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Establishing Local Diagnostic Reference Levels (LDRL) for Low-Dose Lung Cancer Screening Ct Using a Dose Management System: Impact of Gender and Body Weight.

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ABSTRACT

"Purpose: To establish the local diagnostic reference levels (LDRL) for low-dose CT (LDCT) using an automated dose management system and to evaluate the relative impacts of gender and body weight on radiation dose.
Methods: A retrospective analysis was conducted on clinical LDCT data from 785 patients collected over a six-month period (April to September 2025). Dose metrics (including $CTDI_{vol}$ and DLP), gender, and body weight were extracted from the dose management system. Statistical analysis was performed to compare the 75th percentile (LDRL), mean, and median doses between male and female cohorts, with a specific focus on stratified analysis within the same weight intervals.
Results: The 75th percentile of $CTDI_{vol}$ for the entire cohort, males, and females was 2.32 mGy, 2.50 mGy, and 1.88 mGy, respectively. Within the 55–75 kg weight category, the 75th percentile of $CTDI_{vol}$ for males (2.28 mGy) remained notably higher than for females (2.00 mGy). A consistent trend was observed in DLP metrics, where male doses (85.12 mGy·cm) significantly exceeded female doses (72.41 mGy·cm) within the same weight interval. Similar patterns were also found in both mean and median values of $CTDI_{vol}$ and DLP. Interestingly, there were no significant differences in dose metrics between the entire cohort and the 55–75 kg sub-group. Overall, gender demonstrated a more significant impact on dose variance than body weight.
Conclusion: The study demonstrates that gender is a significant independent factor influencing LDCT dose, likely due to anatomical attenuation differences. Establishing gender-specific LDRLs may provide a more accurate benchmark for clinical quality assurance and facilitate personalized protocol optimization in lung cancer screening programs."

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INTRODUCTION

Since 2022, Taiwan has implemented a nationwide low-dose computed tomography (LDCT) lung cancer screening program for high-risk populations, substantially increasing the demand for LDCT examinations. The rapid increase in screening volume highlights the importance of optimizing radiation dose and establishing local diagnostic reference levels (LDRLs).

Existing studies on Diagnostic Reference Levels (DRLs) primarily focus on routine chest CT examinations, with relatively limited data available for low-dose CT protocols used in lung cancer screening.

Conventional manual collection of radiation dose indicators is inefficient and prone to human error. The use of an automated radiation dose management system facilitates comprehensive and standardized collection of clinical dose data.

This study aimed to establish local Diagnostic Reference Levels (LDRLs) for low-dose lung cancer screening CT using data acquired from a specific CT scanner, providing a baseline for protocol optimization and dose management.

METHODS AND MATERIALS

Study Population
- A retrospective review was conducted on clinical lung cancer screening data acquired from a multi-slice CT scanner (Revolution CT, GE Healthcare, USA) within our institution.
- Study period: April–September 2025.

Data Collection
- Radiation dose data were extracted using a Radiation Dose Management (RDM) system (MPTronic Medical Software, France).
- The Statistics function was used to analyze the distribution of dose metrics, including:
  - Minimum, mean and maximum values
  - Percentile: 5th, 25th, 50th (median), 75th, 95th.
- Collected indicators included:
  number of acquisitions, number of patients, $CTDI_{vol}$, and DLP.

Cohort Stratification
Data were analyzed according to gender and weight
- Full weight distribution
  - Overall gender (A), males (B), and females (C)
- Adult median weight without gender distinction: 65 ± 10 kg
  - Overall gender (D), males (E), and females (F)
- Male adult median weight: 70 ± 10 kg (G)
- Female adult median weight: 58 ± 10 kg (H)

Local Diagnostic Reference Level (LDRL):
Be defined as the 75th percentile of the $CTDI_{vol}$ and DLP distributions.

Table 1. Scan Parameters and Protocol Settings of the GE Revolution CT for LDCT Screening.

Scan type	Collimation (mm)	kVp	Rotation time (s)	mAs	Pitch	Reconstruction algorithm
Helical	128*0.625	120	0.5	Smart mA	0.992	Stnd, Asir-V 40%

Table 2. Patient characteristics and radiation dose metrics for each study cohort.

		A	B	C	D	E	F	G	H
Patients (n)		785	374	411	324	183	215	150	174
Mean number of acquisitions		3	3	3	3	3	3	3	3
CTDI (mGy)	75%	2.32	2.5	1.88	2.14	2.39	1.81	2.28	2
	average	1.97	2.23	1.73	1.91	2.16	1.65	2.03	1.81
	50%	1.87	2.24	1.62	1.86	2.21	1.63	2.02	1.74
DLP (mGy·cm)	75%	87.76	95.33	68.49	79.49	92.39	65.99	85.12	72.41
	average	74.04	86.11	63.05	71.59	83.55	60.62	78.21	65.88
	50%	70.96	85.37	59.77	70.33	82.93	60.15	77.72	63.96

Figure 1. Distribution of DLP across different sex and body weight groups.

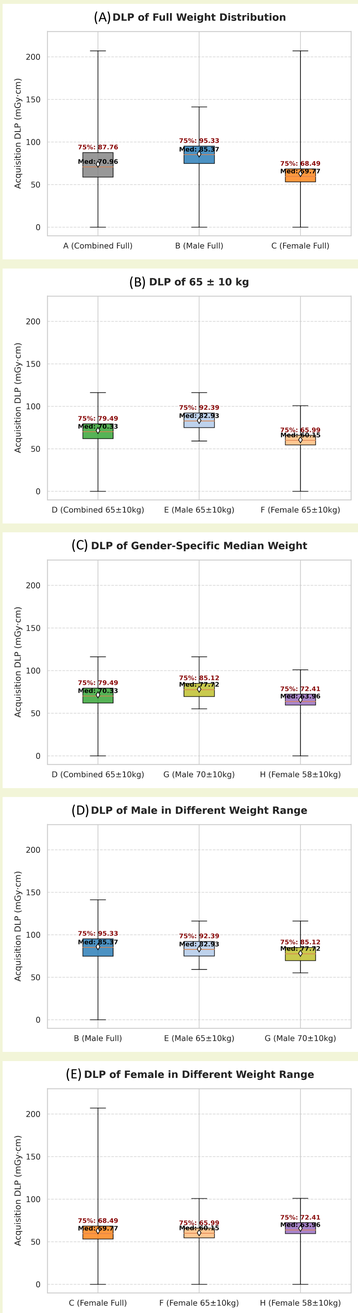
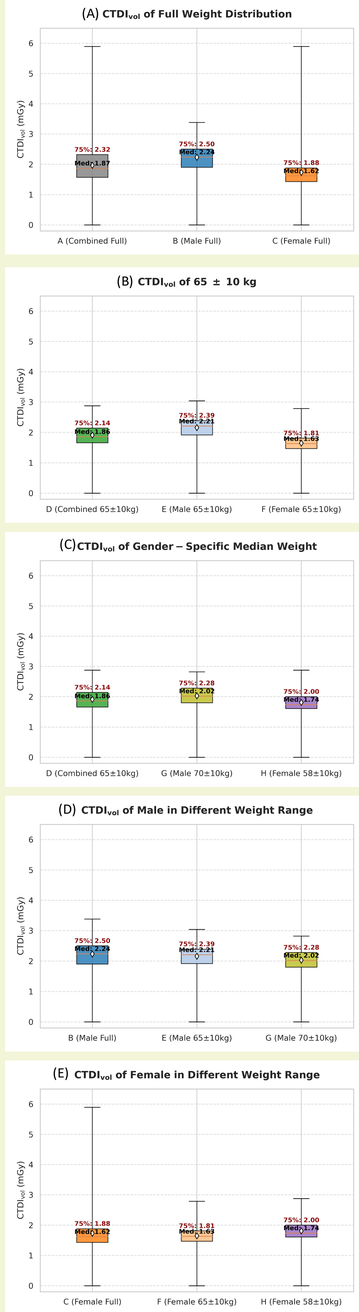


Figure 2. Distribution of $CTDI_{vol}$ across different sex and body weight groups.



RESULTS

A total of 785 patients undergoing LDCT lung cancer screening were included. Each examination consisted of three acquisitions on average.

The proposed Local Diagnostic Reference Levels (LDRLs), defined as the 75th percentile, were $CTDI_{vol}$= 2.32 mGy and DLP = 87.76 mGy·cm for the overall study population.

Male participants demonstrated consistently higher radiation dose metrics than females, with LDRLs of 2.50 vs. 1.88 mGy for $CTDI_{vol}$ and 95.33 vs. 68.49 mGy·cm for DLP.

Restricting analysis to participants with body weight 65 ± 10 kg reduced the differences in radiation dose between males and females, suggesting that body weight contributes substantially to dose variation.

When sex-specific median body weight groups were analyzed (70 ± 10 kg for males; 58 ± 10 kg for females), $CTDI_{vol}$ and DLP became more comparable between male subgroups ($CTDI_{vol}$= 2.28 mGy and DLP = 85.12 mGy·cm), whereas female-specific groups ($CTDI_{vol}$= 2.00 mGy and DLP = 72.41 mGy·cm) continued to demonstrate lower dose metrics than male groups.

Compared with the full-weight distribution, gender-specific body weight stratification reduced variability in both $CTDI_{vol}$ and DLP, resulting in more homogeneous dose distributions.

CONCLUSIONS

A radiation dose management system enabled efficient and standardized collection of LDCT dose data for establishing scanner-specific Local Diagnostic Reference Levels (LDRLs).

The proposed LDRLs for the overall population in this specific CT scanner were CTDI_{vol} = 2.32 mGy and DLP = 87.76 mGy·cm.

Radiation dose distributions differed between males and females, and body weight was an important determinant of CT dose.

Sex-specific median body weight stratification further reduced the differences in CTDI_{vol} and DLP between male and female cohorts, suggesting that weight-adjusted LDRLs may better reflect patient-specific dose requirements than a single population-based reference level.

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