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ORIGINAL ARTICLE

Pre-operative estimation of esophageal tumor metabolic length in FDG-PET images with surgical pathology confirmation

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Abstract
Objective The aim of this study was to evaluate a 3D tumor segmentation method for fluorodeoxyglucose positron emission tomography (FDG-PET) in the context of noninvasive estimation of tumor metabolic length (L_m), as it correlates with surgical pathology and phantom results.
Methods Thirty-four patients (7 women, 27 men) with esophageal cancer were retrospectively evaluated. All patients underwent FDG-PET-computed tomography (CT) imaging following endoscopic ultrasound (EUS). Seventeen patients had esophagectomy after PET/CT, without prior neoadjuvant therapy. Tumor length was assessed by EUS (L_e, $n = 31$) and histopathology (L_p, $n = 17$). Images were evaluated quantitatively with a 3D threshold-based region-growing program (Medical Image Processing Analysis and Visualization). L_m, total metabolic volume (V_m), maximum standardized uptake value (SUV_{max}), and average SUV (SUV_a) over the entire tumor were obtained for several threshold values (mean activity in the liver plus 0-, 1-, 2-, 3-, and 4-SD of the activity in the liver).
Results L_m showed a good correlation with L_p for all thresholds (best correlation for $L_{m(2\text{-}SD)}$, $r = 0.74$, $P < 0.001$). A positive nonsignificant correlation was observed between L_p and L_e ($r = 0.30$, $P = 0.29$). $L_{m(2\text{-}SD)}$ correlated well with L_e ($r = 0.71$, $P < 0.001$). Good correlations were also observed between $L_{m(2\text{-}SD)}$ and $V_{m(2\text{-}SD)}$ ($r = 0.89$, $P < 0.001$) and $SUV_{a(2\text{-}SD)}$ ($r = 0.38$, $P < 0.05$). $V_{m(2\text{-}SD)}$ also had a significant correlation with L_p ($r = 0.61$, $P < 0.05$) and L_e ($r = 0.57$, $P < 0.001$).
Conclusions FDG-PET-derived tumor metabolic length of untreated esophageal carcinomas correlates well with surgical pathology results, and provides preliminary evidence that noninvasive delineation of the superior and inferior extent of viable tumor involvement might be feasible using computer-generated metabolic length measurements.

Keywords PET/CT · FDG · PET · Esophageal cancer · Tumor length · Tumor segmentation

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Introduction

Esophageal cancer is the seventh most common cause of cancer-related deaths in developed countries. Lower esophageal adenocarcinomas are increasing in incidence at a faster rate than any other type of gastrointestinal cancer [1]. Despite improvements in surgical and neoadjuvant therapies, the majority of patients with esophageal carcinoma die within 1 year of diagnosis, and only approximately 17% of patients are alive at 5 years, with a median survival of 18 months [2].

It is believed that tumors involving long segments of the esophagus are likely to be more advanced and carry a worse prognosis than shorter lesions. Earlier studies

Representative Results:

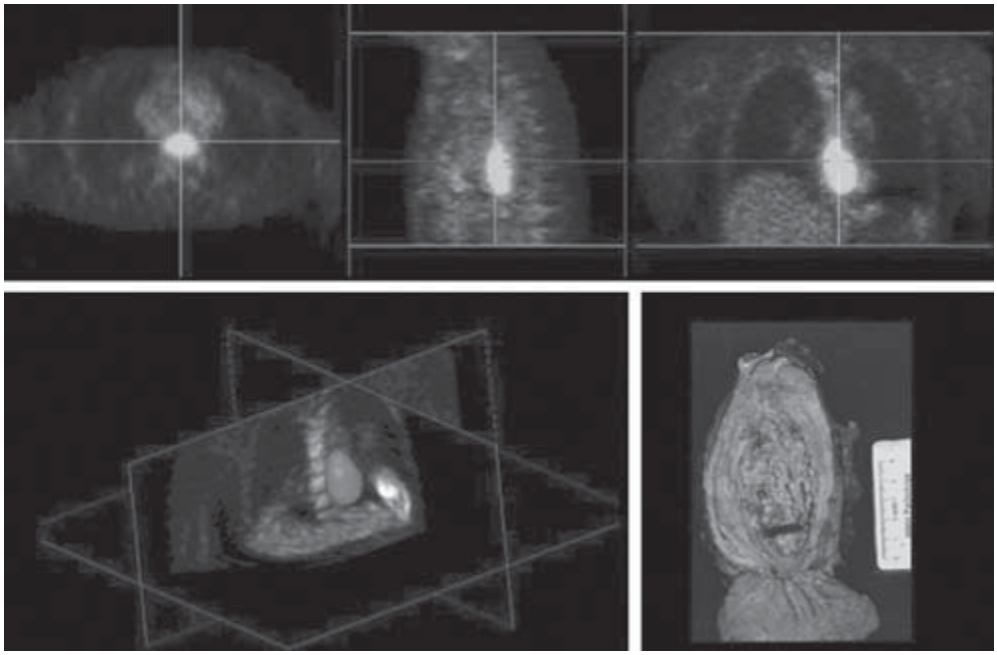

Fig. 2 Example of a typical case with multiplanar and volume rendering images and its corresponding surgical specimen (subject #9). **a** Multiplanar image with its respective volume of interest generated from the iterative algorithm by medical image processing analysis and visualization using 2-SD threshold (metabolic tumor length was defi ned as 45.8 mm). **b** Volume rendering image of esophageal tumor (5.7 cm3). **c** Surgical specimen from subject #9 (tumor length defi ned by pathology as 60 mm)