

## ARTICLE

# “Two are better than one”: a pilot study of how radiologist and oncologists can collaborate in target volume definition

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### Abstract

The purpose of this study was to explore how radiologist and oncologists may work together efficiently and effectively to define target volume for radiotherapy treatment. Ten patients were chosen at random from those needing radiotherapy between December 2004 and June 2005. Sites of primary cancer included head and neck, pelvis, lung and brain. Diagnostic scans were available on the hospital PACS system and radiotherapy planning image data sets were available on the Eclipse radiotherapy planning system. A radiologist and two oncologists (one consultant, one senior registrar) outlined separately and without initial consultation the gross tumour volume (GTV). Analysis of target volume concordance rates was undertaken to assess and explore the reasons for any differences noted. Three of ten volumes defined (all head and neck tumours) were judged to be similar based on quantitative and qualitative data. There were varying degrees of difference in volume definition for the remaining seven patients. In three of these there were differences in GTV but when the treatment volume was drawn the differences were not clinically significant, as any areas of disagreement were included anyway in the fields in both plans. The remaining four cases had showed significant differences between the volume delineated by the oncologist and the radiologist. In all cases where the GTV was easily identifiable on the diagnostic and planning scans, there was concordance. In cases where the final treatment field used was much bigger than the GTV (e.g. a four-field box for pelvic fields) then small differences were negligible, although with conformal therapy these differences could become important. There were specific radiological anatomy learning points for the oncologists and the radiologist needed to be familiar with the process of treatment planning. A larger prospective study will continue to explore the potential gains from and the practicalities of collaborative working.

**Keywords:** Radiotherapy target volume definition; collaboration.

### Introduction

Conformal radiotherapy (CRT) is now the accepted standard for curative radiotherapy of many tumours. It offers the advantage of improved coverage of the tumour and high-risk areas, together with sparing of normal tissues, thereby improving the therapeutic ratio and allowing increased cure with fewer side effects.

CRT relies on the accurate definition of target volumes and critical normal structures, usually on CT images, according to the principles set out in ICRU 62<sup>[1,2]</sup>. The accuracy of linear accelerators in delivering the prescribed dose is very good ( $\pm 1$  mm). The random day to day errors in patient position and quality assurance can be measured, minimized and accounted for in the margins allowed around the tumour (the set-up

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margin) and can be kept to less than 1–3 mm in most situations<sup>[3]</sup>.

Of much more importance are the systematic errors which will affect each daily treatment. Systematic errors occur when malignant cells are not included within the treatment volume due to tumour movement with respiration, incorrect volume definition, positioning errors at CT simulation and tumour shrinkage during the course of radiotherapy. These systematic errors can effectively cause the very precise dose distribution designed for each patient to be moved away from the target. Many can be identified and corrected but incorrect volume definition of the GTV may be a common problem. Systematic errors will tend to be additive rather than cancelling each other out (as set up errors tend to).

The GTV is defined by ICRU 62 as ‘the gross demonstrable extent and location of the tumour growth’ by ‘clinical examination and/or various imaging techniques’. It is usually drawn using contouring software on axial CT slices from the simulation scan. Subclinical tumour extension is encompassed by defining a clinical target volume (CTV), and a further margin is added to take into account differences in treatment set up from day to day (PTV).

The usual practice in the UK is that the oncologist outlines the GTV using clinical information and diagnostic images. If there are questions related to the definition of the GTV, a radiologist is consulted on an ad-hoc basis. It has been established for several tumour sites that different people draw different GTV contours for the same tumour and that radiologists as a group interpret CTs differently from oncologists<sup>[4–7]</sup>. It is not clear why these differences occur but it is often assumed that it may be related to oncologists’ relatively poorer knowledge of radiological anatomy.

The Royal College of Radiologists’ recent document ‘Imaging for Oncologists’ has suggested that ‘the clinical oncologist and clinical radiologist should work together to define the GTV’<sup>[8]</sup> but there is little evidence to guide how this should occur.

When the new radiotherapy department at NNUH was planned, funding was obtained for sessions for a dedicated radiologist to assist with target volume definition for radiotherapy treatment planning. This study is designed to document differences between the radiologist and oncologist in GTV definition, to evaluate the benefits of collaboration, to work towards standard protocols for volume definition at particular tumour sites and to assess by how much more accurate GTV definition contributes to improving the therapeutic ratio.

This pilot study was designed to test the feasibility of the project using retrospective images before a prospective study begins.

## Patients and methods

Ten patients (with archived CT image datasets) who were to receive radical treatment were selected. In all cases the initial history and examination were recorded on the department’s electronic notes system, diagnostic imaging was available on the PACS system and CT images of the patient in the treatment position were available on the Eclipse radiotherapy planning system. The patients had planning CT scans performed without IV contrast with relevant immobilization devices according to unit protocols as part of the planning process. A radiologist and two oncologists (one consultant, one senior registrar) outlined what they considered to be the gross tumour volume (GTV).

In each case the operator was asked to score on a visual analogue scale their degree of confidence in their accuracy of GTV definition. Any difficulties were noted. The time needed to define the contour was recorded. Volumes defined were measured for each participant. The oncologists and radiologist then met to record concordance or disagreement in the volumes and to categorise any differences.

## Results

Ten patients were chosen at random from those treated between December 2004 and June 2005. Sites of primary tumour included head and neck, pelvis, lung and brain. Three of ten volumes defined were judged to be similar based on quantitative and qualitative data (1–3 in Table 1). These consisted of head and neck cases (base of tongue, tonsil, anterior tongue). The remaining seven patients had varying degrees of difference in volume definition, and of these there were clinically significant differences in treatment volumes in four cases.

### *Concordance*

These three were all head and neck cancers (tonsil, base of tongue, anterior tongue) with GTV easy to visualize on both planning and diagnostic images and good descriptions or diagram of tumour extent by ENT surgeons. No patient received induction chemotherapy; all had lymph node negative disease. At present, one patient is alive and well, one has recurrent disease within the GTV and the remaining patient who suffered from congenital muscular atrophy died during treatment from pneumonia.

### *Not concordant but clinically insignificant because of treatment plan chosen*

These three cases included a recurrent squamous cell cancer of the cervix with a large pelvic mass that invaded the left sacral ala, piriform muscle and sciatic

**Table 1** Quantitative and qualitative data

Patient number	Tumour site	GTV (cm <sup>3</sup> )			Score <sup>a</sup>		Time (min)	
		Oncologist	Radiologist	Actual	Oncologist	Radiologist	Oncologist	Radiologist
1	Tonsil	31	30	21	4	4	30	25
2	Base of tongue	31	16	15	4	5	35	25
3	Tongue	53	41	33	2	4	40	30
4	Cervix	396	482		8	9	70	60
5	Lung	107	113	93	9	10	25	15
6	Brain	108	67		8	6	25	20
7	Lung	161	183	230	8	9	40	25
8	Supraglottis	138	119	35	7	6	45	30
9	Tonsil	44	50	27	5	6	40	30
10	Lung	247	152	98	7	5	35	30

<sup>a</sup>Score = confidence score for oncologist or radiologist.

notch. Because of the lack of oral contrast the tumour was difficult to separate from small bowel superiorly. However the GTV outlined by both the oncologist and radiologist was well encompassed by the treatment plan which consisted of a four-field box technique using an anterior, posterior and two lateral fields to treat the whole pelvis. Similarly for a glioblastoma the treatment field was much bigger than the GTV outlined and so the differences between radiologist and oncologist were not clinically significant. In the third patient with a peripheral lung cancer T2N0M0, there was a difference in the GTV defined at the lateral chest wall but when each GTV was expanded to CTV and finally PTV the differences in volume became negligible.

### *Not concordant and clinically significant*

In this group there were two lung and two head and neck cancers (6–10 in Table 1). In the lung cases PET/CT fusion would have helped with the delineation of the superior extent in both cases where it was difficult to differentiate between collapse and tumour. In one case the oncologist included a nodule in the left lower zone which the radiologist felt was a metastasis and not the primary lesion. In the other case the oncologist included the unrecognized left atrial appendage in the GTV. This was poorly visualized on the diagnostic contrast scan with 5 mm slices but was much clearer on a CT pulmonary angiogram with thinner slices which the radiologist used to help define GTV.

In the two head and neck cases, the major differences in GTV definitions occurred when there was very little abnormality on the diagnostic scans. The oncologist relied heavily on the descriptions and diagrams by the ENT surgeons. For one left tonsillar cancer, the radiologist outlined the whole tonsillar fossa which was essentially a CTV rather than the GTV, whereas the oncologist drew according to the ENT descriptions. In this case the radiologist noted a new 8 mm right level 2 lymph node that was not present on the diagnostic MRI scan. This was biopsied before treatment started

and was benign. In the second case the superior extent drawn differed because the oncologist used the ENT diagram and the radiologist used the diagnostic MRI images although the head is not immobilized for this examination and so is not in the same position as the planning CT scan. There was an 8 mm right jugular lymph node obscured by a large internal jugular vein that the oncologist included in the GTV and the radiologist felt was not malignant by size criteria.

Three of the patients are alive and well and one died during treatment of diverticulitis.

In each case the person defining the volume was asked to record the total time taken to draw each GTV. The average time taken for the radiologist was 29 min and by the oncologist was 38.5 min (Table 1).

Each person was also asked to rate their confidence that the GTV reflected the actual gross tumour. This was scored from 1 (not confident) to 10 (very confident). The average score for the radiologist was 6.4 and for the oncologist was 6.2 (Table 1).

## Discussion

Three of the ten volumes defined were judged to be similar based on quantitative and qualitative data. These included three head and neck tumours (base of tongue, tonsil, anterior tongue). In all cases the GTV was easily identifiable on the diagnostic and planning scans.

In three cases the volumes defined were not similar but when the treatment volume was drawn the differences were not clinically significant, as the areas of contention were included in the fields in both plans. These cases included brain, lung and cervix cancers. For example the pelvis case was treated with a four-field box technique so the GTV drawn was well within the field edges in both of the volumes delineated.

In the final four cases (two head and neck, two lung cases) there were differences in the volumes defined by the oncologists and the radiologist. In the two lung cases the differences in GTV were because the oncologist had included normal vascular structures erroneously within

the GTV (no IV contrast was given in the planning CT scans) and because of difficulties differentiating between lung collapse and tumour. In the head and neck volumes the oncologist relied on the ENT diagrams and descriptions, whereas the radiologist used the staging MRI although the neck position was different because of the immobilization device used in radiotherapy planning. Also in one of these cases the radiologist defined a volume that corresponded to the CTV not the GTV.

Planning CT scans can pick up lesions which have appeared since the staging scans, especially new lymph nodes. The radiologist noted a new lymph node discovered on the planning CT that was not present on diagnostic imaging. An ultrasound guided fine needle aspiration was performed and the cytology was negative for malignancy.

Where imaging clearly showed the tumour, concordance between clinicians was good. In some situations it was obvious that access to CT/MRI and PET could have reduced uncertainty.

As anticipated some differences could be explained by the radiologist's expertise in radiological anatomy. Working together with the oncologist provided a teaching/learning opportunity. Unfamiliarity of the radiologist with the process of radiotherapy treatment planning led to some initial areas of confusion. It was not appreciated that radiation oncologists use the full range of window settings to optimize their view of the tumour margins. On one occasion there was confusion over defining CTV (GTV plus a margin for subclinical tumour spread) instead of GTV. There needs to be appreciation of the importance of differences in patient positioning between diagnostic and therapeutic scans.

In three cases differences became insignificant because the treatment plan chosen was not conformal. Increasingly more conformal field arrangements are being used to optimize treatment and these differences might then have become important.

In the remaining cases, differences in GTV led to increased discrepancies as the volumes were expanded

by the margins for CTV and PTV. Small errors at GTV definition could therefore become magnified in the final treatment plan leading to poorer treatment outcomes.

Oncologists took into account clinical data from sources other than diagnostic imaging such as ENT surgical diagrams which were considered to be very informative.

A considerable investment of time by radiologists and oncologists was needed for this study and in practice this may prove to be a constraint for routine joint working.

We are now undertaking a large prospective study with consultant and trainee radiologists and oncologists to assess how quickly concordance develops with learning and what areas require ongoing close collaboration in the process of GTV definition.

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