Fully Automated Dual-Projection Topogram-Based Region-Specific Size-Specific Dose Estimate Calculation for Personalized CT Dose Management

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ABSTRACT

Purpose: Size-specific dose estimates (SSDE) are essential for personalized CT dose management; however, implementation in routine clinical workflows remains challenging. Existing automated approaches based on axial CT images are often constrained by field-of-view (FOV) limitations in large patients and substantial computational requirements. Although AAPM Report 204 recommends dual-projection topograms for patient size estimation, fully automated region-specific implementations suitable for routine clinical use have not been clearly described. This study aimed to develop and validate a fully automated dual-projection topogram-based framework for region-specific SSDE calculation.

Methods: An automated pipeline was developed to detect anatomical landmarks on paired anteroposterior (AP) and lateral (LAT) topograms for region localization and patient size estimation. Anatomical regions were defined based on pelvis and lung boundaries to ensure clinically relevant dose assessment. AP and LAT dimensions were measured to calculate effective diameters, and SSDE was estimated using AAPM Report 204 conversion factors. The framework was retrospectively validated using 151 adult CT examinations from two vendors (Canon, Philips), yielding 232 evaluable anatomical regions, including chest (n=50), abdomen (n=101), and pelvis (n=81). Technical success was defined as successful algorithm execution with anatomically plausible landmark detection and valid measurements.

Results: Technical success rates were 98% (49/50) for chest, 91% (92/101) for abdomen, and 95% (77/81) for pelvis. Overall, 218 of 232 regions (94%) were successfully processed, producing valid AP and LAT measurements. Mean effective diameters were 27.4 ± 2.2 cm for the chest, 26.4 ± 3.2 cm for the abdomen, and 26.9 ± 2.8 cm for the pelvis, demonstrating clinically meaningful region-dependent size variation. The method generalized across heterogeneous patient anatomies.

Conclusion: Fully automated dual-projection topogram-based SSDE calculation is clinically feasible, achieving a 94% overall success rate across 151 CT examinations. By enabling region-specific dose assessment without the computational burden or FOV limitations of axial images, this approach provides a scalable solution for personalized CT dose management and supports integration into routine clinical workflows.

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INTRODUCTION

Background

- CT accounts for approximately 10% of medical imaging examinations but contributes more than 60% of the collective medical radiation dose. [1]
- $CTDI_{vol}$ and DLP are scanner-output indices based on standard phantoms and do not fully account for patient size. [2]
- SSDE improves patient-specific dose assessment by correcting $CTDI_{vol}$ using patient size information. [3]
- Existing automated SSDE methods based on axial CT images may be limited by FOV truncation in large patients and increased computational workload.[4]
- AAPM Report 204 recommends the use of AP and lateral topograms for patient size estimation. [3]
- However, a fully automated, region-specific topogram-based SSDE workflow for chest, abdomen, and pelvis has not been clearly established. [4]

Objective

To develop and validate a fully automated dual-projection topogram-based framework for region-specific SSDE calculation.

$CTDI_{vol}$ ⇒ patient-size correction ⇒ region-specific SSDE

METHODS AND MATERIALS

Study Dataset

A total of 151 adult CT examinations from Canon and Philips scanners were retrospectively analyzed, yielding 232 evaluable anatomical regions: chest (n = 50), abdomen (n = 101), and pelvis (n = 81). Paired AP/LAT topograms, axial CT images, and dose information were collected under IRB approval (TYGH114060). Cases with metallic or high-attenuation objects affecting localization, or with arms not raised, were excluded.

Automated Pipeline

Paired AP and lateral topograms were processed through an automated workflow consisting of DICOM preprocessing, body contour segmentation, anatomical region localization, AP/LAT dimension extraction, and region-specific SSDE calculation (Figure 1). AP dimension was derived from the lateral topogram, while LAT dimension was derived from the AP topogram.

$$D_{eff} = \sqrt{AP \times LAT}$$
$$SSDE = CTDI_{vol} \times f(D_{eff})$$

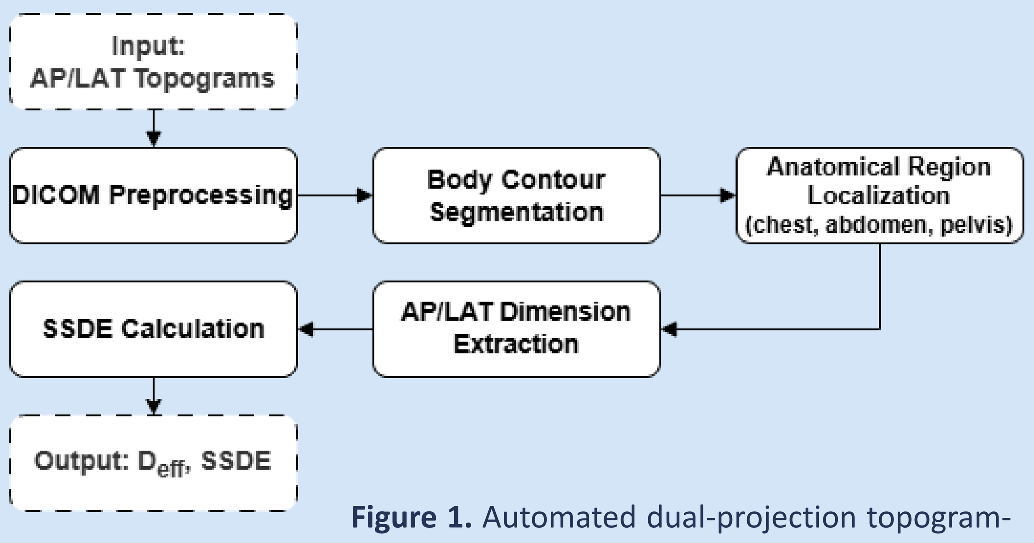

Figure 1. Automated dual-projection topogram-based SSDE calculation workflow.

RESULTS

- The automated pipeline successfully processed 218 of 232 evaluable anatomical regions, achieving an overall technical success rate of 94%.
- Topogram-derived D_{eff} showed a group-level tendency toward underestimation compared with axial D_{eff}, with regional error ranges within ±11%.
- The workflow generated region-specific SSDE directly from paired AP/LAT topograms without full axial image processing.

Table 1. Technical success rates across evaluable anatomical regions.

Region	Evaluable regions	Failed regions	Successful regions	Success rate
Chest	50	1	49	98%
Abdomen	101	9	92	91%
Pelvis	81	4	77	95%
Overall	232	14	218	94%

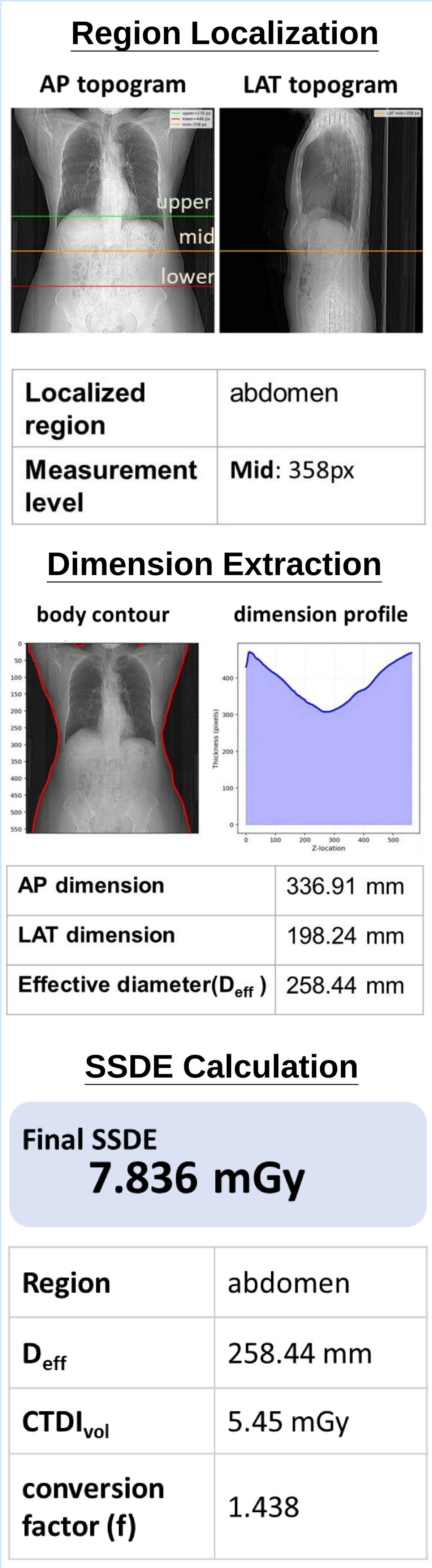

Figure 2. Representative automated region-specific SSDE output.

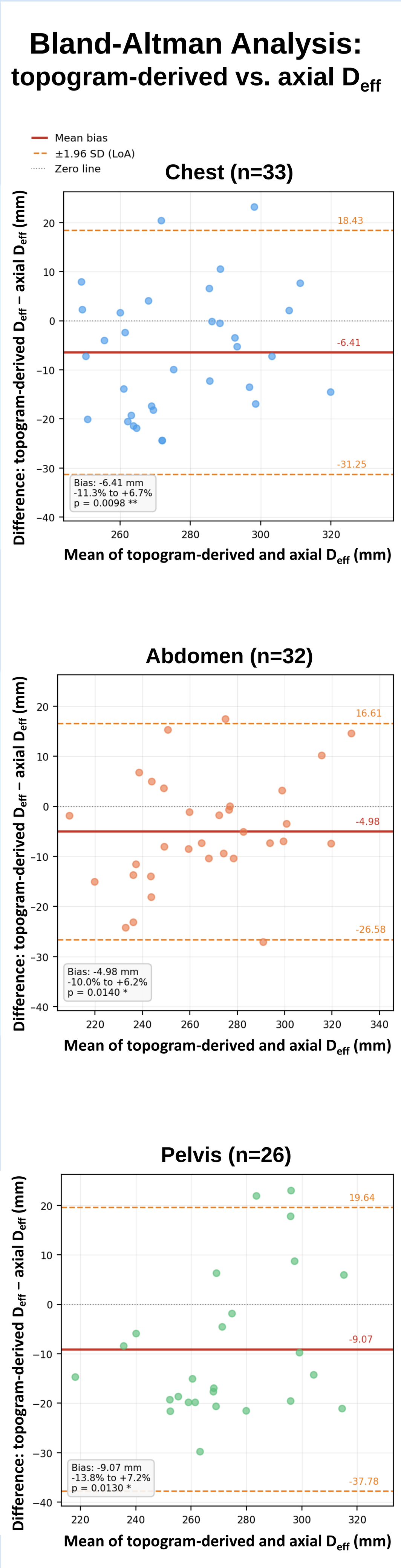

Figure 3. Bland-Altman analysis of topogram-derived versus axial D_{eff} in cases with available axial measurements.

DISCUSSION

- The proposed framework achieved high technical success across chest, abdomen, and pelvis, supporting the clinical feasibility of automated dual-projection topogram-based SSDE calculation.
- Abdomen localization showed the lowest success rate because its upper and lower boundaries were derived from chest and pelvic landmarks, respectively. Failure of either landmark detection, or incomplete topogram coverage of the chest or pelvis, could propagate to inaccurate abdominal boundary definition.
- Topogram-derived D_{eff} showed a group-level tendency toward underestimation compared with axial D_{eff}; however, the regional relative error ranges remained within approximately ±11%, suggesting acceptable agreement for automated patient-size estimation.
- The workflow does not require full axial CT image processing, thereby reducing computational burden and avoiding potential FOV-related limitations in large patients.
- A remaining limitation is that geometric D_{eff} may overestimate chest water-equivalent diameter because of lung air content.[2] Future work will incorporate tissue-composition and topogram magnification corrections to improve thoracic SSDE estimation.

CONCLUSIONS

- A fully automated dual-projection topogram-based framework was developed for region-specific SSDE calculation.
- The proposed framework achieved 94% overall technical success, successfully processing 218 of 232 evaluable anatomical regions from 151 adult CT examinations acquired on Canon and Philips scanners.
- Topogram-derived D_{eff} agreed with axial D_{eff} within approximately ±11% across chest, abdomen, and pelvis.
- The method does not require full axial CT image processing, thereby reducing computational burden and potential FOV-related limitations.
- This approach may support scalable personalized CT dose management in routine clinical workflows.

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