

of a planning scan. There is no tool describing doses outside this region or relating all calculated doses to radiosensitive organs to long-term adverse effects e.g. second cancer induction and/or cardiac events.

We have developed a new software program called aRRESt (Radiotherapy Risk Evaluation System) which provides an interactive 3D visualisation of second cancer and cardiac risks in out-of-field organs. It can be used to compare classes of treatment plan and aid decision-making. The ultimate aim is to provide individualised risk profiles on a per-patient basis.

**Materials and Methods:** A cross-platform graphical user interface (GUI) was developed using the Python programming language, with 3D visualisation and interaction provided by the Visualisation Tool Kit (VTK) module. The GUI provides an indication of lifetime attributable risk (LAR) of second cancer induction using the BEIR VII risk model [1], and the total risk of major coronary events caused by excess heart dose from Darby et al [2].

The program works by extracting the dose cube and outlined regions of interest (ROI) from DICOM files exported from a commercial treatment planning system. Mean organ doses are calculated from this data, and are used to estimate the LAR/cardiac risk.

**Results:** The program has been tested on treatment plans extracted from the Philips Pinnacle treatment planning system. These plans were based on a full body CT scan of the anthropomorphic Rando phantom, with approximate organ positions outlined by an expert practitioner. Meaningful differences between plan types were clearly visible (see Fig. 1). Initial feedback from clinicians was positive.

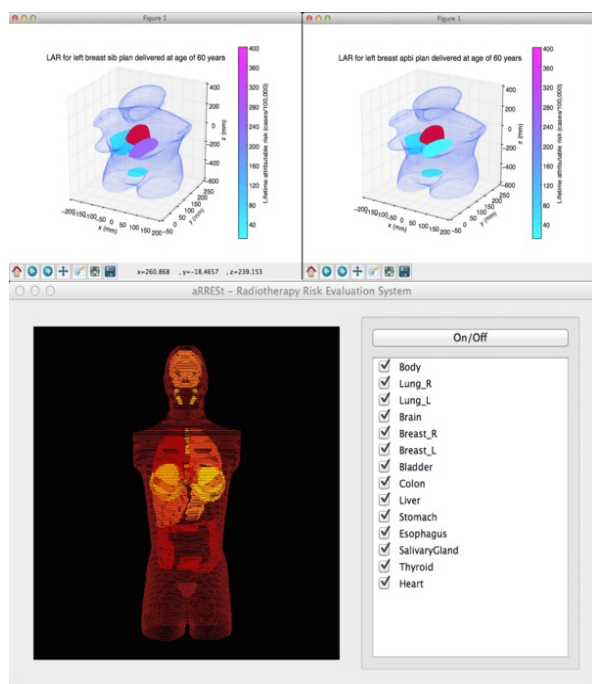


Figure 1: Top: LAR risk profiles for SIB and APBI left breast treatment plans delivered at an age of 60 years. Left breast, contralateral lung and bladder second cancer risks are shown, alongside risk of a major coronary event. Bottom: 3D interactive visualisation of ROIs outlined on a CT scan of the

Rando phantom, extracted from the Pinnacle treatment planning system.

**Conclusions:** The aRRESt program provides a quick and convenient method of visualising the risks of second cancer induction between different radiotherapy treatment deliveries. The underlying uncertainties in the risk models used are large, but as more data is accumulated and a better understanding of radiobiology is obtained, more sophisticated risk models can easily be incorporated into the software.

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Does gastric toxicity influence dose escalation in lower oesophageal tumours? A radiobiological investigation

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**Purpose/Objective:** The incidence of lower third oesophageal tumours are increasing in most Western populations (1) and it is becoming increasingly clear that chemo-radiotherapy (CRT) is now a viable alternative to surgical resection in the treatment of both oesophageal and gastroesophageal junction (GEJ) cancer (2). With the role of radiotherapy dose escalation being identified as a research priority in improving outcomes (3), it is important to quantify the increased toxicity that this may pose to sites such as the lower oesophagus that have vital adjacent organs that up to now may not have been taken into consideration. This study therefore aims to investigate the feasibility of lower oesophageal dose escalation with a focus on stomach tissue toxicity.

**Materials and Methods:** 10 patients from the SCOPE 1 database classified as having with tumours in the lower region were selected at random. The original 3D conformal treatment plan (50<sub>3D</sub>) was available for review and was compared to two RapidArc plans created retrospectively to represent the treatment arms of the forthcoming SCOPE 2 trial: RA<sub>50</sub> and RA<sub>60</sub> (PTV 50Gy with a simultaneously integrated boost of 60Gy to PTV2). The stomach was contoured as both whole organ and stomach wall and dose constraints set according to QUANTEC (4).

Plans were compared using dose metrics and radiobiological modelling of TCP was performed using the model by Geh et al (5). Normal tissue complication probability (NTCP) was

estimated for the stomach and stomach wall with endpoints of ulceration and gastric bleeding respectively (6) & (7).

Results: The stomach wall model showed larger values of NTCP than the whole stomach. There was a mean increase of 5.93% (-0.42, 18.71%) in NTCP from the 50Gy<sub>3D</sub> to the 60Gy<sub>RA</sub> plans and a mean increase of 8.15% (-0.42, 19.79%) in NTCP from the 50Gy<sub>RA</sub> to the 60Gy<sub>RA</sub> plans. When the NTCP modelling is restricted to that outside PTV2, there was a mean decrease of 0.92% (-4.70, 1.00%) in NTCP from the 50Gy<sub>3D</sub> to the 60Gy<sub>RA</sub> plans, and a mean increase of 2.25% (-0.42, 6.91%) in NTCP from the 50Gy<sub>RA</sub> to the 60Gy<sub>RA</sub> plans. There was a strong correlation between the NTCP value and the Stomach Wall/PTV1 overlap volume for all treatment plans (Pearson's R=0.80, 0.77 and 0.77 for the 60Gy<sub>RA</sub>, 50Gy<sub>RA</sub> and 50Gy<sub>3D</sub> plans respectively). There was also a strong correlation between the NTCP value and the Stomach Wall/PTV2 overlap volume for the 60Gy<sub>RA</sub> plan (R= 0.82).

Conclusions: Radiobiological modelling suggests that increasing the prescribed dose to 60Gy may be associated with a significantly increased risk of toxicity to the stomach. The results of this study also suggest that the maximum prescribed dose safely achievable for each patient in the future may be dependent on the volume of the stomach within the treatment volume. It is recommended that stomach toxicity be closely monitored prospectively when treating patients with lower oesophageal tumours in the forthcoming SCOPE 2 trial.

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Lung SABR: radiobiological multi planning comparison in a perspective of a multi-institutional study

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Purpose/Objective: The Italian Association of Medical Physics (AIFM) instituted in 2012 a working group dedicated to the Stereotactic ablative body radiotherapy (SABR). The aim of this work is to identify possible criticisms in approaching multicentric clinical trial for lung SABR, comparing, from a radiobiologic and dosimetric point of view, the plans obtained with different treatment planning systems, techniques and planners.

Materials and Methods: Five CT series from a database of patients treated with RT on lung were sent to the participants. Dose prescription was 54 Gy in 3 fractions of 18 Gy each to planning target volume (PTV). Each participant was asked to prescribe dose in conformity to its experience (i.e. 100%, 80%, mean dose) to stress the individuality of every center. For all plans were calculated: the PTV gEUD (generalized equivalent uniform dose), the MLD (mean lung dose) equivalent to 2 Gy for ipsilateral lung minus CTV and OAR (organ at risk) maximum dose. The dosimetric data and the parameters related to each center were analyzed including : expertise, equipment, size of leaves, TPS, radiation technique, and energy of radiation. Furthermore, a performance index was defined for each dosimetric parameter to compare plans with differences in terms of the PTV gEUD. For example the performance index regarding MLD<sub>eq</sub>2Gy is defined a PI = (MLD<sub>eq</sub>2Gy/gEUD)<sub>Reference</sub> / (MLD<sub>eq</sub>2Gy/ gEUD)<sub>center</sub>. and the Reference value belongs to a center with mean performances.

Results: Twenty-six centers with 3D-Conformal RT, IMRT, VMAT (Linac 88%), CyberKnife (4%) and Tomotherapy (8%)