Reinventing Reject Analysis for Radiographic Quality Improvement

Seeking a Value-Driven Strategy for Quality Patient Care

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Purpose

The Value of [Reject] Analysis in Digital Radiography

The occasional need to repeat an image is inherent in projection imaging where image value is dependent on alignment of anatomy yet unseen, or the ability of the patient to hold a painful appendage fixed for an extended time. While the move to digital radiography reduced the number of exposure related image rejects, it didn't eliminate the role of technical factors in repeated or poorer quality imaging.

Traditionally, reject analysis (RA) programs have functioned in the mindset of quality assurance (QA) : attaining and maintaining a target rate. A primary focus of QA programs is to check for adherence with standard protocol. While that remains of value, this limited framework may lose site of the challenges and opportunities for quality improvement (QI); opportunities that may relate to some of the following challenges in digital radiography:

- **Variability in Exposure (*Dose Creep*):** Radiographic technique and acquisition strategies can vary widely without obvious image compromise [1]. A feedback loop is needed for standardization toward a target [2]. To both identify proper exposure targets and enable standardization, dedicated exposure analysis is needed [3]. This review can also help identify areas for quality improvement in default techniques.
- **Ease of Repeats (*Reject Creep*):** Evidenced in a recent report [4], the ease of repeating images with DR may change the decision point for whether to keep trying for better positioning or other image quality improvement.
- **Variability in Images, Variability in Standards:** It may be increasingly challenging for technologists to know what "good enough" looks like. Image appearance may vary more with variation in equipment and processing settings. Practice thresholds for image quality acceptability can vary with variable tolerance of radiologists, clinical context, or challenges in communication (increasingly common with remote reading allowed by the digital practice).
- **Increasing System Complexity:** Different and complex modes of failure related to digital image processing can confound the technologist's ability to accurately label the cause of a problem or know how to fix it.

All of these issues can impact not only repeated imaging but can also affect excess exposure and image quality in accepted images.

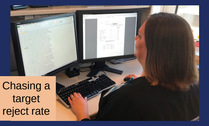
Objective

Using DMAIC (define, measure, analyze, improve and control) strategy, we sought to improve the value of RA as part of a digital radiography analytics quality improvement program to identify relevant sources of information, methods of analysis, useful interventions and meaningful results that can uncover problems or reinforce positive strategies for quality care.

Physics staff, along with technologists and radiologists review data and images to set standards and identify quality gaps

Background

Problems with Common Practices



Chasing a target reject rate

Many DR reject analysis programs seemingly aim to replicate screen film practices but without the image review.

Voluntary Reporting is Inaccurate

Our previous reject analysis program relied on voluntary recording of reject data. Reject rates were typically low (~5%) with some sites consistently below 4%. When we adopted system-integrated, required recording, we saw the reject percent jump up. For one site, with the implementation of integrated and required recording, the reject rates went from 3.3% to 14.3% without other practice changes.

Arbitrary Targets

When the focus of reject analysis is on reaching a target rate within a voluntary reporting program, activity becomes focused on reporting compliance rather than on any patient–care relevant quality improvement. The general response to an actionable change in reject rate is to urge reporting compliance and re-measure until the anticipated number is achieved. Focusing on RA with a QA - mindset of reaching a standard target, ignores that different anatomy and practices should have different target rates; this mindset ignores opportunity for quality improvement.

Vague or Inaccurate Reject Reasons

RA programs vary in what can be recorded and how difficult or time consuming it is to accurately record. It may be challenging to pick a category that reflects causation when aspects are intertwined (e.g. positioning and AEC exposure). Technologist responses may also be influenced if they feel there may be judgment applied to certain choices.

Limited Information

Reject rates don't provide actionable information. Unspecified factors or aggregated analysis can hide root causes. To get an understanding of what happened in a particular case, or is happening in general, one really needs to look at the images and image data as well as talk with techs. Not all vendor RA programs provide easy access (or possibility of access) to correlated images or data. Reject-only focused analysis can be an incomplete story, leaving out important correlated information like what might also be affecting the quality of accepted images, or what a radiologist considers "good enough".

Limited Perspectives

Our RA program used to be done by technical staff separately from the technologists. Communication focused on reporting compliance. This inhibited learning about quality issues and possibilities for positive practice change. Technologist-only review may have limited perspective on equipment related factors.

Core Elements for Program Re-Design

1. Accurate Data: We used vendor-integrated software with required reject reporting.
2. Meaningful Analysis Granularity:
   - ✓ Causes of image rejects may relate to a variety of challenges which can be anatomical-view or vendor-platform specific.
   - ✓ Reject rate targets may vary depending on imaging challenges and practice quality standards.
3. Practical Scope Constraint:
   - ✓ Quality analysis can be resource intensive: practice and time sampling required
   - ✓ Our favored strategy for practical intervention with measurable outcome is based on specific targeting
4. Sufficient Data:
   - ✓ Rejected image percentage with tech-provided reasons
   - ✓ Rejected images with image data to better understand the story for the reject
   - ✓ Sample of accepted images for overall quality review
   - ✓ Image data (with opportunity for image correlation) from accepted and rejected images for technique-image exposure analysis
5. Diverse Team Perspectives
   - ✓ Radiologist(s) to define sufficient image quality as well as to 'ok' any interventions that may affect exam quality.
   - ✓ Physics staff to perform data analysis, understand technical limitations or related root causes
   - ✓ Lead technologists or supervisors to appreciate workforce challenges and the potential for intervention
   - ✓ Clinical educators who see the practice from a different perspective and help design educational interventions
   - ✓ Rotating participation by different technologists allows for wider practice engagement, the perspective of workflow or utilization challenges as root causes, and perspective on potential consequences of interventions.

Reject Analysis + Exposure and Quality Analysis

QA + QI

Fig 1: Quality Ranking

Two lead technologists scored sets of accepted images, guided by image examples for each category

QR1	Should have been rejected	Minimal value in this image
QR2	Marginal, definitely needs improvement	Has value but insufficient for diagnosis (e.g. two images needed where one should have sufficed unless needed for body habitus)
QR3	Acceptable but could be better	Not ideal but sufficient
QR4	Quality diagnostic image	Good or ideal

Methods

Quality Project : Lateral Cervical Spine

Included data: From 9 DR and CR acquisition systems

Definition of the standard
- Image exposure target (using Exposure Index)
- Image-based quality target
- Expectations for technique and positioning

Measurement
- Rejected image percentage
- Quality ranking of accepted images (Fig 1)
- Exposure mean and spread for all lateral c-spine
- Image-based measurement of patient neck size

Analysis (identification of quality gaps)
- View of rejected images for reporting accuracy and cause
- View of exposure outliers for cause
- Review of acquisition techniques with patient size data and exposure index for
  - Compliance with designated technique
  - Adequacy and appropriateness of designated technique to achieve exposure targets
- Comparison of AEC vs Manual exposure statistics

Improvements
- Change in techniques
- Technologist education (Fig 2)
- Re-measurement

Quality Gaps Identified

Manual exposures were **too high** and highly variable compared to AEC (Fig. 3)

- Poor correlation with patient size and technique chosen (Fig. 4)
- Designated technique was higher than desired for target exposure

AEC acquired images were underexposed when positioned too far forward or used for flexion views (Fig. 5)

Lateral views were sometimes acquired with the AP protocol selection, related to

- Image being tied to the incorrect processing
- Default technique yielding incorrect AEC setting (for lower exposure)

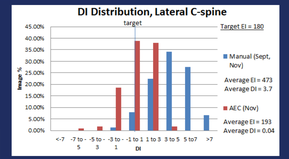
Fig 2: Standards, practice changes and educational nuggets along with reject rates and exposure statistics were shared with technologists in Image Quality Bulletins, at daily huddles and at in-services.

Details of Analysis and Interventions

Fig 3: AEC vs Manual Exposure

Data is shown using the deviation index (DI) which relates the exposure index to the target exposure

Deviation Index	% off target
3	~100% too high
2	~58% too high
1	~26% too high
0	Correct
-1	~21% too low
-2	~37% too low
-3	~50% too low



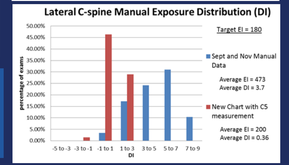


Fig 4: Ideal improvements from change in manual technique with C5 measurement

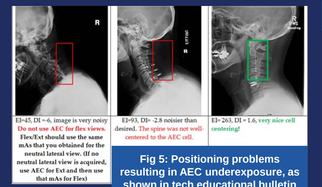


Fig 5: Positioning problems resulting in AEC underexposure, as shown in tech educational bulletin

Results

Lateral C-Spine

July Reject Rate: 11.6%	*November Reject Rate:* 7.9%
Noisy Image % of rejects: 19%	Noisy Image % of rejects: 0%

Table 1: Noisy image repeats resolved

Table 2: Manual excess exposure reduced by 83 %

Manual exposure variability reduced by 56%

LATERAL C-SPINE		AEC	Manual
July 2016	Average EI	184.6	412.6
	Std Dev EI	65	262.9
March + April 2017	Average EI	206	219
	Std Dev EI	72	115

	Baseline	Post-Intervention
	July, Aug, Sept	Nov, Jan, Feb, Mar
Total Image Count	402	511
Rejected Images	54	51
Reject Rate	13.4%	10.0%
Accepted Images Reviewed	86	216
Quality Rank of 3+	97.7%	96.7%

Fig 6: Modest reject rate reduction seen with continued follow-up. Quality rank either not affected or not sufficiently sensitive

Conclusions

Often repeat/reject analysis is conducted in ways that add little value to quality improvement, a reality reflected in the removal of repeat/reject analysis from the 2016 ACR Digital Mammography QC Manual [5]. Increasingly, value is being ascribed to other practice analysis strategies including Image Quality Review [6], or Protocol and Exposure review [7] as required for Mammography and CT by the FDA and Joint Commission respectively.

Strangely, it is in radiography with perhaps the greatest technologist-dependent variation in quality and image exposure where we seem to have less adoption of more comprehensive practice reviews. This is not surprising given the differing contexts of regulation, accreditation, screening functions and amount of exposure; and perhaps also related to the challenging extent of variability. However, we have seen the benefit when applied to our digital radiography practice.

While reject rate analysis by itself may struggle to translate into measurable quality improvements, we've seen that examining rejected images as part of a more comprehensive review, targeted to specific practice scope can help uncover practice issues, and opportunities for improvement that may help improve not only wasted imaging but overall image quality and dose reduction in digital radiography.

References

1. MacDougall R. "Consideration and Strategies for setting Target Exposure Indicator", AAPM Annual Meeting, 2017.
2. Dave J and Jones AK. "Use of the Deviation Index for Quality Control in Digital Radiography," AAPM Annual Meeting, 2017.
3. Jones AK, et al. Ongoing quality control in digital radiography: report of AAPM Imaging Physics Committee Task Group 151. Med Phys 2015;42:6658-70.
4. Little K, et al. " Unified Database for Rejected Image Analysis Across Multiple Vendors in Radiography", JACR 2016; http://dx.doi.org/10.1016/j.jacr.2016.07.011
5. 2016 Digital Mammography Quality Control Manual. ACR 2016
6. https://www.fda.gov/ForIndustry/Radiation-EmittingProductsMammographyQualityStandardsActandProgram/FacilityCertificationandInspection/UCM526239.pdf
7. http://www.jointcommission.org/assets/1/18/AHC_DiagImagingRpt_MK_20150806.pdf