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Original Article

Cost Minimisation Analysis: Kilovoltage Imaging with Automated Repositioning Versus Electronic Portal Imaging in Image-guided Radiotherapy for Prostate Cancer

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Abstract

Aims: To compare the treatment time and cost of prostate cancer fiducial marker image-guided radiotherapy (IGRT) using orthogonal kilovoltage imaging (KVI) and automated couch shifts and orthogonal electronic portal imaging (EPI) and manual couch shifts.
Materials and methods: IGRT treatment delivery times were recorded automatically on either unit. Costing was calculated from real costs derived from the implementation of a new radiotherapy centre. To derive cost per minute for EPI and KVI units the total annual setting up and running costs were divided by the total annual working time. The cost per IGRT fraction was calculated by multiplying the cost per minute by the duration of treatment. A sensitivity analysis was conducted to test the robustness of our analysis. Treatment times without couch shift were compared.
Results: Time data were analysed for 8648 fractions, 6057 from KVI treatment and 2591 from EPI treatment from a total of 294 patients. The median time for KVI treatment was 6.0 min (interquartile range 5.1–7.4 min) and for EPI treatment it was 10.0 min (interquartile range 8.3–11.8 min) (P value < 0.0001). The cost per fraction for KVI was A$258.79 and for EPI was A$345.50. The cost saving per fraction for KVI varied between A$66.09 and A$101.64 by sensitivity analysis. In patients where no couch shift was made, the median treatment delivery time for EPI was 8.8 min and for KVI was 5.1 min.
Conclusions: Treatment time is less on KVI units compared with EPI units. This is probably due to automation of couch shift and faster evaluation of imaging on KVI units. Annual running costs greatly outweigh initial setting up costs and therefore the cost per fraction was less with KVI, despite higher initial costs. The selection of appropriate IGRT equipment can make IGRT practical within radiotherapy departments.

Key words: Cost minimisation analysis; fiducial markers; IGRT; prostate cancer; treatment time

Introduction

Dose escalation in prostate cancer reduces biochemical failure [1]. Image-guided radiotherapy (IGRT) may allow safe dose escalation by avoidance of inadvertent irradiation of normal tissue [2,3]. There are numerous methods for conducting IGRT in prostate cancer [4,5]. In our experience, IGRT using implanted fiducial markers and orthogonal imaging is emerging as a practical, reliable and effective method to ensure target localisation before each fraction of radiotherapy [6,7].

Previous studies have shown that online prostate fiducial marker IGRT with orthogonal electronic portal imaging (EPI) takes longer to deliver than conventional prostate radiotherapy [8]. For many departments, the longer treatment time with IGRT may affect waiting lists. Technology that reduces treatment time could make IGRT more practical for routine implementation in busy radiotherapy departments. Several recent linear accelerator engineering innovations may allow quicker IGRT treatment. Gold seed fiducial markers show up with more clarity on kilovoltage imaging (KVI) compared with megavoltage imaging (MVI; see Figure 1) [9–11]. Another recently introduced technology is automated couch repositioning, which refers to the adjustment of the treatment couch made directly from the treatment console without the radiation therapist having to re-enter the treatment room [12].

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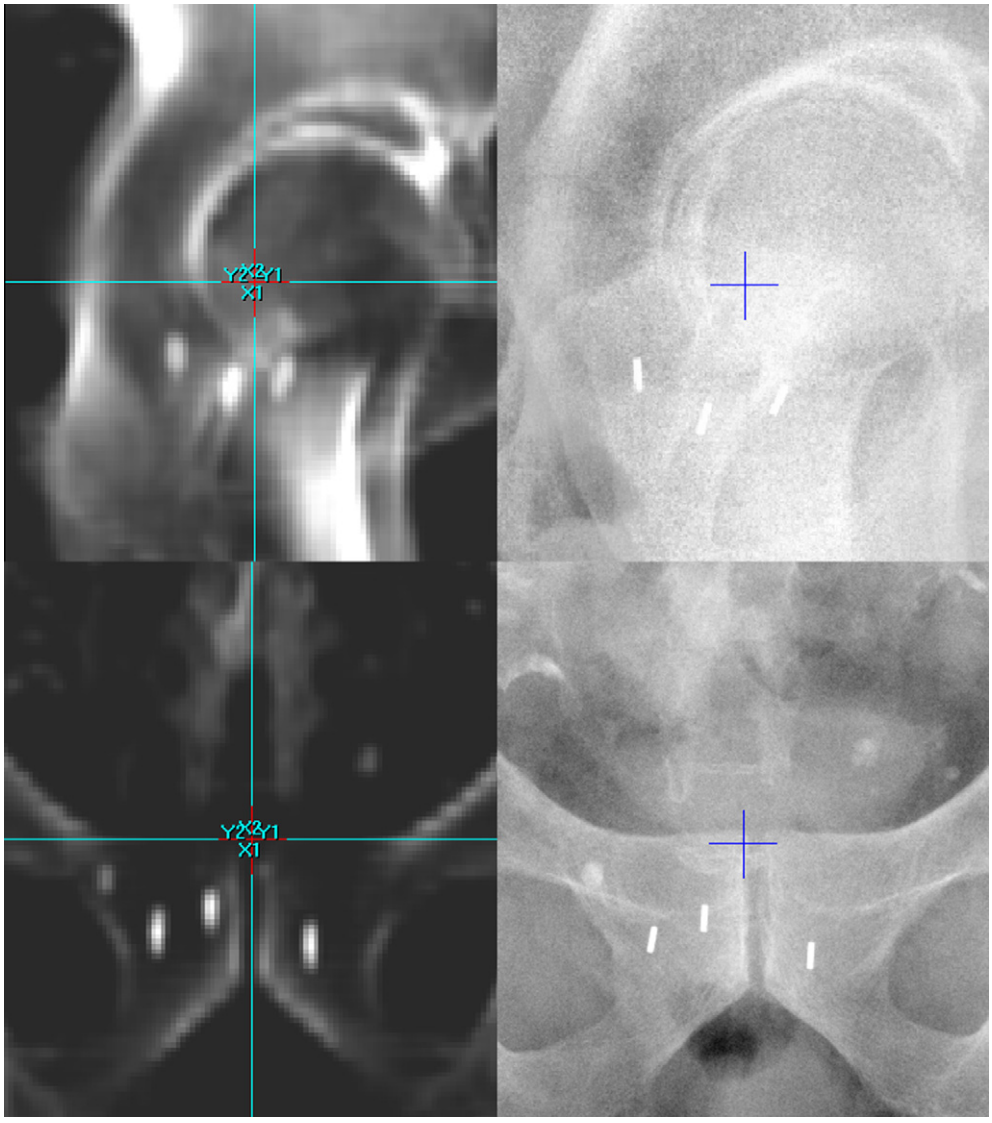

Fig 1. Comparison of electronic portal imaging (EPI) (on the left) and kilovoltage imaging (KVI) in a prostate cancer patient with three gold seed fiducial markers implanted in the prostate gland illustrating the difference in image quality and visualisation of the fiducial markers.

A 2007 survey of UK National Health Service radiotherapy centres showed that nearly half the centres surveyed did not plan on implementing IGRT mostly due to cost issues [13]. The purpose of this study was to compare IGRT treatment time using EPI with manual shift and KVI with automated shift to determine if costs can be saved by using new technology in IGRT through any potential reduction in treatment time. The purchase costs of new technology are greater, and it is unknown if any potential reduction in treatment time could offset this. To explore this, a cost minimisation analysis was conducted, whereby we assumed that the two units have equivalent clinical outcomes and only financial costs were explored [14].

Materials and Methods

IGRT was introduced in 2007 to a functioning radiotherapy centre that had six EPI and four KVI units installed. Patients were assigned to either unit based on availability. Details of the patient group, gold seed implantation procedure, simulation and planning and quality assurance processes have been published previously [6].

Between March 2007 and January 2009 treatment delivery time data were collected prospectively from 294 prostate cancer patients treated with IGRT, of which 6% were treated with intensity-modulated radiotherapy and 94% with conformal radiotherapy. All patients were treated on Varian linear accelerators (Varian Medical Systems, Palo Alto, USA).

The protocol in our department is to treat all radical IGRT prostate patients to a total dose 78 Gy in 39 fractions 5 days per week. Image registration was carried out using Impac Software (IMPAC Medical Systems Inc., Sunnyvale, CA, USA) on the EPI linear accelerators, and directly on the treatment console on KVI linear accelerators. On both units, only translational shifts were corrected, there was no rotational or tilt correction. On EPI, after manual couch shift but before the fraction was delivered, a repeat set of verification images