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On-table CBCT emphysema adaptive radiotherapy post tracheostomy tube placement

Fiona Li, PhD; Alexander Podgorsak, PhD; Sean Tanny, PhD; Dandan Zheng, PhD; Neil Joyce, MSc; Deepinder Singh, MD
University of Rochester Medical Center, Rochester, New York

ABSTRACT

Tracheostomy is a surgical procedure that creates an opening in the trachea and inserts a tube to secure the airway in patients with an obstruction. A rare complication of this procedure is subcutaneous emphysema, when air leaks from this opening into the subcutaneous tissues. Here we present a case of subcutaneous emphysema following a tracheostomy in a patient who was set to start radiation treatment for a squamous cell carcinoma of the oropharynx. The presence of air pockets in the neck and supraclavicular regions led to significant dose inhomogeneity and increased the day-to-day anatomical variation between treatment fractions. Instead of delaying the patient's treatment for the subcutaneous emphysema to subside or acquiring an additional planning CT scan, we instead decided to utilize on-table CBCT-guided adaptive radiation therapy to account for the daily anatomy changes due to the emphysema resolving. Through the use of this adaptive treatment paradigm, the patient completed radiation therapy successfully without any delay in their treatment.

CONTACT

Fiona Li
University of Rochester Medical Center
Rochester, New York
Fenglifiona_li@urmc.Rochester.edu

INTRODUCTION

Changes in initial anatomy post CT-simulation can pose a challenge in radiotherapy treatment planning, immobilization, and treatment delivery.

The occurrence of subcutaneous emphysema after CT simulation but prior to the onset of radiation therapy presents a particularly challenging scenario as the initial anatomy is unlikely to accurately represent the patient's actual treatment geometry. Despite this potential impact on radiation therapy delivery accuracy, there is limited literature that addresses the management of such cases within radiation oncology. In this report, we present a patient with head and neck cancer who developed significant subcutaneous emphysema following the placement of a tracheostomy tube after CT simulation and before treatment initiation. In this report, we highlight the role of adaptive radiation therapy in responding to this unanticipated anatomic change and discuss practical considerations for maintaining safe and effective treatment delivery.

CASE REPORT

A 67 year-old male with 55 pack/year smoking history was presented with dysphasia and thick mucus. PET/CT shows large mass in bilateral base of tongue extending into the right tonsillar pillar with no nasopharynx involvement. Biopsy confirmed HPV associated palatine tonsil squamous cell carcinoma, stage III. Definite chemoradiation with Cisplatin and 70Gy in 35 fractions was prescribed as first line therapy.

Patient underwent CT simulation and treatment plan was generated based on the image. Shortly after initiation of chemotherapy, patient developed dyspnea with stridor, tracheostomy was placed resulting in subcutaneous emphysema. Conventionally, this would require a re-simulation and re-planning which is time consuming. Fig 3 shows axial view of the patient from original simulation to first day of treatment.

To prevent delay in the treatment, radiation treatment based on the initial CT simulation image was initiated using an online direct-to-unit (DTU) adaptive planning approach. Original plan was converted into reference adaptive plan.

On first day of treatment, adaptive workflow was followed. The HyperSight CBCT image set was used to generate contours. Clinician modified contours based on the first day anatomy along with the plan generated from the adaptive workflow was converted into image guided radiotherapy (IGRT) for subsequent fractionation.

OBSERVATIONS

By adapting the DTU process, the PTV overlapping with the tracheostomy and emphysema showed better coverage. The adaptive plan for the PTV was 95.8% compared to the scheduled plan which was 88.6%. If the patient was treated without a re-simulation, the coverage would be suboptimal. Qualitative dose distribution is shown in figure 1. Additionally, the DVH dose fall off for the adaptive plan was sharper indicating improved target coverage and dose conformity while sparing adjacent normal tissue. The DVH for the OARs were comparable (Fig 2).

By day 9 of treatment, the subcutaneous emphysema subsided (Fig 4). However, clinical decision was made to continue with IGRT until 27th fraction due to weight loss. A new plan was generated using an off-table adaptive replan protocol based on the day 27 HyperSight CBCT image. The plan was treated till completion.

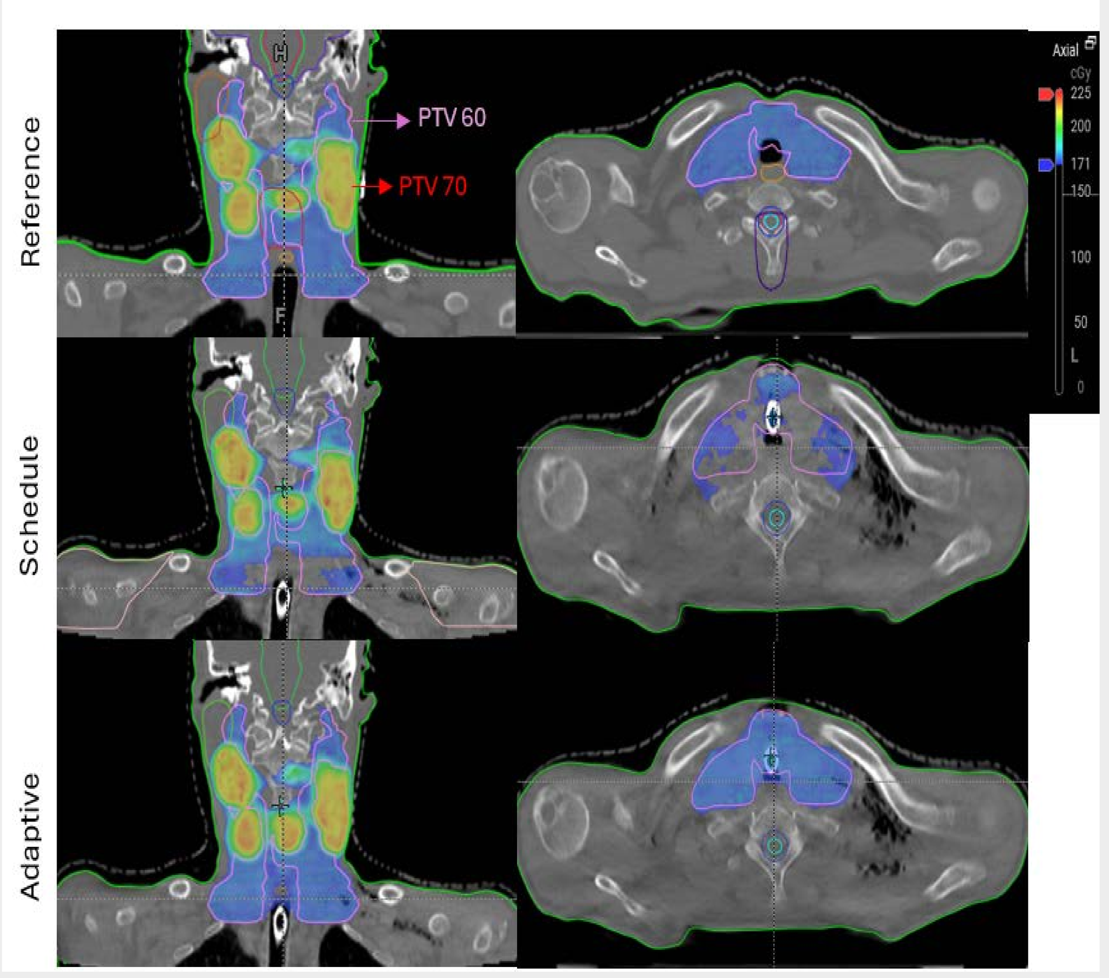

Fig 1: Comparison of dose distribution for the reference plan (top), scheduled plan (middle) and adaptive plan (bottom). Sagittal (left) and axial (right) views are shown.

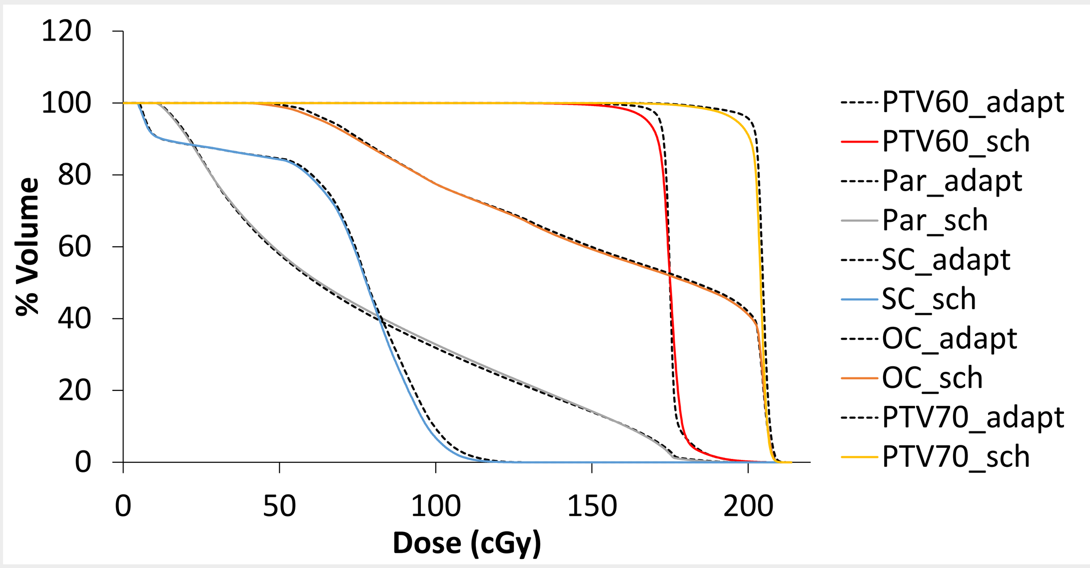

Fig 2: DHV of PTV60 and PTV70, parotid gland (par), Spinal cord (SC), and oral cavity (OC) for adaptive (adapt) vs. scheduled (sch). The adaptive and scheduled are shown by the dashed and solid line respectively

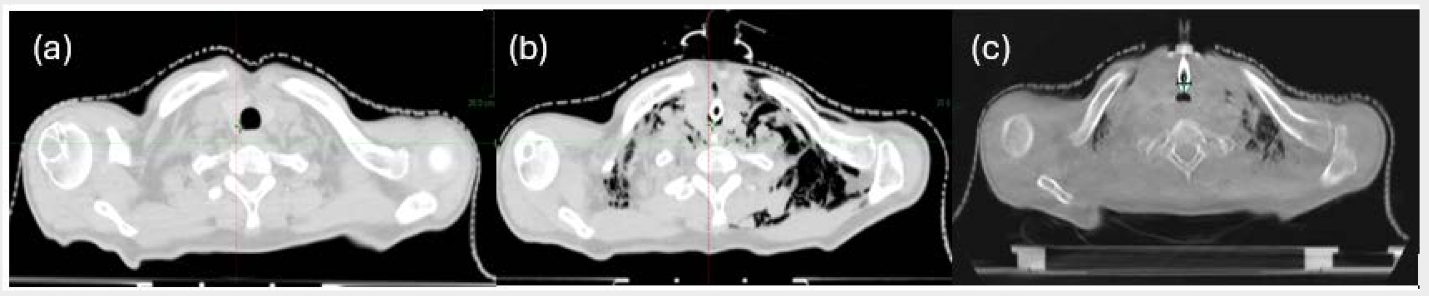

Fig 3: Axial view comparing simulation scans of patient (a) before, and (b) after tracheostomy tube placement. Subcutaneous emphysema developed from tracheostomy is appreciable on the "after" image (b). (c) day 1 of HyperSight CBCT image showing the treatment day anatomy with partially resolved emphysema

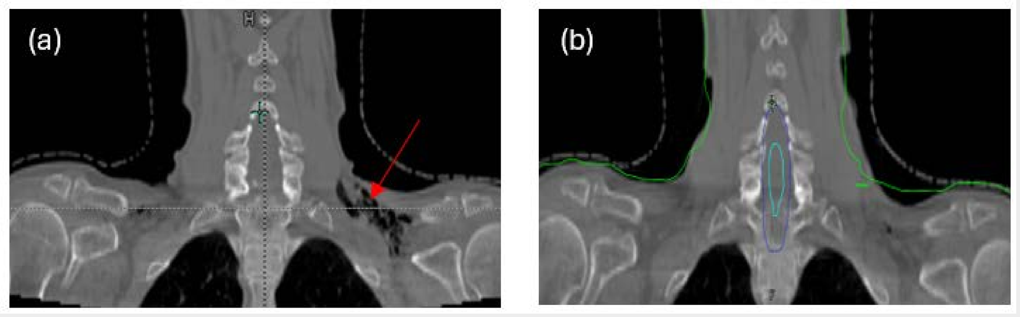

Fig 4: Coronal view of the patient demonstrating the emphysema resolution comparing (a) day 1 of treatment, and (b) day 9 of treatment

DISCUSSION

With conventional radiotherapy workflow, change in body habitus would warrant a re-simulation and replan which would take days resulting in significant clinical treatment delays. By adapting DTU workflow, rapid replan generation following tracheostomy placement was achieved without any delay in treatment initiation with concurrent chemoradiation.

On first day of treatment, the plan based on the original CT re-simulation was used as reference for adaptive therapy. The whole process during the first day of adaptive treatment was completed in 43 min. By converting the adaptive treatment into IGRT for subsequent treatment have significantly reduced the replan process from 3-5 days to a mere 43 min.

With DTU process, the first day adaptive plan was converted into image-guided RT for subsequent fractionation. This reduced workflow burden on both the patient and the treatment team.

Clinically, subcutaneous emphysema is usually managed by compression bandages which can delay treatment by a week. Without medical intervention, it requires one month for spontaneous resolution.

CONCLUSIONS

Implementation of this adaptive workflow allowed the patient to proceed with treatment without re-simulation and without delaying the initiation of planned concurrent chemotherapy. This approach also reduced workflow burden on the CT resources, the patient, and the clinical care team. Waiting for subcutaneous emphysema to resolve could require weeks to months and would not be clinically advantageous in the treatment setting.