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A comparison between Inverse-Planning IMRT versus Forward-Planning IMRT for left-sided breast cancer with breath hold technique

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Abstract

Introduction

Radiation therapy using tangential fields is a common treatment for breast cancer, targeting the tumor while reducing radiation exposure to surrounding healthy tissues such as the heart and lungs. Forward-planned "field-in-field" IMRT (FP-IMRT) is widely used for its ability to provide uniform dose distribution and spare normal tissue despite requiring high planning skill and time. Inverse-planning IMRT (IP-IMRT) offers a better conformal dose to targets with reduced planning variability and time. This study compares FP-IMRT and IP-IMRT in left-sided breast cancer patients using the deep inspiration Breath-Hold (DIBH) technique.

Method

A retrospective analysis was conducted on 10 patients treated with hypofractionation protocol. Each patient was planned using FP-IMRT and IP-IMRT techniques with the same beam orientation and prescription. Metrics for breast coverage and dose to organs at risk (OARs) were analyzed using IBM SPSS Statistics.

Result

Results showed no significant difference in the dose covering 5% and 95% of the planning target volume (PTV) between FP-IMRT and IP-IMRT. However, IP-IMRT significantly reduced hot spots compared to FP-IMRT. For OARs, IP-IMRT demonstrated a lower mean lung dose, though there were no significant differences in lung V20Gy and V5Gy between the techniques. Heart dose metrics were comparable, with IP-IMRT showing a slight advantage.

Conclusion

This study concludes that IP-IMRT provides similar breast coverage to FP-IMRT while reducing hot spots and mean lung dose, making it a preferable option for left-sided breast cancer treatment using the DIBH technique. Further research with a larger patient cohort is recommended to validate these findings.

Introduction

According to the World Health Organization, in 2020, there were 2.3 million women diagnosed with breast cancer and 685,000 deaths globally[1]. As of the end of 2020, there were 7.8 million women alive who were diagnosed with breast cancer in the past five years, making it the world's most prevalent cancer[1]. Implementation of breast screening programs have been shown to significantly improve outcomes by detecting early-stage breast cancer and enabling appropriate treatment techniques[2]. The biggest risk factor for breast cancer is increasing age; other commonly known risk factors include female gender, early menarche, late menopause, nulliparity first childbirth over 30 years, BRCA1 and BRCA2 genetic mutations, and prior breast disease[3]. It is worth mentioning that breast cancers in younger women are often more aggressive than what is typical in older women.

Breast cancer is a systemic disease that demands a comprehensive therapeutic approach consisting of surgery, chemotherapy, and radiotherapy[4]. When appropriate, hormone and antibody therapies may be incorporated as complementary treatments. In the United States and Europe, breast-conserving surgery followed by adjuvant radiotherapy is regarded as the standard treatment method for early cases of breast cancer. Numerous randomized data, including meta-analyses, have shown a lower recurrence rate and better long-term survival of 5–10% after adjuvant 3D-conventional irradiation (3DCRT) (Karpf et al., 2019). 3D-CRT utilizes tangential beam arrangement to adequately treat breast tissue susceptible to hosting microscopic residual disease after breast-conserving surgery. However, this traditional method can make it difficult to achieve target conformity and uniform dose distribution, leading to more irradiation around the target or normal tissue, such as the lung and heart, and more tissue damage and complications[6]. To improve the uniformity in dose distribution, a newer technique of intensity modulation was developed called intensity-modulated radiotherapy (IMRT). There are two types of planning techniques: inverse planning IMRT and forward planning IMRT[7].

Radiation therapy using tangential fields is a common treatment approach for breast cancer patients. It is designed by using two opposing tangential fields to target the breast tumor while reducing incident radiation to surrounding healthy tissues, such as the heart and lungs. Forward-planned "field-in-field" IMRT (FP-IMRT) is used widely by many institutions nowadays. Field-in-Filed (FIF) technique is created by using sub-fields in the tangential fields with multileaf collimator (MLCs), which can effectively reduce hot spots to critical structures. The main advantages of FP-IMRT are uniform dose distribution and spare of normal tissue while requiring high skill and a long time in planning[8]. On the other hand, Inverse-Planning IMRT (IP IMRT) allows for a better conformal dose to the targets by allowing variation in the fluence, thus spatially modulating the intensity of the beam[7]. IP-IMRT is an optimizer driven using MLCs, and dividing a beam into small beamlets results in fluence modification, leading to a sharp dose to the target with a minimum dose to the critical organs. This technique uses customized algorithms to shape the desirable dose distributions. It also reduces planning time and creates less variability between planners with tailored optimized templates.

When dose constraint to critical structures like lungs and heart is not achievable, it is important to consider IMRT technique. IMRT with two or more static beams is commonly used, and later, volumetric modulated arc therapy (VMAT) has been introduced to improve breast dose homogeneity and significantly reduce dose to organs at risk (OAR). The two static tangential IMRT beam arrangements are often replaced by two tangential arcs in VMAT treatment. Tangent IMRT maintains the traditional tangential beam orientations and has been proposed as a means of reducing incidental irradiation to the heart. Even though the application of breast IMRT has been shown to enhance homogeneity and reduce the severity of acute radiation dermatitis, it is essential to recognize that no degree of intensity modulation can create a substantially concave dose distribution when only two nearly opposed (tangential) IMRT fields are used. The dose to the heart can be reduced if it is defined as an organ at risk (OAR) and a strong planning constraint is applied to it. However, this reduction in dose to the heart will inevitably come at the expense of a reduction in dose to the breast tissue, which lies medial and lateral to the heart in the path of the beam[9]. To test this hypothesis, we conduct our study to compare IP-IMRT and FP-IMRT in terms of breast coverage and OAR dose in left-sided breast patients using the DIBH technique.

Literature Review

In 2012, Zakiya et al. compared 20 patients with left-sided breast cancer using 3D-CRT, FiF-FP-IMRT, and IP-IMRT. The main dependent variables in the study were homogeneity of dose to planning target volume (PTV) and the dose delivered to the heart and contralateral breast. It was found that all three techniques achieved a comparable radiation dose of 95% breast PTV covered by the prescribed dose. The independent variables 3D-CRT and FP-IMRT had similar homogeneity and conformity indices (CI), while the IP-IMRT plans created a better conformity index at the cost of less homogeneity. The low-dose volumes (V5Gy) in the heart and lungs were larger in IP-IMRT than in the other techniques. Moreover, the ipsilateral lung had a mean dose higher in IP-IMRT than with FiF-FP-IMRT and 3D-CRT. It was concluded that FP-IMRT proved to be a simple and efficient planning technique for breast irradiation compared to 3D-CRT and IP-IMRT. The study used eight different beam directions for IP-IMRT plan, which significantly lower CI values but, at the same time, created lower dose and mean dose to healthy tissue. In this study, we are going to use two beam directions for IP-IMRT with the same angles as FP-IMRT with the goal to limit as much low-dose volumes as possible.

One recent comprehensive study focused on comparing 3DCRT, IMRT, VMAT, Ecomp, and Hybrid techniques for breast radiation therapy. In 2020, Chen et al. assessed and evaluated dosimetric parameters obtained between many different radiation delivery techniques. The independent variables were 3DCRT, three-dimensional field-in-field (3DFIF), 5-field intensity-modulated radiotherapy (IMRT MF5), tangential IMRT (tIMRT), tangential volumetric modulated arc therapy (tVMAT), electronic tissue compensation (Ecomp), and Hybrid treatment plans. The study analysed many dependent variables such as Homogeneity Index (HI), ipsilateral lung dosimetry, heart dosimetry, and total monitor units. It was concluded that planning target volume HI was found to be significantly different among all techniques with Ecomp providing in better HI value. In regards to ipsilateral lung dose, tVMAT had the highest lung mean dose, followed by IMRT MF5; no significant difference was observed among other tangential techniques. There was statistically significant differences among all seven methods. Heart mean dose was well beyond dose tolerance limit, which is 4 Gy for both tVMAT and IMRT MF5; no significant difference was found between techniques with tangential field arrangement.

Many previous studies focused on multi-directional IMRT and VMAT, which achieve better homogeneity and conformity than the tangential fields approach. However, Tangential intensity-modulated radiotherapy (t-IMRT) significantly and considerably reduced dose to organs at risk as well as normal tissue integral dose. Excess absolute risk (EAR) for the induction of secondary tumours was significantly lower following t-IMRT than multi-directional IMRT and VMAT techniques[4]. Another study done by Dean et al., 2016 focused on the clinical applicability of IP-IMRT to determine if this technique could replicate the plans achieved by using FP-IMRT for adjuvant breast radiotherapy. It was concluded that there was improvement in PTV coverage and increased homogeneity, as well as a tendency towards lower lung doses. The study also demonstrated that it is feasible to utilize a template-based planning solution to generate IP-IMRT plans for breast patients[10]. The limitation of this study, however, was conducted using only free-breathing technique for both left-sided and right-sided breast patients. We aimed to utilize Breath-Hold technique in our study in combination with IP-IMRT to further decrease the risk of cardiac toxicity especially for patients with a very medial or lateral tumor bed.

Besides treatment planning techniques, deep inspiration Breath-Hold (DIBH) can significantly reduce undesired radiation exposure to surrounding normal tissue, including lung and heart tissues. The benefits of DIBH were especially emphasized in heart dose reduction for left breast cancer patients receiving chest wall irradiation[11]. During DIBH, patients take a deep breath and hold it, which results in the expansion of the chest wall and the separation of the heart and lung tissue from the target breast area. For left-sided breast cancer patients, the heart is located close to the treatment area. DIBH significantly reduces radiation exposure to the heart and minimizes the risk of cardiac side effects, such as heart disease or coronary artery damage. It also spares the lung tissue, reducing the potential for radiation-induced lung complications. By expanding the chest wall during Breath-Hold, DIBH allows for a more stable and consistent breast shape, resulting in improved target coverage. This means the radiation can be accurately delivered to the cancerous tissue while sparing healthy surrounding structures. The DIBH technique is generally well-tolerated by patients, as it involves breath-holding during radiation sessions, which typically lasts for only a few seconds at a time. This improved comfort and patient compliance contributted to the successful implementation of the treatment plan.

In 2018, Yu et al compared 14 left breast cancer patients using tVMAT with DIBH and Free-breathing (FB) techniques. It was concluded that, the mean heart dose of DIBH in tVMAT was reduced from 7.9 Gy to 3.2 Gy when compared to FB. There was also significant evidence that V30 in left lung was reduced from 12.9% to 5.7%. DIBH technique was found to provide better treatment quality and is an efficient treatment strategy to consider.

It is expected that by using DIBH on left-sided breast patients using IP-IMRT, there could be a decrease in radiation dose to heart and lung normal tissues while maximizing dose coverage to PTV. To test this hypothesis, this planning study conducted compares IP-IMRT and FP-IMRT in terms of breast coverage and OAR dose on left-sided breast patients using DIBH technique.

Research Design Methodology

Patient Selection

This is a retrospective study that includes 10 previously treated patients. The inclusion criteria were women with left-sided breast cancer, no nodal involvement, using breath-hold technique for simulation and treatment, and treated with hypofractionation protocol. Various-sized breast was selected to represent a range in anatomy. These patients were planned by the same dosimetrist using the FP-IMRT technique. Dose-fractionation was 42.5Gy in 16 fractions with 4-5 fractions of boost to up to 52.56Gy in total. Patients were treated daily for five days a week.

CT Simulation

All patients were simulated supine on the CIVCO breast board with both arms up and head turned right. The angle of the breast board was chosen so that the sternum was parallel with the treatment table. The doctor outlined breast tissue borders and lumpectomy scar with wires by visual inspection and palpation. Initial three radiopaque localization bb's were placed at a stable location on the abdomen as a starting point. Once marking and immobilization were finished, a CT scout was obtained to ensure the patient was straight in the treatment position. CT images were obtained at 2.5mm intervals. Two scans were obtained with one free-breathing and one Breath-Hold technique. Initial bb's were placed during free-breathing cycle; therefore, free-breathing scan would be used to set user origin and then fused with Breath-Hold scan. Breath-Hold scan would be used for treatment planning and delivery.

Treatment Planning Preparation

The treatment plan was created using the following prescription: 42.56 Gy with 2.66 Gy per fraction for 16 fractions. These 10 patients also received additional four to five fractions of boost with 10 Gy int total to lumpectomy site. However, this study will not compare the boost plan. AI software called MIMs ProtégéAI+ were used to delineate OARs such as lungs, heart, liver, spinal cord, and esophagus. A visual inspection was carried out by a certified medical dosimetrist to verify the accuracy of the contoured structures. The heart was contoured superiorly from the base of the great vessels to the lowest point of the myocardium, encompassing the pericardium below. The left lung was delineated from the apex to the base. The body and bone contour were generated automatically by the treatment planning system and verified by the dosimetrist. The doctor did not contour the target structures, which is the breast tissue PTV. Therefore, it required the expertise of the dosimetrist to set up appropriate field borders to cover the entire breast tissue. Wires from the simulation scan were helpful in delineating the superior and inferior borders of the breast tissue. The medial field border was set so that the contralateral breast would not receive any radiation exposure. The lateral field border was given 2.0 cm flash to include all breast tissue and potential swelling.

FP-IMRT

The standard protocol for whole breast irradiation at our institution is a forward-planned field-in-filed technique. FP-IMRT was created by using two tangential opposed beams with 6MV for the opened field and 15MV for the field-in-filed to minimize peripheral hot spots and allow better coverage. The plan was created by the same dosimetrist for 10 selected patients in the study. The beam angle and beam weighting were chosen to optimize for the best coverage of the entire breast tissue while minimizing the dose to the heart, ipsilateral lung, and contralateral breast.

The heart was completely blocked by using MLCs without significantly compromising coverage to breast tissue. Collimator was set to be around 350 degree so that MLCs don't have to travel far from the primary jaws in order to prevent leakage. Maximum of 3 field-in-fields were introduced to ensure efficiency and superficial dose coverage was not compromised. All plans were normalized to have 95% isodose line cover the entire chest wall.

IP-IMRT

The same 10 patients were then parallel-planned with IP-IMRT technique using the same beam orientation and prescription. The same prescription was applied to inverse optimization in Eclipse as part of the template. Since breast planning volume is required for optimization in IP-IMRT plans, the PTVeval was created by using MIM's AI contour to delineate Left Breast tissue and cropping inside the patient contour by 0.5 cm. A visual check was completed to ensure proper delineation of the breast volume. This volume will be used as a structure for the optimiser in the planning system, as well as a volume for statistical evaluation. One study conducted by Dean et al., 2016 also mentioned an additional constraint applied to PTVeval by cropping the lateral extents of PTVeval to prevent volume wrapping around the chest wall adjacent to the cardiac contour. The same method was utilized here for the best optimization and data analysis.

The same beam energy from FP-IMRT was used for IP-IMRT. Some breast plans required a combination of 6x and 15x for adequate coverage of breast tissue. We copied the same beam orientation and beam energy combination from FP-IMRT for the purpose of comparison. In the optimization window, the highest priority was given to 95% of PTVeval receiving at least 95% of the prescription dose. Also, no part of PTV would receive more than 110% hot spots.

Additional constraints were placed to minimize heart dose as much as possible without compromising coverage to the breast tissue. We put an upper and mean dose to optimize the heart. No constraint was put in for lungs as we chose the best beam angle to eliminate as much lung tissue as possible. A 2.5 cm flash extension was applied to the properties of the PTVeval volume to ensure the fields covered the anterior of the breast tissue. This allowed for daily setup variation and patient motion.

Institutional Review Board

A request for evaluation by the hospital's Institutional Review Board (IRB) was necessary to determine if this project constitutes human subjects research. It was concluded that this project was exempt. A request was then sent to Grand Valley State University Institutional Review Board. It was also determined that this project did not meet the definition of human subjects. Therefore, it didn't require further review and approval by the IRB. Appropriate training through Collaborative Institutional Training Initiative (CITI) program was completed before the initiation of the research project

Metrics

Initially, each patient's data set was run with a standard template. Necessary adjustments were made to generate clinically acceptable plan aligned with the protocol objectives. The plan was first evaluated through visual inspection, focusing on breast tissue coverage and the location of hot spots. Per the clinical goals of the facility, the Dmax should remain under 107% of the prescription. The 105% isodose line should be contained within the target tissue and should not fall within the subject's posterior musculature or the nipple. The minimum dose to the PTV was recorded by looking at the 95% isodose line. Dose constraints for OARs are as followed: Mean Heart < 400 cGy, V16<5%, V8<30%, Ipsilateral Lung V8<35%, V4<50%, and Contralateral Lung V4<10%

Statistical Analysis

For the purpose of this study, homogeneity and conformity as well as mean, maximum, and minimum were calculated for PTVeval. Homogeneity index (HI) was defined as D95 / D5 with D95 and D5 are the dose that covered 5% and 95% volume of the PTVeval. Conformity Index (CI) was generated from DVH. Organs at risks were compared on the basis of volume of heart receiving 5 Gy, 20 Gy, and Mean Heart; both lungs receiving 5 Gy and 20 Gy and mean dose.

Statistical analysis was conducted using Sign Test due to having small sample size, and the normality assumption for T Test was not being met.

Results

The purpose of this study was to determine if an Inversed Planning IMRT approach would allow for better overall plan quality by decreasing hot spots, increasing coverage, and lowering OAR doses for patients of left-sided breast cancer utilizing Breath-Hold technique for treatment. Ten previously treated patients were selected. The criteria for the subjects in the study were for patients treated with hypofractionated prescription of 266 cGy for 16 fractions to a total dose of 4256 cGy. The initial 3D treatment was copied and used for Inverse Planning with the same beam angle, collimation, energy and prescription. Multiple metrics were used to compare the two plans to determine which treatment was superior in term of coverage and OAR dose. Statistical analysis was done using IBM SPSS Statistics. Sign Test was used with a resulting p-value <0.05 was determined to be statistically significant.

PTV

The first metric evaluated were the D5%. When comparing the FP_IMRT (Median = 44.52, STD= 0.19) to the IP_IMRT (Median = 44.56, STD= 0.11), the dose that cover 5% of the PTV volume was not statistically significant. The similar result was also applied to the D95% with FP_IMRT (Median = 41.07, STD= 2.34) and IP_IMRT (Median = 41.19, STD= 0.6). This means the prescription dose delivered to 5% and 95% of the PTV volume was relatively similar between the two plans. Another metric that was evaluated was the conformity of the dose. It was also reported that there was no statistically significance in CI and HI between the two plans. For FP-IMRT, the 105% volume ranged from 0.99% to 6.3% (Median 2.6%). While the 105% for IP-IMRT ranged from 0% to 2.2% (Median 0.2%). It was statistically significant that FP-IMRT reported higher amount of 105% of prescription dose compared to IP-IMRT (p=0.02).

Organs at Risk

There was no difference in Lung V20Gy between the two plans with Median of 5.15 for FP-IMRT and 4.15 for IP-IMRT. There was also no significant difference in Lung V5Gy. However, it was discovered that there was sufficient evidence to suggest Forward Panning had higher mean Lung dose compared to Inverse Planning with Median 2.94 and STD 0.86 vs Median 2.45 and STD 0.62 (p=0.04). All metrics for Heart doses were comparable with IP-IMRT plans, resulting in slightly lower V20Gy and V5Gy (V20Gy Median 0.05 vs 0.0 and V5Gy Median 2.45 vs 1.69)

Discussion

This study aimed to investigate if using Inversed Planning IMRT approach would make a difference in plan homogeneity and lower OAR dose for patients with left-sided breast cancer utilizing Breath-Hold technique. One study done by Dean et al, 2016 focused on clinical applicability of IP-IMRT to determine if this technique could replicate the original plans using FP-IMRT for adjuvant breast radiotherapy. It was concluded that there was improvement in

PTV coverage and increased homogeneity as well as a tendency towards lower lung doses[10]. The limitation of this study, however, was done using only free-breathing technique for both left-sided and right-sided breast patients. This study was conducted retrospectively, using standard protocol FP-IMRT plans as a reference to determine a significant difference between the two planning techniques using Breath-Hold method; multiple metrics were gathered, including the planning target volume and dose constraints to organ at risk. The initial 3D treatment was copied and used for Inverse Planning with the same beam angle, collimation, energy and prescription for the purpose of comparison. Upon evaluation of all the metrics, it was determined that there were two significant differences between IP-IMRT and FP-IMRT. Eleven metrics and objectives were reviewed, and two out of eleven metrics had statistical significance in favor of Inverse-Planning. Nine metrics had no significant differences between the two planning techniques.

PTV

The primary measure of an acceptable plan was the inspection of 95% isodose coverage and assessment of hotspots. It was found that the two plans have similar coverage since PTV coverage is a high priority in treatment planning. Conformality around the PTV was also found to be insignificant between two plans including D5%, D95%, CI, and HI. Dean et al. reported that the coverage was better in IP-IMRT method compared to the FP-IMRT which was not consistent with our result. However, FP-IMRT showed to have higher amount of 105%. This metric is important in regard to cosmetic outcomes. A higher percentage of 105% prescription dose can increase the risk of dermatitis[12]. It becomes more important for patients with a large volume of breast issue due to a higher amount of skin folds and an increase in treatment separation. A study doing research on skin toxicities for large breast patients discovered that grade I dermatitis occurred in 55% of patients and grade II dermatitis occurred in 40.8% of patients that received 3D hypo fractionated radiation therapy[12]. IP-IMRT proved to be effective in providing appropriate coverage and reducing skin reaction.

Organs at Risk

The tangential field setup significantly reduced the number of organs at risk that radiation may transverse through. This study focused on the two most organs of concern in breast treatment, the lungs and heart. Looking at the ipsilateral lung, V20Gy was one of the most important metrics as it significantly increased the risk of pneumonitis. The higher the mean lung dose when irradiating left-sided breast cancer, the higher the risk for developing radiation-induced pneumonia[13]. According to the Quantitative Analysis of Normal Tissue Effects in Clinic (QUANTEC), the lungs volume receiving 20 Gy should remain less than 30% to reduce risk of pneumonitis less than 20%. In a study over 20 unselected patients, Rudat et al. concluded that tangential beam IMRT significantly reduced the ipsilateral mean lung dose by an average of 21% (11.29 Gy vs. 14.37 Gy, $p < 0.01$) and D30 by 43% (9.60 Gy vs. 16.95 Gy, $p < 0.01$)[14]. This is consistent with our research as there was sufficient evidence to suggest Inverse Planning had lower mean Lung dose compared to Forward Planning with Median 2.45 and STD 0.62 ($p=0.04$) vs Median 2.94 and STD 0.86. Study done by Dean et al also suggested lower ipsilateral lung doses for IP-IMRT vs FP-IMRT with 3.7 Gy (SD: 1.3) and 3.9 Gy (SD: 1.3) respectively[15].

Dose to the heart is a concern in breast cancer patients. Balancing between the high dose region of the heart and mean heart dose is still the most direct and best strategy to reduce cardiac injury from radiation. Deep inspiration Breath-Hold has been shown to reduce cardiac exposure. A number of reports have demonstrated that multifield IMRT plans employing non-tangential beams can reduce high-dose radiation to the heart but at the expense of increased low-dose exposure to other organs such as the heart, contralateral breast, and lungs. Therefore, the use of tangential beams either through FP-IMRT or IP-IMRT coupled with DIBH are widely accepted by our clinicians as a method to reduce dose to the heart. This study found that all metrics for Heart doses were comparable between IP-IMRT and FP-IMRT with IP-IMRT plans resulting in slightly lower V20Gy and V5Gy (V20Gy Median 0.05 vs 0.0 and V5Gy Median 2.45 vs 1.69). This is consistent with another study which determined there was no statically significant difference between 3D-Conformal and IMRT in mean heart dose[16]. Another study done by Mirjam et al compared 3D-CRT and IMRT treatment plans based on free-breathing. It was found that the heart mean, maximum, and V20 for 3D-CRT vs IMRT were 3.3 vs 2.7, 29.9 vs 24.7, and 5 vs 3.5, respectively[17]. The application of IMRT provides better local control without increased heart toxicity as well as lower mean lung dose in those requiring local-regional treatments.

Planning time between the two techniques was considered but not measured for every patient. Preparation and contouring prior to planning requires more time for IP-IMRT due to the delineation of PTVeval. However, the use of a template based optimization greatly offset this time difference and produced optimal plan in less time than manually adjusting MLC segments. On the contrary, IP-IMRT requires additional QA test which adds more time and resources.

Study Limitation

A limitation of the study is the population size. With a small sample size of 10 patients, it is not feasible to generate an accurate result for the whole population. More patients would provide more adequate comparison between coverage and OARs dose. Opportunity for future research could include comparison of radiation dose to left anterior descending artery (LAD) in two treatment techniques as LAD correlated with adverse cardiac events.

Conclusion

Compared to FP-IMRT, IP-IMRT in left-sided breast irradiation considerably reduces dose to lungs with comparable a dose to heart, as well as providing similar coverage to the breast target. Therefore, Inverse planning for adjuvant breast radiotherapy is a suitable alternative. The study also utilized a template-based optimization for treatment planning to generate IP-IMRT. This approach provides a consistent and reasonable platform to standardise Inverse Planning technique in breast cancer treatment planning regardless the variability in PTV. Given the above benefits, IP-IMRT has been proven to be an effective strategy to create consistent PTV coverage and increased homogeneity as well as tendency towards lower lung and heart doses.

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Figure 1. Box plot of mean lung doses of FP-IMRT and IP-IMRT data collected.