A Comparative Dosimetric Study of Adjuvant 3D Conformal Radiotherapy for Operable Stomach Cancer Versus AP-PA Conventional Radiotherapy in NCI-Cairo

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ABSTRACT

Purpose: This study was to compare this multiple-field conformal technique to the AP-PA technique with respect to target volume coverage and dose to normal tissues.

Materials and Methods: Seventeen patients with stages II-III denocarcinoma of the stomach were treated with adjuvant postoperative chemoradiotherapy presented to radiotherapy department in National Cancer Institute, Cairo in period between February 2009 to March 2010 using 3D conformal radiotherapy technique that consisted of a monoisocentric arrangement employing 4-6 radiation fields. For each patient, a second radiotherapy treatment plan was done using an antroposterior (AP-PA) fields, the two techniques were then compared using dose volume histogram (DVH) analysis.

Results: Comparing different DVHs, it was found that the planning target volume (PTV) was adequately covered in both (3D & 2D) plans while the left kidney and spinal cord demonstrate lower radiation doses on using the conformal technique. The liver doses is higher in the 3D tecq, but still well below liver tolerance.

Conclusions: Both 3D conformal radiotherapy and AP-PA conventional techniques doses are within range of normal tissues tolerance. Regarding the left kidney and spinal cord the 3D conformal radiotherapy is superior than the AP-PA conventional techniques but with higher doses to the liver in the 3D conformal radiotherapy compared to the AP-PA conventional techniques.

Key Words: Dosimetric study in cancer stomach.

INTRODUCTION

Adenocarcinoma of the stomach has a reported incidence in National Cancer Institute, Cairo, between January 2002 and December 2003 of 326 new cases. These cases represents 10.3% of the newly diagnosed gastrointestinal tract cancer cases and 1.8% of all newly diagnosed cancer cases [1].

Surgery is considered the mainstay of therapy but still loco regional recurrence is a great problem which accounts for about 85% of failures [2].

Patients typically achieve 5-year survival rates of only 20-30%, because most tumors are in advanced stages at presentation [3]. To improve the outcome for these patients, adjuvant treatment strategies have been used, now radiation therapy is considered as the standard of care in the adjuvant settings of gastric cancer following the gastric adjuvant trial (INT0116) that showed a survival advantage to the use of adjuvant chemoradiotherapy [4].

However, many radiation oncologists are reluctant to treat such large abdominal volumes with anterior and posterior fields due to concerns about normal tissue toxicity, particularly in relation to the kidneys and spinal cord. Current modern techniques of radiation delivery employ multiple radiation fields that conform more accurately to the high-risk volume, with the potential to produce superior dose distributions and reduce normal tissue toxicity.

The objectives of this study was to compare this multiple-field conformal technique to the
AP-PA technique with respect to target volume coverage and dose to normal tissues.

MATERIAL AND METHODS

This study included 17 patients of stomach cancer who presented to radiotherapy Department in National Cancer Institute, Cairo in period between February 2009 to March 2010, all patients underwent surgical resection and all of them were indicated for adjuvant chemoradiotherapy (i.e. stage II-IIIB).

Radiotherapy followed the techniques used in INT0116 study [4]. A radiation dose of 45Gy was delivered in 25 fractions at 1.8Gy per fraction, five days per week over five weeks, to the tumor bed, anastomoses, stumps and regional lymphatics, dose variation in the planning target volume (PTV) was kept in accordance with ICRU 50/62 recommendations. The design of the radiation treatment fields was individualized depending upon the extent and location of the primary tumor and involved lymph nodes, lymph node stations included in the radiation fields were perigastric, coeliac, splenic hilar, supra-pancreatic, porta hepatitis, pancreaticoduodenal and local paraaortic nodes. The clinical target volume (CTV) was delineated using CT planning according to a defined CTV contouring protocol, and a standard 1cm margin was given around the CTV to generate the PTV. All patients were treated using a standardized 3D conformal technique that consisted of a mono isocentric arrangement employing 4-6 radiation fields, radiation was delivered using 6-18 MV photons. A Presice treatment planning computer system was used for CTV contouring and planning, and treatment was delivered with a Electa linear accelerator, with MLC and dynamic wedge. Dose volume histograms (DVH) were recorded for the kidneys, liver, spinal cord and PTV in all patients. A second radiotherapy treatment plan was generated for each patient utilizing closely contoured AP-PA fields. Corresponding DVHs were again recorded for the kidneys, liver, spinal cord and PTV. The field weightings, beam angles, and wedges were optimized individually for each patient. Patients received one cycle of 5 fluorouracil (5FU) and leucovorin followed by a combination of bolus 5 fluorouracil and radiotherapy (RT). After the RT was completed, two additional cycles of 5-FU and leucovorin were given.

RESULTS

The clinical characteristics of the 17 patients included in this study are summarized in Table (1). For each of the 17 studied patients, two DVHs were constructed for each of the kidneys, liver, spinal cord and PTV; one for the conformal technique, and the other for an AP-PA technique. They were then exported from the Presice treatment planning computer system and averaged using Microsoft Excel to produce a 'mean' DVH for each organ or volume, the percentage volume receiving different doses was calculated and then averaged over the 17 patients to obtain a 'mean' value. These values were then plotted to produce a mean DVH.

Table (1): The characteristics of patients.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Sex:</td>
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<tr>
<td>Males</td>
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<td>76.5</td>
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<tr>
<td>Females</td>
<td>4</td>
<td>23.5</td>
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<tr>
<td>Stage:</td>
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</tr>
<tr>
<td>II</td>
<td>5</td>
<td>29.5</td>
</tr>
<tr>
<td>III</td>
<td>9</td>
<td>53</td>
</tr>
<tr>
<td>IV</td>
<td>3</td>
<td>17.5</td>
</tr>
<tr>
<td>Surgery:</td>
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<td></td>
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<tr>
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<td>5</td>
<td>29.5</td>
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<tr>
<td>Total gastrectomy</td>
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<tr>
<td>R0 (negative)</td>
<td>13</td>
<td>76.5</td>
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<tr>
<td>R1 (microscopic)</td>
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</table>

Radiation dose to the spinal cord is considerably lower with 3D conformal radiotherapy Fig. (1), the average maximum dose received by the spinal cord in the AP-PA technique is 48Gy compared to 44Gy in the 3D conformal technique. The average mean dose for 3D conformal plane was 15Gy versus 22Gy for AP-PA technique.

The mean dose volume histograms for the right kidney are shown in Fig. (2) which showed lower V20 in favor of the 3D conformal technique (32%) compared to 38% for the AP-PA technique. The average mean dose is in favor
of 3D conformal plane versus AP-PA conventional plane (13Gy versus 17Gy).

Mean dose volume histograms for the left kidney are shown in Fig. (3) which showed lower V20 in favor of the 3D conformal technique (34%) compared to 62% for the AP-PA technique. The average mean dose is in favor of 3D conformal plane versus AP-PA conventional plane (17Gy versus 26Gy).

Radiation doses to the liver are higher with this conformal technique in Fig. (4). The V30 is 30% for the conformal technique versus 21% for the AP-PA technique. The average mean dose was 20Gy for conformal radiotherapy versus 13Gy for AP-PA technique.

Regarding the coverage of the PTV, Fig. (5) shows that it is nearly the same for the conformal technique when compared to AP-PA field arrangements, but there is slight difference at 50% of the PTV in favor of the conformal technique (41.5Gy compared to 40Gy for AP-PA field arrangements).
DISCUSSION

Although surgery still represents the cornerstone of management, adjuvant strategies have been shown to offer survival advantages in prospective randomized trials. European investigators (Medical Research Council Adjuvant Gastric Infusional Chemotherapy Trial [MAGIC]) proved that patients with operable adenocarcinoma of the stomach derived benefits in terms of decreased tumor size and stage, as well as improved progression-free survival and overall survival from a perioperative regimen of epirubicin, cisplatin, and fluorouracil.

However, the European protocol omitted the use of RT. Before this, American researchers [4] who had demonstrated that postoperative chemoradiotherapy consisting of fluorouracil and leucovorin combined with 45Gy of RT conferred advantages in terms of relapse-free survival and overall survival.

Thus, at this juncture, Class I evidence exists to support two viable adjuvant strategies in the management of adenocarcinoma of the stomach [5,6].

The nature of irradiation to the gastric bed predisposes several organs (most notably the kidneys & spinal cord) to chronic sequelae from irradiation, data presented by Verheij et al. [7] on functional renal impairment after adjuvant RT (45Gy administered through AP-PA fields) and chemotherapy (5-fluorouracil/leucovorine, capecitabine, or capecitabine/cisplatin) for gastric cancer, patients were studied with renography (technetium-99m mercaptotriglycylglycine) at baseline and after treatment, the baseline renal test findings were normal in all subjects.

Our results demonstrate that this multiple-field conformal technique produces superior dose distributions compared to AP-PA techniques especially left kidney and spinal cord, the use of multiple fields has allowed considerable sparing of these organs.

Our results was in concordance to the results achieved with Trevar et al. [8] and Viacheslav et al. [9], regarding kidney, our study showed lower doses in favor of 3D conformal plane versus AP-PA conventional plane (average mean dose to Rt kidney was 13Gy versus 17Gy; respectively, also lower V20 of 32% versus 38%, respectively, the average mean dose to Lt kidney was 17Gy versus 26Gy; respectively, also lower V20 (34% versus 62%; respectively) which is in concordance with the (QUANTEC review) [10] which stated that the V20 value must not exceed 32%, while Viacheslav et al. [9] study showed a lower average mean dose to Rt kidney in favor of 3D conformal plane versus AP-PA conventional plane (14Gy versus 22Gy respectively) while the average mean dose to left (Lt) kidney was 19Gy for 3D conformal plane versus 30Gy for AP-PA conventional plane with lower V20 of right (Rt) kidney is (18% versus 55% respectively) while left (Lt) kidney V20 is (45% versus 68%; respectively). Also Trevar et al. [8] study showed a lower average mean dose to Rt kidney in favor of 3D conformal plane versus AP-PA conventional plane (15Gy versus 19Gy; respectively) while the average mean dose to Lt kidney was 16Gy versus 23Gy; respectively, with lower V20 of Rt kidney is (30% versus 45% respectively) while Lt kidney V20 is (32% versus 43% respectively).

Regarding spinal cord our results showed that the average mean dose for 3D conformal plane is 15Gy versus 22Gy for AP-PA conventional plane and that the average maximum dose is 44Gy versus 48Gy; respectively. This is in concordance with the (QUANTEC review) [10] which stated that the maximum dose must not exceed 50Gy. It is in concordance with both Trevar et al. [8] study were the average mean dose was 14Gy versus 24Gy in favor of 3D

![Fig. (5): Mean DVH for PTV using AP-PA technique and conformal technique.](image-url)
conformal plain also the average maximum dose is 43Gy versus 50Gy; respectively. Viacheslav et al. [9] study were the average mean dose of spinal cord was 17Gy versus 23Gy in favor of 3D conformal plain while the average maximum dose is 35Gy versus 54Gy respectively.

Regarding average mean dose to the liver in the present study was 13Gy for AP-PA conventional plane versus 20Gy for 3D conformal plane which is in concordance with the (QUANTEC review) [10] which stated that the mean dose to the liver must range between 28Gy to 36Gy. It is also in concordance with the study of Trevar et al. [8] which showed a lower average mean dose to the liver of 14Gy versus 22Gy in favor of the AP-PA conventional plane and that of Viacheslav et al. [9] study which showed also lower average mean dose to the liver 15Gy versus 24Gy in favor of AP-PA conventional plane. The V30 is 30% for the conformal technique versus 21% for the AP-PA technique, which is in concordance with the NCCN recommendations which stated that the V30 must not exceed 40%. This is also in concordance with both Trevar et al. [8] study which showed that the V30 is 38% for the conformal technique versus 28% for the AP-PA technique and Viacheslav et al. [9] study which showed that the V30 is 45% for the conformal technique versus 30% for the AP-PA technique.

The use of laterally directed fields to spare the kidneys and spinal cord will invariably direct more radiation dose to the liver. We applied the Emami tolerance doses for the liver, which recommend TD5/5 of 50, 35 and 30Gy for irradiation of one third, two thirds or the entire liver respectively [11], we also observed the Intergroup recommendations, which limits doses so that less than 60% of the hepatic volume is exposed to more than 3000cGy of radiation.

The mean dose to the liver was lower in the AP-PA fields compared to 3D conformal plane (primarily because the AP-PA beam arrangement was not accompanied by a contribution from the lateral portals, which directly enter and exit through the liver) [12].

Investigators from the University of Michigan have recently reported the largest series of patients treated with partial liver irradiation (RILD), based on this data, estimates of the TD5/5 for uniform irradiation of one third, two thirds, and the whole liver are 90, 47, and 31Gy; respectively [13].

The planning target volume (PTV) in the present study was adequately covered in both planes (both AP-PA fields and 3D conformal plane). This was different from Trevar et al. [8] study which showed that 99% of the PTV receiving 95% of the prescribed dose in 3D conformal plane versus 93% of the prescribed dose in the AP-PA conventional plane.

Conclusions:

Both 3D conformal radiotherapy and AP-PA conventional techniques doses are within range of normal tissues tolerance. However, regarding left kidney and spinal cord the 3D conformal radiotherapy is superior than the AP-PA conventional techniques but with higher doses to the liver in the 3D conformal radiotherapy compared to the AP-PA conventional techniques. Thus, it is important to use IMRT technique with the possibility of lowering the liver dose.

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REFERENCES


