Stereotactic Body Radiotherapy (SBRT) in the lung is a challenging technique which requires high quality clinical trials to answer the unresolved clinical questions. Quality assurance of these clinical trials not only ensures the safety of the treatment of the participating patients but also minimises the variation in treatment, thus allowing the lowest number of patient treatments to answer the trial question. This review addresses the role of dosimetry audits in the quality assurance process and considers what can be done to ensure the highest accuracy of dose calculation and delivery and its assessment in multi-centre trials.

1. Introduction

Stereotactic Body Radiotherapy (SBRT) is an advanced technique requiring extensive technology that must work correctly and accurately in order to treat patients safely with highly conformal, large dose fractions of highly conformal doses [1,2]. In order to successfully treat an SBRT patient, centres must achieve stringent requirements and use appropriate modalities for treatment. There are currently numerous trials running world-wide to test different approaches for the treatment of lung cancer using SBRT techniques, as well as those which test SBRT against another treatment (e.g., surgery), see Table 1. As there are many aspects to effective and accurate planning and delivery of SBRT, including the use of 4DCT, use of other imaging techniques such as Positron Emission Tomography (PET), motion management, and the use of large and highly conformal doses in very few fractions, the requirements for quality assurance both locally in the centres and from the clinical trial are demanding. The importance of clinical trial quality assurance is most pronounced in the setting of multi-institutional clinical trials where the different aspects of planning and delivery of SBRT will be implemented differently in different centres. The fundamental requirement for the quality assurance (QA) in the trial is to ensure protocol compliance and consistency between the recruiting centres [3]. This is tested by each step of the process from development of the protocol through to patient imaging, planning and treatment where an end-to-end delivery audit can give an indication of the ability to correctly deliver the required dose to the required location, see Table 2. This review examines the role of dosimetry audit in the quality assurance process and considers what can be done to ensure the highest accuracy of dose calculation and delivery and its assessment in multi-centre trials.

2. Clinical trial credentialing

The first and perhaps most important step in trial QA is the definition of the trial requirements. This includes all aspects of the trial, from patient selection criteria, diagnostic and therapeutic imaging to treatment planning, execution and follow-up and guidelines for trial protocol writing have previously been published [15,16] with specifics clearly defined such as the definition of acceptable therapeutic imaging methods, e.g., is 3D imaging allowed or is 4D-CT mandatory? It is particularly important for lung SBRT to specify which image set may be used for delineation...
and dose calculation, as well as margin expansion from Clinical Target Volume (CTV) to Planning Target Volume (PTV) or Internal Target Volume (ITV) [17,18]. To properly define the OAR and target volumes, delineation examples are often given in the protocol, although several delineation atlases have also been developed to help maximize consistency [19–23].

Dose volume criteria must be clearly defined in the trial protocol, and these form the basis on which benchmark cases (planning exercises on anatomy similar to the protocol) and patient cases are reviewed. In order to prevent confusion about the content of QA procedures, it is advised to use the trial QA nomenclature consensus as proposed by the Global Harmonisation Group [24]. To review benchmark or patient cases, the differentiation between per protocol, acceptable variation, and unacceptable variation must be clearly defined in the protocol.

Some trials have specific imaging protocols for simulation (e.g. ROSEL [18]), whilst others are more open to the techniques already used in the centres [9,10]. These may be CT only based or may allow the use of PET-CT. To date there has been little quality assurance carried out on these imaging methods, however an audit has been developed in the UK for end-to-end dosimetry of motion management, which includes the use of 4DCT for the pre-treatment imaging [25]. Issues exist with consistency in using different approaches for volume delineation in 4DCT. A trial protocol should have guidance to help reduce these with the aim of standardization across the different centres, and most SBRT lung trials now promote the use of 4DCT. Similarly, for treatment execution, it is important to define the level of image guidance that is needed. Some trials accept Electronic Portal Imaging Device (EPID) based set-up verification, whereas others mandate volumetric (Cone Beam CT (CBCT)) imaging [7,8,18] and in future may promote 4D CBCT. To date there has been less emphasis on quality assurance of the imaging which a centre undertakes during treatment delivery. However some trials, such as LungTech [8] collect all the CBCT data and associated set-up corrections in a retrospective manner. Using this data, reconstruction of the actual given dose is foreseen. This data, combined with the local control data and toxicity information, will be used to improve the respective TCP and NTCP models.

The use of benchmark cases or pre-treatment patient case review (i.e. review of the case after planning but before treatment has begun) is of particular importance in SBRT trials as many departments may have to cope with different prescription approaches from their routine clinical practice (e.g. to different iso-dose lines). Reviewing a benchmark or patient case before a treatment has been conducted can aid in the training of the centre to fully understand and implement the trial protocol with more routine post-treatment case reviews used to confirm that the newly learned approach is being consistently applied.

### 3. Dosimetry audit

Consistency in clinical trials is essential to provide proper study power and prevent important findings from being obscured. As described above, consistency means that institutions prescribe doses according to the protocol specifications. However, it is equally important that institutions accurately deliver the dose they have prescribed. The most robust test of dose delivery is an independent end-to-end dosimetry audit, as offered by several clinical trial QA and other QA groups around the world [26–28]. Such audits are typically based on a phantom that the institution treats like a patient. The delivered dose is compared against the dose calculated by the institution’s treatment planning system (TPS). Often, this phantom will include motion so motion management is implicitly evaluated as part of this audit.

For lung SBRT the key areas of interest in the dosimetry audit lie in the accuracy of their small field [29] and FFF modelling and whether any motion is taken into account during the dosimetry verification. Several groups have run such audits [30,31], and other groups in the process of doing so (Ontario Clinical Oncology Group (OCOG – Canada), TransTasman Radiation Oncology Group (TROG Australia/New Zealand)) but each have different formats and may be specifically for lung SABR or for all lung trials. The SBRT dosimetry QA is often performed by means of measurements in anthropomorphic thorax phantoms [8,31], see Fig. 1. Some trial protocols determine pass and fail criteria for such measurements before patient may be included (e.g. Imaging and Radiation Oncology Core (IROC – USA)), while sometimes these measurements are mainly used to determine the clinically achievable accuracy and the determine how further dosimetric improvements could be implemented [8,31].
دریافت فوری
متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات