Interobserver variation in target delineation -what does it mean?

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Some uncertainties include; Motion of the target. Patient setup errors. Patient movement. Target delineation error.

- Target movement Displacement and deformities can occur –
 - -Between fraction (interfraction).
 - -During beam delivery (intrafraction).
- Cause physiological Rectum & bladder filling, resp. cardiac movement.
- Set up error /Pt movement Isocenter shift.
- IGRT addresses the issue of target movement.
- Many imaging techniques have been introduced to track the motion of tumour.

The difference in precision and accuracy. The centre of the circle represents the true value and the black dots represent the measured values.

- (a) Is the traditional 3D conventional RT.
- (b) Is the conformal RT with small margin.





- Target delineation the problem;
- Current definition of target volume as proposed by ICRU – GTV, CTV, PTV
- GTV visible disease on imaging.
- CTV- subclinical and microscopic spread.
- These are below the resolution of modern imaging.
- Margins are based on assumptions built from clinical or pathological experience.
- Subject to high degrees of uncertainty.
- Making target delineation highly imprecise.

- Major sources of tumour volume delineation variation are-
- Visibility of the target, including its extensions - impact of imaging protocol.
- Disagreement on the target extension.
- Interpretation or lack of delineation protocols.

Visibility of the target- impact of imaging protocol



Disagreement in target delineation.



Variations in H&N target delineation. Highly distinct CTV designs from two H&N experts which illustrate broad variation in target delineation strategies for the identical tonsil case.

A side-by-side comparison of the differences between six different subspecialist delineators is shown on just a single slice from a cervical cancer patient (extracted from up to 40 slices acquired



Jr of applied Med. Physics 2005 Dee H Wu et al

Volumetric differences are illustrated graphically for different delineators across 20 cervical cancer patients.



Patient Evaluated

Challenges noted for tumor delineation included the following:

(1) Partial voluming by parametrial fat at the periphery of the uterus;

(2) Extension of the tumor into parametrial space;

(3) Similar signal intensity of structures proximal to the tumor such as ovaries, muscles, bladder wall, bowel loops, and pubic symphysis;

(4) Postradiation changes such as heterogeneity and necrosis;

(5) Susceptibility artefacts' from bowels and vaginal tampons;

(6) Presence of other pathologies such as atypical myoma;
(7) Factors that affect pelvic anatomy, including the degree of bladder distension, bowel interposition, uterine malposition, retroversion.



Weiss and Hess reviewed literature highlighting the level of inter and intra-observer variability

-The varia. in the ratio of max. to mini. contoured vol. in prostate - 1-1.6

-Variation was highest at top and bottom of prostate.

- At Seminal vesicle level it was 4 fold



Computed tomography image (detail) of a Patient with the contours made by 11 radiation oncologists.

Target volume delineation for partial breast radiotherapy



British Columbia Cancer Agency Seroma Clarity Scale.



- a) Conformity index (CI) = ratio of overlapping volume to encompassing delineated volume. Diagrammatic representation of CI 0, 0.5, and 1.
- b) (b) Illustrative case of seroma contouring performed by three observers.

IJROBO 2007 Peterson et al

Illustrative cases with low conformity indices



(a)Computed tomography transverse plane showing a seroma abutting the pectoralis major muscle (yellow contour)

-the presence of a benign breast calcification.

Failure to exclude muscle when contouring the seroma and misidentification of a benign breast calcification as a surgical clip

-low conformity index of 0.46. (b) Computed tomography transverse plane showing a seroma with tissue extension from the core volume. The inclusion of this tissue extension in the seroma definition by one observer reduced the conformity index to 0.50. (c) Computed tomography transverse plane showing a seroma located near the skin surface, with indistinct borders and dense surrounding breast parenchyma. The conformity index was 0.38.

- The widest range in inter-observer variation was reported in the delineation of -
- Head and neck cancers.
- Esophageal cancers.
- Lung cancers.
- The size of the largest GTV was more than eight times the size of the smallest volume.

- Weiss et al concluded that,
- Inter-observer variations in the delineated vol. have to be considered even for well circumscribed carcinomas such as prostate and cerebral tumors.
- Average factor of variations was from 1.3 to 2.

- Delineation of the critical organs- also impacts the evaluation of the treatment plan.
- Saarnak and colleagues found interobserver variations of 10% in the bladder and of 11% in the rectum.
- Differences in delineation among the observers were attributed to unclear organ boundaries in the CT images.



(b)





- Causes of variability in target delineation that can be attributed to many factors-
- Impact of imaging (imaging modality and the technique).
- Influence of the observer (specialty, training, and personal bias).
- There are variable interpretations of the extent of microscopic involvement.

Solution

- Despite developments in CT and better visibility of the tumors-
- Interpretation of target extension remains a major source of error.
- CT has limitations in terms of distinguishing between benign and malignant tissues.

- The visibility of the target can be greatly improved with the use of multimodality imaging.
- By co-registration of CT with a second modality such as-
- Magnetic resonance imaging (MRI) and/or Positron Emission Tomography (PET).

- CT-MRI co-registration decreases the target volume and its variability in -
- Prostate.
- Head and neck.
- Rectal cancers.
- MRI good depiction of soft tissue extension.
- Easy acquisition of multiplanar view.

- Villeirs etal did a quantifying study in interobserver variation of prostate and seminal vesicle delineations using CT only versus CT + MRI in consensus reading with a radiologist.
- 13 patient.
- 3 radiation oncologist delineated first on CT subsequently with the addition of MRI data.
- Results:
- Using CT + MRI as compared to CT alone, the mean CTV, prostate and seminal vesicle volumes significantly decreased by 6.54%, 5.21% and 10.47%, respectively.





inter-observer variability in prostate cancer delin. dropped by a factor of up to 3.5 when MRI is used with CT. Base of tongue cancer imaged with CT and MRI showing a large mass on the left side of the oropharynx. These features are better visualized using MRI than CT.







CT and MRI scans showing a rectal cancer in the lower rectum.



Growth extending to the anorectal junction with invasion of the left posterolateral wall.

<u>CT-PET co registration</u>

- CT not suitable for distinguishing between malignant and non malignant tumor.
- PET on other hand is limited by poor spatial resolution.
- Despite limitation FDG-PET has an accuracy of 85% to 100% in identifying pathologic lymph nodes.
- The limitations of both modalities have been significantly reduced by combining PET/CT.

¹⁸ F -FDG PET in delineating volume of lung cancer



CT slices from patient with lung cancer located in left hilar region, associated with retro-obstructi-ve atelectesis of entire It lung, and associated with major pl effusion.
Metabolic information provided by 18F- FDG PET. Allowing for significant modification of target volume

Target deli. On CT only



Caldwell et al. - found reduction in vol. and obs. variability. The mean ratios of largest to smallest gross tumor volume were 2.31 for CT only and 1.56 for PET/CT co-registered data.

Target deli. With co registration with PET







(e)

PET frequently detected tumor out side CT based GTV (15-34% vol)







IJROBP 2007 Scnigel et al.

¹⁸F-FDG PET can help in delineating GTV before treatment and in replanning radiation treatment during course of treatment. White arrows indicate urinary bladder.



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- It is evident that tumour delineation is the weakest link in radiotherapy accuracy.
- To address the short comings of target delineation.
- Tumour should be characterised in terms of the 3Ms-"morphology, movement and molecular (functional) profiling.
- Continuing education and training on target del. is essential – ASTRO has introduced – e-contouring.

- Improved guidelines for tumour delineation will increase agreement.
- It is also recommended that radiation oncologists collaborate with other specialists.
- With advances in computer programming and imaging technology, especially in functional imaging with PET the possibility exists of making tumour identification and definition less subjective and less observer dependent.

THANK YOU