# Correlation between Breast Volumes and Heart Doses for Left-sided Whole Breast Treatment in Photon and Proton Radiation Therapy

Jen Yu, PhD, Alonso Gutierrez, PhD, Marcio Fagundes, MD and Minesh Mehta, MD

*Department of Radiation Oncology, Miami Cancer Institute, Miami, Florida 33176, USA*

Miami Cancer Institute

## Introduction

To investigate if a correlation exists between treated breast volumes and heart doses for left-sided whole breast treatment in photon tangent field-in-field (FinF) and proton pencil beam scanning (PBS) therapy.

## Methods & Materials

For thirty left-sided breast cancer patients, seventeen patients were treated with FinF modality using free-breathing (FB). The FinF plans were also generated on breath-hold (BH) CTs. Thirteen patients were treated with proton therapy with FB, and the PBS plans were created with one or two enface beams with a single field optimization technique. Volumes of whole breast PTV and heart mean dose were used for analysis. The prescribed dose was 50 Gy (RBE) for both photon and proton treatments. The breast PTV volumes and heart mean dose were used for statistical analysis of total 30 patients.

## Conclusions

For left-sided whole breast treatment with the photon FinF technique, patients with large breast volumes (> 1000 cc) are more likely to receive higher heart doses than patients with smaller breast volumes. FinF with BH or proton PBS can significantly lower heart doses. For proton treatment, the heart doses were minimal and patients' breast volumes were not correlated with heart doses.

| | **Photon FinF with FB** | | | **Photon FinF with BH** | | | **Proton PBS** | | |
|---|---|---|---|---|---|---|---|---|---|
| Heart dose | Mean dose (cGy) | Lower 95% (cGy) | Upper 95% (cGy) | Mean dose (cGy) | Lower 95% (cGy) | Upper 95% (cGy) | Mean dose (cGy) | Lower 95% (cGy) | Upper 95% (cGy) |
| PTV < 1000 cc | 204.4 | 94.1 | 314.6 | 100.2 | 62.0 | 138.4 | 23.9 | 11.7 | 36.0 |
| PTV > 1000 cc | 356.9 | 269.7 | 444.1 | 160.3 | 127.2 | 193.4 | 26.6 | 13.7 | 39.5 |

## Results

For the FinF modality treated with FB, when the breast PTVs were larger than 1000 cc, the average value of heart mean dose was 3.6 ± 0.4 Gy, and when the volumes were less than 1000 cc, the average value of heart mean dose was 2.0 ± 0.5 Gy. Differences between the two groups were statistically significant (p* = 0.036). For the FinF treated with BH, the average heart mean doses were 1.6 ± 0.2 and 1.0 ± 0.2 Gy for the PTVs larger and smaller than 1000 cc, respectively (p*=0.0237). For proton PBS, however, there were no differences of heart doses between the two groups (p=0.7). For all patients, the average heart mean doses were 3.0 ± 1.3, 1.3 ± 0.5 and 0.25 ± 0.17 Gy for photon FinF with FB, with BH, and proton PBS, respectively (p* < 0.001).

Figure 1, 2 and 3 show the quantiles box plots and the diamond plots for the photon FinF treatments with FB, with BH, and proton PBS. One-way Anova with a significance lever of 0.05 was used to analyze the differences of the heart mean doses between the two groups (breast PTV volume larger than 1000 cc vs the group of smaller volume). Significant differences were shown for photon FinF with FB and BH (p* = 0.036, 0.0237), but not for proton PBS treatments (p = 0.7). The table lists the heart mean dose of average values and 95% confidence intervals for the two groups treated with the 3 techniques. The reduction of heart dose with BH and proton PBS were significant (p < 0.001) based on Wilcoxon signed-rank test.

## Discussion

For left-sided whole breast treatment, we identified that in photon tangent field-in-field (FinF) modality, large breast volume (> 1000 cc) is more likely to receive higher heart dose than smaller breast volume. We did not observe such a correlation in proton pencil beam scanning (PBS) therapy.

For photon FinF modality, the tangential beams could unavoidably include portion of heart. Larger and thicker breast volume could increase the portion of heart being irradiated in the tangential fields. This can be illustrated in Figure 4 and 5, which show two patients with breast volume of 1298 cc and 423 cc, respectively. The orange line indicates the field boarder of the tangent beams. The heart location, however, could change the received dose for a given breast volume. For proton PBS technique, en-face beam(s) were used, and proton range was optimized to be shallower than heart regardless of the breast volumes (Figure 6). Therefore, patients' breast anatomy has little effects on heart dose.

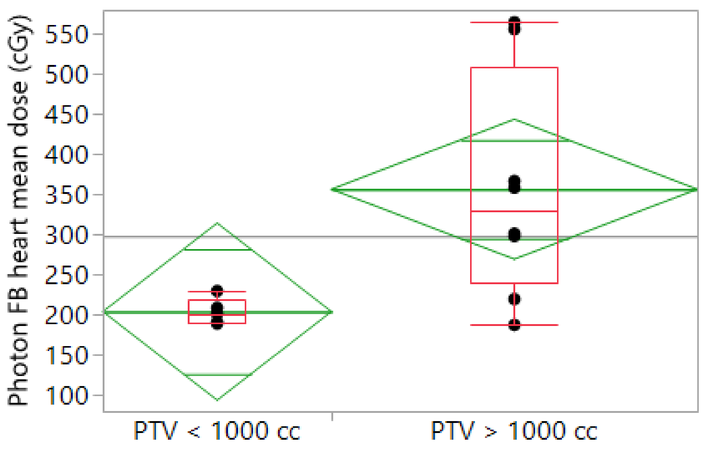


Figure 1

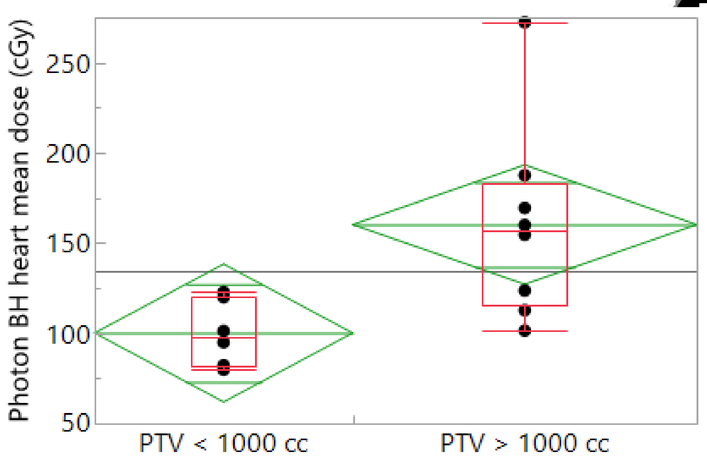


Figure 2

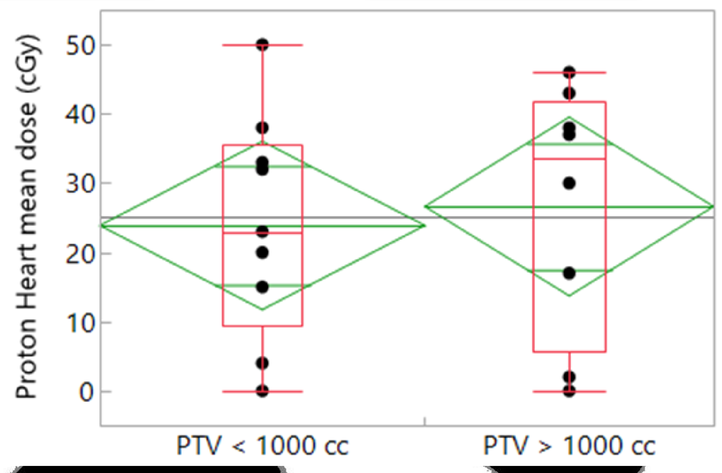


Figure 3

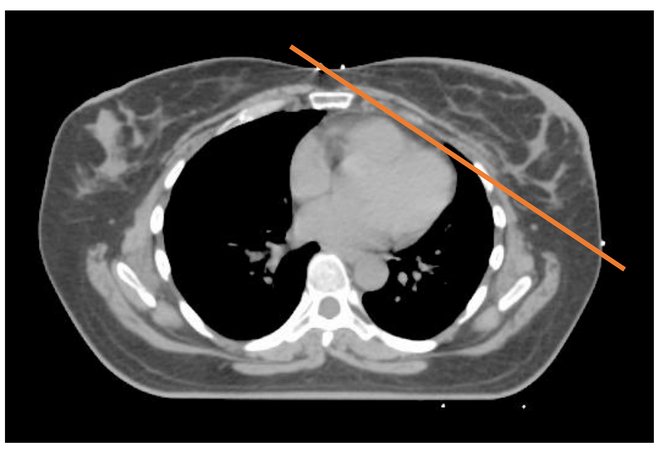

Figure 4

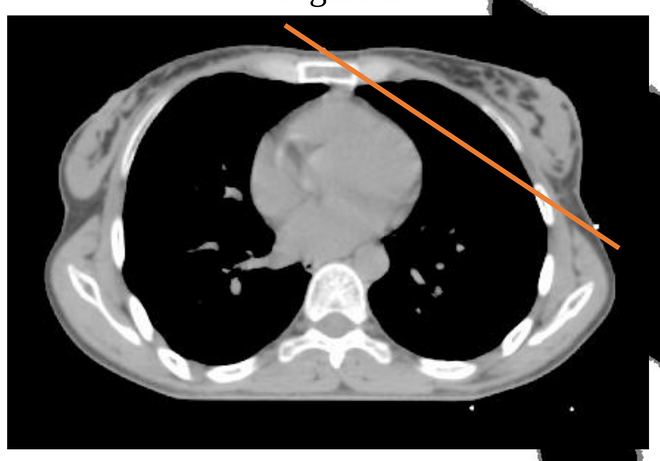

Figure 5

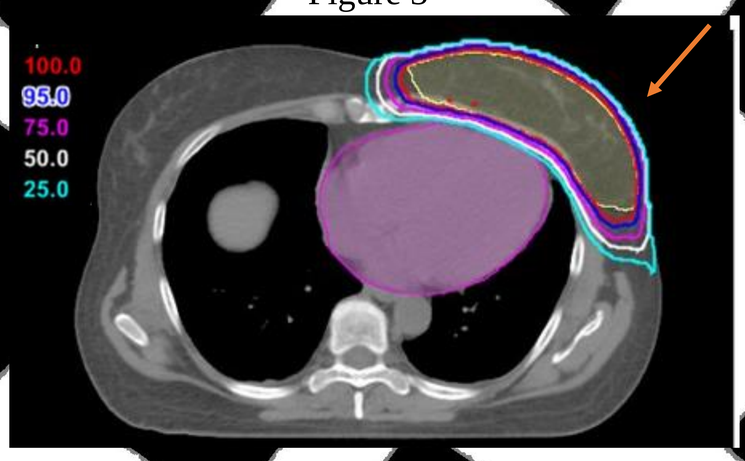


Figure 6