Radiation Dose Index Monitoring Systems: Implementing MPPG 6

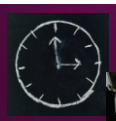
Donna Stevens, MS, DABR
Northwest Permanente, PC

Disclosures

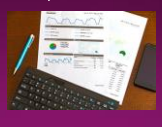
- Disclosures
  No financial disclosures

- TG 257 members
  Dustin Gress
  Renee Dickinson
  William Erwin
  David Jordan
  Robert Kobistek
  Donna Stevens
  Mark Supanich
  Jia Wang
  Lynne Fairobent

Overview



- Drivers of dose index monitoring
- Goals and rationale
- Before you start – document structure
- Planning and implementation
- Getting started – the Team, end product, informatics, and data
- Medical Physicist role(s)
- Some experiences



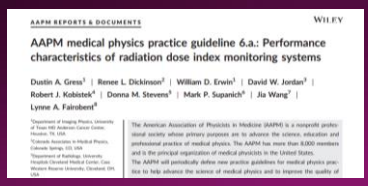
Open source images

Drivers for dose index monitoring

- Increased public concern over the use of radiation
  - "What's my dose?"
  - "I've already had a lot of x-rays, so I'm not going to have this one."
- Requirements from regulatory and accrediting bodies to
  - Establish typical dose indices for imaging procedures
  - Follow up when a dose index exceeds a threshold value
- Joint Commission
  - Fluoro Sentinel Event follow-up
  - Investigation of CT indices exceeding established values (and establishing the values)
  - New fluoro requirements effective 1 Jan 2019

Congratulations…

- You've been asked to implement a "dose tracking" system.
- Where do you start?
- https://aapm.onlinelibrary.wiley.com/doi/abs/10.1002/acm2.12089



AAPM REPORTS & DOCUMENTS

WILEY

AAPM medical physics practice guideline 6.a.: Performance characteristics of radiation dose index monitoring systems

Dustin A. Gress[1] | Renee L. Dickinson[2] | William D. Erwin[1] | David W. Jordan[3] | Robert J. Kobistek[4] | Donna M. Stevens[3] | Mark P. Supanich[4] | Jia Wang[1] | Lynne A. Fairobent[4]

[1]Department of Imaging Physics, University of Texas MD Anderson Cancer Center, Houston, TX, USA
[2]Colorado Associates in Medical Physics, Colorado Springs, CO, USA
[3]Department of Radiology, University Hospitals Cleveland Medical Center, Case Western Reserve University, Cleveland, OH, USA

The American Association of Physicists in Medicine (AAPM) is a nonprofit professional society whose primary purposes are to advance the science, education and professional practice of medical physics. The AAPM has more than 8,000 members and is the principal organization of medical physicists in the United States. The AAPM will periodically define new practice guidelines for medical physics practice to help advance the science of medical physics and to improve the quality of

Radiation Dose Index Monitoring (RDIM) systems

- Retrospective collection of radiation dose indices
- Enhancement of existing QA/QC programs
- Meet regulatory and accreditation requirements
- These can be developed "in house" or purchased from vendors

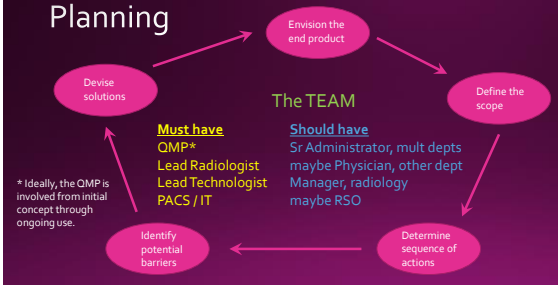
- "Estimated organ and effective dose values **must** only be used with the direction and involvement of a Qualified Medical Physicist, and with careful consideration of limitations of the quantities."

- "These estimated … dose values should NOT be included in the physician's dictated report."

Document structure

- 1. Overview – scope, goals, cautions
- 2. Definitions and acronyms
- 3. The RDIM team
- 4. Informatics
- 5. Common elements, independent of modality
- 6. through 9. Recommendations specific to modalities
  - CT
  - Fluoro
  - Projection x-ray (with Mammo and CR/DR)
  - Nuclear Medicine
- 10. Conclusions
- References – excellent collection of clinically-relevant "go-to" documents

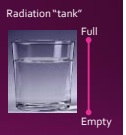
Planning



- Primary goal: compliance or quality improvement?
- Reporting structure (QAC, RSC, etc)?
- How can/will data be used?
- Which indices are needed?
- Meaning of indices? (relevant?, accurate?, accuracy needed?, how many?)
- Are the indices available? (supported by the device)
- Where to store/analyze?
- Compatibility between device and RDIM? and how to transfer the data?
- When should derived doses be summed (or not)?
- Who needs access? and how much access?

Qualified Medical Physicist

- Appropriate use and interpretation of the data
  - Population vs individual
  - Stochastic vs deterministic effects
  - Diagnostic Reference Levels and Achievable Administered Activity
- To add or NOT to add estimated doses –
  - Healthcare providers will want the total dose from all past studies, and vendors will sell it to them.
  - Cumulative estimated doses do **not** account for biologic repair
- Radiation Dose Index ≠ Absorbed dose
  - Most healthcare providers don't know the difference
  - Many radiologists not comfortable with the indices and meanings
- What are reasonable, feasible, and relevant alert levels
  - Deterministic – CT and interventional
  - Stochastic – age, gender, body habitus, etc



Risk from Diagnostic studies

- Diagnostic medical imaging procedures result in whole-body effective doses that are typically much lower than 100 mSv.
- Describing potential radiation risks using predictions of hypothetical cancer incidence and deaths can lead some patients to fear or refuse appropriate medical imaging.
- When the procedures are appropriate, the anticipated benefits to the patient are highly likely to outweigh any small potential risks.
- When addressing a patient's concerns about the radiation dose for diagnostic procedure, it is important to discuss the medical benefit of the procedure (including negative outcome).

AAPM position statement

Informatics

- HIPPA, PHI, and privacy
- Data integrity and backup (automatic, periodic)
- Interface with:
  - variety of imaging systems
  - PACS, RIS, EMR
  - Voice recognition and dictation systems
  - Critical results reporting systems
  - Operational and quality dashboards
- Configuring the system to send (is a service call required?)
- Continuity at upgrade or replacement of imaging equipment
- Sufficient data processing capacity
- Ownership and portability of data (non-proprietary format) if change RDIM systems; includes reports and exported data

IT recommendations/requirements

- Communicate via appropriate DICOM and HL7 standards, conform with appropriate IHE profiles
- User – written plan for data management and security; cloud storage, PHI encryption, etc
- Accepts RDI from all vendors and platforms
- RDIM system supports one or more methods of data collection – DICOM RDSR, DICOM MPPS, screen captures, manual entry, IHE REM profile, protocol or dose info from DICOM header
- User considers – workstations (user or vendor), locations, connectivity, configurations (global or w/in protocol), transmit method (automatic?), etc

Common Elements

Elements	Description	Notes
Essential RDI	Essential RDI of modality must be recorded. If not automated, then must allow manual entry	Multiple irradiation events, live fluoro,… rejected images,
Notification of RDI outside of defined range	User-defined thresholds that trigger auto-notifications must be configurable	
Review/follow-up documentation	User who reviews the alert must be able to acknowledge each alert and document status/outcome of follow-up	Status flag or tag for each alert, categories (ie, Under Review), free-text notes, HIPPA-compliant
User management	Access must be limited to authorized users determined by facility	
Audit trails	Must capture user ID, date, time, details of activity for all manual inputs, edits, deletions	Should retain copy of original data that was edited or deleted
RDI analysis tools	Should be provided to assist w/ use of collected information	Meaningful ways to analyse data (among systems, trending, …)
User interface elements	Should provide key functionalities of reviewing the RDI and image acquisition parameters	

Elements Specific to CT

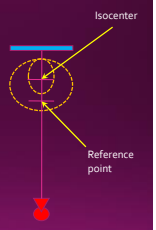
Elements	Description	Notes
Essential RDI	CTDIvol, CTDI phantom, and DLP for each CT series **must** be recorded	
Notification of RDI outside of defined range	User-defined thresholds that trigger auto-notification to a set of end users **must** be configurable	
Transmission of anonymized data to data repositories/registries	The software **must** possess the capability to transmit CT RDI to data repositories/registries	
Size-Specific Dose Estimate (SSDE) calculation	Calculation of SSDE for applicable acquisitions **should** be available.	

Specific to Fluoroscopy

Elements	Description	Notes
Essential RDI	Fluoro time, K_a, and P_{KA} must be recorded; for bi-plane systems, RDI must be recorded separately for each tube. Number of irradiation events and acquisition details (kV, mA, #frames, etc) should be recorded.	Acquisition logs of technical factors, acquisition mode (2D, 3D), gantry angle, etc, for estimation of peak skin dose
Manual entry of RDI data and fluoro time	Manual entry should be available for those systems with no RDI info displayed or w/o ability to transfer	
Exposure incidence map	Graphical indicator across 2D plane that can be used to estimate peak skin dose should be available for systems connected using RDSR	
Notification of RDI outside of defined range	User-defined thresholds that trigger auto-notification to a set of end users must be configurable.	TJC sentinel event alerts; patient dose management refs: NCRP 168; Balter, et al.

Metrics for fluoro

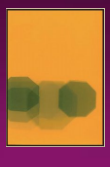
- The air kerma-area product (PKA) is a measure of total x-ray energy absorbed by the patient. It is an indicator of stochastic risk from fluoroscopically-guided interventional procedures.
- The relationship between displayed reference incident air kerma ($K_{a,r}$) and peak skin dose depends on the clinical procedure and how the physician maneuvers the x-ray equipment during the case.
- Measures that reduce total radiation dose (PKA) will also reduce peak skin dose and the amount of scattered radiation.



NCRP Report 168. Radiation Dose Management for Fluoroscopically-guided Interventional Procedures.

Peak skin dose maps

- Peak skin dose maps can be used as an indication of the variation in beam projection angle during the procedure and gives a visual indication of the degree to which the radiation dose was spread over larger areas of the skin.



Specific to Projection Imaging

Elements	Description	Notes
Essential RDI	KAP, $K_{a,r}$ and AGD (mammo only) must be recorded if available	Also desirable: machine technical factors, patient demographics; Mammo: phantom AGD and compressed thickness
Exposure Indices	Exposure indices (whether IEC or manufacturer defined) must be imported and recorded	Should allow capture of image receptor EI or DI; Must allow protocol-specific target indices. Proprietary EI should be captured, alerts must have high and low limits
Notification of RDI outside of defined range	User-defined thresholds that trigger auto-notification to a set of end users must be configurable.	Alert ranges should be established by facility QA program (with QMP); Alerts must be unique to exam, view, and patient habitus

Specific to Nuclear Medicine

Elements	Description	Notes
Essential RDI and RDI-related parameters	Software must record all RDI-related parameters. See section 9.a. for Nuc Med elements	Procedure, nuclide, pharmaceutical, assayed and residual activities, admin day and time, route of admin, patient info (age, gender, weight, height)
Manual entry of RDI and RDI-related parameters	Software must support manual entry of procedure and patient RDI-related parameters	
Multiple radiopharmaceutical administrations	Software must support single procedures involving multiple radiopharmaceutical admins	e.g. stress-rest myocardial perfusion; simultaneous solid/liquid gastric emptying
Organ and effective dose estimates	Software should support calculation of reference organ and effective dose estimates.	May support patient-specific dose calcs; references must be clearly stated.
Notification of RDI outside of defined range	User-defined thresholds that trigger auto-notification to a set of end users must be configurable.	Must allow thresh defn by activity or dose; Should allow defn by organ, gender, age

Nuclear Medicine "Dosing" and Doses

- Pediatric: the standard is based on recommended activity per unit body mass, primarily taken from the North American Consensus Guidelines.
- Adults: administered activity is recommended by the manufacturer based on a standard 70 kg person and provided in the package insert as required by the US Food and Drug Administration.
- Parameters that impact body and organ doses:
  - Gender, age, radioisotope, pharmaceutical, route of administration, weight, height …
  - Mathematical model used for internal dosimetry

Nuclear Medicine Indices

- Reference levels (RL) and Achievable Administered Activity (AAA) are part of the optimization process.
- A Reference Level is an investigational (action) level that identifies higher than typical administered activities for routine nuclear medicine and molecular imaging procedures.
- If a facility or practice consistently exceeds an RL, it should review its procedures and equipment to determine if acceptable image quality can be achieved with a lower administered activity.
- When modifying administered activity, image quality must be maintained at an appropriate level as administered activity is decreased.

ACR–AAPM Practice Parameter for Reference Levels and Achievable Administered Activity for Nuclear Medicine and Molecular Imaging

Implementation

Plan	Implement	Gotchas?
CT Protocol standardization	Gather data w/o Alert levels; address biggest issues; then establish alerts	"Alert fatigue"; RadLex mapping
Patient size	SSDE is ideal; Average patient in population vs "standard" patient; CTDIvol and ht / wt or BMI	Quality: Extra data analysis Compliance-only: one-size-fits-all thresholds
Generate reports	Multiple scanners/site and multiple sites/region	IT: Using the min number of workstations or remote access can significantly increase Processing time; Manual comparisons for regional practices with multiple sites
RDIM software-specific data management		incomplete data; data not linked to protocol or patient name;
Preconception of time commitment		The reality of the time commitment!

Take-home points

- Medical Physicist needs thorough understanding of each dose index or metric and to convey appropriate uses for each metric to client
- Participate from the beginning (if you have the opportunity)
- Understand needs of client: compliance-only, best practices, or in between; level of physicist support they expect or are willing to pay for
- Ask a lot of questions:
  - Software capability, user interface, IT requirements
  - Client facility concerns and goals
  - Cost
  - Time
  - Others who have previously implemented similar software
- Give feedback to RDIM software manufacturers/vendors

Thank you!