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Target volume delineation of FDG PET images post one cycle of induction chemotherapy in oropharyngeal cancer using advanced automated segmentation methods

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Introduction

FiGaRO is a feasibility study investigating the role of dose escalation based on ^{18}F-FDG-PET using intensity-modulated radiotherapy (IMRT) in patients with primary oropharyngeal tumours post one cycle of induction cisplatin and 5-fluorouracil (5FU) chemotherapy. In IMRT accurate delineation of the biological gross tumour volume (GTV_{PET}) from PET imaging is critical to achieve highly conformal dose to the target volume whilst minimising dose to neighbouring organs at risk. Segmentation algorithms applied to ^{18}F-FDG PET imaging (PET-AS) have an impact on the GTV_{PET}.

Aims & Objectives

The aim of this study was to evaluate the performance of PET-AS methods in the delineation of the GTV_{PET} from FDG PET images acquired post one cycle of induction chemotherapy.

Materials & Methods

Twenty-three patients were enrolled between October 2013 and March 2017. After exclusions, twenty patients with squamous cell carcinoma (SCC) of the oropharynx were included. Approval for the feasibility trial by the research ethics committee was granted in July 2012 (REC:12/LO/1724). Patients received 1 cycle of neoadjuvant cisplatin and 5FU chemotherapy with repeat PET/CT imaging acquired at 3 weeks. 350MBq of ^{18}F-FDG was administered with scan acquisition at 90 minutes' post injection. The GTV_{PET} was delineated by a nuclear medicine physician and a clinical oncologist. Contours were derived using sixteen PET-AS, including the machine learned method ATLAAS [1,2]. Table 1 describes the implementations of the PET-AS. The volume of the PET-AS derived GTV_{PET}, as well as the Dice Similarity Coefficient (DSC) was calculated in comparison to the clinician-derived GTV_{PET}.

Results

- Figure 1 shows box plots of the mean DSC for the sixteen PET-AS methods used to contour the MTV compared to the GTV_{PET}.
- Mean DSC (+/- SD) for ATLAAS, 60% Peak Thresholding (60%), Adaptive Thresholding (AT) and Watershed Thresholding (WT) was 0.72 (+/- 0.10), 0.61 (+/- 0.20), 0.63 (+/- 0.15) and 0.60 (+/- 0.21) respectively.
- The mean volume [range] derived by ATLAAS was 6.01 [1.3 – 24] mL, 60% 8.66 [3.28 – 44.01] mL, AT 3.85 [1.30 – 8.75] mL, WT 7.20 [0.54 – 27.55] mL. The mean volume of the GTV_{PET} was 6.22 [1.12 – 21.25] mL.
- Figure 2 shows GTV_{PET} contours for AT, ATLAAS, 60% and GCM3. A Kruskall Wallace test showed significant difference (P = 0.0003) between the manually derived GTV_{PET} volume and the volume delineated by ATLAAS, PT60, AT and WT PET-AS methods.

Conclusion

Compared to other PET-AS methods, ATLAAS had the highest DSC, smallest SD and the volume was the most consistent with the manually derived GTV_{PET}, demonstrating machine learning can improve the robustness and accuracy of automated segmentation in H&N cancer. ATLAAS segmentation compared very well with manual expert delineation of the GTV_{PET} in FDG PET images acquired post one cycle of induction chemotherapy in Oropharyngeal cancer. AT was the second best performing segmentation method.

Table 1: Descriptions of PET-AS used to delineate GTV_{PET}.

Algorithm	Description
AT	3D Adaptive iterative thresholding, using background subtraction
RG	3D Region-growing with automatic seed finder and stopping criterion
KM2/KM3	3D K-means iterative clustering with custom stopping criterion
FCM2	3D Fuzzy-C-means iterative clustering with custom stopping criterion
GCM3/GCM4	3D Gaussian Mixture Models-based clustering with custom stopping criterion
WT	Watershed Transform–based algorithm, using Sobel filter.
ATLAAS	A decision tree based segmentation methodology incorporating individual PET-AS included within this study.

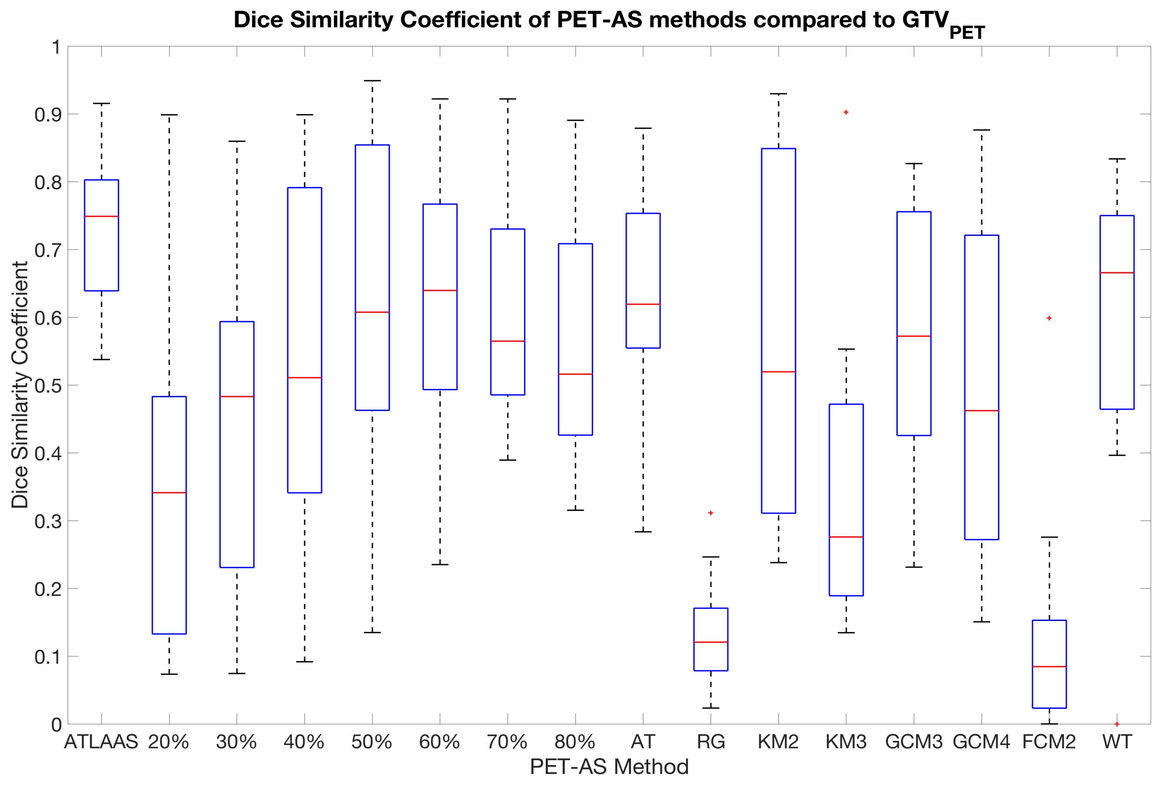

Figure 1: The mean DSC for the GTV_{PET} derived by sixteen PET-AS methods compared to the manually derived GTV_{PET}.

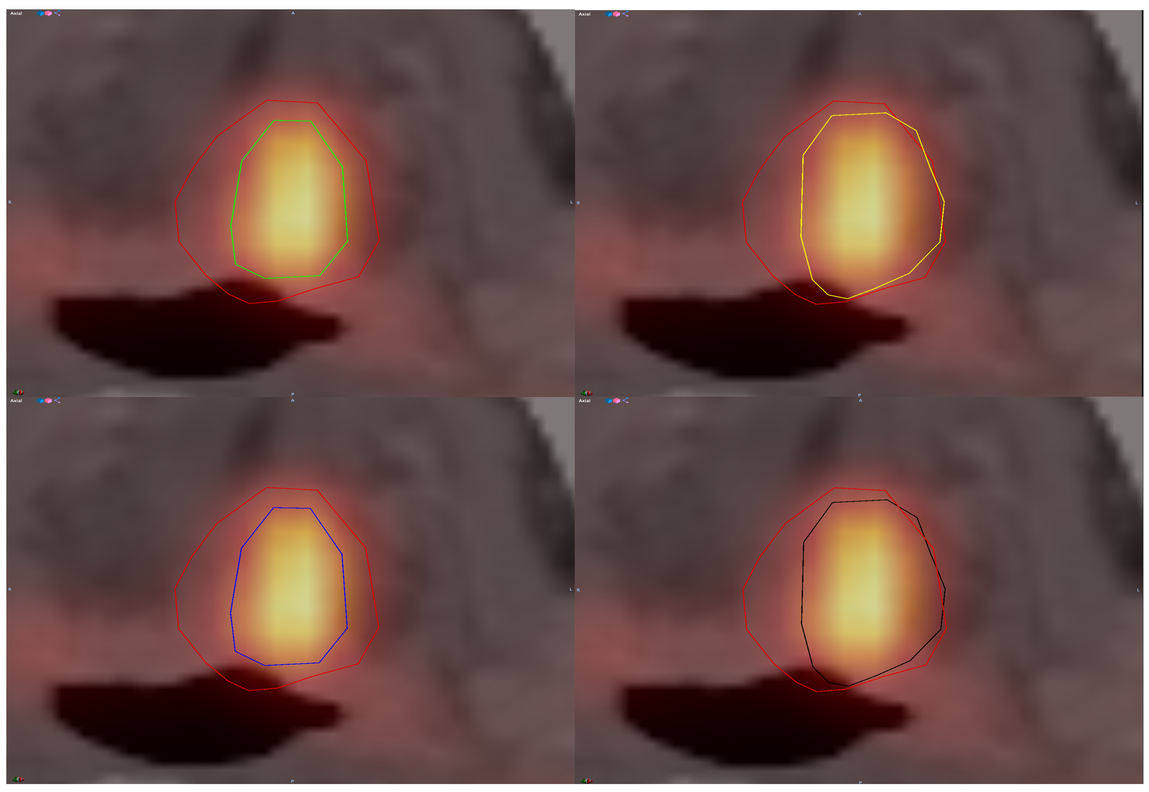

Figure 2: The GTV_{PET} delineation for AT (Green, top left), ATLAAS (Yellow, top right), 60% (Blue, bottom left), WT (Black, bottom right) compared to manual GTV_{PET} (Red).

References

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