Deep Inspiration Breath Hold (DIBH) Technique and Irradiated Lung Mass and Volume During Radiotherapy of Breast Cancer and Associated Lymph Nodes

O. VILLA[1], M. COONCE[2], and G. JOZSEF[1]
1Weill Cornell Medicine, New York City, NY, USA 2NewYork-Presbyterian Hospital, New York City, NY, USA

JULY 12–16 2020 VIRTUAL
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

Breast cancer is the most common cancer in American women, not counting skin cancers, with average risk of developing it sometime in her life being about 13%. A typical treatment is a complex combination of surgery, chemotherapy, hormone therapy, biological therapy, and radiation therapy (RT). Primary goal in breast cancer radio-therapy is to deliver the prescribed radiation dose to treatment volume that could include the entire or partial breast, the chest wall following the mastectomy, and possibly regional nodes as indicated by diagnosis. Typically two opposed tangential beams are used on a linear accelerator to teat breast cancer patient. If lymphatic nodes are included in the treatment volume, an additional beams are added.

The secondary goal of RT is to minimize the dose to the surrounding healthy tissues. For left-sided breast cancer patients, the heart, major coronary arteries, and left lung inevitably receive radiation dose due to their closeness to the treatment volume. The heart dose can be reduced in deep inspiration breath hold (DIBH) techniques as the irradiation takes place only at or near maximum inspiration during the phase where the maximum separation of the target area and heart occurs. The heart dose reduction during supine tangential breast irradiation DIBH technique is well studied and documented.

On the other hand, DIBH technique increases the irradiated volume of lung, and hence a risk factor for lung tissue damage. This lung dose effect is analyzed less rigorously.

AIM

To assess the percentages of irradiated lung volume and tissue during DIBH driven breast irradiation including axillary and supraclavicular nodes.

METHOD

- Cohort: 10 DIBH breast cancer patients with RT including axillary and supraclavicular nodes and with available free-breathing (FB) CT scans
- Eclipse 15.6 was used to contour lung with automatic lung segmentation and to calculate radiation treatment plans that included axillary and supraclavicular nodes
- HU_{air} calculated assuming that V_{Tissue} in the whole lung is the same for DIBH and FB.
- The volumes of tissue for the ipsilateral lung and for the in-field lung in both the DIBH and FB plans can be obtained from average HU values as

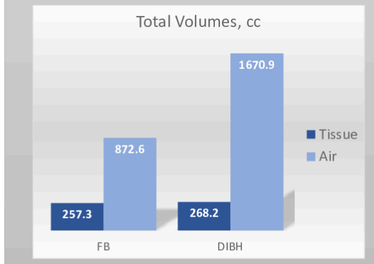
$$HU_{avg} = \frac{V_{air} \cdot HU_{air} + V_{tissue} \cdot HU_{tissue}}{V_{air} + V_{tissue}}$$

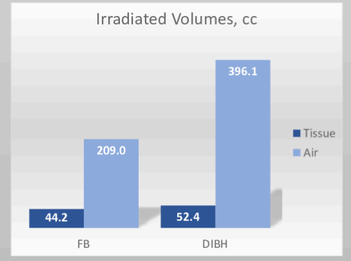
where HU_{tissue}=45 and HU_{air} =-970

$$V_{tissue} = \frac{(HU_{ava} - HU_{air}) \cdot V_{lung}}{HU_{tissue} - HU_{tissue}}, \quad \text{where} \quad V_{lung} = V_{air} + V_{tissue}.$$

- 50% isodose contour defines irradiated volumes.
- This study is follow-up of the study with tangential field arrangements only

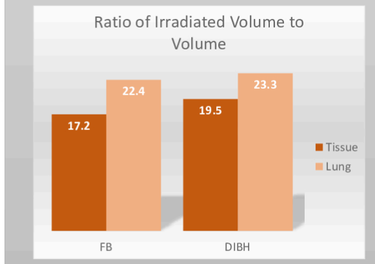
RESULTS



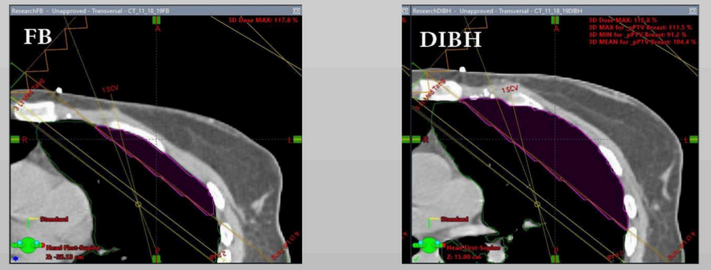


The total and irradiated averages of lungs' air and tissue volumes for free breathing and DIBH techniques.

Total Volumes, cc												
Free Breathing						DIBH						
	V_{tissue}	V_{air}	V_{lung}	V_{tissue}/V_{lung}	V_{air}/V_{lung}		V_{tissue}	V_{air}	V_{lung}	V_{tissue}/V_{lung}	V_{air}/V_{lung}
AVG	257.3	872.6	1129.9	22.8%	77.2%	AVG	268.2	1670.9	1939.1	14.1%	85.9%
StDev	49.1	132.2	163.3	3.0%	3.0%	StDev	42.3	392.8	422.6	1.9%	1.9%
In Field Volumes, cc												
Free Breathing						DIBH						
	V_{tissue}	V_{air}	V_{lung}	V_{tissue}/V_{lung}	V_{air}/V_{lung}		V_{tissue}	V_{air}	V_{lung}	V_{tissue}/V_{lung}	V_{air}/V_{lung}
AVG	44.2	209.0	253.2	17.8%	82.2%	AVG	52.4	396.1	448.5	12.1%	87.9%
StDev	16.5	85.9	101.2	2.5%	2.5%	StDev	13.2	125.0	136.9	2.0%	2.0%



- The average ratio of the irradiated tissue to the total tissue is 17.2% (StDev 6.0%) for FB cases and 19.5% (StDev 4.3%) for DIBH.
- The average ratio of the irradiated volume to the total volume is 22.4% (StDev 8.5%) for FB cases and 23.3% (StDev 6.74%) for DIBH.
- For all cases the DIBH lung tissue was more than that of FB.



Typical patient's left lung axial images of the FB (right) and DIBH (left) breast cancer radiation therapy

CONCLUSIONS

- Recap of the previous study: 17 left-sided and 3 right-sided breast cancer patients treated with DIBH and two tangential opposed beams only. It showed that compared to free-breathing patients, there is an increase in irradiated lung volume and lung tissue. The average ratio of the irradiated tissue to the total tissue is 9.1% (StDev 4.4%) for FB cases and 12.3% (StDev 3.6%) for DIBH. The average ratio of the irradiated volume to the total volume is 12.4% (StDev 5.6%) for FB cases and 16.1% (StDev 3.6%) for DIBH. The infield lung volume is still only 5% to 20% of the total ipsilateral lung volume. (Ref 5)
- This repeated study was focused on a retroactive analysis of radiation treatment plans of the DIBH technique including axillary and supraclavicular nodes. A comparison of the numbers in the results section to the recap above are similar in that more lung volume and lung tissue is irradiated in DIBH technique compared with that of FB as in the previous investigation. However, the difference is smaller than in the study with tangential fields only.

REFERENCES

1. Americal Cancer Society. Cancer Statistics Center. http://cancerstatisticscenter.cancer.org Accessed 06/24/2020
2. Zurl, B., Stranzl, H., Winkler, P., & Kapp, K.S. (2010). Quantitative Assessment of Irradiated Lung Volume and Lung Mass in Breast Cancer Patients Treated with Tangential Fields in Combination with Deep Inspiration Breath Hold (DIBH). *Strahlentherapie und Onkologie, 186*, 157-162.
3. Hepp R., Ammerpohl M., Morgenstern C., Nielinger L., Erichsen P., Abdallah A., Galalae R. Deep inspiration breath-hold (DIBH) radiotherapy in left-sided breast cancer: Dosimetrical comparison and clinical feasibility in 20 patients. Strahlenther. Onkol. 2015;191:710–716
4. Nissen HD, Appelt AL. Improved heart, lung and target dose with deep inspiration breath hold in a large clinical series of breast cancer patients. *Radiother Oncol.* 2013;106(1):28–32.
5. Villa OV, Coonce MC, Jozsef G, Deep inspiration breath hold (DIBH) technique and irradiated lung mass and volume. MO-E115-GePD-F3-01 Medical Physics, 46 (6), June 2019

CONTACT INFORMATION

Oksana N Villa: onv4001@med.cornell.edu