Providing Value Beyond Accreditation: Repeat/Reject Rate Analysis

Sean Rose, Ph.D.
Disclosures

Author has a patent “Apparatus for Tomography Repeat Rate/Reject Capture”

Author has previously received grants from GE Healthcare outside the current work.
Outline

• Repeat/reject rate analysis in radiography
• Repeat/reject rate analysis in CT
• Future directions and discussion
Historical RA in Radiography

Repeat/reject rate analysis (RA) originated in the days of screen film

• Collected rejected films in a “reject bin”

• Had both financial and quality incentives
  • Screen film costs money
  • Could identify areas for improvement (mispositioning errors, over/under-exposure, etc.)
  • Every extra exposure is “unnecessary" dose

\[
\text{Reject rate} = \frac{\text{# Rejected scans}}{\text{# Scans total}}
\]
Digital Era RA in Radiography

RA in the digital era is a bit more complicated

• Typically relies on scanner log files
• Still have quality incentive, but not as much financial
  • Acquiring an extra digital image doesn’t cost more money
  • Can still identify areas for improvement (mispositioning errors, over/under-exposure, etc.)
• Every extra exposure is still “unnecessary” dose

Collect log files from scanners → Do some fancy data analysis → Get repeat/reject rate

Reject rate = \# Rejected scans / \# Scans total
Digital Era RA in Radiography

Tons of great work on this topic (not a comprehensive list)


Is reject analysis necessary after converting to computed radiography?

Rosemary Honea, Maria Elissa Blado, Yinlin Ma

Journal of Digital Imaging

Digital Repeat Analysis; Setup and Operation


Journal of Digital Imaging

Digital Radiography Reject Analysis: Data Collection Methodology, Results, and Recommendations from an In-depth Investigation at Two Hospitals

David H. Foos, W. James Soehnert, Bruce Reiner, Elliot L. Siegel, Arthur Segal, and David L. Waldman

Journal of Digital Imaging

One Year’s Results from a Server-Based System for Performing Reject Analysis and Exposure Analysis in Computed Radiography

A. Kyle Jones, Raimund Polman, Charles E. Willis, and S. Jeff Shepard

Journal of Digital Imaging

Ongoing quality control in digital radiography: Report of AAPM Imaging Physics Committee Task Group 151

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Journal of the American College of Radiology

Unified Database for Rejected Image Analysis Across Multiple Vendors in Radiography

Kevin J. Little, PhD, Ingrid Reiner, PhD, Lili Liu, MS, Tiffany Kinsey, BS, Adrian A. Sanchez, PhD, Kate Land Haas, MA, Florence Malorny, BS, Carmen Frisman, MBA, and Zheng Feng Lu, PhD

Published: September 29, 2016 • DOI: https://doi.org/10.1016/j.jacr.2016.07.011

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Digital Era RA in Radiography

Selected results/recommendations from those works

From Report of TG 151

- Rejected image rates in digital departments have been reported to range from 4% to 8%
- This task group recommends that 8% be used as target for overall rejected image rate, and 10% as a threshold for investigation and possible corrective action

Most rejects are positioning errors

Little et al. found higher reject rates on DR than CR

Rates can vary substantially across protocols

TG 305 – Development of Standards for Vendor-Neutral Reject Analysis in Radiography
Tasked to provide guidance document recommending standard information and an effective dataflow to enable vendor-neutral reject analysis
Outline

• Repeat/reject rate analysis in radiography
• Repeat/reject rate analysis in CT
• Future directions and discussion
Unjustified imaging and repeated studies in CT

Lots of work on unnecessary repeat imaging, “frequent flyers”, repeats in trauma transfers, unindicated phases, etc.

The salutary effect of an integrated system on the rate of repeat CT scanning in transferred trauma patients: Improved costs and efficiencies

Unjustified CT examinations in young patients

Repeated CT scans in trauma transfers: An analysis of indications, radiation dose exposure, and costs

Providing formal reports for outside imaging and the rate of repeat imaging
Not much out there on RA in CT

RA not primary purpose of paper, but reports reduction in repeat rate from 13/100 to 0/100 on head CT protocol after protocol optimization

Validation study for an automated RA method based on DICOM metadata

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<th>Impact to institution</th>
<th>Impact to patient</th>
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<tr>
<td>Scanner protocol error</td>
<td>Systematic issues likely with this scanner</td>
<td>Diagnostic utility of images decreased, may inhibit physician interpretation</td>
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<td>Issue with contrast delivery</td>
<td>Possible patient safety concerns.</td>
<td>Extravasation related issues greatly reduce patient satisfaction.</td>
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<tr>
<td>Patient Motion</td>
<td>N/A</td>
<td>Diagnostic utility of images decreased, may inhibit physician interpretation</td>
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<td>Error with scan execution</td>
<td>Unpredictable variability with exam quality</td>
<td>If patient realizes there was a mistake, patient satisfaction decreases</td>
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Why do repeat/reject rate analysis in CT? Lots of **quality incentives**!

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### Causes of Repeat Scanning in CT

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### Why do Repeat/Reject Rate Analysis in CT? Lots of Quality Incentives!

**Elevated repeat rates indicate poor protocol design and/or poor technologist performance.**

**EVERY instance of a repeat in CT means unnecessary patient dose.**

- Long exam times
  - Reduced revenue as less patients can be scanned
  - Satisfaction decreases as scheduled exam times are not met
- Variable exam times
  - Scheduling templates exam time estimates needlessly inflated for non-repeat exams
  - Satisfaction decreases as scheduled exam times are not met
- Re-dosing the patient with ionizing radiation
  - Data submitted to dose registries will be increased
  - Increased stochastic risk of cancer
- Re-dosing the patient with Iodine contrast
  - Reduced profit as you cannot double bill for contrast
  - Increased risk of contrast induced complications (i.e. kidney issues)
Of 103,752 exams, 1,447 contained repeated helical scans (1.4%). Overall helical repeat rates differed among institutions ($p < 0.001$) ranging from 0.8% to 1.8%.

Large patient CTPA repeat rates ranged from 3.0% to **11.2%** with the odds of a repeat being 4.8 [3.5, 6.6] times higher for large relative to medium patient CTPA protocols!

Repeat rates can be much higher for a given protocol.

**Repeat rate** = \(\frac{\text{# studies containing repeated helicals}}{\text{# total studies}}\)

Different definition than traditionally used in radiography!
Outline

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Physicist’s role in RA

• Radiography (recommendations from TG151)
  • QMP should design and implement RA program
  • Should involve radiologist and QC technologist
  • QMP should participate in the analysis

• CT (my opinions)
  • RA becoming available as part of some vendors’ dose monitoring software
  • We can be the owners of this data and analysis, providing actionable info to managers, radiologists, and technologists
RA in CT: Should we be quantifying wasted contrast?

- 100mL and 150mL contrast vials are typically single use
- Consider scanner doing 10,000 exams per year, 60% with contrast
  - Assume contrast costs ~$0.14/mL
  - Assume we’re only using single use 100mL vials

- Cost of 5% repeat rate
  \[
  \frac{10,000}{\text{year}} \times 0.6 \times 0.05 \times $14 = \frac{$4200}{\text{year}}
  \]

- Cost of 1.5% repeat rate
  \[
  \frac{10,000}{\text{year}} \times 0.6 \times 0.015 \times $14 = \frac{$1260}{\text{year}}
  \]

Could potentially save around $3000 per scanner annually by reducing repeat rate from 5% to 1%
Should we be looking at MRI?

- Andre et al. investigated prevalence of motion artifact in 1 week’s worth of MR exams across 3 scanners
- 19.8% of examinations (38 of 192) contained repeat sequences
  - There were 68 repeat sequences across these 38 exams
  - 203 sequences contained moderate or severe motion artifact (authors’ criteria states these should have been repeated)
- 68 repeats required 278.5 minutes of additional scan time
- Assuming a cost of $444.32 for a 45 minute exam, this translates to about $917 per scanner per week
- Around $40,000-$50,000 per scanner annually. Andre et al. estimated $140,000 for their 3 scanners

Including the sequences that “should” have been repeated, Andre et al. estimated cost of >$115,000 per scanner annually

Toward Quantifying the Prevalence, Severity, and Cost Associated With Patient Motion During Clinical MR Examinations

Jalal B Andre 1, Brian W Bresnahan 2, Mahmud Mossa-Basha 2, Michael N Hoff 2, C Patrick Smith 3, Yoshimi Anzai 2, Wendy A Cohen 2
Providing Value Beyond Accreditation: CT Scanner Purchases

Sean Rose, Ph.D.
Physicist’s role in equipment purchasing decisions

• From ACR 2017 CT QC manual

procedural or equipment errors. The QMP tests are also useful to help to understand the design strategy used in producing a particular CT scanner and recommend the equipment specifications most appropriate for a given practice.

• From ACR Guide to Professional Practice of Clinical Medical Physics (2018)

D. General Responsibilities

Some typical responsibilities of a medical physicist may include, but are not limited to, the following items. The scope of these varies widely based on the size and staffing of the institution.

1. Performance of acceptance testing, calibration, and safety surveys of imaging and radiation therapy equipment.

2. Participation in the development of purchasing and acceptance specifications for imaging and radiation therapy equipment.

• Does this happen in practice?
  • My personal experience: Highly dependent on institution, radiologists, managers, culture, etc.
  • We need to demonstrate value to be brought to the table!
How can we be useful?

• The fundamentals: Know what scanner options are required for different exam types!
  • Scanners come with different “options bundles”
  • E.g., a vendor may have a cardiac bundle that includes cardiac gating and metal artifact reduction. A model with wide axial collimation would also be beneficial for cardiac
  • As physicists, we can be the gatekeepers that make sure a site doesn’t buy a scanner that doesn’t have the options they need!
  • Work with sales reps

• Lots of resources
  • Textbooks
  • ACR practice parameters
  • Buyer’s guides

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How can we be *more* useful?

- Know what scanner options a site *doesn’t need* on a new scanner
- This has traditionally been a role more suited to managers
- Thanks to dose monitoring software, we are now in a unique position to do this. We are the “owners” of some very useful data
  - We can review historic exam volumes and see which scanners are being used for what
  - We can talk to managers about what the intended uses are for a new scanner
  - Depending on use case, this could mean saving on the order $10,000-$100,000 on a new scanner!

- Examples
  - Many sites perform all or almost all of their CT guided interventions on one scanner
    - Not necessary to buy CT Fluoroscopy package on all scanners
  - Is it possible for a site to direct most of the cardiac workload to one or two scanners?
    - This could mean not buying a cardiac gating package on multiple scanners
  - Is it possible to do all of your neuro perfusion scans on one or two scanners?
    - Similar to cardiac case, may not need perfusion package on multiple scanners in your fleet
How many cardiac (perfusion) capable scanners do you need?

*Preliminary results*

Data provided by Imalogix Research Institute

- 63 institutions, 330 locations, 583 scanners, 6 months of data
- Cardiac (perfusion) ready defined as doing more than 1 gated cardiac (perfusion) exam per week over the scanner’s active lifespan
How many cardiac (perfusion) capable sites do you need?

*Preliminary results*

Data provided by Imalogix Research Institute

63 institutions, 330 locations, 583 scanners, 6 months of data

Cardiac (perfusion) ready site defined as having at least one cardiac (perfusion) ready scanner