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Impact of advanced techniques of radiotherapy on organ at risk dose distribution in treatment of gastric cancer patient

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ABSTRACT : **The aim of this work was to compare different radiotherapy planning techniques for gastric cancer and impact of advance techniques on dose to OAR (Organ at Risk). A total of 20 gastric cancer patients were involved in current study and each patient was scheduled IMRT and VMAT techniques. Dose-volume histogram statistics, conformal index (CI), hand monitor units (MUs) were analyzed to compare treatment plans, treatment planning system eclipse Algorithm AXB with energy true beam linear accelerator Varian model. The VMAT plans exceeded the IMRT technique for coverage planning tumor volume dose and reduction dose for organs at risk in the kidneys, but not in the liver. VMAT exhibited a better mean CI (0.89±0.03), than the other techniques. In addition, for the kidneys the dose sparing (V13, V18 and mean kidney dose) was improved by VMAT plans. However, IMRT showed a marginal advantage in V30 and mean dose in normal liver when compared with VMAT. This study suggests that VMAT provides improved tumor coverage when compared with IMRT, while VMAT haven't no advantage in liver protection when compared with IMRT.**

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I. INTRODUCTION

Gastric disease is the fourth most regular kind of harmful tumor around the world (1) and the yearly number of novel cases is ~95 million. Every year ~70 million people surrender to gastric disease, which makes it the second most normal reason for malignant growth related mortality around the world (2). Since the SWOG/INT-0116 preliminary (3) in 2001, adjuvant chemoradiotherapy has become a set up standard therapy for gastric disease. As opposed to the INT-0116 preliminary, which included D0-or D1-resected gastric malignancy patients, Kim et al (4) contemplated D2-resected members utilizing the equivalent chemoradiotherapy regimens, and furthermore exhibited that simultaneous chemotherapy expanded endurance and diminished repeat.

Due to improved dose of organs at risk (OAR), intensity modulated radiotherapy (IMRT) and volumetric modulation radiotherapy (VMAT) have become the only real or equivalent customary in tumors of the girdle that are treated, definitive or palliative radiation (5-13) . This method is additional conformal than typical radiation techniques. Many studies have compared IMRT gastric cancer technique with VMAT. VMAT is typically related to less dose to the OAR(14-18). This also translated into higher clinical outcome measured by grade a pair of however also ≥3 acute duct toxicity, internal organ toxicity (19, 20). Despite these benefits of VMAT in compared to IMRT to marginal misses within the initial experiences of VMAT in Gastric cancer, up to now, IMRT continues to be the suggested technical customary of treatment, even if VMAT is appropriate for special cases that don't meet dose constraints with 3D-RT.

Volumetric adjusted bend treatment (VMAT), as an altered rendition of IMRT, utilizes the direct quickening agents Elekta Synergy VMAT and Elekta Precise (Elekta Oncology Systems, Crawley, UK) to lead dynamic regulation turn radiotherapy. The upsides of VMAT when contrasted and IMRT, remember a decrease for the quantity of monitor units (MUs), more limited conveyance times and lower presentation of OARs. Practically speaking, the VMAT advancement relies upon the quantity of circular segments and the gantry point separating between ensuing control focuses. As of now, contention exists concerning whether a solitary curve VMAT can accomplish portion circulations tantamount to IMRT plans. Bertelsen et al (9) exhibited that solitary bend is adequate to accomplish an arrangement quality like IMRT, in any case, Guckenberger et al (10) have announced that it is subject to the multifaceted nature of the objective volume.

VMAT is viewed as same as or better than IMRT for specific malignancies, including head and neck, prostate, lung, cervical and pancreatic disease (11), nonetheless, an absence of thorough examination between IMRT to VMAT exists concerning gastric malignant growth treatment. Thusly, the current investigation meant to explain the dosimetric nature of two ARC VMAT for gastric malignancy, contrasted and 7-field IMRT (7F-IMRT).

II. Materials and Methods

Immobilization, simulation and target delineation

All patients were immobilized in a recumbent situation, with arms crossed over the head utilizing a thermoplastic shell. Intravenous differentiation upgraded figured tomography (CT)- reenactment was performed at 3 mm timespans utilizing Gemini GXL positron outflow tomography/CT (Philips Medical Systems).

Table 1: OARs dose constraints. Vn, percentage of volume receiving at least x Gy; OARs, organs at risk

OARs	Prescribed dose limit
Spinal Cord	Dmax<40 Gy
Liver	V30<30%
Kidney	V13<50%
	V18<33%
Small intestine	Dmax<50 Gy
	V50<10%
	V45<15%
Duodenum	Dmax<50 Gy
	V50<10%
	V45<15%

Respiratory control and stomach pressure were not utilized. Following reenactment, the CT pictures were moved to the Pinnacle3 form 9.2 radiation therapy arranging framework (Philips Medical Systems). The clinical target volume (CTV) included tumor bed and per gastric lymph hubs, following the proposals delineated in the INT-0116 preliminary (3). The CTV to planning target volume (PTV) expansion was typically 5–10 mm to account for daily setup error and organ motion. Normal structures, including the spinal cord, liver, colon, duodenum, small intestine and kidneys were also contoured. All the contours were drawn by the same physician. Each patient had one 7F-IMRT and Two ARC–VMAT plan created by the same radiation therapist. A similar portion limitations were utilized for formation of 7F-IMRT and VMAT, which is summarized in Table 1.

Treatment planning and optimization;
IMRT plan arrangement

The IMRT optimization was performed using the direct machine parameter optimization algorithm in the treatment planning system (Eclipse treatment planning Systems version 15.6). IMRT uses seven coplanar beams; seven beam irradiations, angles of 0, 51, 102, 153, 204, 255 and 306°. In the plan generation, the maximum iterations in the plan optimization were 80. There were no limitations with regard to the MUs per segment. Plans were generated for the Varian true beam with 6-MV.

VMAT plan arrangement

The plans were optimized in the same planning system as mentioned previously. The double arc VMAT was planned with a beam delivery time of ≤120 sec x2, and with a gantry rotation of 181-180-181° (a control point every 4°). Plans were generated with 6-MV and all the objective parameters and algorithm used were the same as that for the single arc VMAT. All the plans were repeatedly optimized until the objectives were met.

III.RESLUTS And DISCUSSIONS

For the PTV, D98, D95, D50 and D2%, where D is the tolerant portion and n is the level of the PTV, were chosen to agree to the International Commission on Radiation Units and Measurements Report No. 83 (13). The conformal record (CI) for PTV were determined. The CI was characterized as follows: CI = cover factor (the level of the PTV volume getting 50.4 Gy) × spill factor (the volume of the PTV accepting the 50.4 Gy comparative with the absolute remedy portion volume).The following dosimetric boundaries were reflectively dissected: Volumes of kidney accepting a portion of ≥13 and 18 Gy (V13 and V18); volumes of liver getting a portion of ≥30 Gy; D2 of the spinal line; volumes of small digestive system and colon getting a portion of ≥50 Gy (V50); the mean portion to OARs and remaining volume in danger; the most extreme portion to 1, 5 and 10 cm3 of the pancreas and duodenum; and the volume of pancreas and duodenum accepting 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 Gy.

3.1. PTV coverage

The assessment of the DVH-based boundaries of the PTV is appeared in Table 2. The D98 and D95 of the PTV were comparative among the 7F-IMRT and VMAT plans, separately, and no critical contrasts were recognized between two methods (P>0.05). For the PTV inclusion, the mean CI of the VMAT plans (0.89±0.03) was essentially higher than that of 3DCRT (0.87±0.02), IMRT (0.94±0.02) individually (P<0.05). Moreover, VMAT designs additionally displayed a lower D2 (54.43±1.10 Gy) when IMRT (54.62±0.43Gy) (P<0.05). An ordinary portion dispersion in the cross over segment is appeared in table 2.

Table 2: Comparisons of the dose-volume histogram-based parameters of the planning tumor volume.

	Radiotherapy Radiotherapy		**P-value P-value**	
Parameters	IMRT	VMAT	IMRT	VMAT
D98, Gy	49.20±0.57	49.16±0.51	0.680	0.624
D95, Gy	50.45±0.44	50.51±0.38	0.104	0.446
D50, Gy	51.20±8.81	53.53±0.54	<0.001	0.944
D2, Gy	54.62±0.43	54.43±1.10	<0.001	0.001
CI	0.87±0.02	0.89±0.03	<0.001	0.012
HI	0.14±0.17	0.13±0.02	0.003	0.013

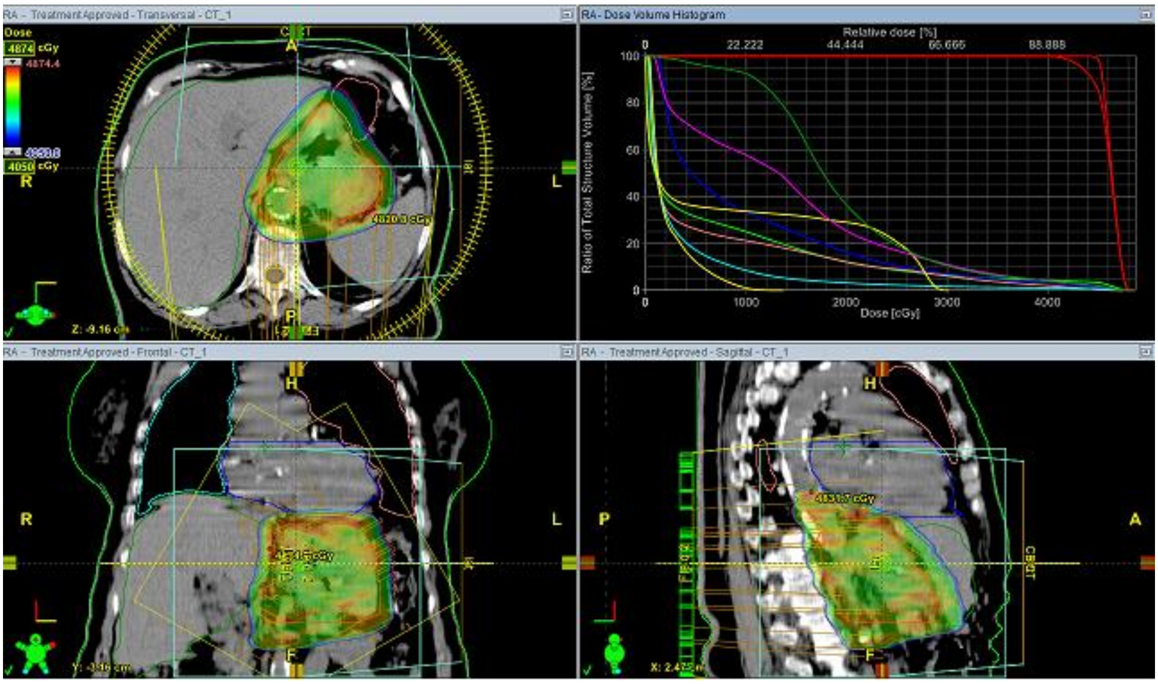
3.2. OARs

. VMAT essentially diminished the mean portion (14.54±1.58Gy), V13 (0.38±0.04 Gy) and V18 (0.28±0.03 Gy) of the left kidney. Likewise, a lower mean portion (11.24±1.88 Gy), V13 (0.28±0.06 Gy) and V18 (0.18±0.05 Gy) were seen in the contralateral kidney with VMAT. The mean portions to the typical liver for every strategy were 22.00±1.39 Gy (DA-VMAT), 21.98±1.48 Gy (IMRT), with the mean portion to the ordinary liver with IMRT discovered to be the most reduced. Moreover, the V30 Gy (%) with VMAT (0.22±0.05) was higher than that IMRT (0.19±0.03) (P<0.05) and DA-VMAT (0.19±0.03), (P<0.05). The outcomes are appeared in Table 3.

Table. 3: Comparisons of the dose-volume histogram-based parameters of the kidneys and liver in present study.

	P-value	
OARs	**IMRT**	**VMAT**
Left kidney		
V13	0.40±0.04	0.38±0.04
V18	0.28±0.04	0.28±0.03
Mean dose, Gy	15.10±1.91	14.54±1.58
Right kidney		
V13	0.36±0.05	0.28±0.06
V18	0.25±0.04	0.18±0.05
Mean dose, Gy	12.93±2.03	11.24±1.88
Liver		
V30	0.2±0.03	0.22±0.05
Mean dose, Gy	21.98±1.48	22.0±1.39

VMAT plan :- Double ARA arrangement



IMRT plan: 7 Field arrangement:

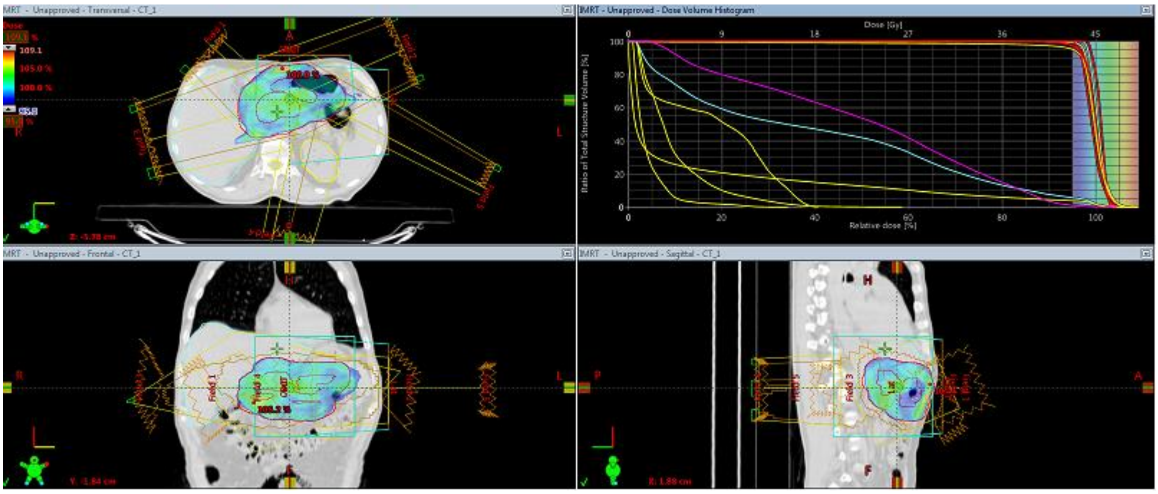
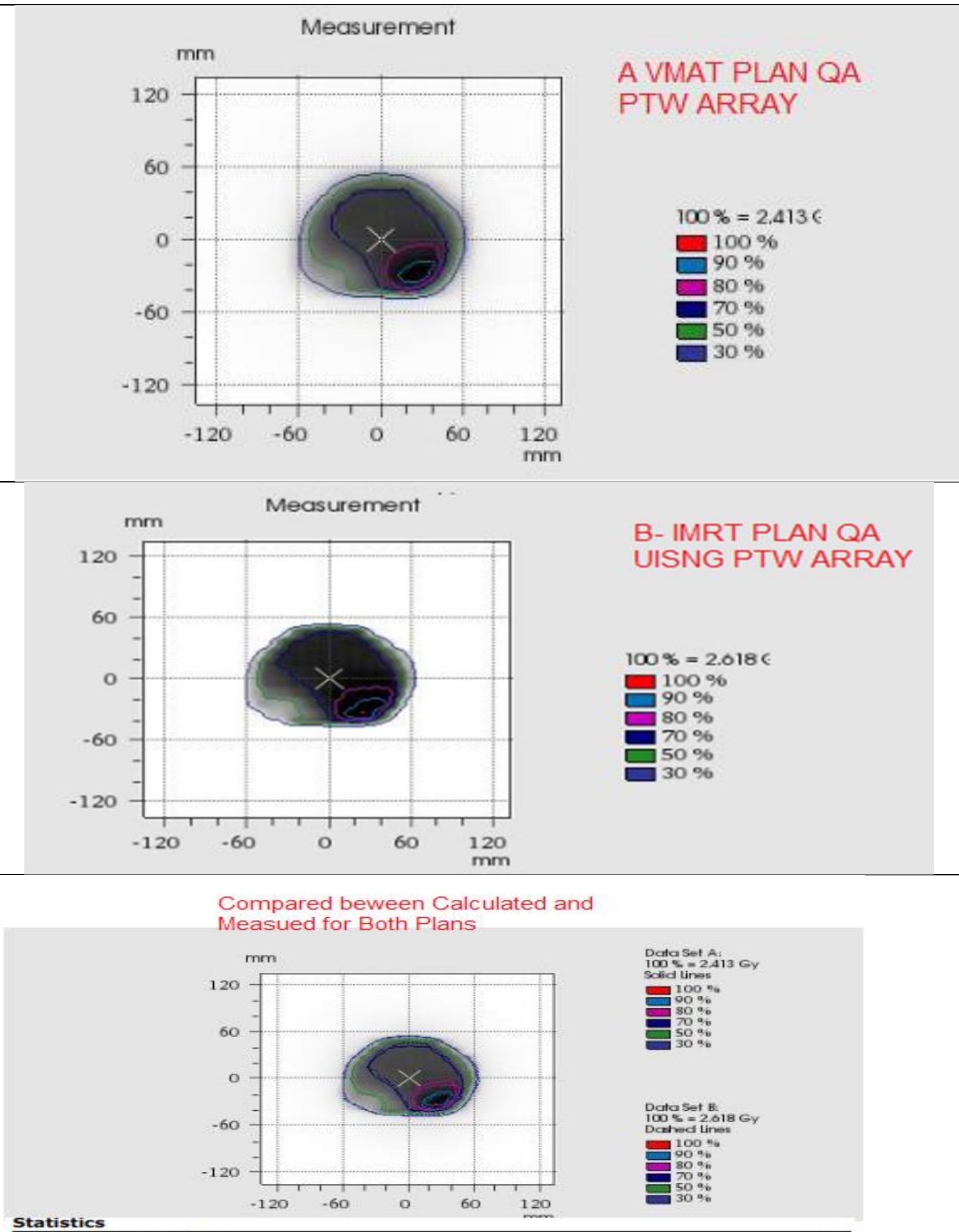


Fig (1): VMAT plan and IMRT Plan and different plan views Axial, Sag. And Co – DVH for PTV and OARs.



Statistics — IMRT results

Number of Dose Points	729
Evaluated Dose Points	729 (100.0 %)
Passed	682 (93.6 %)
Failed	47 (6.4 %)
Result	93.6 % (Green)

Statistics — VMAT results

Number of Dose Points	729
Evaluated Dose Points	729 (100.0 %)
Passed	691 (94.8 %)
Failed	38 (5.2 %)
Result	94.8 % (Green)

Fig. 2. Comparison between the VMAT and IMRT as Quality Assurance.

As shown in Fig. 2. the results for VMAT plan are matching more IMRT in QA results. with good agreement with planning data for good accuracy for VMAT for dose the OAR dose

IV. Discussion

However, due to the combination of radiotherapy and chemotherapy, treatment-associated toxicities are enhanced, which often leads to relinquishment of treatment among patients. A number of studies on dosimetric comparison of IMRT has shown that IMRT exhibits improved OAR sparing. Few studies have investigated the application of VMAT in treating postoperative gastric cancer patients (14).

It is realized that the multifaceted nature of the objective volume and the quantity of VMAT circular segments are significant determinants of whether VMAT is favorable when contrasted and IMRT (11). moreover, the OARs in gastric malignant growth radiotherapy were discovered to be more radiosensitive than that in other site for some disease radiotherapy (8,9). True to form, the information in the current examination showed that the therapy anticipating gastric malignant growth VMAT plans accomplished unrivaled portion inclusion for PTV (CI was improved; P<0.05), a favorable position when contrasted not IMRT.

What's more, It is known that the kidney is a radiosensitive organ and that damage to the kidneys is an inevitable side effect of pelvic or abdominal radiotherapy. Previous studies (20,21) have suggested that total doses of 18-23 Gy and 28 Gy in 0.5-1.25 Gy/fractions may be associated with a 5 and 50% risk of injury in five years, respectively. Jansen et al (22) conducted a prospective study analyzing kidney function in 44 gastric cancer patients following abdominal irradiation and observed an 11 and 52% decrease in left renal function after six months and 18 months, respectively. The V20 (left kidney) and mean left kidney dose were identified as parameters associated with decreased kidney function. Therefore, in the present study V13 and V18 Gy were selected as indicators. The doses to the kidneys were significantly decreased in DA-VMAT plans; however, the V13 Gy, V18 Gy and Dmean in the left kidney were generally higher than those of the right kidney. One reason for this may be that the majority of the left kidney is located in the superior section of the target volume. In order to optimize dose distribution in the tumor bed, which is anterior to the left kidney, it is difficult for TPS to reduce the irradiation dose to the left kidney. By contrast, the right kidney is located in the lower section which is the paraaortic lymph node region. Since it is much smaller and more regular than the upper section, it is easier to complete dose computation.

As a parallel organ, the radiation injury to the liver is found to positively correlate with the volume and dosage of radiation to the normal hepatic tissues. Emami et al (23) reported that TD5/5 (the tolerance dose leading to a 5% complication rate at five years) for one-third, two-thirds and the whole liver at one dose of 8-2 Gy/day were 50, 35 and 30 Gy, respectively. Furthermore, the risk of hepatitis B virus (HBV) radiotherapy reactivation has been identified, which must be radiation considered. Previous study has revealed that radiotherapy is a significant risk factor to radiation-induced liver disease (RILD) in patients with postgastrectomy adenocarcinoma carrying HBV (24).

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