Overview: Quantitative methods of tumor response have traditionally been global in nature and primarily began with monitoring changes in tumor maximal diameter. Over time, methods have progressed to involve monitoring changes in volume and now also include FDG-PET measures of response such as SUVmax and Total Glycolytic Activity (SUVmean x volume). These measures have become more prevalent with the increasing use of PET/CT for monitoring response. FDG-PET has begun to play an important role in the earlier detection of response with changes in the metabolic activity of tumors often being seen earlier than anatomical changes.

MIM provides a comprehensive multimodality solution for quickly and accurately generating quantitative statistics for therapy response. Tools are provided to aid the clinician from initial diagnosis to follow-up with multiple comparison exams over time to monitor response to therapy.

Tumor Segmentation: When using tumor statistics to evaluate response such as volume and Total Glycolytic Activity, accurate tumor segmentation is essential. PET Edge, an automatic PET segmentation tool, is based on image intensity gradients and has been shown to provide more accurate and consistent results1, with less inter-observer variability2, than constant threshold PET segmentation methods and manual contouring.

PET Edge uses the actual image data and is not affected by display contrast, which is one of the limitations of manual visual contouring techniques. PET Edge is able to account for heterogeneous activity in tumors, which is not possible with constant threshold techniques, and is less sensitive to changes in source-to-background ratio and partial volume effects1. In data presented at the SNM 2009 Annual Meeting, D Nelson et al demonstrated that the more accurate segmentations from PET Edge resulted in statistically more accurate Total Glycolytic Activity measures. This result has the potential to be important with the increasing evidence that Total Glycolytic Activity can play an important role in prognosis3,4 and therapy response3,5.

Segmented tumors can be saved as RTstructs for comparison to later exams, saved to PACS, or sent to treatment planning systems for use in Radiation Therapy. Accurate segmentations of the PET data is essential when this information is being used in creating target volumes for radiation treatment.

Visualize Changes: Changes between exams are highlighted through the creation of Difference Images. Difference images are created by subtracting the previous PET from the current PET, providing quantitative results, tumor activity graphs, and visual confirmation of changes over time (see Figure 1). Contours can also be rigidly or deformably copied from the previous exam to the current exam, allowing tumor statistics to be calculated even when there is negligible FDG tumor uptake on the current exam.

For situations where tumor size changes significantly during treatment making rigid comparisons insufficient, a CT deformable registration method can be used to compensate for changes in size and shape (see Figure 3). PET/SPECT image volumes aligned to CT image volumes, as well as contours, can be deformed with identical parameters used to deform the CT image volume. While global measures of tumor response can play an important role in assessing changes from therapy, tumors may also have regional differences in tumor response due to: 1) Varied cell division rates across the tumor; 2) Regional blood flow differences within the tumor that affect delivery of chemotherapy or monoclonal therapy; and 3) Regional variation of radiation damage due to hypoxia and changes in tumor size and shape during therapy. Through the use of difference images, subtracting the activity from one time point to the next, regional differences in uptake between exams can be highlighted.

MIM automatically registers any number of exams using the accuracy of a CT-CT registration, allowing easy comparison of any number of time points. Tumor contours from the previous time points can be loaded and the new PET/CT can be quickly contoured with PET Edge, providing quantitative results, time activity graphs, and visual confirmation of changes over time (see Figure 2). Contours can also be rigidly or deformably copied from the previous exam to the current exam, allowing tumor statistics to be calculated even when there is negligible FDG tumor uptake on the current exam.

References:

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