Using Image-Guided IMRT for the Extended-Field Radiation Treatment of Cervical Cancer

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INTRODUCTION

Cancer that arises in the cervix typically spreads in an orderly progression through the lymphatic system from the pelvic lymph nodes to the external iliac nodes up the para-aortic chain toward the chest and neck. Treating cervical cancer patients with evidence of pelvic lymph-node involvement prophylactically with an extended field of radiation to the abdomen from the T12 vertebral body through the ischial tuberosities has been shown to improve cure rates.[1] However, extended-field radiotherapy has also been associated with significant gastrointestinal toxicity, especially when it is combined with chemotherapy.[2] For this reason, the technique has not been widely adopted.

At UPMC, we have demonstrated that image-guided, intensity-modulated radiation therapy (IG-IMRT) reduces the radiation dose to normal tissues of the abdomen, making extended-field radiotherapy, in combination with chemotherapy, a feasible treatment option for appropriately selected cervical cancer patients.[3, 4]

This case study details the successful treatment of one such patient. In 2005, this patient received extended-field IG-IMRT with a simultaneous integrated boost to the involved lymph nodes. Her comprehensive treatment plan also included concurrent tandem and ring brachytherapy to the cervix and cisplatin chemotherapy.

CASE REPORT

A 67-year-old African-American female presented with intermittent postmenopausal bleeding. Physical examination showed a barrel-shaped cervix and a 4-centimeter expansile mass with bilateral parametrial extensions. A Pap smear and endometrial biopsy confirmed a diagnosis of squamous cell cervical cancer. An MRI revealed a tumor measuring 4.6 x 3.6 x 4.5 centimeters. (Figure 1.) In addition, an FDG PET/CT scan showed spread to the left obturator and external iliac lymph node. Based on these findings, she was staged at II$_B$ cervical cancer.

Treatment

The large size of the cervical mass and the evidence of pelvic lymphadenopathy made this patient an ideal candidate for extended-field radiation treatment. We devised a treatment plan for her that (1) was extended-field IMRT, (2) integrated a simultaneous boost, (3) was PET/CT based, (4) involved 4D CT evaluation of abdominal organ motion, and (5) used all the elements of onboard imaging to localize and verify her positioning each day.

We delivered a radiation dose of 45 Gy (1.8 Gy per fraction) over five weeks to an extended field that included the pelvis and the para-aortic chain. Simultaneously, we delivered an in-field radiation boost of 55 Gy (2.2 Gy per fraction) to the FDG-avid abnormal lymph nodes.

PET/CT simulation images were utilized by the Varian Eclipse™ treatment planning system to create the highly conformal plan with the integrated boost. We used 4D CT imaging to contour the gross tumor volume (both primary and lymph node), as well as the lymph node regions, small bowel, rectum, bladder, bone marrow, and femoral heads. In addition, we delineated the treatment margin based on 4D imaging taken during the entire respiratory cycle. (Figure 2.)

The PET/CT-based IMRT treatment plan was delivered with the Varian Trilogy® system, using a sliding-window technique to shape the beam. (Figure 3.) Patient setup was verified daily by kV-kV and gated kV-kV image matching, and twice a week by cone-beam CT, using the Trilogy's On-Board Imager®. (Figure 4.) Trilogy also allows respiratory gating of the treatments to compensate for the intrafractional motion of the kidneys in and out of the extended radiation field caused by patient breathing. In this case, our pretreatment 4D CT assessment showed that respiratory gating during the treatment would not be necessary.

Figure 1. The pretreatment sagittal MRI demonstrates expansile cervical mass and intrauterine fluid collection. *Image courtesy of the University of Pittsburgh Cancer Institute.*

Figure 2. Axial (left upper), coronal (left lower), and sagittal (right lower) views show the contours of the cervical cancer and regional lymph nodes. The lymph nodes are outlined in green, and the regional nodal and cervical cancer is outlined in orange. The modeled view (right upper) shows the extended field, including the cervix and lymph nodes. The abnormal lymph nodes are outlined in green. *Image courtesy of the University of Pittsburgh Cancer Institute.*

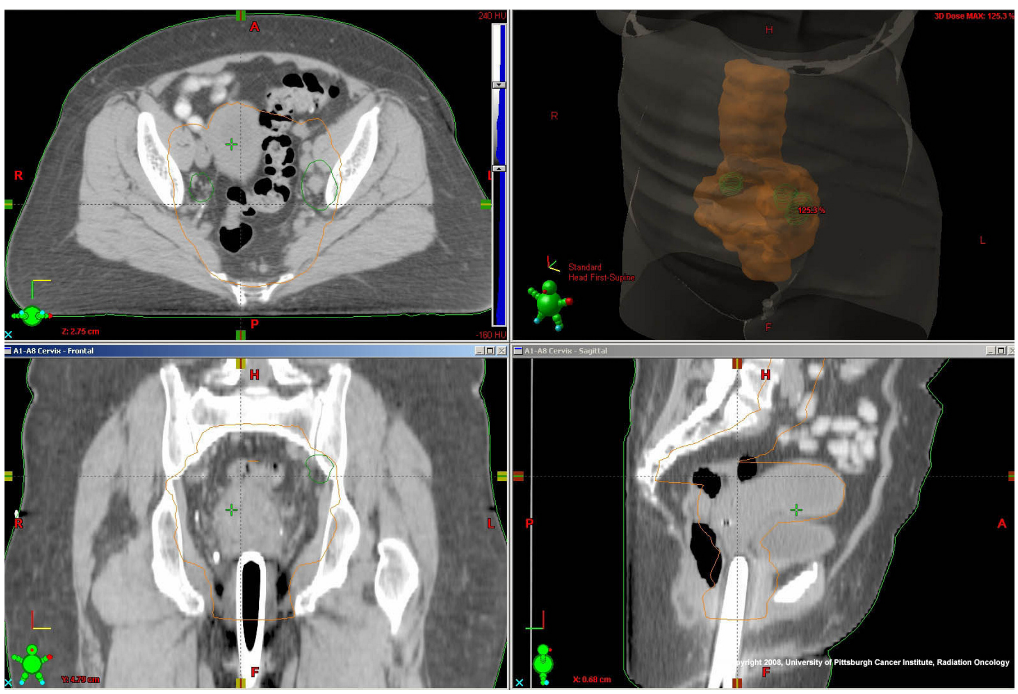


Figure 3. This 4D CT with isodose distribution demonstrates coverage of the extended field and shows the treatment field arrangement. *Image courtesy of the University of Pittsburgh Cancer Institute.*

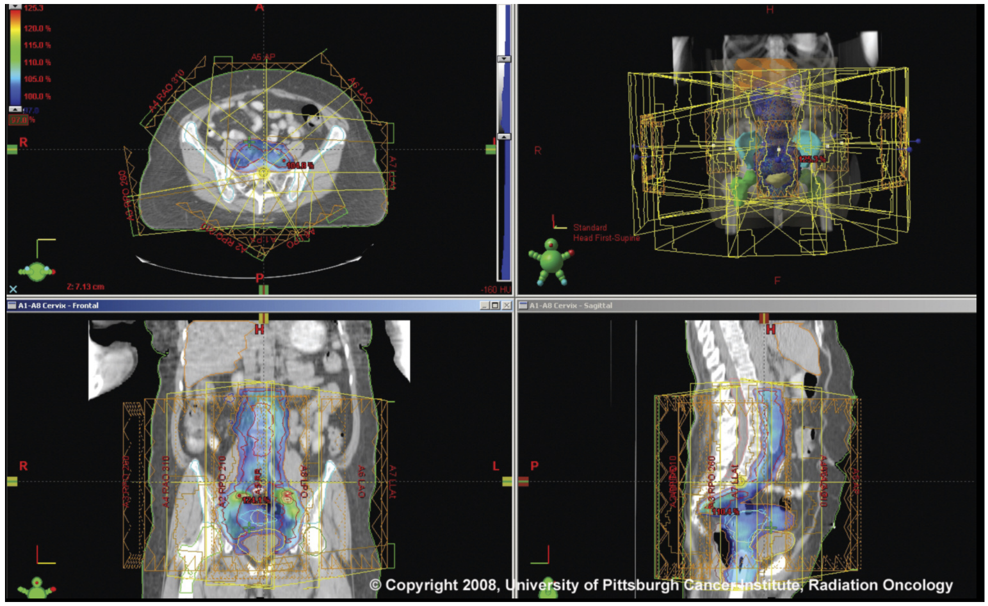
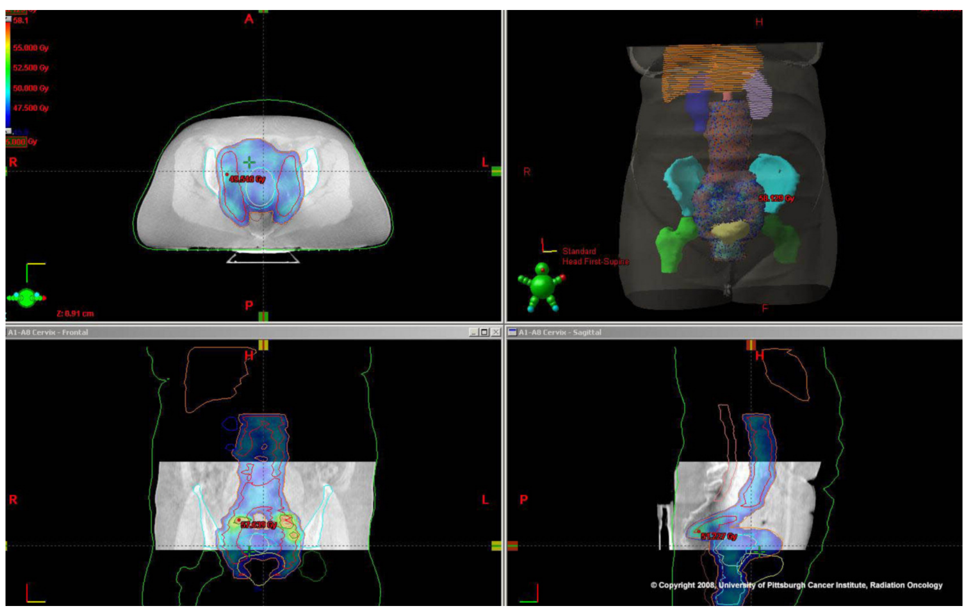


Figure 4. The cone-beam CT with isodose distribution demonstrates the coverage of the extended field. The liver is shown in orange, the right kidney in purple, and the left kidney in pink. *Image courtesy of the University of Pittsburgh Cancer Institute.*



When the weekly onboard cone-beam CT images, along with physical examination, showed that the tumor had regressed sufficiently, the patient was started on concurrent HDR brachytherapy to her cervix. We prescribed 25 Gy over 5 fractions and conformed the radiation dose so that point A received a total of 70 Gy from the brachytherapy and IMRT combined. The patient received IMRT and brachytherapy treatment on alternating days.

Concurrent with the IMRT treatments, this patient received a weekly dose of cisplatin chemotherapy (30 mg/m2).

Results

By integrating the radiation boost to the lymph nodes into the IG-IMRT plan and overlapping the brachytherapy with the extended-field IG-IMRT treatment, we were able to shorten the duration of the patient's radiation therapy by three weeks, compared to delivering the treatments sequentially.

The patient tolerated the treatment well. The only adverse effect was a self-limited grade 2 GI toxicity that occurred in the last week of treatment and resolved within a week. By the time of her first follow-up examination six weeks after the completion of treatment, her PET scan showed a complete resolution of her pelvic adenopathy as well as normal FDG uptake in the cervix. Subsequent PET/CT scans every 3 to 4 months have remained negative for signs of cancer over 18 months. Furthermore, she has shown no evidence of late treatment-related toxicity.

CONCLUSIONS

UPMC Cancer Centers have treated cervical patients, similar to the case presented, for seven years with extended-field radiotherapy. Our experience indicates that this treatment approach is both feasible and desirable, particularly in patients who are at high risk for pelvic and abdominal failure. Image guidance gives us the ability to deliver these treatments with precision, which reduces the risks of gastrointestinal toxicity when the radiation therapy is combined with concurrent chemotherapy. With comprehensive integration of image guidance, we have been able to reduce the high-grade toxicities typically seen with extended-field radiotherapy by 80 percent. We favor selecting candidates for extended-field treatment carefully by using PET/CT imaging to identify those patients who are at risk for having para-aortic nodal involvement.

References

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