Improving safety for cancer patients using a radiation dose verification system

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Background

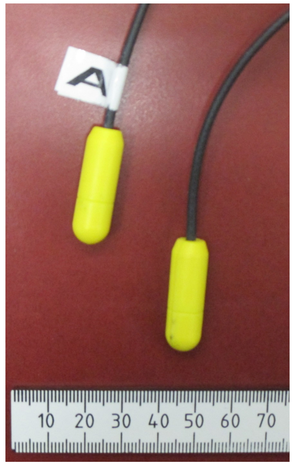
Radiation therapy (RT) is a complex and rapidly advancing technology that is used to treat cancer. It utilises ionising radiation to effectively kill cancer cells leading to cure or symptomatic relief. If delivered incorrectly the radiation can have debilitating side effects and even result in death. As such it is imperative that we are able to accurately measure that the dose is being delivered as intended.

The measuring of dose at the point of each delivery (in vivo dosimetry) is considered the gold standard for dose verification. Following serious radiation incidents (the most notable in Epinal, France and Glasgow, Scotland) the use of in vivo dosimetry has become an objective for all international departments and mandatory in some countries.

The Problem

The current in vivo dosimetry technique used at Christchurch Hospital is where a silicon diode detector is placed at the centre of the treatment field (see picture). The issues with this technique are:

1. The diode is difficult to place which can lead to false positive/ negative results
2. Diode placement is time intensive for RTs. Approximetely 5 minutes per patient
3. There is currently only 1 diode system available for 4 machines. This means that each patient's dose is measured once each treatment course - not necessarily on the first day
4. Not suitable for advanced treatment techniques (IMRT (Intensity Modulated Radiation Therapy) and VMAT (Volumetric Modulated Arc Therapy)) meaning in vivo dosimetry is not available for around 30% of our patients.



Aims

1. Implement in-vivo dosimetry without adding additional time to treatment appointments.
2. To change practice from measuring only a sample of patients to measuring all patients treated with curative intent by the end of 2016.
3. Reduce false positive results from baseline data to less than 5% by the end of 2016.

Project Proposal and Planning

A formal proposal was made to the Great Radiotherapy Ideas Network (GRIN.) This is a multidisciplinary group that reviews and provides a framework (utilising the Canterbury Districts Health Board's model for improvement Plan, Do, Study Act), support and monitoring for departmental projects. The project was approved in 2013.

A search was done to see what solutions where available internationally and EPIgray was identified (see centre insert for information on Epigray).

Key stakeholders were engaged (Physics, RT's, Finance, Information Services, Radiation Oncologists) and a business case was written. This was approved in 2014.

A project plan was developed that included key milestones, deliverables and responsibilities.

EPIgray

EPIgray is a software product marketed by DOSIsoft. It is an independent in vivo transit dosimetry system that uses the Electronic Portal Imaging Device (EPID) attached to each treatment unit to detect errors in dose delivery and patient positioning on each fraction.

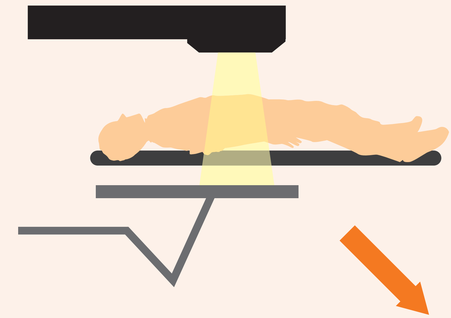
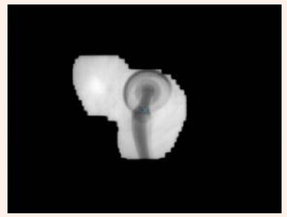
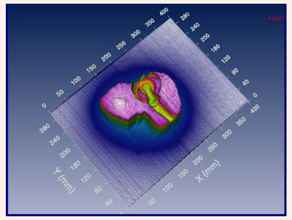
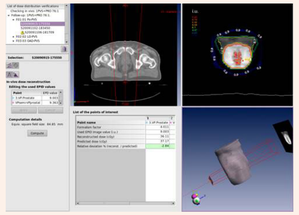


Image taken during treatment



EPIgray creates dose map based on pixels density





Compared to plan

The system uses an image that is taken by the treatment unit as part of the normal treatment course (meaning no additional time) and then calculates the dose delivered by translating the image's pixel values back into a dose value. This can be compared to the doses that are predicted by the treatment planning system and confirm the accuracy of the dose delivered or identify a discrepancy. The image can also be used to confirm the beams location is correct.

Implementation

The initial phase involved working with the supplier to get the system installed. A small multidisciplinary project team was formed to write and test working guidelines prior to the full roll out. All staff were educated on the system and kept up to date with progress through specific education sessions and routine updates at business meetings.

Both systems were used concurrently to ensure familiarity with and the reliability of EPIGray prior to the removal of diodes.

Results

The implementation of EPIgray has met all the original project aims and the table below shows the overall benefits that moving to EPIgray has provide:

Diode In vivo Dosimetry		EPIgray In vivo Dosimetry
Dose variation action threshold +/- 7%	→	Dose variation action threshold +/- 5%
Additional 5 minutes per patient	→	No additional time required
Dose verified at a single beam entry point	→	Dose verified on whole treatment field and 'in' patient
Measure dose once per patient per treatment course	→	Potential to measure daily treatments
Use on 1 machine at a time	→	Use on multiple machines at a time
Noticeable to patient	→	Not noticeable to patient
Limited use in advanced techniques	→	Suitable for IMRT and VMAT
Requires additional equipment	→	Uses equipment we already have
Requires accurate placement of diode	→	No external equipment required
Time delay for results	→	Instant results
Results can only be viewed on the treatment unit	→	Results can be reviewed from any computer

As the system requires the use of the treatment units imaging panel, the calibration, testing and preventative maintenance for this equipment has increased. This makes the equipment more reliable and less likely to breakdown.

The success of this project required multiple disciplines working collaboratively and has therefore also led to the development of better working relationships throughout the department.

"We like the fact that we can achieve dose delivery measurements at the point of treatment without interupting our clinical workflow. The addition of this software means real enhanced safety for cancer patients treated at our centre"

- Quote from Lead Medical Physicist

Achievements and The Future

- Continue to embed and sustain the use of EPIgray until it becomes business as usual.
- Develop and implement site specific dose variation action thresholds to continue improving accuracy and patient safety.
- Presentation at International Physics Conference.

Conflict of Interest Statement
Software beta testing agreement with DOSIsoft

Acknowledgements
Andrew Cousins and Michael Barlow (Physics), Hayley Wooding and Gillian Wyatt (Radiation Therapists) and Letitia Moorhouse (Quality Facilitator).

Canterbury District Health Board
Te Poari Hauora o Waitaha