Mathematical Modelling of Automatic Tube Current Modulation in Computed Tomography using a Customised Phantom

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The introduction of automatic tube current modulation (ATCM) has resulted in more complex relationships between Computed Tomography scanner parameters, patient body contours, radiation dose, and image quality. ATCM automatically modulates tube current angularly and/or along the longitudinal axis, by adjusting x-ray flux based on attenuation characteristics and selected scanner protocols. This study aims to develop regression models for these complex relationships, considering all relevant exposure parameters. A customised homogeneous phantom, comprising of 5 discrete diameter steps, a conical section, and an air-pocket to mimic the lungs, was developed following guidelines of the AAPM TG-233 report. Data was collected from a Philips Brilliance iCT 256, a GE Healthcare Optima CT660, and a Canon Aquilion ONE PRISM edition scanner. R statistical software was used to fit the multiple linear regression models. While previous studies have explored the impact of varying settings on ATCM, none have quantitatively modelled these relationships considering all relevant parameters. This study modelled tube current (I) and image noise (σ) as a function of tube potential (U), pitch (P), rotation time (t) and diameter (D) for all 3 scanners with adjusted R-squared values over 0.9 and 0.7, respectively. Further, this study present clinicians with the ability to predict the impact of fine-tuning exposure parameters on patient radiation dose and output image quality, by plugging scanner settings and patient effective diameter into the regression models to predict I and s values in a holistic manner. Thus, the models developed may be used as a practical tool to optimize scan protocols according to specific patient requirements and clinical objectives before their implementation in clinical operations.

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