

The Comparison Study of Quadratic Infinite Beam Program on Optimization Intensity Modulated Radiation Therapy Treatment Planning (IMRTP) between Threshold and Exponential Scatter Method with CERR® In The Case of Lung Cancer

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Abstract. This research compares the quadratic optimization program on Intensity Modulated Radiation Therapy Treatment Planning (IMRTP) with the Computational Environment for Radiotherapy Research (CERR) software. We assumed that the number of beams used for the treatment planner was about 9 and 13 beams. The case used the energy of 6 MV with Source Skin Distance (SSD) of 100 cm from target volume. Dose calculation used Quadratic Infinite beam (QIB) from CERR. CERR was used in the comparison study between Gauss Primary threshold method and Gauss Primary exponential method. In the case of lung cancer, the threshold variation of 0.01, and 0.004 was used. The output of the dose was distributed using an analysis in the form of DVH from CERR. The maximum dose distributions obtained were on the target volume (PTV) Planning Target Volume, (CTV) Clinical Target Volume, (GTV) Gross Tumor Volume, liver, and skin. It was obtained that if the dose calculation method used exponential and the number of beam 9. When the dose calculation method used the threshold and the number of beam 13, the maximum dose distributions obtained were on the target volume PTV, GTV, heart, and skin.

1. Introduction

Radiotherapy, one of the cancer treatment methods has experienced a rapid development in recent years. To minimize the side effects during a treatment, the treatment planning process are needed to make the treatment effective. Treatment planning process which is known as Radiation Treatment Planning System (RTPS) consists of various steps, and it has developed into a more complex way to create a more efficient treatment plan. One matter that is needed to be developed in RTPS has the addition of optimization techniques in order to find the appropriate treatment plan. Defining volume is conducted to determine the appropriate dose calculation and distribution. The distribution of the dose is given as much as possible to the target planning area volume and the minimum dose is given to organs which are at risk (OAR). In IMRT, inverse planning method has been used to generate a treatment plan. This method is used to determine the fluence distribution model based on the intensity of the beam (Sun, 2010). The aim of this study is to conduct a comparison study of QIB program on



optimization IMRTP between threshold and exponential scatter method using CERR in the case of lung cancer.

2. Methods

In this study, IMRT plan optimization began by collecting the patients information which consisted of PTV, organ at risk (OARs), and normal tissues, which were delineated from CT images in the case of lung cancer. In this case the CT image data input was obtained from the unit testing on CERR Master with 106 slices. We assumed that the number of beams to be used for the treatment given by the treatment planner was about 9 and 13 beams. In the case the energy of 6 MV with SSD of 100 cm from target volume was used. For dose calculation algorithm QIB with IMRTP from CERR was used. The comparison study used CERR between Gauss Primary threshold method and Gauss Primary exponential method. In the case of lung cancer, the threshold used variation between 0.01, and 0.004. The IM parameter is those in IMRTP. Table 1 shows variations of IM parameters to compute dose calculation with algorithm QIB Gauss Primary. Sigma_100 is Gaussian blur of pencil beam (PB) at 100 cm (in cm). Variation sigma_100 used were 0.0 cm and 0.4 cm. Number CT Sample points indicate the number of ray-trace points for radiological path length calculation. In this study the cut off distance used never compute dose further than the distance from the PB ray. The output of the dose was distributed with a plot of cumulative analysis in the form of dose-volume histogram (DVH) from CERR in the treatment volume of PTV, CTV, GTV, heart, liver, and skin.

Table 1. Variation of IM Parameters to compute dose calculation with algorithm QIB Gauss Primary

Beam	sigma_100 (cm)	scatter method	Threshold	Random step	Number CT Sample Points	Cut off Distance
9	0,0	Threshold	0.01	30	300	4
13	0,4	Threshold	0.01	30	300	4
9	0,0	Exponential	0.004	90	900	12
13	0,4	Exponential	0.004	90	900	12

2.1 Input Data and Dose Calculation

To set up the model, each anatomical structure was discretized into voxels. We noted that the size of the problem and the quality of the resulting plan would be affected by the choice of voxel sizes and the sampling scheme. For the method of Fluence map Optimization (FMO), the beam angle candidates were also predetermined. In our analysis, we employed CERR software to generate the patient information and employed dose data for the treatment plan. CERR® was implemented on Matlab® environment which provide various functional components including the routines of importing and visualizing the AAPM/RTOG treatment planning format, the contouring tools to edit and create anatomical structures, the routines of generating the influence matrix with a beam setup, the plan analysis tools to generate and visualize dose-volume histograms, and dose color-washes from the solution of treatment planning. In particular, the influence matrix of each patient was calculated using the QIB Gauss Primary algorithm for lung cancer case. The Total Radiation Dose at a voxel P is shown as below:

$$D_{pW} = \sum_{i \in B} \sum_{j \in N_i} D_{p(i,j)} w_{(i,j)} \quad (1)$$

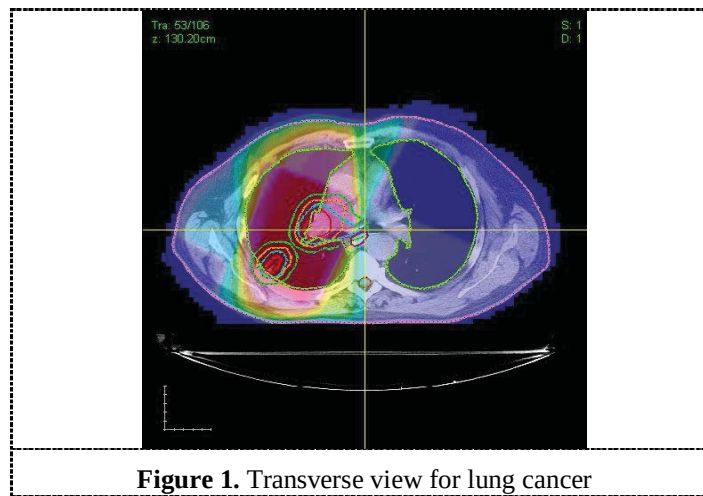


Figure 1. Transverse view for lung cancer

3. Result and Discussions

In our computational experiments, the patient of the case of lung cancer was selected, and the treatment input data were generated from CERR®. Using CERR®, we evaluated the solution plan via DVH. As shown in Table 2, 3, and 4 which were the DVH analysis for lung cancer was used to determine the dose distribution between threshold scatter method and exponential scatter method. The output of the dose was distributed with a plot of cumulative analysis in the form of DVH from CERR. In this case, the dose distribution is for treatment volume of PTV, CTV, GTV, heart, liver, and skin. The DVH analysis is shown as below

Table 2. DVH analysis for lung cancer using algorithm QIB gauss primary with threshold scatter Method

Organ	Beam	DVH status			
		Threshold Scatter method			
		mean Dose	total volume	max dose (Gy)	min dose (Gy)
PTV	9	60.116	618.1427	80.1	0.1
	13	64.5823	618.1427	86.7	0.1
CTV	9	64.4287	283.7231	80.1	0.3
	13	69.14	283.7231	86.5	0.3
GTV	9	76.4888	90.5407	79.9	73.3
	13	82.0325	90.5407	86.3	76.7
Heart	9	5.1874	600.248	74.7	0.1
	13	5.5085	600.248	81.5	0.1
Liver	9	0.1	1785.3235	0.1	0.1
	13	0.1	1785.3235	0.1	0.1
Skin	9	5.2822	31461.7457	80.1	0.1
	13	5.6785	31461.7457	86.7	0.1

Table 3. DVH analysis for lung cancer using algorithm QIB gauss primary with exponential scatter Method

Organ	beam	DVH status			
		Exponential Scatter method			
		mean Dose	total volume	max dose (Gy)	min dose (Gy)
PTV	9	64.5823	618.1427	86.7	0.1
	13	64.5823	618.1427	86.7	0.1
CTV	9	69.14	283.7231	86.5	0.3
	13	69.14	283.7231	86.5	0.3
GTV	9	82.0325	90.5407	86.3	76.7
	13	82.0325	90.5407	86.3	76.7
Heart	9	5.5085	600.248	81.5	0.1
	13	5.5085	600.248	81.5	0.1
Liver	9	0.1	1785.3235	0.1	0.1
	13	0.1	1785.3235	0.1	0.1
Skin	9	5.6785	31461.7457	86.7	0.1
	13	5.6785	31461.7457	86.7	0.1

Table 4. DVH analysis used to perform comparison of dose distribution between threshold method and exponential method

Organ	Beam	DVH analysis			
		Threshold Method		Exponential Method	
		max dose	% volume	max dose	% volume
PTV	9	79.9645	0.00029674	86.3426	0.2752
	13	86.4261	0.16649	86.5111	0.066425
CTV	9	79.9645	0.0063298	86.3426	0.036029
	13	86.4261	0.016916	86.4211	0.01806
GTV	9	79.6099	0.059624	85.8796	0.79767
	13	85.0515	6.0206	85.8796	0.79776
heart	9	74.6454	0.0036175	81.25	0.001104
	13	81.2715	0.0010092	81.325	0.00077283
liver	9	0.1	0	0.1	1.11E-14
	13	0.17182	0	0.1	0
Skin	9	79.9645	0.00029674	86.3426	0.0065568
	13	86.4261	0.0039002	86.5056	0.0015069

Table 4 is DVH analysis of CERR in the treatment volume of PTV, CTV, GTV, heart, liver, and skin. Through the DVH analysis the comparison of dose distribution between threshold scatter method and exponential scatter method could be observed. The number of beam used has increased and the maximum dose of the target volume has become greater. The maximum dose distributions was obtained for the target volume of PTV, CTV, GTV, liver, and skin. It was obtained when the dose calculation method used exponential and the number of beam 9. When the dose calculation method used threshold and the number of beam 13, the maximum dose distributions obtained were on the target volume PTV, GTV, heart, and skin.

4. Conclusions

Optimization is one of the most researched aspects in radiotherapy. In this study, a comparison of QIB program on optimization IMRTP between threshold and exponential scatter method using CERR was used in the case of lung cancer. The experiment, the case of lung cancer, showed the quadratic infinite beam gauss primary algorithm approaches worked successfully as the result of dose distribution with DVH analysis. The results have shown agreement with another study [4]. In the future, comparisons between the variation beam and implementation using a Monte Carlo dose calculation will be investigated.

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5. References

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