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INTENSITY-MODULATED ARC THERAPY FOR TREATMENT OF HIGH-RISK ENDOMETRIAL MALIGNANCIES

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Purpose: We developed an intensity-modulated arc therapy (IMAT) technique for the treatment of women with high-risk endometrial malignancies. In the context of multimodality therapy, nodal and tumor bed irradiation was delivered while respecting tolerance doses for critical structures.

Methods and Materials: Five patients were planned and treated with the IMAT technique after hysterectomy. Computed tomographic (CT) scans for treatment planning were acquired with the tumor bed contoured as the clinical target volume (CTV_{tumor_bed}) and the iliac and presacral vessels contoured as the gross tumor volume (GTV). In 2 patients the lower para-aortic nodes were included into the GTV. The small bowel, iliac crests, femoral heads, bladder, and rectum were contoured as critical organs. For the nodes, a CTV_{nodes} was generated with a 7–10-mm margin around the vessels, and the planning target volume (PTV_{nodes}) was generated by a further 5-mm expansion. For the tumor bed, the PTV_{tumor_bed} was generated with a margin of 7–10 mm around CTV_{tumor_bed}. Planning constraints included adequate coverage of the tumor bed (>95% receiving ≥45 Gy) and nodes (≥95% receiving ≥40 Gy). Arc combinations with different extents were tested, and the final plan was generated based on the balance between complexity (number of arcs), PTV coverage, and critical structure sparing. Conventional and 8-field intensity-modulated radiation therapy (IMRT) plans were generated for each patient for comparison purposes. All patients were treated with IMAT.

Results: We found that two anterior intensity-modulated arcs (300° to 30° and 330° to 60°) adequately treated the PTVs. Furthermore, this IMAT technique allowed sparing of small bowel and the iliac crests (marrow space) to a similar degree as the 8-field IMRT. The 8-field IMRT yielded better dose uniformity than IMAT in the target volumes; however, neither technique was as uniform as the conventional plan. In the 5 patients, IMAT treatment was well tolerated and completed as planned.

Conclusions: We successfully piloted an optimized intensity-modulated arc technique to treat 5 high-risk endometrial cancer patients undergoing multimodality treatment. This allowed a significant reduction in dose to bone marrow and small bowel compared with conventional techniques and was simpler to deliver than multifield IMRT. **© 2005 Elsevier Inc.**

Intensity modulation, Arc therapy, Bone marrow, Endometrial cancer.

INTRODUCTION

Adjuvant radiotherapy to the pelvis and regional lymphatics is commonly delivered for patients with gynecologic malignancies (1). Typically, 2 to 4 fields conventional (nonconformal) techniques are used and such treatments will involve the irradiation of small bowel, bladder, rectum, and pelvic bone marrow with resultant array of toxicities. In the context of multimodality therapy such as surgical staging and myelosuppressive chemotherapy, some of these toxicities may limit the dose and more seriously, utilization of radiotherapy.

Well-differentiated endometrial cancers that are treated with surgery, with or without adjuvant radiotherapy, generally have a good prognosis. However, adverse histology disease such as papillary serous carcinoma is associated with a poor outcome. A review of our institution's data on patients treated between 1991 and 1999 ($n = 43$) showed that those with localized disease generally received radiotherapy (whole abdomen in most cases) and patients with more advanced disease were given platinum-based chemotherapy alone. Mehta and Mundt (2) recently established that pathologic Stage I-II papillary serous carcinoma is associated with a high rate of pelvic and distant recurrence and the optimal approach may be pelvic radiation therapy and chemotherapy. The use of paclitaxel and platinum-

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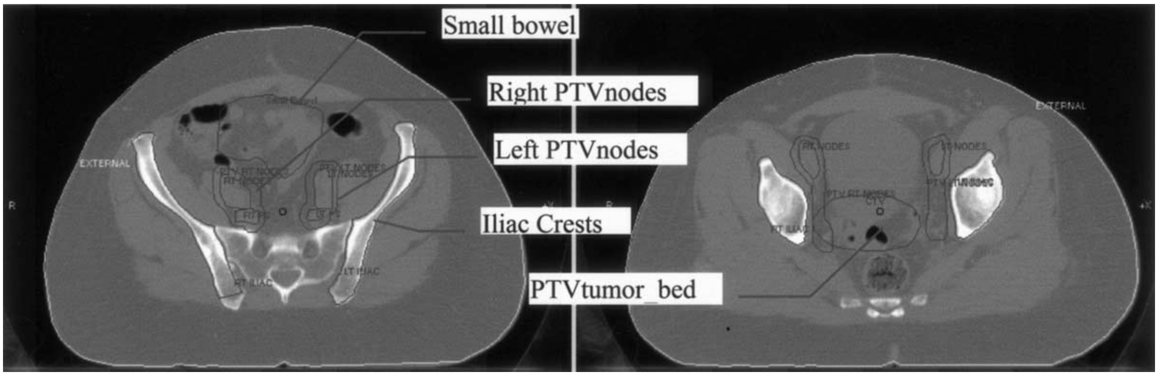

Fig. 1. Two computed tomography slices contoured with planning target volumes (PTV), PTV_{tumor_bed}, and PTV_{nodes}, small bowel, and iliac crests.

based chemotherapy in this disease is promising, with activity demonstrated in advanced disease (3).

After surgical staging, the ideal combination of chemotherapy and radiotherapy is not yet known. We propose to use a standard dose of paclitaxel and platinum-based chemotherapy (3), but modify the radiotherapy technique such that we would be: (*1*) giving treatment sequentially; (*2*) using a target volume that was less than what is used for whole abdominal treatment; and (*3*) conforming the radiation fields to treat the target volume and avoid normal structures in an attempt to minimize toxicities.

Supporting evidence for this approach is emerging. Brixey *et al.* (4) recently demonstrated that there is a statistically significant difference in hematologic toxicities for patients who underwent chemotherapy between conventional radiotherapy and intensity-modulated radiation therapy (IMRT). Although their IMRT technique was not designed to be bone marrow sparing, the effect of using large number of fields lowered the dose to the bone marrow.

In this article, we describe an intensity-modulated arc therapy (IMAT) (5, 6) technique that is designed to deliver adjuvant pelvic plus or minus lower para-aortic radiation in high-risk endometrial cancer. The primary goal for this IMAT technique is to reduce dose to the bone marrow. The first use of IMAT at our institution was for the treatment of prostate cancer and has been implemented successfully. The IMAT technique is compared with a conventional radiotherapy technique and an 8-field IMRT technique. The details of the IMAT technique (computed tomography [CT] volume definitions, isocenter location, beam energy, arc ranges, leaf sequences) are described. Comparisons of dose distributions and dose–volume histograms for IMAT, conventional, and

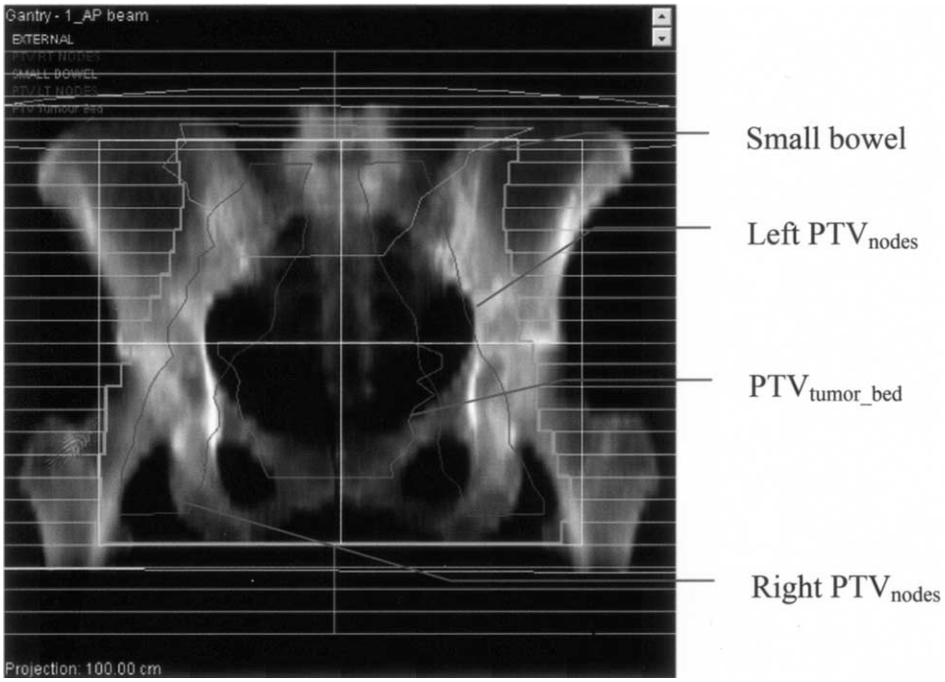

Fig. 2. Digitally reconstructed radiograph in the anterior-posterior beam for the two-field conventional plan along with the projections of the planning target volumes (PTV), PTV_{tumor_bed}, left and right PTV_{nodes} as well as the small bowel.