

PET TUMOR SEGMENTATION: MULTI-DISCIPLINARY VALIDATION OF A GRADIENT-BASED METHOD USING A NSCLC PET PHANTOM



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Objectives

A consistent and accurate method for PET tumor segmentation is needed for Radiologists and Radiation Oncologists alike to aid in therapy response and radiation therapy planning. Previously we demonstrated the superior accuracy of a gradient-based PET segmentation method (Gradient) to constant thresholds¹⁻³ and manual contouring^{1,2}. Gradient is a spatial derivative method that defines the tumor edge based on the changes in count intensity (Figure 1). In this current study we used a larger cohort of observers including Radiation Oncologists and PET-trained Radiologists to evaluate the Gradient method, the Constant Threshold method (Threshold), and Manual contouring using Monte Carlo simulated PET scans of the thorax. The simulated PET scans used were designed specifically to test PET segmentation methods and were validated with statistical and visual comparisons to real FDG-PET images from patients and determined to mimic clinical reality well⁴.

Methods

Thirty-one tumors of varying size (7-265ml), shape and location were simulated. Observers (4 Radiation Oncologist, 3 Radiologists) segmented each tumor with Gradient, Threshold, and Manual Contouring. Threshold was performed using 25-50% of maximum counts at 5% increments. Tumor volumes for each method were compared to known volumes prior to simulation. Accuracy was measured by calculating the mean absolute % error in volume and bias by the mean % error in volume for each group using all methods.

Results

Gradient was the most accurate technique (see Table 1) with an overall mean absolute % error of 10.99% (11.9% SD). 25% Threshold, with 17.5% (29.4%), and Manual Contouring, with 19.5% (17.2%), were significantly less accurate (p-value < 0.01). Gradient also had the least systematic bias (see Table 2) with an overall mean % error of -0.05% (16.2%) compared with -2.1% (34.2%) and -16.3% (20.2%) for 25% Threshold and Manual, respectively (p-value < 0.01). Inter-observer variability was significantly reduced using Gradient compared to both 25% Threshold and Manual contouring (p-value < 0.01, Levene's Test). There were no significant differences between Radiologists and Radiation Oncologists for accuracy using any of the methods.

Conclusions

Gradient was the most accurate and consistent PET tumor segmentation technique for both Radiologists and Radiation Oncologists and has the potential to play an important role in both therapy response and radiation therapy planning. Further studies using pathological size confirmation are planned for additional clinical validation.

Figure 1
Spatial Derivative

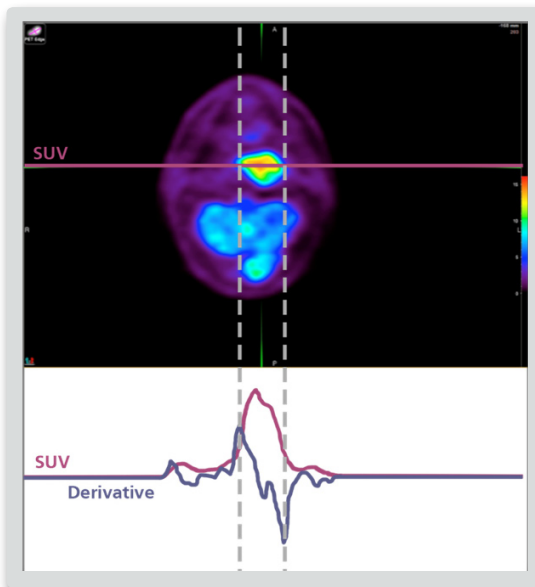


Table 1
Accuracy (Mean Absolute % Error)

Technique	Nuclear Radiologist Observers			Radiation Oncologist Observers				Overall (Average)	Standard Deviation
	1	2	3	4	5	6	7		
GRADIENT	10.80	8.38	11.92	11.02	10.98	13.11	10.78	11.00	11.93
MANUAL	10.99	11.24	30.47	25.18	13.60	36.54	8.24	19.47	17.17
25% THRESHOLD	16.37	30.77	16.64	11.24	13.43	12.78	21.58	17.54	29.44

Table 2
Bias (Mean % Error)

Technique	Nuclear Radiologist Observers			Radiation Oncologist Observers				Overall (Average)	Standard Deviation
	1	2	3	4	5	6	7		
GRADIENT	0.93	2.01	-0.12	-0.51	-0.35	-3.87	1.55	-0.05	16.24
MANUAL	-7.96	-6.76	-29.18	-23.37	-7.28	-35.28	-4.58	-16.35	20.17
25% THRESHOLD	0.18	17.72	2.94	-6.39	-5.54	-4.21	-19.28	-2.08	34.23

References

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