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Original Article

Changes in Patterns of Intensity-modulated Radiotherapy Verification and Quality Assurance in the UK

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Abstract

Aims: Between 2012 and 2014 the number of patients treated in the UK with intensity-modulated radiotherapy (IMRT) techniques increased significantly. One reason for this was the radiotherapy innovation fund for the centres in England. Before the announcement of the fund, a survey of radiotherapy centres was carried out in 2012 which collected data on IMRT uptake, obstacles to implementation, equipment used, delivery techniques and verification methods. A repeat survey was carried out in 2014 to identify key changes to IMRT quality assurance and verification practices.

Materials and methods: An online questionnaire was sent out to all 65 UK radiotherapy centres in the summer of 2012 and again in the summer of 2014. Questions covered background and equipment, machine tolerance and quality assurance, machine-based verification, software-based verification and future plans.

Results: There have been significant changes in the delivery techniques used for IMRT, with more than twice as many centres reporting the use of volumetric-modulated arc therapy techniques in 2014 compared with 2012. This has been combined with an increase in Monte Carlo-based algorithms in treatment planning systems. In 2012 all centres reported the need to carry out machine-based measurements for IMRT plan verification, dropping to 93% in 2014. Nineteen per cent of centres now report making only one measurement per month for prostate plans and 8% of breast plans never have physical measurements. Most centres use detector arrays for quality assurance measurement (86% in 2012 and 91% in 2014), but a significant number still use film and/or ionisation chambers (51% and 41%). In the analysis of these measurements there has been an increase in the use of tighter criteria. There has been a significant increase in the use of software for verification from 63% in 2012 to 95% in 2014. All centres reported that they needed further resources in order to efficiently achieve the quality assurance required for the number of patients planned to be treated in their centre.

Conclusions: The increased numbers of patients being treated with IMRT has meant that there have been significant changes in the way that quality assurance is carried out. These have been mainly in the reduction of measurements and the increase in software-based verification. However, quality assurance is still a significant burden and still has an effect on the numbers of patients who can be treated with IMRT.

Key words: IMRT; quality assurance; VMAT

Introduction

The uptake of intensity-modulated radiotherapy (IMRT) techniques within the UK was relatively slow compared with some other countries and in August 2012 only 13.6% of radiotherapy patients in England received IMRT [1–3]. Later that year the Department of Health England created a Radiotherapy Innovation Fund, releasing £23million of funding to cancer centres to increase IMRT capacity. The aim of the fund was to address obstacles to IMRT treatment and to reach a goal of treating more than 24% of all radical radiotherapy patients with IMRT, with this figure already reaching 22.3% by April 2013. It has been suggested that up to 50% of radiotherapy patients may benefit from IMRT [4–6]. Volumetric-modulated arc therapy (VMAT) has now also been introduced to reduce the time taken to deliver IMRT and has been implemented more quickly than static

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gantry IMRT was, with over 50% of UK centres now offering this [7].

Thirty-eight per cent of the fund was spent on advanced treatment planning, 22% on linac upgrades, 17% on image-guided radiotherapy equipment and 12% on IMRT and image-guided radiotherapy quality assurance. The remaining (11%) was spent on staffing costs, training, software and immobilisation equipment [8].

The quality assurance burden associated with the implementation of IMRT and VMAT has been considerable and the desire to increase patient numbers means that verification processes play a key role in the extent to which a centre can provide this service [9]. This burden generally falls to the physics department to address. Before the announcement of the fund a survey of radiotherapy centres was carried out in 2012 which collected data on IMRT uptake, obstacles to implementation, equipment used, delivery techniques and verification methods. A repeat survey was carried out in 2014 to identify key changes to IMRT quality assurance and verification practices. Such information may inform centres seeking to increase their IMRT provision further, of potential areas to address and resources required.

Materials and Methods

An online questionnaire was sent out at two different time points, July to October 2012 and July to October 2014, to all 65 UK radiotherapy centres. For the purposes of this survey, IMRT was defined to be inverse planned and included all linac-based deliveries (including TomoTherapy and CyberKnife) as well as static and rotating gantry techniques. Questions covered background and equipment, machine tolerance and quality assurance, machine-based verification, software-based verification and future plans.

Results

In 2012 and 2014, 96.9% (63/65) and 89.2% (58/65) of centres responded, respectively. A large range of experience was reported from >10 years to only just started.

How the Radiotherapy Innovation Fund was used

For the English centres, the top three answers for how the Radiotherapy Innovation Fund was spent were treatment planning system (TPS) software (licenses) 88.9%, TPS hardware (51.1%) and delivery hardware (linacs) 44.4%. However, when asked how a further fund would be spent, TPS licences was still the top response (71.4%), second was increasing the number of staff members (57.1%) and on TPS hardware (49.0%) was the third most common answer.

Equipment

The proportions of centres using linacs from each manufacturer were consistent at the two time points 2012 (2014), being 66% (68% in 2014) Varian (Varian Medical Systems Inc., Palo Alto, CA, USA), 27% (31%) Elekta (Elekta AB, Stockholm, Sweden), 4% (4%) Siemens (Siemens AG, Erlangen, Germany), 11% (9%) TomoTherapy (Accuray-Tomo-Therapy, Madison, WI, USA) and 9% (9%) CyberKnife (Accuray-Tomo-Therapy). It should be noted that a number of centres used more than one manufacturer. In 2014 all centres used 6 MV with some use of 10 MV (30% up from 22% in 2012) and a few using 8 MV (3%, same as 2012) and 15 MV (3%, increased from 2% in 2012). There was a shift towards more complex treatment planning algorithms, with an increase in Monte Carlo-based algorithms (from 7.0% to 17.6%) and a reduction in pencil beam methods (23.9% to 14.9%). There was also a significant change in delivery techniques with 74% of centres reporting the use of VMAT techniques (compared with 34% in 2012). There was also a slight reduction in static field IMRT (41% to 35% for dynamic [Varian and CyberKnife] and 49% to 41% for step and shoot) (see Figure 1).

Numbers Treated

In 2012, 82% of centres reported a limit on the numbers of IMRT patients they were able to treat. This was reported to have dropped to 48% in 2014. Typical reasons given for this were limited resources (TPS and staff), clinician outlining time, machine availability and, of course, the availability of funding for these resources.

Timing

The survey also asked how long it took to carry out planning and quality assurance for different treatment sites (see Tables 1 and 2). In Figure 2 the total amount of time for head and neck cases shows that overall there was a decrease in the time taken for planning and quality assurance, with a marked decrease in those taking 4+ h and an increase in 1–3 h.

Audit

There are now a considerable number of external audits available with an IMRT component and 87% of centres have been credentialed to join one of several trials with IMRT in the National Cancer Research Institute portfolio in 2014. Seventy-six per cent took part in the national IMRT audit [10] and 60% in the national rotational IMRT audit [7,11]. More recently there has been an increase in the number of centres participating in interdepartmental audits with IMRT measurements (from 45% in 2012 to 62% in 2014) [12].

Machine Tolerance and Quality Assurance

Fifty-five radiotherapy centres responded to the questions about their Multi-leaf collimator (MLC) tests, tolerances and frequencies. The most common test and frequencies with tolerances are given in Table 3.

In both 2012 and 2014, about 40% of radiotherapy centres used in-house developed tests for MLC tests, including leaf speed, leaf calibration, dosimetric leaf gap, picket fence test, log files, complex fluences and electronic portal imaging

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