



## Optimization Strategies in Non-Contrast Head CT Examinations for Patients Based on The Role of Radiographers and Clinical Protocols: A Literature Review

Putri Pradita Nuramalia<sup>1\*</sup>, Muhammad Irsal<sup>1</sup>, Shinta Gunawati Sutoro<sup>1</sup>, Eny Supriyaningsih<sup>1</sup>,  
Muhammad Rizqi<sup>1</sup>, Sri Hartati<sup>2</sup>

<sup>1</sup> Department of Radiodiagnostics and Radiotherapy, Health Polytechnic Ministry of Health  
Jakarta II, Jakarta, Indonesia

<sup>2</sup> Nusantara Jakarta Academy of Radiodiagnostics and Radiotherapy, Jakarta, Indonesia

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**\*Corresponding author**

Email: [putri.pradita15@gmail.com](mailto:putri.pradita15@gmail.com)

### ORIGINAL ARTICLE

**ABSTRACT**

Non-contrast head computed tomography (CT) examinations are associated with a potential risk of unnecessary radiation exposure when optimization principles are not consistently applied in clinical practice. Radiographers play a pivotal role in implementing appropriate clinical protocols to ensure patient radiation safety without compromising diagnostic image quality. This study aimed to review optimization strategies for non-contrast head CT examinations with a particular focus on the role of radiographers and clinical protocols. Literature review was conducted using articles retrieved from the PubMed database published between 2020-2025. The selected studies were analyzed descriptively by examining study characteristics, optimization approaches, and their implications for clinical radiography practice of non-contrast head CT examination. The results indicate that optimization of non-contrast head CT can be achieved through appropriate adjustment of technical parameters by radiographers, application of iterative reconstruction techniques, minimization of patient positioning errors in anteroposterior, posteroanterior, and lateral orientations, use of eye shielding combined with tube current modulation (TCM), and implementation of diagnostic reference levels (DRLs) based on clinical indications. In addition, regular radiographer training contributes to the consistent application of optimization strategies. In conclusion, effective optimization of non-contrast head CT examinations requires an integrated approach that combines radiographer competency and evidence-based clinical protocols to minimize patient radiation exposure while maintaining diagnostic image quality.

**Keywords:** Non-Contrast Head CT, Optimization, Radiographer Role, Clinical Protocols.

**ABSTRAK**

Pemeriksaan computed tomography (CT) kepala non-kontras berpotensi menimbulkan unnecessary exposure apabila prinsip optimisasi tidak diterapkan secara konsisten dalam praktik klinis. Radiografer memiliki peran sentral dalam penerapan protokol klinis yang tepat, guna menjamin keselamatan radiasi pasien tanpa mengurangi kualitas diagnostik. Penelitian ini bertujuan untuk mengkaji upaya optimisasi pada pemeriksaan CT kepala non-kontras dengan menitikberatkan pada peran radiografer dan penerapan protokol klinis. Metode penelitian menggunakan literature review terhadap artikel ilmiah yang diperoleh dari basis data PubMed pada rentang tahun 2020–2025. Artikel yang terpilih dianalisis secara deskriptif dengan mengidentifikasi karakteristik penelitian, upaya optimisasi, serta implikasinya terhadap peran radiografer dan protokol klinis pada pasien pemeriksaan CT kepala non-kontras. Hasil tinjauan menunjukkan bahwa optimisasi CT kepala non-kontras dapat dilakukan melalui pengaturan protokol klinis CT Kepala non-kontras oleh radiografer dengan penerapan iterative reconstruction, pengendalian kesalahan posisi pasien, penggunaan pelindung mata yang dikombinasikan dengan tube current modulation (TCM), serta penerapan diagnostic reference level (DRL) sesuai indikasi klinis. Selain itu, pelatihan radiografer secara berkala berperan penting dalam menjaga konsistensi penerapan protokol optimisasi. Kesimpulannya, optimisasi pemeriksaan CT kepala non-kontras memerlukan integrasi antara kompetensi radiografer dan penerapan protokol klinis berbasis keselamatan radiasi untuk meminimalkan paparan radiasi pasien secara optimal.

**Kata Kunci:** CT Kepala Non-Kontras, Optimisasi, Peran Radiografer, Protokol Klinis.

## INTRODUCTION

Computed Tomography (CT) is a widely used diagnostic imaging modality due to its ability to produce high-resolution images with relatively short acquisition times, particularly in neurological and emergency cases. Globally, CT examinations have contributed significantly to medical radiation exposure among patient populations. Numerous studies have demonstrated that radiation doses from CT are higher compared to other radiological modalities, such as conventional radiography. Therefore, dose optimization should not focus solely on technical aspects of imaging equipment, but also on the role of radiographers in the implementation of examination protocols (Mettler et al., 2008; Smith-Bindman et al., 2009; Ramazan, Aarts, & Widdowfield, 2022; Albalawi et al., 2024; Devery, Cody, & Sweetman, 2025).

In the past decade, a substantial number of academic publications and journal articles have addressed CT dose optimization primarily through technical approaches, including exposure parameter adjustment and the use of iterative reconstruction techniques. Several studies have reported successful dose reduction without significant degradation of diagnostic image quality. However, most of these studies are experimental in nature or focus on a single technical variable, limiting the generalizability of their findings to comprehensive clinical procedures (Singh et al., 2009; McCollough et al., 2012; Delios et al., 2022; Diener et al., 2022; Tresker, 2022).

Publications specifically addressing dose optimization in non-contrast head CT examinations remain relatively limited compared to those focusing on abdominal or thoracic CT. This limitation highlights the lack of publication-based reviews that systematically integrate various dose optimization strategies for non-contrast head CT. Nevertheless, non-contrast head CT is one of the most frequently performed CT examinations in clinical practice, thereby having significant implications for population radiation exposure (Özsoykal et al., 2018; Bos et al., 2023; Dieckmeyer et al., 2023; Alotaibi et al., 2024; Najjar, 2024).

Based on survey results from the Indonesian Nuclear Energy Regulatory Agency (BAPETEN) for the period 2018–2021, CT examinations accounted for the largest contribution to medical radiation dose, representing 97.45% of the total medical radiation exposure, with a collective dose reaching 40.91 mSv per capita. These data indicate that patients received radiation doses ranging from 9.26 to 176.8 mSv per capita. The findings underscore the urgency of evaluating and strengthening dose optimization strategies for CT examinations in healthcare facilities (Rusmanto & Kunarsih, 2024).

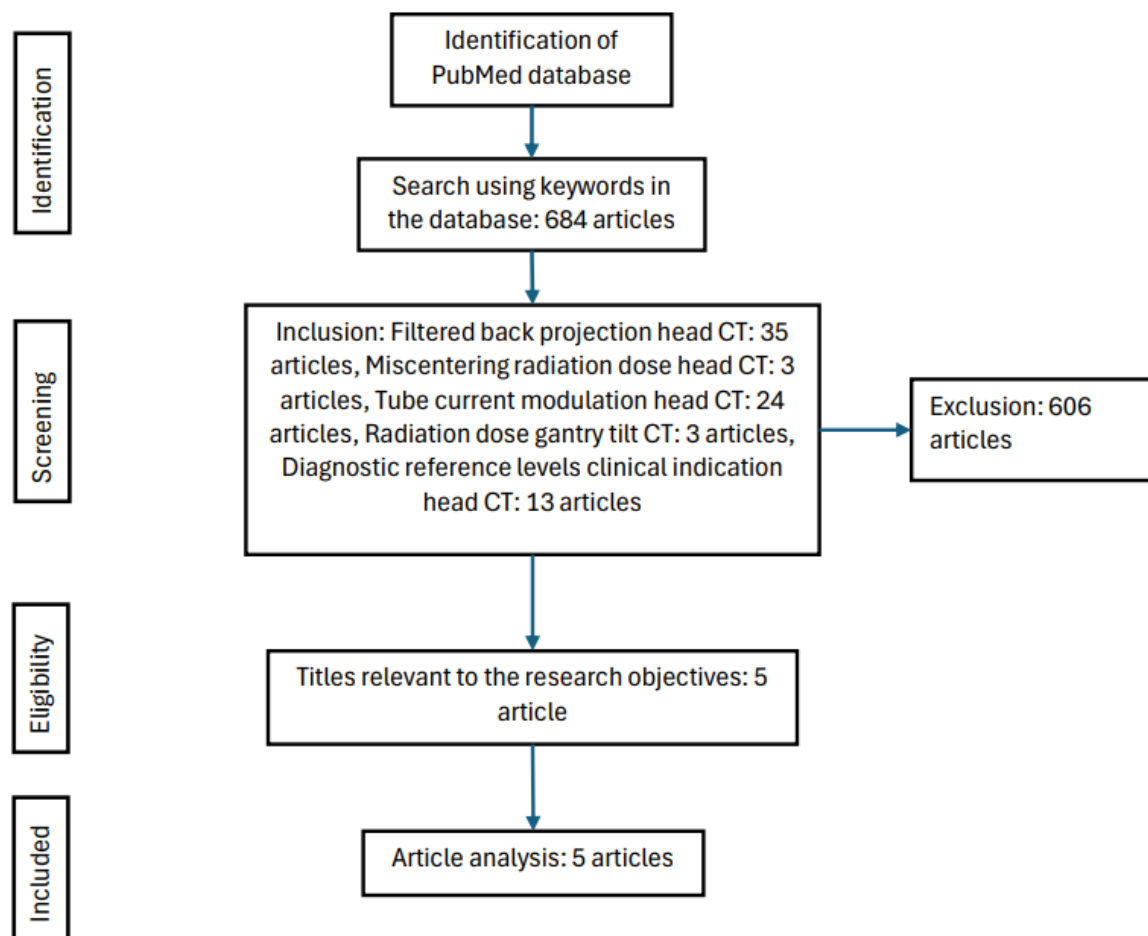
The high contribution of radiation dose indicates a potential for unnecessary exposure, particularly in routinely performed CT examinations such as non-contrast head CT. This condition emphasizes the importance of consistently implementing evidence-based dose optimization procedures in clinical practice. Therefore, this study aims to present a current review of journal publications on dose optimization procedures in non-contrast head CT examinations using the PubMed database for the period 2021–2025, in order to bridge existing research gaps. Specifically, this review seeks to integrate technical aspects and the role of radiographers in the application of clinical protocols oriented toward patient optimization in non-contrast head CT examinations.

## RESEARCH METHODS

This study employed a literature review methodology by conducting a systematic search for scientific articles in the PubMed database, which is managed by the National Center for Biotechnology Information (NCBI) as part of the U.S. National Library of Medicine (NLM) under the National Institutes of Health (NIH). PubMed was selected because it is one of the primary databases in the fields of health sciences and radiology, providing access to more than 38 million citations and abstracts of peer-reviewed scientific articles, thereby serving as a relevant and credible source of research data.

The article selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow as a guideline to ensure transparency in the identification, screening, and eligibility stages of article selection, which is presented in the form of a flow diagram in Figure 1. Although this review was not intended to be a systematic review, the use of the PRISMA flow aimed to enhance the traceability and reproducibility of the literature selection process. Articles that met the inclusion criteria were subsequently analyzed

descriptively by examining their methodological characteristics and key findings, which were then synthesized to address the objectives of the study.



**Figure 1.** Flow diagram of the study selection process

The inclusion criteria in this study were established to determine the eligibility of the literature to be analyzed. The literature search was conducted on July 21, 2025, between 10:00 and 13:00 WIB. Articles considered for inclusion were scientific publications published between 2020 and 2025, employing either experimental research methods or review article designs, and available as full-text papers with unrestricted access. Included articles were published in English and addressed non-contrast head CT examinations within the context of clinical practice. The primary outcomes considered in the literature selection included radiation dose parameters (CTDIvol and DLP) as well as image quality assessment, both subjective and objective.

Exclusion criteria were applied to filter out literature that did not align with the objectives of the study. Articles excluded from the analysis comprised non-peer-reviewed sources, studies involving animal experiments, and research findings that were inconsistent with established scientific principles. The literature identification stage was conducted through searches in the PubMed database, which was selected due to its capacity to provide information relevant to the topic of this study. To obtain comprehensive search results, Boolean operators were applied using the following keywords: “radiation dose gantry tilt,” “filter back projection head CT,” “miscentering radiation dose,” “dose reduction tube current modulation,” “dose-modulated head CT,” or “diagnostic reference levels clinical indications head CT.” The initial search yielded a total of 684 articles, which were subsequently screened in a stepwise manner following the PRISMA flow.

At the eligibility stage, all retrieved articles were imported into Microsoft Excel for further selection based on compliance with the predefined inclusion criteria. During the title and abstract screening stage, a substantial number of articles were excluded because they did not specifically address non-contrast head CT, lacked a dose optimization component, or focused on other types of CT examinations. At the data extraction (included) stage, information from the selected articles was collected and presented in tabular form. Extracted data included authors' names, year of publication, study design, study results, and key findings relevant to optimization procedures in non-contrast head CT examinations. These analyses were subsequently used as the basis for developing a descriptive synthesis to address the objectives of the study.

## RESULTS

The literature search conducted in the PubMed database yielded a total of 684 articles across all applied keywords. Based on the search results restricted to publications within the last five years (2020–2025), the number of articles retrieved for each keyword was as follows: filter back projection head CT (35 articles), miscentering radiation dose head CT (3 articles), tube current modulation head CT (24 articles), radiation dose gantry tilt CT (3 articles), and diagnostic reference levels clinical indications head CT (13 articles). The number of articles associated with each keyword reflects variations in research focus and study context.

Subsequently, title and abstract screening was performed based on relevance to the theme of dose optimization in non-contrast head CT examinations, resulting in the selection of five relevant articles. At the eligibility stage, all five articles met the inclusion criteria and did not meet any of the exclusion criteria; therefore, all were included in the data analysis and synthesis stages. The article selection process followed the PRISMA flow and is described in detail in the study flow diagram (Figure 1). Articles that met the criteria were then analyzed and presented in the form of a data synthesis, as shown in Table 1. The table was used to summarize the main characteristics of each study, while differences in research context among the articles were described narratively to avoid redundancy in the presentation of key findings.

**Table 1.** Characteristics and Key Findings of Included Studies.

| <b>Author</b>      | <b>Year</b> | <b>Study Design</b>  | <b>Study Results</b>  | <b>Key Findings</b>   |
|--------------------|-------------|--|---|---|
| Gohla et al.       | 2025        | Experimental comparative study in clinical non-contrast head CT patients; comparison of ADMIRE, SAFIRE, and Filtered Back Projection (FBP) reconstruction algorithms under standard-dose and low-dose protocols. | ADMIRE and SAFIRE demonstrated reduced image noise and improved image quality compared with FBP, particularly under low-dose protocols. | Iterative reconstruction protocols, particularly ADMIRE, enable dose optimization in non-contrast head CT while maintaining diagnostic image quality. |
| Ravenscroft et al. | 2024        | Experimental phantom study; evaluation of the effects of patient miscentering  | Patient miscentering resulted in a significant increase in radiation dose, especially when an AP localizer was used.                    | Patient positioning and localizer orientation play a critical role in head CT dose optimization.  |

|                   |      |   |   |
|-------------------|------|---|---|
|                   |      | and localizer orientation (AP vs. PA) on radiation dose in head CT.   |   |
| Kosaka et al.     | 2020 | Experimental study using both phantoms and clinical patients; evaluation of eye lens dose reduction using tungsten functional paper and organ-based tube current modulation (TCM) | The use of tungsten functional paper and TCM significantly reduced eye lens dose without a meaningful increase in total radiation dose. The combination of organ-specific shielding and TCM is effective for eye lens protection in head CT examinations. |
| Tan et al.        | 2023 | Descriptive observational study in clinical patients at a single hospital; evaluation of CT DIvol and DLP based on clinically indicated protocols.                                | CT DIvol and DLP values were below the national Diagnostic Reference Levels (DRLs) for all clinical indications. Implementation of clinically indicated head CT protocols supports dose optimization in accordance with radiation safety standards.       |
| Tarkiainen et al. | 2023 | Pre–post interventional study in clinical patients; evaluation of the impact of radiographer training on gantry tilt and scan length optimization.                                | A significant reduction in eye lens dose was observed following radiographer training. Radiographer training directly contributes to head CT dose optimization through more appropriate technical parameter adjustments.                                  |

## DISCUSSION

The results of this literature review indicate that various dose optimization approaches for non-contrast head CT examinations have been developed through both technical strategies and human resource–based interventions. A study by Gohla et al. demonstrated that the implementation of iterative reconstruction algorithms (SAFIRE and ADMIRE) allows simulated dose reductions of up to 70–90% compared with standard-dose protocols while maintaining diagnostically acceptable image quality (Gohla et al., 2025). However, these findings were derived from a retrospective study conducted at a single radiology facility with a limited sample size. Therefore, their broader clinical implementation particularly in facilities using different CT systems or lacking iterative reconstruction software requires further consideration.

Patient positioning–based optimization approaches were highlighted in a phantom study by Ravenscroft et al., which identified that vertical miscentering in both AP and PA localizer orientations contributed to increased radiation dose, whereas lateral positional variations did not show a significant effect (Ravenscroft & Baker, 2024). Although these findings provide valuable insights into patient dose behavior, the use of phantom models limits direct clinical applicability due to the variability in real patient conditions. Consequently, implementation of these findings necessitates clinical adaptation and prior radiographer training.

The study by Kosaka et al. showed that the combination of tungsten functional paper (TFP) eye lens shielding and organ-based tube current modulation (TCM) resulted in the greatest reduction in eye lens dose compared with standard protocols (Kosaka et al., 2020). While diagnostic image quality was preserved, the use of additional shielding may introduce artifacts, particularly in uncooperative patients. Therefore, the effectiveness of this approach is highly dependent on examination conditions and radiographer expertise.

A clinical protocol–based optimization approach was reported by Tan et al., who found that CTDIvol and DLP values were below national Diagnostic Reference Levels (DRLs) when head CT protocols were tailored to specific clinical indications (Tan et al., 2023). Although these findings support the use of DRLs as an optimization tool, the study was conducted at a single radiology facility. As such, variations in clinical practice across institutions and differences in patient population characteristics were not fully represented.

The role of radiographers as a key factor in dose optimization was clearly demonstrated in the study by Tarkiainen et al., which showed that training on variations in gantry tilt and scan length significantly reduced eye lens dose by up to 75–95% (Tarkiainen et al., 2023). However, the sustainability of such improvements is highly dependent on the continuity of training programs, which may be challenging to implement consistently in facilities with limited resources or high workload demands.

Based on the findings of this literature review, dose optimization in non-contrast head CT examinations is most effective when implemented through an integrated approach combining iterative reconstruction and TCM-based clinical protocols, technical control emphasizing the radiographer's role in patient positioning and gantry angle selection, application of DRL-based protocols, and continuous radiographer training. This integrated strategy enables a reduction in patient radiation exposure while maintaining diagnostic image quality. Nevertheless, implementation should be tailored to the technological capabilities of CT systems and the available human and infrastructural resources at each facility.

This study also has several limitations. First, the literature search was conducted using only a single database, PubMed, which may have resulted in the omission of relevant publications from other databases. Second, the number of analyzed articles was relatively limited, which may restrict the extent to which the reviewed evidence represents the full spectrum of global clinical practice. Additionally, most of the reviewed studies were single-center or phantom-based, limiting the generalizability of the findings to broader clinical populations.

## **CONCLUSION**

This literature review concludes that optimization of non-contrast head CT examinations can be effectively achieved through the combined role of radiographers and clinical protocols, including the implementation of iterative reconstruction techniques, minimization of vertical miscentering, consideration of bilateral eye shielding combined with TCM, establishment of DRLs based on clinical indications, and the provision of regular training for radiographers on optimization strategies in non-contrast head CT examinations. These measures enable a reduction in patient radiation exposure while preserving diagnostic image quality. Future research is recommended to focus on multicenter studies and the development of standardized national protocols for non-contrast head CT examinations based on clinical indications.

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