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Teaching Case

The great esophageal escape: A case of extreme esophageal interfraction motion during neoadjuvant chemoradiation therapy

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Case Report

A 69-year-old otherwise healthy man presented with a 30-lb weight loss and progressive dysphagia to solids. An esophagogastroduodenoscopy with endoscopic ultrasound revealed a mass extending from 37 to 43 cm from the incisors and involving the gastroesophageal junction (Fig 1A). Biopsies were consistent with moderately differentiated adenocarcinoma and the tumor was staged uT3N1 with a small periesophageal lymph node. A positron emission tomography computed tomography (PET/CT) scan revealed a fludeoxyglucose avid primary mass with no hypermetabolic adenopathy or metastatic disease (Fig 1B). The patient was dispositioned to receive neoadjuvant chemoradiation.

Thirteen days following the PET/CT scan, the patient underwent a 4-dimensional CT (4DCT) simulation in the supine position with arms abducted overhead and nothing by mouth for 3 hours. The treating radiation oncologist noted the lower esophagus to be in a markedly different position compared with the PET/CT scan, having shifted 4.6 cm to the right and 1.9 cm anteriorly (Fig 2A). There was relatively little target motion throughout the patient's respiratory cycle (Fig 2B) and, on re-review of the PET/CT, the stomach was similar in size and shape and had minimal gastric contents. A repeat 4DCT simulation was obtained for a second reference point 2 days later and showed the esophagus to be in a similar position as the original simulation. The second simulation image set was used to design a volumetrically modulated arc therapy plan with a 3-cm gross tumor volume (GTV) to clinical target volume mucosal margin, 1-cm GTV to clinical target volume radial margin, and a 5-mm planning target volume margin to a dose of 50.4 Gy in 28 fractions, concurrent with weekly carboplatin (area under the curve, 2) and Taxol (50 mg/mm^2).

Daily cone beam CT (CBCT) scans were performed during radiation and showed significant interfraction motion based on boney alignment (Fig 3A) (eVideo; available as supplementary material online only at www.practicalradonc.org), although not to the degree of movement seen between the PET/CT scan and simulation. Resimulation after fraction 13 and showed a left/anterior esophageal shift of 1.2 cm with a decrease in cross-sectional area from 15.6 to 4.6 cm^2 (Fig 3B). At this point, a new plan was created and implemented for the final 11 fractions. The esophagus never shifted back to the position seen in the staging PET/CT scan. Six weeks after

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Conflicts of interest. None.

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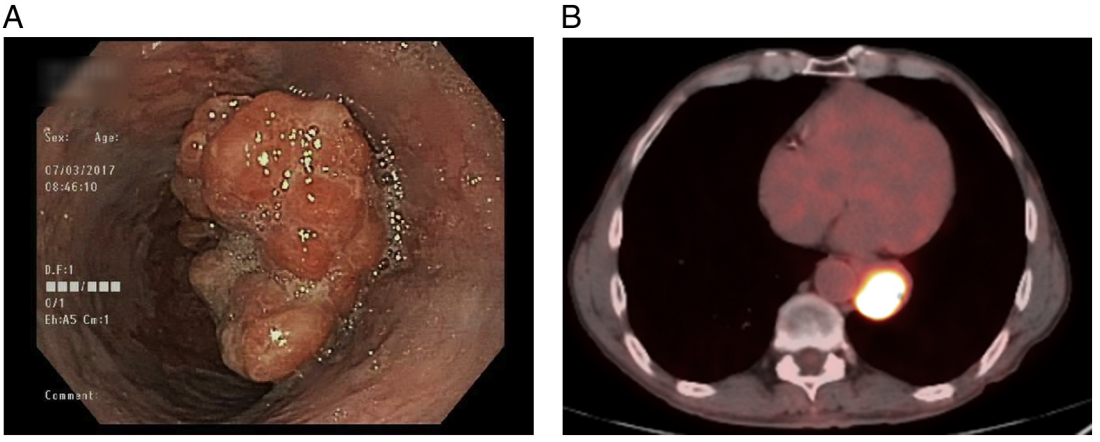

Figure 1 (A) Image from a diagnostic esophagogastroduodenoscopy revealing a partially obstructive distal esophagus mass. (B) Axial image of a PET/CT scan showing a 6-cm hypermetabolic esophageal tumor.

completing chemoradiation, the patient had a minimally invasive Ivor Lewis esophagectomy that showed a pathologic complete response to treatment and 0/19 involved lymph nodes.

Discussion

Chemoradiotherapy is the preferred initial treatment strategy for locally advanced or node positive esophageal cancer, with a near doubling of survival in the preoperative setting compared with surgery alone.[1] Patients may be appropriately treated with 3-dimensional conformal radiotherapy, intensity modulated radiation therapy, volumetrically modulated arc therapy, or proton therapy, depending on local practice and individual anatomic and dosimetric considerations.[2] With the increase in using more conformal radiation techniques, several studies have explored the anatomic changes of the esophagus through the course of treatment.[3-10]

Inter- and intrafraction motion

Uniquely positioned near the lungs, mediastinum, and diaphragm, esophageal motion is largely attributable to respiration, cardiac movement, and peristalsis. The esophagus is subject to both intrafraction motion, which is movement occurring during a single session of treatment, as well as interfraction motion, which describes positional shifts between treatment sessions. In general, studies have shown slightly greater interfraction compared with intrafraction motion[7] and have consistently demonstrated the most movement in the superoinferior direction[3-6] and in tumors of the distal esophagus.[3-5] Interfractionally, the position of the esophagus correlates with tidal volume and diaphragmatic excursion and, through the course of treatment, has a tendency to shift toward the left and decrease in size.[6,7] Although there is significant variability between patients, average esophageal movement has been shown to be about 1.5 to 4 mm radially and 3 to 9 mm craniocaudally with 3% to 18% of

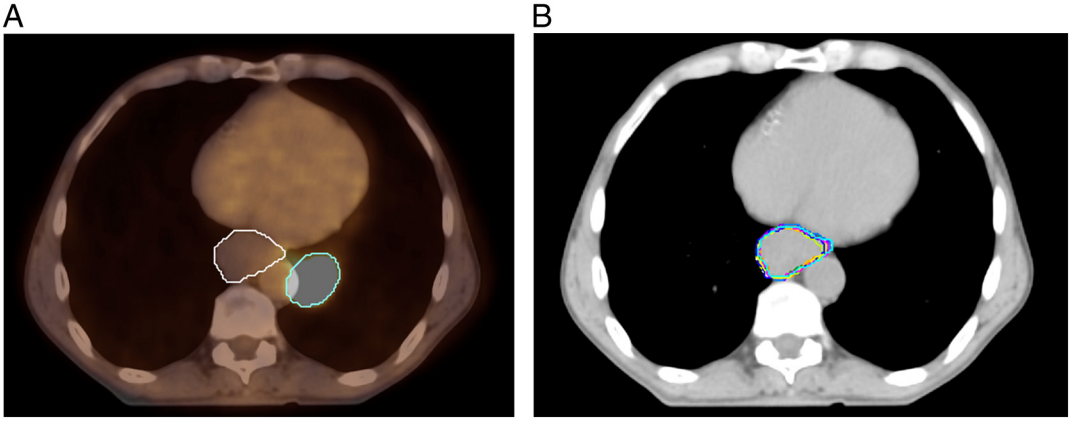

Figure 2 (A) Fusion of axial PET/CT scan (sky blue contours) and initial 4DCT simulation maximum intensity projection (light pink contours) images aligned to bone, illustrating shift in esophagus mass toward the right/anterior direction. (B) Images from the initial simulation with a different color for each individual phase of respiration.