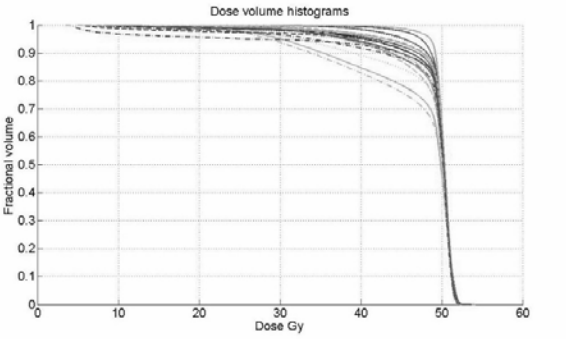
to 20% lower than planned. Most common anatomical areas not receiving 95% dose were vagina, obturator and external iliac nodes for both cases and superior nodal aspect for case 1. The DVH below shows the gold standard PTV coverage for each centre's RapidArc plan.



Conclusion: This quality assurance exercise demonstrates that, using IMRT, CTV delineation variation leads to potentially clinically important PTV dosimetric variations. Therefore, as IMRT use increases, the importance of accurate target volume delineation also increases.

PO-0940

The problems found within the on-site dosimetry audits of radiotherapy centres in the Czech Republic

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Purpose or Objective: The aim of the study is to report the most important problems found within the on-site dosimetry audits of radiotherapy centres. On-site audits of therapeutic units are performed by our institute after commissioning and acceptance test for each external radiotherapy and brachytherapy unit in the Czech Republic since 1997. They are performed with the same dosimetry equipment by the same persons to reduce the uncertainty in the results. The system of on-site audits includes the basic audit aimed at the verification of selected mechanical and dosimetric parameters, advanced audit to verify selected functions of TPS, and end-to-end audit to check the whole radiotherapy chain from planning to delivery. When high deviation is found (not only exceeding tolerance level), the auditors always try to find the reason, rectify the problem on-site, or give appropriate recommendations to the particular centre. The results of the audits are reported to the national regulatory body.

Material and Methods: The results from on-site basic, advanced, and end-to-end audits have been reviewed and analysed. Statistical process control (SPC) has been performed where appropriate.

Results: We report important errors that might lead to the radiological accident if not revealed by the on-site audit. In early years, the main typical errors were caused by incorrect input data in the TPS after the acceptance test. Of the main importance were: incorrect determination of dose rate for 60Co unit; incorrect output factors or wedge factors; using ionisation data instead of dose data measured with ion chamber for electron beams; incorrect SSD for measurement; incorrect detector; not taking into account couch attenuation etc. These types of errors are not so frequent but still observable nowadays, regardless the high quantity of published recommendations and literature on that topic. Currently, with new algorithms implemented in the TPS, various errors were found due to the lack of training, in particular for Monte Carlo (MC) algorithms. The TPSs were not commissioned i.e. with MC input data used in clinical practice but with data calculated for highest accuracy to comply with the measurements. End-to-end audit enabled to reveal insufficient patient QA, inaccuracy in TPS calculations for non-reference material, incorrect CT numbers to RED calibration curves, not following the ICRU and other international reports.

Conclusion: All the examples can serve as a learning system. In early years, the main cause of errors was a lack of time for measurements evaluation and verification. More recently, the other cause of the errors is a lack of time to get familiar with new equipment, especially with the software (TPS). In all cases, the errors were found at centres with a lack of clinical medical physicists with sufficient continual professional development.This work was supported by the project No. TB04SUJB001.

PO-0941

3D printed bolus for chestwall radiation therapy

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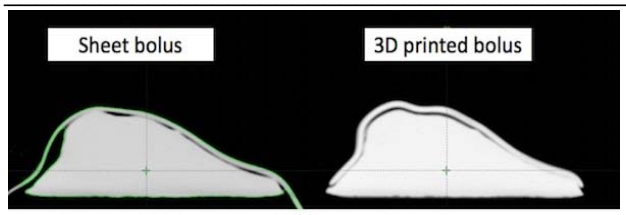
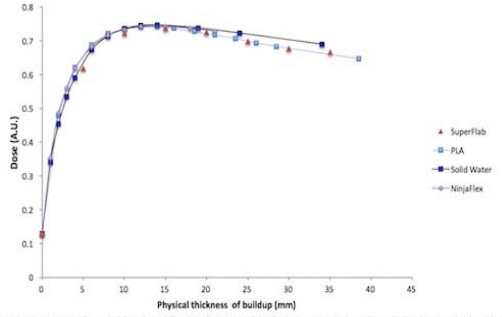
Purpose or Objective: 3D printing technology introduces the potential for improved accuracy of bolus in conforming to patients and may provide efficiency gains through automation of production based on planning CT data. The objectives of this study are i) to compare build-up depth dose characteristics of solid and flexible 3D printed bolus material to both Solid Water and standard sheet bolus material, ii) to assess the fit of 3D printed bolus to chestwall anatomy based on CT imaging compared to sheet bolus, and iii) to examine dosimetric accuracy of the treatment plan compared to OSLD measurements with 3D printed bolus.

Material and Methods: Depth dose measurements were performed with a Markus parallel plate chamber for polylactic acid (PLA) and flexible (Ninjaflex) 3D printing materials, and results were compared to both standard sheet bolus (Superflab) and Solid Water. For three chestwall patients, ballistics gel molds of the chestwall were fabricated to produce spatially realistic phantoms with plasticity similar to that of tissue. 5 mm thick, 3D printed chestwall boluses were fabricated for these phantoms based on CT data. CT imaging was then used to assess conformity to the surface and presence of air cavities. Optically Stimulated Luminescent Dosimetry (OSLD) was used to measure dose under both 3D printed and sheet bolus at nine locations on the chestwall surface for typical field-in-field treatment deliveries.

Results: In the build-up region, PLA and Ninjaflex bolus material exhibit similar depth dose characteristics. Both types of 3D bolus yield a greater dose compared to Solid Water, however differences remain below 5%. CT imaging of gel phantoms show an improved fitting of 3D printed bolus, with air cavities below the bolus reduced by 9% to 321% compared to standard sheet bolus. Treatment planning studies show better uniformity of skin dose for 3D printed bolus compared to sheet bolus, with the former giving a standard deviation of 1.8% compared to 4.2%. On average, the agreement of OSLD-measured to planned dose was similar between sheet bolus and 3D printed bolus, however standard sheet bolus shows greater variability in the measured-to-planned dose ratio (15% range for sheet bolus compared to 6% for 3D printed bolus).



3D bolus reduced total air gap volume by 9% to 321% compared to conventional sheet bolus.



Depth dose characteristics for solid (PLA) and flexible (NinjaFlex) 3D bolus compared to sheet bolus (SuperFlab) and Solid Water.

Conclusion: Rigid (PLA) and flexible (Ninjaflex) bolus materials provide build-up characteristics within 5% of Solid Water. When incorporated into treatment planning calculations, planned dose for 3D bolus agrees with OSLD measured dose to within 2% on average, and 3D printed bolus gives lower variability in the agreement of the delivered to planned dose. In summary, 3D printed chestwall bolus may be produced in an automated fashion and gives improved consistency of delivered dose accuracy compared to standard sheet bolus.

PO-0942

VMAT planning and treatment preparation process adapted for failure mode and effect analysis

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Purpose or Objective: Mitigating risks in radiotherapy is paramount for patient safety. A volumetric modulated arc therapy (VMAT) adapted to failure mode and effect analysis (FMEA) and implemented through workflow-integrated checklists is presented. This work is in line with efforts done by organizations to integrate a culture of patient safety into radiotherapy processes.

Material and Methods: VMAT is currently being offered to our patients using RapidArc®, Eclipse® 11, Aria-11®, and TrueBeamTM; all by Varian Medical Systems (Palo Alto, CA). All systems went clinical in February 2013. Three months into the VMAT program, we realized our operation may be optimized by using the new Workflow feature introduced in Aria® version 11. Consequently, a workgroup consisting of 2 physicists, 3 radiation oncologists, one radiation therapist and one IT was created to identify modes-of-failure in our VMAT planning and preparation process; and to implement a workflow that mitigates their risks. A process-centered risk analysis for VMAT employing FMEA was performed. Risk priority numbers (RPN) for occurrence, severity and detection, were assigned for identified modes of failure based on a simplified model of the AAPM TG100 scoring. FMEA for one task in our VMAT process (Figure 1) is presented as example in Table1. Mitigation actions were implemented into Aria-11® Workflow via integrated checklists where e-signatures are enforced. Risk mitigation strategies employing redundancy, implementation of related policies-and-procedures, documentation, and peer-review were hardwired into the VMAT process.

Results: A VMAT workflow (Figure 1) was designed and included 114 potential-modes-of-failure distributed into 4 groups: (1) 59 modes recurring redundantly, (2) 3 decision-type modes forcing re-planning, (3) 33 recurring modes aimed for enhancing communication, and (4)19 modes occurring only once; some with residual RPN's necessitating implementation of policies-and-procedures. In the 18 months period leading up to this study, more than 600 VMAT planning and preparation processes were delivered conforming to the workflow in Figure 1. No aberrations in treatments occurred. Shortcomings in e-chart preparations were virtually eliminated.

Conclusion: An adaptation of the VMAT planning and preparation process to FMEA using the Aria-11® workflow was presented. Risk analysis was performed, and risk mitigation was achieved through hardwiring appropriate checklists into the VMAT planning tasks. The adaptation to FMEA resulted in marked improvements in patient safety, process control and process documentation. The presented workflow adaptation to FMEA could serve as a reference or model for clinics offering VMAT.

RapidArc Planning Workflow adapted to FMEA

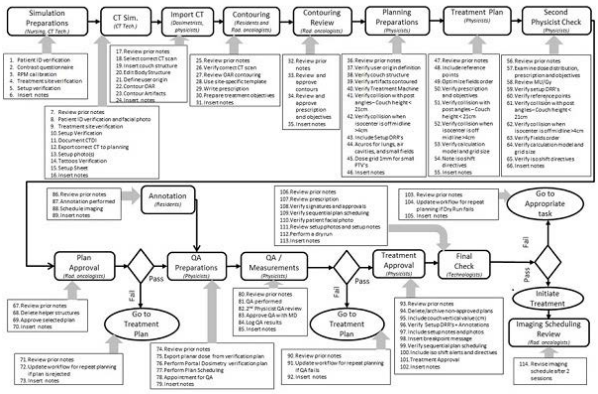

TABLE 1: FMEA for the "Planning Preparations" task is shown with associated checklist-items as mitigating actions. The owners usually of this task are physicists and dosimetrists.

Potential Failure Mode (checklist-item)	Potential Effect of Failure	Pre-mitigation Severity RPN	Potential Cause of Failure	Pre-mitigation Occurrence RPN	Existing detection Mode before risk mitigation actions	Pre-mitigation Detectability	RPN	Action(s) Taken Or Risk Mitigation Control(s)	Post-mitigation Severity RPN	Post-mitigation Occurrence	Post-mitigation Detectability RPN	Residual RPN
36. Review prior notes	Could be serious in case an important note or directive is overlooked.	7	Operator error	4	none	7	196	* Checklist-item in Planning Preparations task	7	1	1	7
37. Verify User Origin definition	Serious. Could cause an offset in treatment isocenter.	7	Operator error	4	CT import Checklist: Define User Origin	1	28	* Checklist-item to verify User Origin on simulation tattoo (redundancy)	7	1	1	7
38. Verify couch structure	Wastes planning time to correct.	4	Operator error	4	CT import Checklist: Insert couch struct.	1	16	* Checklist-item to Insert Couch Structure depending on technique (redundancy)	4	1	1	4
39. Verify artifacts contoured	Inaccurate distribution at and near artifacts.	2	Operator error	4	none	9	72	* Checklist-item to define artifacts	2	1	1	2
40. Verify machine	Wastes planning time and beam scheduling inconveniences to patients.	1	Operator error	2	May be detected in later tasks or at first session	2	4	* Beam energies are matched * Include machine in prescription * Include checklist-item to verify machine	1	1	1	1
41. Check for potential collision with posterior angles – Couch height <21cm	Ranges from serious as in patient injury to waste of time for re-planning.	9	Operator error	4	Could go undetected till later tasks which would waste time.	7	252	* Checklist-item to verify potential collision with posterior angles. Couch height should be less than 21cm * Dry-run check in the later Verify Check tasks reduced the residual RPN to 7	9	2	2	36
42. Check for potential collision when isocenter is off midline >4cm	Ranges from serious as in patient injury to waste of time for re-planning.	9	Operator error	4	Could go undetected till later tasks which would waste time.	7	252	* Checklist-item to verify potential collision when isocenter is off midline by greater than 4cm * Dry-run check in the later Final Check task reduced the residual RPN to 7	9	2	2	36
43. Include setup fields and DRR's	Wastes planning time to correct.	2	Operator error	4	Will be detected at a later stage in the process	2	16	* Checklist-item to include setup fields and DRR's right after isocenter placement and potential collision check.	2	1	1	2
44. Select Acuros for lung and air cavity sites and in small volumes e.g. SRS	Slight distortion in dose representation.	4	Operator error	4	none	9	144	* Select Acuros for calculation model	4	1	1	4
45. Reduce dose grid to 1mm for small PTV's	Slight distortion in dose representation.	2	Operator error	4	none	10	80	* Checklist-item to set dose grid to 1mm for small PTV's	2	1	1	2
46. Insert notes relevant for later tasks and users	Information about the task remains undocumented and non-disseminated.	4	Operator error	4	none	10	160	* Include checklist-item for workflow notes documenting directives	4	1	1	4

PO-0943

Dutch national head and neck plan comparison significantly improved treatment planning quality

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Purpose or Objective: The National Platform RT Head and Neck Cancer (HNC, Landelijk Platform Radiotherapie Hoofdhals Tumoren, LPRHHT) is a working party of the Dutch Society of Radiation Oncology, and is engaged in regulating and improving RT for HNC. One of the objectives of the LPRHHT is to evaluate the variation in treatment plan (TP) objectives and possibly improve treatment planning by increased organ at risk (OAR) sparing and reduction of variation between institutes.