110.5
One down, one on pillow	66.1	54.0	45.5	47.3	126.2
Both down	69.0	57.7	55.3	46.3	120.7
Both on front	68.3	42.4	5.0	64.9	94.9
Both on pillow	115.3	50.6	14.7	77.0	123.9
With Pearl Probelt	133.5	46.2	27.7	68.2	72.6
Both across chest	96.9	21.5	0.7	57.0	0.9

# Organ dose changes (%) – $W_T = 0.08 / 0.04$

	Gonads	Bladder	Liver	Oesophagus	Thyroid
One up, one down	21.1	17.1	48.0	8.0	-3.8
One up, one on front	-0.5	0.0	39.5	11.1	-3.0
One up, one on pillow	3.8	-0.2	33.6	19.5	-5.0
One down, one on front	33.3	22.5	105.9	45.1	-16.7
One down, one on pillow	28.7	22.7	104.4	34.1	-14.5
Both down	50.0	34.2	98.0	34.3	-17.3
Both on front	5.6	-0.9	129.2	37.3	-17.3
Both on pillow	6.1	0.1	123.8	60.9	-16.0
With Pearl Probelt	4.7	12.7	69.8	65.9	-15.0
Both across chest	2.2	0.1	0.5	78.8	79.7

# Organ dose changes (%) – $W_T = 0.12$

	Average across all 5 organs	% change DLP
One up, one down	28.9	25.9
One up, one on front	19.4	15.6
One up, one on pillow	20.0	13.3
One down, one on front	70.4	51.9
One down, one on pillow	67.8	53.3
Both down	69.8	55.6
Both on front	55.1	40.7
Both on pillow	76.3	48.2
With Pearl Probelt	69.6	43.7
Both across chest	35.4	22.2

Dose increase to 5 most radiosensitive organs underestimated by change in displayed dose

# Limitations

- Phantom arm positions not fully representative of what could be achieved clinically
- Phantom lacking some internal organs, also breast tissue
- Phantom not representing large patients in whom arm positioning issues are common
  - Provide greater challenged for AEC function
- Artefact severity not specifically assessed
- Patient comfort not considered

# Implications for practice

For scans involving the chest, having arms up remains ideal

If only one arm can be raised, placing other across front +/- pillow leads to smallest increase in effective dose

If neither arm can be raised, placing both across front leads to smallest increase in effective dose

Using positioning aids (pillow, Pearl Probelt) may aid patient comfort

For A/P scans, arms raised remains ideal, but placing arms across the chest yields only ~3% increase in dose to irradiated organs

# References

- Bhalla AS, Das A, Naranje P, Irodi A, Raj V, Goyal A. Imaging protocols for CT chest: A recommendation. Indian J Radiol Imaging. 2019 Jul-Sep;29(3):236-246. doi: 10.4103/ijri.IJRI\_34\_19
- Buchhave E.Ø. , Rasmussen C.D., Lentz R., Frederiksen E.H., Kipp J.O., Leftes M.Ø., Effect of arm position on image quality and radiation dose during thorax and abdomen computed tomography scans, Radiography, Volume 30, Issue 4,2024, <https://doi.org/10.1016/j.radi.2024.04.015>.
- Christianson O, Winslow J, Frush DP, Samei E. Automated Technique to Measure Noise in Clinical CT Examinations. AJR Am J Roentgenol. 2015 Jul;205(1):W93-9. doi: 10.2214/AJR.14.13613. PMID: 26102424.
- Graef, J., Bressemer, K. K., Asbach, P., Hamm, B., & Niehues, S. M. (2022). Changing the Patient's Position: Pitfalls and Benefits for Radiation Dose and Image Quality of Computed Tomography in Polytrauma. Diagnostics, 12(11), 2661. <https://doi.org/10.3390/diagnostics12112661>
- Henwood S, Clinical CT Techniques and Practice. City University Hospital, 2011
- Kahn J, Grupp U, Maurer M, How does arm positioning of polytraumatized patients in the initial computed tomography (CT) affect image quality and diagnostic accuracy?, European Journal of Radiology, Volume 83, Issue 1, 2014, Pages e67-e71, <https://doi.org/10.1016/j.ejrad.2013.10.002>.
- Kawashima H, Ichikawa K, Takata T, Mitsui W, Algorithm-based artifact reduction in patients with arms-down positioning in computed tomography, Physica Medica, Volume 69, 2020, 61-69, <https://doi.org/10.1016/j.ejmp.2019.11.019>.
- Liu H, Gao Y, Ding A, Caracappa PF, Xu XG. The profound effects of patient arm positioning on organ doses from CT procedures calculated using Monte Carlo simulations and deformable phantoms. Radiat Prot Dosimetry. 2015 Apr;164(3):368-75. doi: 10.1093/rpd/ncu284.
- McCollough C, Bakalyar DM, Bostani M, Bradey S, Boedeker K, Boone JM, et al. Use of Water Equivalent Diameter for Calculating Patient Size and Size-Specific Dose Estimates (SSDE) in CT 2014 Contract No.: AAPM 220
- Speelman, E.S., Brocx, B., Wilbers, J.E. et al. The influence of arm positions on abdominal image quality of whole-body computed tomography in trauma: systematic review. Emerg Radiol 27, 141–150 (2020). <https://doi.org/10.1007/s10140-019-01732-w>



# Thank you

[g.r.iball@bradford.ac.uk](mailto:g.r.iball@bradford.ac.uk)



16/10/2025

CTUG - Newcastle - 16th October 2025

22