**Purpose:** A paperless quality assurance (QA) program for linear accelerators (linacs) was recently adopted at our institution as a part of a sustainability initiative. The purpose of this study was to identify which components of our QA program would be most affected by this transition using failure mode and effects analysis (FMEA). **Materials and methods:** Our linac QA program was divided into three main categories for FMEA: QA preparation, on-unit measurements, and analysis and records. Four medical physics assistants (MPAs) discussed each category to identify sub-processes, potential failures, causes and effects of failures, and the current controls in place to prevent each possible failure for both paper-based and paperless environments. Nine MPAs individually ranked the occurrence (O), detectability (D), and severity (S) of each mode according to TG-100 recommendations. Risk priority numbers (RPN = O × D × S) for paper-based and paperless QA programs were computed and compared using two-tailed paired *t*-tests. *P*-values were adjusted using the Benjamini-Hochberg procedure (significant if $P < 0.05$). **Results:** For identical failure modes in the paper-based and paperless QA programs, no statistically significant differences in RPNs were identified. Overall, MPAs had a tendency to assign lower RPNs (lower risk) on average to failure modes in a paperless environment. Two failure modes in the paperless QA program were assigned higher RPNs (higher risk) on average and were associated with vulnerabilities in digital records archiving and communication. **Conclusions:** This study shows that the risks associated with paper-based and paperless linac QA programs are comparable. Therefore, the transition to paperless linac QA is favourable.

## Poster Reception – 19

**Dose escalation in 5-fraction palliative thoracic radiotherapy: A feasibility and safety planning study**

Donna Murrell, Melody Qu, Barbara Millman, David Palma, Alexander Louie, London Health Sciences Centre, Sunnybrook Health Science Centre

**Purpose:** This treatment planning study was performed to evaluate feasibility and safety of 5-fraction dose escalation for palliation in patients with advanced lung cancer. **Methods:** Patients who received palliative thoracic radiotherapy for lung cancers (n = 10) were included. The planning target volume (PTV) was defined as a 1 cm expansion on the gross target volume. Standard 20 Gy in 5-fraction plans were generated using parallel opposed pairs (POP) exposing the PTV + 0.8 cm. Dose-escalated 5-fraction plans were generated using arcs at the following levels: 25, 30, and 35 Gy. Plans were optimized to prioritize organs-at-risk (OAR) constraints and compromise PTV coverage, if necessary. Target dose was evaluated on the PTV-eval (=PTV-overlapping OAR) aiming for D95 ≥ 95%. Published normal tissue complication probability models were used to predict toxicity. **Results:** The median (range) PTV-eval $D_{95\%}$ for POP plans was 18.32 Gy (15.68–19.64). Dose escalation to 25 Gy without compromising PTV coverage was feasible in 9/10 cases and $D_{95\%}$ was 23.89 Gy (23.70–24.77). Significant PTV compromise was required for 30 and 35 Gy plans; however, increased dose was still feasible with $D_{95\%}$ of 27.97 Gy (26.90–28.87) and 28.91 Gy (27.67–33.17), respectively. Dose constraints reported in the UK Consensus Guideline for cord, esophagus, airways, heart, lung, and plexus were met for all plans. The median probability of esophagitis was <5% for all dose levels (max:12%). **Conclusions:** Dose escalation from 25 to 35 Gy appeared feasible without significant predicted toxicity. Based on these data, a dose-escalation clinical trial is planned under the auspices of the Canadian Pulmonary Radiotherapy Investigators (CAPRI) Group.

## Poster Reception – 21

**The impact of rectal gas content on rectal dose during prostate cancer radiotherapy**

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**Purpose:** To quantitatively measure rectal gas content over the course of prostate cancer radiotherapy and to examine how rectal filling type (gas or feces) impacts rectal dose. **Methods:** Rectums were manually contoured on daily cone-beam CT images of 9 prostate cancer patients previously treated with hypofractionated radiotherapy. Rectal filling contents were labelled as gas or non-gas by sorting voxels based on Hounsfield unit values. Daily rectum doses were calculated twice: once with the true material densities of the rectum and once with the rectum treated as water. The impact of filling type on rectal dose was evaluated by examining the differences between DVHs calculated using the two methods. **Results:** Rectal gas content was observed to vary more in some patients than others. While the majority had minimal (3) gas levels, three patients regularly had much larger gas volumes during the treatment course. When investigating the effect filling type had on rectal dose, it was observed that large gas volumes (>20 $cm^3$) posterior to the PTV led to increased $V30_{Gy}$ and $V35_{Gy}$ values compared to the same volume of fecal filling. DVHs were most impacted by filling type above the prescription dose of 60 Gy due differences in beam attenuation between gas and feces. **Conclusions:** The presence of gas in the rectum during prostate radiotherapy results in increased portions of the rectum receiving moderate doses and also influences the proportion of the rectum receiving doses above prescription.

## Poster Reception – 23

**Clinical Implementation of 3D-Printing Technology**

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The use of three dimensional (3D) printing technology is being introduced to the radiation treatment program of the Thunder Bay Regional Health Sciences Centre (TBRHSC). The process undertaken in the clinical implementation of prototyping, or 3D printing technology, at TBRHSC will be presented. Traditionally, bolus and missing tissue compensators have been made manually using in-house or commercial materials. Such commonly used media may fail to make optimal contact with the patient surface. Moreover, the reproducibility of such manual fabrication has always been potentially inconsistent due to the variation in the shapes and patient positioning during day-to-day delivery of a treatment. A treatment planning system (TPS) is used to generate a rendering of the required product based upon the computed tomography (CT) DICOM images routinely acquired from simulation. Once a satisfactory design is achieved in the TPS, 3D slicer software uses both the DICOM-RT format of the rendered structure and DICOM CT-image data to segment the virtual product and convert the data to the STL format recognized by the 3D-printer. Image data from a CT scan of the product is then analyzed using in-house code developed with MATLAB to determine the mass density, CT number, relative electron density, and effective atomic number. Apart from quantifying the physical and dosimetric properties, the geometric accuracy of various products is assessed and dose measurements are performed using TLDs to verify the accuracy of TPS distributions. Finally, metrics and processes for routine QA of components manufactured for clinical use have also been developed.

## Poster Reception – 25

**Total Body Irradiation on a Linac Couch Using Matching Fields with Dynamic MLC Broadened Beam Penumbra**

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**Purpose:** Total body irradiation (TBI) techniques usually require additional custom patient supporting devices due to either far-extended distance or continuous patient motion. We demonstrate preliminary planning studies of a matching-field technique that could effectively treat TBI patients on a linac couch. **Methods:** We simulated TBI plans in the Eclipse planning system on a virtual water slab, 190 cm (length) × 40 cm (width) × 20 cm (height) on a linac couch 60 cm below isocentre with 90° couch rotation. Three supine fields of 40 cm X-jaw sizes are matched in divergence, and the mirror opposite of these fields are used for simulating prone position treatment. The penumbra of adjacent fields is broadened by 2 cm relative to the X-jaw using dynamic sliding MLC. Further dynamic MLC modulation is used to generate uniform dose across the whole body. **Results:** Using a three fields matching technique we can achieve dose uniformity within ±5% across the virtual water slab to lengths of 183 and 189 cm, respectively, with or without field penumbra broadening. The dose error at the junction per mm of patient shift error is reduced to 3.3%, and the effect of jaw error is eliminated with the dynamic MLC field penumbra broadening, as compared to dose error of 12% per mm of patient shift error, and 16% per mm of jaw error at the junctions of conventionally matched fields. **Conclusions:** Matching large fields with broadened beam penumbra could be an effective TBI technique for treating patients on the treatment couch of a currently configured linac.