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METHODS OF SEGMENTATION OF METABOLIC TUMOR VOLUME MEASURED BY POSITRON EMISSION TOMOGRAPHY

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ABSTRACT
PET/CT is a very valuable tool in the follow up of many types of malignancies, SUVmax is the most commonly used PET parameter and represent the voxel of the highest activity within the ROI. However, other parameters as MTV gain an interest in recent studies. Metabolic tumor volume (MTV) is a measurement of the tumor volume with a high metabolism and multiple studies have shown that baseline MTV has prognostic value. Quantification of MTV is time-consuming, especially when performed on patients with disseminated diseases or the metabolically active lesions is overlapped with areas of physiologic uptake of the radiotracer, so there is great interest in automated calculation of MTV. Different imaging processing methods have been developed to define MTV with a widespread interest in the development of automated segmentation algorithms. Numerous PET segmentation algorithms have been developed and applied to FDG PET images which can generally be classified into threshold-based methods and algorithm-based methods.

KEYWORDS: *Positron Emission tomography, metabolic tumor volume, tumor segmentation methods.*

INTRODUCTION
^{18}F-Flurodeoxy glucose positron emission tomography (18F-FDG PET)/CT is an integrated imaging technique, which provides both functional metabolic data from18F-FDG PET and structural anatomic information from CT in one examination. PET/CT is very valuable in diagnosis, staging, restaging and follow up of many types of malignancies.[1]

There is an increasing evidence for the prognostic value of quantitative parameters obtained from initial staging using 18FDG PET/CT in patients with many solid tumors. To date, the SUVmax has been the most widely studied parameter. More recent studies include the volume-based metabolic assessments such as MTV and TLG.[2]

Metabolic tumor volume (MTV) is a measurement of the tumor volume with a high metabolism, MTV theoretically has prognostic value in a variety of malignancies with multiple studies have shown that baseline MTV has prognostic value and high MTV is a predictor of worse prognosis.[3]

Quantification of MTV is time-consuming, especially when performed on patients with disseminated diseases or the metabolically active lesions is overlapped with areas of physiologic uptake of the radiotracer, so there is great interest in automated calculation of MTV.[4]

Different imaging processing methods have been developed to define MTV with a widespread interest in the development of automated segmentation algorithms for PET as there is strong dependence of most image-derived response indices on quantification of lesion volume so standardization and consistent determination of these volumes in PET images is required so there has been a rapid growth of segmentation algorithms for PET reported in the literature.[3]

METHODS TO SEGMENT TUMOR FOR MEASURING MTV
Numerous PET segmentation methods have been developed and applied to FDG PET images which can generally be classified into threshold-based methods and algorithm-based methods, both classes can be further broken down into subclasses. the algorithm method is more advanced and sophisticated than threshold-based methods, and this method requires familiarity with professional image analysis software. In contrast, threshold-based segmentation methods can be easily

implemented and widely used because of their simplified methodology.[5]

The different proposed PET segmentation strategies were validated in ideal condition (e.g. in spherical objects with uniform radioactivity concentration), while the majority of cancer lesions doesn't fulfill these requirements.[6] Difficulties encountered by these algorithms for automatic lesion segmentation in PET images are local contrast variations due to heterogeneous FDG uptake in the lesion, adjacent FDG-avid anatomy and lymph nodes, and relatively high noise content of PET images, often rendering the task of automatic lesion delineation challenging.[7]

1. Threshold-based methods

In threshold-based methods, the image is partitioned into tumor and background using a distinct threshold value—all voxels with SUV above the threshold are assigned to the tumor, and all SUV below the threshold belong to the background.[5] Many methods exist: fixed absolute threshold, fixed relative method, background threshold, adaptive threshold methods.[8]

Regarding absolute SUV thresholds, all voxels with SUV above the fixed-absolute threshold value within the VOI are assigned to the tumor and those below the threshold are considered background. SUV2.5 is the most widely accepted threshold because of its consistently good prediction for prognosis. For relative thresholds, which are defined as a certain percentage of the SUVmax of a tumor, 40% or 42% are the most widely accepted thresholds for their predictive values.[9]

2. Algorism based method.

The developed PET segmentation algorithm combines an automatic threshold-based algorithm for the definition of MTV and a k-means clustering algorithm for the estimation of the background. The method is based on parameters always available in clinical studies. Validation of the method was performed both in ideal (e.g. in spherical objects with uniform radioactivity concentration) and non-ideal (e.g. in non-spherical objects with a non-uniform radioactivity concentration) conditions.[7] These methods include Gradient-Based Methods, Classifier-Based Method, Statistical Methods

Best Condition For Each Tumor Segmentation Methods

The optimal tumor segmentation method may be different according to the purpose of the study, In a study by IM HJ et al they recommend using fixed absolute threshold method when the study purpose is predictive of prognosis, while algorithm-based methods may be more suitable for estimating MTV during or after treatment since the methods are compatible with tumors with various ranges of FDG uptake values.[3]

CONCLUSION

Several MTV segmentation methods are present in literature, although the optimal tumor segmentation method may be different according to the purpose of the study, standardizing one or two methods for segmentation may be required for better comparative studies.

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