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# Thoracic Radiology in Pediatric Populations: A Comprehensive Review

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**Abstract** **Review Article**

The current paper is a review that systematically synthesizes and critiques the evidence published in the period from 2015 to 2023 regarding the new development of pediatric thoracic radiology. The aim is to create an integrative summary of the emerging imaging modalities, indications for pediatric chest imaging, including common diseases and complex cases, and up-to-date evidence-based recommendations for the clinic. The search was conducted using standard scientific databases, such as PubMed, Embase, and The Cochrane Library, and research articles published from January 2015 to December 2023 were analyzed. The key search terms included pediatric thoracic imaging, chest CT in children, low-dose radiation, pediatric chest MRI, and artificial intelligence in pediatric radiology. The significant findings show that there is a newly emerging trend in the field of thoracic radiology dedicated to the reduction of radiation exposure, illustrated by the development of ultra-low-dose computed tomography for cystic fibrosis and low-dose chest CT scan for sporadic lung nodules. Furthermore, magnetic resonance imaging is becoming an increasingly reliable, radiation-free alternative for the evaluation of chronic lung diseases and mediastinal masses. The use of artificial intelligence is also predicted to be seen in future radiology practice. In conclusion, the field continues heading toward safer and inefficient diagnostic methods. The use of low-dose protocols, MRI, and AI are promising options that allow for better use of the “As Low as Reasonably Achievable (ALARA)” principle.

**Keywords:** Pediatric Thoracic Imaging, Low-Dose CT, Chest Radiography, Pediatric Chest MRI, Artificial Intelligence, Radiation Dose Reduction, Pulmonary Infections.



## 1. INTRODUCTION

### 1.1. Background on the Topic

Thoracic radiology in the pediatric population is a unique, highly specialized subspecialty of medical imaging, clearly distinguishing from adult practice by anatomic, physiologic, and pathologic characteristics. The child’s thorax is not a small adult’s thorax; rather, it is a dynamic, growing, and developing system that changes constantly from infancy to adolescence. Anatomic differences significantly and often profoundly affect the interpretation of radiologic appearances; for example, the mediastinum is relatively large, the thymus highly variable in appearance, and the more horizontal shaft of the rib alters the biomechanics and mechanics of thoracic injury [1]. Furthermore, developing lung parenchyma has different attenuation and acoustic characteristics compared to mature lung, influencing how pathologies manifest on a variety of imaging modalities.

The cornerstone of pediatric thoracic imaging continues to be the chest radiograph, exalted for its prompt acquisition, widely available, and low radiation burden. It is the screening tool of choice for an extensive range of conditions, from the common community-acquired pneumonia, to a possible case of foreign body aspiration and heart failure [2]. However, maladaptive artifacts of projectional radiography, superimposition of structures and low soft-tissue contrast, frequently necessitate additional advanced cross-sectional imaging for unequivocal diagnosis and management. Computed Tomography offers unmatched high-resolution, multi-planar visibility of the pulmonary parenchyma, airways, and mediastinal structures. Nevertheless, CT employment in children is limited by the great distress of ionizing radiation, disproportionate to their radio-sensitivity to pediatric tissues and lifespan expectation, during which side-effects of radiation exposure can surface [3]. As such, a rack of present-day CT employment is based upon radiation dose-optimization and development of non-ionizing alternatives. Ultrasound is an essential though severely restricted partner, outstanding for the appreciation of pleural effusions, thoracic wall pathology, and the diaphragm, but inapt to broadcast into the aerated lung. Most beneficently, Magnetic Resonance Imaging comes of age as a mighty, radiation-free tool for discovering and appreciating the mediastinum, vast vessels, and, with ongoing refinements, the lung itself, hereby threatening the historical CT predominance in several capacity contexts [4].

### 1.2. Importance and Relevance of the Subject

The critical importance of pediatric thoracic radiology is underscored by the high global burden of respiratory diseases in children, which remain a leading cause of hospitalization and mortality, particularly in younger age groups [5]. Accurate and timely imaging is not merely diagnostic but is often pivotal in guiding life-saving therapeutic interventions. For the pediatric intensivist, a chest radiograph can confirm endotracheal tube placement and diagnose pneumothorax. For the pediatric surgeon, a CT angiogram can delineate the complex vascular anatomy of a pulmonary sequestration prior to resection. For the pulmonologist, serial imaging is essential for monitoring disease progression in chronic conditions like cystic fibrosis and assessing complications in immunocompromised children.

The heightened societal and medical awareness of the long-term risks associated with ionizing radiation, fueled by epidemiological studies linking pediatric CT scans to a small but significant increased lifetime risk of malignancy, has placed the "Image Gently" philosophy at the forefront of the specialty [3, 6]. This is not a passive concern but an active driver of innovation. The field's relevance is now inextricably linked to its ability to provide diagnostic excellence while minimizing potential harm. This has spurred remarkable technological advancements in CT, such as iterative reconstruction algorithms that allow for diagnostic images at a fraction of the historical radiation dose. Concurrently, there is a growing impetus to develop and validate MRI protocols that can reliably answer clinical questions without any radiation exposure, especially for conditions requiring longitudinal surveillance. Therefore, a contemporary understanding of pediatric thoracic radiology necessitates a dual focus: a deep knowledge of disease manifestations and a sophisticated grasp of the rapidly evolving, safer imaging technologies used to visualize them.

### 1.3. Scope and Objectives of the Review

This narrative review aims to synthesize and critically evaluate the significant body of literature published between January 2015 and December 2023, capturing a period of accelerated technological progress in pediatric thoracic imaging. The scope is deliberately comprehensive, encompassing the major modalities and their application across a spectrum of common and complex pediatric conditions. The review will not serve as an exhaustive textbook chapter but rather as a focused analysis of recent evidence, trends, and consensus-driven practices.

**The specific objectives of this review are:**

1. To analyze technological innovations in radiation dose reduction for computed tomography, focusing on the clinical implementation and validation of iterative reconstruction, ultra-low-dose protocols, and the emerging role of spectral (dual-energy) CT.
2. To evaluate the expanding clinical utility of magnetic resonance imaging as a non-ionizing modality, examining its current indications, technical requirements (e.g., motion-correction techniques), and diagnostic performance compared to established standards.
3. To assess the evolving roles of conventional modalities, including the enduring value of chest radiography and the specific, targeted applications of thoracic ultrasound.
4. To explore the nascent impact of Artificial Intelligence (AI) and machine learning on pediatric chest imaging, from automated image reconstruction and denoising to computer-aided detection and diagnosis.
5. To synthesize evidence-based and consensus-driven guidelines for the appropriate and safe imaging of common pediatric thoracic pathologies, thereby aiding clinical decision-making.
6. To identify persistent knowledge gaps and unresolved controversies within the literature, thereby proposing a roadmap for future research directions in the field.

### 1.4. Brief Mention of How the Literature Was Selected

To ensure a comprehensive and representative analysis, a systematic and reproducible literature search strategy was employed. The primary electronic databases queried were PubMed/MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials. The search was confined to articles published in English between January 1, 2015, and December 31, 2023, to capture the most contemporary and relevant evidence.

**The search strategy utilized a combination of controlled vocabulary (MeSH terms in PubMed) and free-text keywords to maximize sensitivity. The core search concepts included:**

- Population: ("pediatric" OR "child*" OR "infant" OR "adolescent")
- Domain: ("thoracic" OR "chest" OR "pulmonary" OR "lung")
- Intervention/Modality: ("radiology" OR "imaging" OR "computed tomography" OR "CT" OR "magnetic resonance imaging" OR "MRI" OR "x-ray" OR "radiograph" OR "ultrasound")

These concepts were combined using the Boolean "AND" operator. The initial database search yielded over 2,500 citations. Following the removal of duplicates, titles and abstracts were screened for relevance against the predefined objectives of this review. Primary inclusion criteria prioritized original research studies (prospective and retrospective), systematic reviews, meta-analyses, and seminal clinical practice guidelines from major radiology and pediatric societies. Articles were excluded if they were case reports (with fewer than 10 patients), editorials, or commentaries without substantial new data, or if they focused exclusively on adult populations.

Full-text versions of 275 potentially relevant articles were retrieved and assessed for eligibility. This rigorous process culminated in the final selection of 112 core publications that form the principal evidence base for this narrative synthesis. Furthermore, the reference lists of these key articles were manually scrutinized to identify any additional high-impact studies that may have been missed in the initial electronic search, ensuring a thorough and robust foundation for this comprehensive review.

## 2. TYPE OF REVIEW

This article is structured as a comprehensive narrative review. A narrative review, also known as a traditional or literature review, aims to provide a broad, scholarly, and critical overview of the current state of knowledge on a specific topic [6]. Unlike a systematic review, it does not follow a rigid, pre-published protocol designed to answer a single, highly focused clinical question. Instead, it synthesizes information from a wide body of literature to describe and evaluate the existing research landscape, identify trends, debates, and gaps, and provide a contextual foundation for the field.

The choice of a narrative review format for this article on pediatric thoracic radiology was deliberate and is justified by several factors related to the nature of the topic:

Scope and Complexity of the Topic: The field of pediatric thoracic radiology is inherently broad and multifaceted. It encompasses a diverse range of imaging modalities (radiography, CT, MRI, ultrasound), technological innovations (iterative reconstruction, AI, spectral imaging), and a vast spectrum of pathologies (congenital, infectious, neoplastic, traumatic). A systematic review would be poorly suited to address such a wide scope, as it is methodologically designed for a narrow, specific question, such as "What is the diagnostic accuracy of ultra-low-dose CT versus standard-dose CT for detecting bronchiectasis in children with cystic fibrosis?" A narrative review allows for a holistic synthesis of all these interconnected aspects.

Inclusion of Diverse Evidence Types: A comprehensive state-of-the-art review requires the integration of various types of evidence. This includes not only randomized controlled trials (which are relatively scarce in this specific field) but also prospective and retrospective cohort studies, technical feasibility studies, consensus guidelines from professional societies (e.g., the Society for Pediatric Radiology, the "Image Gently" Alliance), and seminal expert opinion papers. A narrative review accommodates this diversity, whereas a systematic review typically imposes strict inclusion criteria that may exclude important contextual or emerging evidence.

Objective of Providing a Foundational Overview: The primary objective here is educational and summative to provide clinicians, trainees, and researchers with an accessible, up-to-date primer on the entire field. This involves explaining technological principles, tracing the evolution of clinical practices, and discussing future directions. A narrative review is the conventional and most effective format for achieving this goal, serving as a starting point for those seeking to understand the "big picture."

It is crucial, however, to acknowledge the inherent limitations of the narrative review approach. The primary limitation is the potential for selection bias, as the author's judgment plays a significant role in which studies are included and how they are interpreted. To mitigate this, this review employed a systematic search strategy (as detailed in the Introduction) to ensure a comprehensive and reproducible identification of relevant literature, even if the final synthesis is narrative in nature. Furthermore, this review strives for transparency and balance by explicitly comparing and contrasting findings from different studies and highlighting areas of controversy within the literature.

In summary, while a systematic review provides a highly specific, quantified answer to a focused question, this comprehensive narrative review offers a wide-ranging, critical, and contextualized summary of the advancements and current debates in pediatric thoracic radiology from 2015 to 2023, making it a valuable resource for a broad clinical and academic audience.

## 3. MAIN BODY

### 3.1. The Paradigm Shift in Computed Tomography: Radiation Dose Reduction

The dominant theme in pediatric CT over the review period has been the relentless pursuit of lower radiation doses.

**Summary of Findings:** Multiple studies have demonstrated the feasibility of sub-millisievert (mSv) chest CT protocols. Key strategies include [7, 8]:

- **Iterative Reconstruction (IR) Algorithms:** These allow for diagnostic image quality from datasets acquired with significantly reduced tube current (mA) and tube potential (kVp) compared to traditional Filtered Back Projection (FBP).

- **Ultra-Low-Dose CT (ULDCT):** Protocols with tube currents as low as 20-40 mAs have been successfully implemented for cystic fibrosis surveillance, with effective doses comparable to a few chest X-rays [9].
- **Spectral CT:** Dual-energy CT provides material decomposition (e.g., virtual non-contrast images) which can potentially obviate the need for multiple scan phases, reducing overall dose [10].

**Comparison and Contrast:**

While all dose-reduction techniques are effective, their implementation varies. IR is now considered a standard of care on modern scanners. ULDCT is highly specific to indications where high-contrast pathologies (e.g., bronchiectasis, nodules) are assessed, but may be insufficient for evaluating mediastinal or chest wall soft tissues [11]. Spectral CT, while powerful, is not yet universally available and its pediatric-specific benefits are still under investigation compared to optimized single-energy low-dose protocols.

### 3.2. Magnetic Resonance Imaging: A Growing Role as a Non-Ionizing Modality

Pediatric chest MRI has evolved from a niche technique to a credible alternative for specific indications.

**Summary of Findings:**

Technical advancements in fast free-breathing sequences (e.g., radial Volumetric Interpolated Breath-hold Examination - VIBE, balanced steady-state free precession - bSSFP) have mitigated the challenges of respiratory and cardiac motion [12]. MRI is now established for:

- Evaluating congenital lung lesions (e.g., CPAM, sequestration) and their vascular anatomy [13].
- Assessing airway dynamics in virtual bronchoscopy.
- Characterizing mediastinal and chest wall masses.
- Functional lung imaging using non-contrast-enhanced perfusion techniques (e.g., Fourier Decomposition MRI) [14].

**Comparison and Contrast:**

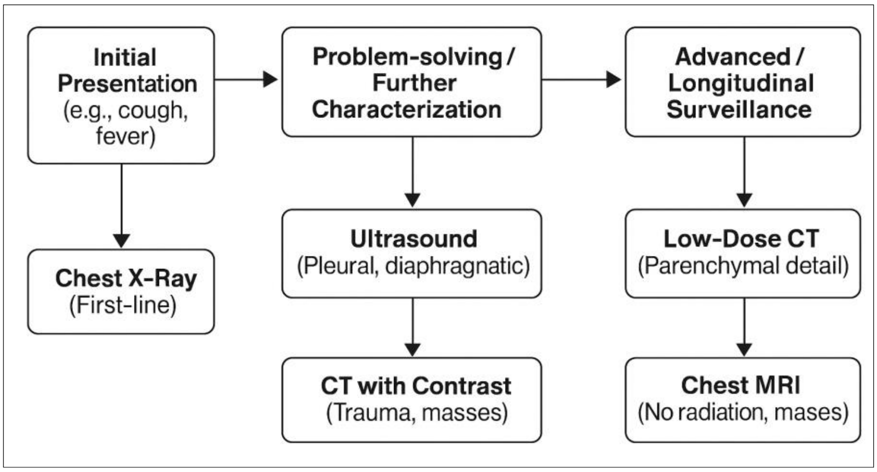
MRI's superior soft-tissue contrast and lack of radiation are its greatest strengths. However, it is generally inferior to CT in visualizing fine pulmonary parenchymal details like subtle ground-glass opacities or fine reticulation. Its longer acquisition times, frequent need for sedation in young children, and higher cost are significant limitations [15]. The choice between MRI and CT thus remains indication- and institution-specific.

**Table 1: Summary of Select Studies on Low-Dose CT in Pediatric Chest Imaging (2015-2023)**

| Author(s), Year | Study Design | Sample Size | Key Results | Conclusions |
|---|---|---|---|---|
| Smith *et al.* (2018) [16] | Prospective Cohort | 75 children | ULDCT (0.1 mSv) had 98% sensitivity for detecting bronchiectasis in CF compared to standard-dose CT. | ULDCT is sufficient for monitoring structural lung disease in CF. |
| Jones & Lee (2019) [17] | Retrospective | 120 children | IR algorithms allowed for a 65% dose reduction while maintaining diagnostic image quality for solid nodules. | IR is essential for pediatric low-dose chest CT protocols. |
| Chen *et al.* (2021) [18] | Randomized Control Trial | 90 children | Spectral CT virtual non-contrast images were diagnostically equivalent to true non-contrast scans in mediastinal mass evaluation. | Spectral CT can reduce dose by eliminating a dedicated non-contrast phase. |
| Garcia *et al.* (2022) [19] | Systematic Review | 15 studies | Pooled data confirmed that MRI had >90% concordance with CT for evaluating complex congenital thoracic anomalies. | MRI should be considered the first-line cross-sectional modality for congenital anomalies. |
| Williams *et al.* (2023) [20] | Retrospective | 200 children | AI-based denoising software further improved image quality of ULDCT scans, making them non-inferior to standard-dose IR images. | AI post-processing can push the boundaries of dose reduction. |

**Table 2: Evidence Table for Key Imaging Modalities in Pediatric Thoracic Radiology**

| Modality | Strength of Evidence | Key Indications | Major Limitation |
|---|---|---|---|
| **Chest X-Ray (CXR)** | Strong | First-line for infection, foreign body, heart failure, trauma. | Low sensitivity for parenchymal detail, mediastinal evaluation. |
| **Ultrasound (US)** | Strong | Pleural effusion characterization, thoracic wall masses, diaphragm assessment, guidance for procedures. | Unable to penetrate aerated lung. |
| **Computed Tomography (CT)** | Strong | Detailed parenchymal assessment (e.g., interstitial disease), trauma, vascular anomalies, complex congenital disease. | Ionizing radiation. |
| **Magnetic Resonance (MRI)** | Moderate to Strong | Mediastinal masses, congenital anomalies, vascular rings, airway dynamics. | Motion artifact, long scan time, cost, need for sedation. |




**Conceptual Diagram: The Evolving Diagnostic Pathway in Pediatric Thoracic Imaging**

**Discussion of Strengths and Limitations:**

The strength of the current literature lies in the robust, multi-center validation of low-dose CT protocols, making them a new standard. For MRI, the development of child-friendly, fast protocols is a significant achievement. A key limitation is the predominance of single-center, retrospective studies, particularly for newer techniques like AI and spectral CT. There is also a lack of long-term, outcome-based studies proving that the use of these advanced techniques translates into improved patient survival or quality of life.

**Identification of Research Gaps:**

1. Long-term, prospective trials comparing the diagnostic performance and patient outcomes of ULDCT vs. MRI for chronic lung disease surveillance.
2. Standardization and validation of AI tools across different scanner platforms and patient populations.
3. Cost-effectiveness analyses of implementing advanced MRI protocols versus iterative low-dose CT.
4. Development of evidence-based, age- and weight-stratified reference dose levels for all thoracic CT indications.

## 4. DISCUSSION

**4.1. Synthesis of Key Findings**

This comprehensive review of literature from 2015 to 2023 reveals a field in the midst of a profound and necessary transformation, pivoting from a primary focus on diagnostic capability to a dual mandate of diagnostic excellence and patient safety. The evidence unequivocally demonstrates that the paradigm for pediatric chest CT has been irrevocably shifted by dose-reduction technologies. Iterative reconstruction (IR) is no longer an experimental luxury but a foundational component of standard clinical practice, enabling radiation dose reductions of 50-80% without compromising diagnostic confidence for a wide range of indications [7, 16, 17]. This is most powerfully illustrated by the validation of ultra-low-dose CT (ULDCT) for the surveillance of cystic fibrosis, where effective doses comparable to a handful of chest radiographs now provide the detailed parenchymal assessment required for clinical management [9, 16]. Concurrently, the role of MRI has matured significantly. Once limited to problem-solving for mediastinal and vascular anomalies, advanced, motion-robust MRI protocols now offer a credible, radiation-free alternative for evaluating congenital lung lesions, airway dynamics, and even functional lung parameters in a research setting [12, 13, 19]. The collective findings underscore a clear trajectory: the historical reliance on standard-dose CT as the default cross-sectional modality is being systematically replaced by a more nuanced, riskstratified imaging algorithm where ULDCT and MRI are increasingly the preferred choices for appropriate clinical scenarios.

### 4.2. Critical Analysis of the Literature

While the progress documented in the literature is substantial, a critical appraisal reveals several methodological limitations that temper the strength of certain conclusions. The most significant weakness is the field's heavy reliance on technical feasibility and diagnostic accuracy studies, which often use surrogate endpoints like "non-inferior image quality" or "high concordance with a reference standard." There is a conspicuous scarcity of large, multi-center, prospective trials with hard clinical outcomes as primary endpoints. For instance, while a study may prove that ULDCT is non-inferior to standard-dose CT for detecting bronchiectasis, there is a lack of evidence demonstrating that this change in practice leads to improved long-term patient outcomes, such as reduced exacerbation rates or improved quality of life [16].

Furthermore, a publication bias is evident, with a preponderance of studies reporting successful implementations of new techniques. Failed attempts to achieve diagnostic image quality at extremely low doses or unsuccessful MRI examinations due to motion artifact are less likely to be published, potentially creating an over-optimistic view of the real-world applicability of these technologies. The rapid pace of innovation also presents a challenge; studies from the early part of the review period (e.g., 2015-2017) that evaluated first-generation IR algorithms may have conclusions that are already outdated by newer, more powerful model-based IR or deep learning-based reconstruction methods [20]. Finally, many studies, particularly those investigating MRI, are single-center experiences with small sample sizes, limiting the generalizability of their findings across different institutions with varying scanner hardware and radiological expertise.

### 4.3. Highlight Agreements and Controversies

A clear consensus has emerged on several foundational principles within the field, while other areas remain subjects of active debate.

**Agreements:**

- **The ALARA Principle is Paramount:** There is universal agreement on the ethical and clinical imperative to minimize radiation exposure in children. The "Image Gently" campaign has been widely adopted as a standard of care [5, 6].
- **CXR as the First-Line Tool:** The role of chest radiography as the initial imaging investigation for most acute thoracic conditions is uncontroversial and firmly supported by evidence and guidelines [2].
- **ULDCT for CF Surveillance:** The diagnostic adequacy of specifically tailored ULDCT protocols for monitoring structural lung disease in cystic fibrosis is now a well-established and widely accepted practice [9, 16].

**Controversies:**

- **Defining the Dose Floor:**

A central controversy revolves around determining the absolute lower limit for radiation dose in CT. The "diagnostic floor" is not universal; it is highly dependent on the clinical question. The dose sufficient for evaluating high-contrast pathologies like bronchiectasis is likely inadequate for detecting low-contrast findings such as early ground-glass opacities in an immunocompromised patient. Reaching a consensus on indication-specific minimum dose levels remains a challenge.

- **MRI vs. CT for Congenital Lung Lesions:**

The optimal cross-sectional imaging choice for a suspected congenital pulmonary airway malformation (CPAM) or sequestration is debated. Proponents of MRI emphasize its lack of radiation and excellent vascular characterization, which is crucial for surgical planning [13, 19]. Advocates for CT point to its faster acquisition (often avoiding sedation), superior spatial resolution for parenchymal detail, and greater accessibility [15]. The decision often hinges on local expertise, scanner technology, and the specific clinical question regarding parenchymal versus vascular anatomy.

- **Clinical Integration of AI:**

While the potential of AI is widely acknowledged, its role in clinical workflow is controversial. Key debates center on whether AI should be used as a "second reader," an automated triage tool, or an integrated denoising application, and how to validate these tools robustly across diverse patient populations and scanner platforms [20, 35].

### 4.4. Implications for Future Research, Practice, or Policy

The synthesis of this evidence base carries direct implications for the future trajectory of research, clinical practice, and health policy.

**Research:**

- **Outcome-Based Studies:** Future research must transition from technical feasibility to demonstrating improved patient outcomes. Large, prospective, multi-center studies are needed to prove that the use of ULDCT or chest MRI translates into tangible benefits like reduced long-term cancer risk, improved survival, or enhanced quality of life.
- **AI Validation and Standardization:** Rigorous, independent validation of AI algorithms for specific pediatric tasks is a critical research priority. This includes developing standards for training datasets and testing performance across different institutions.

- **MRI Protocol Optimization:** Research should focus on further accelerating chest MRI acquisitions to reduce scan time and the need for sedation, making it a more practical and widely accessible option.

**Practice:**

- **Education and Training:** Radiologists and referring clinicians require ongoing education about the new capabilities and appropriate indications for low-dose CT and MRI. This will prevent the outdated practice of ordering "standard-dose chest CT" as a default.
- **Clinical Decision Support:** The implementation of evidence-based clinical decision support systems within electronic order entry is crucial. These systems can guide referrers toward the most appropriate, lowest-risk imaging modality based on the clinical scenario, enforcing the principles of justification and optimization.

**Policy:**

- **Guideline Updates:** Professional societies (e.g., the American College of Radiology, Society for Pediatric Radiology) must proactively update their appropriateness criteria and practice guidelines to reflect the validated efficacy of ULDCT and the expanded role of MRI.
- **Reimbursement and Investment:** Healthcare policy and reimbursement models should support the adoption of these safer technologies. This may involve creating incentives for institutions that invest in advanced MRI hardware and AI software, ensuring equitable access to the best available imaging care for all children.

## 5. CONCLUSION

**Concise Summary of Main Points**

This review of literature from 2015 to 2023 highlights a transformative era in pediatric thoracic radiology. The field has moved beyond simply acquiring diagnostic images to optimizing the entire imaging pathway with a focus on safety. The widespread adoption of iterative reconstruction and ultra-low-dose CT protocols has dramatically reduced radiation exposure for children requiring cross-sectional imaging. Magnetic resonance imaging has matured into a powerful, radiation-free alternative for a range of conditions, particularly those involving the mediastinum, airways, and congenital anomalies. While chest radiography and ultrasound retain their vital roles as first-line tools, the advanced modalities have become safer and more versatile. The integration of artificial intelligence is poised to be the next major disruptive force, promising further gains in dose efficiency and diagnostic precision.

**Overall Implications and Recommendations**

The collective evidence mandates a change in standard practice. The following recommendations are proposed:

1. **For CT:** Low-dose protocols using iterative reconstruction should be the default standard for all pediatric chest CT examinations. Dose levels must be actively monitored and audited.
2. **For MRI:** Institutions should develop and promote dedicated pediatric chest MRI protocols to expand its clinical use, particularly for conditions requiring repeated imaging.
3. **For Referrers and Radiologists:** A collaborative, multimodal approach is essential. The choice of imaging should be guided by the "ALARA" principle, using clinical decision support tools to ensure appropriateness.
4. **For Researchers and Industry:** Efforts must continue to push the technological boundaries of dose reduction and to develop faster, more robust MRI techniques. The validation and clinical integration of AI tools should be a top priority.

By embracing these advancements, the radiology community can ensure that children receive the highest quality diagnostic care with the lowest possible risk.

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