THE EFFECT OF OBESITY ON CHEST RADIOGRAPHY AND DIGITAL TOMOSYNTHESIS - A PHANTOM STUDY

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PURPOSE

Radiography of overweight and obese patients can be challenging and frequently requires higher radiation dose due to increased body thickness and tissue density. Occasionally, results may be suboptimal or non-diagnostic due to reduced image quality. The purpose of this study was to evaluate the impact of different body habitus (soft tissue thickness) on the quality of Thoracic Skeleton and Chest/Lungs Digital Tomosynthesis (DTS) compared to radiography.

METHODS

A phantom-based study was executed to evaluate the effect of body habitus on DTS and radiography, using a multipurpose chest phantom N1 "Lungman" (Kyoto Kagaku, Japan). Soft tissue thickness simulating up to 95 percentile of the USA population dimensions (circumference) was obtained by adding increasing numbers of gel layers (Bolux-I, Action Products Inc, USA, a tissue-equivalent flexible material with a physical density of approximately 1.03g/cc)1. All gel layers were positioned on the "anterior chest wall". Chests/lungs simulations were done with 0/5/10 gel layers (Fig.1). Thoracic skeleton simulations were done similarly, adding 0/3/6/10 gel layers. Both DTS and radiographs were performed for each setup, with protocol adjusted to the "body habitus" of the phantom. Two nodules from the simulated nodule kit (Kyoto Kagaku, Japan) were embedded in the phantom prior to the chest/lung scans.

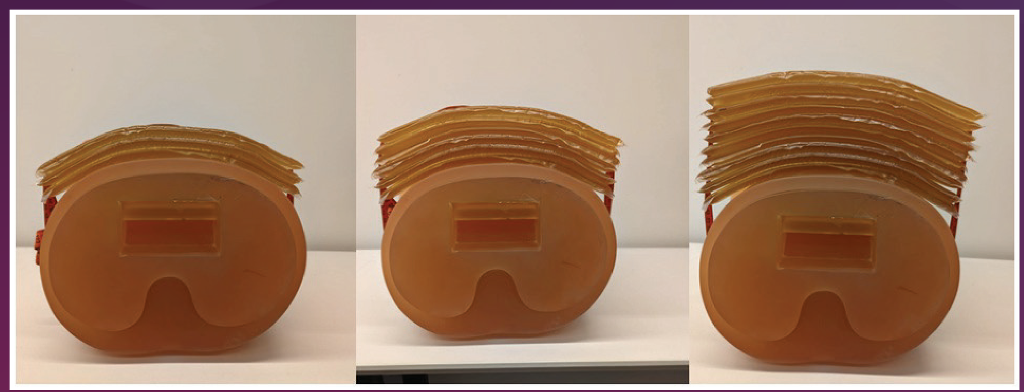

FIG 1: ADDED GEL LAYERS TO THE PHANTOM: 0, 5, 10 FROM LEFT TO RIGHT, RESPECTIVELY.

For calculation of total circumference, lateral gel layers were added to simulate the thickness of the lateral soft tissues. The total circumference was calculated as follows: for the 0 and 3 anterior gel layers no additional waist fat was added, for 6 anterior gel layers 2 side gel layers on each side were added (adding 15 cm) and for the 10 anterior gel layers 3 side layers were added on each side (adding 22 cm) (Table 1). The circumference of the chest with 5 gel layers was interpolated.

The circumferences were compared based on the information supplied by the Anthropometric Reference Data for Children and Adults United States 2015–2018, NATIONAL CENTER FOR HEALTH STATISTICS. As the statistics are divided into different age groups, the 95 percentile of the population slightly varies. The waist circumference that represents up to 95% of the USA BMI population is 126.7-136 cm for adult men and 119-133.6 cm for adult women.

Phantom	Patient type	Circumference (cm)
Chest without gel layers	Thin	84
Chest with 3 gel layers	Normal	92
Chest with 5 gel layers	Normal	108 *
Chest with 6 gel layers	Thick	116
Chest with 10 gel layers	Thick	132

* Interpolated

TABLE 1: GEL LAYER TO PATIENT SIZE CORRELATION

Conventional radiographs were obtained with Carestream Health DRX evolution using routine protocols and automatic exposure (Table 2).

Phantom	kV	mAs
Chest w/o gel layers	110	0.9
Chest with 3 gel layers	110	1.5
Chest with 5 gel layers	110	1.7
Chest with 6 gel layers	120	1.9
Chest with 10 gel layers	120	2.5

TABLE 2: RADIOGRAPHY ACQUISITION PARAMETERS

DTS images were acquired using Nanox.ARC, a stationary, floor-mounted, cold cathode, multi-source DTS system. Acquisition parameters of the DTS are detailed in table 3.

Phantom	kV	mAs	N^0 of tubes	Sweep angle	Projections
Chest w/o gel layers	90	0.20	3	15	30
Chest + 3 & 5 gel layers	100	0.22	3	15	30
Chest + 6 & 10 gel layers	110	0.25	3	15	30

TABLE 3: DTS ACQUISITION PARAMETERS

Detection of the lung nodules was evaluated on the chest/lung studies. Qualitative evaluation of the costovertebral joints was performed in the thoracic skeleton studies. These joints are posterior structures that might be difficult to detect on a conventional radiograph and are distant from the source.

RESULTS

All Chest/Lungs DTS studies clearly demonstrated the embedded lung nodules and the anatomic structures of the chest without reduction in quality, while the embedded lung nodules were barely seen on any of the radiographs. Even when retrospectively evaluated they appeared as a hazy slight increased opacities and did not have the appearance of a nodule (Fig. 2).

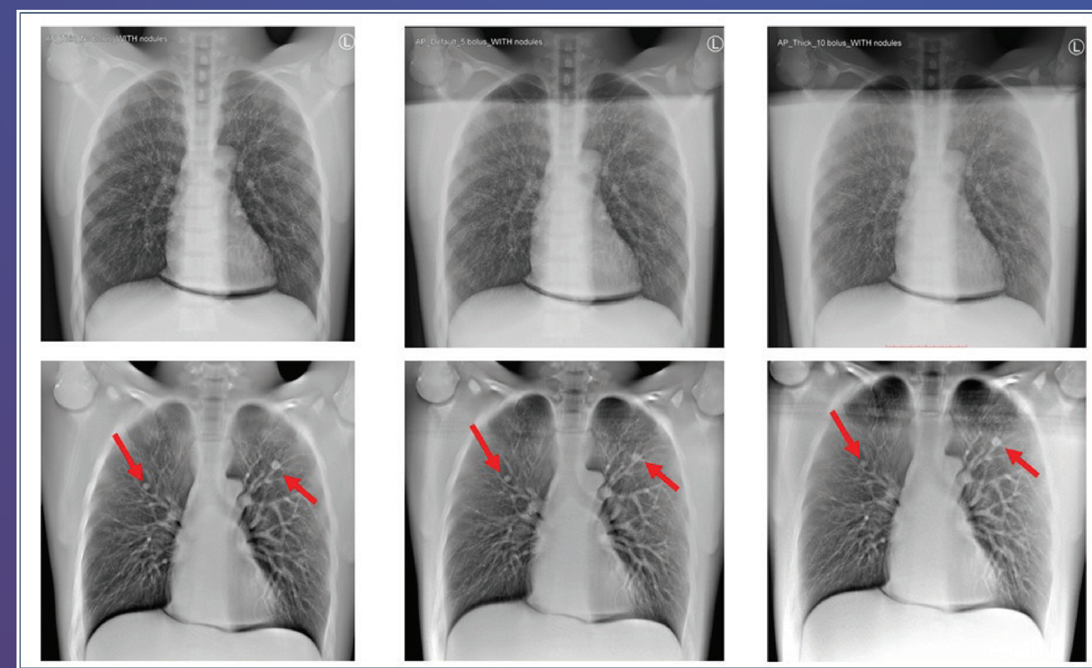

FIG 2:

Fig 2: Chest radiograph (upper row) and chest DTS (lower row) of the phantom with and without gel layers. The embedded lung nodules are clearly seen on all the DTS studies (red arrows) regardless of the number of added gel layers. They are not seen on any of the chest radiographs.

The costovertebral joints were clearly seen on all DTS studies while on radiographs, detection was reduced as the soft tissues became thicker (Fig. 3).

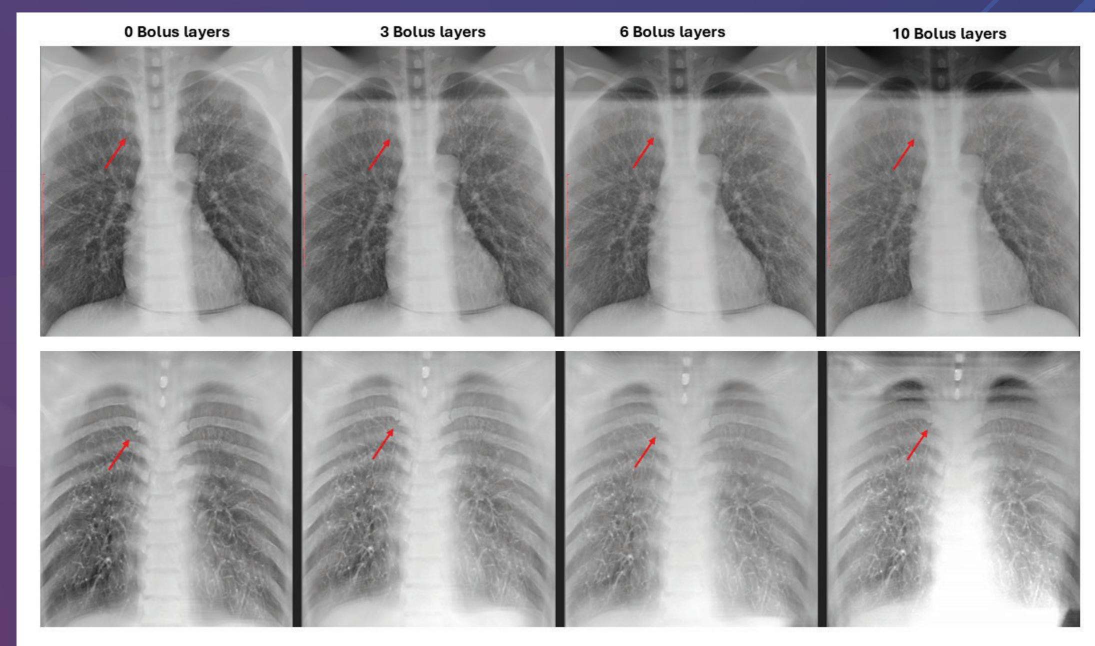

FIG 3:

Thoracic skeleton radiographs (upper row) and thoracic skeleton DTS (lower row) of the phantom with and without gel layers. A costovertebral joint that is in the plane of focus is marked by the red arrow.

CONCLUSION

DTS imaging may be superior to conventional radiography in detecting lung and skeletal abnormalities even in patients with higher BMI, based on a phantom study. The quality of the DTS images of an obese phantom does not reduce in oppose to conventional radiography.

REFERENCES

1. R.F Moyer et al. A Surface Bolus Material for High-Energy Photon and Electron Therapy. Radiology, Vol. 146, No. 2, 531-2, February 1983.