Reject Analysis in a Digital Radiography (DR) Quality Assurance (QA) Program

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Requirements for DR QA

- Pursuant to the Mammography Quality Standards Act (MQSA), US FDA mandates QC testing for mammographic DR (21CFR900.12(e)(3)(ii)).

- Texas regulations (25 TAC §289.227(r)) and requires a documented QA/QC program for DR.

Recommendations for DR QA

- Joint Commission accredited facilities, are required to have encompassing QA programs which include DR.
- The American College of Radiology (ACR) recommends a QA program with physicist oversight for digital image receptor performance[1].
- The American Society of Radiologic Technologists (ASRT) recommends a DR QA program [2]

[1] ACR, *ACR technical standard for diagnostic medical physics performance monitoring of radiographic and fluoroscopic equipment*, ACR Technical Standard, (2006). Available at:
http://www.acr.org/~/media/ACR/Documents/PGTS/standards/MonitorRadioFluoroEquipment.pdf
[2] ASRT, *Best Practices in Digital Radiography*, ASRT White Paper, (2012). Available at:
http://www.asrt.org/docs/whitepapers/asrt12_bstpracdigradwhp_final.pdf

APPM Guidelines for DR QA

- **Reports**
  - **Report No.74:** Quality Control in Diagnostic Radiology.
  - **Report No.93:** Acceptance Testing and Quality Control of Photostimulable Storage Phosphor Imaging Systems.

- **Task Groups**
  - **TG-150:** Acceptance testing and quality control of digital radiographic imaging systems.
  - **TG-151:** Ongoing quality control in digital radiography. (Draft Report under review)

European Standards for DR QA

DIN V 6868-58 Image quality assurance in diagnostic X-ray departments - Part 58: Acceptance testing of projection radiography systems with digital image receptors.
DIN 6868-13 Image quality assurance in X-ray departments - Part 13: Constancy testing of projection radiography systems with digital image receptors.
BS IEC 61223-2-11:1999 Evaluation and routine testing in medical imaging departments. Constancy tests. Equipment for general direct radiography.
IPEM Report 91 Recommended Standards for the Routine Performance Testing of Diagnostic X-Ray Imaging Systems.

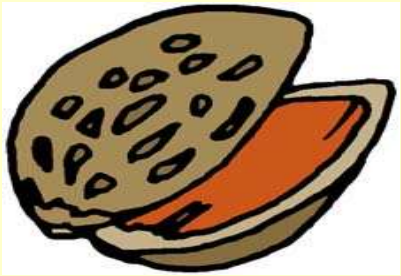
European standards

DIN: German Institute for Standardization
IEC: International Electrotechnical Commission
IPEM: Institute of Physics and Engineering in Medicine

Appropriate QA/QC activities are reflective of organizations that value quality assurance and quality improvement processes

In Diagnostic Radiology: Quality Imaging with Minimum Exposure (ALARA) to Patients and Staff

Reject Analysis Programs (RAP)



Rejected images represent:

- un-necessary radiation exposure to patients, and
- wasted time and resources.

Recommendations for RAP

ASRT Position

It is a best practice in digital radiography to implement a comprehensive quality assurance program that involves aspects of quality control and continuous quality improvement, including repeat analyses that are specific to the digital imaging system.

ACR, ASRT and AAPM specifically include RAP for DR QA/QC programs

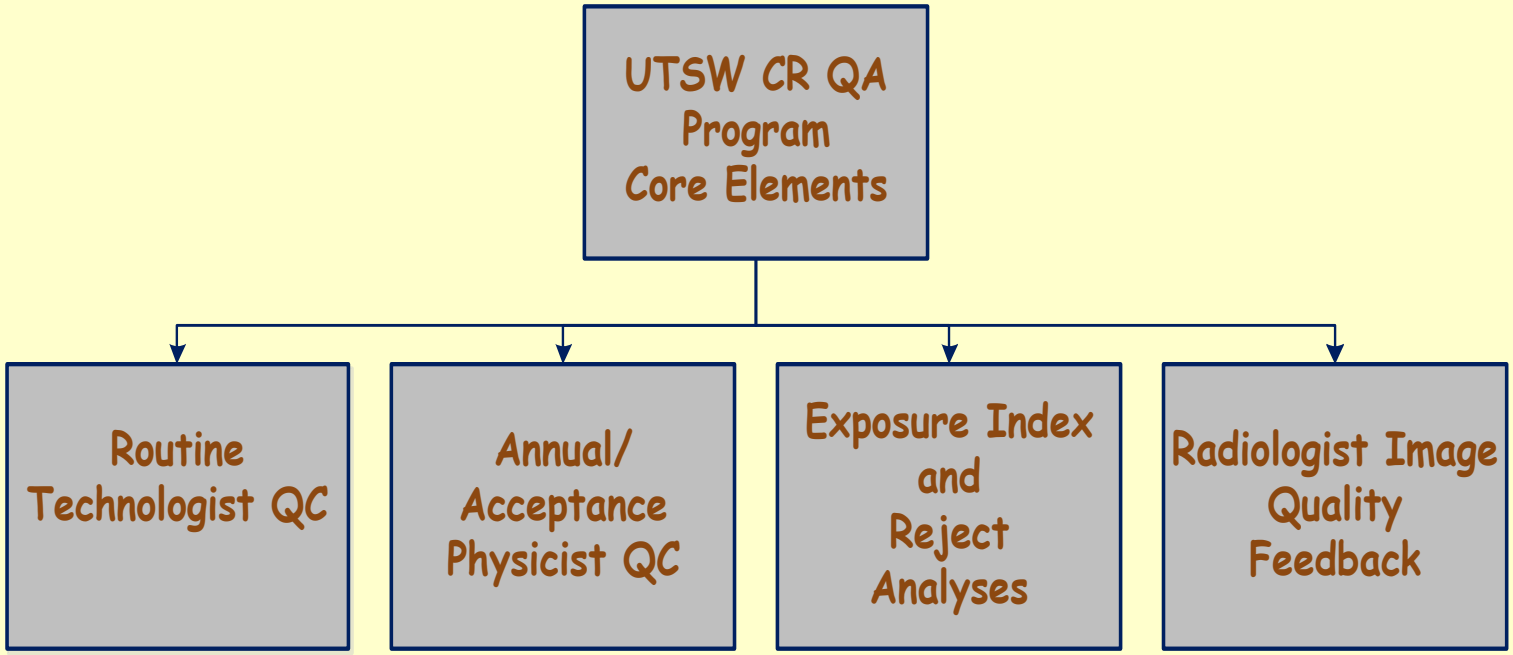
RAP Benefits

- Repeat images are a leading contributor to undue patient exposure in radiography.

- Repeat monitoring is a useful QA process to
  - assess image quality,
  - optimize examination protocols,
  - identify staff education needs, and
  - track patient radiation exposures.

- RAP QA is consistent with:
  - pay for performance and
  - Image Gently initiatives.

UTSW DR QA Program



- Program initially developed for computed radiography (CR) systems based on AAPM Report No 93 and vendor recommendations.
- Incorporates repeat/reject analyses and image review elements.

RAP Responsibilities

- Qualified Medical Physicist (QMP):
  - design and over-site, and
  - annual review and consultation

- QC Technologist:
  - rejected image review,
  - data collection and analysis,
  - record keeping,
  - identification and implementation of corrective actions (e.g. education), and
  - notification of the QMP and radiologist to problems.

- Radiologist
  - design and over-site and
  - identification of non-diagnostic quality images.

Radiologist Feedback

- A critical component of an effective RAP is radiologist participation.
- Weak radiologist participation can lead to substandard imaging and misleading low rejection rates.
- Radiologists should be able to easily flag non-diagnostic quality images and also provide positive feedback.
- Negative feedback should trigger a investigation and documented resolution.
- Radiologist feedback data should be included in reject data analysis.

Radiologist Image Quality Feedback

UTSW will use PACS message system to send email alerts for technologist/physics image review

RAP (In Practice)

Buy-in from management is critical for the success of any QA/QC program (e.g., allotting QC technologist time).

Diligent oversight is usually required to ensure program continuity

Rejects/Repeats/Retakes (Film)

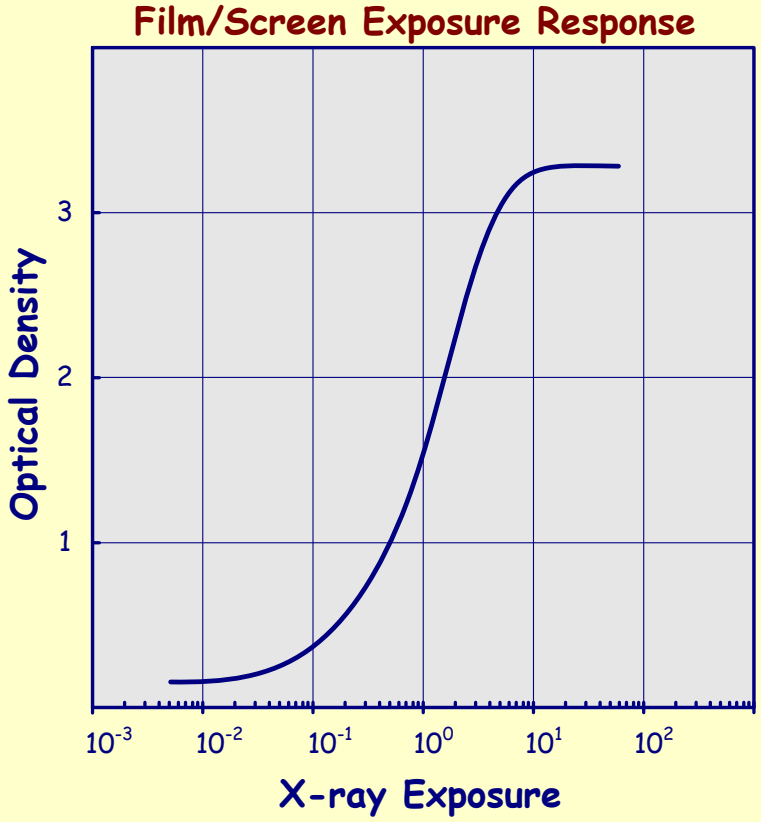
- Rejects: All rejected films, including repeat (retake) films.
- Repeats: Patient films repeated resulting in additional patient exposure.

Rejects/Repeats/Retakes (Digital)

- Rejects: All rejected images, including repeats (retakes).
- Repeats: Patient images repeated, resulting in additional patient exposure.

Reject is an encompassing term, an effective RAP will need to determine reasons for image rejection to distinguish repeats

Film/Screen Exposure Response



The narrow exposure latitude of film/screen results in the high rejection rates for under/over exposed films

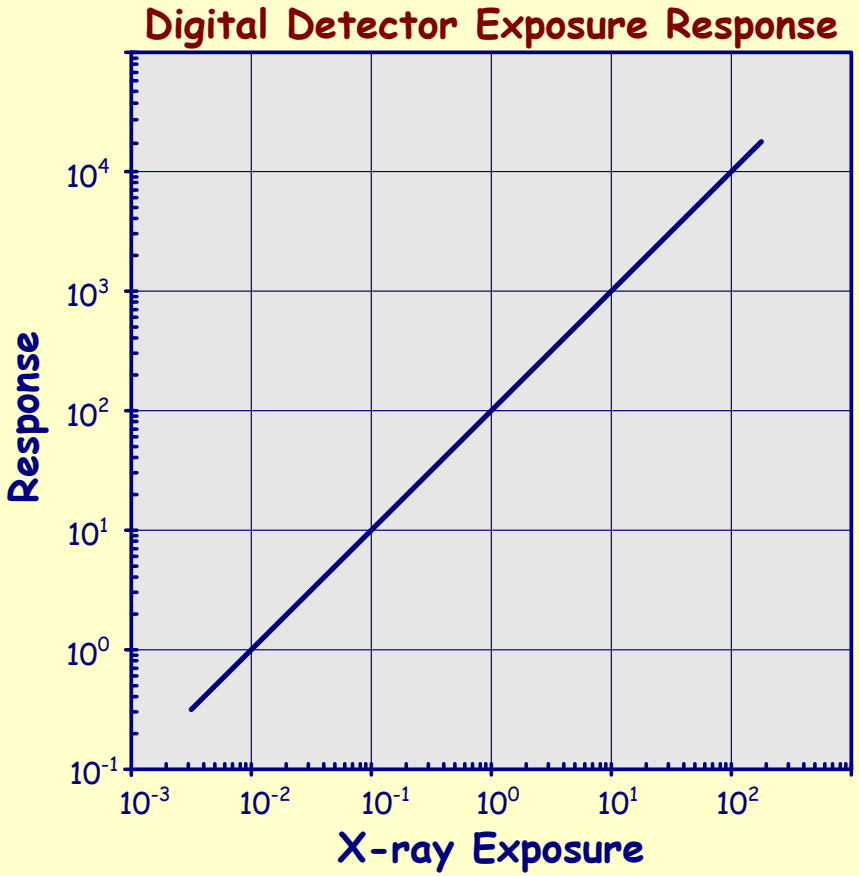
Film/Screen Reject Rates

- Reject film collected in containers and manually sorted for rejection reason.
- Rejects included waste film (defective/fogged film etc.) which was important to evaluate due to high cost of film.

Film/screen reject rate ~ 10%, ~45% of rejects due to exposure errors[1]

[1] TG-151 Draft Report literature review.

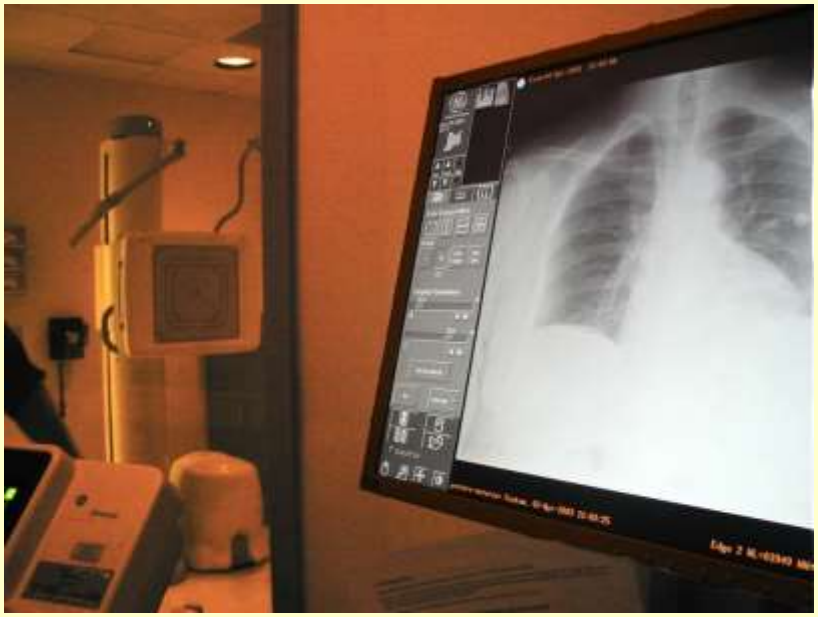
Digital Exposure Response



An early expectation was that RAP might not be necessary for DR due to wide exposure latitude and digital image processing.

DR Reject Rates

- Repeat images are still an issue with DR.
- Downside: Due to ease of acquisition, DR can facilitate the repetition of images (especially for flat panel technologies).
- Upside: Reject data collection and analyses can be automated.



DR reject rate 4-8%, primarily due to due to positioning errors[1]

[1] TG-151 Draft Report literature review.

Performing Reject Analysis

$$\text{Rejection Rate} = \frac{\#\ \text{Rejected Images}}{\#\text{Images Acquired}}$$

Simple calculation insufficient for identifying and correcting practice problems, data stratification is necessary

Standardize Reject Reasons

- Standardized reasons for rejection should be implemented.
- Customization of reject reasons is usually possible, depending on practice setting.

Reason
Positioning
Exposure Error
Grid Error
System Error
Artifact
Patient Motion
Test Images
Other

Reject reasons from TG-151 Draft Report

Information Required for an Effective RAP

Field	Function	Required/Optional
Acquisition station/digitizer	Identify specific stations with problems	Required
Accession number	Links study through RIS	Required
Exam date and time	Temporal sorting of data	Required
Body part/View	Sorting	Required
Exposure indicators	Exposure analysis/troubleshooting	Required
Reject category	Allows reject analysis	Required
Technologist ID	Linking technologist and study	Required
Reject comments	Further clarifies reason for rejection – free field	Optional
Technique Factors	Troubleshooting	Optional
Thumbnail image	QC of reason for rejection	Optional

TG-151 recommendations: Required items are for a functional RAP.

DR System Databases

- Modern DR systems have data bases containing information required for a functional RAP.
- Data can be usually be downloaded (e.g., via USB), or in some cases accessed remotely (web-browser, ftp, etc.).
- TG-151 Draft Report recommends that vendors provide remote access to DR system databases.

Local DR system databases are unreliable.

Regular downloads are necessary. Data is often lost after service/applications visits (e.g., a common solution for problems is re-imaging the computer hard disk).

RAP Analyses Frequency

- Reject analyses should be performed frequently enough to catch and correct potential issues before they become problems.

- TG-151 Draft Report recommends quarterly documented analyses (monthly preferable).

Target Repeat Rates (TG-151 Draft Report)

- Overall repeat target limits:
  - 8% for general radiography
  - 5% pediatric radiography

- Corrective action limits
  - Upper and lower limits (+/- 2%)
  - Note: too low a rate may signal problems with compliance or acceptance of poor quality images

- Special considerations
  - Practice and setting
  - Type of exam
  - Trainees

RAP Experience with Carestream Computed Radiography (CR) Systems

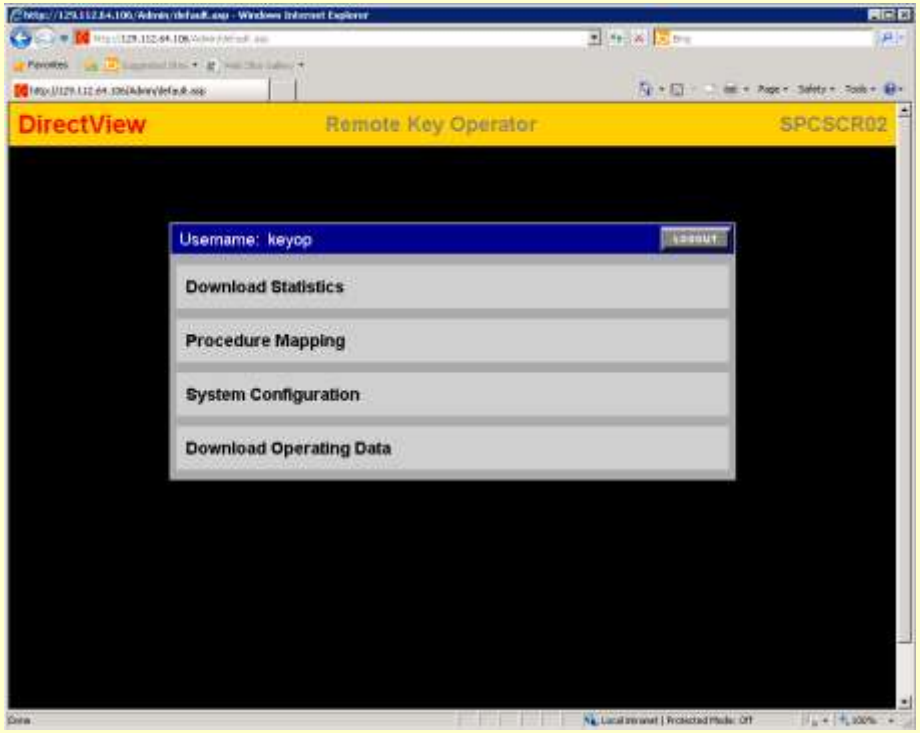
Carestream CR Install Base

Institution	Systems (#)
University Hospital & Clinics	4 multi-plate
	4 single-plate
University Hospital Zale-Lipshy	1 multi-plate
	1 single-plate

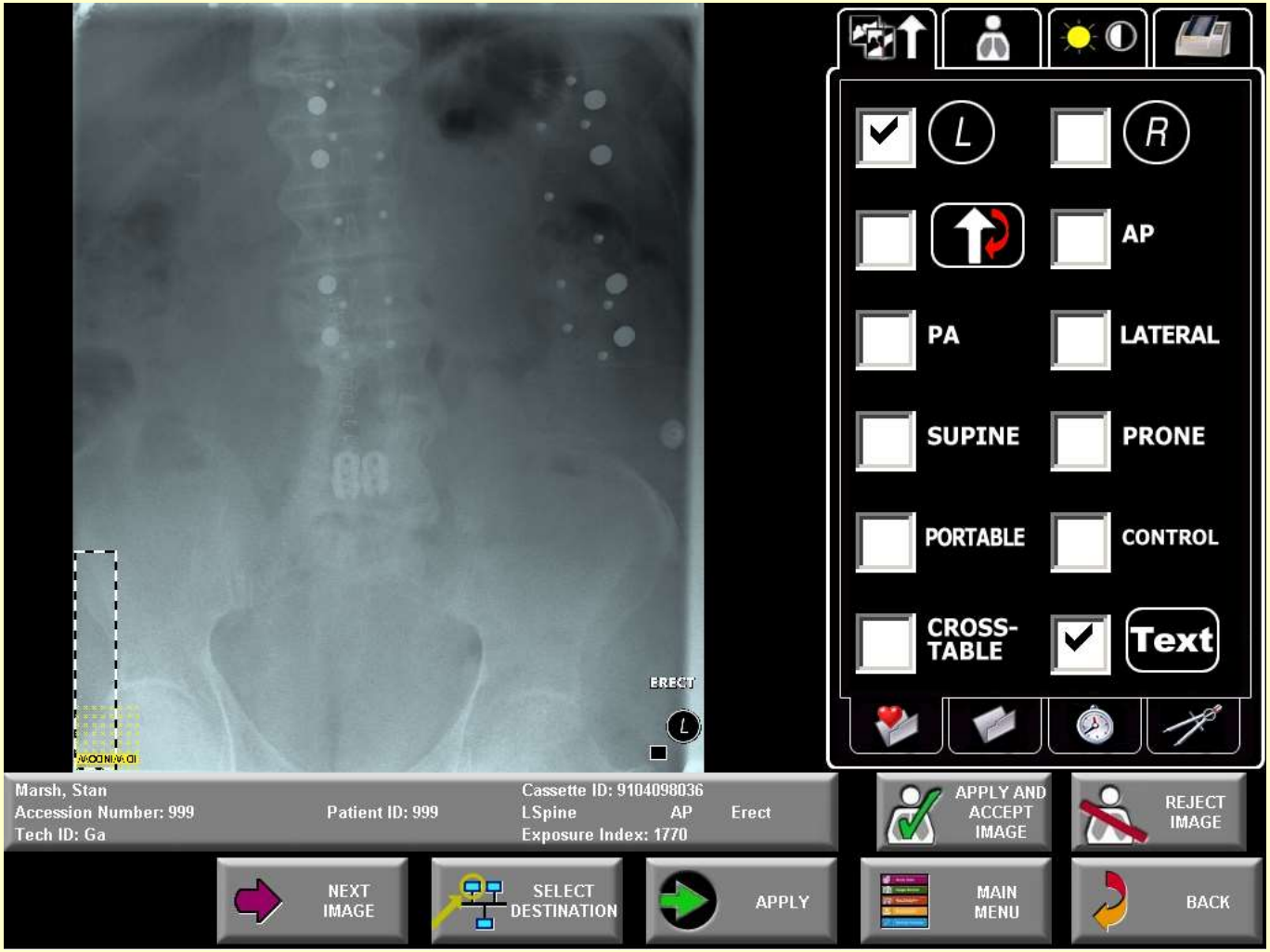
Ten CR reader systems widely dispersed in two hospitals and associated clinics.

Carestream CR Remote Access

- Carestream CR readers feature an image statistics database accessible remotely through a Web-Browser.
- Downloadable MS Excel files recording details of all reader images (consistent with TG-151 recommendations).



Carestream CR Reader Reject Entry



Documentation

- Medical physics downloads CR reader databases monthly into an Access relational database for analyses/reporting.
- Monthly documented analyses by medical physics emailed to QC technologists and radiology management.
- Yearly in-depth analyses by medical physics reviewed with QC technologists and radiology management.

UTSouthwestern Hospital Kodak CR Report

5/1/2013 to 5/31/2013

Note: Kodak recomends EI 1700-1800 for most imaging. High kV exposures (e.g.: bucky chest) should produce Exposure Indexes around 1650- 1750. Extremities generally should have an Exposure Index around 2000. A (+/-) shift of 300 in EI represents a (doubling/halving) of exposure.

Hospital Break Down	Valid Exposures	Rejects (% Total)		EI (Valids) Mean	EI (Valids) StDev
UHSP	9248	2%	183	1787	269
UHZL	988	3%	35	1805	272

Unit Break Down	Class	Valid Exposures	Rejects (% Total)	EI (Valids) Mean	EI (Valids) StDev
ABCSCR02	Total	3893	2%	1765	299
	Abdomen	39	5%	1775	234
	Chest	260	1%	1432	189
	Extremity	2262	1%	1767	278
	NG Chest	5		1878	261
	Pelvis	516	3%	1785	264
	Ribs	10	9%	1616	145
	Shoulder	470	4%	1858	343
	Skull	24	4%	1660	326
	Special	0			
	Spine	305	3%	1876	311
	Test	2		1140	566
SPCSCR01	Total	57	3%	1946	263
	Abdomen	3		1770	61
	Chest	1		1820	
	Pediatric	53	4%	1958	269
SPCSCR02	Total	104	1%	2095	373
	Abdomen	8		2050	372
	Chest	4		2410	449
	Extremity	45	2%	2040	367
	NG Chest	23		1948	140
	Pelvis	20		2297	367
	Shoulder	4		2328	773

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EI/reject analysis report stratified by reader and exam type.

Documentation: By Reader

Unit Break Down	Class	Valid Exposures	Rejects (% Total)	EI (Valids) Mean	EI (Valids) StDev
ABCSCR02	Total	3893	2%	1765	299
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	Special	0			
	Spine	305	3%	1876	311
	Test	2		1140	566

Reader report with exam type break down showing valid exposures, rejects and exposure index (EI).

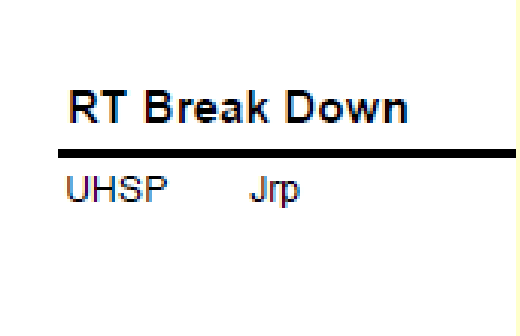
Documentation: By Technologist

RT Break Down		Class	Valid Exposures	Rejects (% Total)	EI (Valids) Mean	EI (Valids) StDev
UHSP	Jrp	**Total**	907	2%	1707	260
		Abdomen	7	13%	1737	108
		Chest	62	5%	1497	214
		Extremity	480	1%	1717	272
		Pelvis	175	2%	1731	220
		Ribs	9		1599	428
		Shoulder	94	2%	1750	223
		Skull	6		1590	85
		Spine	74	1%	1730	269

Technologist report with exam type break down showing valid exposures, rejects and exposure index (EI).

Technologist ID

- Ability to uniquely identify (ID) technologists is critical for a functional RAP.
- Options:
  - Automatic: ID bar code, technologist log-on.
  - Manual: Required Tech ID field entry
- Compliance can be an issue:
  - Log-on disrupts work flow,
  - circumvention.



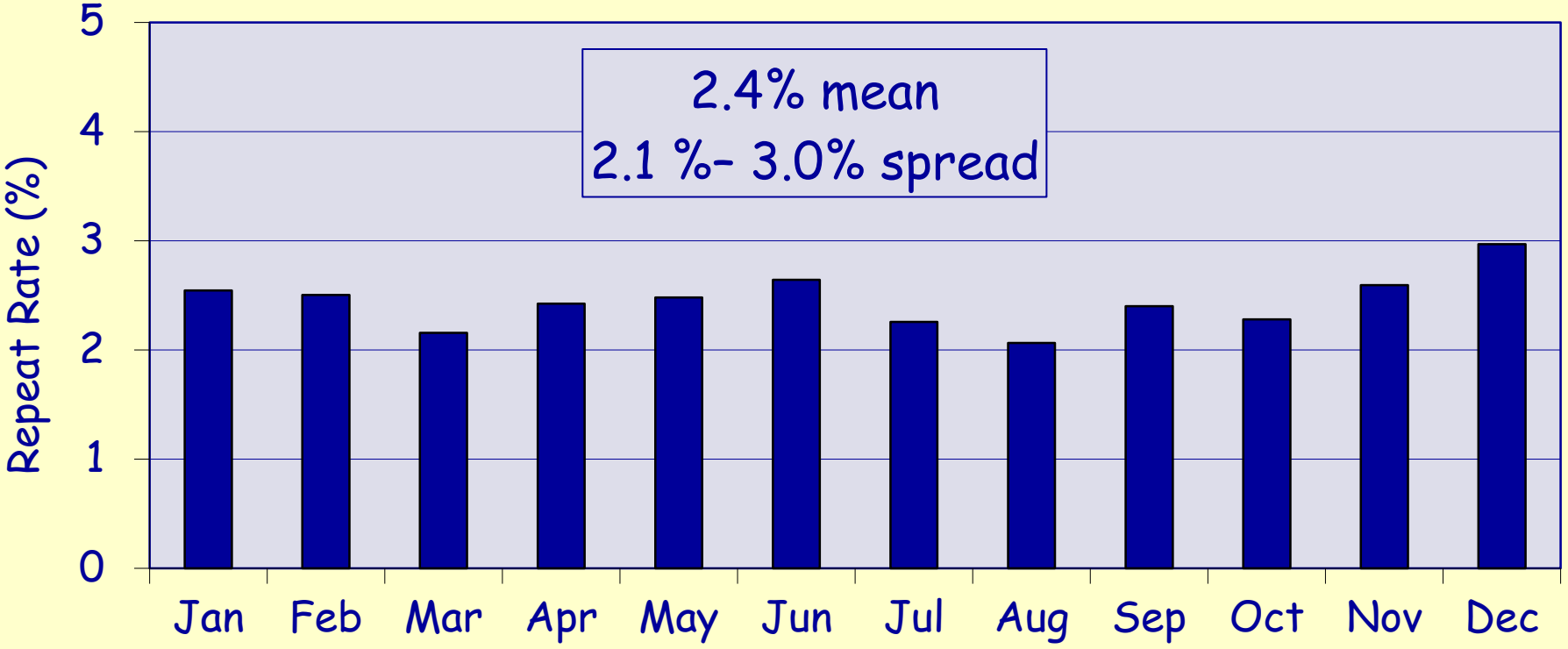
Establish a consistent technologist ID convention (e.g., technologist initials).

Program General Comments

- High staff-turnover and dispersed CR systems necessitated medical physics administration of data collection and analyses to ensure consistency and program continuity.

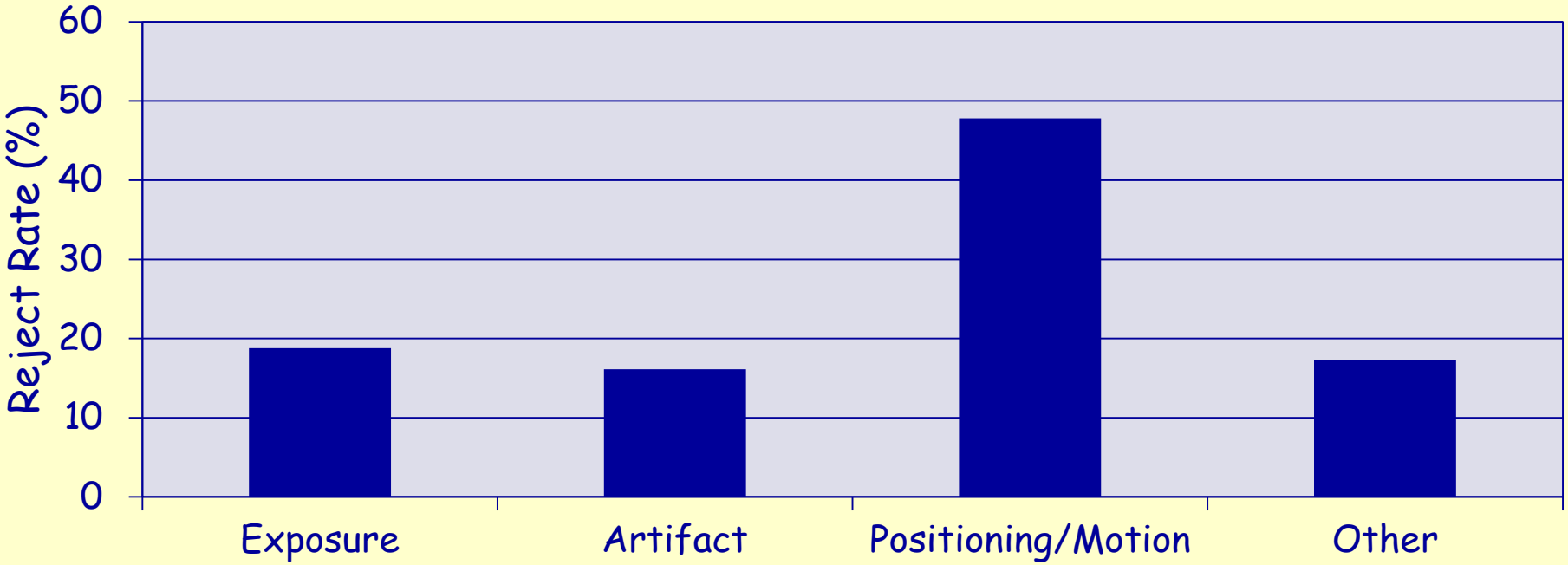
- Software to analyze database provided by vendor was rudimentary (excel spreadsheets). Access database preferable for relational analyses.

Repeat Rate: Time Trend



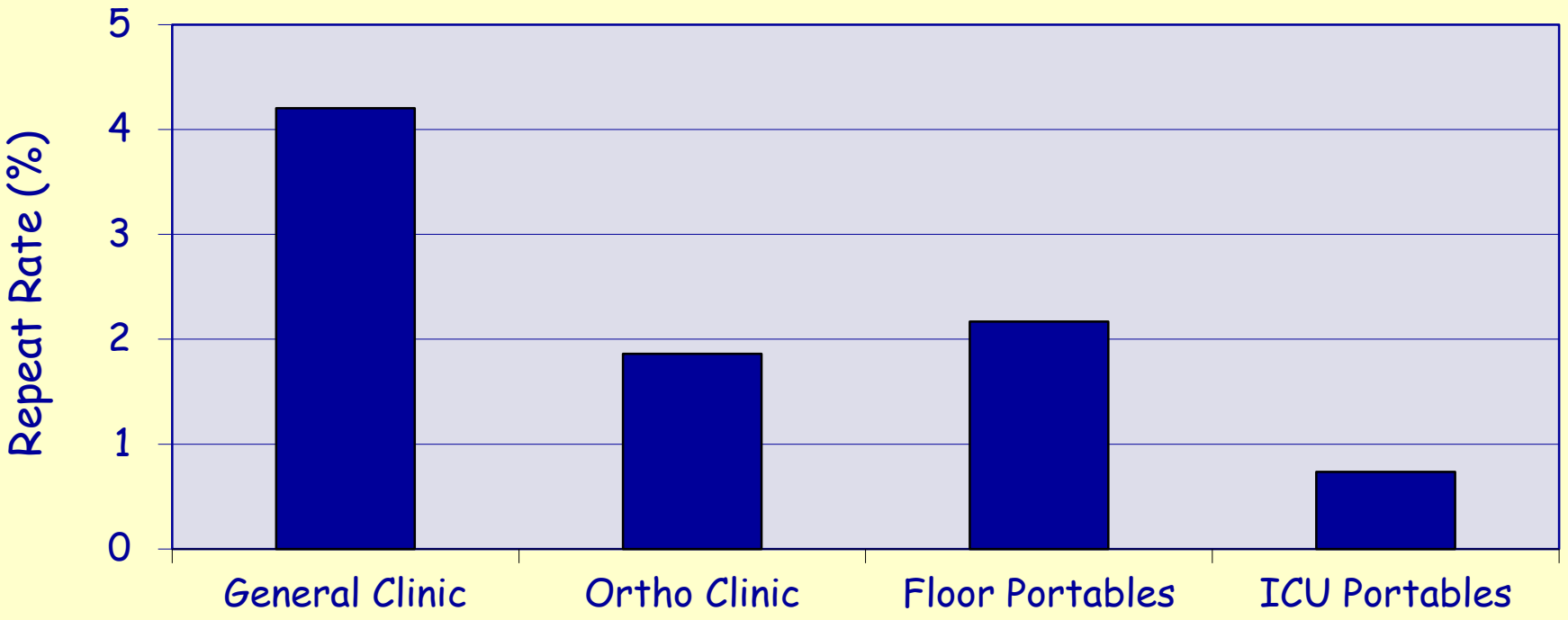
- Repeat rates well below target 8% rate.
- However, low rate may suggest:
  - well trained staff,
  - acceptance of poor image quality
  - circumvention.
- Radiologist feedback should help resolve this

Reject Rates: By Reason



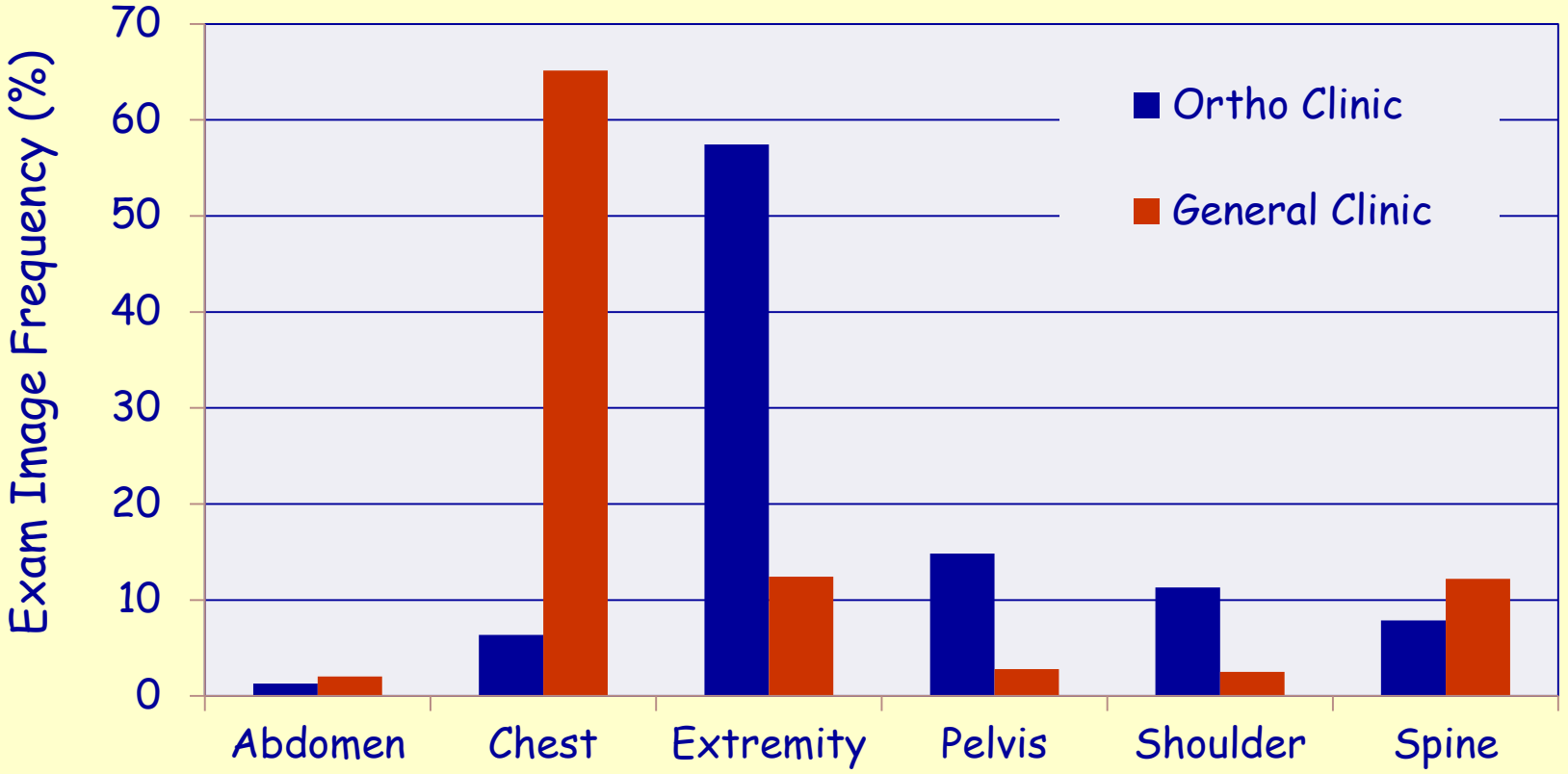
- With DR, positioning rejects dominate.
- Exposure rejects should be related to low exposure.

Repeat Rates: Practice Setting



Portables low reject due to difficulty in repeating exams and remote location of CR readers.

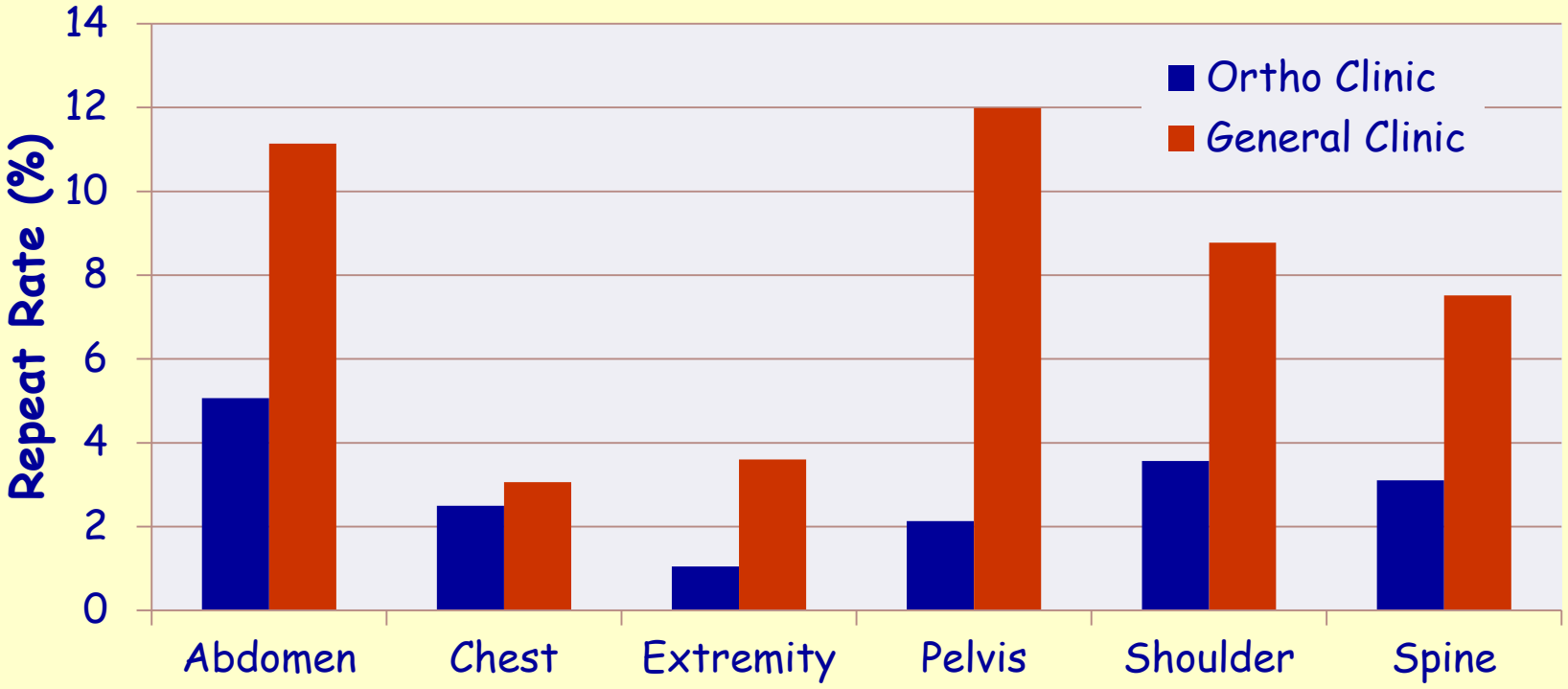
Clinic Repeat Rates: Exam Image Mix



Different exams distributions:

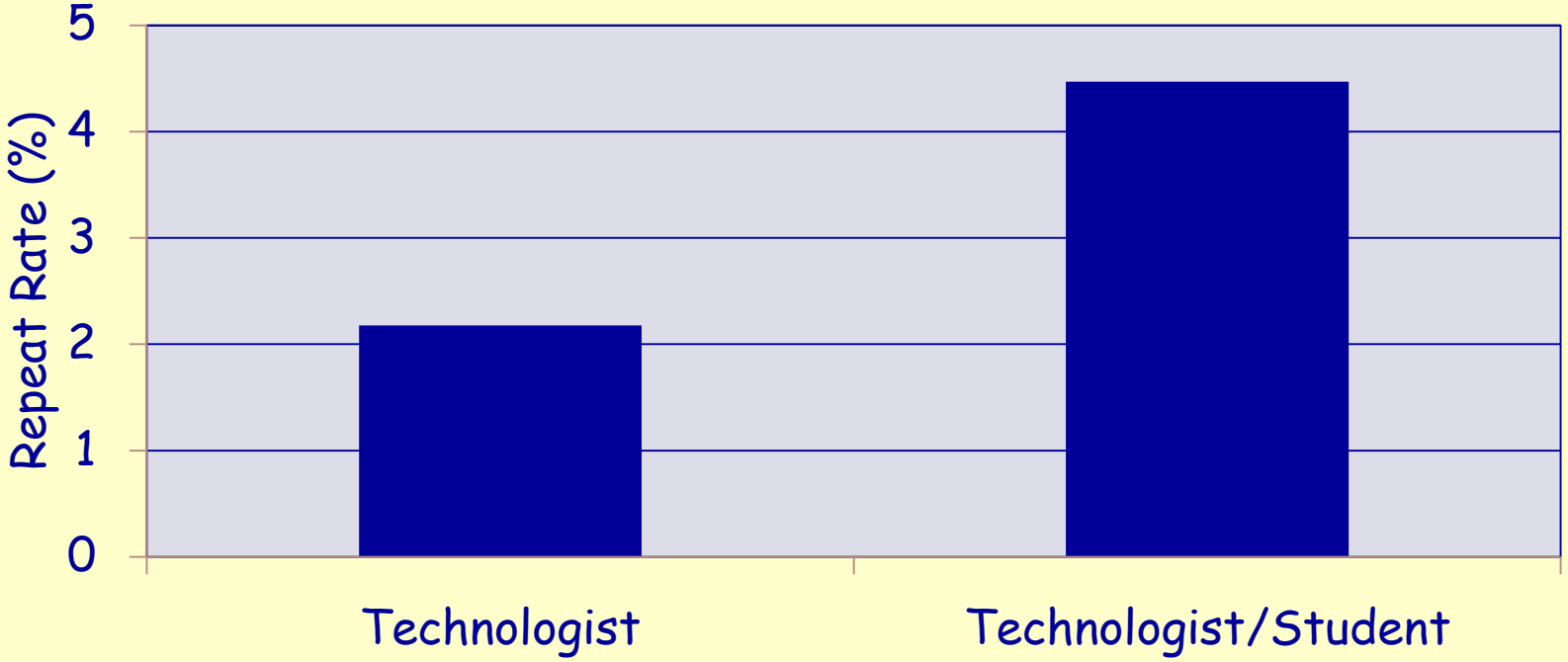
- General Clinic mostly chest exams
- Ortho clinic mostly extremities

Clinic Repeat Rates: By Exam



- Ortho: repeat low in specialty (small parts, no motion), and 2%-5% in other.
- General: Chests ~ 2.5% (larger part, motion), however, large repeat rats for others may indicate inexperience and/or need for training.

Repeat Rate: Trainees



- Images performed by students identified from Tech ID (technologist initials/student initials).
- Repeat rate doubled.

Thank you
for your attention