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A Change in an Absorbed Dose of the Heart in General and Respiratory Control Radiation Treatment Plans

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ABSTRACT

In radiation treatment, it is unavoidable to block the influence of scattered ray on a skin and prevent internal normal organs from being exposed to radiation. It is fair to say that radiation therapy aims to reduce an absorbed dose of normal tissues. In particular, in radiation therapy of left-sided breast cancer, the internal neighboring organs are normal breast tissues, the heart, and the lung. The side effects on the heart include cardioplegy and myocardial infarction. This study tried to observe changes in the volume and dose of the heart in general radiation therapy plan and respiratory control based radiation therapy plan for patients with left-sided breast cancer, and to find the heart's volume and dose generated by respiration. According to the 4D computer tomography (CT), a volume of the heart had 12.8±8.7 cc on average, and its dose had 17.3±12.1 cGy on average. The differences in the volume and dose may cause side effects in radiation treatment. Therefore, it is necessary to apply respiratory control technique to establish the radiation treatment plan based on an accurate position of the heart.

Keywords: radiation therapy, heart dose, breast cancer

I. INTRODUCTION

The most frequently applied therapies for cancer patients are surgical operation, chemotherapy, and radiation treatment. Although these therapies can be different depending on a type of diagnosed cancers and metastasis, they are known to be mostly applied. A key to radiation treatment among them is to deliver an accurate dose prescribed by a medical doctor to malignant tumors, and at the same time to let neighboring normal tissues absorb the dose less.[1]

If an unnecessary radiation dose is absorbed by neighboring normal tissues, cells and tissues can have an improper reaction which is called a radiation hazard. A dose, though small, can generate side effects probabilistically. Therefore, when radiation treatment is applied to a patient, it is required to check spatial dose distribution.[2]

The reasons why a radiation dose is absorbed by neighboring organs of tumor tissues are setup errors and the patient setup errors made by a patient's respiration or organ move.[3] These days, to overcome the limit of respiration, the radiation treatment introducing temporal environmental changes, or 4D radiation treatment, is conducted for treatment. According to AAPM report, it is suggested that if the move of tumors exceeds 5mm, it is necessary to manage respiratory move.[4]

In ICRU Report 62, planning target volume is divided into ETV(External Target Volume) and

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ITV(Internal Target Volume).[5]

Despite the effort for normal tissues near tumors, the probability of side effects can increase if normal tissues are adjacent to tumor tissues. In particular, in case where a radiation treatment is applied to a patient with left-sided breast cancer, since the tumor tissues are spatially close to the heart, a radiation dose absorbed by the heart can be different depending on respiration and organ move and thereby side effects can occur.

Therefore, this study tried to observe changes in the volume and absorbed dose of the heart depending on respiration and organ move when left-sided breast cancer is treated and thereby to minimize the side effects of the heart in radiation treatment.

II. MATERIAL AND METHODS

1. Subjects

The subjects of this study were 43 patients who were diagnosed with left-sided breast cancer, fully understood the purpose and method of this research, and agreed on participation. As shown in Table 1, the study subjects had their characteristics as follows: in terms of age, 7 patients were in their 30s, 8 in their 40s, and 5 in their 50s; in terms of stage, 9 patients were in stage 1, 9 in stage 2, and 2 in stage 3; in terms of therapy technique, 20 patients had partial mastectomy and all patients had breast tissues left.

Table 1. Patients Characteristics

Sort		Detail
Lesion Location		Lt Breast
Age	30-39	7
	40-49	8
	50-59	5
Stage	Ⅰ	9
	Ⅱ	9
	Ⅲ	2
Treatment Technique	PM	18
	MRM	2

2. Experiment practice

As a tester, Sensation open CT of SIEMENS was used for simulation. As an image acquisition method, 3 mm Slice Thickness was used. The region of treatment were determined by a medical doctor, and the 2 mm region was extended on the basis of GTV and then set as PTV.

As a medical linear accelerator for experiment is Fig 2, Artiste CT Vision(SIEMENS) was used. As a radiation treatment planning system for experiment, Pinnacle Ver 8.0, Philips, was used.

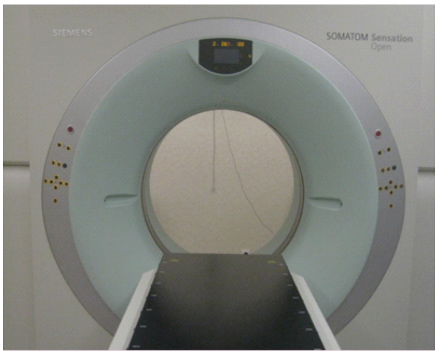

Fig. 1. CT simulation(Siemens Sensation open CT).

Fig. 2. Medical Linac(Siemens Artiste CT vision).

3. Prescribe dose and Normal Tissue

The lung and the heart were set as the neighboring organs with normal tissues, and their limited dose was set to $V_{25}<25\%$ and $V_{15}<10\%$, respectively. A prescription dose was based on the one of an actual breast cancer patient, or 5040 cGy.

4. Analysis Method

A patient's heart volume was divided into Free Breathing and Gating methods in order for analysis. Accordingly, a dose of the heart was analyzed with the mean and the max value. In addition, how much the heart is involved in a radiation volume was measured so as to observe a difference in a heart absorbed dose between Free Breathing and Gating methods.

5. Statistic Method

SPSS version 12.0.1, SPSS Inc., was used for statistical analysis of data. To compare the two methods, Paired t-test was conducted. Analyze the effects of motion and volume on dose. If a p value is less than 0.05, it is considered to be significant statistically.

III. RESULT

1. Analysis of heart volume

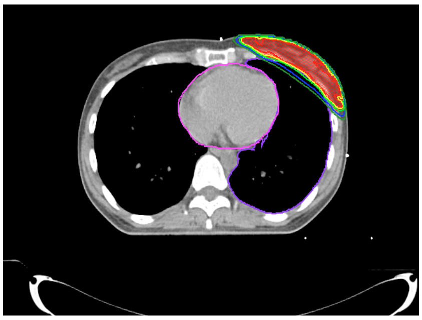

Fig. 3. Breast cancer Contouring.

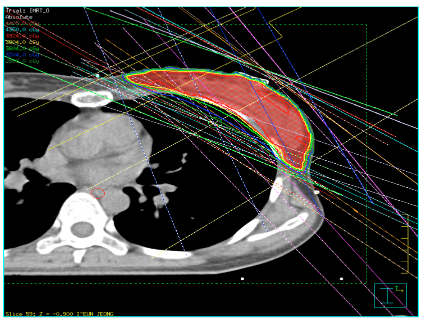

Fig. 4. Laft breast cancer under RT.

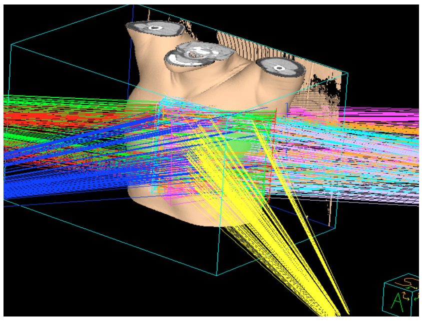

Fig. 5. Breast Cancer REV.

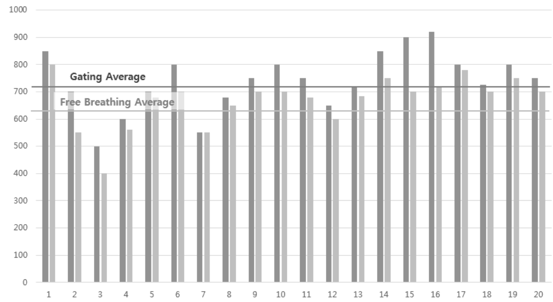

Fig. 6. Diagram of heart volume (unit: cc).

When Gating method was applied to all 20 patients, the average volume of their heart was 739.9cc; when Free Breathing method was applied, the average volume of their heart was 667.8cc in Fig 6.

2. Analysis of heart dose

When Gating method was applied to all 20 patients in Fig.3~5, the maximum dose of their heart was 4,625 cGy and mean dose was 437.9 cGy; when Free Breathing method was applied, maximum dose of heart was 4,835 cGy and mean was 420.7 cGy in Fig 7~8.

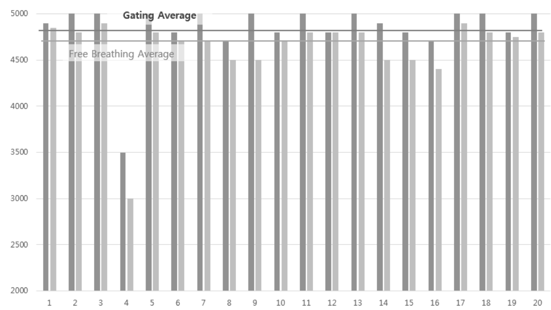

Fig. 7. Maximum dose of heart (unit: cGy).

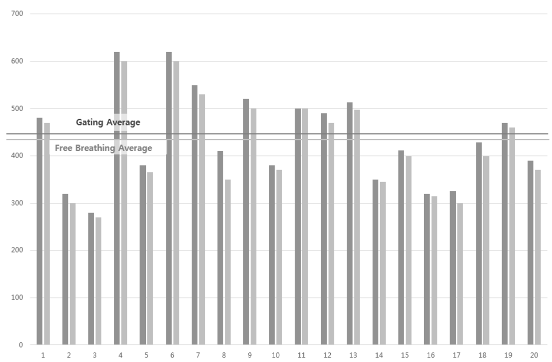

Fig. 8. Mean dose of heart. (unit: cGy)

3. Heart contain under field volume

When Gating method was applied to all patients, the mean dose average of heart in the field size of their heart was 20.25 cGy; when Free Breathing method was applied, the mean dose average of heart in the field size of their heart was 7.5 cGy in Fig 9.

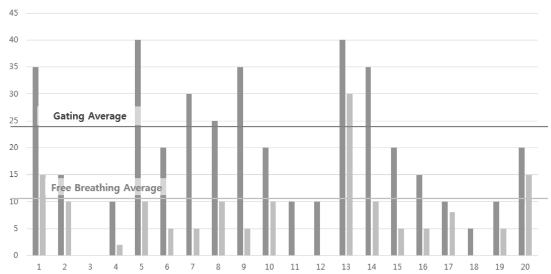

Fig. 9. Mean dose of heart under field size (unit: cc).

4. DVH between free breath and gating

When Gating method's 90% volume dose was 1000 cGy; when Free Breathing method's was 5 cGy. also, 10% absorbed dose was 500 and 250 cGy in Fig 10.

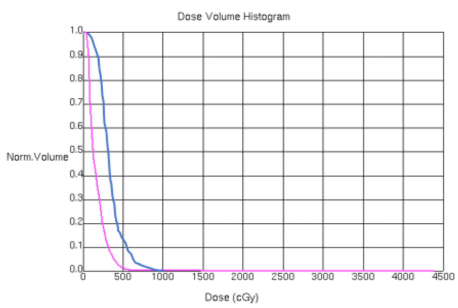

Fig. 10. DVH.

IV. DISCUSSION

Radiation treatment covers a local region and the whole body, including a primary tumor and a metastasis lesion.

It was predicted that the CT simulator was used and that the gating had a small volume and the dose could be concentrated..

CT simulator was used to analyze the heart volumes in general tomography based therapy plan and 4D therapy plan. As a result, a dose increased up to 10Gy more in general tomography based therapy plan than in 4D therapy plan, and a heart volume rose up to 200 cc.

The 4D plan is established on the basis of the image of heart move observed in real time.. For this reason, the heart seems to be more involved in a radiation volume, and consequently an absorbed dose of the heart is judged to rise.

Paszat et al. reports that patients with left-sided breast cancer who had radiation treatment after surgical operation show a higher risk of fatal myocardial infarction for radiation treatment of the right side.[6] It is researched that if dose homogeneity is secured, better aesthetic result is drawn and the risk of heart and lung complications is reduced.[7]

Reportedly, radiation hazards of the heart include pericarditis, cardiomyopathy, valvular heart disease. conduction defect, and ischemic cardiovascular disease.[8,9]

In a previous study, a young woman with left-sided breast cancer who had myocardial infarction after radiation treatment received coronary artery angiography, and the relation with a range of radiation was analyzed; blood clots of proximal left anterior descending artery of coronary arteries and diffuse lesion from proximal and distal were observed.[10]

The previous studies on radiation treatment based on respiration control were analyzed. YJkim et al.[11]

reported that to increase the effect rate of radiation treatment, the regions related to respiration and organ move needed to be fixed. There was research that VMAT technique was more effective at breast cancer patients.[12]

In the wedge filter based conventional breast cancer therapy, an excess dose of the heart and heterogeneity of hot spot and dose occurred, and consequently bad aesthetic result was drawn. Many studies already reported that wedge filter technique showed 15～20% dose heterogeneity in the upper and lower regions of a breast.[13-15]

For a patient with left-sided breast cancer, it is unavoidable to get a part of the patient's heart involved in a radiation area. Although whether radiation-induced myocardial injury triggers coronary artery disease needs to be tracked and observed longer, the early myocardial injury of radiation treatment was diagnosed in nuclear medicine examination.

Early diagnosis of breast cancer was increased with screening inspection. Accordingly, it is estimated that there will be more young breast cancer patients with good prognosis. In this aspect, the method of minimizing a dose of the heart and coronary arteries is a key to preventing a patient's cardiac diseases.

According to histogram pattern comparison of the dose volume of a patient's heart, in gating, more than 90% of heart volume was exposed to 1000～1500 cGy radiation, and in free breathing, if an absorbed dose is 5~10, more than 40% of heart volume was exposed to 2200 cGy and 1300 cGy radiation.

According to the 4D computer tomography (CT), a volume of the heart had 12.8±8.7 cc on average, and its dose had 17.3±12.1 cGy on average. The differences in the volume and dose may cause side effects in radiation treatment.

To minimize heart injury in radiation treatment of the left breast, multi beam therapy can be applied to reduce the heart volume exposed to a scattering dose and low dose radiation area of the heart.

Strength-controlled radiation treatment of the breasts features improved dose homogeneity, reduced exposure doses of the lung and the heart, and a reduced scattering dose of the breast on the other side. As a result, it has been researched that this therapy was able to bring about reduced risk of heart and lung complications and reduced risk of the breast on the other side.[16-18]

In this study, a radiation treatment plan including heart move in gating was established. In radiation treatment, irradiation occurs for a certain time. Therefore, it is considered that four dimensional radiation planning is better to set an exposure range than spot filmed image. Compared with the previous studies of respiratory regulatory radiation therapy, it is reviewed as a confirmation paper on existing studies.

V. CONCLUSION

According to the experiment of this study, the volume and dose of the heart observed in gating radiation treatment technique planning were somewhat high. Therefore, to apply radiation treatment to left-sided breast cancer, it is necessary to pay attention to respiration and heart move.

Reference

[1] ICRU, International Commission on Radiation Units a nd Measurements. Report 62: Prescribing, Recording and Reporting Photon Beam Therapy (Supplement to ICRU Report 50), 1999

[2] Brenner D: Induced cancers after prostate-cancer radi otherapy: No cause for concern? Journals of Radiatio n Oncology Biology Physics Vol. 65, pp. 637-639, 2 006

[3] R. Wagman, E. Yorke, E. Ford, P. Giraud, G. Mager as, B. Minsky, and K. Rosenzweig: Respiratory gatin g for liver tumors: use in dose escalation, Journals o f Radiation Oncology Biology Physics, Vol. 55, No. 3, pp. 659-668, 2003.

[4] P. J. Keall, G. S. Mageras, J. M. Balter, R. S. Emery, K. M. Forster, and S. B. Jiang: The management of respiratory motion in radiation oncology report of AAPM Task Group 76, Medical Physics, Vol. 33, No. 10, pp. 3874-3901, 2006.

[5] Jin JY, Ajlouni M, Chen Q: Quantification of incidental dose to potential clinical target volume (CTV) under different stereostactic body radiation therapy (SBRT) techniques for non-small cell lung cancer-tumor motion and using internal target volume (ITV) could improve dose distribution in CTV. Journals of Radiation Oncolog, Vol. 85, pp. 267-276, 2007

[6] L. F. Paszat, W. J. Mackillop, P. A.Groome: Mortality from myocardial infarction after adjuvant radiotherapy for breast cancer in the surveillance, epidemiology, and end-results cancer registries, Journals of Clinical Oncology, Vol. 16, No. 8, pp. 2625-2631, 1998.

[7] F. Lohr, F. Heggemann, T. and Papavassiliu: Is cardiotoxicity still an issue after breast -conserving surgery and could it be reduced by multifield IMRT?, Strahlentherapie und Onkologie, Vol. 185, No. 4, pp. 222-230, 2009.

[8] Fulvio Orzan, Antonoio Brusca, Maria R Conte, Patrizia Presbirero, Maria C Figliomeni: Severe coronary artery disease after radiation therapy of the chest and mediastinum, Clinical presentation and treatment. Br Heart J, Vol. 69, pp. 496-500, 1993.

[9] Ho choon Park, Young jae Kim, Seong joo Jang: The Usability Evaluation Half Beam Radiation Treatment Technique on the Esophageal Cancer, The Korean Society of Radiology, Vol. 9, No. 5, 2015.

[10] Joong Sun Bin, Jae Myung Lee, Byung Dong Cho, Won Seok Choo, Sang Gyu Choi, Jung Bae Park, Young Cheoul Doo, Kyung Pyo Hong, Jong Yoon Im, Do Hoon Oh, Hoon Sik Bae: Acute Myocardial Infarction after Radiation Therapy for Left Sided Breast Cancer, The Korean Society of Circulation, Vol. 25, No. 1, pp. 114-118, 1995.

[11] Y. J. Kim, Y. I. Jang, Y. S. Ji: Evaluation on Usefulness of Applying Body-fix to Four Dimensional Radiation Therapy, The Journal of the Korea Contents Association, Vol. 13, No. 10, pp. 419-426, 2013.

[12] Hye-Jin Ko, Young-Jae Kim, Seong-Joo Jang: The Comparison of Dose Distribution on Radiation Therapy between IMRT and VMAT in Modified Radical Mastectomy Patients, The Journal of the Korea Contents Associationn, Vol. 14, No. 8, pp. 226-232, 2014.

[13] Solin LJ, Chu JC, Sontag MR: Three-dimensional photon treatment planning of the intact breast. Journals of Radiation Oncology Biology Physics, Vol. 21, pp. 193-203, 1991.

[14] Chin LM, Cheng CW, Siddon RL: Three-dimensional photon dose distributions with and without lung corrections for tangential breast intact treatments. Journals of Radiation Oncology Biology Physics, Vol.17, pp. 1327-1335, 1989.

[15] Fraass BA, Lichter AS, McShan DL: The influence of lung density corrections on treatment planning for primary breast cancer. Journals of Radiation Oncology Biology Physics Vol. 14, pp. 179-190, 1988.

[16] Evans PM, Hansen VN, Mayles WP: Design of compensators for breast radiotherapy using electronic portal imaging. Journals of Radiation Oncology Biology Physics, Vol. 37, pp. 43-54, 1995.

[17] Hong L, Hunt M, Chui C: Intensity-modulated tangential beam irradiation of the intact breast, Journals of Radiation Oncolgy Biology Physics, Vol. 44, pp. 1155-1164, 1999.

[18] Bortfeld TR, Kahler DL, Waldron TJ, Boyer AL: X-ray field compensation with multileaf collimators. Journals of Radiation Oncology Biology Physics Vol. 28, pp. 723-730, 1994.

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일반 및 호흡조절 방사선치료계획에서 심장의 흡수선량 변화

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요 약

방사선 치료시 산란성 등의 피부영향을 피할 수 없으며 내부의 정상장기의 피폭은 피할 수 없다. 방사선 치료의 역사는 정상조직의 흡수선량 감소를 위한 역사라고 해도 과언이 아니다. 특히, 왼쪽 유방암의 방사선 치료시 내부 인접 장기로는 정상유방조직, 심장과 폐를 대표로 들 수 있는데 심장에 발생할 수 있는 부작용은 심정지, 심근경색 등이 있다. 본 논문에서는 왼쪽 유방암 환자의 방사선 치료시 호흡조절기법을 사용한 것과 일반 방사선치료계획을 시행하는 것 사이에 심장의 체적과 선량의 변화를 관찰하여 호흡으로 인해 발생하는 심장의 체적과 선량을 알아보았다. 연구결과 4차원 컴퓨터 단층촬영영상을 기준으로 심장의 체적은 평균 12.8±8.7 cc의 차이가 나타났으며 이에 대해 선량은 평균 17.3±12.1 cGy의 차이를 보였다. 이러한 체적과 선량의 차이는 향후 방사선 치료시 부작용을 발생시킬 수 있는 우려가 있으므로 호흡조절기법을 활용하여 심장의 정확한 위치를 기반으로 방사선 치료계획을 수립하여야 할 것이다.

중심단어: 방사선치료, 심장선량, 유방암