


Radiotherapy

Evidence Update

September 2017



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Tues 17th Critical Appraisal

Wed 25th Interpreting Statistics

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Thu 2nd Literature Searching

Fri 10th Critical Appraisal

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Wed 29th Critical Appraisal

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Current Journals: Tables of Contents

Click on journal title (+ Ctrl) for hyperlink

Journal	Month	Volume	Issue
Radiotherapy and Oncology	September 2017	124	3
International Journal of Radiation Oncology Biology and Physics	November 2017	99	3
Clinical Oncology	November 2017	29	11

If you require full articles please email: library@uhbristol.nhs.uk

Department Publications

[Intrafraction monitoring of prostate motion during radiotherapy using the Clarity® Autoscan Transperineal Ultrasound \(TPUS\) system](#)

A.K. Richardson, P. Jacobs

Radiography, vol 23, no 4, November 2017, pp 310–313



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NICE National Institute for
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[Biodegradable spacer insertion to reduce rectal toxicity during radiotherapy for prostate cancer](#)

Interventional procedures guidance [IPG590] Published date: August 2017



Franklin J, Eichenauer DA, Becker I, Monsef I, Engert A. [Optimisation of chemotherapy and radiotherapy for untreated Hodgkin lymphoma patients with respect to second malignant neoplasms, overall and progression-free survival: individual participant data analysis](#). Cochrane Database of Systematic Reviews 2017, Issue 9. Art. No.: CD008814. DOI: 10.1002/14651858.CD008814.pub2.

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[Cardiotoxicity of radiation therapy for breast cancer and other malignancies](#)

Authors: [Lawrence B Marks, MD](#); [Louis S Constine, MD](#); [M Jacob Adams, MD, MPH](#)

Literature review current through: Sep 2017. | This topic last updated: Aug 09, 2017.

Guidelines

[Royal College of Radiologists](#)

[Radiotherapy target volume definition and peer review – RCR guidance](#)

Provides a practical framework of formative support for all clinicians involved in radiotherapy planning.

Royal College of Radiologists, August 2017

[Society of Radiographers](#)

[Institute of Physics and Engineering in Medicine](#)

[Policy statement on the Provision of a Physics Service to Intraoperative Radiotherapy](#)

First published: 2017: 1st Review: August 2020

Current Awareness Database Articles

Below is a selection of articles recently added to the healthcare databases, grouped in the categories:

- **In vivo dosimetry**
- **Intra-fractional Imaging**
- **ABC gating**

If you would like any of the articles in full text, or if you would like a more focused search on your own topic, please contact us: library@bristol.nhs.uk

In vivo dosimetry

1. In vivo dosimetry with optically stimulated luminescent dosimeters for conformal and intensity-modulated radiation therapy: A 2-year multicenter cohort study.

Author(s): Riegel, Adam C; Chen, Yu; Kapur, Ajay; Apicello, Laura; Kuruvilla, Abraham; Rea, Anthony J; Jamshidi, Abolghassem; Potters, Louis

Source: Practical radiation oncology; 2017; vol. 7 (no. 2); p. e135

Publication Date: 2017

Publication Type(s): Multicenter Study Journal Article Validation Studies

PubMedID: 28274404

Abstract: PURPOSE Optically stimulated luminescent dosimeters (OSLDs) are utilized for in vivo dosimetry (IVD) of modern radiation therapy techniques such as intensity modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT). Dosimetric precision achieved with conventional techniques may not be attainable. In this work, we measured accuracy and precision for a large sample of clinical OSLD-based IVD measurements. METHODS AND MATERIALS Weekly IVD measurements were collected from 4 linear accelerators for 2 years and were expressed as percent differences from planned doses. After outlier analysis, 10,224 measurements were grouped in the following way: overall, modality (photons, electrons), treatment technique (3-dimensional [3D] conformal, field-in-field intensity modulation, inverse-planned IMRT, and VMAT), placement location (gantry angle, cardinality, and central axis positioning), and anatomical site (prostate, breast, head and neck, pelvis, lung, rectum and anus, brain, abdomen, esophagus, and bladder). Distributions were modeled via a Gaussian function. Fitting was performed with least squares, and goodness-of-fit was assessed with the coefficient of determination. Model means (μ) and standard deviations (σ) were calculated. Sample means and variances were compared for statistical significance by analysis of variance and the Levene tests ($\alpha = 0.05$). RESULTS Overall, $\mu \pm \sigma$ was $0.3 \pm 10.3\%$. Precision for electron measurements (6.9%) was significantly better than for photons (10.5%). Precision varied significantly among treatment techniques ($P < .0001$) with field-in-field lowest ($\sigma = 7.2\%$) and IMRT and VMAT highest ($\sigma = 11.9\%$ and 13.4% , respectively). Treatment site models with goodness-of-fit greater than 0.90 (6 of 10) yielded accuracy within $\pm 3\%$, except for head and neck ($\mu = -3.7\%$). Precision varied with treatment site (range, 7.3%-13.0%), with breast and head and neck yielding the best and worst precision, respectively. Placement on the central axis of cardinal gantry angles

yielded more precise results ($\sigma = 8.5\%$) compared with other locations (range, 10.5%-11.4%). CONCLUSIONS Accuracy of $\pm 3\%$ was achievable. Precision ranged from 6.9% to 13.4% depending on modality, technique, and treatment site. Simple, standardized locations may improve IVD precision. These findings may aid development of patient-specific tolerances for OSLD-based IVD.

Database: Medline

2. Wearable glass beads for in vivo dosimetry of total skin electron irradiation treatments

Author(s): Nabankema S.K.; Peet S.C.; Binny D.; Crowe S.B.; Jafari S.M.; Sylvander S.R.

Source: Radiation Physics and Chemistry; Nov 2017; vol. 140 ; p. 314-318

Publication Date: Nov 2017

Publication Type(s): Article

Abstract: Glass beads have recently been proposed for use as radiation therapy dosimeters. Glass beads have a number of characteristics that make them suitable for in vivo skin dose measurements, including an ability to be worn on a string, and therefore avoid possible patient discomfort that may result from the use of adhesives. In this study, their use for in vivo dose measurements in total skin electron irradiation treatments has been tested. First, the dosimetric properties of cylindrical beads with a 3 mm diameter were characterised using electron fields produced by a linear accelerator. The mean individual bead reproducibility was demonstrated to be within 3%; and a batch variation of 7% was observed. The beads were shown to have a linear dose response, and both dose rate and beam energy independence, within the measurement uncertainty. Phantom measurements were then performed for a total skin electron irradiation beam arrangement, and results compared against optically stimulated luminescent dosimeters at five anatomical sites. For a majority of measurement locations, agreement within 3% was observed between the two dosimetry techniques, demonstrating the feasibility of glass beads as in vivo dosimeters for total skin electron irradiation; though further investigation may be needed to minimise uncertainty in results. Copyright © 2016 Elsevier Ltd

Database: EMBASE

3. In vivo dosimetry and acute toxicity in breast cancer patients undergoing intraoperative radiotherapy as boost.

Author(s): Lee, Jason Joon Bock; Choi, Jinhyun; Ahn, Sung Gwe; Jeong, Joon; Lee, Ik Jae; Park, Kwangwoo; Kim, Kangpyo; Kim, Jun Won

Source: Radiation oncology journal; Jun 2017; vol. 35 (no. 2); p. 121-128

Publication Date: Jun 2017

Publication Type(s): Journal Article

PubMedID: 28712278

Abstract: PURPOSE To report the results of a correlation analysis of skin dose assessed by in vivo dosimetry and the incidence of acute toxicity. This is a phase 2 trial evaluating the feasibility of intraoperative radiotherapy (IORT) as a boost for breast cancer patients. MATERIALS AND METHOD Eligible patients were treated with IORT of 20 Gy followed by whole breast irradiation (WBI) of 46 Gy. A total of 55 patients with a minimum follow-up of 1 month after WBI were evaluated. Optically stimulated luminescence dosimeter (OSLD) detected radiation dose delivered to the skin during IORT. Acute toxicity was recorded according to the Common Terminology Criteria for Adverse Events v4.0. Clinical parameters were correlated with seroma formation and maximum skin

dose. RESULTS Median follow-up after IORT was 25.9 weeks (range, 12.7 to 50.3 weeks). Prior to WBI, only one patient developed acute toxicity. Following WBI, 30 patients experienced grade 1 skin toxicity and three patients had grade 2 skin toxicity. Skin dose during IORT exceeded 5 Gy in two patients: with grade 2 complications around the surgical scar in one patient who received 8.42 Gy. Breast volume on preoperative images ($p = 0.001$), ratio of applicator diameter and breast volume ($p = 0.002$), and distance between skin and tumor ($p = 0.003$) showed significant correlations with maximum skin dose. CONCLUSIONS IORT as a boost was well-tolerated among Korean women without severe acute complication. In vivo dosimetry with OSLD can help ensure safe delivery of IORT as a boost.

Database: Medline

4. Roles of in-vivo dose verification for brachytherapy

Author(s): Tanderup K.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 3135

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: With the advent of new treatment device technologies and the increasing complexity of radiation therapy, patient safety and quality assurance are witnessing a revival of attention and becoming an important focus to ensure the safe and effective delivery of radiation therapies. An important aspect of a comprehensive quality assurance and safety is in vivo dosimetry. This symposium will focus on in vivo dosimetry and its role in radiation therapy for external beam radiation therapy, proton therapy and brachytherapy. Historically, in vivo dosimetry, using traditional detectors (TLD, MOSFETS, diodes, etc.) has been limited to dose measurement performed externally (i.e., skin) or to monitor the dose that may be delivered to implanted devices such as implantable pulse generators (pacemakers) or cardioverter defibrillators. More recently, transmission detectors such as EPIDS are gaining popularity. Furthermore, there is increasing focus on real-time in vivo dosimetry as this facilitates identification of errors during treatment delivery. These aspects of in vivo dosimetry will be briefly presented, however, new avenues that are or will become available will be discussed in this symposium for each treatment modality (Photons, Protons and Brachytherapy). Learning Objectives: 1. Brief overview of the characteristics, advantages and limitations of the detectors that are commonly used for in-vivo dosimetry. 2. What are the expected roles of in vivo dosimetry at present and in the near future to make in vivo dosimetry become more effective? 3. Become familiar with the types of errors and failures that online real-time in vivo dosimetry may be able to prevent for different treatment modalities (photon, proton and brachytherapy).

Database: EMBASE

5. Dosimetric impact of placement errors in optically stimulated luminescent in vivo dosimetry

Author(s): Tariq M.; Riegel A.; Gomez C.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 2899

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: Optically stimulated luminescent dosimeters (OSLDs) are increasingly used for in vivo dosimetry of intensity-modulated radiation therapy (IMRT) and volumetric-modulated arc therapy (VMAT). Given the high-dose gradients in IMRT and VMAT, placement uncertainty may have an outsize role in variability of measured-to-planned dose agreement. The purpose of this work was

to characterize placement errors using cone-beam computed tomography (CBCT) and to measure the potential dosimetric impact of misplaced OSLDs. Methods: We examined 293 CBCTs where OSLDs were visible of 128 patients of varying anatomical sites. The CBCTs were registered with the treatment plan in which the planned location and actual placement of the OSLD were analyzed. A reference beam was created en face to the skin at the planned OSLD location. Using the beam's eye view, placement error was measured as the two-dimensional distance between the planned and actual OSLD location. Dosimetric impact was assessed by projecting the actual placement point to the skin on the treatment plan, comparing this point dose to the planned dose and expressing the difference as percent error. Dosimetric errors were correlated with placement errors. Results: OSLDs were grossly misplaced for 19 CBCTs and were excluded. For the remaining 274 CBCTs, average placement error was 9.7+/-9.5 mm with average dosimetric error of -2.37+/-19.29%. Dosimetric change was weakly correlated with placement error ($R^2=0.3933$). There were several outliers for which small placement errors yielded large dosimetric differences and vice versa. The former scenario was caused by placement near field edges or high intensity-modulated dose gradients. Conclusion: We observed an average placement error of approximately 1 cm and a large variability of dosimetric impact with small placement errors potentially producing large measured-to-planned percent dose errors. Accurate OSLD placement for IMRT and VMAT treatment is critical for minimizing measured-to-planned dose variance.

Database: EMBASE

6. Methodology for in vivo dosimetry using TLD-100 for radiotherapeutic treatment

Author(s): Teiga Rodrigues B.; Domingues De Souza P.; Daruich De Souza C.; Chuery Martins Rostelato M.; Zeituni C.; Ribeiro Nogueira B.; De Oliveira Marques J.; Sorgatti De Souza A.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 2898-2899

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: Cancer is a public health problem that affects approximately 27 million people worldwide. The most common type in Brazil among men is prostate cancer with 61 thousand cases. There are two forms of radiotherapy treatments that can be used: teletherapy and brachytherapy. Before starting the teletherapy treatment, a planning is done that makes the acquisition of the anatomical information of the patient to then classify the areas of interest. Dosimetry is performed as a quality control to ensure that the calculated dose is equal to that received by the patient. In vivo dosimetry acts as an independent measurement and this work aims at comparing the dosimetry performed using thermoluminescent dosimeters (LiF: Mg, Ti - TLD - 100) with dose values calculated in the planning system (TPS). Methods: All dosimeters were prepared to be used in an anthropomorphic phantom. A selection of dosimeters, 50 micro TLD's, selected after heat treatment, were then irradiated and a reading was made. A case planned by TPS was selected and compared the dosimetry performed in an anthropomorphic phantom for the same case. Results: All values obtained were within the deviation (+/-5%) allowed by the protocol. The results of this work will help to implement a new quality program in the Radiotherapy Service at Hospital das Clinicas de Sao Paulo. Conclusion: The accurate dosimeter selection provided a feasible and reliable evaluation that enabled the comparison.

Database: EMBASE

7. Experimental sensitivity analysis of x-ray acoustic computed tomography for radiotherapy dosimetry applications

Author(s): Hickling S.; Hobson M.; El Naqa I.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 3209-3210

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: X-ray acoustic computed tomography (XACT) is an emerging dosimetry technique that detects radiation-induced acoustic waves to form images of the dose deposited in an irradiated medium. This work explores the ability of XACT to detect changes in field size, field location, and source to surface distance (SSD). Methods: An immersion ultrasound transducer was placed inside a water tank to detect the acoustic waves induced following irradiation by a 10 MV flattening filter free beam. By rotating the collimator, transducer signals were obtained every 6 degree around the field. A filtered back projection algorithm was used to reconstruct an image of the relative dose distribution. Nominally, the water tank was placed at an SSD of 90 cm and the field size was set to 4 cm x 4 cm at the detector depth of 10 cm. XACT images were acquired and analyzed for incremental changes in field size, field location, and SSD. Results: Profiles extracted from XACT images were sensitive to collimator field size changes of 2 mm, with XACT and film measured field sizes agreeing within experimental uncertainty. When the field center was shifted 2 mm, the center of the field as determined from the XACT image was found to shift by 1.9 +/- 0.2 mm. An XACT image acquired at an SSD of 92 cm had a decrease in relative image intensity of 10 +/- 5% compared to an XACT image at an SSD of 90 cm. This is close to the expected change in intensity of 4%, as determined by the inverse square law. Conclusion: XACT is sensitive to field size changes and field shifts of 2 mm, and relative dose changes on the order of 4%. This makes XACT a promising dosimetry technique for a variety of applications, including relative water tank and in vivo dosimetry.

Database: EMBASE

8. In vivo dosimetry for lung radiotherapy including SBRT.

Author(s): McCurdy, Boyd M C; McCowan, Peter M

Source: Physica medica : PM : an international journal devoted to the applications of physics to medicine and biology : official journal of the Italian Association of Biomedical Physics (AIFB); May 2017

Publication Date: May 2017

Publication Type(s): Journal Article Review

PubMedID: 28576581

Abstract: SBRT for lung cancer is being rapidly adopted as a treatment option in modern radiotherapy centres. This treatment is one of the most complex in common clinical use, requiring significant expertise and resources. It delivers a high dose per fraction (typically ~6-30Gy/fraction) over few fractions. The complexity and high dose delivered in only a few fractions make powerful arguments for the application of in vivo dosimetry methods for these treatments to enhance patient safety. In vivo dosimetry is a group of techniques with a common objective - to estimate the dose delivered to the patient through a direct measurement of the treatment beam(s). In particular, methods employing an electronic portal imaging device have been intensely investigated over the past two decades. Treatment verification using in vivo dosimetry approaches has been shown to identify errors that would have been missed with other common quality assurance methods. With the addition of in vivo dosimetry to verify treatments, medical physicists and clinicians have a higher degree of confidence that the dose has been delivered to the patient as intended. In this review, the technical aspects and challenges of in vivo dosimetry for lung SBRT will be presented, focusing on transit dosimetry applications using electronic portal imaging devices (EPIDs). Currently available solutions will be discussed and published clinical experiences, which are very limited to date, will be highlighted.

Database: Medline

9. Out-of-field in vivo dosimetry using TLD in SABR for primary kidney cancer involving mixed photon fields.

Author(s): Lonski, P; Keehan, S; Siva, S; Pham, D; Franich, R D; Taylor, M L; Kron, T

Source: Physica medica : PM : an international journal devoted to the applications of physics to medicine and biology : official journal of the Italian Association of Biomedical Physics (AIFB); May 2017; vol. 37 ; p. 9-15

Publication Date: May 2017

Publication Type(s): Journal Article

PubMedID: 28535921

Abstract: PURPOSE To assess out-of-field dose using three different variants of LiF thermoluminescence dosimeters (TLD) for ten patients who underwent stereotactic ablative body radiotherapy (SABR) for primary renal cell carcinoma (RCC) and compare with treatment planning system (TPS) dose calculations. METHODS AND MATERIALS Thermoluminescent dosimeter (TLD) measurements were conducted at 20, 30, 40 and 50cm from isocentre on ten patients undergoing SABR for primary RCC. Three types of high-sensitivity LiF:Mg,Cu,P TLD material with different ⁶Li/⁷Li isotope ratios were used. Patient plans were calculated using Eclipse Anisotropic Analytical Algorithm (AAA) for clinical evaluation and recalculated using Pencil Beam Convolution (PBC) algorithm for comparison. RESULTS Both AAA and PBC showed diminished accuracy for photon doses at increasing distance out-of-field. At 50cm, measured photon dose was 0.3cGy normalised to a 10Gy prescription on average with only small variation across all patients. This is likely due to the leakage component of the out-of-field dose. The ⁶Li-enriched TLD materials showed increased signal attributable to additional neutron contribution. CONCLUSION LiF:Mg,Cu,P TLD containing ⁶Li is sensitive enough to measure out-of-field dose 50cm from isocentre however will over-estimate the photon component of out-of-field dose in high energy treatments due to the presence of thermal neutrons. ⁷Li enriched materials which are insensitive to neutrons are therefore required for accurate photon dosimetry. Neutron signal has been shown here to increase with MUs and is higher for patients treated using certain non coplanar beam arrangements. Further work is required to convert this additional neutron signal to dose.

Database: Medline

10. Preliminary results of in-vivo dosimetry by EPID

Author(s): Giancaterino S.; Falco M.; De Nicola A.; Adorante N.; Di Tommaso M.; Trignani M.; Allajbej A.; Perrotti F.; Genovesi D.; Greco F.; Grusio M.; Piermattei A.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective This study reports in-vivo dose verification (IVD) results elaborated with SOFTDISO software on 300 cancer patients treated with 3D-CRT, IMRT and VMAT techniques. SOFTDISO uses the integral EPID image referred to each single static or dynamic beam providing a quasi- real-time test elaboration. Material and Methods The selected patients for this study were treated with an Elekta Synergy Agility LINAC at SS. Annunziata Hospital. 3D-CRT, IMRT and VMAT treatment plans of 300 patients were randomly selected. IVD tests were processed with the SOFTDISO software who provides two type of tests: (i) R ratio between the reconstructed isocenter dose and the planned one; (ii) transit dosimetry based on gamma- analysis of EPID imaging (Pg (%))

and gmean). Results We identified class-1 errors, derived from inadequate QCs, and class-2 errors due to patient morphological changes. Considering overall (6697) tests, we found out that only 5% of them showed out-of-tolerance mean R values. For gamma index analysis, in 13% of the overall tests were found to be out of tolerance. Ignoring class-2 errors, 100% of patients treated with different radiotherapy techniques (except 3DCRT breast treatment, for which no class-2 errors were observed) reported mean Pg (%) values within tolerance levels. Thus, the percentage of out-of-tolerance tests decreases from 13% to 7%. However, considering all the techniques, only 4.4% of mean gmean tests resulted out of tolerance. In addition, removing class-2 errors, this percentage decreases to approximately 3%. Actually the workload of IVD procedures on 9 patients is 1 hour per day. Conclusion IVD performed using SOFTDISO assures: (i) a rapid response of dose delivery alert with a reduced workload; (ii) a large number of patients tested daily and (iii) for out-of-tolerance tests repeating IVD in the subsequent day, the possibility to verify the efficacy of the adopted corrections.

Database: EMBASE

11. Improving the accuracy of dosimetry verification by non-uniform backscatter correction in the EPID

Author(s): Md Radzi Y.; Spezi E.; Windle R.S.; Lewis D.G.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective Challenges in improving the accuracy of EPID-based patient dose verification have been widely discussed and remain a key topic of interest for patient safety, as exemplified in the UK by the 'Towards Safer Radiotherapy' 2008 report [1]. In particular, one of which is for every radiotherapy centre to have protocols for in vivo dosimetry (IVD) to be used for most patients as recommended in the Annual Report of the Chief Medical Officer for 2006 and it is already a legal requirement in many European Countries [2]. In this presentation, we report on commissioning and implementation of the commercially available Dosimetry Check (DC) [3, 4] system. Particular emphasis has been given to addressing the significant non-uniform backscatter effect from the VARIAN aSi-1000 EPID arm [5, 6]. Material and Methods A backscatter correction matrix was developed by combination of dosimetric information from a set of segmented fields sampling on different positions around the active area of the imager. The matrix was then used to correct EPID images using MATLAB programming scripts. The corrected image was created in DICOM format and exported to Dosimetry Check to read and analyse. Example treatment fields were generated in our Oncentra MasterPlan (OMP) Treatment Planning System (TPS), with several equidistant dose reference points relative to central axis included. A dose comparison given by DC with reference to the TPS was recorded in an auto-generated report. Assessment and comparison undertaken included the (i) asymmetry evaluation of equidistant points before and after correction being applied with respect to TPS, (ii) improvement in segmented IMRT dose profiles after correction, and (iii) OMP-DC pass rate with gamma criterion 3%/3mm [7], as well as 2-D Gamma Volume Histogram (GVH) evaluation on outlined PTVs. Results (i) Correction for non-uniform backscatter improved with overall agreement between fields generated in OMP and those recorded in DC from within 3% to better than 1%. (ii) Agreement between OMP and DC for IMRT dose profiles with a sample Head & Neck case was improved by approximately 3% using the correction methodology (Table 1). (iii) For gamma comparison of fields in OMP and DC with 3%/3mm, pass rates were improved from around 80% to around 90% by the correction method. Similarly in GVH evaluation for the outlined PTVs, pass rate has increased from around 80% to 90% after correction being applied. Conclusion The correction method implemented herein for the Dosimetry Check

system has proved to be an effective way to reduce verification inaccuracy caused by backscatter from the Varian EPID arm and can be used to enhance the previously established portal verification method for IMRT using this technology.

Database: EMBASE

12. Clinical use of transit dosimetry to analyze inter-fraction motion errors

Author(s): Ebrahimi Tazehmahalleh F.; Moustakis C.; Haverkamp U.; Eich H.T.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective The aim of this work was to inquire the correlation between the target and organ at risks motions and volume discrepancy with the dosimetric variations at hospital levels. The high resolution, large active area, and effectiveness of the Electronic portal imaging devices offers it to be used for in vivo dosimetry during radiation therapy as an additional dose delivery check. The transit dosimetry has the potential of testifying dose delivery, the accuracy of MLC leaf positioning and the calculation of dose to a patient or phantom. Material and Methods In total 42 patients with stereotactic plans were evaluated. Delivery was carried out on a Varian TrueBeam linac equipped with an aS1000 EPID. Continuous portal imaging was performed at each treatment fraction during the delivery of treatment for all beams. To validate the method, we executed treatment plans on a commercial respiratory motion phantom containing plastic spheres as target. Phantom CT scans were made in different phases. First phase were done by applying sinusoidal breathing cycle in different motion amplitudes (-20, -10, 0, 10, 20 mm) in superior/inferior direction and second phase was done by pre-defined breathing simulation with a short pause after exhalation in oscillation mode. Three techniques: 3D-CRT, IMRT and VMAT-SBRT were generated and on board transit dose was collected by EPID during the treatment. The daily obtained portal image were compared with the reference image using the gamma evaluation method with criterion 2% dose difference and 2 mm distance to agreement (DTA) criteria with a threshold value of 5% of maximum value. Results The area gamma passing rate per arc in most of the plans was higher than the acceptable limit but in some arcs it had lower agreement, the lowest value was 3.7%. Besides irradiating phantom in planned respiratory motion, we reirradiated the same plans due to displacement of the target by stopping the movement or changing the breathing speed. Gamma parameters such as maximum gamma, average gamma, and percentage of the field area with a gamma value >1.0 were analyzed. For all the VMAT arcs in phantom measurements, the gamma evaluations were within the tolerance limits (gammax = 3.5, gammaavg = 0.5 and gamma% >1 = 2%) though in some measurement 20 mm target displacement was applied. For IMRT fields, measurements were not in good agreement in different tumor motion. 3DCRT fields showed poorest gamma agreement in portal dosimetry analysis. Conclusion This research increases the need of a tool for monitoring inter-fraction errors by confirming the tumor position within the treatment field over the course of therapy. Using daily EPID images over the course of treatment could potentially provide accurate verification of dose delivery to heterogeneous anatomical regions in patients receiving 3D-CRT and IMRT radiation therapy treatments. However, further studies are required to assess 3D IN VIVO dose verification of VMAT techniques of various treatment sites.

Database: EMBASE

13. Clinical set up and first results of EPID in vivo dosimetry in an overload Chinese Radiotherapy

Author(s): Li J.; Wang P.; Kang S.; Xiao M.; Tang B.; Liao X.; Xin X.; Orlandini L.C.; Piermattei A.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective In vivo dosimetry (IVD) is an important tool able to verify the accuracy of the treatment delivered. In an environment where several linacs of different types support daily heavy treatment workload over different shifts of therapists, physicists and Radiation oncologists, IVD checks can be strongly recommended to avoid important dosimetric discrepancies. The work describes the setup of IVD procedure with electronic portal imaging devices (EPID) in an overload radiotherapy clinical workflow, and the preliminary results obtained. Material and Methods 64 patients that underwent a VMAT or IMRT treatments for head and neck, brain, breast, lung, thorax, abdomen and pelvis where scheduled for in vivo dosimetry procedure with EPID. A commercial software (SOFTDISO, Best Medical, Italy) was used at this purpose. Two indexes were analysed: the ratio R between the reconstructed (Diso) and planned (Dtps) isocenter dose ($R = \text{Diso}/\text{Dtps}$) and Pgamma% obtained performing a gamma analysis between the first EPID image and the next ones acquired. The acceptance criteria adopted for the ratio R was +/-5%, while for the 2D gamma-analysis in term of Pgamma index, we adopted Pgamma > 90% with a passing criteria of 3% global difference and 3mm distance to agreement for head and neck treatment and 5%, 5mm for the others districts. The percentage of patients P% with Rmean and Pgamma in the tolerance level P%(Rmean) P%(Pgamma) respectively, and the percentage of IVD test T% with R and Pgamma in the tolerance level T%(R) and T%(Pgamma), were evaluated. For each district P% take into account the patients with the mean values of the indexes within the tolerance levels, while the T% is referred to the number of tests. If one of the indexes resulted out of tolerance, corrective actions were performed and the test repeated at the next fraction. Results The results of 1211 IVD tests over 64 patients, were reported in Table 1. All the patients analysed shown both indexes (Rmean and Pgamma) in tolerance with the exception of breast and thorax treatments. For VMAT and IMRT thorax treatments P%(Pgamma) decreased to 67%. The thorax patients were revised considering the high gradient regions of the isocenter and the positioning set up was optimized. For IMRT breast treatment, P%(Pgamma) decreased to 50%: two (over four) IMRT breast patients were revised adjusting the bolus positioning over the mask in order to realign the reproducibility of the treatment (Pgamma index) in the tolerance level. Adopting the appropriate corrections, the successive IVD tests guaranteed at the end of the treatment P% values within the tolerance levels. For thorax and breast treatments, due to the limitation of IVD tests acquired, the mean P%(Py) index values after the correction, were again out of tolerance but the effect of the correction was always efficient. Conclusion IVD with EPID, is a powerful tool that can be inserted in an overload radiotherapy department. It can be helpful daily to monitor the accuracy of the treatment and enable a quickly correction of misalignment or discrepancies occurred during the treatment course. (Table Presented).

Database: EMBASE

14. Acute toxicity and in-vivo dosimetry of a two week hypofractionated schedule within the HYPOR study

Author(s): Saha A.; Goswami G.; Mandal S.; Mahata A.; Chatterjee S.; Midha D.; Ahmed R.; Agarwal S.; Ray S.; Das J.; Datta S.S.; Sinha S.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective There are no standard palliative breast radiotherapy regimens for local control but many use the dose equivalent as in the adjuvant setting (40Gy/15 fractions). Within

HYPOR study we are exploring a dose of 35 Gy in 10 fractions over 2 weeks prescribed to the breast and supraclavicular fossa (SCF) to palliate advanced incurable breast cancers. Material and Methods A gafchromic RTQA2 film based matching of the junction of tangents and Supraclavicular (SCF) fields (JF) is being carried out to assess the geographical overlap or separation during first 3 fractions. Similarly during the first 3 fractions, in-vivo thermo luminescent dosimetry (TLD) is being performed to confirm received dose by placing a TLD over isocenter of the tangential fields and another at JF. Primary objective for the study has been set to assess the acute toxicity using CTCAE version 4 in 30 total patients. Results Of the required 30 patients, 19 have been recruited. Median dose planned to receive by 95% volume of the breast PTV was 96.3% (range=95.2-98.9%). The median dose max planned to the breast PTV was 106.4% (range=105.4-106.9%). Breast PTV receiving $\geq 105\%$ of the prescribed dose was planned to be 1.75% (median) with no point dose $\geq 107\%$. Organ at risks (OAR) dose constraints were met for all patients. The junction movement range using gafchromic RTQA2 film was between -2mm to +3mm. TLD measured dose (median) and percentage variation of tangential field isocenter dose and field junction dose for first three fractions is summarized in table 1. Median percentage variation for tangential field isocenter dose as measured using TLD was 3% (Range = -9.7 to 9.4%) and similarly median percentage dose variation for JF as measured with TLD was 1.2% (Range= -8.5 to 8.9%). At a median follow up of 5 months only 1 patient reported grade 2 acute skin toxicity (others had grade 1). None of the patients complained of dysphagia or acute brachial plexopathy. Conclusion QA measures in the HYPOR study confirm the delivery of the prescribed two week dose schedule with no significant over dosage at the JF. A dose of 35Gy is well tolerated.

Database: EMBASE

15. Feasibility study of in vivo dosimetry with optically stimulated dosimeters for 50kVp Papillon beam

Author(s): Dejean C.; Mana A.; Gauthier M.; Feuillade J.; Colnard C.; Gerard J.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective to evaluate optically stimulated luminescence dosimeters (OSL, nanodot Landauer TM) to be used for in vivo dosimetry with 50kVp beam. Material and Methods Papillon mobile xray generator is delivering a 50kVp treatment beam that can be used for skin or rectum treatment. A new machine based on the same beam, Papillon+ is being launched to add the opportunity of delivering intra operative breast treatment. OSL principle is to detect light emitted when the luminescence material, which is exposed to radiation, is stimulated with visible light. Associated reader is Microstar ii. Nanodots were irradiated with Papillon beam treatment to establish calibration curves and to evaluate attenuation. Attenuation was measured by a second nanodot situated under the first one which is a pessimistic way of determination as both plastic disk infused with Aluminium oxide doped with Carbon Al₂O₃:C encased in a plastic case. Results Detectors were read after irradiation from 10 to 22.5Gy. No saturation was observed unlikely expected. Results highlight a linear calibration curve with a regression linear coefficient R²=0.9853. Concerning attenuation, results are ranging from 80 to 70% of reference measurements with this methodology. Discussion: While dose used is in treatment range (around 20 Gy), linear calibration can be used which is different from literature results. It may be linked to the evolution made by Landauer concerning the Microstar reader between (Price, Medical Physics 2013) and today. So, OSL can be used at a time to evaluate skin dose but also delivered dose at applicator surface. Attenuation methodology needs to be modified to be more relevant according to our clinical use. Gafchromic films may be used to evaluate surface attenuation. Conclusion OSL nanodots are usable

with 50kVp Papillon beam for breast intraoperative radiotherapy for example. OSL reading is fast and without delay. Attenuation surface of the detector is 0.9x0.9cmxcm that has to be clinically validated before replacing thermoluminescence dosimeters (TLD) classically used. Uncertainties are on the same level as published one concerning TLD (around 17%), they will be determined with Papillon+ beam that permits to treat breast in an intraoperative mode.

Database: EMBASE

16. In-vivo dosimetry using Dosimetry Check: 5-year experience on 345 prostate cancer patients

Author(s): Nailon W.H.; Welsh D.; MacDonald K.; Cooke G.; Cutanda F.; Puxeu-Vaque J.; Kehoe T.; Andiappa S.; Burns D.; Forsyth J.; McLaren D.B.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective It is recommended that all radiotherapy centres in the United Kingdom (UK) have a protocol for in vivo dosimetry (IVD) and in several European countries IVD is now mandatory. Electronic portal imaging devices (EPIDs), which although developed primarily for the purposes of imaging, are now widely used for IVD and consequently for treatment quality assurance (QA). Here we present results from 5-year clinical experience of using IVD for verification of prostate cancer patients. Material and Methods Between 2011 and 2016 IVD was performed by Dosimetry Check (DC) (Math Resolutions LLC, Columbia, MD, USA) on 345 prostate cancer patients. Treatment plans were prepared in Eclipse (Varian Medical Systems, Inc., Palo Alto, CA, USA) with 285 patients treated with a volumetric modulated arc therapy (VMAT) technique and 60 patients treated with a three-dimensional conformal radiotherapy (3DCRT) technique. The difference between the dose calculated by Eclipse at a reference point and the dose measured by DC at the same reference point at time-of-treatment was recorded. In cases where the dose difference exceeded +/-10% an alert was triggered and a full three-dimensional gamma analysis (4%/4mm) performed on the treatment plan. This led to either the measurement being repeated or further positional and patient-specific QA checks being performed. Results Figure 1 shows the percentage difference in point doses calculated by Eclipse and measured by DC for the 3DCRT and VMAT treatments monitored. The mean and standard deviation ($\mu \pm \sigma$) of the percentage difference in dose obtained by DC and calculated by Eclipse was $1.23 \pm 4.61\%$ in VMAT and $-3.62 \pm 4.00\%$ in 3DCRT. A total of 12 plans exceeded the +/-10% alert criteria accounting for 3.5% of all prostate cancer treatments monitored. In all of these cases further investigation using 3D gamma analysis and additional patient-specific QA found no reportable treatment errors. Conclusion The preliminary results of this pilot study show that EPID-based IVD using the DC software has the potential to detect errors and identify sub-optimal treatments. With the addition of more data it may also be possible to establish site-specific alert levels, which could improve the quality of radiotherapy.

Database: EMBASE

17. Epid-based in vivo dosimetry for SBRT-VMAT treatment dose verification

Author(s): Cilla S.; Ianiro A.; Craus M.; Viola P.; Fidanzio A.; Azario L.; Greco F.; Grusio M.; Piermattei A.; Deodato F.; Macchia G.; Valentini V.; Morganti A.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective In vivo dosimetry (IVD), a direct method of measuring radiation doses to cancer patients during treatment, has shown unique features to trace deviations between planned and actually delivered dose distributions. Extracranial stereotactic radiotherapy (SBRT) involves the delivery of high doses in a few fractions (1-5) for ablative purposes. Then SBRT treatments strongly benefit from IVD procedures, as any uncertainties in dose delivery is more detrimental for treatment goals or patient safety. We assessed the feasibility of EPID-based IVD for complex clinical VMAT treatments for SBRT. Material and Methods 15 patients with lung, liver, bone and lymphnodal metastases treated with Elekta VMAT were enrolled. All plans were generated with Masterplan Oncentra and Ergo++ treatment planning systems (Elekta, Crawley, UK) with a single 360degree arc VMAT. All targets were irradiated in 5 consecutive fractions, with total doses ranging from 40 to 50 Gy depending on anatomical sites. All patients passed pre-treatment 3%/3mm g-analysis verification. IVD was performed using SOFTDISO (Best Medical Italy), a dedicated software implemented in our clinic for conformal, IMRT and VMAT techniques. IVD tests were evaluate by means of (i) R ratio between isocenter daily in-vivo dose and planned dose and (ii) gamma-analysis between EPID integral portal images in terms of percentage of points with gamma-value smaller than one (gamma%) and mean gvalues (gammamean), using a global 3%-3 mm criteria. Alert criteria of +/-5% for R ratio, gamma% 0.67 were chosen, the last two in order to accept only 10% of the values to exceed 3%/3mm and an average discrepancy of the order of 2%/2mm, respectively. Results A total of 75 transit EPID images were acquired. Five images (6.6%) were removed from analysis for image deterioration and/or electronic acquisition failures. The overall mean R ratio was equal to 0.999 +/- 0.021 (1 SD) for all patients, with more than 98% of tests within 5% alert criteria. The 2D portal images g-analysis show an overall gammamean of 0.29+/-0.13 with 100% of tests within alert criteria, and a mean gamma% equal to 96.9+/-5.2% with 96.0% of tests within alert criteria. In contrast to our past experience of patients with head-neck and pelvic treatments, where the systematic use of IVD revealed some discrepancies due to major anatomical variations or random anatomical changes in terms of filling of rectum/bladder, no relevant discrepancies were detected in SBRT patient. The results are supplied in quasi realtime, with IVD tests performed and displayed after only 1 minute from the end of arc delivery. Figure 1 shows the SOFTDISO user interface. Conclusion The present EPID-based IVD algorithm provided a fast and accurate procedure for SBRT-VMAT delivery verification in clinical routine, with results obtained 1 minute after each arc delivery. This strategy allows physics and medical staff to promptly act in case of major deviations of dose delivery.

Database: EMBASE

18. Studies on optical fiber dosimeters for in-vivo dosimetry in HDR brachytherapy

Author(s): Moutinho L.; Freitas H.; Melo J.; Veloso J.F.C.A.; Rachinhas P.J.; Simoes P.C.P.S.; Santos J.A.M.; Pereira A.; Silva J.; Pinto S.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective Dose verification and quality assurance in radiotherapy should be assessed in order to provide the best treatment possible and minimize risks for patient. Notwithstanding, due technical constraints in certain treatments there's no such tools capable to perform real-time dose measurement. An ideal dosimeter for prostate brachytherapy should provide real-time and in-vivo dose measurement, present high sensitivity and no dependencies on energy, dose and dose rate and temperature. Also should be detectable in the anatomic volume to check its position, easy to use and calibrate and not expensive/disposable use of its implantable part. Material and Methods We developed a fiber optic dosimeter suitable for realtime dose

monitoring in breast and prostate brachytherapy, thus opening the possibility for real-time dose correction. The dosimeter comprehends a sensitive optical fiber probe of 1mm or 0.5 mm diameter where a 5 mm length scintillating optical fiber is coupled. The clear optical fiber providing scintillation light guidance into the photodetectors. Results The first round of in-vitro tests in clinical ambient allowed to demonstrate that fiber optical based dosimeters are suitable for dosimetry in regimes such the ones in HDR prostate brachytherapy. The versatility of this kind of device and easiness of use allows application in other radiotherapy modalities. The dosimeter response was evaluated under irradiation with a 10.07 Ci Ir-192 HDRbrachytherapy The dosimeter shows a linear response with dose and is capable of detecting μGy dose variations like an ionization chamber. Conclusion The first round of in-vitro tests in clinical ambient allowed to demonstrate that fiber optical based dosimeters are suitable for dosimetry in regimes such the ones in HDR prostate brachytherapy. The versatility of this kind of device and easiness of use allows application in other radiotherapy modalities. The dosimeter shows a linear response with dose and is capable of detecting μGy dose variations like an ionization chamber. (Figure Presented).

Database: EMBASE

19. In-vivo dosimetry for kV radiotherapy: Clinical use of micro-silica bead TLD & Gafchromic EBT3 film

Author(s): Palmer A.L.; Jafari S.M.; Muscat S.; Mone J.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective kV radiotherapy continues to be an important modality in modern radiotherapy, but has received less research attention in recent years. There remains a challenge to accurately calculate and verify treatment dose distributions for clinical sites with significant surface irregularity or where the treated region contains inhomogeneities, e.g. nose and ear. The accuracy of current treatment calculations has a significant level of uncertainty [1, 2]. The objective of this work was to characterise two novel detectors, micro-silica bead TLDs and Gafchromic EBT3 film, for in-vivo measurements for kV treatments, and to compare measured doses with conventional treatment calculations. [1. Currie (2007) Australas Phys Eng Sci Med, 2. Chow (2012) Rep Pract Oncol Radiother.] Material and Methods Micro-silica bead TLDs (1 mm diam.) and Gafchromic EBT3 film were calibrated against an NPL traceably calibrated ionisation chamber using an Xstrahl D3300 kV radiotherapy treatment unit. Energy response was evaluated over 70 to 250 kV and compared to 6 MV, useable dose range was evaluated from 0 to 25 Gy, and uncertainty budgets determined. Silica beads were cleaned, annealed, and TL response individually calibrated. EBT3 film was used with triple-channel dosimetry via FilmQAPro with procedures to reduce uncertainties. Commissioning tests were undertaken in standard conditions using Solid Water blocks and in simulated clinical treatment condition using a custom made 'wax face with nose' phantom. Pilot in vivo measurements were made for a consecutive series of eight clinical patient treatments, including cheek, ear, nose and rib sites, over 70 to 250 kV, and 4 to 18 Gy. Results for the two dosimetry systems were compared to conventional treatment planning calculations. Results Energy response varied by 460% for beads and 9% for film, from 70 kV to 6 MV, necessitating energy-specific calibration. Both dosimeters were useable up to 25 Gy. Standard uncertainty was 3.1% for beads, 2.1% for film. The figure shows typical film and bead positions within the lead cut-out of a kV treatment to the cheek. The table provides calculated and measured doses. Average deviation over 6 patients was -1.3% for beads, -0.9% for film. 3 patients had larger deviations; See table note 1: tumour sitting over the maxillary sinus may reduce dose. Note 2: beads placed along surface of tumour into ear, most distal bead received dose -17.5% from prescription, doctor made compensation. Note 3: Increased

uncertainty due to curved surface, film required offset to corner as patient sensitive to contact. Note 4: Uncertainty increased due to large respiratory motion at treatment site. Conclusion Both micro-silica bead TLDs and EBT3 film were characterised as suitable for in vivo dosimetry in kV radiotherapy, providing assurance of delivered doses. Film is simpler to prepare, use and read. A line of beads allows conformation to irregular anatomy across the field. A clinical service is now available to verify dose delivery in complex clinical sites. (Table Presented).

Database: EMBASE

20. Study of dosimetric characteristics of a commercial optically stimulated luminescence system

Author(s): Jain G.K.; Chougule A.; Kaliyamoorthy A.; Akula S.K.

Source: Journal of Radiotherapy in Practice; May 2017 ; p. 1-15

Publication Date: May 2017

Publication Type(s): Article In Press

Abstract:Background: Optically stimulated luminescence dosimeters (OSLDs) have a number of advantages in radiation dosimetry making them an excellent dosimeter for in vivo dosimetry. The study aimed to study the dosimetric characteristics of a commercial optically stimulated luminescence (OSL) system by Landauer Inc., before using it for routine clinical practice for in vivo dosimetry in radiotherapy. Further, this study also aimed to investigate the cause of variability found in the literature in a few dosimetric parameters of carbon-doped aluminium oxide (Al₂O₃:C). Materials and methods: The commercial OSLD system uses Al₂O₃:C nanoDot™ as an active radiation detector and InLight™ microStar as a readout assembly. Inter-detector response, energy, dose rate, field size and depth dependency of the detector response were evaluated for all available clinical range of photon beam energies in radiotherapy. Results: Inter-detector variation in OSLD response was found within 3.44%. After single light exposure for the OSL readout, detector reading decreased by 0.29% per reading. The dose linearity was investigated between dose range 50-400 cGy. The dose response curve was found to be linear until 250 cGy, after this dose, the dose response curve was found to be supra-linear in nature. OSLD response was found to be energy independent for Co60 to 10 MV photon energies. Conclusions: The cause of variability found in the literature for some dosimetric characteristics of Al₂O₃:C is due to the difference in general geometry, construction of dosimeter, geometric condition of irradiation, phantom material and geometry, beam energy. In addition, the irradiation history of detector used and difference in readout methodologies had varying degree of uncertainties in measurements. However, the large surface area of the detector placed in the phantom with sufficient build-up and backscatter irradiated perpendicularly to incident radiation in Co60 beam is a good method of choice for the calibration of a dosimeter. Understanding the OSLD response with all dosimetric parameters may help us in estimation of accurate dose delivered to patient during radiotherapy treatment. Copyright © Cambridge University Press 2017

Database: EMBASE

21. In vivo dosimetry in UK external beam radiotherapy: current and future usage.

Author(s): MacDougall, Niall D; Graveling, Michael; Hansen, Vibeke N; Brownsword, Kevin; Morgan, Andrew

Source: The British journal of radiology; Apr 2017; vol. 90 (no. 1072); p. 20160915

Publication Date: Apr 2017

Publication Type(s): Journal Article

PubMedID: 28205452

Abstract:OBJECTIVE Towards Safer Radiotherapy recommended that radiotherapy (RT) centres should have protocols in place for in vivo dosimetry (IVD) monitoring at the beginning of patient treatment courses (Donaldson S. Towards safer radiotherapy. R Coll Radiol 2008). This report determines IVD implementation in the UK in 2014, the methods used and makes recommendations on future use. METHODSEvidence from peer-reviewed journals was used in conjunction with the first survey of UK RT centre IVD practice since the publication of Towards Safer Radiotherapy. In March 2014, profession-specific questionnaires were sent to radiographer, clinical oncologist and physics staff groups in each of the 66 UK RT centres. RESULTSResponse rates from each group were 74%, 45% and 74%, respectively. 73% of RT centres indicated that they performed IVD. Diodes are the most popular IVD device. Thermoluminescent dosimeter (TLD) is still in use in a number of centres but not as a sole modality, being used in conjunction with diodes and/or electronic portal imaging device (EPID). The use of EPID dosimetry is increasing and is considered of most potential value for both geometric and dosimetric verification. CONCLUSIONOwing to technological advances, such as electronic data transfer, independent monitor unit checking and daily image-guided radiotherapy, the overall risk of adverse treatment events in RT has been substantially reduced. However, the use of IVD may prevent a serious radiation incident. Point dose IVD is not considered suited to the requirements of verifying advanced RT techniques, leaving EPID dosimetry as the current modality likely to be developed as a future standard. Advances in knowledge: An updated perspective on UK IVD use and provision of professional guidelines for future implementation.

Database: Medline

22. Clinical Implementation of a Model-Based In Vivo Dose Verification System for Stereotactic Body Radiation Therapy-Volumetric Modulated Arc Therapy Treatments Using the Electronic Portal Imaging Device.

Author(s): McCowan, Peter M; Asuni, Ganiyu; Van Uytven, Eric; VanBeek, Timothy; McCurdy, Boyd M C; Loewen, Shaun K; Ahmed, Naseer; Bashir, Bashir; Butler, James B; Chowdhury, Amitava; Dubey, Arbind; Leylek, Ahmet; Nashed, Maged

Source: International journal of radiation oncology, biology, physics; Apr 2017; vol. 97 (no. 5); p. 1077-1084

Publication Date: Apr 2017

Publication Type(s): Journal Article

PubMedID: 28332992

Abstract:PURPOSETo report findings from an in vivo dosimetry program implemented for all stereotactic body radiation therapy patients over a 31-month period and discuss the value and challenges of utilizing in vivo electronic portal imaging device (EPID) dosimetry clinically. METHODS AND MATERIALSFrom December 2013 to July 2016, 117 stereotactic body radiation therapy-volumetric modulated arc therapy patients (100 lung, 15 spine, and 2 liver) underwent 602 EPID-based in vivo dose verification events. A developed model-based dose reconstruction algorithm calculates the 3-dimensional dose distribution to the patient by back-projecting the primary fluence measured by the EPID during treatment. The EPID frame-averaging was optimized in June 2015. For each treatment, a 3%/3-mm γ comparison between our EPID-derived dose and the Eclipse AcurosXB-predicted dose to the planning target volume (PTV) and the $\geq 20\%$ isodose volume were performed. Alert levels were defined as γ pass rates $< 85\%$ (lung and liver) and $< 80\%$ (spine). Investigations were carried out for all fractions exceeding the alert level and were classified as follows: EPID-related, algorithmic, patient setup, anatomic change, or unknown/unidentified errors. RESULTSThe percentages of fractions exceeding the alert levels were 22.6% for lung before frame-average optimization and 8.0% for lung, 20.0% for spine, and 10.0% for liver after frame-average optimization. Overall, mean (\pm standard deviation) planning target volume γ pass rates were

90.7% ± 9.2%, 87.0% ± 9.3%, and 91.2% ± 3.4% for the lung, spine, and liver patients, respectively. CONCLUSIONS Results from the clinical implementation of our model-based in vivo dose verification method using on-treatment EPID images is reported. The method is demonstrated to be valuable for routine clinical use for verifying delivered dose as well as for detecting errors.

Database: Medline

23. In vivo Portal Imaging Dosimetry Identifies Delivery Errors in Rectal Cancer Radiotherapy on the Belly Board Device.

Author(s): Peca, Stefano; Sinha, Richie Siddhartha; Brown, Derek Wilson; Smith, Wendy Lani

Source: Technology in cancer research & treatment; Jan 2017 ; p. 1533034617711519

Publication Date: Jan 2017

Publication Type(s): Journal Article

PubMedID: 28585490

Abstract: PURPOSE We recently developed a novel, open-source in vivo dosimetry that uses the electronic portal imaging device to detect dose delivery discrepancies. We applied our method on patients with rectal cancer treated on a belly board device. METHODS In vivo dosimetry was performed on 10 patients with rectal cancer treated prone on the belly board with a 4-field box arrangement. Portal images were acquired approximately once per week from each treatment beam. Our dosimetry method used these images along with the planning CT to reconstruct patient planar dose at isocenter depth. RESULTS Our algorithm proved sensitive to dose discrepancies and detected discordances in 7 patients. The majority of these were due to soft tissue differences between planning and treatment, present despite matching to bony anatomy. As a result of this work, quality assurance procedures have been implemented for our immobilization devices. CONCLUSION In vivo dosimetry is a powerful quality assurance tool that can detect delivery discrepancies, including changes in patient setup and position. The added information on actual dose delivery may be used to evaluate equipment and process quality and to guide for adaptive radiotherapy.

Database: Medline

24. A Simple Method for 2-D In Vivo Dosimetry by Portal Imaging.

Author(s): Peca, Stefano; Brown, Derek Wilson; Smith, Wendy Lani

Source: Technology in cancer research & treatment; Jan 2017 ; p. 1533034617711354

Publication Date: Jan 2017

Publication Type(s): Journal Article

PubMedID: 28585491

Abstract: PURPOSE To improve patient safety and treatment quality, verification of dose delivery in radiotherapy is desirable. We present a simple, easy-to-implement, open-source method for in vivo planar dosimetry of conformal radiotherapy by electronic portal imaging device (EPID). METHODS Correlation ratios, which relate dose in the mid-depth of slab phantoms to transit EPID signal, were determined for multiple phantom thicknesses and field sizes. Off-axis dose is corrected for by means of model-based convolution. We tested efficacy of dose reconstruction through measurements with off-reference values of attenuator thickness, field size, and monitor units. We quantified the dose calculation error in the presence of thickness changes to simulate anatomical or setup variations. An example of dose calculation on patient data is provided. RESULTS With varying phantom thickness, field size, and monitor units, dose reconstruction

was almost always within 3% of planned dose. In the presence of thickness changes from planning CT, the dose discrepancy is exaggerated by up to approximately 1.5% for 1 cm changes upstream of the isocenter plane and 4% for 1 cm changes downstream. CONCLUSION Our novel electronic portal imaging device in vivo dosimetry allows clinically accurate 2-dimensional reconstruction of dose inside a phantom/patient at isocenter depth. Due to its simplicity, commissioning can be performed in a few hours per energy and may be modified to the user's needs. It may provide useful dose delivery information to detect harmful errors, guide adaptive radiotherapy, and assure quality of treatment.

Database: Medline

25. Clinical results of an EPID-based in-vivo dosimetry for lung cancer radiation therapy

Author(s): Giancaterino S.; De Nicola A.; Adorante N.; Di Tommaso M.; Trignani M.; Nuzzo M.; Genovesi D.; Falco M.D.

Source: Journal of Thoracic Oncology; Jan 2017; vol. 12 (no. 1)

Publication Date: Jan 2017

Publication Type(s): Conference Abstract

Abstract:Background: In-vivo dose verification is a step of quality assurance to ensure that the dose delivered during treatment agrees with the prescribed. This work reports the in-vivo dosimetry (IVD) results obtained with SOFTDISO (Best Medical Italy). Methods: SOFTDISO was developed by National Institute of Nuclear Physics and Catholic University of Sacred Heart (Rome). The software reconstructs in quasi-real time the dose at isocenter (Diso) from the transit signal acquired by the EPID and the comparison between EPIDs of every fractions. For each beam and fraction, the R ratios between Diso in 3D-CRT plans for lung targets and the dose (2 Gy/fraction) calculated by the treatment planning system Diso, TPS (Oncentra) were computed. The acceptance criteria was 0.9590% and gammamean13% for R, >35% for Pgamma and >16% for gammamean. For each patient the Rmean value was within the tolerance level. As regards Pgamma and gammamean, 70% and 86% of patients had values within the tolerance, respectively. These values were obtained considering set-up errors and morphological changes (tumor reduction, atelectasis and/or air). Figure 1. shows the results in one patient. Conclusion: Results of an EPID-based in-vivo dosimetry for lung cancer treatments are in tolerance for the dose at the isocenter (Rvalue). The g-analysis suffer from some restrictions due to morphological changes that affect the results. The SOFTDISO realtime analysis allows to daily investigate the dose delivery. (Figuer Presented).

Database: EMBASE

Intra-fractional imaging

1. Evaluation of reproducibility of tumor repositioning during multiple breathing cycles for liver stereotactic body radiotherapy treatment.

Author(s): Bedos, Ludovic; Riou, Olivier; Aillères, Norbert; Braccini, Antoine; Molinier, Jessica; Moscardo, Carmen Llacer; Azria, David; Fenoglio, Pascal

Source: Reports of practical oncology and radiotherapy : journal of Greatpoland Cancer Center in Poznan and Polish Society of Radiation Oncology; 2017; vol. 22 (no. 2); p. 132-140

Publication Date: 2017

Publication Type(s): Journal Article

PubMedID: 28490984

Abstract:AIM To evaluate the tumor repositioning during gated volumetric modulated arc therapy (VMAT) for liver stereotactic body radiotherapy (SBRT) treatment using implanted fiducial markers and intrafraction kilovoltage (kV) images acquired during dose delivery. MATERIALS AND METHOD Since 2012, 47 liver cancer patients with implanted fiducial markers were treated using the gated VMAT technique with a Varian Truebeam STx linear accelerator. The fiducial markers were implanted inside or close to the tumor target before treatment simulation. They were defined at the maximum inhalation and exhalation phases on a 4-dimensional computed tomography (4DCT) acquisition. During the treatment, kV images were acquired just before the beam-on at each breathing cycle at maximum exhalation and inhalation phases to verify the fiducial marker positions. For the five first fractions of treatment in the first ten consecutive patients, a total of 2705 intrafraction kV images were retrospectively analyzed to assess the differences between expected and actual positions of the fiducial markers along the cranio-caudal (CC) direction during the exhalation phase. RESULT The mean absolute intrafractional fiducial marker deviation along the CC direction was 1.0 mm at the maximum exhalation phase. In 99%, 95% and 90% cases, the fiducial marker deviations were ≤ 4.5 mm, 2.8 mm and 2.2 mm, respectively. CONCLUSION Intrafraction kV images allowed us to ensure the consistency of tumor repositioning during treatment. In 99% cases, the fiducial marker deviations were ≤ 4.5 mm corresponding to our 5 mm treatment margin. This margin seems to be well-adapted to the gated VMAT SBRT treatment in liver disease.

Database: Medline

2. Development of 3-dimensional transperineal ultrasound for image guided radiation therapy of the prostate: Early evaluations of feasibility and use for inter- and intrafractional prostate localization.

Author(s): Trivedi, Apoorva; Ashikaga, Takamura; Hard, Daphne; Archambault, Jessica; Lachaine, Martin; Cooper, David T; Wallace, Harold James

Source: Practical radiation oncology; 2017; vol. 7 (no. 1); p. e27

Publication Date: 2017

Publication Type(s): Journal Article

PubMedID: 27742558

Abstract:PURPOSE Transperineal ultrasound (TPUS) allows for continuous imaging of the prostate gland, but the accuracy of TPUS has not been rigorously studied. We determined the feasibility of prostate imaging with TPUS and subsequently compared prostate localization with TPUS and computed tomography (CT). METHODS AND MATERIALS We completed 2 sequential evaluations of TPUS. The feasibility study included 15 men with localized prostate cancer and tested if TPUS adequately imaged the prostate. Image qualities of the prostate and adjacent normal structures were measured. The subsequent study included 17 men who at the time of initial radiation treatment planning and in 3 subsequent sessions had CT and TPUS imaging performed and compared. RESULTS Feasibility of TPUS was confirmed in the first trial. After expected hardware and software modifications were completed, TPUS provided near complete edge definition of the prostate in the final 5 patients in the feasibility trial. The second study allowed for the comparison of 30 image sets. The differences between TPUS and CT in each direction (mean + standard deviation) were found to be 0.06 ± 2.86 mm (anteroposterior), 0.49 ± 3.49 mm (superoinferior), and 0.63 ± 3.27 mm (left-right), with no significant difference between the 2 modalities (all $P > .32$). The Euclidean distance variance using the 2 techniques was 5.25 ± 1.79 mm, which was significantly different. CONCLUSION STPUS provides good imaging of the prostate gland. We noted excellent correlation in gland localization when TPUS is compared with CT scans when comparing routine 3-dimensional positional data. Euclidean distance variation suggests the potential that summation of

small errors may in fact lead to significant differences in actual gland positional certainty. The reported difference is within the range of standard planning target volume expansion however requires additional evaluation.

Database: Medline

3. Impact of sampling interval in training data acquisition on intrafractional predictive accuracy of indirect dynamic tumor-tracking radiotherapy.

Author(s): Mukumoto, Nobutaka; Nakamura, Mitsuhiro; Akimoto, Mami; Miyabe, Yuki; Yokota, Kenji; Matsuo, Yukinori; Mizowaki, Takashi; Hiraoka, Masahiro

Source: Medical physics; Aug 2017; vol. 44 (no. 8); p. 3899-3908

Publication Date: Aug 2017

Publication Type(s): Journal Article

PubMedID: 28513922

Abstract:**PURPOSE**To explore the effect of sampling interval of training data acquisition on the intrafractional prediction error of surrogate signal-based dynamic tumor-tracking using a gimbal-mounted linac.**MATERIALS AND METHOD**Twenty pairs of respiratory motions were acquired from 20 patients (ten lung, five liver, and five pancreatic cancer patients) who underwent dynamic tumor-tracking with the Vero4DRT. First, respiratory motions were acquired as training data for an initial construction of the prediction model before the irradiation. Next, additional respiratory motions were acquired for an update of the prediction model due to the change of the respiratory pattern during the irradiation. The time elapsed prior to the second acquisition of the respiratory motion was 12.6 ± 3.1 min. A four-axis moving phantom reproduced patients' three dimensional (3D) target motions and one dimensional surrogate motions. To predict the future internal target motion from the external surrogate motion, prediction models were constructed by minimizing residual prediction errors for training data acquired at 80 and 320 ms sampling intervals for 20 s, and at 500, 1,000, and 2,000 ms sampling intervals for 60 s using orthogonal kV x-ray imaging systems. The accuracies of prediction models trained with various sampling intervals were estimated based on training data with each sampling interval during the training process. The intrafractional prediction errors for various prediction models were then calculated on intrafractional monitoring images taken for 30 s at the constant sampling interval of a 500 ms fairly to evaluate the prediction accuracy for the same motion pattern. In addition, the first respiratory motion was used for the training and the second respiratory motion was used for the evaluation of the intrafractional prediction errors for the changed respiratory motion to evaluate the robustness of the prediction models.**RESULT**The training error of the prediction model was 1.7 ± 0.7 mm in 3D for all sampling intervals. The intrafractional prediction error for the same motion pattern was 1.9 ± 0.7 mm in 3D for an 80 ms sampling interval, which increased larger than 1 mm in 10.0% of prediction models trained at a 2,000 ms sampling interval with a significant difference ($P < 0.05$). The intrafractional prediction error for the changed respiratory motion pattern increased to 5.1 ± 2.4 mm in 3D for an 80 ms sampling interval; however, there was not a significant difference in the robustness of the prediction model between the 80 ms sampling interval and other sampling intervals ($P > 0.05$).**CONCLUSIONS**Although the training error of the prediction model was consistent for the all sampling intervals, the prediction model using the larger sampling interval of the 2,000 ms increased the intrafractional prediction error for the same motion pattern. The realistic accuracy of the prediction model was difficult to estimate using the larger sampling interval during the training process. It is recommended to construct the prediction model at sampling interval $\leq 1,000$ ms and to reconstruct the model during treatment.

Database: Medline

4. Inter- and Intrafractional Variation in the 3-Dimensional Positions of Pancreatic Tumors Due to Respiration Under Real-Time Monitoring.

Author(s): Akimoto, Mami; Nakamura, Mitsuhiro; Nakamura, Akira; Mukumoto, Nobutaka; Kishi, Takashi; Goto, Yoko; Mizowaki, Takashi; Hiraoka, Masahiro

Source: International journal of radiation oncology, biology, physics; Aug 2017; vol. 98 (no. 5); p. 1204-1211

Publication Date: Aug 2017

Publication Type(s): Journal Article

PubMedID: 28721905

Abstract:**PURPOSE**To quantify the 3-dimensional pancreatic tumor motion during the overall treatment course using real-time orthogonal kilovoltage X-ray imaging.**METHODS AND MATERIALS**This study included 10 patients with pancreatic cancer who underwent 6-port static intensity modulated radiation therapy with real-time tumor tracking in 15 fractions, except for 1 patient (5 fractions). The tumor and abdominal wall positions were acquired simultaneously during the overall treatment course. Then the tumor motion amplitude and reference positions were determined.**RESULTS**The mean tumor amplitudes were 4.9, 6.5, and 13.4 mm in the left-right (LR), anterior-posterior (AP), and superior-inferior (SI) directions, respectively. The intrafractional variations of the reference tumor position were up to 5.4, 10.2, and 10.7 mm in the LR, AP, and SI directions, and those of the reference abdominal position were up to 10.5 mm. The reference tumor position drifted significantly in the AP and SI directions after 10 minutes, and that of abdominal wall motion drifted during the first 15 minutes ($P < .05$). The interfractional variation of the reference tumor position after setup correction, based on bony structures, was up to 8.9, 9.8, and 11.0 mm in the LR, AP, and SI directions, respectively.**CONCLUSIONS**Appropriate respiratory motion management techniques should be applied for the accurate localization of pancreatic tumors.

Database: Medline

5. Impact of robotic ultrasound image guidance on plan quality in SBRT of the prostate.

Author(s): Gerlach, Stefan; Kuhlemann, Ivo; Ernst, Floris; Fürweger, Christoph; Schlaefer, Alexander

Source: The British journal of radiology; Jul 2017 ; p. 20160926

Publication Date: Jul 2017

Publication Type(s): Journal Article

PubMedID: 28749165

Abstract:**OBJECTIVES**Ultrasound provides good image quality, fast volumetric imaging, and is established for abdominal image guidance. Robotic transducer placement may facilitate intra-fractional motion compensation in radiation therapy. We consider integration with the CyberKnife and study whether the kinematic redundancy of a seven-degrees-of-freedom robot allows for acceptable plan quality for prostate treatments.**METHODS**Reference treatment plans were generated for ten prostate cancer cases previously treated with the CyberKnife. Considering transducer and prostate motion by different safety margins, ten different robot poses, and three different elbow configurations, we removed all beams colliding with robot or transducer. For each combination, plans were generated using the same strict dose constraints and the objective to maximize the target coverage. Additionally, plans for the union of all unblocked beams were generated.**RESULTS**In nine cases the planning target coverage with the ultrasound robot was within 1.1 percentage points of the reference coverage. It was 1.7 percentage points for one large prostate. For one preferable robot position, kinematic redundancy decreased the average number of blocked beam directions from 23.1 to 14.5.**CONCLUSIONS**The impact of beam blocking can largely be offset

by treatment planning and using a kinematically redundant robot. Plan quality can be maintained by carefully choosing the ultrasound robot position and pose. For smaller planning target volumes the difference in coverage is negligible for safety margins of up to 35 mm. Advances in Knowledge: Integrating a robot for online intra-fractional image guidance based on ultrasound can be realized while maintaining acceptable plan quality for prostate cancer treatments with the CyberKnife.

Database: Medline

6. Investigating the surface dose contribution of intrafractional kV imaging in CyberKnife-based stereotactic radiosurgery.

Author(s): Canbolat, Abdulmecit; Zorlu, Faruk; Hurmuz, Pervin; Yeginer, Mete; Ozyigit, Gokhan

Source: Medical dosimetry : official journal of the American Association of Medical Dosimetrists; Jul 2017

Publication Date: Jul 2017

Publication Type(s): Journal Article

PubMedID: 28739211

Abstract: CyberKnife treatment consists of hundreds of noncoplanar beams and numerous intrafractional images that can be taken during a single treatment fraction; thus, doses because of imaging should be considered in this technique. The aim of this study is to investigate the in-field and out-of-field surface doses induced from kV imaging system during stereotactic radiosurgery (SRS) treatment. The imaging-induced surface doses were measured at the center of the imaging field and within ± 15 -cm distance from the center in both craniocaudal and lateral directions. TLD100H thermoluminescence dosimeters and EBT2 gafchromic films were used to take the measurements at the locations of 0, ± 5 , ± 10 , and ± 15 cm in the 2 orthogonal directions on abdominal region of a Rando phantom. The surface dose contributions of imaging system for the 4 most commonly used energy options of 90, 100, 110, and 120 kVp with 3 mAs options of 10, 30, and 90 mAs were measured and compared. Imaging dose values have a positive correlation with both parameters of energy and mAs. The energy options of 100, 110, and 120 kVp, in average, induced 60%, 101%, and 141% more doses per mAs than 90 kVp energy in the imaging field center. A threefold increase in mAs values, i.e., from 10 mAs to 30 mAs and from 30 mAs to 90 mAs, caused higher dose in field center with a factor of 2.53 ± 0.08 when the energy value was kept constant. The in-field dose distributions within ± 10 cm in both directions showed a flat pattern with a standard deviation lower than 5%, whereas the out-of-field doses at ± 15 -cm distance from the field center suddenly dropped to almost half of the central doses. Although a single imaging attempt causes a very low dose compared with the therapeutic dose level, one should be aware of the cumulative surface dose increase with higher imaging number. Proper patient setup, fiducial usage, and reduction of both the mAs values and the imaging numbers should be, therefore, considered to keep the cumulative surface dose in a lower level.

Database: Medline

7. A new method to reconstruct intra-fractional prostate motion in volumetric modulated arc therapy.

Author(s): Chi, Y; Rezaeian, N H; Shen, C; Zhou, Y; Lu, W; Yang, M; Hannan, R; Jia, X

Source: Physics in medicine and biology; Jul 2017; vol. 62 (no. 13); p. 5509-5530

Publication Date: Jul 2017

Publication Type(s): Journal Article

PubMedID: 28609300

Abstract: Intra-fractional motion is a concern during prostate radiation therapy, as it may cause deviations between planned and delivered radiation doses. Because accurate motion information during treatment delivery is critical to address dose deviation, we developed the projection marker matching method (PM3), a novel method for prostate motion reconstruction in volumetric modulated arc therapy. The purpose of this method is to reconstruct in-treatment prostate motion trajectory using projected positions of implanted fiducial markers measured in kV x-ray projection images acquired during treatment delivery. We formulated this task as a quadratic optimization problem. The objective function penalized the distance from the reconstructed 3D position of each fiducial marker to the corresponding straight line, defined by the x-ray projection of the marker. Rigid translational motion of the prostate and motion smoothness along the temporal dimension were assumed and incorporated into the optimization model. We tested the motion reconstruction method in both simulation and phantom experimental studies. We quantified the accuracy using 3D normalized root-mean-square (RMS) error defined as the norm of a vector containing ratios between the absolute RMS errors and corresponding motion ranges in three dimensions. In the simulation study with realistic prostate motion trajectories, the 3D normalized RMS error was on average [Formula: see text] (range from [Formula: see text] to [Formula: see text]). In an experimental study, a prostate phantom was driven to move along a realistic prostate motion trajectory. The 3D normalized RMS error was [Formula: see text]. We also examined the impact of the model parameters on reconstruction accuracy, and found that a single set of parameters can be used for all the tested cases to accurately reconstruct the motion trajectories. The motion trajectory derived by PM3 may be incorporated into novel strategies, including 4D dose reconstruction and adaptive treatment replanning to address motion-induced dose deviation.

Database: Medline

8. Examination of a deformable motion model for respiratory movements and 4D dose calculations using different driving surrogates.

Author(s): Wölfelschneider, Jens; Seregini, Matteo; Fassi, Aurora; Ziegler, Marc; Baroni, Guido; Fietkau, Rainer; Riboldi, Marco; Bert, Christoph

Source: Medical physics; Jun 2017; vol. 44 (no. 6); p. 2066-2076

Publication Date: Jun 2017

Publication Type(s): Journal Article

PubMedID: 28369900

Abstract: **PURPOSE**The aim of this study was to evaluate a surrogate-driven motion model based on four-dimensional computed tomography that is able to predict CT volumes corresponding to arbitrary respiratory phases. Furthermore, the comparison of three different driving surrogates is examined and the feasibility of using the model for 4D dose re-calculation will be discussed. **METHODS**The study is based on repeated 4DCTs of twenty patients treated for bronchial carcinoma and metastasis. The motion model was estimated from the planning 4DCT through deformable image registration. To predict a certain phase of a follow-up 4DCT, the model considers inter-fractional variations (baseline correction) and intra-fractional respiratory parameters (amplitude and phase) derived from surrogates. The estimated volumes resulting from the model were compared to ground-truth clinical 4DCTs using absolute HU differences in the lung region and landmarks localized using the Scale Invariant Feature Transform. Finally, the γ -index was used to evaluate the dosimetric effects of the intensity differences measured between the estimated and the ground-truth CT volumes. **RESULTS**The results show absolute HU differences between estimated and ground-truth images with median value (\pm standard deviation) of (61.3 ± 16.7) HU. Median 3D distances, measured on about 400 matching landmarks in each volume, were (2.9 ± 3.0) mm. 3D

errors up to 28.2 mm were found for CT images with artifacts or reduced quality. Pass rates for all surrogate approaches were above 98.9% with a γ -criterion of 2%/2 mm. **CONCLUSION**The results depend mainly on the image quality of the initial 4DCT and the deformable image registration. All investigated surrogates can be used to estimate follow-up 4DCT phases, however, uncertainties decrease for volumetric approaches. Application of the model for 4D dose calculations is feasible.

Database: Medline

9. Three-dimensional intrafractional internal target motions in accelerated partial breast irradiation using three-dimensional conformal external beam radiotherapy.

Author(s): Hirata, Kimiko; Yoshimura, Michio; Mukumoto, Nobutaka; Nakamura, Mitsuhiro; Inoue, Minoru; Sasaki, Makoto; Fujimoto, Takahiro; Yano, Shinsuke; Nakata, Manabu; Mizowaki, Takashi; Hiraoka, Masahiro

Source: Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology; May 2017

Publication Date: May 2017

Publication Type(s): Journal Article

PubMedID: 28532607

Abstract:**PURPOSE**We evaluated three-dimensional intrafractional target motion, divided into respiratory-induced motion and baseline drift, in accelerated partial breast irradiation (APBI).**METHODS**Paired fluoroscopic images were acquired simultaneously using orthogonal kV X-ray imaging systems at pre- and post-treatment for 23 patients who underwent APBI with external beam radiotherapy. The internal target motion was calculated from the surgical clips placed around the tumour cavity.**RESULTS**The peak-to-peak respiratory-induced motions ranged from 0.6 to 1.5mm in all directions. A systematic baseline drift of 1.5mm towards the posterior direction and a random baseline drift of 0.3mm in the lateral-medial and cranial-caudal directions were observed. The baseline for an outer tumour cavity drifted towards the lateral and posterior directions, and that for an upper tumour cavity drifted towards the cranial direction. Moderate correlations were observed between the posterior baseline drift and the patients' physical characteristics. The posterior margin for intrafractional uncertainties was larger than 5mm in patients with greater fat thickness due to the baseline drift.**CONCLUSIONS**The magnitude of the intrafractional motion was not uniform according to the direction, patients' physical characteristics, or tumour cavity location due to the baseline drift. Therefore, the intrafractional systematic movement should be properly managed.

Database: Medline

10. Dosimetric implications of inter- and intrafractional prostate positioning errors during tomotherapy : Comparison of gold marker-based registrations with native MVCT.

Author(s): Wust, Peter; Joswig, Marc; Graf, Reinhold; Böhmer, Dirk; Beck, Marcus; Barelkowski, Thomasz; Budach, Volker; Ghadjar, Pirus

Source: Strahlentherapie und Onkologie : Organ der Deutschen Röntgengesellschaft ... [et al]; May 2017

Publication Date: May 2017

Publication Type(s): Journal Article

PubMedID: 28466155

Abstract:**INTRODUCTION**For high-dose radiation therapy (RT) of prostate cancer, image-guided (IGRT) and intensity-modulated RT (IMRT) approaches are standard. Less is known regarding

comparisons of different IGRT techniques and the resulting residual errors, as well as regarding their influences on dose distributions. PATIENTS AND METHODS A total of 58 patients who received tomotherapy-based RT up to 84 Gy for high-risk prostate cancer underwent IGRT based either on daily megavoltage CT (MVCT) alone (n = 43) or the additional use of gold markers (n = 15) under routine conditions. Planned Adaptive (Accuray Inc., Madison, WI, USA) software was used for elaborated offline analysis to quantify residual interfractional prostate positioning errors, along with systematic and random errors and the resulting safety margins after both IGRT approaches. Dosimetric parameters for clinical target volume (CTV) coverage and exposition of organs at risk (OAR) were also analyzed and compared. Interfractional as well as intrafractional displacements were determined. RESULTS Particularly in the vertical direction, residual interfractional positioning errors were reduced using the gold marker-based approach, but dosimetric differences were moderate and the clinical relevance relatively small. Intrafractional prostate motion proved to be quite high, with displacements of 1-3 mm; however, these did not result in additional dosimetric impairments. CONCLUSION Residual interfractional positioning errors were reduced using gold marker-based IGRT; however, this resulted in only slightly different final dose distributions. Therefore, daily MVCT-based IGRT without markers might be a valid alternative.

Database: Medline

11. Planar kV imaging dose reduction study for Varian iX and TrueBeam linacs

Author(s): Gershkevitsh E.; Zolotuhhin D.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective IGRT has become an indispensable tool in modern radiotherapy with kV imaging used in many departments due to superior image quality and lower dose when compared to MV imaging. Since, the frequency of kV images continues to increase (intrafractional imaging, etc.) the reduction of additional dose assumes high priority. Many departments use manufacturer supplied protocols for imaging which are not always optimised between image quality and radiation dose (ALARA). Material and Methods Whole body phantom PBU-50 (Kyoto Kagaku Ltd., Japan) for imaging in radiology has been imaged on Varian iX OBI 1.5 and TrueBeam 2.5 accelerators (Varian Medical Systems, USA). Manufacturer's default protocols were adapted by modifying kV and mAs values when imaging different anatomical regions of the phantom (head, thorax, abdomen, pelvis, extremities). Images with different settings were independently reviewed by two persons and their suitability for IGRT set-up correction protocols were evaluated. The suitable images with the lowest mAs were then selected. The entrance surface dose (ESD) for manufacturer's default protocols and modified protocols were measured with RTI Black Piranha (RTI Group, Sweden) and compared. Image quality was also measured with kVQC phantom (Standard Imaging, USA) for different protocols. The modified protocols have been applied for clinical work. Results The default manufacturer's protocols on TrueBeam linac yielded 9.4 times lower ESD than on iX linac (range 2.5-24.8). For most cases it was possible to reduce the ESD on average by a factor of 3 (range 0.9-8.5) on iX linac by optimising imaging protocols. Further ESD reduction was also possible for TrueBeam linac. Conclusion The imaging doses on new TrueBeam accelerator is substantially lower than on previous iX platform. Manufacturer's default IGRT protocols could be optimised to reduce the ESD to the patient without losing the necessary image quality for patient set-up correction. For patient set-up with planar kV imaging the bony anatomy is mostly used and optimization should focus on this aspect. Therefore, the current approach with anthropomorphic phantom is more advantageous in optimization over standard kV quality control phantoms and SNR metrics.

Database: EMBASE

12. Analysis of intrafraction motion in image-guided stereotactic radiosurgery of spinal metastases

Author(s): Svestad J.G.

Source: Radiotherapy and Oncology; May 2017; vol. 123

Publication Date: May 2017

Publication Type(s): Conference Abstract

Abstract: Purpose or Objective Stereotactic radiosurgery of spinal metastases include tight margins and steep dose gradients to the surrounding organs at risk (OAR). The proximity of the target to the adjacent spinal cord and the aim of keeping the dose to the spinal cord within tolerance require a high degree of precision in dose delivery. This study aimed to evaluate intrafractional motion using cone beam computed tomography (CBCT) image guidance, for immobilized spinal stereotactic radiosurgery patients, with correction in all six degrees of freedom. Material and Methods Intrafractional motion during spine radiosurgery treatment in 16 patients (26 fractions) was retrospectively analyzed. All patients were immobilized in the BlueBAG BodyFIX (Elekta, Stockholm, Sweden) that uses a vacuum pump to create a precise mold of the patient's position. Radiation treatment was performed using a Varian Truebeam STx linear accelerator equipped with a PerfectPitch 6 degrees of freedom couch (Varian Medical Systems, Inc., Palo Alto, USA). Following initial setup, a CBCT was acquired for patient alignment and patient position was corrected in all six degrees of freedom. Patients were resetup manually, and the process was reinitiated if the +/- 3degree rotational couch tolerance was exceeded. A post treatment CBCT was acquired and analyzed using the offline image review workspace in Mosaic (v1.60, Elekta, Stockholm, Sweden) to determine intrafractional patient movements. From each CBCT, 3 translational and 3 rotational coordinates were obtained. Results The average time between the patient setup CBCT and the post treatment CBCT was 9 minutes (range, 6-14). The average absolute translational variations (+/- 1 SD) obtained from the post-treatment CBCT was 0.7 +/- 0.7, 0.7 +/- 0.8 and 0.5 +/- 0.6 mm in the lateral, longitudinal and vertical directions, respectively. The average absolute rotational angles were 0.8 +/- 0.7, 0.7 +/- 0.4 and 0.8 +/- 0.6 degree along pitch, roll and yaw, respectively. Histograms of translational and rotational deviations for all patients are shown in figure 1. Conclusion Near-rigid body immobilization, CBCT image guidance and six degrees of freedom correction yields minimal intrafractional motion and safe stereotactic spine radiosurgery delivery. It is not easy to determine the effect of rotational deviations. However, for treatment plans with the isocenter placed in the center of the target volume, which is the case for these patients, small rotations would not result in large deviations in dose to the target volume or adjacent OARs. There are different approaches that could result in less patient motion and increased precision in dose delivery. The combination of a polyethylene sheet with a vacuum cushion would presumably result in a more rigid immobilization. Intrafractional imaging during treatment is another alternative that could increase precision in dose delivery. (Figure presented).

Database: EMBASE

13. 3D image-based adapted high-dose-rate brachytherapy in cervical cancer with and without interstitial needles: measurement of applicator shift between imaging and dose delivery.

Author(s): Karlsson, Leif; Thunberg, Per; With, Anders; Mordhorst, Louise Bohr; Persliden, Jan

Source: Journal of contemporary brachytherapy; Feb 2017; vol. 9 (no. 1); p. 52-58

Publication Date: Feb 2017

Publication Type(s): Journal Article

PubMedID: 28344604

Available in full text at [Journal of Contemporary Brachytherapy](#) - from ProQuest

Abstract: PURPOSE Using 3D image-guided adaptive brachytherapy for cervical cancer treatment, it often means that patients are transported and moved during the treatment procedure. The purpose of this study was to determine the intra-fractional longitudinal applicator shift in relation to the high risk clinical target volume (HR-CTV) by comparing geometries at imaging and dose delivery for patients with and without needles. MATERIAL AND METHODS Measurements were performed in 33 patients (71 fractions), where 25 fractions were without and 46 were with interstitial needles. Gold markers were placed in the lower part of the cervix as a surrogate for HR-CTV, enabling distance measurements between HR-CTV and the ring applicator. Shifts of the applicator relative to the markers were determined using planning computed tomography (CT) images used for planning, and the radiographs obtained at dose delivery. Differences in the physical D90 for HR-CTV due to applicator shifts were simulated individually in the treatment planning system to provide the relative dose variation. RESULTS The maximum distances of the applicator shifts, in relation to the markers, were 3.6 mm (caudal), and -2.5 mm (cranial). There was a significant displacement of -0.7 mm (SD = 0.9 mm) without needles, while with needles there was no significant shift. The relative dose variation showed a significant increase in D90 HR-CTV of 1.6% (SD = 2.6%) when not using needles, and no significant dose variation was found when using needles. CONCLUSION The results from this study showed that there was a small longitudinal displacement of the ring applicator and a significant difference in displacement between using interstitial needles or not.

Database: Medline

14. Automated target tracking in kilovoltage images using dynamic templates of fiducial marker clusters:

Author(s): Campbell W.G.; Miften M.; Jones B.L.

Source: Medical Physics; Feb 2017; vol. 44 (no. 2); p. 364-374

Publication Date: Feb 2017

Publication Type(s): Article

PubMedID: 28035655

Abstract: Purpose: Implanted fiducial markers are often used in radiotherapy to facilitate accurate visualization and localization of tumors. Typically, such markers are used to aid daily patient positioning and to verify the target's position during treatment. These markers can also provide a wealth of information regarding tumor motion, yet determining their accurate position in thousands of images is often prohibitive. This work introduces a novel, automated method for identifying fiducial markers in planar x-ray imaging. Methods: In brief, the method was performed as follows. First, using processed CBCT projection images, an automated routine of reconstruction, forward-projection, tracking, and stabilization generated static templates of the marker cluster at arbitrary viewing angles. Breathing data were then incorporated into the same routine, resulting in dynamic templates dependent on both viewing angle and breathing motion. Finally, marker clusters were tracked using normalized cross correlations between templates (either static or dynamic) and CBCT projection images. To quantify the accuracy of the technique, a phantom study was performed and markers were manually tracked by two users to compare the automated technique against human measurements. Then, 75 pretreatment CBCT scans of 15 pancreatic cancer patients were analyzed to test the automated technique under real-life conditions, including several challenging scenarios for tracking fiducial markers (e.g., extraneous metallic objects, field-of-view limitations, and marker migration). Results: In phantom and patient studies, for both static and dynamic templates, the method automatically tracked visible marker clusters in 100% of projection images. For scans in which a phantom exhibited 0D, 1D, and 3D motion, the automated technique showed median errors of 39 μm , 53 μm , and 93 μm , respectively. Human precision was worse in comparison; median

interobserver differences for single markers and for the averaged coordinates of four markers were 183 μm and 120 μm , respectively. In patient scans, the method was robust against a number of confounding factors. Automated tracking was performed accurately despite the presence of radio-opaque, nonmarker objects (e.g., metallic stents, surgical clips) in five patients. This success was attributed to the distinct appearance of clusters as a whole compared to individual markers. Dynamic templates produced higher cross-correlation scores than static templates in patients whose fiducial marker clusters exhibited considerable deformation or rotation during the breathing cycle. For other patients, no significant difference was seen between dynamic and static templates. Additionally, transient differences in the cross-correlation score identified instances where markers disappeared from view. Conclusions: A novel, automated method for producing dynamic templates of fiducial marker clusters has been developed. Production of these templates automatically provides measurements of tumor motion that occurred during the CBCT scan that was used to produce them. Additionally, using these templates with intrafractional images could potentially allow for more robust real-time target tracking in radiotherapy. Copyright © 2016 American Association of Physicists in Medicine.

Database: EMBASE

ABC gating

1. Feasibility study of ultrasound imaging for stereotactic body radiation therapy with active breathing coordinator in pancreatic cancer.

Author(s): Su, Lin; Iordachita, Iulian; Zhang, Yin; Lee, Junghoon; Ng, Sook Kien; Jackson, Juan; Hooker, Ted; Wong, John; Herman, Joseph M; Sen, H Tutkun; Kazanzides, Peter; Lediju Bell, Muyinatu A; Yang, Chen; Ding, Kai

Source: Journal of applied clinical medical physics; Jul 2017; vol. 18 (no. 4); p. 84-96

Publication Date: Jul 2017

Publication Type(s): Journal Article

PubMedID: 28574192

Abstract: PURPOSE Stereotactic body radiation therapy (SBRT) allows for high radiation doses to be delivered to the pancreatic tumors with limited toxicity. Nevertheless, the respiratory motion of the pancreas introduces major uncertainty during SBRT. Ultrasound imaging is a non-ionizing, non-invasive, and real-time technique for intrafraction monitoring. A configuration is not available to place the ultrasound probe during pancreas SBRT for monitoring. METHODS AND MATERIALS An arm-bridge system was designed and built. A CT scan of the bridge-held ultrasound probe was acquired and fused to ten previously treated pancreatic SBRT patient CTs as virtual simulation CTs. Both step-and-shoot intensity-modulated radiation therapy (IMRT) and volumetric-modulated arc therapy (VMAT) planning were performed on virtual simulation CT. The accuracy of our tracking algorithm was evaluated by programmed motion phantom with simulated breath-hold 3D movement. An IRB-approved volunteer study was also performed to evaluate feasibility of system setup. Three healthy subjects underwent the same patient setup required for pancreas SBRT with active breath control (ABC). 4D ultrasound images were acquired for monitoring. Ten breath-hold cycles were monitored for both phantom and volunteers. For the phantom study, the target motion tracked by ultrasound was compared with motion tracked by the infrared camera. For the volunteer study, the reproducibility of ABC breath-hold was assessed. RESULTS The volunteer study results showed that the arm-bridge system allows placement of an ultrasound probe. The ultrasound monitoring showed less than 2 mm reproducibility of ABC breath-hold in healthy volunteers. The phantom monitoring accuracy is 0.14 ± 0.08 mm, 0.04 ± 0.1 mm, and 0.25 ± 0.09 mm in three directions. On dosimetry

part, 100% of virtual simulation plans passed protocol criteria. CONCLUSIONS Our ultrasound system can be potentially used for real-time monitoring during pancreas SBRT without compromising planning quality. The phantom study showed high monitoring accuracy of the system, and the volunteer study showed feasibility of the clinical workflow.

Database: Medline

2. Impact on clinical workflow of volume modulated arc stereotactic body radiation therapy (VMAT-SBRT)

Author(s): Lewis B.; Kim S.; Kim T.; Fields E.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 2971

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: To evaluate the changes to clinical workflow of volume modulated arc stereotactic body radiation therapy (VMAT-SBRT) without or with the use of an active breathing coordinator (ABC) system for deep inspiration breath hold (DIBH). Methods: 31 SBRT patients were observed during treatment, totaling 116 individual fractions. Ten of these patients were treated using the ABC system for DIBH, for 42 individual fractions. Each fraction was timed, as well as a subset of timepoints throughout each treatment fraction. Patients were positioned using in room lasers and markings on the personal immobilization equipment. The AlignRT surface tracking system was used to make fine corrections to patient roll and position, matching to the surface DICOM image from the simulation CT. They then received orthogonal 2D kV images, and a cone beam CT (CBCT) scan before beginning treatment. Patient shift distances were recorded in addition to treatment time points. Results: Patients spent an average of 27.2 +/- 7.8 minutes, and 42.4 +/- 10.4 minutes for non-ABC and ABC patients, respectively. ABC patients required an average of 16 breath holds per fraction. The average time from the start of beam on time, to the end of the final beam was 2.5 +/- 1.2 minutes, and 7.0 +/- 4.4 minutes for non-ABC patients and ABC patients, respectively. Superior-inferior (S-I) shifts were -1.39 +/- 4.42 mm and -0.17 +/- 4.42 mm, anterior-posterior (A-P) shifts were -1.29 +/- 4.10 mm and -2.20 +/- 4.51 mm, and left-right (L-R) shifts were -0.22 +/- 4.26 mm and 0.15 +/- 4.22 mm for non-ABC and ABC patients respectively. Conclusion: The addition of the ABC system during SBRT results in longer average treatment times. It is recommended to increase allotted appointment time by at least 15 minutes. This increased treatment time, however, is justified by the improved setup accuracy, and reduced target motion, reported by previous studies.

Database: EMBASE

3. The effect of beam interruption when implementing deep inspiration breath hold during volume modulated arc stereotactic body radiation therapy

Author(s): Oh S.; Lewis B.; Watson A.; Kim S.; Kim T.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 2970

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: To determine the dosimetric effect of beam interruption during partial-arcs of a volume modulated arc stereotactic body radiation therapy (SBRT) plan delivery. Clinical implementation of breath hold, utilizing an active breathing coordinator, during SBRT increases the probability of beam interruption during partial-arc delivery. Methods: 10 SBRT plans were retrospectively selected, five using a 6 MV flattening filter free (FFF) beam, and five using a 10 MV FFF beam. All plans had four partial-arcs, with the exception of one, consisting of six partial-arcs, and

were all delivered using a Varian Truebeam linear accelerator. The plans were delivered in three scenarios: The first with no partial-arc interruptions (0int), second with one interruption of each partial-arc (1int), and third with two interruptions of each partial-arc (2int). Dose was measured using the ArcCheck cylindrical 3D diode array. 2D global gamma evaluations and dose difference (DD) were calculated using the SNC Patient software suite. Delivered MU variations were evaluated at the beam interruption angles using the log files generated during beam delivery. Results: The interruptions caused a total increase of 3.6 +/- 1.7 MU and 6.5 +/- 2.5MU for 1int and 2int, respectively, at the beam interruption angles. Total delivered MU per plan was 2450 +/- 472 MU for all plans. All plans for using 6 MV FFF and 10 MV FFF beams passed the clinical gamma analysis threshold of 3%/3 mm for 90% of the measurement points. All plans delivered with the 1int and 2int scenarios were also within 3% DD of the 0int measured data. Conclusion: Only minimal change was observed in gamma analysis, DD, and log file analysis with up to 12 interruptions occurring during treatment with SBRT. Delivering dose with multiple beam interruptions is clinically viable due to these small variations.

Database: EMBASE

4. Liver position consistency across breath holds with ABC used for SBRT

Author(s): Holler S.; Padilla L.; Kim T.; Fields E.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 3056

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: To investigate the validity of the current active breathing coordinator (ABC) system for use with stereotactic body radiotherapy (SBRT) by evaluating changes in liver position as measured on simulation CT images and relating them to lung volume variation as measured by the ABC spirometer. Use the results to inform treatment margins and determine the need for a more clinically reliable system. Methods: Eighteen abdominal CT simulations for SBRT for liver tumors were used in this study. All eighteen simulations involved three sequential CT scans (Philips Big Bore) done under three separate breath holds. On each scan, the liver was contoured. Position shift was measured by the treatment planning system (Pinnacle v9.8) upon completion of the contours. Shifts in position of superior boundary of the liver were quantified and examined with respect to the variation in lung volume. Results: Results were broken down into three groups based on clinical treatment margins and magnitude shift. A change of position of 6 mm, the average magnitude change for the superior boundary of the liver was 7.6 +/- 1.5 mm. Two patients exhibited changes > 10 mm, with an average magnitude shift of 13.5 +/- 1.2 mm. Additionally, one patient's scan showed a respiratory motion artifact (duplication) while the spirometer indicated sustained breath hold. Conclusion: In four patients, large changes (7.6 mm) in liver position were observed with small changes in lung volume. It is especially concerning that a patient may breathe while the ABC system is registering a breath hold, which results in sizable shifts in the liver. Due to differences across breath holds and the possibility of unregistered free breathing, a geometric miss could occur, leading to under dosing of the target and overdosing of normal tissue.

Database: EMBASE

5. Deep inspirational breath hold to reduce cardiac dose in left-sided breast radiotherapy

Author(s): Welgemoed C.; Rogers J.; McNaught P.; Cleator S.; Riddle P.; Gujral D.

Source: Journal of Radiotherapy in Practice; Jun 2017 ; p. 1-7

Publication Date: Jun 2017

Publication Type(s): Article In Press

Abstract:Background: During left-sided breast radiotherapy, the heart is often exposed to radiation dose. Shielding can be utilised to reduce heart exposure, but compromises the dose delivered to the breast tissue and, in a proportion of patients, to the tumour bed. Deep inspiration breath hold (DIBH) can be used as a technique to move the heart away from the treatment area and thus reduce heart dose. This study examines the efficacy of the Elekta Active Breathing Coordinator (ABC), a DIBH method, in reducing heart dose. Materials and methods: In total, 12 patients receiving radiotherapy to the left breast were planned for treatment with both a free-breathing (FB) and an ABC scan. The dose volume histogram data for the plans was analysed with respect to heart V13, V5 Gy, mean heart dose and ipsilateral lung V18 Gy. Tumour bed D98%, threshold lung volume in breath hold (BH) and the maximum BH time for each patient was also measured. Patients then received their radiotherapy treatment using the ABC plan and the systematic error in the craniocaudal, lateral and vertical axes was assessed using orthogonal imaging. Results: The median heart V13 Gy for FB and DIBH patients was 3% (range, 0.85-11.28) and 0% (range, 0-1.56), respectively, with a mean heart dose of 2.62 Gy (range, 1.21-4.93) in FB and 1.51 Gy (range, 1.17-2.22) in ABC. The median lung V18 Gy was 8.7% (3.08-14.87) in FB plans and 9% (4.88-12.82) in ABC plans. The mean systematic set-up errors in all three planes were within the departmental set-up tolerance of 5 mm for both techniques. Median FB tumour bed D98% was 97.4% (92.8-99.5) and 97.5% (97.3-98.5) for ABC. Conclusion: ABC represents a good method of reducing radiation dose to the heart while not compromising on dose to the tumour bed, and it has a clear advantage over FB radiotherapy in reducing the risk of cardiac toxicity. It is tolerated well by patients and does not produce any difficulties in patient positioning. Copyright © Cambridge University Press 2017

Database: EMBASE

6. Feasibility study: Auto-triggered consecutive-short-breath-hold control with ABC in cancer radiotherapy

Author(s): Lee D.; Lewis J.; Kim S.; Palta J.; Kim T.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 2844

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract:Purpose: Active Breathing Coordinator (ABC) is clinically used to control respiratory-related tumor motion and spare critical organs in gated radiotherapy. However, long breath-hold (~ 20 s) may cause patient discomfort and baseline shift, potentially causing unsatisfactory outcomes. To reduce breathhold duration while maintaining the duty cycle, we proposed an auto-triggered consecutive short breath-hold integrated with ABC (cs-ABC). The proposed technique was compared with the conventional long ABC breath-hold (l-ABC) in terms of efficiency of breath-holds and the variation of lung volume. Methods: The cs-ABC method was developed by utilizing the ABC display signal for lung volume data and visual guidance. In this feasibility study, one healthy volunteer with an ABC breath-hold threshold level at 1.5 l participated in 3 breath-hold sessions: two l-ABC sessions (10 breathholds x 20 s) with verbal instruction and with visual guidance and a cs-ABC session with visual guidance (34 breath-holds x 6 s). l-ABC and cs-ABC were compared in terms of (1) efficiency of breath-holds assessed by measuring the total session time and (2) lung volume consistency during breath-holds. This study is ongoing for fifteen volunteers. Results: Compared to l-ABC, cs-ABC improved the breath-hold efficiency by 33% from 600 s (Verbal l-ABC) to 400 s (Visual cs-ABC) and 20% from 500 s (Visual l-ABC) to 400 s (Visual cs-ABC). Compared to l-ABC, cs-ABC also improved the consistency of lung volume by 62% from 0.13 l (Verbal l-ABC) to 0.05 l (Visual cs-ABC) and 50% from 0.10 l (Verbal l-ABC) to 0.05 l (Visual cs-ABC). Conclusion: This study demonstrated that an autotriggered consecutive short ABC breath-hold can be utilized to improve the efficiency and

consistency of breath-hold control in terms of lung volume and abdominal position, respectively. These results may provide a pathway to achieve more accurate cancer radiation treatment by utilizing the proposed breath-hold procedure.

Database: EMBASE

7. An assessment of setup accuracy and deep inspiration breath hold reproducibility using intra-fraction portal imaging for conformal breast radiotherapy

Author(s): Gray A.; Erven T.; Arumugam S.

Source: Medical Physics; Jun 2017; vol. 44 (no. 6); p. 2799

Publication Date: Jun 2017

Publication Type(s): Conference Abstract

Abstract: Purpose: To assess the dosimetric impact of geometrical uncertainties in patient setup and Active Breathing Coordinator™ (ABC) assisted Deep Inspiration Breath Hold (DIBH) in conformal breast radiotherapy. Methods: Eight left breast cancer patients received ABC assisted DIBH conformal radiotherapy on an Elekta linear accelerator (linac) with treatment gated by the ABC signal. The patient setup was supine on a breast board, set up to tattoos, anterior-posterior source-to-surface distance checked, then shifted to isocenter. Setup images for days 1-3 were assessed and an average shift subsequently applied if greater than 5 mm. Images were taken during the delivery of each segment of treatment using the linac's electronic portal imager. The intra-fraction DIBH reproducibility was assessed by comparing the manually segmented lung area, using MATLAB, in images taken during the same fraction for similarly shaped fields. Setup reproducibility was assessed by comparing lung area in treatment images to the planned digitally reconstructed radiographs. The delivered dose to the planning target volume (PTV), lung and heart were estimated by comparing the average treated lung area to offset isocenter plans. Results: The average difference in lung area for the 255 same fraction field pairs was 0.2 cm² (StDev = 3.1 cm²). The average difference between the treated and planned lung area was -5.2 cm² (StDev = 6.8 cm²). 89% of the 643 images were within the 5 mm tolerance however two patients skewed the results. The ipsilateral and combined lung volumes receiving 20 Gy were 33.3% and 15.4% (2.2% and 1.1% higher than planned). The mean heart dose was 3.0 Gy (0.6 Gy high). The maximum values were 37.6%, 18.2% and 4.5 Gy respectively. The mean PTV dose was 0.02% higher than planned. Conclusion: While the DIBH reproducibility images demonstrated small differences in treated lung area, larger differences resulted from the setup error. The delivered doses to the lung and heart were higher than planned but not unacceptable.

Database: EMBASE

8. Lung volume reproducibility under ABC control and self-sustained breath-holding.

Author(s): Kaza, Evangelia; Dunlop, Alex; Panek, Rafal; Collins, David J; Orton, Matthew; Symonds-Taylor, Richard; McQuaid, Dualta; Scurr, Erica; Hansen, Vibeke; Leach, Martin O

Source: Journal of applied clinical medical physics; Mar 2017; vol. 18 (no. 2); p. 154-162

Publication Date: Mar 2017

Publication Type(s): Journal Article

PubMedID: 28300372

Abstract: An Active Breathing Coordinator (ABC) can be employed to induce breath-holds during CT imaging and radiotherapy of lung, breast and liver cancer, and recently during lung cancer MRI. The apparatus measures and controls respiratory volume, hence subject lung volume reproducibility is

its principal measure of effectiveness. To assess ABC control quality, the intra-session reproducibility of ABC-induced lung volumes was evaluated and compared with that reached by applying the clinical standard of operator-guided self-sustained breath-holds on healthy volunteers during MRI. Inter-session reproducibility was investigated by repeating ABC-controlled breath-holds on a second visit. Additionally, lung volume agreement with ABC devices used with different imaging modalities in the same institution (MR, CT), or for a breast trial treatment, was assessed. Lung volumes were derived from three-dimensional (3D) T1-weighted MRI datasets by three observers employing semiautomatic lung delineation on a radiotherapy treatment planning system. Inter-observer variability was less than 6% of the delineated lung volumes. Lung volume agreement between the different conditions over all subjects was investigated using descriptive statistics. The ABC equipment dedicated for MR application exhibited good intra-session and inter-session lung volume reproducibility (1.8% and 3% lung volume variability on average, respectively). MR-assessed lung volumes were similar using different ABC equipment dedicated to MR, CT, or breast radiotherapy. Overall, lung volumes controlled by the same or different ABC devices agreed better than with self-controlled breath-holds, as suggested by the average ABC variation of 1.8% of the measured lung volumes (99 mL), compared to the 4.1% (226 mL) variability observed on average with self-sustained breath-holding.

Database: Medline

9. Development and evaluation of a new 4D ultrasound real-time tracking system for external-beam radiotherapy of upper abdominal lesions under breath hold - A phantom study

Author(s): Sihono D.S.K.; Boda-Heggemann J.; Vogel L.; Tholking J.; Lohr F.; Wenz F.; Wertz H.

Source: Strahlentherapie und Onkologie; 2016; vol. 192 (no. 1); p. 20-21

Publication Date: 2016

Publication Type(s): Conference Abstract

Available in full text at [Strahlentherapie und Onkologie: Organ der Deutschen Rontgengesellschaft ... \[et al\] \[Strahlenther Onkol\] NLMUID: 8603469](#) - from EBSCOhost

Available in full text at [Strahlentherapie und Onkologie](#) - from ProQuest

Abstract: Purpose/Objective: Hypofractionated SBRT is an effective and low-toxic therapy option for primary liver cancer, hepatic and adrenal metastases. In our department, liver SBRT is performed in DIBH (Deep Inspiratory Breath Hold) with ABC (Active Breathing Coordinator) and interfractional image-guidance with breath-hold CBCT. However, residual errors, intrafractional reproducibility of the breath-hold with ABC and organ position stability potentially enlarging the PTV-CTV margin has to be considered. For additional monitoring of the target (liver lesion) and/or surrogate structure (liver veins, renal pelvis) position, an ultrasound-based tracking system has been developed. We evaluated the accuracy of this tracking system on a 4D phantom. Materials/Methods: The overall tracking accuracy of the experimental 4D ultrasound system (Clarity "Anticosti", Elekta AB, Sweden) was evaluated using an Aktina 4D phantom with a spherical structure moving in water. Clarity Anticosti's monitoring function is based off of a prostate tracking model. The Aktina 4D phantom was programmed with sinusoidal and breathing patterns simulating the ABC-based breath-hold. A stray-marker was attached to the motion mechanical part of the phantom to obtain the actual movement of the sphere. The scanning range of ultrasound was varied to obtain optimal parameters to track along with respiratory motion. Results: The ultrasound system could track the sphere motion in the phantom using 2 sinusoidal and 5 breathing patterns simulating ABC-based breath-hold with a total of 56 scanning sessions. The accuracy of ultrasound tracking increased with decreasing of scanning range. Differences (mean +/- standard deviation) (N=56) between the measurement and the reference of sphere motion with amplitude of 5-20 mm and a cycle time of 5 s can be seen in Table 1. (Table Presented) Although the accuracy of ultrasound tracking increased

with decreasing of scanning range, the probability of lost tracking in small scanning range is higher. We found that the mean lost tracking occurred in 10degree and 20degree scanning range were 43.09% and 13.54%, respectively. We observed that 30degree is the optimal scanning range to track along with respiratory motion with probability of lost tracking below 0.1%. Conclusions: The new ultrasound system showed a good performance using the Aktina 4D phantom with a mean accuracy of 1.083 mm using optimal parameters (30degreescanning range) to track along with respiratory motion. Maximal error in all cases was below 1.6 mm. Further improvement of the tracking algorithm is still needed to improve accuracy along with respiratory motion if using larger scanning angles for detection of high-amplitude motion and non-linear transformations of the tracking target.

Database: EMBASE

10. Clinical implementation of a breast DIBH treatment technique using the Active Breathing Coordinator™ system in manual gating mode

Author(s): Yim J.

Source: Journal of Medical Radiation Sciences; 2016; vol. 63 ; p. 26

Publication Date: 2016

Publication Type(s): Conference Abstract

Abstract:In the recent years, Deep Inspiration Breath Hold (DIBH) treatments have achieved a solid foothold in left sided breast cancer radiotherapy. Current literature indicates that DIBH is both feasible and of benefit to patients because of the reduction in the volume of heart in typical treatment beam portals. The Active Breathing Coordinator™ (ABC) was purchased for the purpose of delivering DIBH treatments at the Mater Crows Nest site. As a Varian linear accelerator site, the ABC system, an Elekta product has limited connectivity and therefore unable to perform automatic gated treatments. Manually gated treatments presents itself as a different mode of treatment delivery compared with all other Genesis Cancer Care sites in NSW as automatic gated treatments is the standard protocol. If manually gated treatments are not performed correctly, potential mistreatment could occur leading to suboptimal treatment and patient outcomes. Therefore, consistent staff training and protocol implementation was of paramount importance. This presentation aims to report on the entire implementation process which involved research, protocol development, quality assurance tasks, specific GenesisCancerCare approval processes and staff training.

Database: EMBASE

11. Exploring the Experiences of Left-Sided Breast Cancer Patients Receiving Radiation Therapy Using the Active Breathing Coordinator

Author(s): Cashell A.; Qadeer J.; Rosewall T.

Source: Journal of Medical Imaging and Radiation Sciences; Dec 2016; vol. 47 (no. 4); p. 323-328

Publication Date: Dec 2016

Publication Type(s): Article

Abstract:Background The Active Breathing Coordinator (ABC) to induce breath hold during radiation therapy is used with the intent to reduce the risk of long-term, radiation-induced cardiovascular morbidity. Many studies have explored the dosimetric and toxicity benefits of using the device, but limited research has been done on the patient's perspective. The aim of this study was to explore the patient's experience using the ABC device and to evaluate the teaching provided. Methods and Materials Following Research Ethics Board approval and written informed consent, paper questionnaires were used, and cross-sectional data were collected from 30 English-speaking women

receiving radiation therapy for left-sided breast cancer using the ABC device. Questions were both quantitative (a 10-point Likert scale) and qualitative in nature and evaluated patient-reported anxiety levels, confidence levels, and suggestions for process improvement. Descriptive and inferential statistics were used to analyze the results, with thematic analysis of qualitative comments. Results Fifty-three percent of patients reported higher than 5 on the Likert scale for anxiety related to using the ABC device. Half the sample indicated that they were equally anxious about using the ABC as they were about receiving radiation therapy, a third reported being more anxious about using ABC than they were about receiving radiation therapy. Participants under 50 years were significantly more likely to feel "highly" anxious about using ABC than those older than 50 years (37% vs. 5%; $P = 0.001$). Half the participants indicated that their confidence level increased as treatment progressed, and suggested that the inclusion of a training video, practice sessions and constant communication via the treatment unit intercom would be helpful in reducing their anxiety. Conclusions This hypothesis generating study suggests that moderate-to-high levels of anxiety were common for left-sided breast cancer patients using the ABC device, particularly for patients younger than 50 years. As treatment progressed, patients seemed to become less anxious and more confident using the device. These preliminary findings support the need for further research in this area, using formal validated anxiety scoring tools. Copyright © 2016 Canadian Association of Medical Radiation Technologists

Database: EMBASE

12. Inter-and intrafraction motion during deep inspiration breath-hold associated with Elekta Active Breathing Coordinator (ABCTM) in left-sided breast radiotherapy

Author(s): O'Connor P.; Beaton N.

Source: Australasian Physical and Engineering Sciences in Medicine; Dec 2016; vol. 39 (no. 4); p. 1090

Publication Date: Dec 2016

Publication Type(s): Conference Abstract

Abstract: Introduction Reducing heart dose in left-sided breast cancer radiotherapy is key to avoiding long term cardiac complications. One strategy for reducing heart dose is deep inspiration breathhold (DIBH), which in effect moves the heart out of the field but retains the full target coverage. One commercial system for respiratory gating is the Elekta Active Breathing Coordinator (ABC). As part of clinical introduction of this equipment, the reproducibility and stability of breath-hold and any inter- and intrafraction motion associated with using ABC with left-sided breast radiotherapy patients was investigated. Method The Elekta iView GT electronic portal imaging device (EPID) was used to take portal images of left breast treatment fields 1-3 times per week. Typically, an image was taken during the initial breath-hold, and another two images were taken during beam delivery whilst under a second breath-hold. The first two images were compared to assess the reproducibility of the system, whilst comparison between the second and third images gave an indication of the stability of the breath-hold. The image processing software ImageJ was used to measure the position of the chest wall on each image. Chest wall position was compared between images from a single treatment fraction and across treatment fractions to measure intra- and interfraction motion respectively. Results There was minimal movement of the chest wall between breath-holds administered by ABC in different treatment fractions; maximum motion was 1.4 mm, with 0.8 mm measured on average. Mean intrafraction motion was found to be 0.56 mm. Sub millimetre intrafraction motion was detected when analysing multiple images of the same breath-hold (i.e. DIBH was stable using ABC) Conclusion The results collected give confidence in the reproducibility of the DIBH technique using the Elekta ABC equipment. Results also provide assurance that there is minimal intrafraction motion associated with the equipment.

Database: EMBASE

13. Dosimetric comparison for active breathing coordinator reduces radiation dose to the heart and lungs in patients with left breast cancer using VMAT techniques

Author(s): Prabakaran C.; Mokha S.S.; Jain P.; Kumar N.B.; Kumar G.; Dutt C.; Manigandan D.

Source: Journal of Cancer Research and Therapeutics; Nov 2016; vol. 12 (no. 6)

Publication Date: Nov 2016

Publication Type(s): Conference Abstract

Available in full text at [Journal of Cancer Research and Therapeutics](#) - from ProQuest

Available in full text at [Journal of cancer research and therapeutics \[J Cancer Res Ther\]](#) NLMUID: [101249598](#) - from EBSCOhost

Abstract:Introduction: For women with left-sided breast cancer, there is risk of potential cardiotoxicity from the radiation therapy. Different breath-hold methods have been utilized. The two dominant methods are the spirometry-based active breathing coordinator (ABC R3.0) system (Elekta Ltd., Crawley, UK) and the video-based real-time position management (RPM) system (Varian Medical Systems, Palo Alto, USA). The device is essentially a mouth piece attached to a spirometer and the patient's nose is pegged to ensure they are breathing only through the device. As the spirometer is connected to a computer, the Radiation Teams are able to visualize the patient's level of inspiration. Once the patient has reached the required threshold, pinch valves in the spirometer remotely close, preventing the patient from exhaling or inhaling outside the required threshold. A wide array of planning techniques has been reported in the DIBH literature, but one planning study compared VMAT-Deep Inspiration Breath-Hold (DIBH) Technique and VMAT-Free-Breathing (FB) Technique. DIBH allows this potentially superior planning technique to be used while minimizing cardiac dose. Materials and Methods: The Pinnacle treatment planning system, v.9.8 (Philips Radiation Oncology Systems, Fitchburg, WI) employs a collapsed cone convolution (CCC) algorithm method is currently regarded as one of the better practical options for dose calculation. Philips Pinnacle v9.8 TPS is used to generate VMAT plans, for a Elekta Infinity machine with a Agility 160 MLC (Elekta Ltd., Crawley, UK). Our VMAT planning protocol uses a single isocenter with two partial composite arcs, each consisting of two complementary arcs of identical gantry rotations. Again Plan is used to generate Free- Breathing (FB) plans, for Infinity with a Pinnacle TPS. The plan quality was evaluated by dose conformity, homogeneity, dose fall-off and leakages. Efficiency is measured in treatment planning and delivery time. In order to investigate the dosimetric impact of the ABC, two sets of CT images were acquired. Results and Discussion: Ten left-sided breast cancer cases are studied. The PTV volumes plan range from 534 to 620 cc. Plans were evaluated by target coverage, minimum and maximum dose to target, Quality of Coverage (QI), Homogeneity Index (HI) and conformity index (CI). Dosimetric parameters for analysis included RTOG protocol in Heart, Left Lung, Right Lung, Greater Vessels, Opposite Breast, Liver, Spine max dose including Monitor Units (MU). Patient selection is long breath-hold 20- 30 sec is desirable. All plans were optimized using six megavolts (6 MV) X-ray, and the objective dose-volume parameters were identical at the beginning of optimization for the different plans, Planning study compared VMAT-Deep Inspiration Breath-Hold (DIBH) Technique and VMAT-Free-Breathing (FB) Technique. DIBH allows this potentially superior planning technique to be used while minimizing cardiac dose [Table 1], Lungs dose etc. ABC is viable options to reducing margin for respiratory motion and main advantage was automated beam on and off during treatment of the patients without man interrupts the machine beam.(Table presented).

Database: EMBASE

14. Active breathing coordinator based treatment of liver SBRT patients

Author(s): Karotki A.; Erler D.; Chu W.; Chung H.T.

Source: Medical Physics; Aug 2016; vol. 43 (no. 8); p. 4950

Publication Date: Aug 2016

Publication Type(s): Conference Abstract

Available in full text at [Medical physics \[Med Phys\] NLMUID: 0425746](#) - from EBSCOhost

Abstract: Purpose: Accuracy of treatment delivery for liver SBRT patients can be compromised by breathing induced motion. Recently we started using active breathing coordinator (ABC) to "freeze" the breathing motion. This work describes our initial experience with ABC based treatment of liver SBRT patients. Methods: Patients are treated in maximum exhale state with a minimum required breath hold time of 20 s. Fluoroscopy is used to assess diaphragm stability before both simulation and treatment. Depending on the proximity of organs at risk, 30-60 Gy are given in five fractions every other day and delivered via VMAT. CBCT is used for patient setup verification with robotic couch compensating for translations/rotations. An additional CBCT is acquired after every fraction to confirm patient's stability during treatment. Results: Six patients have successfully been treated using the ABC protocol so far with an approximate treatment time of 1 h. CBCT acquired after the treatment suggests that patients are stable and the liver position, when locked by ABC, is reproducible throughout the treatment (average deviation 1.9 mm). The major immediate benefit of using ABC is a drastic improvement in image quality of the CT simulation as well as CBCT images. Conclusions: ABC eliminates breathing motion and, as such, substantially improves the quality of the images acquired at CT simulation as well as CBCT images leading to more reliable dose delivery. The position of the liver remains stable for the duration of treatment when using the ABC system. The treatment is well tolerated by the patients.

Database: EMBASE

15. Initial experience with an active breathing coordinator device for breath hold radiotherapy treatment of breast

Author(s): Martignano A.; Menegotti L.; Valentini A.; Vanoni V.; Magri E.

Source: Physica Medica; Feb 2016; vol. 32

Publication Date: Feb 2016

Publication Type(s): Conference Abstract

Abstract: Introduction: In this work first data on radiation therapy treatments with the Active Breathing Coordinator (ABC, Elekta) device are analyzed. Materials and Methods: The ABC device was used to immobilize the breathing motion in a mid-inhale position with a computer controlled valve. The patients were trained before the simulation CT to establish the patients specific volume threshold and breath hold time. A free breathing CT was also acquired. Two tangential beams treatment plans were created for each patient: one in breath hold and the other in free breathing. The planned dose was 50 Gy in 25 fractions. A software was written to analyze ABC software logs. Differences in ipsilateral lung volume, left ventricle distance from the PTV (for left breast treatments), reproducibility of inhale volume and patient positioning were evaluated. Patient setup reproducibility was verified by comparing EPID images acquired randomly during the treatment with DRR generated by the TPS. Results: Five patients have been evaluated thus far. The inhale breath hold volume threshold has an average value of 1.34 +/- 0.42 L and the breath hold duration has an average value of 20.8 +/- 1.8 s. The average volume increase of the ipsilateral lung using ABC compared to the free breathing situation is 67.6 +/- 22.3%. The mean minimum distance increment of the left ventricle to the PTV compared to the free breathing situation is of 1.3 +/- 0.9 cm. The mean number of breath holds per fraction is 8.5 +/- 2.0 and the mean inhale volume is 1.7 +/- 0.5 L.

The inter-fraction coefficient of variation (CV) of the inhale volume among the patients is 3.6 +/- 0.7%, while the mean intra-fraction CV is 3.5 +/- 1.2%. The mean random setup error during the treatment is below 2 mm. Conclusions: The ABC device is used to reduce respiratory motion in breast cancer patients. The device has demonstrated very good intra- and interfraction reproducibility of inhale volume and patient setup thus far.

Database: EMBASE

Exercise:

Sensitivity and Specificity

Sensitivity:

If a person has a disease, how often will the test be positive (true positive rate)?

If the test is highly sensitive and the test result is negative you can be nearly certain that they don't have disease.

Specificity:

If a person does not have the disease how often will the test be negative (true negative rate)?

If the test result for a highly specific test is positive you can be nearly certain that they actually have the disease.

Quick Quiz:

1. A very sensitive test, when negative, helps you:

- a: Rule-in disease
- b: Rule-out disease
- c: Confuse medical students
- d: Save money

2. A test which is highly specific, when positive, helps you:

- a: Rule-in disease
- b: Rule-out disease
- c: Confuse medical students
- d: Save money

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Answers: 1b, 2a



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