Conclusion
The world’s first clinical real-time motion-including tumor dose reconstruction during radiotherapy was demonstrated. This milestone marks a significant step towards real-time monitored radiotherapy with important potential applications for real-time QA and dose-guided treatment adaptation.

Award Lecture: Company Award Lectures

OC-0544 Distributed learning on 20 000+ lung cancer patients
1Maastricht University Medical Centre, The D-Lab: Decision Support for Precision Medicine- GROW - School for Oncology and Developmental Biology, Maastricht, The Netherlands; 2Radboud University Medical Center, Department of Radiation Oncology, Nijmegen, The Netherlands; 3The Netherlands Cancer Institute - Antoni van Leeuwenhoek, Department of Radiation Oncology, Amsterdam, The Netherlands; 4The University of Manchester, Manchester Academic Health Science Centre - The Christie NHS Foundation Trust, Manchester, United Kingdom; 5Università Cattolica del Sacro Cuore, Radiotherapy Department, Rome, Italy; 6Fudan University, Department of Radiation Oncology- Fudan University Shanghai Cancer Center- Department of Oncology- Shanghai Medical College, Shanghai, China; 7Cardiff University, School of Engineering, Cardiff, United Kingdom; 8Velindre Cancer Centre, Clinical Oncology, Cardiff, United Kingdom; 9Erasmus MC Cancer Institute, Department of Radiation Oncology, Rotterdam, The Netherlands; 10Maastricht Clinic, Department of Radiotherapy, Maastricht, The Netherlands

Purpose or Objective
Access to healthcare data is crucial for scientific progress and technological innovation. Sharing healthcare data is time-consuming and notoriously difficult due to privacy and regulatory concerns (e.g., GDPR). Leaving health data at its source and bringing research questions to the data overcomes these privacy issues. Our infrastructure connects FAIR (Findable, Accessible, Interoperable, Reusable) data sources and allows distributed data analysis and machine learning. This infrastructure facilitates assembling study consortia and executing analyses in a short time frame, therefore paving the way for the era of rapid learning healthcare.

Material and Methods
NSCLC-specific databases (tumor staging and post-treatment survival information) of oncology departments were translated according to FAIR principles. Distributed learning software was installed on-site to receive machine learning algorithms. An iterative alternating direction method of multipliers-based logistic regression (LR) algorithm and data analysis procedures were implemented in MATLAB. These algorithms are privacy-preserving by design as only summary statistics and LR coefficients are exchanged between healthcare institutes and the central server. The LR algorithm was trained to predict post-treatment 2-year survival on 2/3 of the eligible patient data. The LR model performance was evaluated on the remaining 1/3 by receiver operating characteristic curves (ROC) per site and their area under the curve (AUC), and root mean square error (RMSE).

Results
Eight healthcare institutes in Europe and Asia supplied data of 37 090 patients on which descriptive statistics were computed. Strong variation in patient cohorts across sites was observed. Inclusion criteria for prediction modelling of 2-year survival were met for 23 203 patients (Fig. 1). An LR model was distributively trained on 14 810 patients diagnosed between 1978-2011. The LR training algorithm converged after 81 iterations (25 minutes). When applying the final LR model on the validation cohort of 8 393 patients diagnosed between 2012-2015, the total RMSE was 0.43 and the AUCs ranged between 0.58-0.85 across sites (Fig. 2).
Conclusion

Our infrastructure was deployed across 8 healthcare institutes in 5 countries in 4 months. A 2-year survival prediction model was trained and validated in more than 20,000 NSCLC patients. This infrastructure demonstrably overcomes patient-privacy barriers to healthcare data sharing and allows training population-based predictive models. Scaling up and combining future imaging and genomic data analyses via the infrastructure will bring us closer to the ultimate goal of model-based treatment individualization.

Symposium: Adaptive RT: reactive or proactive?

SP-0545 Clinical perspective and evidence on RT adaptation, has it improved outcome?

M. Guckenberger1
1University Hospital Zürich, Department of Radiation Oncology, Zurich, Switzerland

Abstract text

Already in 1997, Di Yan et al. described the aims and process of adaptive radiotherapy "Adaptive radiation therapy is a closed-loop radiation treatment process where the treatment plan can be modified using a systematic feedback of measurements. Adaptive radiation therapy (ART) intends to improve radiation treatment by systematically monitoring treatment variations and incorporating them to re-optimize the treatment plan early on during the course of treatment". More than 20 years later, we have predominantly been working on solving the methodological challenges of ART, in particular improving in-room image quality, fast and automatic image segmentation, re-define adaptive planning objectives, fast and robust treatment plan optimization and quality assurance. Many in-silico planning studies have been conducted, focusing in particular on conventionally fractionated radiotherapy of lung cancer and head and neck cancer; whereas most studies reported a clinically relevant benefit of ART - organs-at-risk sparing or iso-toxic dose escalation - the magnitude of benefit varies substantially, most likely because of variation in ART methodology and endpoints. Clinical results of ART are still very rare, because its clinical implementation has only recently accelerated due to the commercial availability of the MRI-Linac technology and advances in software for image processing and treatment planning. On 12/2018, a total of 15 clinical trials are listed in clinicaltrials.gov with ART as the intervention: head and neck cancer is the most frequent indication (4/15 trials).

Results of these trials are eagerly awaited to evaluate the true clinical benefit of ART.

SP-0546 Physics perspective on RT adaptation including role of predictive modelling in RT adaptation

J. Sonke1
1Netherlands Cancer Institute, Department of Radiation Oncology, Amsterdam, The Netherlands

Abstract text

Adaptive radiotherapy (ART) utilizes an imaging feedback loop and replanning to 1) improve target coverage, 2) reduce toxicity and/or 3) improve tumor control after radiation therapy. Firstly, when adequate PTV margins are used to account for geometrical uncertainties, ART is only required for a limited number of patients with large variability to restore target coverage. On the other hand, more extensive use of ART allows for margin reduction with constant target coverage and reduced organ at risk exposure. Secondly, ART can be utilized to modify the treatment plan for patients where the delivered dose deviates from the planned dose. Effective use of such strategies requires normal tissue complication probability (NTCP) models to discriminate clinically relevant from irrelevant changes. Most NTCP models available, however, are based on the planned dose instead of the delivered dose. These models need to be updated using delivered dose to effectively use such adaptive strategies. Similarly, in the context of daily adaptive replanning, dose objectives and constraints should be reevaluated. Thirdly, adaptive strategies utilizing repetitive biological imaging aim to characterize treatment response and modify the treatment plan accordingly. Such strategies also require predictive models to translate (heterogeneous) treatment response to modified dose prescription between patients or even within the target itself.

SP-0547 Role of the RTT in the clinical implementation of adaptive radiotherapy

A. Baker1, H. Mcnair2
1Oxford University Hospitals NHS Foundation Trust, Radiotherapy, Oxford, United Kingdom; 2The Royal Marsden NHS Foundation Trust, Radiotherapy, London, United Kingdom

Abstract text

In the UK we are aiming for adaptive radiotherapy (ART) to be the standard of care1 with IGRT as a core, essential component. These national recommendations define a roadmap to modern 4D-ART within a multi-professional team (MPT) environment with each profession bringing different perspectives to the development and implementation process. ART can be reactive, proactive, scheduled and real-time. Each have workflow considerations which should be carefully considered including roles and responsibilities of the MPT. Standardisation of clinical practice is essential for the delivery of safe, accurate radiotherapy treatments. New protocols and processes for ART should be developed which can be at both local and national levels. These can be established using existing evidence, through clinical trial participation and driven by technology. Examples of these approaches, from a radiation therapist (RTT) perspective, will be discussed.

Clinical trials enable new technologies to be evaluated with regard to outcome, in a controlled environment. There have been a number of ART clinical trials in the UK which use a proactive plan of the day technique for bladder treatments. This assisted the centres involved to develop ART standards within their departments within a quality assured clinical trial. One such standard was the competency of RTT’s to select the plan of the day. Clearly defined guidelines within the protocol and the advice and support of the QA team enabled successful implementation throughout the UK.