

From Examination-Based to Acquisition-Based DRLs: A Paradigm Shift in CT Dose Optimization and Radiation Protection

A retrospective analysis of emergency CT dose profiles from a Portuguese hospital, exploring the limitations of conventional DRLs and the emerging concept of Single Acquisition Diagnostic Reference Levels (saDRLs).

RADIATION PROTECTION

DOSE OPTIMISATION

COMPUTED TOMOGRAPHY

DIAGNOSTIC REFERENCE LEVELS

SADRL

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Why CT Dose Management Matters

The Challenge

CT contributes disproportionately to collective radiation dose from medical imaging due to the relatively high doses involved. The increasing utilisation of CT has raised concerns about stochastic effects, particularly carcinogenesis.

The Regulatory Framework

Diagnostic Reference Levels (DRLs), introduced by the ICRP and reinforced by **Directive 2013/59/EURATOM**, are established using parameters such as CTDIvol and DLP. However, this examination-level methodology may not adequately reflect dose variability in multi-acquisition or multi-phase protocols.

Study Aims & Design

This retrospective observational study characterised dose profiles in emergency CT examinations and evaluated the relevance of acquisition-based dose assessment for future optimisation strategies.

01

Data Collection

Emergency CT data collected randomly over three consecutive days at a hospital in northern Portugal.

02

Equipment

Siemens 16-slice CT scanner operating under institutional imaging protocols.

03

Statistical Analysis

IBM SPSS v28.0.1.0; significance level 0.05. Tests included Student's t-test, Kruskal-Wallis, Spearman and Pearson correlation.

Study Sample

138

Total Patients

Included in the retrospective analysis

51.4%

Male

71 male patients

48.6%

Female

67 female patients

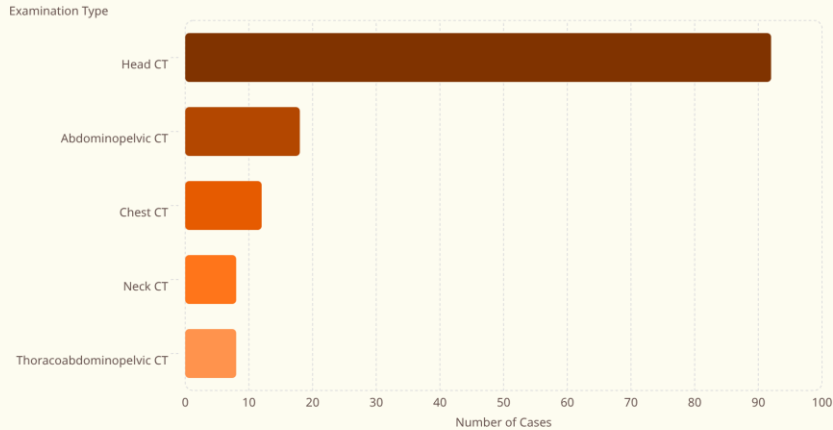
69.5

Median Age

Age range: 0–99 years

Variables analysed included CT DIvol, DLP, TotalDLP, acquisition type, contrast administration, patient sex, age, and anatomical dimensions.

Examination Frequency & CTDIvol Results



Mean CTDIvol by Examination (mGy)

Neck CT

57.71 ± 37.11 mGy — highest CTDIvol

Head CT

51.89 ± 21.20 mGy

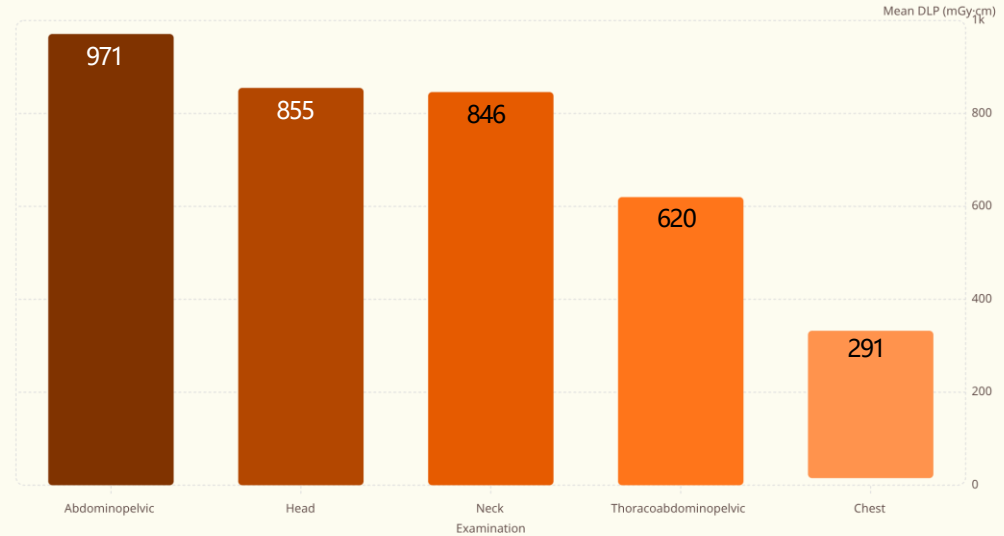
Chest CT

11.98 ± 8.76 mGy — lowest CTDIvol



DLP Results & Dose Length Product Variability

Statistically significant differences were observed between examination categories for CTDIvol, DLP, and TotalDLP ($p < 0.001$).



Mean and Standard Deviation of CT Dose Indicators According to Examination Type

Examination Type	n	CTDIvol (Mean ± SD)	DLP (Mean ± SD)	Total DLP (Mean ± SD)
Head	91	51.89 ± 21.20	855.39 ± 272.58	867.42 ± 288.98
Neck	8	57.71 ± 37.11	846.42 ± 476.86	891.50 ± 456.42
Chest	12	11.98 ± 8.76	273.01 ± 125.03	291.17 ± 145.74
Abdominopelvic	18	21.60 ± 14.27	971.01 ± 605.75	974.67 ± 605.89
Thoracoabdominopelvic	8	15.72 ± 8.25	768.61 ± 323.77	775.88 ± 326.45

Mean values and standard deviations of CTDIvol, DLP, and Total DLP for the different Computed Tomography examination categories included in the study population. Dose variability was observed between anatomical regions, with neck and head CT examinations presenting the highest CTDIvol values, while abdominopelvic examinations demonstrated the highest DLP and Total DLP values.

Acquisition Type & Contrast: Key Dose Drivers

Sequential vs. Helical Acquisitions in Head CT

Sequential acquisitions demonstrated **significantly higher CTDIvol** values compared with helical acquisitions (**p = 0.007**), supporting the case for acquisition-specific optimisation strategies.

Contrast-Enhanced Head CT

CTDIvol

64.64 vs. 49.37 mGy

DLP

1013.47 vs. 824.19 mGy·cm

TotalDLP

1072.47 vs. 826.95 mGy·cm

Differences statistically significant: **p < 0.001**

Cranial CT Examinations: Statistical Analysis According to Contrast Administration, Acquisition Type, and Sex

Variable	Category	n	Mean \pm SD	p-value
CTDIvol	Without contrast	76	49.37 \pm 18.77	0.097
	With contrast	15	64.64 \pm 28.15	0.003
	Sequential acquisition	57	56.69 \pm 24.24	<0.001
	Helical acquisition	34	43.83 \pm 11.04	<0.001
	Male	41	54.46 \pm 24.22	0.740
	Female	50	49.77 \pm 18.34	0.236
DLP	Without contrast	76	824.19 \pm 257.82	<0.001
	With contrast	15	1013.47 \pm 299.17	<0.001
	Sequential acquisition	57	891.33 \pm 301.86	0.296
	Helical acquisition	34	795.14 \pm 205.05	0.156
	Male	41	900.29 \pm 304.58	—
	Female	50	818.58 \pm 240.15	—
Total DLP	Without contrast	76	826.95 \pm 261.31	<0.001
	With contrast	15	1072.47 \pm 342.22	<0.001
	Sequential acquisition	57	894.11 \pm 305.80	—
	Helical acquisition	34	822.68 \pm 256.47	—
	Male	41	922.98 \pm 328.67	—
	Female	50	821.86 \pm 245.97	—

Correlation Analysis Between Dose Indicators, Age, and Patient Dimensions in Cranial CT Examinations

Variables	n	Correlation Coefficient (r)	p-value
Age vs Total DLP	91	0.11	0.301
AP Thickness vs Total DLP	92	0.081	0.445
Lateral Thickness vs Total DLP	92	-0.164	0.119
Total DLP vs AP Thickness	91	0.236*	0.024
Total DLP vs Lateral Thickness	91	0.142	0.180

Significant differences were observed between contrast-enhanced and non-contrast examinations, as well as between sequential and helical acquisition protocols, particularly for CTDIvol values. Correlation analysis demonstrated a weak but statistically significant association between Total DLP and anteroposterior patient thickness.

The Case for Single Acquisition DRLs (saDRLs)

Traditional examination-based DRLs aggregate dose metrics, potentially obscuring relevant differences between individual acquisitions — a limitation especially evident in emergency CT with multiphase protocols.



Precise Dose Auditing

Enables identification of high-dose acquisitions that would otherwise be hidden within examination-level averages.



Protocol Optimisation

Supports targeted improvements to individual acquisition phases, reducing unnecessary exposure.



Improved Comparability

Facilitates better comparison between acquisition techniques and enhanced standardisation of clinical practice.

Discussion: Alignment & Implications

European Alignment

Results are broadly aligned with European reference levels for head and chest CT. However, variability associated with acquisition type, contrast administration, and protocol design highlights the limitations of examination-level DRLs.

Regulatory Context

Findings are particularly relevant within the context of **Directive 2013/59/EURATOM** and the increasing implementation of dose management systems. Contrast-enhanced examinations consistently produced higher DLP and TotalDLP values, reinforcing the need for multiphase protocol optimisation.



Conclusions & Key Takeaways

1

Significant Variability Found

Dose differences confirmed across examination type, acquisition technique, and contrast administration in emergency CT.

2

Examination-Level DRLs Are Insufficient

Aggregated metrics conceal dose variability in modern multi-acquisition CT protocols.

3

saDRLs as the Way Forward

Acquisition-based DRLs improve radiation protection, facilitate protocol auditing, and enable more personalised dose management.

 Key references: ICRP Publication 135 (DRLs in Medical Imaging); Council Directive 2013/59/EURATOM



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References



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Thank You

For questions or further information, please contact the authors.

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