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Pushing the Frontier of Automation: Applications & Safe Incorporation into Clinical Care

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AAPM Annual Meeting

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Outline

- Motivation
- Value of automation
- Automation at different process steps
- Department workflow
- Summary and conclusions

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Example Safety Reports

ASTRO Safety White Paper Series – 2011-2016 on different topics

AAPM Reports such as Task Group 100 – Formal Risk Analysis for Safety (Huq et al)

2012

https://www.asrt.org/docs/default-source/publications/whitepapers/rt-safety---the-critical-role-of-the-rad-therapist.pdf?sfvrsn=2

United Kingdom Report - 2008

2014 – National Incident Learning System launched by ASTRO and AAPM

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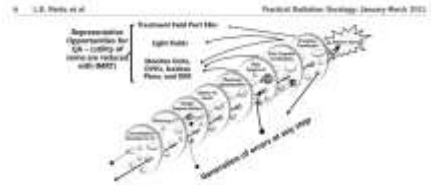
Swiss Cheese Model



Marks et al, The challenge of maximizing safety in radiation oncology, PRO, 2011

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Hierarchy of Effectiveness

To improve safety:

E.g. Force that only treatment approved plans (after checks) can be moded up at the treatment unit

Marks et al, The challenge of maximizing safety in radiation oncology, PRO, 2011

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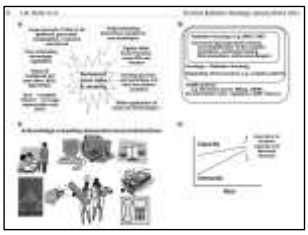
Challenges in Radiation Oncology

Our processes are complex.



Marks et al, PRO, 2011

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With RO-ILS – we know where events happen and where discovered

We find events with pre-tx QA review but would prefer to prevent errors or to identify them sooner.

RO-ILS

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Precision Medicine & AAPM Guidance for Clinical Trials: TG113

From TG113: Physics Practice Standards for Clinical Trials

Moran et al, TG113, https://www.aapm.org/pubs/reports/detail.asp?docid=172 ; Executive Summary JACMP (June 2018)

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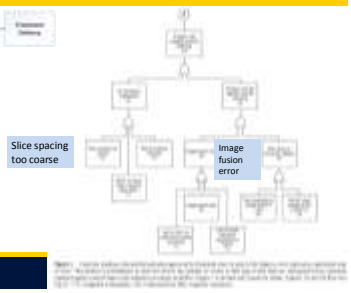
Incident Reporting related to Imaging: Multiple Pathways

To 2016-Q3: 2344 events with 396 were high priority and reviewed again

A fault tree analysis was performed

1. "problematic plan approved for treatment,"
2. "wrong shift instructions given to therapists,"
3. "wrong shift performed at treatment."

Fault trees were created showing how different errors



Ezzell et al, PRO, 2018

QA of Organs at Risk – Leveraging Standardization & Automation

QA of OARs based on historical contours: computers first, then people

Hui et al, Med Phys, 2018

QA of Organs at Risk – Leveraging Standardization & Automation

Manual Delineation:

Tool identified 94% of the simulated errors

Improved the ability of individuals to identify errors

Hui et al, Med Phys, 2018

Automation to Fabricate Custom Immobilization

Gensheimer et al, PRO 2017

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Automation for Treatment Decisions in Precision Medicine

Which modality is best?

How do clinicians incorporate and balance different data sources?

An analytical pipeline approach

Cheng et al, Radiother Oncol, 2016

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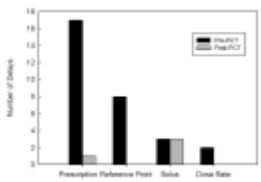
Mitigating Incidents at the Planning Stage

- **Automation of 19 of 33 initial checks led to a 60% decrease in delays at the treatment unit compared to prior to release**
- **Automation saved 488.8 hours**
- **Results automatically uploaded to EMR**
- **Improves quality and efficiency; decreases treatment delays**



Covington et al, Plan Checker, JACMP 17, 2016

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Mitigating Incidents at the Planning Stage

Data pulled from different systems with automation to highlight information for users

Halabi and Lu, JACMP, 2014

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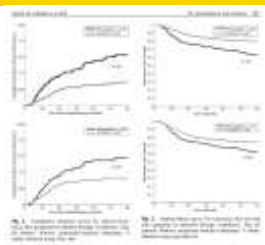
Safety, efficiency, etc can affect patient outcomes

Ohri et al evaluated patient compliance and found that missed treatments resulted in lower rates of recurrence-free survival



Ohri et al, IJROBP, 2015

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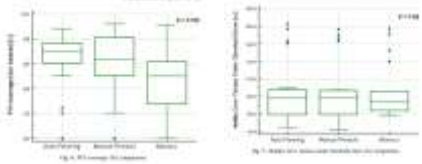
SBRT Planning – Automation to Improve Dose Metrics

↓ Variability with autoplanning

Better target coverage for similar normal tissue sparing



Gallio et al, Physica Medica, 2018

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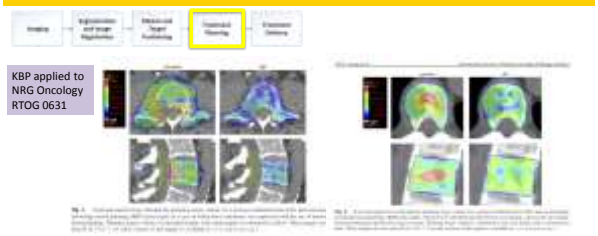
Knowledge-based planning (KBP) – Automation to improve plan quality



KBP applied to NRG Oncology RTOG 0631

Younge et al, PRO 2018

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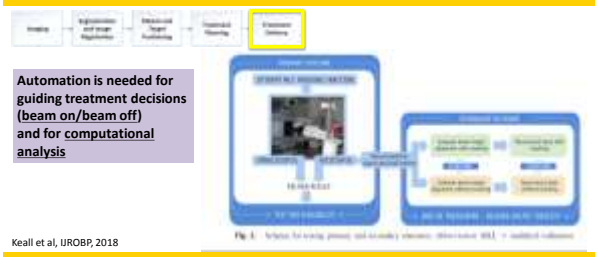
Pushing the Frontier: Automation enables MLC Tracking



Automation is needed for guiding treatment decisions (beam on/beam off) and for computational analysis

Keall et al, IJROBP, 2018

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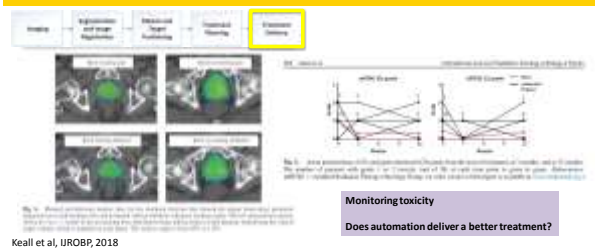
Automation: Delivery of precision medicine in RT



Monitoring toxicity

Does automation deliver a better treatment?

Keall et al, IJROBP, 2018

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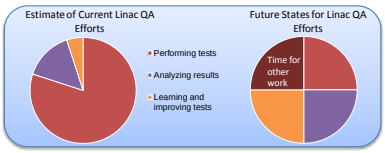
Rethinking the QA Paradigm: Improving Efficiency

- Identify key data to track
- Look for outliers
- Agree on actions when something is out of tolerance
- Are the tests effective?



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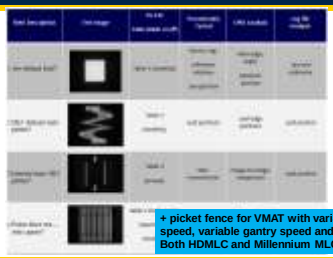
Automated QA – Standard tests & Automated Analysis

Some tests recommended by AAPM TG142 Klein et al

15 minutes to deliver test suite

~1 minute to analyze

Initial consortium was 8 institutions in the US and Australia



+ picket fence for VMAT with variable gantry speed, variable gantry speed and dose rate
Both HDMLC and Millennium MLC supported

Eckhause et al Med Phys 42, 2015.

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Automated QA – Trends & Analysis for Exceptions

- A framework has been built to support different QA procedures, drag and drop functionality and automated analysis

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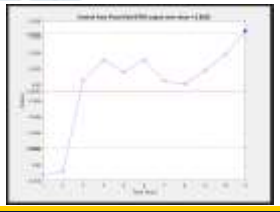
Automation for Linac QA

Mean, upper and lower control limits

Enable ongoing quantitative evaluation of QA test results



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Automation for Workflow & Process Improvements

We want real-time quality control …if the system cannot be designed to prevent certain incorrect tasks by a user.

Automate communication, testing

Hadley et al, JACMP 17: 387-395, 2016.

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Automation cannot do it all – Kapur et al

- "Effort targeted **an overprocessing and safety defect**.
  - **…suboptimal systems integration of a patient collision detection system** … leading to spurious alerts and thus a need for an **override by the therapist**.
- **Alert and override fatigue resulted in a therapist missing a true alert that caused a collision**. Annually, performing these overrides …an estimated **2.6 weeks per machine**.
- The proposed solution was to turn off the collision detection system in lieu of a **peer-reviewed dry run** … rather than **overreliance on automation** to eliminate this defect. **No collisions** have been reported since this change was made.

Kapur et al, PRO 2017

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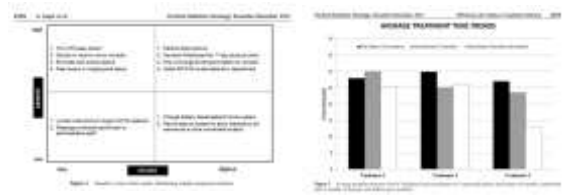
Effort vs Benefit Analysis to Select Areas for Action



Kapur et al, PRO 2017

Summary and Conclusions

- Automation can be applied to any part of the radiation therapy process
- Incident reporting systems, such as RO-ILS, can help us identify processes where automation can support quality
- The appropriate inspection may steps may be needed to ensure accurate results from automation
- To push the frontiers of precision medicine, both real-time and offline automation may be of value
- Automation of quality control steps can enable lead to efficiencies allowing for advances in clinical practice and clinical trials (KBP)

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Other Organizations and References

- DICOM 7 Working Group
- IEC 62083 – manufacturer efforts
- Radiation Oncology – Safety Stakeholders Initiative (RO-SSI) – ongoing discussions on how to encourage more communication between users, manufacturers, and those developing standards
  - Feel free to join! http://info.radoncssi.org/about
- ASTRO White Papers on Safety
  - https://www.astro.org/Clinical-Practice/White-Papers/All-White-Papers.aspx
- ASTRO Safety is No Accident
  - https://www.astro.org/Clinical-Practice/Patient-Safety/Blue-Book/bfp/index.html#/0
- RO-ILS quarterly and annual reports
  - https://www.astro.org/RO-ILS-Education.aspx

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