Introduction

- ¹⁸F-fluorodeoxyglucose Positron Emission Tomography with Computer Tomography (FDG-PET/CT) is widely used in diagnosis, staging, and restaging of human solid tumors.

- FDG standardized uptake value (SUV) has been used as an index of metabolic activity for diagnosis and therapy assessment of these tumors. Disadvantages in SUV measurements have led to the development of the metabolic tumor volume (MTV) and total glycolytic activity (TGA) as biomarkers for better characterizing tumors.

Objectives

- Establish the reliability between pathological tumor volume and the invivo FDG PET metabolic tumor volume using different segmentation methods.

Methods

- Patient Selection
  - Patients selected for study had undergone:
    - A baseline PET/CT scan and subsequent resection of head and neck, lung, colorectal tumors between 2007-2011 at BMC.
    - Patients were excluded from this study if they received any therapy between the time of the baseline PET/CT and tumor resection.
    - 53 patients with lung, head and neck, and colorectal cancer were included in the study.
  - Median time interval between the in vivo metabolic tumor volume PET/CT and enbloc surgical resection was 4.7 weeks.

- Two semi-automated segmentation methods were used to estimate the in vivo metabolic volume of the tumors.
  - (a) Gradient Based Segmentation method
    - The center of the lesion is estimated by the reader.
    - 6 axes extend radially from the assigned center with spatial gradients calculated along each axes.
    - The length of the axis reflects and is limited by the size of the gradient between the tumor FDG uptake and background uptake.
    - The result is an ellipsoid estimate of the lesion defined by the detection of a gradient in each axis.

- (b) Fixed Threshold Segmentation
  - The reader defines a sphere using axial, sagital, and coronal imaging planes to cover the area of a primary tumor.
  - Voxels within that sphere greater than a reader-defined percentage (30%, 40%, or 50%) of the maximum voxel are delineated from the surrounding tissue.
  - The edges of the primary tumor are outlined and calculated using the boundaries of the delineated tissue.

Pathological Volume

- Ellipsoid volume calculated using three dimensions of pathologic volume using the following formula: Pathological volume = \( \pi/6 \times (d_{path}^2 \times d_{path} \times d_{path}) \)

Methods

- Results

Figure 1: (A) Enbloc resected right upper lobe non small cell lung cancer (B) Invivo PET metabolic volume (C) Invivo CT tumor volume. A well circumscribed yellow/white right upper lung lobe tumor measuring 7.5cm x 6.5cm x 6.5cm. The tumor was resected along with the right upper lung lobe. The pathological volume was calculated using the formula for the volume of an ellipsoid figure. The correlation and reliability of in vivo PET metabolic volume and pathological volume was established using Pearson’s correlation and Bland Altman analysis.

Results

- Figure 2: Pearson’s correlation coefficient between pathological volume of the tumor and in vivo FDG metabolic volume. The correlation coefficients \( r^2 \) were 0.86, 0.61, 0.71, 0.79 for gradient, 30% SUVmax, 40% SUVmax and 50% SUVmax segments respectively (P<0.001).

Figure 3: Bland Altman Analysis for gradient and fixed threshold (30%, 40% and 50% SUVmax) method metabolic tumor volume segmentation and pathological volume. The biases were 0.3 ml (SD 10.7), 2.0ml (SD 17.0), 2.82 (SD17.83) and 5.9ml (SD18.2) for gradient, 30% SUVmax, 40% SUVmax and 50% SUVmax segmentation, respectively.

Conclusion

- Gradient method of segmentation of in vivo metabolic tumor volume has the least bias, variability and best correlation with pathological volume of human solid tumors.
- This method of segmentation can be used in predictive and prognostic biomarker development in human solid tumors.

References


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