

Optimizing dose and improving image quality with ^{SURE}Position technology.

Lance Lennon, MHIthSc
Chloe Steveson, MHIthSc
Jacqui Hislop-Jambrich, PhD
Canon Medical Systems Corporation

Patient positioning and radiation dose

Medical radiation technologists learn very early in their studies the importance of patient positioning for plain X-rays. In Computed Tomography (CT), correct positioning of the patient target anatomy to the gantry isocenter is very important with regard to dose and image quality. The miscentering of a patient within the CT gantry can cause non-uniform image quality and inaccurate calculations of the exposure required when using automatic exposure control (AEC) techniques¹. In order for the AEC to calculate the required exposure, an attenuation profile of the patient is measured in both the AP and lateral directions using a scanogram/localiser radiograph.

If the patient is positioned correctly at the isocenter, the most optimized attenuation profile is measured so that the correct exposure is given to each slice of the requested scan (Figure 1B).

Should the patient be positioned higher than the isocenter, the AP attenuation profile will be magnified creating a situation where the AEC calculation applies to a patient larger than the one in the scanner leading to higher exposure than is required (Figure 1A).

Should the patient be positioned lower than the isocenter, the AP attenuation profile will be reduced resulting in an AEC calculation lower than that required for optimal scanning of the patient in the scanner (Figure 1C).

In a study by Kim et al² they found that 81% of CT patients were not positioned at the isocenter. Another study by Habibzadeh et al³ describes miscentering accounting for between 17-29% increase in dose and 5-10% increase in image noise. Isa et al⁴ demonstrated in a phantom study that radiation dose increased by 5-7%

when the phantom was not positioned in the isocenter in the scan field. This study investigated a fixed mA head protocol with miscentering in the superior/inferior direction only.

Given the attenuation profile used by the AEC is also measured using a lateral scanogram/localiser radiograph, it is important to consider the position of the patient in the lateral direction additionally.

If the patient is positioned correctly at the isocenter, the most optimized attenuation profile is measured and the correct exposure given to each slice of the requested scan. Should the patient be positioned closer to the X-ray tube at the time of the lateral scanogram (lower case), the lateral attenuation profile will be magnified creating a situation where the AEC calculation applies to a patient larger than the one in the scanner leading to higher exposure than is required. Should the patient be positioned further from the X-ray tube at the time of the lateral scanogram, the lateral attenuation profile will be reduced resulting in an AEC calculation lower than that required for optimal scanning of the patient in the scanner (Figure 2).

Radiation dose is only one important factor to consider when thinking about the application of the AEC. Another important factor is image noise.

Patient positioning and image noise

All CT scanners contain beam-shaping filters (wedge or bow-tie), which are designed to do precisely that, shape the X-ray beam to be as homogenous as possible for the body part being scanned. For these filters to operate as they have been designed to do, the patient should be positioned at the isocenter so their center of mass is properly aligned with the center of the gantry and

therefore the center of the wedge.

Should the patient be positioned lower than the isocenter as in (Figure 3a), an increase in noise in the posterior of the abdomen is seen as the X-ray beam is attenuated more by the thicker portion of the beam-shaping filter.

Now let's again consider the position of the patient in the lateral direction.

Should the patient be positioned lateral to the isocenter as in (Figure 3b), an increase in noise in the lateral abdomen is seen as the X-ray beam is attenuated more by the thicker portion of the beam-shaping filter.

Techniques to correct patient positioning

Tech Assist Lateral Slide

Canon Medical has introduced the Tech Assist Lateral Slide that allows for lateral movement of the CT couch 4.2 cm either side of center (Figure 4). This feature can be

applied either prior to the scan during routine patient positioning or following scanogram acquisition using ^{SURE}Position. Tech Assist Lateral Slide can help reduce the risk of injury to the patient and technologist and improve flexibility during CT interventional procedures.

The Canon ^{SURE}Position technology

^{SURE}Position allows the CT operator to correct for up/down and left/right misalignment of patient positioning after the initial scanograms have been acquired. Once the patient position has been adjusted, new virtual scanograms are automatically created and ^{SURE}Exposure calculations are re-calculated according to the new patient position ensuring that an optimized dose is delivered to achieve the desired level of image noise taking into consideration the beam-shaping filter selected in the scan protocol (Figure 5). There is no need to enter the scan room to reposition the patient and acquire new scanograms. The patient is repositioned by the touch of a button at the console, improving examination workflow.

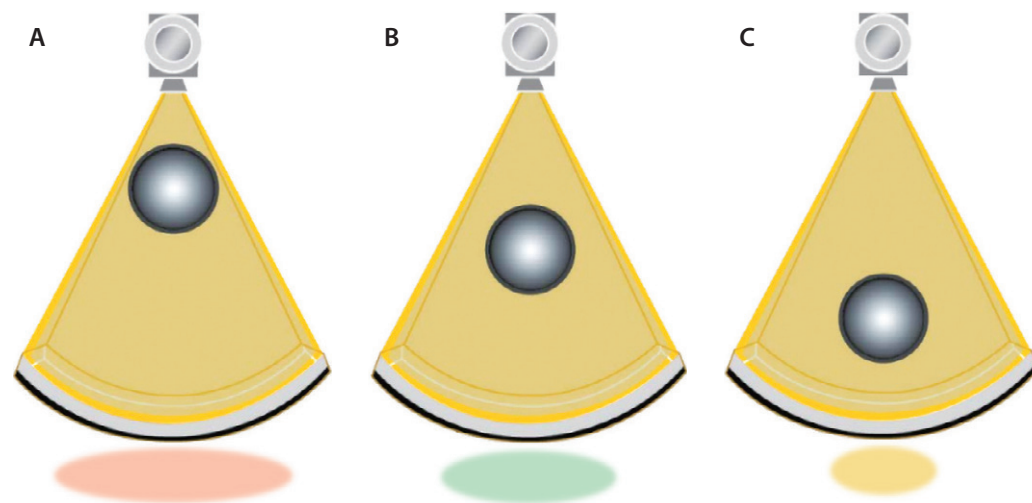


Figure 1 The effect of attenuation profile in AP position when the patient is high (A), centered (B) and low (C) in the gantry.

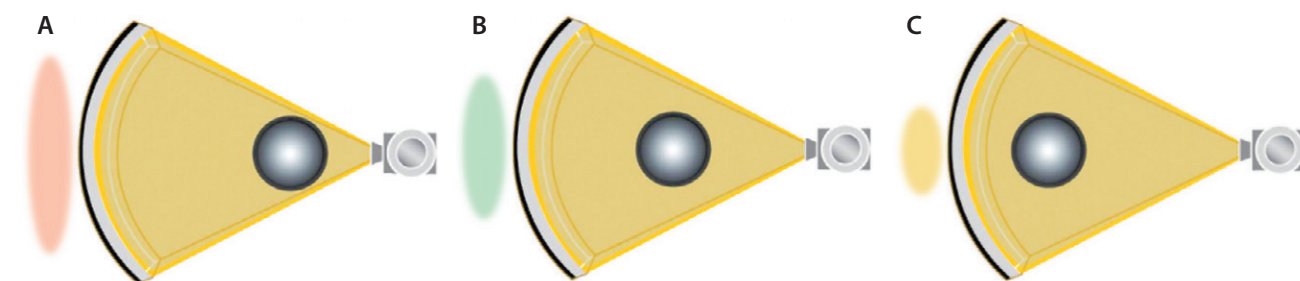


Figure 2 The effect of attenuation profile in lateral position when the patient is closer to the X-ray tube (A), centered (B), and further away from the X-ray tube (C).

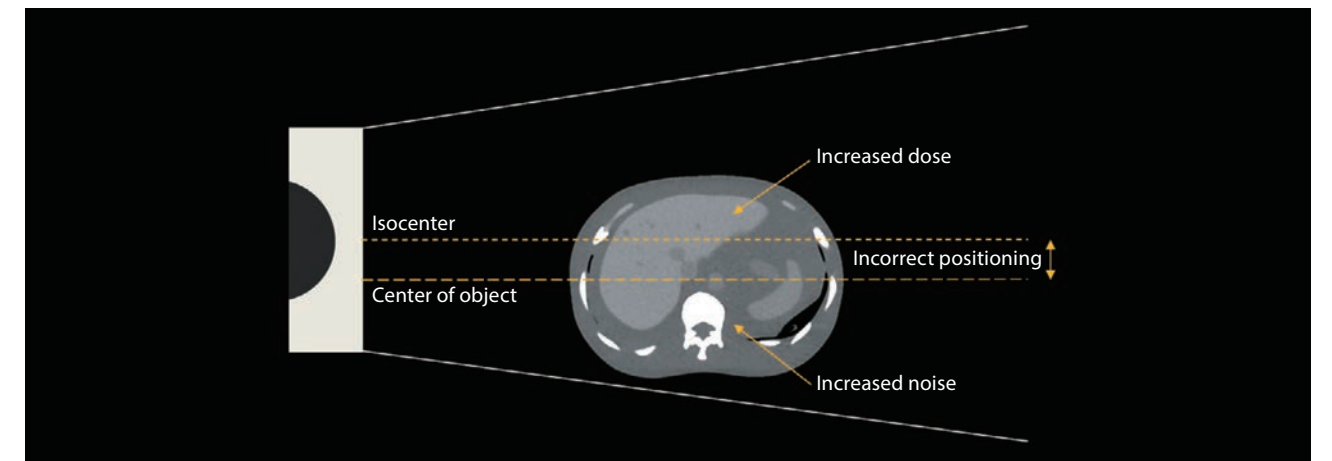


Figure 3a The effect of placing the patient low in the gantry (Image adapted from Habibzadeh, 2010)

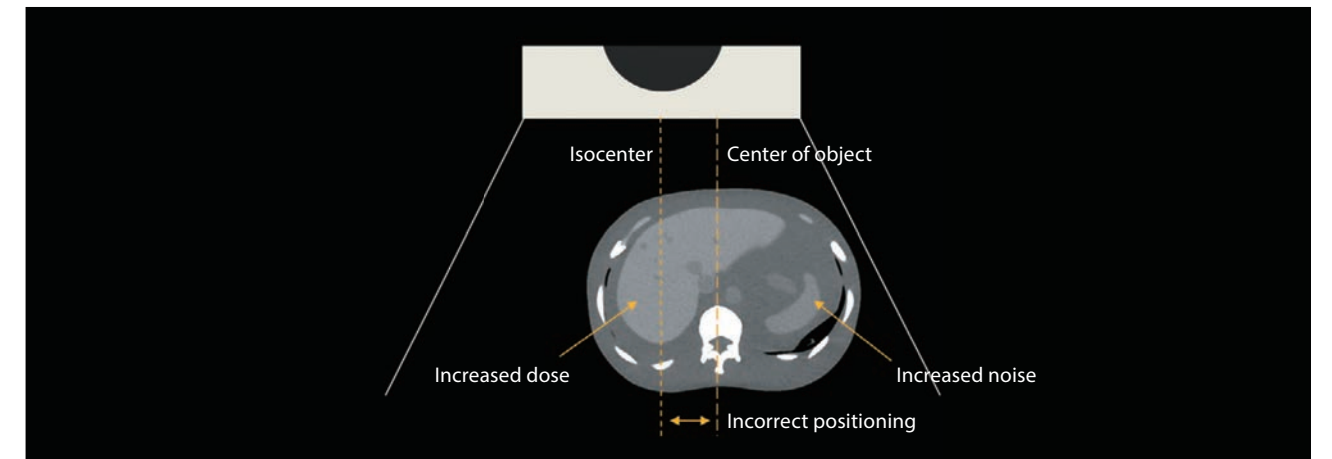


Figure 3b The effect of placing the patient to one side of the gantry (Image adapted from Habibzadeh, 2010)

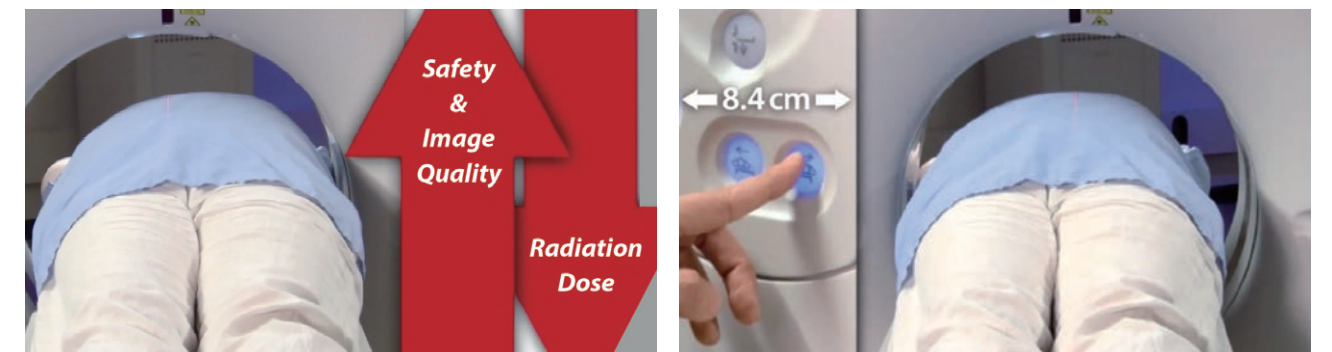


Figure 4 Tech Assist Lateral Slide

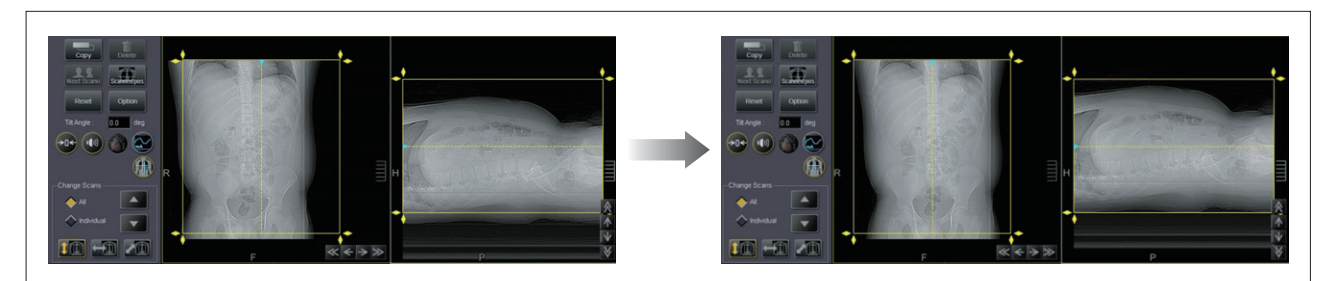


Figure 5 Positioning the patient at the isocenter ensures that AEC delivers the desired image quality.

Phantom tests to confirm effects of incorrect positioning

The aim of this study was to investigate the effects of incorrect patient positioning on radiation dose and image quality.

Methods

Phantom scanning was performed using separate scans of the chest and abdomen sections of a Kyoto CTU-41 CT Torso Phantom and a Canon Aquilion ONE / GENESIS Edition (Canon Medical Systems, Ottawa, Japan). The phantom was scanned at isocenter (133 mm) and 3 heights above and 3 heights below. At each couch height scans were also performed at seven different lateral couch positions to the left and right of isocenter. Scanograms were acquired with each change of phantom position. Identical automatic exposure control settings were used for each scan to ensure mA modulation for each slice of all scans (0.5 × 80, Pitch 0.813, 120 kVp, 0.5 s rot, SD 6.5 targeting 3 mm soft tissue reconstruction FC07 AIDR* 3D enhanced). CTDIvol and DLP were recorded for each scan. Image noise (SD) was measured at the same location for all scans. In the chest, noise (ROI 11.7 × 11.7 mm) was measured in the descending aorta at mid heart slice location. In the abdomen, noise (ROI 19.5 × 19.5 mm) was measured in homogenous liver at mid liver slice location.

* Adaptive Iterative Dose Reduction



Figure 6 Phantom set up

Results – Radiation dose

In order for the phantom to be positioned at the isocenter, the table height required was 133 mm. The CTDIvol and DLP results for the seven different lateral couch positions at this table height for the chest are seen in (Table 1 and Figure 7). Results for the abdomen are seen in (Table 2 and Figure 8). Positive values for the couch lateral position indicate phantom being closer to the X-ray tube. Negative values indicate the phantom being further away from the X-ray tube.

Table 1 Chest results

Couch lateral position (cm)	Couch height (mm)	CTDIvol (mGy)	CTDIvol % change	DLP (mGy·cm)
-4.2	133	7.3	-20%	272.2
-4	133	6.4	-19%	275.6
-2	133	8.1	-11%	300.5
0	133	9.1	-	339.5
2	133	10.1	11%	376.9
4	133	11.2	23%	417.8
4.2	133	11.4	25%	422.8

Table 2 Abdomen results

Couch lateral position (cm)	Couch height (mm)	CTDIvol (mGy)	CTDIvol % change	DLP (mGy·cm)
-4.2	133	8.4	-18%	404.1
-4	133	8.5	-17%	408.5
-2	133	9.2	-11%	445.6
0	133	10.3	-	497.5
2	133	11.6	13%	560.8
4	133	13.4	30%	645.5
4.2	133	13.4	30%	646.8

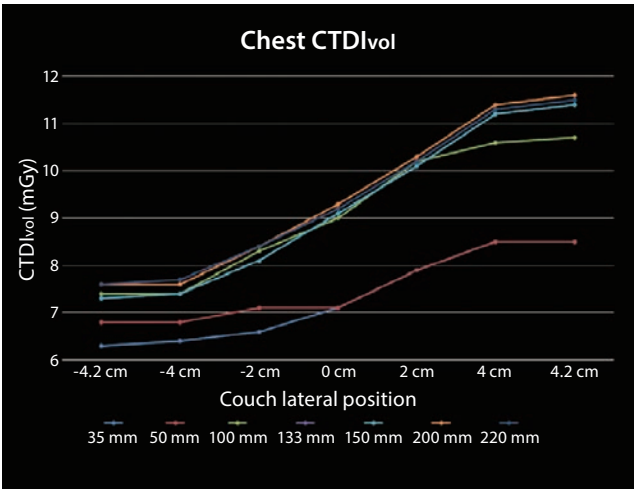


Figure 7 Results for chest CTDIvol and chest DLP

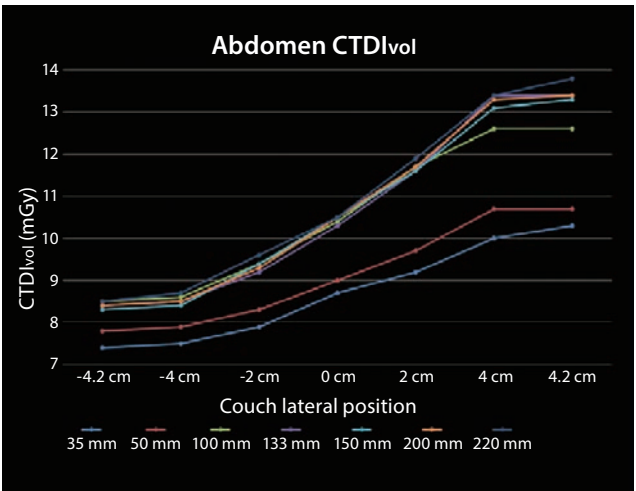
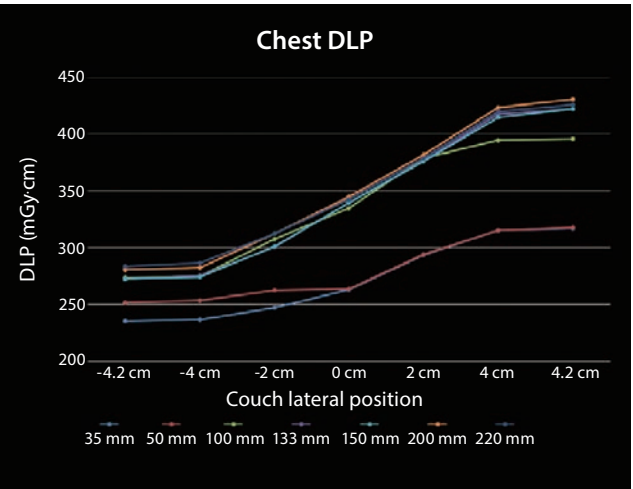
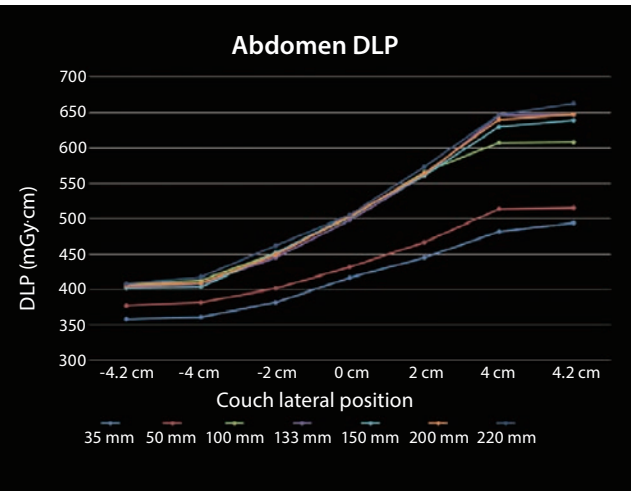


Figure 8 Results for abdomen CTDIvol and abdomen DLP



Results – Image noise

For both the chest and the abdomen, we found that as the couch height increased above isocenter the image noise decreased and as the couch height decreased below isocenter the image noise increased. These findings are in agreement with previously published results.^{2,3} We graphed the SD noise values from each ROI at each height analyzed, and then for each of the lateral couch positions for both chest and abdomen. This shows the broad effect on the SD for patient positions in both x

and y axes (Figures 9 and 10).

For both the chest and the abdomen, we found that when the phantom was positioned closer to the X-ray tube for the lateral scanogram the image noise decreased. When the phantom was positioned further from the X-ray tube for the lateral scanogram the image noise increased.

There are consequential differences seen in both the radiation dose delivered and image noise generated when the phantom was not positioned at isocenter.

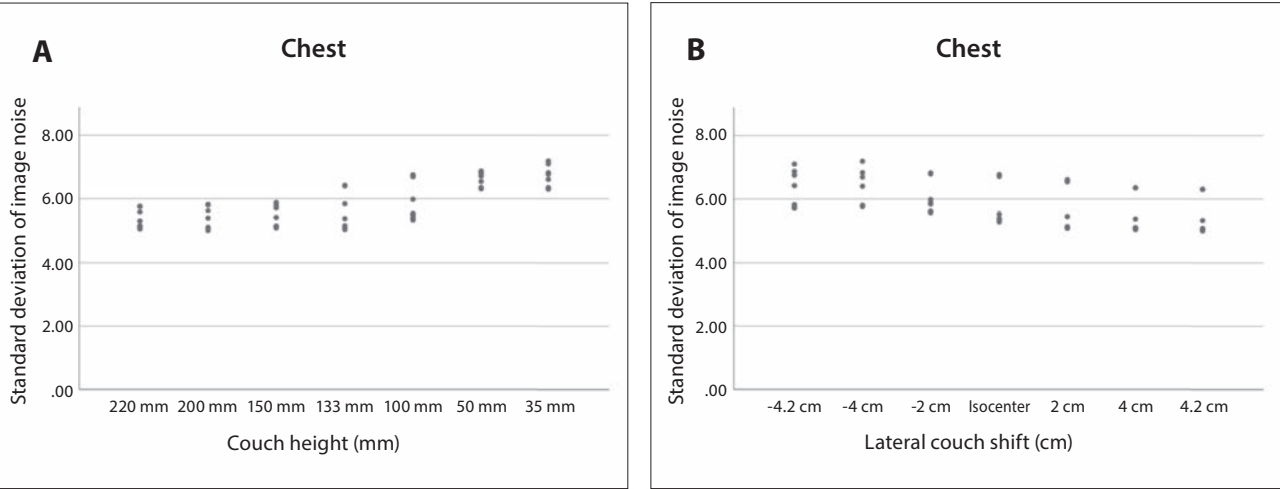


Figure 9 Image noise (SD) for the chest. Couch height vs lateral couch shift (A) and lateral couch shift vs couch height (B).

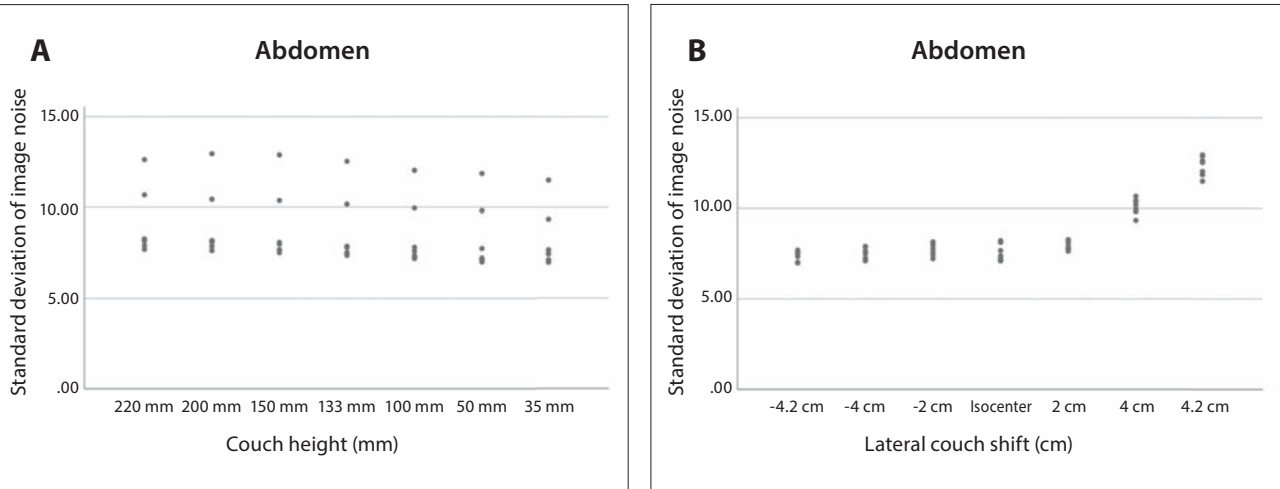


Figure 10 Image noise (SD) for the abdomen. Couch height vs lateral couch shift (A) and lateral couch shift vs couch height (B).

Use of patient positioning aids in clinical use

The amount of adjustment to patient position in both vertical and lateral directions was recorded across four clinical sites including six CT scanners. The total number of chest scans assessed was 133 and the total number of abdomen scans assessed was 141. The frequency of patient position adjustment recorded is seen in (Table 3). Overall patient position adjustment was made in 74% of scans.

The amount of adjustment to patient position at each site is seen in (Figures 11 and 12). The average amount of

patient position adjustment across the four clinical sites was 16 mm in couch height and 14 mm in couch lateral position. Generally lateral couch adjustments were made more often than height adjustments, highlighting the necessity for lateral couch movement.

These results highlight that clinical sites equipped with ^{SURE}Position automated patient centering technology use it for the vast majority of examinations to adjust both vertical and lateral patient position. It is also interesting to note that in the clinical centers queried, that lateral positioning was adjusted more often than vertical.

Table 3 Results of frequency of patient position adjustment from four clinical sites

	Site 1	Site 2a	Site 2b	Site 3a	Site 3b	Site 4
Chest height	81%	46%	70%	65%	78%	78%
Chest lateral	90%	96%	85%	82%	78%	67%
Abdomen height	74%	50%	42%	50%	72%	71%
Abdomen lateral	90%	94%	94%	76%	78%	86%

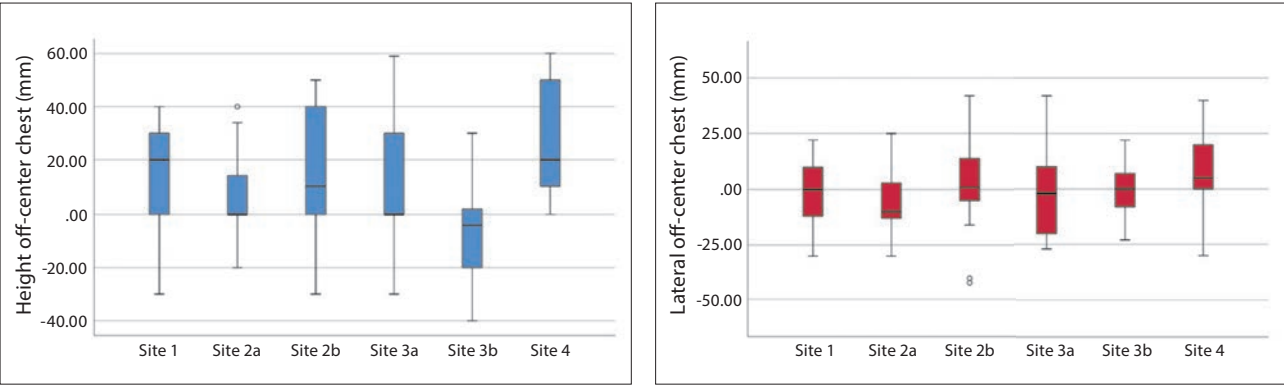


Figure 11 Amount of adjustment of patient position in the chest at clinical sites

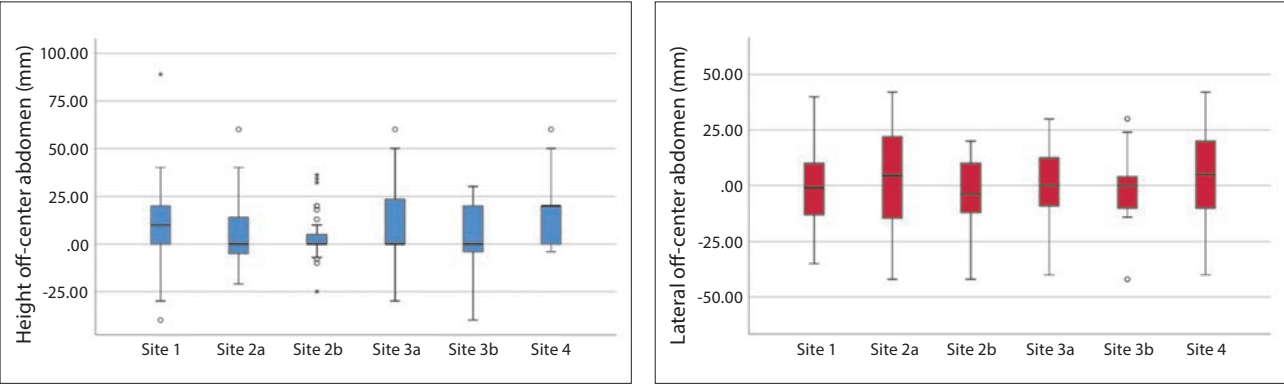


Figure 12 Amount of adjustment of patient position in the abdomen at clinical sites

Conclusion

Numerous studies have demonstrated the importance of patient centering to ensure correct radiation dose and image quality but they have typically focused only on vertical positioning. With the introduction of lateral couch movement combined with ^{SURE}Position it is now possible to easily and accurately position the patient in the true isocenter not just in the vertical plane. This study demonstrates that horizontal positioning is equally important as vertical positioning in ensuring expected image quality and radiation dose delivery. The more surprising finding is in the clinical environment ^{SURE}Position was almost always used by the CT technologists and that patients required position adjustment in the horizontal plane more often than in the vertical. This would suggest that ^{SURE}Position with Tech Assist Lateral Slide is

an invaluable tool to not only ensure consistent image quality at the correct radiation dose but also to maintain fast patient throughput and workflow.

References

- Toth, T et al (2007) The influence of patient centering on CT dose and image noise. *Medical Physics* 34, 3093
- Kim, M et al (2012) Relationship between patient centering , mean computed tomography numbers and noise in abdominal computed tomography: influence of anthropomorphic parameters. *World Journal of Radiology* 7
- Habibzadeh et al (2011) Impact of miscentering on patient dose and image noise in X-ray CT imaging: Phantom and clinical studies. *Physica Medica* 28, 191-199
- I.N.C Isa, et al (2019) The effects of mis-centering on radiation dose during CT head examination: A phantom study. *Journal of X-ray Science and Technology*, Epub ahead of print

CANON MEDICAL SYSTEMS CORPORATION

<https://global.medical.canon>

©Canon Medical Systems Corporation 2020. All rights reserved.
Design and specifications are subject to change without notice.
MWPC0004EA 2020-11 CMSC/SZ/Printed in Japan

Canon Medical Systems Corporation meets internationally recognized standards for Quality Management System ISO 9001, ISO 13485.
Canon Medical Systems Corporation meets the Environmental Management System standard ISO 14001.

Aquilion ONE, Aquilion ONE GENESIS, ^{SURE}Position, ^{SURE}Exposure and Made for Life are trademarks of Canon Medical Systems Corporation.

Made For life