

Quality and Service Improvement in Healthcare Sciences

Dr Nathan Proudlove, Alliance Manchester Business School, The University of Manchester

Invited talk

Service and quality improvement (QI) should be part of everyone's daily work. The HSST programme is one vehicle for embedding this knowledge and experience in senior healthcare scientists. The core thinking and tools fit well with scientific mindsets, perhaps particularly so with physics and engineering.

However, leaders roles in QI extends beyond the knowledge and experience to do QI, to fostering a QI culture. Approaches to this including facilitation and coaching, building on other elements of the HSST programme. At departmental level, a further useful approach is to build and operate a QI-focused quality management system..

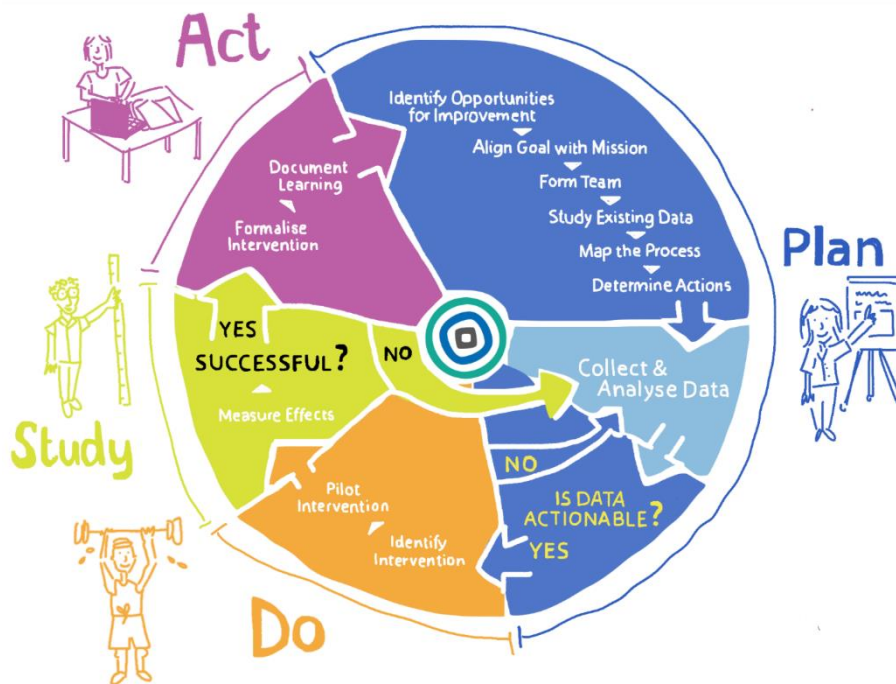
This talk introduces some of the main QI methodologies and tools covered on HSST, with examples of the sort of QI project work undertaken by HSST trainees in both the Physical Sciences specialisms and others (Physiological Sciences, Life Sciences and Bioinformatics).

Strategies for supporting and sustaining a culture of quality improvement

Jen Kohan, Head of the Innovation Agency Coaching Academy

The cycle of continuous improvement has long been a staple for quality improvement practitioners as a model and process guide, and there are seemingly endless tools for navigating and exploring QI. But what happens when the PDSA cycle is “finished”? How can you embed QI within the everyday work of your teams to sustain learning and progress?

In this session, you’ll learn about the Coaching Academy’s “Top Ten” easy-to-implement strategies for creating and nurturing a culture of QI in your teams and across your wider systems. Come with your brain full of learning from the day and identify a few simple ways to share and activate that learning with your teams so they can build their experience and confidence with quality improvement practices.



Improving the linear accelerator QA process using Lean tools and methods and FMEA.

Nicole Jessop, Peterborough City Hospital

Introduction

Lean philosophy focuses on continuously improving processes by eliminating waste, improving standardisation and efficiency, and creating more reliable outputs. Although Lean tools and thinking are widely used in manufacturing they are rarely used in Radiotherapy. Other quality improvement tools such as Failure Mode and Effects Analysis and Process Mapping are also not widely utilised, despite being advocated by the American Association of Physics in Medicine. This quality improvement project used Lean and quality improvement tools and methods to improve the linear accelerator QA process at Peterborough City Hospital.

Method

A Process Map was created for the linear accelerator QA process with input from the physics team. This was then discussed at a process mapping workshop and sixteen different issues were identified. Some of these issues were quick to rectify but others required further investigation leading to a number of individual quality improvement projects. Root Cause Analysis (Five Whys and Fishbone diagrams) was used to ascertain the root cause of some of the issues. Other problems required further information from audits and Failure Modes and Effects Analysis. An evaluation of automatic QA software tools (MPC, IBA myQA® Machines and SunCHECK™ machine) was carried out to assess the benefits and drawbacks of such software tools. In addition to this, Lean tools such as the 5S and identification and elimination of waste were used to improve the QA process. Plan-Do-Check-Act (PDCA) cycles were performed and repeated where necessary to arrive at an optimal solution. These individual quality improvements and changes together made up the linear accelerator QA process quality improvement project.

Results

The wastes of motion, inventory, over production, waiting and defects were identified and minimised or eliminated. In addition to this, Linear accelerator machine time savings totalling 288 hours (29 working days) were achieved by changing the scheduling of the QA to avoid redundant time. Changes to the QA scheduling and recording of incomplete QA has reduced the missed monthly QA by 13% overall, the monthly photon and electron output QA by 26%, and the weekly QA by 7%.

Keywords: Quality improvement, Process Mapping, Lean, linear accelerator, QA, FMEA.

Improving the Safety and Efficiency of the Radiotherapy Treatment Planning Pathway for Electron Patients at Clatterbridge Cancer Centre – A Quality Improvement (QI) Project

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Background. At Clatterbridge Cancer Centre (CCC) we have two linacs commissioned to provide electron radiotherapy and in 2021, 728 electron fractions were administered.

Delay to the start of an appointment for radiotherapy, especially the first appointment is poor for both patient experience and efficiency. The aim of this QI project was for the patients' first treatment to be started within 30 minutes of the allotted appointment time.

Prior to this project, only 33% of electron first fraction appointments were started within the target 30 minutes (the average delay was 54 minutes).

The treatment pathway for these patients was re-designed with the aim of 90% of patients first treatments starting within 30 minutes of the allotted appointment time

Methods. The Model for Improvement (Mfi) and it's Plan-Do-Study-Act (PDSA) cycles were used.

Initially a process map was developed from care paths recorded within ARIA. Tasks were identified as value adding (VA), non-value adding (NVA) or necessary non-value adding (NNVA) steps.

Physicists conducted a root causes analysis (RCA) to the investigate causes of treatment delay at the patients first treatment. An Ishikawa (fishbone) diagram of potential causes of these delays highlighted manual data entry and a lack of trained staff. To investigate these issues further, the 13 incidents recorded between September 2019 and September 2020 were further analysed. The main reported incidents were plan not ready and manual data entry (together causing about 92% of the incidents). These initial analyses motivated the QI project described in this paper.

To assess whether the changes constitute an improvement, a set of metrics was established and analysed using statistical process control (SPC) charts. Incidents were also monitored to check for any inadvertent issues.

The outcome metric (OM) was the delay experienced by the patient from their given appointment time to the time their treatment started. Baseline data had an average delay of 54.0 minutes with considerable process variation. The upper process limit [UPL] shows the expected maximum extent of random variation [mean + 3 standard deviations] was nearly 3 hours. The target was to keep delays below 30 minutes.

Results. Following this quality improvement (QI) project, 69.2% of first treatment appointments start within 30 minutes of the allotted appointment time (the average delay is 27.4 minutes).

Data is no longer entered manually and pseudo plans are produced.

Discussion. The largest improvement was achieved by introducing a proxy (without patient) 'Day 0' appointment. This takes place in advance of the patient's first treatment appointment to ensure the final treatment plan is ready. Subsequent improvements included: automating previously manual planning calculations, making the care path consistent with other external beam radiotherapy (EBRT) care paths at CCC to reduce staff cognitive load and sharing key outcome metric (OM) data with staff. There is still work to do to meet our initial aim.

Conclusion. There have been some successful applications of QI thinking in radiotherapy planning previously, but none specifically targeting electron-treatment planning. The literature demonstrates that electron patients experience longer delays than other external beam radiotherapy (EBRT) patients, and at CCC prior to this project electron patients experienced significant delays at their first fraction.

Key words: Radiotherapy, electrons, quality improvement

The plan check as a safety check

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Background. Background to the study and aim of study including 5-10 key references.

The Clatterbridge Cancer Centre (CCC) is one of the largest cancer care providers in the UK, and delivers around 650 head and neck radiotherapy courses per year. Each radiotherapy plan receives an independent check before treatment. An internal audit found that plan checking at CCC took 3 hours on average, with a high rate of variability between checkers. Low frequency errors are rarely caught by inspection, and quality is better improved upstream in a process (2). The study of risk management in radiotherapy is well covered which can be used as a foundation to improve local processes (1).

Methods. Key methods used in the study including diagrams, images as necessary.

Local and national surveys were performed to understand current practice for H&N plan checking. These results were aggregated and presented to the local physics team in order to encourage discussion. These discussion points were used in a focus group which decided on the changes to be explored. The focus group agreed that a plan check should be to determine that the plan is *safe and free from gross errors*.

A multi-disciplinary FMEA was conducted to evaluate this change, and which identified further low-value activities which could be removed from the check. Updated documentation and training materials were then developed in anticipation of deployment.

Main outcomes are an improved rate of plan checking, which will be measured by retrospective analysis of task duration in the Oncology Information System.

Results. Results of the study including diagrams, images, tables as necessary.

This abstract describes the systematic and risk-focussed implementation of a process change to improve efficiency while maintaining high quality. Post-deployment analysis will also provide quantitative evidence of the efficiency savings for the process.

Discussion. Discussion of the significance of the results

We expect the updated check process to reduce the activity time from 3 hours to 1 hour on average, which would save up to 0.67 WTE operator time for this treatment site alone. This time can be reinvested in quality improvement projects upstream of the check. The national survey results suggested that other centres may benefit from a similar review of their plan check process.

Conclusion. Conclusion relating to the aim of the study.

The local and national audit results provide rich insight into checking philosophies across the UK. There is significant variability in plan checking standards at a local and national level. This can be improved at a local level with standard quality improvement tools.

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Keywords: Plan Check, Safety, Radiotherapy, Head and Neck

Developing a Radiotherapy Physics Performance Dashboard

James Jenkins

Background: In 2019, the Welsh Government introduced the Single Cancer Pathway (SCP), a target for diagnosing and starting treatment more quickly. As a result, all Welsh health boards developed plans to ensure the majority of patients receive diagnostic tests in a timely manner. The SCP is important as Wales had poor survival outcomes compared to other developed countries, with disease staging at diagnosis significantly contributing to poor prognosis (NHS Wales Cancer Implementation Group & Welsh Government, 2019). Patients in Wales spend longer in the healthcare system before starting treatment than in other reported countries (Walters, et al., 2012), and as a result of the COVID-19 pandemic, cancer referral pathways were significantly delayed. There is also a concern for increased psychological distress, tumour growth and metastasis risk for extended waiting times, resulting in poor prognosis (Waaijer 2003 & Bissonnette 2021). In England, referrals via the urgent 2-week-wait pathway were reported to have decreased by up to 84%, resulting in a loss of life up to 0.7 years (Sud et al 2020). In 2018, the Clinical Oncology Sub-Committee (COSC) advised that 'Time to Radiotherapy' should be an indicator of radiotherapy performance. This was the time in days between the 'Decision to Treat' and the start date of radiotherapy. The South West Wales Cancer Centre (SWWCC) is working to a 5-year plan to decrease the time to radiotherapy treatment for its patients. To monitor this progress, the radiotherapy physics department at the SWWCC developed a performance dashboard to review the centre's ability to conform to the 14-day radiotherapy patient pathway key performance indicators (KPI) set out by the Welsh Government. The aim by year 5 is for 95% of emergency patients to start radiotherapy treatment within 1 day, 95% of urgent patients within 2 days and 95% of routine patients within 14 days.

Methods: A performance dashboard was created in Microsoft Excel, populated using Excel Macros with radiotherapy treatment workflow data extracted from the centre's oncology treatment management and workflow system MOSIAQ, using in-house custom SAP crystal reports. The workflow at SWWCC is managed and tracked using quality checklist (QCL) tasks, where each stage of the pathway has its own individual QCL and are scripted to progress to the next stage of the pathway once completed.

Results: The dashboard has been developed in an open format to be updated daily, weekly or monthly to produce treatment pathway times for individual treatment sites at SWWCC. Each site is broken down by pathway stage based on QCLs, including key areas such as treatment booking, planning CT appointment, tumour localisation, treatment planning, plan approval and plan checking.

Discussion: Prior to the development of the dashboard, there was no centralised method of collecting and analysing treatment pathway data in depth in a timely manner at the SWWCC. This dashboard has highlighted areas of excellence and improvements in the treatment pathway and is reviewed at the highest levels within the health board and at COSC. This dashboard allows the senior management team to identify pathway bottlenecks and allocate the necessary pathway resources to make the necessary changes to create a more robust, efficient and effective treatment pathway.

Conclusion: The Welsh Government has set out KPIs for a 14-day radiotherapy treatment pathway to drive innovations and gains in efficiency to improve patient treatment outcomes. SWWCC has developed a performance dashboard to monitor and evaluate the patient pathway against these KPIs and monitor treatment capacity and demand. This dashboard indicates where further resources may be required to address delays in the patient pathway. This dashboard also demonstrates the benefits of automation and delegation, including the effect approval through protocol has on reducing treatment start delays and patient pathway times.

Key References: [1] A. Waaijer, C. T. et al., 2003. Waiting times for radiotherapy: consequences of volume increase for the TCP in oropharyngeal carcinoma. *Radiotherapy and Oncology*, 66(3), pp. 271-276. [2] Bissonnette, J. et al., 2021. Non-small cell lung cancer stage migration as a function of wait times from diagnostic imaging: A pooled analysis from five international centres. *Lung Cancer*, Volume 155, pp. 136-143. [3] NHS Wales Cancer Implementation Group & Welsh Government, 2019. *Single Cancer Pathway - Briefing Paper*, s.l.: NHS Wales Health Collaborative. [4] Sud, A. et al., 2020. Effect of delays in the 2-week-wait cancer referral pathway during the COVID-19 pandemic on cancer survival in the UK: a modelling study. *The Lancet Oncology*, 21(8), pp. 1035-1044. [5] Walters, S. et al., 2012. Comparability of stage data in cancer registries in six countries: lessons from the International Cancer Benchmarking Partnership. *International Journal of Cancer*, 132(3), pp. 676-685.

MRI versus CT MRI planning for Image Guided Brachytherapy (IGBT) for Cervical Cancer: Dosimetric and Process Impacts

Rhydian Caines, Principal Clinical Scientist, Louise Bagley, Treatment Expert Practitioner

Background

IGBT for cervix includes complex and resource intensive workflows with many co- and inter-dependencies. Patients are imaged, planned and treated on the same day sometimes leading to long waits. Previous local process entailed acquiring both a CT and MRI scan of the applicator in situ with image fusion to aid applicator reconstruction and plan dosimetry. This study aimed to streamline the process and reduce radiation burden and overall pathway length for cervix IGBT patients by removing the CT component of the pathway, without impacting plan dosimetry.

Methods

A project plan was put in place following relevant governance processes to facilitate the change. This included technical commissioning, pilot phase and full roll out and FMEA risk assessment accompanying the workflow redesign.

A planning study was performed to evaluate the impact of CT removal on applicator reconstruction and subsequently standard dosimetric outcomes including CTV D₉₀, D₉₈, GTV D₉₈, D2cc on OARs and A point and rectovaginal point, for insertions both with (n=9) and without (n=28) needles.

Care Path data was extracted from ARIA (Varian Medical Systems) at specific measurable points in the patient pathway to quantify the interval duration between imaging and treatment and also absolute treatment times before, immediately after implementation and longer term.

Results

Dosimetry: Mean absolute difference in CTV D₉₀ (MR – CTMR) was -0.1 Gy without needles, and 0.0 Gy with needles. Population statistics were similarly negligibly different for all other dosimetric quantities of interest. A large single disagreement of 4.3 Gy was noted for one extremely small GTV very close to the brachytherapy source (but consistent with existing reconstruction uncertainties).

FMEA risk analysis identified main risks associated with CT removal as difficulty with applicator reconstruction due to motion artefact or other hidden dependencies of existing workflows in the CT image format.

Median duration from imaging to treatment was 270 minutes for CTMR, 246 minutes for MR only immediately following the change, and 184 minutes for MR only subsequently, demonstrating a median pathway reduction of 86 minutes (32% of total interval). The median treatment time reduced from 17:01 with CTMR to 16:30 in the MRI pilot phases and subsequently to 15:33 using MR only routinely.

Discussion

Removing the CT scan from the IGBT cervix process did not affect the plan dosimetry and reduced patient wait by >1 hour per visit on average. A back up CT has been retained within local protocol in case of motion artefact but has never been used in practice. Each patient now has 3 fewer CT scans (1 per insertion), and the process is significantly streamlined with fewer staff handovers and opportunity for error. This has also brought positive effects on capacity and logistics, improved patient experience and reduced fatigue and cognitive load on staff involved in the patient care.

Conclusion

In our experience MRI planning for cervix IGBT (as compared with CTMRI) brings strong quality improvements for patient experience, patient dose, and staff fatigue without compromising treatment plan quality.

Title of Case Study: Easy Access to Radical Lung cancer chemo-radiotherapy (EARLY) – a quality improvement project

Submitters details: Dr Gaurav Kumar¹, Sophie Burns¹, Marie Turnbull¹, Claire Huntley¹, Catherine Wilson¹ and James Green¹, Joe Whitbourn¹ PhD

¹South Tees Hospitals NHS Foundation Trust

Background. Currently all NHS patients have a target of receiving their first treatment within 31 days of the decision to treat (with an operational standard of this being met for 94% of radiotherapy patients receiving it as an adjuvant treatment). However, one of the 6 goals priorities in the consultation on the NHS 10 year cancer plan is to focus on having treatment capacity to support curative treatments 'within the timeframe patients have the right to expect'.

The Easy Access to Radical Lung cancer chemo-radiotherapy (EARLY) is a local quality improvement initiative started within an NHS trust. This project aims to ensure that stage III/IV lung cancer patients initiate chemo-radiotherapy treatment within 14 working days of the decision to treat.

Processes. For this quality improvement project we have followed a program of refinement associated with Plan-Do-Study-Act cycles (PDSA) organised according to the principles of the 'Model for Improvement'.

Process maps were made of the radiotherapy treatment pathway and were evaluated with regards to the different staff groups involved in each stage. A 'fishbone' diagram of potential improvements was created to evaluate potential initial improvements. A strengths/weaknesses/opportunities/threats (SWOT) analysis has been performed at each PDSA cycle to iteratively improve performance. Control measures were put in place to analyse the impact on overall wait times for category 1 patients.

Lessons Learned: Clinical leadership has been a vital part of driving this clinical improvement project and with communicating the change narrative.

We would like easier access to real-time information on wait times for all patients currently scheduled for treatment.

Best Practice: The EARLY project's key steps to improving patient flow were at the *early* stages of the patient pathway. By reducing carve-out of capacity – both of the CT scanner and of CCO time – we have managed to substantially reduce variability in process lead times.

Automation of tasks (were possible) has also substantially reduced lead times.

Conclusion. We have shown the potential feasibility of an accelerated time to treatment for a small cohort of lung cancer radiotherapy patients.

EARLY patients had an average mean wait time of 11.1 working days without impacting on the control measure of mean wait time for all category 1 patients. In comparison a balance group of non-EARLY lung cancer patients had a mean wait time of 19.2 days. We have achieved this without using additional resources at a time when the system faces significant pressure.

Application of failure mode and effects analysis to validate a novel hybrid Linac QC program that integrates automated QC with Varian MPC and conventional QC testing.

Pearson M, Butterworth V, Misson-Yates S, Naeem M, Gonzalez Vaz R, Eaton D, Greener T. Medical Physics Department, Guys and St Thomas' Hospital, London SE1 9RT.

Background. The Varian Machine Performance Check (MPC) automated quality control (QC) tool has been validated independently by a number of Authors^{1,2} by investigating the constancy of MPC results against another established measurement method, or through assessing its ability to detect deliberate errors. We validated MPC in our department by comparing monthly chamber and MPC output measurements, and confirmed its sensitivity in detecting real-world faults through investigating the concordance in MPC and conventional QC results over a 3 year period on 8 TrueBeam Linacs³. This confidence in MPC presented the opportunity to modernise our Linac QC program. A hybrid QC program was developed that consists of automated QC with MPC and DailyQA3 array on the TrueBeam Linac, and Delta4 volumetric modulated arc therapy (VMAT) standard plan measurements, alongside conventional monthly QC at a reduced frequency. The integration of automated and conventional Linac QC, realises the benefits of automated QC of reduced operator error, increased accuracy and efficiency, while avoiding complete reliance on automation through maintaining independent measurement methods. Failure mode and effects analysis (FMEA) was then applied in order to validate the program.

Methods. The FMEA followed the method outlined in TG100. Process maps were created for each treatment type at our centre: VMAT, stereotactic body radiotherapy, conformal, and palliative. Possible failure modes were established by evaluating each stage in the process map. The FMEA followed semiquantitative methods, using data from our QC records from 8 Linacs over 3 years for the occurrence estimates, and simulation of failure modes in the treatment planning system, with scoring surveys for severity and detectability. The risk priority number (RPN) was calculated from the product of the occurrence, severity, and detectability scores and then normalised to the maximum and ranked to determine the most critical failure modes.

Results. Sample FMEA scores for the VMAT treatment type are shown in the table (full results in ⁴). The highest normalized RPN values (100, 90) were found to be for MLC position dynamic for both VMAT and SBRT treatments. The next highest score was 35 for beam position for SBRT, and the majority of scores were less than 20.

Treatment type	Failure mode	Specific Linac fault	Magnitude	Occurrence	Severity	Detectability	RPN	Normalized RPN
VMAT	Patient in wrong place post IGRT	Treatment-imaging isocenter	1.5 mm	2	7.4	2.6	38	23
		Couch moves	1.5 mm	1	7.4	2.6	19	12
		Couch angle	1°	1	3	2.8	8	5

Discussion. Overall, the RPN scores for the hybrid Linac QC program indicated that it would be acceptable, but the high RPN score associated with the dynamic MLC failure mode indicated that it would be valuable to perform more rigorous testing of the MLC.

Conclusion. FMEA proved to be a useful tool in validating hybrid QC prior to clinical implementation in January 2020.

Key references.

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Audit of radical cervix radiotherapy patients at Leeds against ESGO/ESTRO Quality Indicators for patients treated in 2021 and 2022

C Jones, A Clark, E Russell, Z Middleton, R Cooper, J Anderson, K Cardale, P Bownes

Background. Adaptive MR-guided brachytherapy (BT) after external beam radiotherapy (EBRT) with concurrent cisplatin is standard of care for locally advanced cervical cancer. ESGO/ESTRO identified 19 QIs to promote evidence-based radiotherapy for cervix cancer.[1]

Methods. Treatment received by 87 radical cervix cancer patients who started EBRT in 2021 or 2022 was assessed against the QIs. Patients treated in 2022 were investigated to assess if dose planning aims could be met with BT re-optimisation or increased interstitial needle use.

Results. We met published thresholds (in brackets) for 13 of the 19 QIs. The local clinical protocol complies with QIs for all pre/post treatment care and EBRT delivery. We delivered a BT boost to 70 (≥ 10 per year) patients. 80% ($\geq 95\%$) received a BT boost and 27% ($\geq 40\%$) were treated with combined intracavitary/interstitial applicators (IC/IS); 21% in 2021 increasing to 34% in 2022. Combined EBRT and BT dose planning aim compliance for 2021/2022 is given below.

Target (EQD2, $\alpha/\beta = 10$)	>70%	LTHT	>90%	LTHT	OAR (EQD2, $\alpha/\beta = 3$)	>70%	LTHT	>90%	LTHT
D90 HRCTV	>90Gy & <95Gy	18.8%	>85Gy	98.6%	D2cc Bladder	<80Gy	60.9%	<85Gy	79.7%
D90 HRCTV	>90Gy	91.3%	>95Gy	72.5%	D2cc Bladder			<90Gy	100%
D98 HRCTV	>80Gy	85.5%	>75Gy	92.8%	D2cc Rectum	<65Gy	84.1%	<75Gy	100%
D98 GTV	>95Gy	82.5%	>90Gy	90.5%	D2cc Sigmoid	<70Gy	91.3%	<75Gy	100%
D98 IRCTV	>60Gy	75.4%	-	-	D2cc Bowel	<65Gy	89.9%	<75Gy	100%

Discussion. IC/IS use can improve local control for High Risk Clinical Target Volumes (HRCTV) >30cc.[2] Low interstitial use in this cohort could be attributed to relatively small HRCTV volumes (median 15.5cc at fraction 1), all patients except 1 with HRCTV >30cc were treated with IC/IS.

22/32 patients treated in 2022 had HRCTV D90>95Gy. HRCTV D90 could be reduced to <95Gy for 2 patients without compromising GTV or IRCTV coverage or reducing A points to less than 60Gy EQD2 (local tolerance if A points are not representative of dose to the cervix).

Bladder D2cc did not meet the thresholds; however, all plans met the EMBRACE II mandatory constraint of <90Gy. Bladder D2cc doses were reduced in 2022 compared to 2021 (D2cc <80Gy 54.1% in 2021, 68.8% in 2022), possibly due to the introduction of a reduced A point threshold of 60Gy and increased IC/IS use. 6/32 patients in 2022 had bladder D2cc >85Gy, increased use of interstitial needles could reduce this to <85Gy for 3 patients.

Conclusion. The QI provide an evidence-based framework for on-going assessment of quality in cervix radiotherapy. We are performing well compared to the EMBRACE II clinical protocol and the published QIs. Further work is on-going to help identify patients from the pre-brachy MRI that would benefit from IC/IS at fraction 1.

Key references. [1] Chargari C, Tanderup K, Planchamp F, Chiva L, Humphrey P, Sturdza A, et al. ESGO/ESTRO quality indicators for radiation therapy of cervical cancer. *Int J Gynecol Cancer* 2023;ijgc-2022-004180. <https://doi.org/10.1136/ijgc-2022-004180>.

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