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An Analysis of Computed Tomography Diagnostic Reference Level in India Compared to Other Countries

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ABSTRACT

Background: Computed Tomography (CT) is an invaluable diagnostic tool that offers detailed internal images, but it involves exposure to ionizing radiation, which carries inherent risks. To manage these risks, Diagnostic Reference Levels (DRLs) have been developed as benchmarks to optimize radiation doses and ensure patient safety without compromising image quality.

Objectives: This study examines the CT DRLs of some Indian states and then compare these values with some international. Published articles were reviewed in this work in Indian context on the adult Diagnostic Reference Levels for specific anatomic regions to identify the cause and extent of deviations and to examine possible strategies to optimize Computed Tomography radiation dose. This review also underscores the importance of establishing nationally endorsed DRLs influenced by local data and international best practices to promote safer CT imaging across diverse clinical contexts.

Conclusion: Variations in radiation dose within and among Computed Tomography centers are frequently reported, including scanning technology, study design, and the use of computed tomography parameters. There are only few studies published on DRLs in India. These types of studies are essential for developing national standards in different regions of the country and to provide a valuable and correct comparison with international DRLs.

Keywords: Computed Tomography; Diagnostic Reference Levels; Dose-Length Product; CT Dose Index.

INTRODUCTION

Computed Tomography is also called computed axial tomography, CT scan or CAT scan. It is an accepted imaging method to evaluate the whole body. The images are taken directly in the axial plane of different thicknesses of tissue. When compared to traditional x-rays, these tomographic images have the advantage of using computer imaging to provide detailed information for specific cross-sectional areas. Some pathology can be seen in the sagittal and coronal planes by reconstruction of images by the computer. CT has changed significantly over the years, and multi detector CT scanners are now more useful in the clinical setting[1]. CT applications have been enhanced by their development of helical and multi-detector row configurations. The ionizing radiation used in CT scans can pass through the body and create images of internal structures. CT is related to high doses of radiation. Thus, careful use of this imaging modality requires a rigorous adherence to radiation protection principle: justification, optimization, and minimization, making sure that the technique's benefit is not outweighed by the risk to the patient[2,3]. The radiation dosage that is given to the patient can be significantly impacted by the techniques and extensive range of exposure parameters employed by current CT scanners. Diagnostic medicine was transformed by the development of multi-detector computed tomography (MDCT), which

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provides more precise diagnosis and more detailed anatomical information. Multi-planar reformation, isotropic volume data collection, and images with a thickness of less than 1mm are used to achieve this. MDCT has replaced many radiographic and fluoroscopic examinations. CT scans are the most radiation intensive diagnostic procedure. The number of CT exams conducted has noticeably increased over the last three decades[4]. CT exams that focus on particular clinical targets should produce high-quality images without administering an unnecessary dose to the patient. As a result, ICRP proposed DRL, with the goal of optimizing the radiation dose to the patient as the top priority[5,6].

This review examines the state of CT DRLs in India as of right now, analyse CT DRLs in India and compared them with international standards and discusses effective dose optimization strategies. The aim is to offer a road map for standardizing CT radiation dosage procedures in India while bringing them into line with international best practices.

CT dose descriptors

The volumetric-CT dose index (CTDIvol) and dose length product (DLP) are the CT dose indicators used to set up DRL and LDRLs for CT scans. These dose descriptors have a range of reference doses and descriptors in use that allow comparison of CT images at other centers where CT is done.

1.1 CTDI (Computed Tomography Dose Index)

The Computed tomography dose index (CTDI) is a metric used in computed tomography (CT) imaging to determine the patient’s radiation dose. The CTDI is a common way to compare the radiation output from various CT scanners. CTDI is defined in mGy. CTDI was first measured across an ionization chamber that was 100 mm long (CTDI 100) in addition to CTDI for weighted measurements. However, modern helical scanners commonly utilize CTDIvol instead of CTDI100 and CTDIw[7].

1.2 DLP (Dose Length Product)

The dose length product (DLP), which is measured in milligrays per centimeter, is used to describe the radiation that a CT tube emits. DLP takes along the z-axis length of the radiation source (the patient’s long axis). It uses a single phantom slice to measure the dose[8].

$$DLP = (CTDIvol) \times (\text{length of scan})$$

The DLP measurement scale is mGy*cm.

1.3 DRL (Diagnostic Reference Level)

DRLs are a useful tool for optimizing. Diagnostic Reference Levels are a type of investigation or examination level which can be used as a tool to optimize medical exposure protection for patients undergoing interventional and diagnostic procedures. It is used in ionizing radiation medical imaging to show whether the radiation dose given during a procedure is too high or too low in daily routine conditions[9]. A national survey performed in the mid1980s revealed significant variations in hospital practices for similar procedures, leading to the proposal of national reference dosages for some common radiographic examinations in the united kingdom in 1989[10]. The International Commission on Radiological Protection (ICRP) introduced diagnostic reference levels in 1990. The ICRP specifically states that a diagnostic reference level is "a form of investigation level, apply to an easily measured quantity, usually the absorbed dose in air, or in tissue-equivalent material at the surface of a simple standard phantom or representative patient."National and regional diagnostic reference values in diagnostic radiology are typically established at the 75th percentile of the sample's typical dose distribution. Since facilities in various nations and regions may have different equipment and procedures, distinct DRLs have been created for each of these countries and regions[11]. DRLs are not static and must be regularly updated on regular basis with changes in technology. Additionally, DRLs are dynamic and need to be updated frequently to reflect

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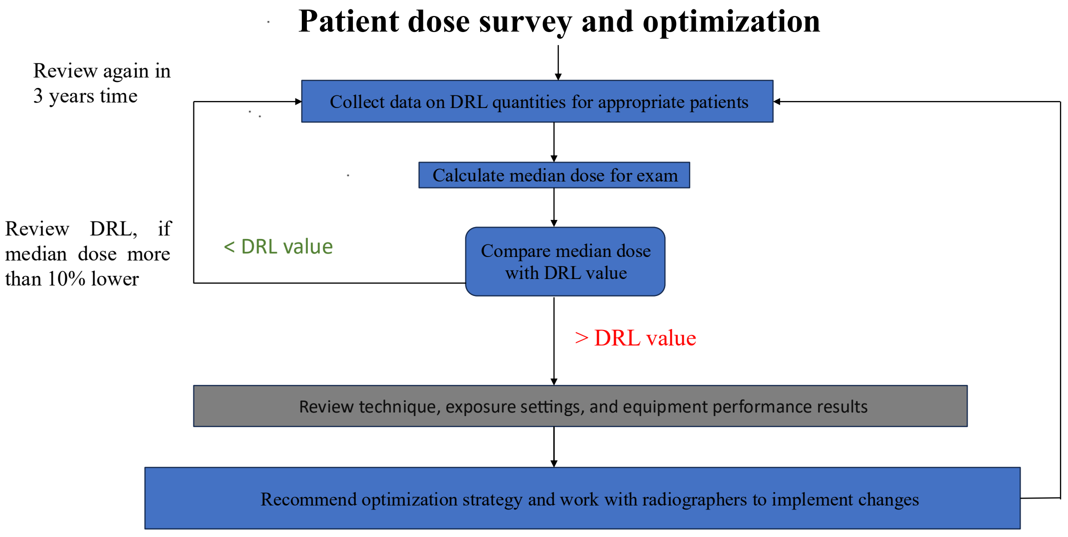

Figure 1 Optimization of radiation protection in digital radiology techniques

2. METHODOLOGY

This review was done by carefully and thoroughly examining a large number of reliable source. It is based on peer-reviewed research articles about CT dose management and important publications by the International Commission on Radiological Protection (ICRP). Documents addressing radiation hazards, international diagnostic reference levels, and new technologies targeted at lowering patient exposure were given particular attention. Furthermore, research on the clinical application of tube parameter adjustments, iterative reconstruction, and automatic exposure control offered significant methodological insights. This approach offers a complete and integrated perspective on enhancing radiation safety in CT imaging by qualitatively synthesizing technical evaluations, dose surveys, and regulatory frameworks.

3. RESULT

The assessment and optimization of radiation doses in CT imaging depend on the evaluation of Diagnostic Reference Level (DRLs). The DRLs set up in India are compared to international standards in this part, along with the various Indian state, with differences between them that reflect regional customs and equipment variations highlighted.

Table.1. Comparison of Indian DRLs with International DRLs for few CT exams (CTDI=mGy, DLP=mGy*cm)

Region/Country	Descriptor	Abdomen	Chest	Head
South India[12]	CTDIv	12	10	47
	DLP	550	445	1041
Puducherry, India[13]	CTDIv	16	12	32
	DLP	482	456	925
Kerala, India[14]	CTDIv	9	5	27
	DLP	319	164	620
IAEA[15]	CTDIw	10.9	9.5	47
	DLP	696	447	527
EC[16]	CTDIv	13-35	10	60
	DLP	46-1200	400	1000
USA[17]	CTDIv	_	12	56
	DLP	_	443	962
UK[17]	CTDIv	14	12	60
	DLP	910	610	970

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The table represent CT Diagnostic Reference Levels (DRLs) for abdomen, chest and head scans across different regions, including South India, Puducherry, Kerala as well as international standards from IAEA, European Commission, USA and UK. The data show that CTDIvol values for abdomen and chest scans in Indian regions range approximately between 5 to 16 mGy, while head CTDIvol values from 27 to 47 mGy. Dose Length Product (DLP) values exhibit similar variation, with South India showing a higher DLP for head scans (1041mGy.cm) compared to Kerala (620 mGy.cm)[12,13,14]. International reference level generally align with or slightly exceed these values with the UK reporting the highest CTDIvol for head CT (60mGy) and corresponding DLP of 970mGy.cm[15,16,17]. Although some states show significantly lower or higher dose metrics, the figures generally imply that regional CT doses in India are roughly comparable to international benchmarks, highlighting opportunities for ongoing dose optimization and standardization.

4. DISCUSSION

The DRL is the benchmark for minimizing radiation exposure in medical imaging without sacrificing the necessary diagnostic information (ALARA). Many optimization strategies and techniques have been developed and put into practice in CT imaging to lower radiation doses to patients while preserving the quality of diagnostic images. Here we present some common strategies and their approximate CT dose reduction[11].

4.1 Automatic Exposure Control (AEC)

The AEC makes sure the proper amount of radiation is only administered where it is required by adjusting tube current according to the size and anatomy of the patient. This technique can reduce dose by 25-50% when used in place of fixed tube current scanning[18].

4.2 Tube voltage selection (kVp optimization)

While preserving image quality, lowering the tube voltage(kVp) reduces the patient dose. The dose can be lowered by 20-30% with 10kVp decrease[19].

4.3 Iterative reconstruction Algorithms

Lower radiation dose settings are made possible by the iterative reconstruction algorithm, which enhances image quality by lowering noise and artifacts. When compared to filtered back projection, these algorithms can lower the dose y 30-60%[20].

4.4 Pitch Adjustment

A dose reduction of 10-40% can be achieved by decreasing the overlap of the received data of the pitch value (feed revolutions per table) rises. High pitch value, however can be occasionally deteriorate image quality[18].

4.5 Dose Modulation

During the scan, dose modulation methods like angular and z-axis tube current modulation dynamically modify the tube current according to the anatomy of the patient. A 20-50% decrease can be achieved, depending on the implementation and patient characteristics[21].

4.6 Organ-Based Dose Reduction

Different organs or area of interest can receive different radiation doses according to specific protocols. The total dose for the patient can be decreased by roughly 10% to 30% by lowering the dose to non-diagnostic areas[22].

4.7 Dose Tracking and Monitoring

To keep dose levels within acceptable ranges, facilities can detect outliers and take corrective actions when dose tracking and monitoring procedures are followed regularly. Continuous improvement and dose reduction of around 10% to 20% can result from such actions[22].

4.8 Radiation protection in Computed Tomography

Computed Tomography (CT) radiation protection guidelines are founded on ALARA principle, which stands for "As Low As Reasonably Achievable." The goal of this principle is to reduce radiation exposure to patients while preserving the quality of diagnostic images. The aim is to strike a balance between minimizing radiation risks and acquiring the required medical information. The following are the main guidelines for CT radiation protection: Justification, Optimization, Patient Dose Monitoring and Dose Alerts, Education and Training, Collimation and Shielding, and Quality Assurance and Quality Control[23].

There could be many ways to reduce radiation dose, one of the ways can be establishing the standard DRLs for various procedures in respective modalities.

The study highlights the critical role of ongoing quality assurance and compliance with international regulations, fostering continued improvements in clinical CT safety and ensuring protocols reflect technological advances and population needs.

Looking ahead, developments in AI-driven protocol optimization and spectral imaging promise further dose reductions, while maintaining or enhancing diagnostic capabilities, calling for continued research and guideline evolution.

5. CONCLUSION

Diagnostic Reference Level (DRLs) serve an essential benchmark in medical imaging to optimize radiation doses during CT examinations. Typically set at the 75th percentile of median patient doses within healthcare facilities. DRLs aim is not only to limit excessive radiation exposure but also to maintain high image quality for accurate diagnosis. At the national scale, DRLs help reduce variability in patient doses, encourage the adoption of best practices, standardize diagnostic quality, and provide a framework for continuous oversight to prevent unnecessary radiation. The responsibility for developing and enforcing DRLs lies with authorized regulatory bodies, which collaborate with healthcare professionals to ensure proper data collection and approval of DRL metrics. Optimization involves reviewing local protocols, comparing doses to established DRLs, assessing the performance of equipment and operators, utilizing dose reduction software specifically designed for CT, and providing targeted training to radiology staff. Importantly, dose optimization strives to balance radiation safety with the need to acquire sufficient diagnostic information, making DRLs a vital tool for guiding facilities in delivering safe, effective patient care while controlling radiation exposure.

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