

IMRT QA for H&N Radiotherapy

Stephen F. Kry, Ph.D.



Overview

- Importance of QA
- MD Anderson techniques and experiences
- Other pre-treatment techniques
- QA during treatment

- Strengths and Limitations
- What do we do when things go wrong

A Phase III Trial Assessing the Efficacy of Hypoxic Toxin, Tirapazamine (TPZ)

JOURNAL OF CLINICAL ONCOLOGYORIGINAL REPORT

Tirapazamine, Cisplatin, and Radiation Versus Cisplatin and Radiation for Advanced Squamous Cell Carcinoma of the Head and Neck (TROG 02.02, HeadSTART): A Phase III Trial of the Trans-Tasman Radiation Oncology Group

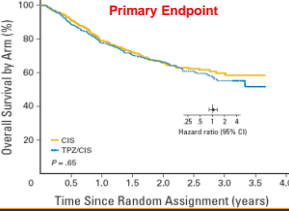
Critical Impact of Radiotherapy Protocol Compliance and Quality in the Treatment of Advanced Head and Neck Cancer: Results From TROG 02.02

28:2996-3001, 2010

- Designed to provide 90% power to detect a 10% difference (70% v 60%) in 2-year overall survival rate
- No IMRT

Impact of Radiotherapy Compliance & Quality

Primary Endpoint



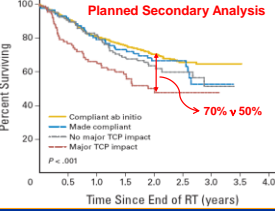
Overall Survival by Arm (%)

Time Since Random Assignment (years)

Hazard ratio (95% CI): 1.1 (0.8, 1.5)

P = .85

Planned Secondary Analysis



Percent Surviving

Time Since End of RT (years)

> 70% v 50%

P < .001

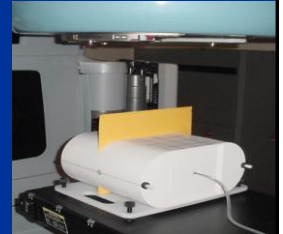
- "It is sobering to note that the value of good radiotherapy is substantially greater than the incremental gains that have been achieved with new drugs and/or biologicals."
- "The clinical impact of radiotherapy quality on outcome increases with more advanced techniques, such as intensity-modulated radiation therapy and stereotactic radiotherapy." (Ang JCO 28:2941-2943, 2010)

Verifying dosimetry

- Dosimetric accuracy is critical
- Major method: IMRT QA
- Numerous tools
 - What have we learned from them
 - Do they tell us what we need to know

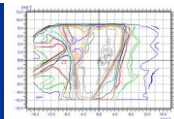
MD Anderson IMRT QA

- Recalculate patient plan on QA phantom (hybrid plan)
- Absolute point dose measurement
 - 0.04 cc ion chamber
- Relative planar measurement
 - EDR film
- Cumulative dose from all gantry angles



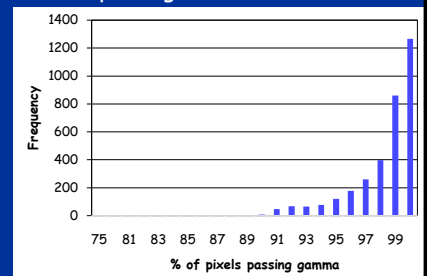
Our Criteria

- Absolute agreement
 - +/- 3%
- Relative planar agreement
 - 5%/3mm gamma criteria
 - 90% of pixels passing
 - 10% low dose threshold
- Since 2005
 - 3797 H&N IMRT patients



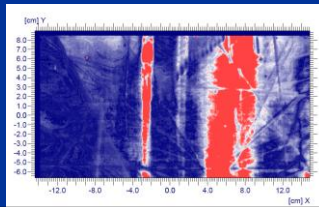
Relative Results (Gamma analysis)

- 17 failures / Failure rate: 0.5%
- Worst gamma: 74.2% passing



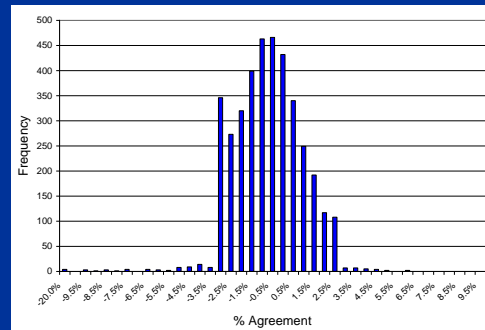
Relative results

- Failures typically related to processor
- Repeat measurement passes or is judged "close enough" (abs. passes)
- Never changed plan based on relative measurement
- Point????



Absolute Results

Average = -0.47%



Failures/course of action

- 91 Failing measurements
- 1 - repeat measurement at a different point
- 2 - measure all beams AP
- 3 - split dose difference (small difference)
- 4 - replan (large difference)

Failure details

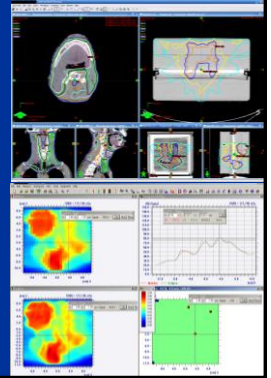
- 91 failing measurements (rate: 2.4%)
 - Worst agreement: -8.7%
- 80 patients with failing measurements (2.1%)
- 18 patients with multiple/unresolved failing measurements (0.5%)
- We are finding problematic plans
 - Sources of error?
 - Are we missing plans?

Other IMRT QA options

- Planar dose measurements
 - Matrixx
 - EPID
 - MapCheck
- Pseudo 3D
 - ArcCheck
 - Delta4
- 3D - gels/Presage

Common Approach

- Measure plane(s)
- Isodose overlay
- Evaluate Profiles
 - Through high dose and relevant normal tissue planes
 - Through points that fail gamma test
- Gamma analysis



How are people doing this?

- 2D diode arrays
- >100 respondents
- Considerable variability
 - Field by field vs. composite
 - Absolute vs. relative dosimetry
 - Failure criteria
 - What to do in case of failure?

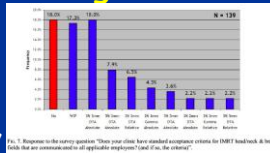


Fig. 1. Response to the survey question "What your clinic, have standard acceptance criteria for IMRT headneck & how often the acceptance would not apply endpoints?" (and "Yes, the criteria")

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A survey on planar IMRT QA analysis
Benjamin E. Nelms^{1,*} and Jeff A. Simon²

Interpretation of results

- No standard approach
- Complicated when it fails
- What about when it passes?
 - Is this information reliable?

On the insensitivity of single field planar dosimetry to IMRT inaccuracies

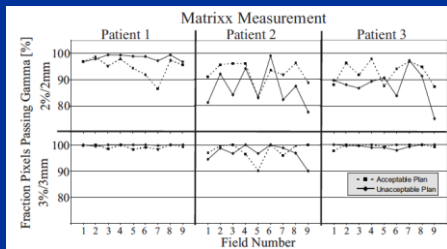
Joni J. Kruse¹
Department of Radiation Oncology, Mayo Clinic, Rochester, Minnesota 55905
(Received 11 November 2009; revised 6 April 2010; accepted for publication 7 April 2010; published 12 May 2010)

Per-beam, planar IMRT QA passing rates do not predict clinically relevant patient dose errors¹⁾

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2D Data

Field by Field gamma analysis (calibrated EPID and Matrixx) did not relate to composite ion chamber errors



Kruse et al., Med Phys 2010

Concerns

- Are we getting useful information?
- Gamma statistics are highly variable dependent on user selections
 - Threshold dose/region of assessment
 - Measured grid or interpolated fine grid
 - Gamma or Digital Gamma algorithm
 - Ratio of chamber spacing to target volume size
 - Dose difference: what is reference dose?

Other QA Concerns

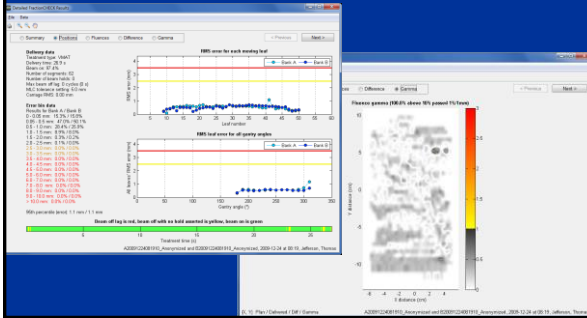
- This has all been pre-treatment QA
- Tests the plan
 - Point dose doesn't well describe the entire plan
 - Film measurements show questionable added value
 - Field by field planar QA may not provide patient-relevant information
- Does not test actual delivery to patient

Delivery assessments

- For Varian linacs, can look at Dynalog files
 - Evaluation of MLC leaf positions every 50 ms
- Evaluate patient treatment
- Evaluate fractions that are of concern

Evaluate fx of concern

Leaf failure during RapidArc treatment

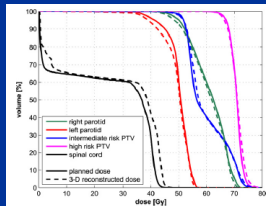
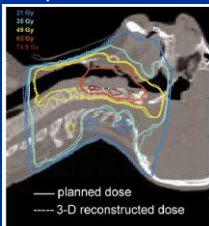


Dynalogs

- Evaluate all fractions of MLC positions
- With automatic systems, can analyse entire tx in ~1 min
- Only MLC positions
 - May be majority of major errors (van Zijtvelde, Radioth Oncol 2006:168-75)
- Not testing patient parameters

In Vivo Transmission Dosimetry

- Measure energy fluence with EPID during treatment
- Back-calculate dose through patient CT
- Calculate isodoses, DVHs, compare to initial plan



Van Elmpt, Radioth Oncol 2008;86-92

Advantages

- Test delivered treatment
- Detect delivery errors
- Setup errors
- Changes in patient anatomy
 - Adaptive therapy

Limitations

- Much larger uncertainty than standard pre-treatment QA
 - Accounting for more things
 - Not an ion chamber/more corrections
 - Less sensitive to detecting each individual components in error
(Louwe, Med Phys 2003) (Gallego, Med Phys 2011)
- Can deliver lethal dose with incorrect first fraction
- Doesn't detect undeliverable plans/collisions
- >5 hours per patient (McDermott, IJROBP 1998;465-74)
- Can catch more errors, but need to show that the increase in time is warranted

Summary

- Accurate dose delivery is important
- Few errors (some catastrophic)
- QA tools provide unclear information
 - Are we using them properly
 - Do we know what we're looking for
- How do we troubleshoot?
- Are we sure we're OK when things look good?
- How much QA is the right amount?

Thank you