

Dosimetric Comparison of 3D-Conformal and IMRT Radiotherapy Techniques in Gastric Cancer

Tahir Çakır^{1*}, Gökhan Yılmaz², Taylan Tuğrul³

¹Van Yüzüncü Yıl University, Medical Faculty, Department of Medical Physics, Van, Turkey

²Medical Park Gebze Hospital, Department of Radiation Oncology, İstanbul, Turkey

³Van Yüzüncü Yıl University, Medical Faculty, Department of Radiation Oncology, Van, Turkey

ABSTRACT

Stomach cancer is a malignancy which has poor prognosis and takes place on the top among deaths related with cancer in the world. Anatomically, stomach has relations with critical organs as heart, liver, kidneys, intestine and spinal cord. Doses which are taken by surrounding critical organs in planning adjuvant radiotherapy of stomach cancer have importance in terms of the control and toxicity. In this study, it was aimed to examine the best dose to target volume and the most appropriate treatment planning technique for maximum protection of organs at risk. The Intensity Modulated Radiation Therapy (IMRT) technique and the 3D-Conformal radiotherapy technique at patients who were operated for stomach cancer were compared in terms of dosimetry. This study was done on the Computed Tomography (CT) simulation images of 21 patients who applied to Van Yüzüncü Yıl University, Radiation Oncology Department. CT simulation of patients was taken with 3 mm thickness at 60th second using intravenous contrast agent. Then CT images were transferred to Prowess Panther treatment planning system. In IMRT planning, 5 fields planning were done with 6 MV photon energy. 3D-conformal planning was performed in 4 fields using 6 and 15 MV photon energy. It is seen that IMRT technique is statistically more advantageous against conformal radiotherapy technique in terms of right-left kidney V20, bilateral kidney V20 and mean dose of liver at the radiotherapy technique applied to the patients who had operation for stomach cancer.

Key Words: IMRT; Stomach Radiotherapy; Gastric Radiotherapy; 3D-Conformal

Introduction

Stomach cancer is a malignancy which has poor prognosis and takes place on the top among deaths related with cancer in the world (1). Stomach cancer is an important reason of the deaths related to cancer with nearly 1 million new cases every year around the world and it is the second reason of mortality related to cancer with 700.000 deaths (2). In the study of Intergroup 0116 (SWOG 9008), chemo-radiotherapy has been shown to have a positive effect on disease-free survival and overall survival. (3,4). Anatomically, stomach has relations with critical organs as heart, liver, kidneys, intestine and spinal cord. In planning adjuvant radiotherapy of stomach cancer, doses placed by treatment planning system on critical organs and target volumes have importance in terms of the control and toxicity. (5).

In this study, it was aimed to examine the best dose to target volume and the most appropriate treatment planning technique for maximum protection of organs at risk (kidneys, heart, liver and spinal cord). The Intensity Modulated Radiation Therapy (IMRT) technique and the 3D-Conformal radiotherapy technique at patients who were operated with stomach cancer in terms of dosimetry have compared.

In the all treatment planning studies, 45 Gy radiotherapy dose were totally applied as 1.8 Gy per fraction in 25 fraction using Siemens Artiste linear accelerator device. At IMRT planning, 5 fields planning were applied with 6 MV photon energy. 3D-conformal plannings were performed in 4 fields using 6 and 15 MV photon energy.

Material and Method

This study was done on the Computed Tomography (CT) simulation images of 21 patients who applied to Van Yüzüncü Yıl University, Radiation Oncology Department between 2013 and 2014 with diagnosis of stomach cancer. 9 patients were female and 12 patients were male. The median age was 60 (between 45 and 72) and the phase was consisted of IIB-IIIC adenocarcinoma cases. Total gastrectomy was applied to 14 patients and subtotal gastrectomy was applied to 7 patients. Operational limits were negative. The wingboard was used for immobilization. CT simulation of patients was taken with 3 mm thickness at 60th second using intravenous contrast agent. Then CT images were transferred to Prowess Panther treatment

*Corresponding Author: Tahir Çakır, Van Yüzüncü Yıl University, Medical Faculty, Department of Medical Physics, Zeve kampüsü, Van-Turkey

E-mail: tcakir2003@yahoo.com, Phone:+90 (432) 215 04 70 internal:25061, Cell Phone:+90 (542) 505 82 09

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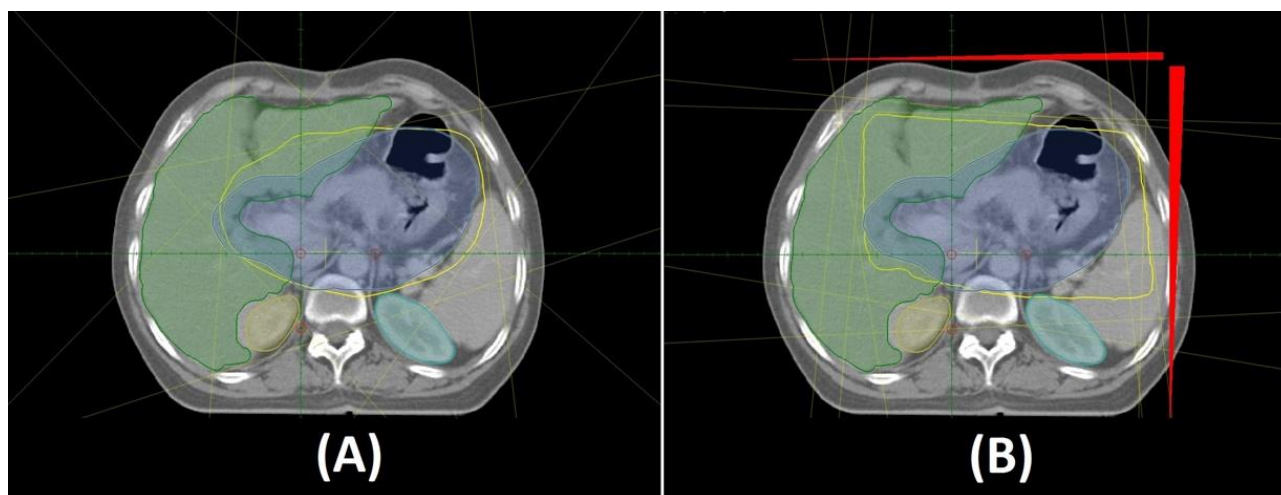


Fig. 1. Dose distribution on CT image. A: IMRT plan. B: 3D-Conformal plan

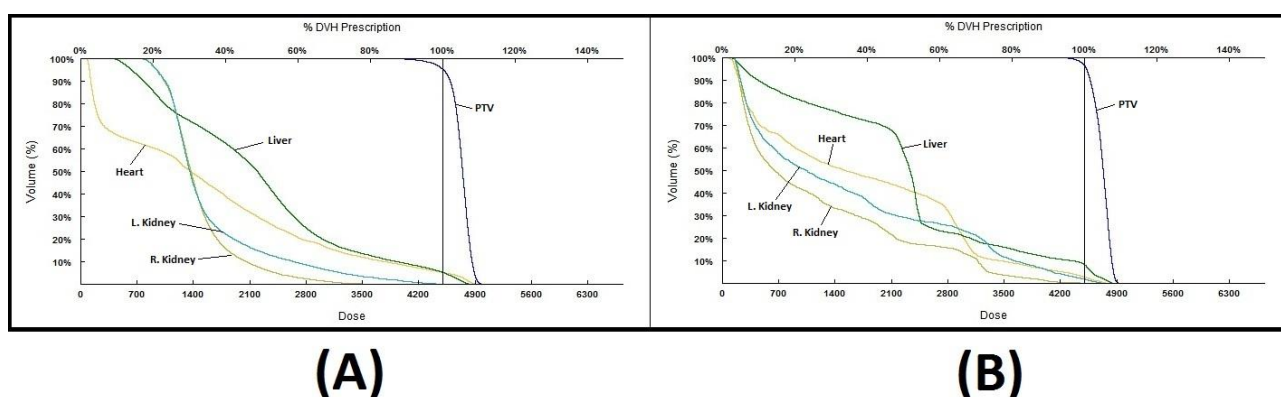


Fig. 2. Dose Volume Histogram. A: IMRT. B: 3D-Conformal Plan

planning system. All contouring were drawn by same radiation oncologist. Medulla spinalis, heart, liver and right – left kidney were contoured as critical organs. Patients were identified as 5 cardiac tumors, 9 corpus tumors and 7 antrum tumors. CTV 45 was given a 1 cm margin to produce PTV 45 volume. CTV 45 was defined at different involvement region and phase of stomach taking account of Tepper and Gunderson Study (5).

In the all treatment planning studies, 45 Gy radiotherapy dose were totally applied as 1.8 Gy per fraction in 25 fraction using Siemens Artiste linear accelerator device. At IMRT planning, 5 fields planning were applied with 6 MV photon energy using degree 285, 320, 0, 40, 75 gantry angles. 3D-conformal plannings were performed in 4 fields. They were showed at Figure 1.

The every treatment plan was examined in dose volume histogram in terms of dose of target volume, critical organs and maximum dose. Volume and dose limitations for organs at risk were determined in perspective of specialist’s view of Quantec and EORTC-ROG (6,7). According to these studies, maximum spinal cord dose shouldn’t exceed 45-50 Gy, mean dose for heart must be under 26 Gy, under

30 Gy for liver and $V_{30} < 30\%$. For bilateral kidney mean dose must be under 18 Gy and $V_{20} < 32\%$. PTV45 which is target volume must be taken minimum 95% of given dose.

Statistical calculation on dose volume histogram (DVH) had been expressed as average, standard deviation, minimum and maximum rates. Student t test was used for comparison of group averages in view of these specifications. Statistical significance level was counted as 5% in calculations and SPSS statistical packet program was used for it.

Results

In the assessment between DVH results achieved by 3D conformal planning and IMRT; homogenous isodose distribution was acquired by IMRT technique on PTV45. However there was no difference in terms of doses taken by PTV45.

It is seen that IMRT planning is more advantageous than 3D conformal planning according to organ at risk dose. DVH data were obtained by both 3D conformal planning and IMRT planning technique have been shown at Figure 2.

Table 1. Comparison of organ at risk dose between 3D-conformal therapy and IMRT

Organ at risk	Group: 3D Conformal Plan n=21				Group: IMRT Plan n=21				p
	Mean	St.Dev.	Min.	Max.	Mean	St.De v.	Min.	Max.	
L.Kidney V20 %	27.8	6.5	15.6	36.6	20.5	5.7	10.0	33.0	0.001
L.Kidney Mean Dose cGy	1524.1	273.8	941	1972	1540	182.8	1232	1833	0.818
R.Kidney V20 %	26.2	7.2	12.7	35.9	10.6	6.9	0.2	26.6	0.001
R.Kidney Mean Dose cGy	1280	255.2	784	1796	1247.2	274.9	700	1644	0.690
Bl.Kidney V20 %	27.0	4.5	18	34.4	15.6	3.7	10.7	22.9	0.001
Bl.Kidney Mean Dose cGy	1401,8	173,4	1090	1675	1393,7	154,1	1053	1619	0,874
Liver V30 %	29.2	5.8	18.8	41.2	28.2	6.7	14.9	40	0.583
Liver Mean Dose cGy	2632.8	247.6	2219	3030	2320	241	1852	2760	0.001
Heart Mean Dose cGy	1065.9	508	332	2131	861	440.5	256	1852	0.172
S.Cord Max Dose cGy	2444.5	1270.5	710	4295	2235.8	980.1	713	3659	0.555

When we analyzed DVH data for left and right kidneys in terms of V20, the data were among the criteria. Mean liver dose was found to be statistically significant on IMRT ($p < 0.05$). V20 was found as mean 27.8% at 3D conformal radiotherapy planning while it was mean 20.5% at IMRT planning for left kidney ($p = 0.001$). V20 was found as mean 26.2% at 3D conformal radiotherapy planning while it was mean 10.6% at IMRT planning for right kidney ($p = 0.001$). Mean dose of left kidney was found as 1524 cGy at 3D conformal radiotherapy planning while it was 1540 cGy at IMRT planning ($p = 0.818$). Mean dose of right kidney was found as 1280 cGy at 3D conformal radiotherapy planning while it was 1247 cGy at IMRT planning ($p = 0.690$).

V20 was found as mean 27% at 3D conformal radiotherapy planning while it was mean 15.6% at IMRT planning for bilateral kidney ($p = 0.001$). Mean dose of bilateral kidney was found as 1401.8 cGy at 3D conformal radiotherapy planning while it was 1393.7 cGy at IMRT planning ($p = 0.874$). V30 was found as mean 29.2% at 3D conformal radiotherapy planning while it was mean 28.2% at IMRT planning for liver ($p = 0.583$). Mean dose of liver was found as 2632 cGy at 3D conformal radiotherapy planning while it was 2320 cGy at IMRT planning ($p = 0.001$). Mean dose of heart was found as 1065 cGy at 3D conformal radiotherapy planning while it was 861 cGy at IMRT planning ($p = 0.172$). Mean dose of spinal cord was found as 2444 cGy at 3D conformal radiotherapy planning while it was 2235 cGy at IMRT planning ($p = 0.555$). They were showed on Table 1.

Discussion

Because adjuvant chemo radiotherapy that was considered on the study of Intergroup 0116 increases disease-free survival and general survival, it is accepted as a standard treatment for the patients who has high risk operated stomach cancer (3,4). Due to target volumes determined at the adjuvant stomach cancer radiotherapy, extensive treatment field is occurred with stomach bed and regional lymph node. In addition, it is generated as a necessity of attention due to toxicity (8).

At the study of Intergroup INT-0116, toxicity was developed in patients who taken chemo radiotherapy at the rate of 41% in G3 patients, 32% in G4 patients and 1% in G5 patients and 17% of patients couldn't complete treatment due to the toxicity (3,4).

Because of the significant toxicity related to wide radiation fields at the 3D conformal radiotherapy applied with Chemotherapy, it is necessary to develop a standard radiotherapy technique (8). At the adjuvant stomach cancer radiotherapy, it is not possible to increase dose because tolerance doses of some critical organs can be even exceed with standard target dose of 45 Gy (8).

In many studies, it is seen that IMRT has a potential for decreasing normal critical organ dose. However, clinical results are limited (9,11).

In the study of Wieland and et al., median kidney dose is decreased in proportion to 50% with IMRT technique (10). In contrast to 3D conformal radiotherapy technique, IMRT technique gives statistically more advantageous results at doses of

right-left kidney, bilateral kidney and liver in terms of dosimetry in our studies too.

Also, in the study of Milano and et al., it is reported that both volume of liver V30 and right-left kidney V20 has been decreased by IMRT technique. Although radiotherapy 50.4 Gy was applied by IMRT technique in this study, no toxicity at grade 3 occurred in any patients (11).

At the study of Alani and et al., it was concluded that medulla spinals and kidney doses decreased only minimal rate at the adjuvant stomach cancer in perspective of consideration of IMRT and 3D conformal radiotherapy techniques and this consideration was only appropriate for patients who has one kidney or nephropathy. Also, it is concluded in this study that there is no difference in consideration of doses at the rate of 95% between IMRT and 3D conformal radiotherapy in terms of volumes (12). Although there was no difference in terms of doses taken by PTV, more homogenous isodose curves were acquired at IMRT technique in our study. At the study of Hans and et al. about comparison of 3D conformal planning and IMRT planning on patients who taken adjuvant chemo radiotherapy, significant differences in terms of liver dose in IMRT planning was observed. Hans and et al. show that doses taken by critical organs make difference according to different segment number and used planning system.

It is seen that IMRT technique is statistically more advantageous against 3D conformal radiotherapy technique in terms of right-left kidney V20, bilateral kidney V20 and mean dose of liver at the radiotherapy technique to be applied the patients who were operated for stomach cancer. Because IMRT technique decreases dose on critical organs like heart, liver, bilateral kidney and medulla spinals, it will be appropriate for using radiotherapy of stomach cancer, especially at chosen case. Finally, IMRT technique is an effective and reliable treatment method for radiotherapy of patients who has adjuvant stomach cancer.

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