PET/CT's Application in Radiation Oncology, continued from page 3

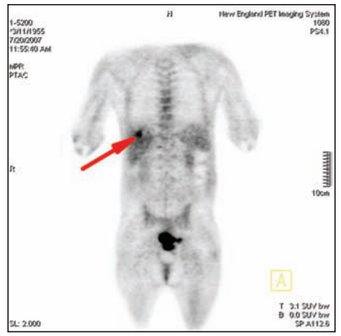
contours occurred when CT and PET FDG uptake data were co-registered. Although methods of target coverage of nodal region for specific malignancy are accepted, the art of target contouring is related to the level of experience as well as professional bias. The target region of interest is operator-defined on the computer for each imaging slice, with edges chosen that will envelop the area that is considered to be tumor. The display of biologically active tumor provides a more specific region for contouring—particularly in the presence of atelectasis, imaging artifacts from surgical clips, or post-treatment or post-surgical fibrosis.

It is likely that more widespread application of PET/CT in radiation planning will result in **more uniform target voluming** among radiation oncologists. The quantitative data provided by PET/CT provide a means to predict prognosis as well as monitor therapeutic response. It has been shown SUV values greater than 10 predicted a worse outcome in head and neck cancer and required aggressive treatment using a combination of radiation therapy and chemotherapy. Also, in imaging non-Hodgkin's lymphoma as well as in Hodgkin's disease, post-treatment FDG PET/CT showing residual uptake is a predictor for relapse.

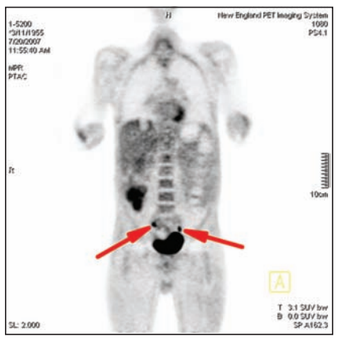
Case #4

This patient is a 52-year-old male who presented with rectal bleeding. A biopsy of the lower rectum's **fixed mass reported as adenocarcinoma.** He was staged at T3 N0 M0 with CT.

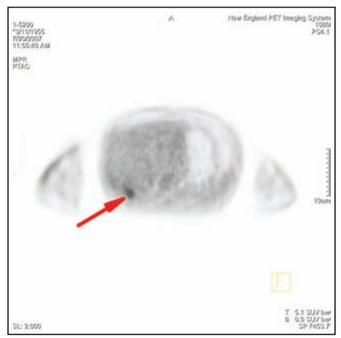
Subsequent **radiation-planning whole body FDG PET/CT** showed a large rectal mass with bilateral iliac nodal metastasis and also one liver metastasis. His staging was changed to T3 N2 M1, and the radiation treatment volume was altered.



PET—liver mets



PET—iliac nodes



PET axial liver lesion

Benefits of Collaboration

PET/CT provides necessary **anatomic information and electronic density mass** for dose calculations and simultaneously provides **more accurate staging and quantitative data** for prognosis and therapeutic monitoring. With close collaboration between the Health Physics staff of Caritas Holy Family Hospital and the professionals of New England PET Imaging System, protocols have been developed that ensure the smooth flow of patients to derive accurate measuring and localization.

The patient is simulated in the hospital Radiation Oncology department under the supervision of the radiation oncologist. The patient then receives a PET/CT scan, and precise localization and registration using a laser is reproduced. After the images are completed, chosen images are exported to the radiation therapy planning computer. These images are analyzed by the radiation oncologist and processed with the input of the radiologist. The target volume is drawn as well as vital structures for radiation therapy planning.

The accompanying cases demonstrate the important role PET/CT can play in radiation therapy planning.

"PET/CT and Radiotherapy." *Quarterly Journal of Nuclear Medicine and Medical Imaging,* March 2006, volume 50, No. 1, page 4.

"Role of PET/CT Scanning in Radiotherapy Planning." *The British Journal of Radiology.* 79, 2006, S27-S35.

"Image-Guided Cancer Therapy Using PET/CT." *The Cancer Journal,* volume 10, no. 4, July 2004, page 221.

New England PET Imaging System is accredited by the American College of Radiology.

www.nepetimaging.com

NEPET at Holy Family Hospital
70 East Street
Methuen, MA 01844
(978) 689-4738

NEPET of Greater Lowell
Lowell General Hospital Cancer Center
295 Varnum Avenue
Lowell, MA 01854
(978) 458-9872

NEPET at Elliot Hospital
One Elliot Way
Manchester, NH 03103
(603) 663-2370

Massachusetts Mobile PET, P.C.
at Anna Jaques Hospital
25 Highland Avenue
Newburyport, MA 01950
(888) 560-4738

Massachusetts Mobile PET, P.C.
at Merrimack Valley Hospital
140 Lincoln Avenue
Haverhill, MA 01830
(888) 560-4738

New England PET Imaging System

PET/CT's Application in Radiation Oncology

By **Santos Shetty, M.D.,** *Med. Dir., Radiation Oncology,* Caritas Holy Family Hospital, and **Robert C. Hannon, M.D.,** *Med. Dir.,* New England PET Imaging System at Caritas Holy Family Hospital

Introduction

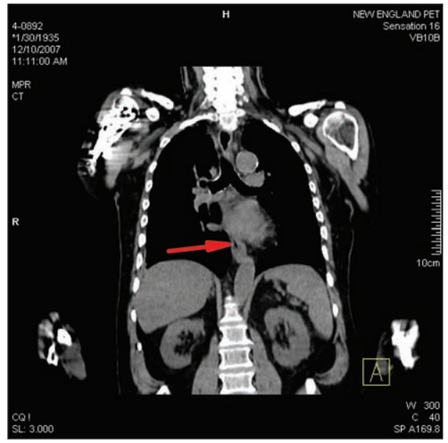
Recent years have witnessed significant technological improvements in the field of radiation oncology. At this time, **radiation therapy equipment** can deliver precise target-directed treatment while sparing the normal structures. In addition to these equipment developments, **advances in medical imaging**—particularly in the application of **PET/CT**—have provided significant benefits in staging for malignancy as well as planning the radiation therapy treatment field.

Continued on page 2

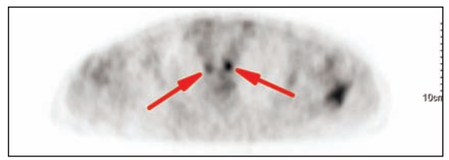
Case #1

This patient is a 72-year-old male who presented with anemia. Esophagogastroduodenoscopy ("EGD") revealed **esophageal tumor** extending from 29.0cm to 38.0cm. Endoesophageal ultrasound staged this as T3 N0 M0 carcinoma. CT scan revealed abnormality involving the distal esophagus. The plan was for radiation therapy combined with chemotherapy and then definitive surgery.

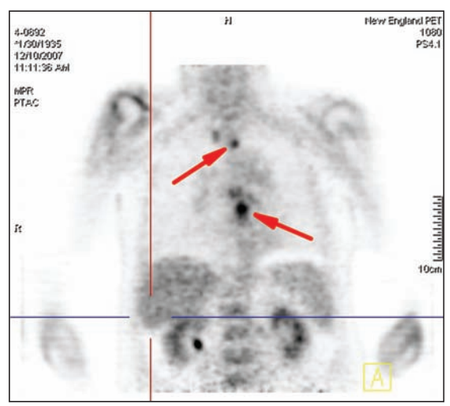
A **radiation-planning whole body FDG PET/CT scan** was ordered prior to onset of treatment. This revealed intense increased uptake of FDG in the distal esophagus and also two abnormal nodes in the anterior mediastinum superior to the primary mass. This was a surprise finding and valuable in changing the radiation treatment volume so as to include these nodes. Both tumor staging and radiation treatment volume were changed as a result of the PET/CT.



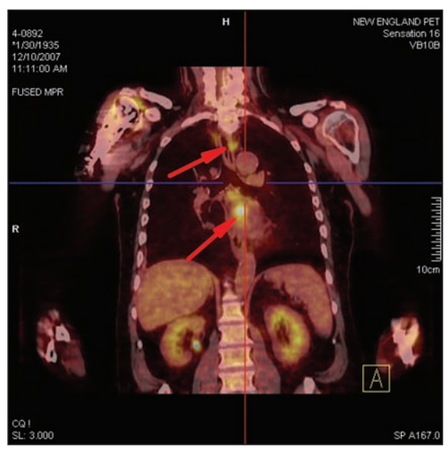
CT—primary



Axial PET



PET—primary and node



Fused PET/CT—primary and node

PET/CT's Application in Radiation Oncology, continued from page 1

Advantages of PET/CT in Radiation Oncology

For many tumor types, PET/CT offers better specificity and sensitivity in both diagnosis and staging compared with the use of CT alone. A recent article reports **a 27% change in patient management** due to changes in staging when PET/CT is included in radiation therapy planning. Precise delineation of target or tumor volume and vital structures is extremely important for the radiation oncologist to deliver precise radiation therapy to the malignancy with maximum protection of the vital structure. With the adjunct of PET/CT to radiation therapy

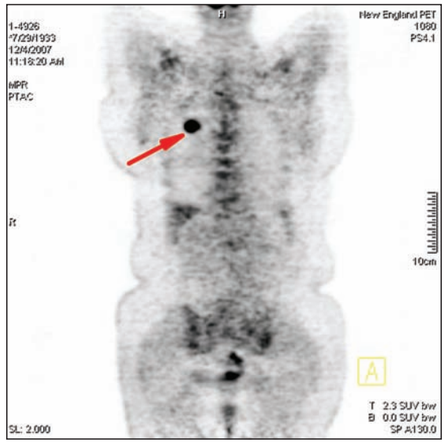
Continued on page 3

Case #2

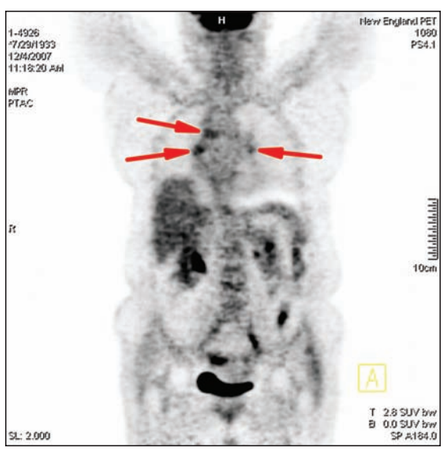
This patient is a 74-year-old female who is a heavy smoker presenting with pneumonia. After clearing of the pneumonia, a persistent right upper lobe nodule was noted. CT scan showed a 1.0 x 2.3cm right **upper lobe nodule and nonspecific small paratracheal lymphadenopathy.** Initially, she was staged as probable T1 N0 M0. CT-guided biopsy was consistent with non-small-cell carcinoma.

Subsequent **radiation-planning whole body FDG PET/CT** revealed intense uptake in the right upper lobe lesion but also noted intense uptake in the right hilar and paratracheal nodes and a left hilar node. Staging was changed to Stage 3B. She was not a surgical candidate and primarily she was offered a combination of radiation therapy and systemic chemotherapy. Both tumor staging and radiation treatment volume were changed as a result of the PET/CT.

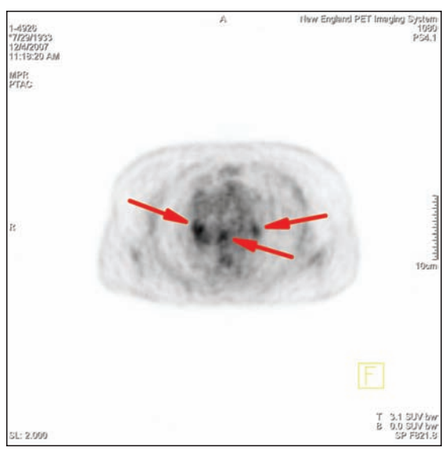
Fused PET/CT



PET—main tumor



PET only—additional nodes



PET axial—additional nodes

PET/CT's Application in Radiation Oncology, continued from page 2

planning, dose escalation is possible with an improvement of cure rate and the reduction of side effects to the normal structures. Anatomic imaging as provided by CT is limited when distortion of normal anatomy occurs because of prior surgery, radiation, or other image artifacts such as a dental filling.

Recent reports indicate **target volume changes as high as 62%** due to improved display of local tumor extent and more accurate identification of local nodal area or skip areas that are not well visualized on CT alone. An additional significant benefit derived from the inclusion of functional PET images is a decrease in inter-observer variability in the definition of tumor contours by the radiation oncologist.

PET/CT and Radiation Therapy Planning

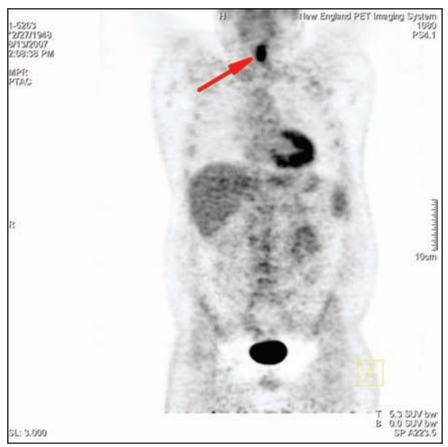
In a prospective study of 30 patients with non-small-cell lung cancer, **more consistent definition of tumor target**

Continued on page 4

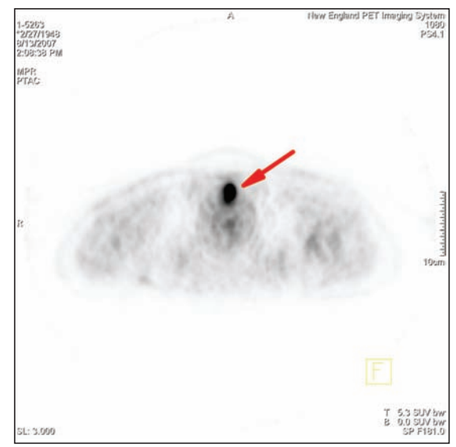
Case #3

This patient is a 59-year-old male who presented with hoarseness. Endoscopy revealed a bulky laryngeal tumor. CT scan revealed a **large laryngeal mass and left cervical node.** He was staged as T3 N1 M0.

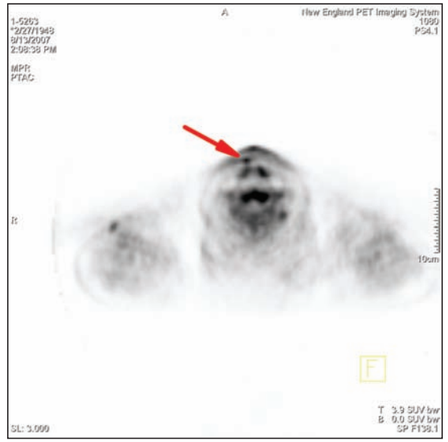
Subsequent **radiation-planning whole body FDG PET/CT** demonstrated the large left-sided laryngeal mass and posterior cervical node seen on CT but also showed bilateral anterior cervical lymph node involvement and the stage was changed to T3 N2B M0 carcinoma. This also changed the radiation treatment field and the dose.



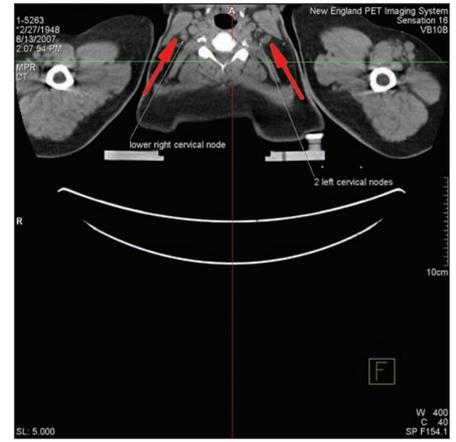
PET coronal primary



PET axial primary



PET axial high right submental node



CT axial—right and left low cervical nodes posterior to the jugular veins