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Impact of CT Window Contouring on Breast Plans

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ABSTRACT

Objective: *To assess the impact of CT window for postmastectomy breast irradiation on Gross tumor volume (GTV) and Internal target volume (ITV) definitions for a target with large movements.* ***Materials and Methods:*** *Tumor movement was simulated with a phantom composed of a water filled table tennis ball. The phantom was elliptically moved in the ap-pa and cranio-caudal or in ap-pa and lateral direction, respectively. CT scans were acquired for the ball with and without movement, both in a "slow" 3D-CT scan and in a 4D-CT scan. The treatment protocol used involved a boost block with ipsilateral breast exclusive of 4 cm around the breast plug. The ball was contoured as GTV or ITV using different window settings (for e.g. "breast window", "soft tissue" window) and the volumes were compared to mathematically calculated volumes ("gold standard").* ***Results:*** *In the 3D-CT of the ghost without development window settings had just a minor effect on GTV. The maximal deviation to the figured size was 12%. Amid moderate 3D-CT sweeps of the moving ball extensive contrasts between the window, settings were found. Best concordance to the ascertained qualities demonstrated the breast window setting (-16.8% and 19.1%). Unmistakable thought little of ITVs were formed utilizing the 500 and delicate tissue window (-84% to -99%). A significant littler impact was found for the 4D-CT. Movement heading had a vital effect on the objective outline, with an underestimation of volumes in the cranio-caudal bearing and an overestimation of volume in the horizontal course for the moderate 3D-CT shaped in breast window.* ***Conclusions:*** *Window settings are vital in the shaping of moving targets, while they are less pertinent for static targets. In moving targets cautious thought of window settings for shaping ought to be finished. Regardless of whether breast windowing is utilized, we emphatically prescribe reconsideration of the formed focus in various planes for the moderate 3D-CT. 4D-CT limits vulnerabilities.*

Keywords: Breast cancer, GTV, Ipsilateral lung, Mastectomy

INTRODUCTION

Treatment of moving targets is as yet a test in radiation oncology. Better imaging modalities that sort CT cuts as indicated by breathing cycle (4D-CT) and better 4D organic imaging like FDG-PET-CT, changes in immobilization systems, and in addition gating and following improved the conceivable outcomes of radiation oncology [1]. In any case, the standard methodology for securing of arranging CTs for radiotherapy of moving targets stays for some centers the "moderate" arranging processed tomography (moderate 3D-CT). Tumor movement amid free breathing is thus more precisely replicated. Anyway, this can prompt target mutilation and can disturb CT picture respectability [2].

Then again, it is realized that window settings (i.e. breast windowing, delicate tissue windowing) affect perceivability and shaping of pneumonic knobs. We don't know about any examination that was led to evaluate the effect of window settings for shaping a moving target. The point of this examination was to break down the effect of window level on the shaping of moving targets, utilizing water filled ghost and distinctive CT-check acquisitions. Wojcieszynski et al [3] have proved that whole breast irradiation with a simultaneous integrated boost to the lumpectomy bed using helical tomotherapy can address the irradiation related toxicity. This study also showed that radiation dose can be further decreased to critical organs at risks like heart and lungs.

MATERIALS AND METHODS

Phantom Measurements

All tests were done utilizing the same "target" - a table tennis ball loaded up with water. The distance across of the ball was 4.0 cm with an ascertained volume of 33.51 cm. The ball was controlled by a LEGO motor (The LEGO gathering, Billund, Denmark) which empowered an ellipsoidal development. The period for one cycle was 4.2 s. CT scans with a slice thickness of 2.5 mm were acquired for each simulation. Appropriate plugs were inserted to account for mastectomy cavity and radiopaque wires were simulated with in house system. This helps in the delineation of lumpectomy cavity. Simulated scans were imported to Philips Pinnacle treatment planning system. Superior, inferior, medial and lateral peripheries of the mastectomy breast were contoured. The lumpectomy bed was contoured as a boost to clinical target volume with a 1 cm expansion to the planning tumor volume [3]. The delineation of critical organs like ipsilateral and contralateral lung, heart, spinal cord, esophagus, trachea, and contralateral breast cavity was done during the optimization phase [3]. Treatment planning parameters included a 2.5 cm field width, pitch of 0.287, and a modulation factor of 1.8 to 2.4 [3]. The semi-major hub of the ellipsoidal movement was 1.75 cm (flat bearing) and the semi-minor hub was 1.25 cm (vertical course). Comparative developments happen for tumors near the stomach and are among the biggest detailed benefits of moving targets [4].

All estimations were performed utilizing a Somatom Emotion PC tomograph (Siemens Medical Solutions, Erlangen, Germany). Moderate 3D-CT pictures were gained with a pitch of 0.45 and goals of $1 \times 1 \times 1$ mm^3. In examination standard (analytic) CT-filters are regularly performed with a pitch of 0.95 [3].

Moderate 3D-CT checks were performed with the static ghost (no development) and with the apparition moving ellipsoidally in a plane parallel (cranio-caudal) or opposite (horizontal) to the table's development course. Also, 4D-CT examines were procured of the moving apparition. Amid 4D-CT filtering, a movement bend of the ball was estimated utilizing the Real-time Position Management framework (RPM, Varian Medical Systems, Palo Alto, CA, USA). The RPM framework tracks the development of a marker square, which was settled to the control bar of the ball. Utilizing these movement bends, CT cuts were recreated for 10 stages mirroring the movement cycle. The reproduced 4D-CT pictures had a goal of $1 \times 1 \times 1$ mm^3.

Evaluation

Molding was performed utilizing the Eclipse programming Version 10.0 (Varian Medical Systems, Palo Alto, CA, USA). To keep away from between spectator changeability all shapes were drawn by a similar individual (KJB). The unmistakable volume of the ball was molded in all CT checks cut by cut.

Three distinctive window levels were utilized for outline of the ghost (Figure 1): a "breast" window setting [LW] (Window Width [WW]=1800 Hounsfield Units [HU] and Window Level [WL]=-100 HU), a "delicate tissue" window setting (WW=350 HU; WL=50 HU) [5] and in addition an exact "500" window setting (WW=1000 HU; WL=0 HU).

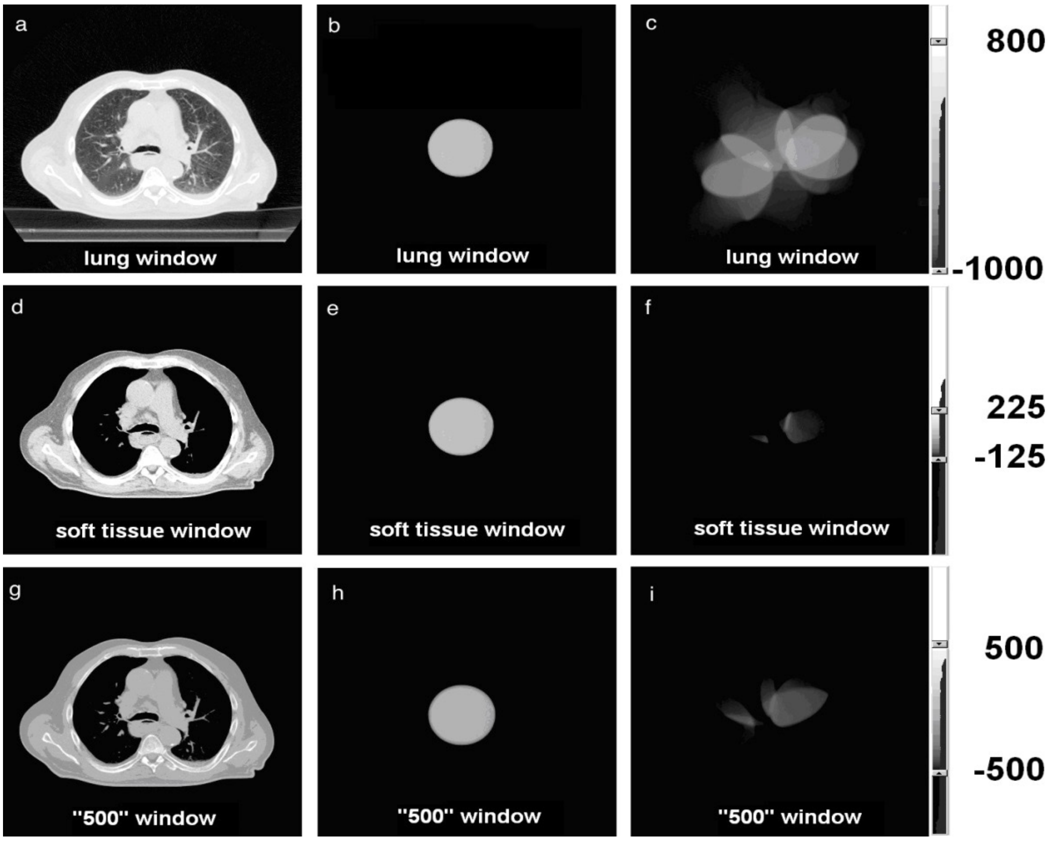

Figure 1 Lung window, soft tissue window, and "500" window and HU scales used for contouring For illustration purposes, an axial view of a patient is depicted on the left (a,d,g). Additionally, slow 3D-CT images of the static phantom (b,e,h) and the phantom moving in a lateral direction (c,f, i) are shown

In the 3D-CT filters performed without the development of the ball, the ball volume was shaped as noticeable and was viewed as a gross tumor volume (outlined GTV). In the event that the ball is moving and a moderate CT is played out, the CT portrays a moving GTV. Subsequently, this structure is relied upon to be bigger than a static GTV. Consequently we considered the structure molded on the ease back CT more like an inward target volume [ITV] (portrayed ITV) and connected the shaped volume to the figured ITV (see underneath). For the 4D-CT filters, the ball was molded in every one of the 10 remade breathing stages (outlined GTV). Further, an ITV was produced by combining the formed GTVs by Boolean administrators (depicted ITV).

For every one of these structures, the volumes were resolved. Further, we quantified the maximal degree of the outlined structure toward apparition development (i.e. travel remove). This was performed so as to test whether the moderate 3D-CT delineates the entire area in which the development of the objective happens.

The volume of the table tennis ball itself without development was 33.5 cm (figured GTV) [5]. The volume of the region inside which the moving of the ball happens (figured ITV) was dictated by utilizing a numerical recreation as 118.5 cm. With a specific end goal to evaluate in which window level the shaped GTV fits best to the figured ball volume, the GTV volume was broke down as a component of window edge. As the ghost was loaded up with water the upper edge was set to an estimation of 0 HU. The lower limit was bit by bit decreased in ventures of 100 HU. For each stage, a GTV was formed and the relating volume was resolved. A complete block of the lung was inserted with a 4 cm expansion around the PTV in order to reduce the radiation dose to ipsilateral lung and reduce dose to normal structures [3]. Dose volume histogram s and homogeneity index were evaluated to control the dosimetric parameters within specification limits [3]. Furthermore, histograms of the HU dispersion for the static or moving ball in a solitary cut (moderate 3D-CT, 4D-CT) were created with the Eclipse programming.

RESULTS

The Impact of Window-Settings on Gross Tumor and Internal Target Maximal Extents

The maximal degree of the ball (i.e. breadth) was 4 cm and the computed voyaging separation of the ball was 7.5 cm (i.e. the maximal degree of the figured ITV). The deliberate degree of the molded GTV extended between 3.7 cm (delicate tissue window with parallel development in 4D-CT) and 4.6 cm (breast window with sidelong development in 4D-CT). The deliberate degree of the outlined ITV ran between 0.8 cm (delicate tissue window with cranio-caudal development in 3D-CT) and 8.7 cm (breast window with parallel development in 4D-CT). The correlation of the figured qualities to the deliberate qualities is delineated in Table 1.

Table 1 Relative differences between the maximal extent of mathematically calculated and of contoured structures

Difference of delineated GTV maximal extent to the mathematically calculated diameter [%]				
	3D-CT Static		4D-CT Cranio- caudal	4D-CT lateral
Breast window	2.5		5	5
Soft tissue window	-5		-5	-5
500 window	0		-2.5	-2.5
Difference of delineated ITV maximal extent to the mathematically calculated travelling distance [%]				
	3D-CT Cranio- caudal	**3D-CT lateral**	**4D-CT Cranio- caudal**	**4D-CT lateral**
Breast window	12	14.7	16	9.3
Soft tissue window	-89.3	-85.3	8	4
500 Window	-9.3	-12	12	8

The Impact of Window-Settings on Gross Tumor Volume and Internal Target Volume

The relative contrasts between the numerically computed volumes and the molded volumes are recorded in Table 2. The formed GTV ran between 0.26 cm (delicate tissue window with cranio-caudal development in 4D-CT) and 50.2 cm (breast window with sidelong development in 4D-CT). The ITV went between 0.26 cm (delicate tissue window with cranio-caudal development in 3D-CT) and 164 cm (breast window with parallel development in 4D-CT).

Table 2 Relative differences between mathematically calculated and contoured volumes of the GTVs and ITVs as contoured in the slow 3D-CT and 4D-CT

Difference of delineated GTV to the mathematically calculated ball volume [%]				
	3D-CT Static		4D-CT Cranio- caudal	4D-CT Lateral
Breast window	8.9		26.5	49.8
Soft tissue window	-11.7		-27.2	-22.7
500 Window	-0.3		-6.9	-6.0
Difference of delineated ITV to the mathematically calculated ball volume [%]				
	3D-CT Cranio- caudal	**3D-CT Lateral**	**4D-CT Cranio- caudal**	**4D-CT Lateral**
Breast window	-16.8	19.1	38.6	30.8
Soft tissue window	-99.8	-99.3	5.1	-4.6
500 Window	-84.5	-84.5	16.5	9.5

In Figure 2, the extent of a formed GTV or ITV is plotted as a component of the lower window limit for a static moderate 3D-CT, a dynamic moderate 3D-CT, and a 4D-CT examine. Comparable outcomes were accomplished for cranio-caudal and for sidelong development. We exhibit the consequences of the ball moving in cranio-caudal course. A lower limit of -500 HU is expected to shape around 100% of the ball if the ball isn't moving. Additionally diminishing of the lower limit brought about overestimated volumes.

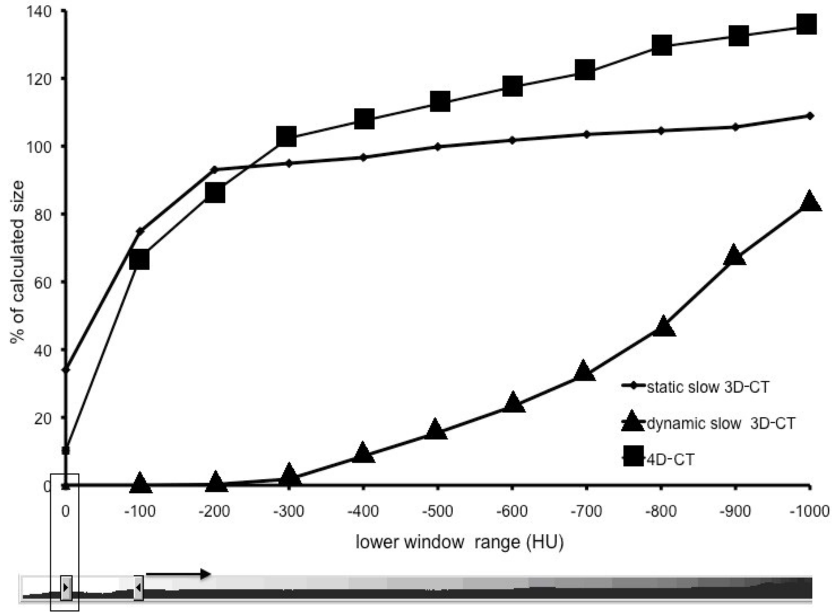

Figure 2 Size of the contoured structures as a function of window settings (phantom moving in cranio-caudal direction) The upper threshold was set to 0 HU. The lower threshold was changed in 100 HU steps (direction of the arrow in the lower part of the figure). Decreasing the lower threshold leads to increasing contoured volumes

In the 3D-CTs with moving focus on, the volume was constantly belittled, regardless of whether the most reduced limit (-1000 HU) was connected. For the 4D-CT, a lower limit of -300 HU accomplished the best ascension (102.4%). Diminishing edges brought about an overestimated shaped ball volume. Moreover, on account of expansive developments of the objective, indistinguishable fringes of the table tennis ball can be found in all pictures with an effect on the circulation of HU pixel esteems.

The dissemination of pixel esteems demonstrates high reliance on the objective development and CT obtaining method. The 3D-CT performed without the development of the ball and the 4D-CT demonstrates a collection of pixel esteems with a focus around 0 HU (water) and -1000 HU (air). Besides, the static 3D-CT is more homogenous with ten times bring down a number of pixels (y hub in the chart). The dynamic 3D-CT with the moving ball has a "level" appropriation between 0 HU and -1000 HU. This compares to an obscured ball shape.

DISCUSSION

Outline of breast tumors and other moving focuses for radiation treatment are tested. Right off the bat, because of vast between spectator inconstancies amongst delineators and also, because of a low relationship of the depicted structures to obsessive discoveries. Further, it is outstanding, that the obvious size of a structure can be changed by utilizing different limit esteems in a CT check [4]. Looking at target depiction in four diverse window settings to pathologically discoveries Macpherson et al. demonstrated that unseemly CT limit esteems can result in bogus estimation of the genuine tumor measure in breast tumors [6]. In general 648 CT-estimations were performed, of which just 321 (49.5%) were inside ± 5 mm of the obsessive size. All things considered, these outcomes cannot be extrapolated to the moderate 3D-CTs utilized in radiation treatment, as in the Macpherson ponder pictures were gotten on demonstrative CTs which were taken in breath hold and hence don't consider moving of the tumor.

The Lego ® apparition was a basic and ease other option to survey the effect of window level in the shaping of static and moving targets. In the event that the objective isn't moving or the reproduction of CT considered (i.e. GTV with a static ball and the GTV on the 4D-CT stages), the distinctions of the real size and the outlined size were not as substantial as in the moderate CT regardless of various window levels utilized for forming. The distinctions were little for the maximal degree (inside 2 mm, 5%), and more essential for the volume (inside 9-11% for the static CT and inside 27-half for the reproduced stages in the 4D-CT). An outline on a CT even with a non-moving target will dependably be an estimate of a genuine target volume. Little differences in the distance across will cause huge changes in volume. Anyway, in Static focuses on, the window level isn't as vital as in moving targets. In the event that the objective is moving the molding in a breast window or in a delicate tissue window will cause noteworthy over-or underestimation of the span of the objective. Besides apparition development obstructs figuring of the thickness of an objective and prompts bigger deviations of the Houndsfield units from genuine qualities (Figure 2).

This causes unclear target fringes and appropriation of the pixels to bring down HU esteems. Window settings need to cover a more extensive scope of HU pixel esteems to guarantee fitting target depiction. Tight window ranges (e.g. delicate tissue window) prompt critical underestimation of the GTV in moderate CTs. Forming of a moving target ought to be performed with substantial window width. It is firmly prescribed to have center particular rules with respect to which window width ought to be utilized for forming of moving targets.

Two other essential components to be considered while shaping moving targets are movement adequacy and bearing. Accessible examinations exhibited that notwithstanding little movement amplitudes protest shape and volume can change fundamentally. Chen et al. examined antiquities of moving articles in a rapid multirow helical CT scanner [2]. They discovered that round test articles can be abbreviated by as much as 20 mm and the question shape was altogether contorted. They could exhibit this impact regardless of whether the adequacy was diminished to 5 mm. Nakamura et al. discovered that objective volumes of patients with breast tumors in view of moderate CT pictures were considerably not quite the same as those on 4D-CT pictures, notwithstanding for patients with breast tumor movement not bigger than 8 mm [7]. Extra edges up to 5.4 mm were important to be added to the objective volume produced on the ease back CT keeping in mind the end goal to envelop the objective volume created by 4D-CT. Notwithstanding, altogether bigger movement amplitudes are accounted for breast tumors, particularly tumors in the lower projection [8]. Moving focuses with such expansive amplitudes ought to be required to be considerably more inclined to shaping mistakes on the moderate CT. We found that a molding in breast window will dependably overestimate the volume of the GTV and additionally the volume of the ITV. The sole special case is the breast window with the objective moving in cranio-caudal heading in the moderate 3D-CT. Here we detailed an underestimation of the volume of approx. 16%. One conceivable clarification is that on account of moving of the objective toward table development more antiques emerge. A few hub cuts will delineate just in part the moving ball, due to developments of the ball outside the field of view when the gantry was pivoting at a particular point. In this way the shaped structure in these cuts is little. This is like the consequences of Nakamura et al. [7]. Nonetheless, in all CTs shaped in breast window, the maximal degree was overestimated when contrasted with the genuine qualities. We unequivocally prescribe reexamination of the molded focus in various planes to avert the wrong estimation of the objective volume. Moreover, particularly when expansive movement amplitudes are normal, a forming on the cuts where the objective is best unmistakable with the introduction of shapes on different cuts where the objective isn't flawlessly obvious could delineate the objective volume best. The other critical factor to be considered is the course of target movement. For thoracic tumors, respiratory and cardiovascular movements are the principle supporters of intrafractional movement [9]. The predominant development of a tumor situated in the lower flap is generally in cranio-caudal heading, which is caused by breath [10,11]. Tumors in the mediastinum demonstrate the biggest dislodging in the horizontal course because of cardiovascular withdrawal or potentially aortic throb much of the time [8].

To test whether this affects target depiction, tumor movement was mimicked in two unique planes (cranio-caudal and parallel). The cranio-caudal development could affect the objective volume depiction in the moderate 3D-CT. The basic development of our ghost could have a few downsides: the ball loaded up with water is encompassed via air. One inquiry emerging is whether the complexity between the encompassing medium and the ball could impact the outline of the ball in the CT pictures. This could be seen best in the delicate tissue shaping in the 4D-CT: the best outcomes were accomplished for ITV utilizing the delicate tissue window (± 5%). We assume this is because of the way that ancient rarities outside the ball are less unmistakable in the delicate tissue window when contrasted with the breast window. The breast window, because of the solid difference amongst air and water can delineate curios that are not noticeable in the delicate tissue window or if the encompassing tissue is more comparable with respect to HU to the objective. Further, our apparition could delineate just periodical and normal developments. We will perform additionally concentrates to address this theme.

CONCLUSION

Window settings are essential in the molding of moving targets. Overall treatment was well tolerated as per existing literature [3]. As per specification in Wojcieszynski et al [3] acute skin toxicity was within tolerance limits and treatment time can be managed within acceptable limits with OAR dose within criteria. Window width is less significant for still target depiction. Be that as it may, in moving targets watchful thought of window width for shaping ought to be finished. Regardless of whether breast windows are utilized, we firmly suggest reexamination of the shaped focus in various planes in the moderate CT. The movement course importantly affected depiction of the objective in the moderate 3D-CT.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

[1] Bundschuh, R. A., et al. “Respiratory gated FDG PET/CT for target volume delineation in stereotactic radiation treatment of liver metastases.” *Radiotherapy and oncology,* Vol. 188, No .7, 2012, pp. 592-98.

[2] Chen, George TY, Jong H. Kung, and Kevin P. Beaudette. “Artifacts in computed tomography scanning of moving objects.” *Seminars in Radiation Oncology,* Vol. 14. No. 1, 2004.

[3] Wojcieszynski, Andrzej P., et al. “Acute toxicity from breast cancer radiation using helical tomotherapy with a simultaneous integrated boost.” *Technology in cancer research and treatment,* Vol. 15, No. 2, 2016, pp. 257-65.

[4] Harris, K. M., et al. “The effect on apparent size of simulated pulmonary nodules of using three standard CT window settings.” *Clinical radiology,* Vol. 47, No. 4, 1993, pp. 241-44.

[5] https://d3mjm6zw6cr45s.cloudfront.net/2018/02/2018ITTFHandbook_v2.pdf_0.pdf

[6] Macpherson, R. E., et al. “Non-small-cell lung cancer dimensions: CT–pathological correlation and interobserver variation.” *The British journal of radiology,* Vol. 82, No. 977, 2009, pp. 421-25.

[7] Nakamura, Mitsuhiro, et al. “Geometrical differences in target volumes between slow CT and 4D CT imaging in stereotactic body radiotherapy for lung tumors in the upper and middle lobe.” *Medical physics,* Vol. 35, No. 9, 2008, pp. 4142-48.

[8] Langen, K. M., and D. T. L. Jones. “Organ motion and its management.” *International Journal of Radiation Oncology Biology Physics,* Vol. 50, No. 1, 2001, pp. 265-78.

[9] Shirato, Hiroki, et al. “Intrafractional tumor motion: lung and liver.” *Seminars in radiation oncology*, Vol. 14, No. 1, 2004.

[10] Ross, Cynthia S., et al. “Analysis of movement of intrathoracic neoplasms using ultrafast computerized tomography.” *International Journal of Radiation Oncology Biology Physics,* Vol. 18, No. 3, 1990, pp. 671-77.

[11] Willich, N. “Technical and methodical developments of radiation oncology from a physician point of view.” *Radiotherapy and oncology,* Vol. 188, 2012, pp. 253-62.