AAPM 2018 Tuesday 1:45 - 2:45 PM

## Contracto

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Lower Responses

- Treatment goal
   What is the Study Subject
   Treatment Goal --- "Value"

  - Reality facing

     Human Performance Mode
     Swiss Cheese model

  - Tools available

  - FMEA
    Lean Six Sigma
    Incident report system
    Root Cause Analysis
- Influence of upstream and downstream operations
  - Simulation variation
  - Check list for simulation variations
  - Treatment delivery variation
  - Check list for treatment planning
  - Collision detection
- Optimizing process to reduce event
  - Event examples

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- Root cause analysis
- Process change discussion

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- Clinical Environment like community hospital
  - 3 linac, 2 CTsim, 1 HDR; 3 Physicists
  - · Routine clinical service mainly, min unusual treatment
  - Favor more towards efficiency
  - Work assignment change, like dosimetrist contour OAR
  - Min physics support, commissioning done by 3rd party
- Paperless environment with EMR
  - data in digital format with image, plan, treatment record, RT image, etc.

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- Hight Efficient
  - Benchmarked by turn around time
  - Real working time and dead time
- High Quality
  - Benchmarked by cure rate
  - · Imaging rejection rate and delivery error
- High Reliability
  - Benchmarked by mistakes, incident and near-miss
  - · Error rate and severity

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set Reveales IN Spenakes

- Humans Work in Three Modes
- Knowledge-Based Performance 50% error rate
   "Figuring It Out Mode" Stop and ask expert
  - IMRT QA, learn to operate the equipment, delivery, documentation
     Policy and Procedure, protocol

  - Graduate program practicum/lab

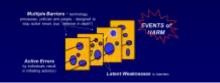
# Rule-Based Performance – 1% error rate "If-Then Response Mode" – Education, Reduce burden, increase risk awareness, improve coaching

- IMRT QA, accumulate experience on trouble shooting if something happens
- Checklist, cheat sheet
- Resident training IMRT QA rotation
- Skill-Based Performance 0.1% error rate
   "Auto-Pilot Mode" Stop and think before acting · IMRT QA, after tens of repeat, it become natural operation and/or
  - · Resident completed rotation/Full time clinical practice every day

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- Swiss Chees Model

  - Holes in cheese highlight role of errors within individual layer in global system failure.
    Potential error need to go through a series holes to reach patient to become accident
- Feta Chees Model
  - Nested block of Cheese
  - Stresses applied to any portion of the block can cause the block to fracture in an unpredictable manner



### aird Revolution Investmentation

- Radiation Oncology Treatment process is moderately coupled complex system, accident occur when
   Component failure

  - External disturbances
  - Dysfunctional interactions among system components are not adequately controlled
  - Reliable/robust components do not guarantee overall system reliability
     Too much focus on sub-unit reliability have negative impact to whole system

  - Each improvement introduce additional opportunities for unforeseen interactions
    Adding layers of quality assurance/safety steps to existing practices may be detrimental

References: Lawrence Marks, Lukasz Mazur Engineering Patient Safety in Radiation Once

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Report

- Error prevention tool:
  - ٠
  - Automation and computerization
  - protocols and standard
  - Independent double-check systems
  - rules and policies

es: Matthew Grissinger, Institute for Safe Medication Practices, on error prevention "toolbox". Medication Safety Alert, June 2 MD-BRC-1 Quality Management Systems in Radiotherapy: M to Safer, F. End. (2011).

# set Reveales IN Spenakes

- Check list for Simulation Variations
  - Patient SI coverage not enough
  - Target AP and LR centering
  - · Metal artifact: like prosthesis, breast expander, dental filling
  - Dose limiting: pacemaker/ICD, fetus, gonald
  - Electron: small field, large oblique angle, extended SSD,
  - backscatter for keloid
  - Breast: Flash, breast expander
  - Nose/extremities: water, rice, bolus
  - Simulation mistake: arm in beam, non-bladder control, excessive gas in rectum, object on patient, accessory/setup error
  - Indexer, respiration belt clipper
  - Recon cutoff like heavy patient
  - Collision detection
  - Patient identification
  - Patient orientation

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Collision

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- Bent Screw from Gantry head
- Collision could cause
  - Collimator rotation chain pop-out, service/calibration needed, cancel patients for the rest of the day.
  - · Scratch or damage of gantry head cover
  - Scratch or damage of couch



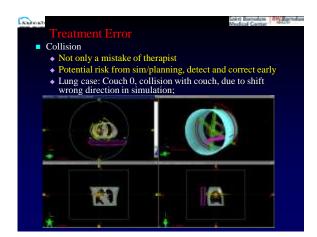
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# Contracto ot Ba abos [TYEs abos Collision • Breast case: PAB field collide with couch. Exact Couch in Trilogy has less clearance than IGRT couch in Truebeam 4.85 Breast Board

## Solve Revealers Inv Romatics

- Treatment delivery Variation
  - · Gantry clearance, especially with couch kick
  - CBCT clearance

- Electron cone clearance
- · Schedule linac simple sim in additional to CT sim
- In-consistent setup
- · Same immobilization device between sim and treatment Couch kick minimization
- Larger PTV margin for couch kick
- Treatment MU/Time
  - Non-SRS mode has max 999 MU limit for Trilogy and 1999 MU for Truebeam
  - · Tx time is not enough for breast FinF patient
- Exact Couch side rail/bar
  - Rail-in affect AP/PA KV imaging
    Rail-in give more room for rail-free arc
- Gantry angle sorting
   Sort KV setup fields/CBCT, 90 deg difference
   Sort MV treatment fields
   179.9 or 180.1 instead of 180.0

# set Reveales IN Spenakes Contracto Treatment delivery Variation Collision Bolus Skin cancer, fall off · Breast cancer, mess out on/off schedule due to tx break Partial Tx Machine down Collision Plan scheduling left out Plan scheduling left out Shift wrong Wrong direction Wrong target Course delivery not complete Rx changed Tx calendar update after Tx break Cone down or plan revision Fraction number matching Settin instruction undate

- Setup instruction update

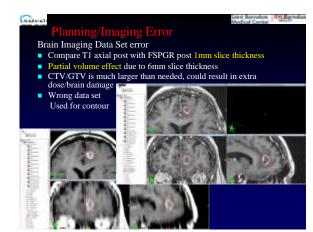
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- Image dataset error
  - Different patient
  - Previous simulation dataset
  - Non-optimal dataset
  - Orientation error

## Process change

- Check patient name and ID during import
- Clean DICOM import directory regularly and automatically
- Verify imaging scanning date from DICOM tag
   Note optimal CT series to use in QCL/task
- Check patient and imaging orientation





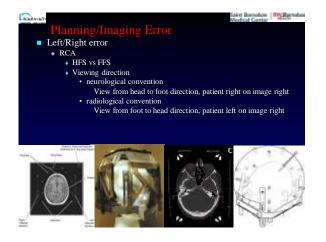
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Left/Right error

Symptom

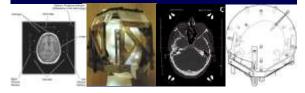
- Right cerebellar lesion need to be treated
- MRI scan with neurological convention instead of usual radiological convention
- Only Left and Right fiducial indicator plate used
- Patient planned and treated to left cerebellar





### Left/Right error

- Process change or checklist
   Stop and think before patient's position indicator
  - Display image annotation if possible
  - Match anatomical lesion with patient pathology/radiology report
  - Trying to use 3<sup>rd</sup> optional anterior fiducial indicator plate (able to indicate left/right), or additional marker needed
  - Check matching of image skin with skull-scaling device measurement

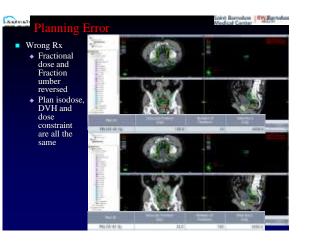


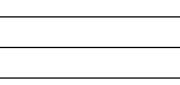
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- Left/Right error
  - prone breast patient, while most patients supine
     In the middle of course, patient told nurse after treatment, that treatment was not same as usual
  - Wrong side of breast was treated by mistake, due to mind set with supine and not changed with prone
- RCA
  - Prone is deviation from typical supine
- Correction
  - Stop and thinking
  - Reminder/alert of prone patient
  - Even patient do not want to have tattoo,
  - mark on skin for setup with ink marker
  - Label breast board about left/right
  - Double check by second therapist
    Verify with IGRT





# Conner

### aird Revolution Investmentation

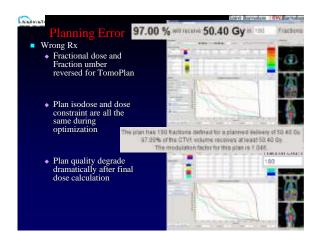
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- Scenario
  - Paper Rx (Prostate 180cGy\*25Fx) and IMRT dose constraint sheet
  - Dose per faction and fractional dose reversed in Eclipse planning Rx
    Dosimetrist tried very hard to meet all constraints
    Radcale secondary check match within 3%

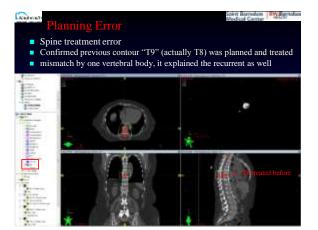
  - Kadcale secondary check match within 3%
     IMRT QA pass rate just above 90% with 3mm 3% using Mapcheck, much lower than typical 95% and above, re-measure confirmed setup, record reviewed by director.
     Reference point dose match Eclipse Rx
     Treatment scheduled 180 times, match with Eclipse Rx
     Treatment scheduled 180 times, match with Eclipse Rx

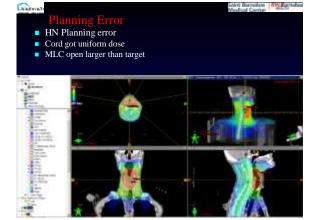
  - Treated multiple fractions, detected by physicist weekly chart check .
- RCA
  - IMRT QA low pass rate should be investigated further

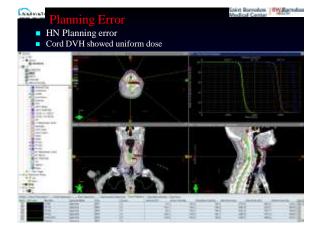
  - Too much focus on sub-unit (planning) have negative impact to whole system
    Reliable/robust components do not guarantee overall system reliability
- Process change
  - · Encourage vendor to add a warning to unusual plan fraction number
  - Paper Rx should be checked to match Eclipse Rx
    Utilize Aria Rx, and Aria Rx to Plan, check reference point dose against Rx dose

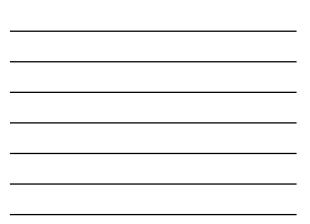


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- Wrong patients
   Prostate patients were treated in a row
   When treating one prostate patient, RVS showed treated already.
   Time out procedure
   Patient identification
   Tore Up

  - Two ID,

    - what kind of two ID?
      is face photo reliable?
      Ask patient what question instead of yes/no question

  - Fise patient what question instead of yes in question
    ID card or ID waist band
    RFID Tracking
    Biometric system like palm vein scanner, finger scanner



# Treatment Error

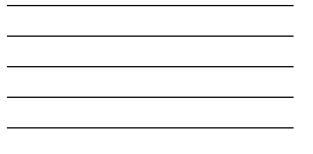
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Plan Pelvis 3D and Plan RP LNs RA share same isocenter

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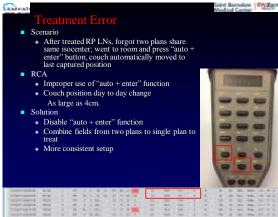
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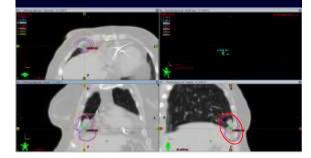
Contracto

- Treatment Error

   Lung CBCT registration error

   Unusual shift of CBCT registration

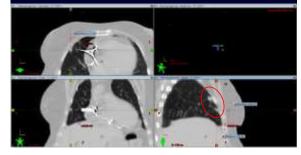
   Plan for Right Lower Lung tumor



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- Treatment Error
  Lung CBCT registration error
  At 21th out of 26 fx, isocenter was align to a high intensity area sup to the target, due to original target was partially covered by large diaphragm motion, both shape are similar



### aird Revolution Investmentation Contracto Lung CBCT registration error

- RCA
  - CBCT shift was large, Inf 1.6cm, Lt 2.2cm, Ant 2.3cm Policy shift > 1cm, need MD approval, not followed
- Process change
  - Registration in large scale first, re-training therapist
    Forcing sign-off by MD if larger than 1cm shift
    Can IGRT replace setup with external marker?

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- Forcing function and automation itself can NOT adapt to unpredicted issues
- Human DO make mistakes even in skill based performance
- Combination could be more efficient and reliable to detect errors

## aket Barrohos | Thy Epimahos

### Vendor

- Varian
- Elekta
- Physicist
  - Jian Liang
  - Yuwei Chi
  - Fan Zhang
  - ♦ Hao Sha
- Facilities
- ♦ Wayne State U
  - DMC/KCI William Beaumont
  - Columbia

  - Bayhealth
- ◆ RWJBH/SBMC