GE Healthcare

Diagnostic Reference Levels and Achievable Doses in Medical Imaging

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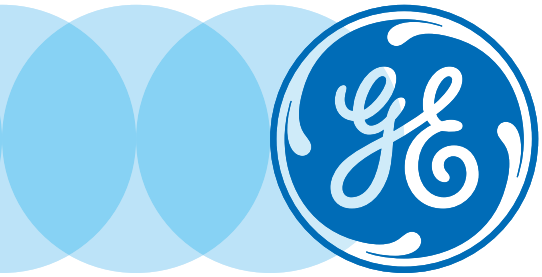

Diagnostic Reference Levels (DRL), Reference Levels (RL) and Achievable Doses (AD) are becoming increasingly important tools for hospitals to manage their patient radiation doses. Traditionally DRLs have been applied in Computed Tomography, but we are now seeing their extention to Interventional Radiology, Mammography, general X-Ray, Nuclear Medicine and even to dental X-Ray.

The purpose of this document is to help Healthcare Professionals understand how DRLs, RLs and ADs are defined. It is also going to provide an overview of recommendations from the National Council on Radiation Protection and Measurements (NCRP) for the use of **Diagnostic Reference Levels (DRL)**, **Reference Levels (RL)** and **Achievable Doses (AD)** as a tool to optimize image quality and the radiation dose delivered to patients.

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Diagnostic Reference Levels (DRL)

DRLs were first introduced by the ICRP in 1996. Their function is to manage the dose to the patient commensurate with the medical purpose of the examination. It should be noted, the application of patient dose management strategies require the monitoring of low doses as well as high doses to ensure the maintenance of image quality. Low radiation dose (high noise) images are also a concern and poor image quality can result in negative patient outcomes.

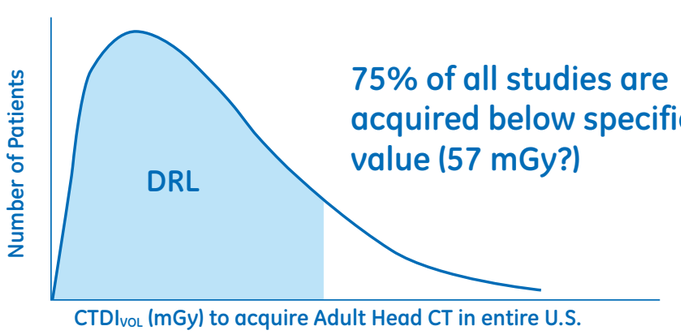
DRLs are a tool designed to identify situations where the levels of patient dose or administered activity are unusually elevated. DRLs are typically established at the 75th percentile of the dose associated with an imaging examination for an entire country *(see Graph 1)*. DRLs are not a dose limit. DRLs are based on actual practice values and must encompass a large population in order to be statistically valid.

In the U.S. several organizations are active in assembling representative dose data for imaging procedures:

1. Nationwide Evaluation of X-Ray Trends (NEXT) started in 1970s
2. Collaboration between the Food and Drug Administration (FDA) and state radiation control officers through the Conference of Radiation Control Program Detectors (CRCPD)
3. The American College of Radiology (ACR) funds the NEXT program and also collects representative dose data through its accreditation and dose index registry programs.

DRLs represent the initial step in the dose optimization process.

Graph 1: Diagnostic Reference Levels



Achievable Dose (AD)

Achievable Dose (AD) represents the 50th percentile (median) of the dose distribution for an imaging examination, suggesting a target for the second phase of optimization *(see Graph 2)*.

Reference Levels (RL)

Reference Levels (RL) are similar to DRLs, except they are applied to non-diagnostic procedures (i.e. Interventional protocols). RLs must rely on patient-based data – as opposed to DRL data which is sometimes based on phantom studies. The estimation of RLs is confounded by several factors:

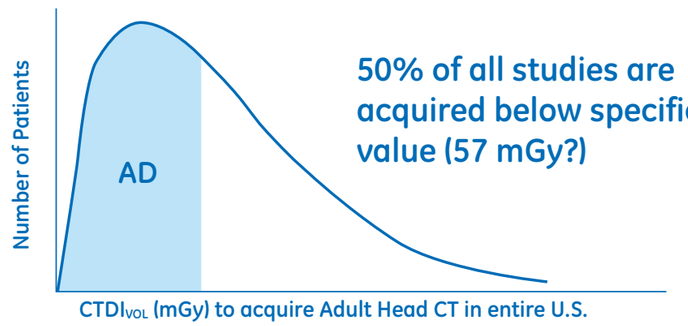
- Patient thickness
- Patient clinical condition
- Skill of the operator
- Imaging equipment features.

Overview – DRLs, ADs and RLs

Substantial Radiation Dose Levels (SRDL) is a value below which deterministic effects (tissue reactions) are highly unlikely and above which deterministic injuries are possible.

Nuclear medicine procedures present unique challenges. In nuclear medicine, dose optimization efforts focus on management of administered activities of radiopharmaceuticals.

Graph2: Achievable Dose



DRLs, ADs and RLs are moving targets and have a useful lifetime of 3-5 years. Values change over time and will vary with methodology used to collect data.

Phantom v. Patient Dose

The use of **phantoms** for dose measurement offers several advantages:

- Avoids the effort and complexities required for the collection of patient dose data
- Standardizes data collection for multiple facilities
- Provides a platform for facilities to compare dose results in conjunction with a dose management program
- Allows observation of changes in clinical practice over time.

In Europe, DRLs rely entirely on patient-based dose data. In the U.S., the majority of DRLs are based on phantom survey data although patient-based dose registries are being developed (i.e. ACR Dose Index Registry for CT).

Phantom-based DRL data has two main variables:

1. different X-Ray equipment
2. facility-to-facility variation in equipment use.

Patient-based data more accurately reflects variation in imaging techniques and are more complex due to variation in individual patient size. Maintenance of acceptable image quality is the first step in the process. Once DRLs, RLs and ADs are established, imaging centers must develop a methodology for comparing local clinical dosimetry to the benchmark. DRLs, RLs and ADs themselves must be evaluated to keep up with trends in clinical practices. As dose optimization programs make progress, DRL, RL and AD values will decrease and local programs will need to amend their target values.

NEXT Survey Data is available for:

- Adult PA Chest
- Adult AP Abdomen
- Adult AP Lumbo-Sacral Spine
- Adult Dental Radiographs (bitewing and lateral cephalometric)
- Adult Fluoscopic Evaluation of Upper GI
- Pediatric AP Chest.

Radiography and Fluoroscopy

Special care must be exercised with digital radiographic imaging. As utilization of digital radiography increases, evidence suggests entrance skin exposures may increase (≈ 10%) compared to traditional screen-film imaging. Due to limited dynamic range, screen-film imaging is more sensitive to elevated radiation exposures. Most digital radiography systems can produce acceptable image quality over a much broader dynamic range.

Conclusion

Diagnostic Reference Levels (DRL) represent an important tool in medical imaging as part of a process to optimize radiation dose delivered to patients.

Achievable Doses (AD) offer additional incentives for facilities already delivering radiation at exposures below DRL targets.

DRLs should not be viewed as absolute determinants of appropriate use of medical radiation.

DRLs are not intended for regulatory or commercial purposes or to establish legal standards of care.

Optimization must take into account both patient dose and clinical utility, based on image quality.

Computed Tomography

The ACR CT Accreditation program has been collecting data since 2002.

The ACR Dose Index Registry (2011) is another source of CTDI data for selected protocols:

- Adult Head
- Adult Chest
- Adult Abdomen
- Pediatric Head
- Pediatric Abdomen-Pelvis.

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