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RESEARCH ARTICLE

OPTIMIZING PAEDIATRIC CHEST IMAGING: CURRENT TRENDS AND TECHNIQUES IN LOW-DOSE RADIOLOGY

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ABSTRACT

Paediatric chest imaging is essential for diagnosing a wide spectrum of cardiopulmonary disorders, yet radiation exposure poses unique risks in this vulnerable population. The principle of ALARA (As Low As Reasonably Achievable) guides contemporary imaging protocols, spurring the development of radiation-reducing techniques across modalities. This review explores current trends, technological innovations, and best practices in low-dose paediatric chest radiology, focusing on digital radiography (DR), computed tomography (CT), and emerging roles of MRI and ultrasound. Emphasis is placed on dose optimization, clinical efficacy, safety, and the integration of artificial intelligence (AI) to support image quality enhancement. By evaluating both established and cutting-edge strategies, this article underscores the importance of tailored imaging protocols that balance diagnostic utility with radiation safety in children.

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INTRODUCTION

Medical imaging plays an indispensable role in paediatric healthcare, particularly in the evaluation and management of thoracic pathologies such as pneumonia, congenital heart disease, asthma exacerbations, and cystic fibrosis. Among these, chest imaging remains a frontline diagnostic tool in both acute and outpatient paediatric settings due to its accessibility, speed, and clinical utility. However, the use of ionizing radiation in children necessitates heightened vigilance, given their increased radiosensitivity and longer lifetime risk of radiation-induced malignancies. Paediatric patients exhibit higher cellular proliferation rates and greater cumulative exposure potential, rendering them particularly vulnerable to the stochastic effects of radiation. In response to these concerns, recent advances in imaging technology have significantly enhanced the capacity to acquire high-quality diagnostic images at substantially lower radiation doses. This progress has been driven by synergistic improvements in hardware, sophisticated image reconstruction algorithms, and protocol optimization tailored to the unique anatomical and physiological characteristics of children. Moreover, the integration of non-ionizing modalities such as magnetic resonance imaging (MRI) and ultrasonography has expanded diagnostic options, offering valuable radiation-free alternatives, especially for follow-up imaging or specific clinical scenarios.

International guidelines and safety initiatives, including the *Image Gently* campaign and the establishment of Diagnostic Reference Levels (DRLs), have been instrumental in promoting standardized, dose-conscious imaging practices across healthcare institutions. These frameworks underscore the importance of evidence-based dose management, particularly in facilities that routinely serve paediatric populations. This review synthesizes current trends and technological innovations aimed at optimizing paediatric chest imaging. It examines low-dose strategies in digital radiography and computed tomography, evaluates the emerging roles of MRI and ultrasound in thoracic diagnostics, and explores the transformative impact of artificial intelligence (AI) in dose reduction, image enhancement, and automated protocol selection. Through this comprehensive overview, the article aims to support clinicians and radiologists in adopting imaging practices that are both diagnostically robust and aligned with the principles of radiation safety in children.

MATERIALS AND METHODS

This narrative review was conducted by systematically collecting and analysing recent literature on paediatric chest imaging with a focus on low-dose techniques. Databases including PubMed, Scopus, and Google Scholar were searched using a combination of keywords such as "paediatric radiology," "low-dose CT," "digital radiography," "radiation reduction," "chest imaging," "AI in radiology," and "non-ionizing imaging in children." The search was limited to articles published in English between 2010 and 2025 in peer-reviewed, indexed journals.

Inclusion criteria consisted of

- Studies evaluating radiation dose optimization techniques in paediatric chest imaging.
- Reviews and guidelines from radiological societies.
- Clinical studies on diagnostic performance and safety of imaging modalities.
- Articles discussing technological innovations such as AI and advanced reconstruction algorithms.

Exclusion criteria included

- Studies focused exclusively on adult populations.
- Non-clinical or purely experimental articles not applicable to patient care.

Data from selected sources were synthesized and categorized under major imaging modalities: digital radiography (DR), computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound (US). Emphasis was placed on comparative studies, dose quantification, and practical implementation of dose-reduction strategies. Additional attention was given to emerging technologies and guidelines published by bodies such as the American College of Radiology (ACR), European Society of Paediatric Radiology (ESPR), and Image Gently Alliance.

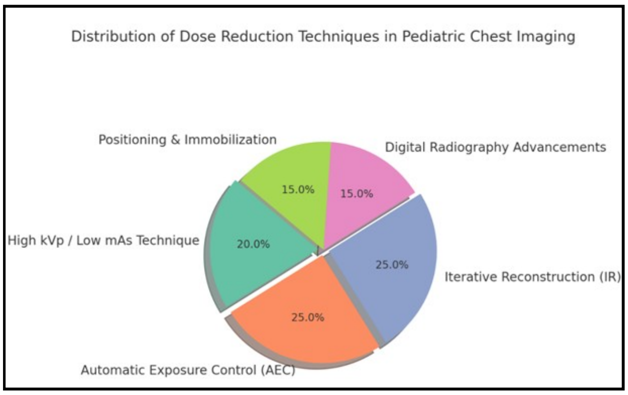
REVIEW OF LITERATURE

Digital Radiography (DR): Digital radiography continues to serve as a primary imaging modality in paediatric chest evaluations due to its swift acquisition time, ease of use in bedside settings, and relatively low radiation exposure. A retrospective analysis by Yahav-Dovrat *et al*. (2022) highlighted the efficacy of high peak kilovoltage (kVp) techniques in neonatal intensive care units. The study found that increasing kVp values above 60 (as opposed to below 60) resulted in a significant reduction in both air kerma and effective dose, without compromising diagnostic image quality. These findings underscore the importance of technique optimization in routine paediatric radiographic protocols.

Computed Tomography (CT): While computed tomography offers superior anatomical detail, particularly in complex thoracic pathologies, its application in paediatrics remains cautious due to heightened sensitivity to ionizing radiation in children. Recent technological advancements have emphasized radiation dose reduction while preserving diagnostic accuracy:

- **Tube Voltage Reduction:** Lowering tube voltage has shown significant benefits in reducing radiation burden. In a study by **Siegel *et al.* (2023)**, comparing photon-counting detector CT and energy-integrated detector CT for paediatric high-resolution chest imaging demonstrated significant reductions in radiation dose while maintaining diagnostic image quality.
- **Automatic Exposure Control (AEC):** AEC systems dynamically adjust the tube current based on the patient's size and attenuation characteristics. Alibek *et al*. (2011) reported that the implementation of AEC in paediatric chest CT could reduce radiation dose by up to 43%, maintaining acceptable image quality.
- **Iterative Reconstruction Techniques:** Advanced algorithms such as model-based iterative reconstruction (MBIR) significantly enhance image quality at reduced radiation levels. According to Smith *et al*. (2014), MBIR enabled a 60–70% dose reduction compared to conventional filtered back projection techniques, particularly in paediatric thoracic imaging.
- **Spectral Shaping and Dual-Energy CT:** Spectral shaping technologies, including tin filtration and dual-energy acquisition, facilitate tissue contrast enhancement while minimizing dose. Rajendran *et al*. (2023) demonstrated that such techniques resulted in an approximate 20% dose reduction in paediatric non-contrast sinus CT, without compromising diagnostic accuracy.
- **Artificial Intelligence (AI) in Dose Optimization**
- Artificial intelligence has revolutionized paediatric imaging by introducing intelligent systems capable of optimizing image quality while minimizing radiation exposure. AI-driven methods leverage deep learning and advanced algorithmic processing for superior dose management:
- **Deep Learning Reconstruction (DLR):** DLR methods reconstruct high-fidelity images from low-dose data. Brady *et al*. (2021) showed that DLR techniques could reduce radiation dose by up to 52% in paediatric chest-abdomen-pelvis CT scans while maintaining high diagnostic confidence.
- **Convolutional Neural Networks (CNNs):** CNN-based denoising outperforms traditional iterative reconstruction by effectively suppressing image noise. Horst *et al*. (2025) reported enhanced image clarity and reduced noise artifacts using CNNs in low-dose paediatric chest CT scans.
- **AI-Enabled Ultra-Low-Dose Reconstruction:** Novel architectures such as the Split Unrolled Grid-like Alternative Reconstruction (SUGAR) network have shown remarkable ability to reconstruct diagnostic-quality images from ultra-low-dose CT data—approaching radiation levels akin to conventional radiographs.

Interpretations and Implications: The convergence of advanced imaging technologies and artificial intelligence has marked a paradigm shift in paediatric chest radiology, enabling substantial reductions in radiation exposure without compromising—and in some cases, enhancing—diagnostic efficacy. The move toward individualized imaging, wherein protocols are meticulously tailored to the patient's size, clinical presentation, and anatomical considerations, underscores a patient-centric approach that aligns with contemporary radiological safety standards. AI-driven reconstruction techniques, particularly those employing deep learning and convolutional neural networks, have emerged as transformative tools in mitigating image noise and improving resolution at ultra-low radiation doses. These innovations not only support superior image interpretation but also pave the way for more confident clinical decision-making in complex paediatric cases. The implications of these advancements extend beyond the technical domain; they call for sustained interdisciplinary collaboration among radiologists, medical physicists, data scientists, and AI developers to ensure validation, regulatory compliance, and ethical deployment across varied clinical settings. Ongoing research and robust multi-institutional trials are essential to refine these technologies, standardize their integration, and promote equitable access, especially in resource-constrained environments. Ultimately, the strategic implementation of AI-enhanced, low-dose imaging protocols represents a forward-looking vision for paediatric radiology—one that balances technological innovation with the imperative of patient safety.



Comparison of Radiation Dose Between Imaging Modalities in Paediatrics

Imaging Modality	Approx. Effective Dose (mSv)
Chest X-Ray (PA)	0.01–0.02
Chest CT	1.0–2.0
Ultra-low-dose CT	0.3–0.5
MRI/USG	0 (non-ionizing)

Current Practices and Future Trends

Current Practices: Contemporary paediatric chest imaging is firmly grounded in the principle of radiation minimization, emphasizing individualized protocols that align with patient-specific anatomical and clinical parameters. Across imaging modalities, a concerted effort is being made to optimize diagnostic yield while adhering to low-dose strategies.

Digital Radiography (DR): The implementation of higher peak kilovoltage (kVp) settings (>60), coupled with meticulous collimation and the selective omission of anti-scatter grids in neonatal imaging, has proven effective in significantly reducing entrance skin dose without compromising image quality. These refinements, as demonstrated by Yahav-Dovrat *et al.* (2022), support the ongoing refinement of DR protocols for neonates and infants.

Computed Tomography (CT)

- **Automatic Exposure Control (AEC)** and tube current modulation have become integral components of modern paediatric CT protocols, enabling real-time dose optimization based on patient size and anatomy (Alibek *et al*., 2011).
- **Iterative reconstruction algorithms**, such as Adaptive Statistical Iterative Reconstruction (ASIR) and Model-Based Iterative Reconstruction (MBIR), are now routinely employed to suppress noise at reduced dose levels, enhancing image clarity in paediatric chest evaluations (Smith *et al*., 2014).
- **Spectral shaping techniques**, particularly those utilizing tin filtration in dual-energy CT, facilitate further dose reduction while enhancing tissue contrast and delineation (Rajendran *et al*., 2023).

Ultrasound and MRI

- **Lung ultrasound** has emerged as a valuable, radiation-free modality for bedside assessment of pneumonia, pleural effusions, and other thoracic pathologies, offering real-time, high-resolution imaging.
- **Magnetic Resonance Imaging (MRI)**, particularly with rapid acquisition sequences, has demonstrated increasing diagnostic utility in evaluating congenital vascular anomalies, mediastinal masses, and thoracic wall pathologies, without the hazards of ionizing radiation.

AI-Based Enhancements

- **Deep Learning Reconstruction (DLR)** algorithms, such as GE's TrueFidelity™, have enabled substantial dose reductions while preserving or enhancing image detail (Brady *et al*., 2021).
- **Convolutional Neural Networks (CNNs)** have shown superior performance in denoising low-dose CT images, improving signal-to-noise ratios and diagnostic confidence in paediatric imaging contexts (Horst *et al*., 2025).

Future Trends: Emerging innovations continue to redefine the landscape of paediatric radiology, with an increasing emphasis on automation, personalization, and the integration of non-ionizing modalities:

- **Ultra-Low-Dose CT:** The integration of AI-powered reconstruction frameworks—such as the Split Unrolled Grid-like Alternative Reconstruction (SUGAR) network—has brought CT imaging doses to levels approaching that of digital radiography, without compromising diagnostic fidelity (Wu *et al*., 2021).
- **Personalized Imaging Protocols:** The future of paediatric imaging lies in AI-driven protocol automation, wherein real-time analysis of patient-specific variables (e.g., age, body habitus, clinical indication) informs the selection of optimal scan parameters, ensuring consistent adherence to the ALARA principle.
- **Expansion of Non-Ionizing Modalities:** Continued refinement of paediatric MRI protocols, including faster sequences and contrast-free techniques, holds the potential to expand MRI's utility beyond its current applications in cardiac and vascular imaging, offering a broader spectrum of radiation-free diagnostics.
- **Automated Quality Assurance Systems:** The development of AI tools capable of providing real-time feedback on patient positioning, exposure settings, and protocol compliance may significantly reduce the incidence of repeat imaging, enhance consistency across operators, and further standardize low-dose practices.

These evolving practices represent a transformative shift in paediatric radiology—from traditional, operator-dependent imaging approaches to intelligent, patient-centered, and safety-conscious paradigms. As technology continues to evolve, the integration of AI and personalized medicine will be instrumental in driving the next generation of paediatric chest imaging—one that harmonizes diagnostic excellence with uncompromising radiation safety.

CONCLUSION

Paediatric chest imaging is undergoing a transformative evolution, driven by the dual imperatives of minimizing ionizing radiation and preserving diagnostic accuracy. Contemporary protocols emphasize individualized, low-dose imaging strategies—such as high-kilovoltage digital radiography, optimized computed tomography with advanced iterative reconstruction algorithms, and an increased reliance on non-ionizing modalities like ultrasonography and magnetic resonance imaging. The integration of artificial intelligence has further revolutionized paediatric radiology. AI-enhanced reconstruction techniques, including deep learning–based denoising and automated protocol optimization, have enabled the realization of ultra-low-dose imaging without compromising anatomical or pathological delineation. These innovations have facilitated the transition from standardized to precision imaging, tailored to the specific anatomical, physiological, and clinical characteristics of paediatric patients. Looking ahead, the trajectory of paediatric imaging points toward fully personalized imaging pathways powered by AI, expanded use of radiation-free modalities, and real-time automated quality assurance systems. These advances will be pivotal in enhancing diagnostic yield while upholding the ALARA (As Low As Reasonably Achievable) principle.
Sustained progress in this domain will require robust interdisciplinary collaboration among radiologists, medical physicists, technologists, and data scientists, as well as institutional commitment to technological investment and regulatory adherence. Collectively, these efforts will define the next generation of paediatric radiology—one that is safer, smarter, and more responsive to the unique needs of the paediatric population.

REFERENCES

1. Yahav-Dovrat, A., Elbakri, I., Rozovsky, K., Abd Elkader, A., &Koplewitz, B. (2022). Radiation dose reduction for chest radiography of infants in intensive care units using a high peak kilovoltage technique. *Pediatric Radiology, 52*(5), 874–882. https:// doi.org/10.1007/s00247-021-05262-x
2. Smith, E. A., Dillman, J. R., Goodsitt, M. M., Christodoulou, E. G., Keshavarzi, N., & Strouse, P. J. (2014). Model-based iterative reconstruction: Effect on patient radiation dose and image quality in pediatric body CT. *Radiology, 270*(2), 526–534. https://doi.org/10.1148/ radiol.13130362
3. Rajendran, K., Voss, B. A., Zhou, W., *et al*. (2023). Radiation dose reduction using spectral shaping in pediatric non-contrast sinus CT. *European Journal of Radiology, 162*, 110697. https://doi.org/10.101 6/j.ejrad. 2023.110697
4. Brady, S. L., Trout, A. T., Somasundaram, E., Anton, C. G., Li, Y., & Dillman, J. R. (2021). Improving Image Quality and Reducing Radiation Dose for Pediatric CT by Using Deep Learning Reconstruction. *Radiology, 298*(1), 180–188. https://doi.org/10.1148/radiol.2020202317
5. Horst, K. K., Zhou, Z., Hull, N. C., Thacker, P. G., Kassmeyer, B. A., Johnson, M. P., Demirel, N., Missert, A. D., Weger, K., & Yu, L. (2025). Radiation dose reduction in pediatric computed tomography (CT) using deep convolutional neural network denoising. *Clinical Radiology, 80*, 106705. https://doi.org/10.1016/ j.crad. 2024.09.011
6. Wu, W., Niu, C., Ebrahimian, S., Yu, H., Kalra, M., & Wang, G. (2021). AI-enabled ultra-low-dose CT reconstruction. *arXiv Preprint*. https://doi.org/10.48550/ ar Xiv. 2106.09834
7. Alibek, S., Brand, M., Suess, C., Wuest, W., Uder, M., &Greess, H. (2011). Dose reduction in pediatric computed tomography with automated exposure control. *Academic Radiology, 18*(6), 690–693. https:// doi.org /10.1016/ j.acra.2011.01.004
8. Takahashi, M. S., Donnelly, L. F., & Siala, S. (2024). Artificial intelligence: A primer for pediatric radiologists. *Pediatric Radiology, 54*(13), 2127–2142. https://doi.org/10.1007/s00247-024-06098-x
9. Ng, C. K. C. (2022). Artificial Intelligence for Radiation Dose Optimization in Pediatric Radiology: A Systematic Review. *Children, 9*(7), 1044. https://doi.org/10.3390/children9071044
10. Nagayama, Y., Goto, M., Sakabe, D., & Hirai, T. (2022). Radiation Dose Reduction for 80-kVp Pediatric CT Using Deep Learning–Based Reconstruction: A Clinical and Phantom Study. *American Journal of Roentgenology, 219*(2), 325–333. https://doi.org/10.2214/AJR.21.27255
11. Jo, G. D., Ahn, C., Hong, J. H., Kim, D. S., Park, J., Kim, H., Kim, J. H., Goo, J. M., & Nam, J. G. (2023). 75% radiation dose reduction using deep learning reconstruction on low-dose chest CT. *BMC Medical Imaging, 23*, 121. https://doi.org/10.1186/s12880-023-01081-8
12. Siegel, M. J., Bugenhagen, S. M., Sanchez, A., Kim, S., Abadia, A., & Ramirez-Giraldo, J. C. (2023). Comparison of Radiation Dose and Image Quality of Pediatric High-Resolution Chest CT Between Photon-Counting Detector CT and Energy-Integrated Detector CT: A Matched Study. *American Journal of Roentgenology, 221*(3), 363–371. https://doi.org /10.2214/A JR.23.29077
13. Malchair, F., & Maccia, C. (2020). Practical advices for optimal CT scanner dose in children. *Radioprotection, 55*(2), 117–122. https://doi.org/10.1051/ radiopro/ 2020 027
14. Shin, D.-J., Choi, Y. H., Lee, S. B., Cho, Y. J., Lee, S., & Cheon, J.-E. (2024). Low-iodine-dose computed tomography coupled with an artificial intelligence-based contrast-boosting technique in children: A retrospective study on comparison with conventional-iodine-dose computed tomography. *Pediatric Radiology, 54*(8), 1315–1324. https://doi.org/10.1007/s00247-024-05953-1
15. Miftahuddin, D., Prayitno, A. G., Hariyanto, A. P., Gani, M. R. A., &Endarko. (2024). Optimization of low-dose pediatric chest CT examination: Pediatric phantom study. *Jurnal Fisika dan Aplikasinya, 20*(1), 15–19. https://doi.org/10.12962/j24604682.v20i1.19814
16. Keshtkar, M. (2024). Paediatric cancer risks associated with chest computed tomography (CT) scans: comparison of routine chest and COVID-19 diagnosis CT protocols. *Radioprotection, 59*(2), 131–137. https://doi.org/10.1051/radiopro/2024008

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