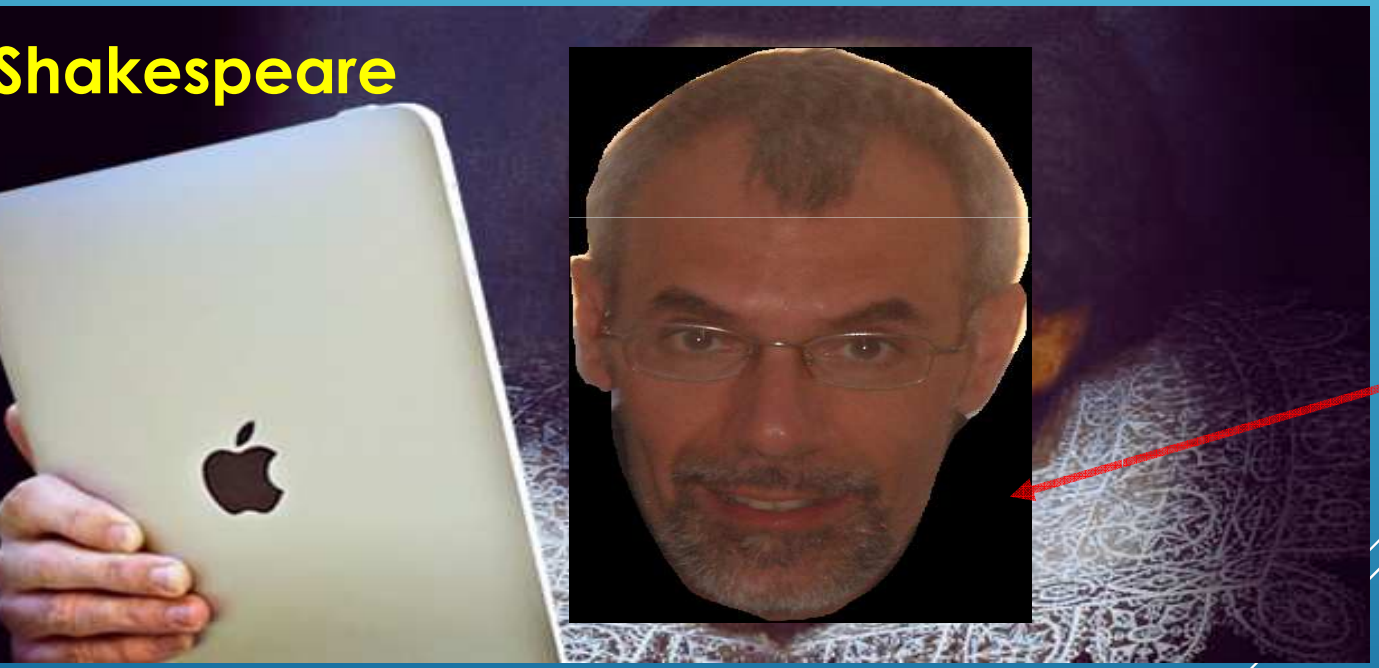
To Be or Not to Be

To Measure or Not to Measure



Physicspeare

That's the Question ??

- Debate: To Measure or Not to Measure

Moderator: Dimitris Mihailidis, PhD

PRESENTERS:
MOYED MIFTEN, PHD---TO MEASURE
JEAN MORAN, PHD---NOT MEASURE

Highly Conformal Radiotherapy: IMRT, Tomotherapy, Stereotactic Radiosurgery, Proton Therapy

2.1. It is necessary to validate each individual IMRT treatment plan before delivery

Chester Ramsey and Scott Dube

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(http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=MPHYA6000030000090022710000001&idtype=cvips&gifs=Yes)

OVERVIEW

Many physicists take the position that IMRT treatment plans are complex and must be validated before use because small errors can adversely affect patient treatment. These physicists feel that the time devoted to validation is completely justifiable. Other physicists believe that such validation can be eliminated, or at least substantially streamlined, if appropriate dosimetric and quality assurance measures are deployed by the physicist. They argue that validation of individual IMRT treatment plans is a misuse of time and resources. This difference in perspective is addressed in this month's Point/Counterpoint.

O MEASURE OR NOT TO MEASURE

Patient-specific QA for IMRT should be performed using software rather than hardware methods

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OVERVIEW

Measurement-based patient-specific quality assurance (QA) for IMRT is both time-consuming and potentially inaccurate, since the measurements are made in phantoms rather than actual patients. It has been suggested that it would be more accurate and considerably less time consuming to perform such QA with software rather than hardware, and this is the topic debated in this month's Point/Counterpoint.

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2.2. It is STILL necessary to validate each individual IMRT treatment plan with dosimetric measurements before delivery

J. Charles Smith and Sonja Dieterich
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(http://dx.doi.org/10.1118/1.3512801)

OVERVIEW

Almost a decade ago, we published a Point/Counterpoint debate on the need for validation measurements for each individual IMRT patient [Med. Phys. 30, 2271–2273 (2003)]. Now, more years of experience with this modality, the necessity for such patient-specific measurer been questioned, and this is the topic discussed in the month's Point/Counterpoint debate.

O MEASURE OR NOT TO MEASURE

tion Oncology (2013) 3, 80–90

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NOT TO MEASURE

Report

ing errors with patient-specific pretreatment ine log file analysis

pathy Rangaraj PhD*, Mingyao Zhu PhD, Deshan Yang PhD,
iya Palaniswaamy PhD, Sridhar Yaddanapudi MS,
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September 2011; revised 2 May 2012; accepted 5 May 2012

robust, efficient, and reliable quality assurance (QA) process is highly desired for nal beam radiation therapy treatments. Here, we report the results of a semiautomatic, patient-specific QA process based on dynamic machine log file analysis clinically for intensity modulated radiation therapy (IMRT) treatments delivered by high accelerators (Varian 2100/2300 EX, Trilogy, iX-D, Varian Medical Systems Inc, Palo he multileaf collimator machine (MLC) log files are called Dynalog by Varian.

Materials: Using an in-house developed computer program called "Dynalog QA," ally compare the beam delivery parameters in the log files that are generated during point dose verification measurements, with the treatment plan to determine any in IMRT deliveries. Fluence maps are constructed and compared between the planned beams.

ce clinical introduction in June 2009, 912 machine log file analyses QA were the end of 2010. Among these, 14 errors causing dosimetric deviation were detected further investigation and intervention. These errors were the result of human operating wed treatment planning, and data modification during plan file transfer. Minor errors orted in 174 other log file analyses, some of which stemmed from false positives and sults; the origins of these are discussed herein.

It has been demonstrated that the machine log file analysis is a robust, efficient, and rocess capable of detecting errors originating from human mistakes, flawed planning, sfer problems. The possibility of detecting these errors is low using point and planar easurements.

Practical Radiation Oncology (2013) 3, 91–92

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TO MEASURE

Commentary

Comment on "Catching errors with patient-specific pretreatment machine log file analysis"

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We read, with great interest, the recent article by Rangaraj et al[1] regarding their analysis of Dynalog files as a component of an intensity modulated radiation therapy quality assurance (IMRT QA) program. They describe an IMRT QA program consisting of 3 components: (1) ion chamber based point dose measurements; (2) a single plane dose array measurement carried out on a field by field basis; and (3) comparison of DICOM [Digital Imaging and Communications in Medicine] RT files manually exported from the planning system with Dynalog files recorded on the accelerator during QA measurements. In the normal course of preparation, a combination of manual and automated steps are used in the copying of data from the treatment planning to the record and verify and to the linear accelerator delivery systems. The third item in their program backs up the first two and, nominally, cross checks that no errors were

they indicate selecting the condition for passing to agreement of 90% of the pixels. The authors note that th is no dosimetric basis for this selection. In their discuss they point out that they have noted that the machine M log files sometimes "contain incomplete data and o defects such as missing data for an entire MLC carria However, in their discussion the authors argue "Compared with the IC and MapCHECK techniqu that Dynalog file analysis is much more sensitive would catch any deviation from the treatment plan." Us the Dynalog process in addition to the measurement reasonable. The suggestion of using it in place of measurement gives us pause.

A condition of no errors is most desirable. Detect errors that can have significant dosimetric consequence most essential. There are many places in a process (am vendor systems, etc) where errors that affect dose ca

effective measures for IMRT QA.[1] Automated, routine Dynalog analysis could provide robust consistency checks throughout a course of treatment and augment careful pretreatment dosimetric verification. However, from our point of view, physical dosimetric checks of IMRT plans should continue to be a mainstay of IMRT QA programs.

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relatively large open fields). Using an intelligent suit

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rification of dynamic and segmental IMRT d
namic log file analysis

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(Received 26 October 2001; accepted for publication 17 December 2

A program has been developed to evaluate the delivered fluence of s segmental and sliding window dynamic multileaf collimator (MLC) tomate these checks, a number of tools have been developed using from the dynamic log files that can be created each time a dynamic de Experiments were performed with a Varian 2100EX with a 120 leaf M with dynamic capabilities. A dynamic leaf sequence is delivered and n film or an amorphous silicon imager. After delivery, the dynamic log by the accelerator control system. The file reports the expected and a for each leaf and the dose fraction every 0.055 seconds. Leaf trajec culated from this data and expected and actual fluence images are cre difference of opposing leaf trajectories. These images can be comp expected delivery, measurements, and calculations of fluence. Too developed to investigate other aspects of the delivery, such as specif beam hold-off flags sent by the control system to the MLC, and gap program is part of a semi-automated quality assurance (QA) system ment fluence verification and daily treatment verification of dynamic limation (DMLC) delivery. © *2002 American College of Medical P*
[DOI: 10.1120/1.1449362]

PACS number(s): 87.53.−j, 87.52.−g

Key words: IMRT, quality assurance, sequence verification, dynamic

RapidArc patient specific mechanical delivery accuracy under extreme mechanical limits using linac log files

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(Received 4 October 2011; revised 9 February 2012; accepted for publication 10 February 2012; published 15 March 2012)

Purpose: To assess the accuracy of RapidArc (RA) delivery for treatment machine operation near allowable mechanical limits in dynamic multileaf collimator (DMLC) leaf velocities, gantry speeds, and dose rates.

Methods: Thirty RA patient plans were created for treatment of lung, gastrointestinal, and head and neck cancers on a Trilogy unit. For each patient, three RA plans were generated; one with medium MLC velocities, highest gantry speeds, and dose rates (case A); one with maximal allowable MLC leaf velocities (case B); and one with lowest gantry speeds (case C). Combinations of dose rates (140–600 MU/min), gantry speeds (2–5.4°/s), and DMLC leaf velocities (1.3–2.4 cm/s) were utilized to test the RapidArc delivery accuracy. Linac delivery log files were acquired after delivery of each plan. In-house developed software was used to read in the original RapidArc DICOM plan and update the plan to reflect the delivered plan by using the leaf position (L), gantry position (G), and MU dose values (D) extracted from the linac log files. This modified DICOM RT plan was imported back to ECLIPSE and the delivered 3D dose map recomputed. Finally, the planned and delivered 3D isodose maps were compared under three criteria to evaluate the dosimetric differences: maximum percentage dose difference, 3D gamma analysis criteria for 3%/3mm DTA, number of dose voxels having a dose difference that is greater than 1%, 2%, or 3% of the maximum dose, and their respective percentages.

Results: For the three cases indicated above, MLC leaf position discrepancies between planned and delivered values are 0.8 ± 0.2, 1.2 ± 0.2, and 0.8 ± 0.2 mm; the maximum gantry position discrepancies are 0.9° ± 0.2°, 0.9° ± 0.2°, and 0.6° ± 0.1°, and the maximum differences in delivered MU per control point are 0.2 ± 0.1, 0.2 ± 0.1, and 0.04 ± 0.01, respectively. Maximum percentage dose difference observed is 6.7%, for a case where 1 cm MLC leaves were used with high MLC leaf velocity. Maximum number (percentage) of dose voxels having a dose difference that is greater than 1%, 2%, and 3% of the maximum dose were 4761 (0.35%), 897 (0.07%), and 188 (0.01%). This also corresponds to the plan utilizing the most number of 1 cm MLC leaves. The 3D Gamma factor acceptance rates are better than 99%.

Conclusions: This work shows that the accuracy of RapidArc delivery holds across the full range of gantry speeds, leaf velocities, and dose rates with small dosimetric uncertainties for 0.5 cm MLC leaves. However, caution should be exercised when using large MLC leaves in RapidArc. A novel technique to obtain the delivered 3D dose distributions using machine log files is also presented.
 [http://dx.doi.org/10.1118/1.3690464]

Key words: MLC QA, linac log files, RapidArc accuracy

I. INTRODUCTION

RapidArc, a volumetric modulated arc therapy (VMAT) technique, is recently being introduced in the clinical practice by Varian Medical Systems (Palo Alto, CA). This technique, originally developed by Otto,[1] incorporates the direct aperture-based optimization (DAO) in conjunction with progressive sampling where groups of control points are added during optimization in different resolution levels in the order 10, 21, 43, 87, and 177 gantry positions. RapidArc incorporates variable dose rate, variable gantry rotation speed, and variable dynamic multileaf collimator (DMLC) leaf positions to optimize dose conformality, and dose delivery efficiency. This allows the RapidArc optimizer to have sufficient degrees of freedom to obtain a very conformal dose distribution. With a maximum of 177 control points per full arc, RapidArc optimization is limited by the machine's delivery capabilities. Mechanical limitations for the modulation factor are the gantry rotation speed, dose rate changes, and the DMLC leaf motion velocities. Although it has been shown[2] that Varian millennium DMLC leaves could move with velocities up to 3.9 cm/s, RapidArc algorithm is restricted to a maximum leaf velocity tolerance of 2.4 cm/s. Gantry speed is kept at its maximum speed of 4.8°/s unless the required MU per degree exceeds what can be delivered at maximum dose rate of 600 MU/min, thus causing a gantry

 0094-2405/2012/39(4)/1846/8/$30.00

MEDICAL PHYSICS, VOLUME 13, NUMBER 5, 2012

iciency and effectiveness of alculation followed by machine inst conventional measurement

pathy Rangaraj,[1,2a] Sunita Boddu,[3] Yang,[1] Geethpriya Palaniswaamy,[2] Omar Wooten,[1] Sasa Mutic[1]
cology,[1] Washington University School of Medicine, f Radiation Oncology,[2] Scott & White Healthcare System, Radiation Oncology,[3] University of California Davis,

11; accepted 30 May, 2012

e commonly used for patient-specific IMRT deliver riety of IMRT QA techniques which have been propose common understanding that not one single method ca The aim of this work was to compare the efficiency an nt dose calculation followed by machine log file analys ent-based methods in detecting errors in IMRT deliver lans (5 head-and-neck, 3 rectum, 3 breast, and 5 prostat ercial treatment planning system (TPS) were recalculate tment plans underwent ion chamber (IC) and 2D diod ame set of plans was also recomputed with another con system and the two sets of calculations were compare simetric measurements and independent dose calculatio parisons included evaluations of DVHs and point dose systems. Machine log files were captured during pr dose measurements and analyzed to verify data transf livery machine. Average deviation between IC measure lations with the two TPSs for head-and-neck plans wer %, respectively. For 2D diode array measurements, th % dose difference and 3 mm distance-to-agreement wa lans. The mean 3D dose differences calculated from tw head-and-neck cases and within 2% for other plans. Th showed that the gantry angle, jaw position, collimato istent as planned, and maximal MLC position error wa ependent dose calculation followed by the machine lo 47 ± 6 minutes, while the experimental approach (usin surements) takes an average about 2 hours in our clini on followed by machine log file analysis can be a reliab ients. Additionally, independent dose calculations hav veral problems (heterogeneity calculations, data corru h the primary TPS, which generally are not identifiab l approach. Additionally, machine log file analysis ca gantry, collimator, jaw setting) which also may not b

NOT TO MEASURE

RapidArc patient specific mechanical delivery accuracy under extreme mechanical limits using linac log files

Krishni Wijesooriya,[a] Eric Aliotta, Stanley Benedict, Paul Read, Tyvin Rich, and James Larner
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NOT TO MEASURE

Revised 2011 (CSC/BOC)*

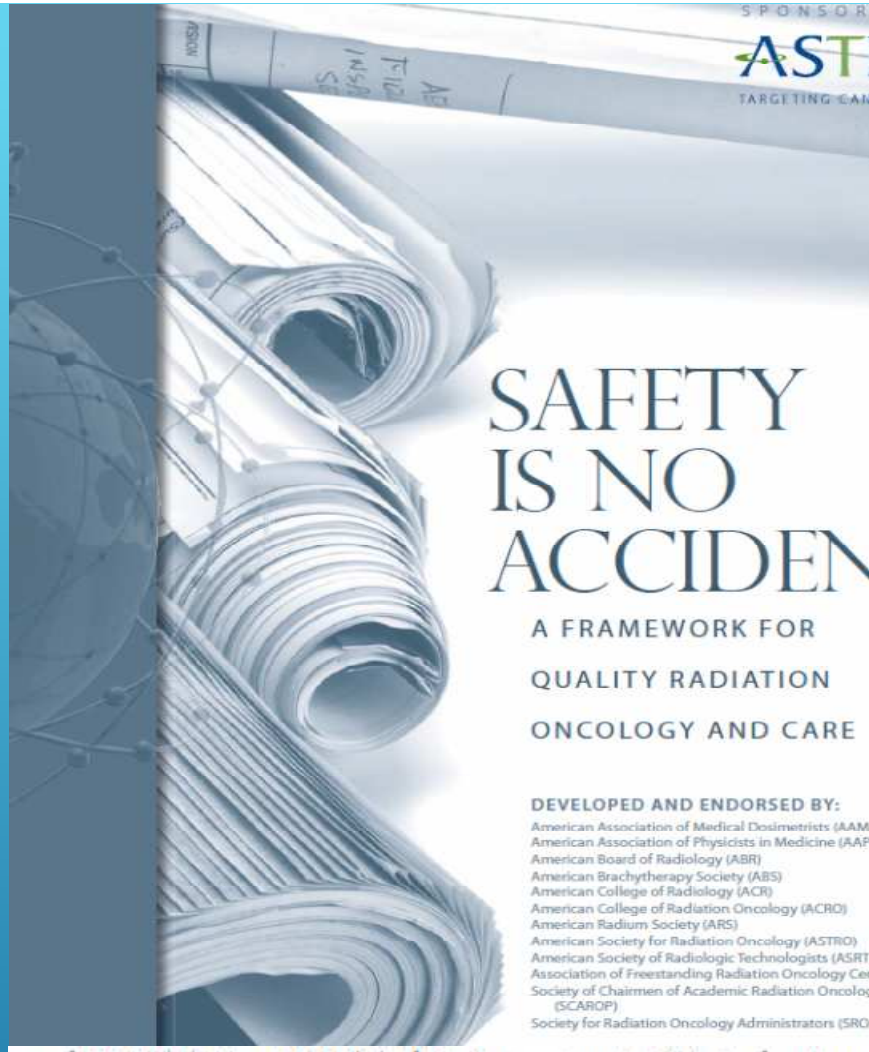
ASTRO PRACTICE GUIDELINE FOR INTENSITY MODULATED TION THERAPY (IMRT)

Delivery Verification by Physical Measurement

al physicist should assure verification of actual radiation doses being received during treatment rior to the start of treatment and using all of the parameters of the patient's treatment plan, the accuracy livery should be documented by irradiating a phantom containing a calibrated dosimetry system to the dose delivered is the dose planned. Multiple points in the delivered distribution should be against the planned distribution, as can be accomplished, for example, using film dosimetry within the 26-29]. This testing procedure has been termed "patient-specific end-to-end testing."

alternative tests provide equivalent or even more detailed verification. It is the responsibility of the ysicist to assure the equivalence or superiority of an alternative testing procedure. For example, one od uses a two-dimensional detector array to verify intensity patterns of individual fields as well as the ttern for the entire IMRT plan. This technique may be considered to provide equivalent information fixed gantry angle delivery, as long as the pattern for each gantry position is verified together with the ttern, and as long as the treatment planning system provides the necessary analogous information for n.

MEASURE



and IMRT. For IMRT, this important QA technique considered to be completely sufficient to guarantee p safety. In addition to this isocenter check procedure, patient-specific QA measurements are also required f IMRT and other complex delivery techniques that u verse treatment planning. In terms of clearly organiz