



Pediatric thoracic magnetic resonance imaging: current evidence, technical advances, and clinical integration

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ABSTRACT

This review summarizes established, emerging, and investigational techniques in pediatric thoracic magnetic resonance (MR) imaging (MRI), with emphasis on practical protocol optimization, motion mitigation, clinical implementation, and modality selection relative to computed tomography (CT). Thoracic MRI remains technically challenging because of low proton density, short apparent transverse relaxation time, and continuous cardiorespiratory motion. Conventional fast and motion-robust sequences, including single-shot T2-weighted imaging, three-dimensional T1-weighted spoiled gradient echo imaging, short tau inversion recovery, balanced steady-state free precession, and periodically rotated overlapping parallel lines with enhanced reconstruction/BLADE, are well established and form the basis of routine clinical protocols. Contrast-enhanced MR angiography, perfusion imaging, diffusion-weighted imaging, and dynamic functional imaging are clinically available for selected indications, particularly in experienced centers. In contrast, ultrashort and zero echo time imaging remain emerging techniques because availability, reconstruction, and implementation vary across vendors and institutions. Non-contrast functional approaches, including Fourier decomposition and arterial spin labelling, remain predominantly investigational, and hyperpolarized gas MRI is primarily research-oriented and requires specialized infrastructure. Protocols should be adapted to patient age, cooperation, and the clinical question, using coaching, feed-and-wrap, sedation, or anesthesia when necessary. Magnetic resonance imaging can replace or complement CT in selected settings, including serial assessment of complicated pneumonia, cystic fibrosis, congenital thoracic abnormalities, mediastinal lesions, chest wall disorders, and selected vascular conditions. However, CT remains the reference standard for rapid emergency assessment, subtle interstitial abnormalities, and very small pulmonary nodules. Wider adoption of advanced MRI techniques will require protocol standardization, automated reconstruction and post-processing, cross-platform reproducibility, and prospective multicenter validation.

KEYWORDS

MRI, pediatric, pulmonary, radiation-free imaging, thoracic

Pulmonary and mediastinal diseases in infants and children comprise a heterogeneous group of congenital and acquired disorders causing considerable morbidity and mortality. Their clinical spectrum differs from adults, with several conditions unique to this population. Moreover, non-specific and variable clinical manifestations often delay diagnosis, emphasizing the importance of advanced imaging modalities.¹

Computed tomography (CT) remains the reference standard for evaluating lung and airway abnormalities due to its high spatial resolution. However, radiation exposure is a major limitation, particularly for children requiring repeated follow-up. Magnetic resonance imaging (MRI) has therefore emerged as a radiation-free alternative, offering excellent soft-tissue contrast and the ability to perform dynamic studies of respiratory mechanics, perfusion, and ventilation.²⁻⁶

Historically, thoracic MRI was limited by low proton density, rapid signal dephasing, and motion artefacts. Recent advances, including ultrashort echo time (UTE) and zero echo time (ZTE) sequences, have improved spatial resolution and motion robustness. In addition, Fourier decomposition can provide regional ventilation- and perfusion-weighted information

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without exogenous contrast, and arterial spin labelling (ASL) enables non-contrast perfusion assessment. Hyperpolarized gas MRI, in contrast, evaluates regional ventilation using inhaled noble gases.⁷⁻⁹

Collectively, these advances have improved the detection and characterization of clinically relevant thoracic abnormalities, with strong MRI–CT agreement reported for pulmonary consolidation, pleural effusion, major airway abnormalities, and congenital lesions, as well as high interobserver agreement in selected cohorts. However, MRI remains less sensitive for very small pulmonary nodules and subtle interstitial changes, supporting an indication-based role rather than universal substitution for CT.⁵⁻¹²

The distinctive contribution of this review is its implementation-oriented and clinically critical perspective. In addition to summarizing contemporary acquisition techniques and disease-specific applications, it explicitly distinguishes routinely established sequences from clinically available advanced methods and emerging or primarily investigational approaches. The review also examines real-world barriers to adoption, including vendor and platform dependency, specialized reconstruction and post-processing requirements, protocol heterogeneity,

and limited availability outside experienced tertiary centers. Furthermore, it translates the available evidence into practical frameworks for indication-based sequence prioritization, patient preparation, workflow integration, and selection between MRI and CT. By combining evidence maturity, technical feasibility, clinical decision-making, and future developments within a single pediatric-focused framework, the review aims to provide radiologists with guidance that is both educational and directly applicable to clinical practice.

Search strategy and study selection

This narrative review focuses on established and emerging techniques and clinical applications of pediatric thoracic MRI. The PubMed/MEDLINE, Scopus, and Web of Science databases were searched through July 2026 using combinations of “paediatric,” “pediatric,” “child,” “thoracic,” “chest,” “lung,” “pulmonary,” “magnetic resonance imaging,” “MRI,” “UTE,” “ZTE,” “diffusion-weighted imaging,” “perfusion,” “ventilation,” “arterial spin labelling,” “Fourier decomposition,” “hyperpolarized gas MRI,” and “MR angiography.” After deduplication, titles and abstracts were screened, followed by full-text assessment. Priority was given to pediatric studies, MRI–CT comparisons, clinical implementation studies, technical developments, practice recommendations, and landmark publications relevant to thoracic MRI. Adult or healthy-volunteer studies were included when directly relevant technical evidence was unavailable for pediatric populations. In total, 107 records were screened, and 55 publications were included in the qualitative synthesis. Animal-only studies, conference abstracts lacking sufficient methodological detail, non-English publications, studies lacking thoracic relevance, and duplicate analyses without additional information were excluded. As this was a narrative review, no meta-analysis or formal risk-of-bias assessment was performed.

Procedure details and patient preparation

The patient should be positioned supine for thoracic MRI. Although a body coil can be utilized as a receive coil, using a local receive coil array optimized for thoracic imaging substantially improves the signal-to-noise ratio (SNR). Typical thoracic MRI coils consist of a flexible anterior part and a posterior part embedded within the patient table.¹³ Proper preparation is crucial for obtaining high-quality diagnostic images. For children aged > 5 years, coaching to perform specific

breathing maneuvers and instructions to remain still during the scan are highly effective. Pre-scan preparations, including an explanation of the magnet, table movement, and loud noises associated with the MRI, help reduce anxiety and improve compliance. Mock MRI environments can further aid in familiarizing children with the procedure, increasing success rates. Parental presence and distraction techniques, such as video goggles, can also alleviate anxiety and minimize the need for sedation.^{14,15}

For children aged < 5 years and those unable to follow instructions, moderate sedation or general anesthesia is typically required. Sedation agents such as midazolam or chloral hydrate are commonly used due to their efficacy and safety profiles. However, the risk of anesthesia-related complications, such as atelectasis, necessitates careful planning to minimize scan duration and optimize image acquisition. In neonates and infants, many centers adopt the “feed-and-wrap” method, where the infant is fed immediately before the scan and swaddled to promote comfort and minimize movement during imaging. Although this method is effective for static body parts, its application in lung imaging may be limited due to respiratory motion and higher resting respiratory rates in this age group.^{14,16}

Careful preparation and a tailored approach based on the child’s age and maturity are essential for successful imaging. Co-operative children with adequate coaching can achieve high-quality diagnostic images without sedation, whereas younger or more anxious children may benefit from sedation or anesthesia to ensure diagnostic accuracy. The choice of preparation methods must balance image quality with the safety and comfort of the patient.¹⁴

Technical challenges and contemporary solutions in pediatric thoracic magnetic resonance imaging

The physical properties of the lung parenchyma differ markedly from those of soft tissues, such as the liver or brain, posing unique challenges for MRI. The two main limitations are low proton density and marked susceptibility differences at air–tissue interfaces.

Low proton density

The lung’s proton density (≈ 0.1 g/cm³) produces an MR signal nearly 10 times weaker than that of surrounding tissues, resulting in an inherently low SNR. Increasing the voxel size can improve the SNR but risks missing

Main points

- Thoracic magnetic resonance imaging (MRI) provides a radiation-free alternative to computed tomography (CT) for evaluating pulmonary, mediastinal, and chest wall diseases in children.
- Recent technical advances, such as ultra-short and zero echo time sequences, have substantially improved thoracic MRI image quality and motion robustness.
- Fourier decomposition and arterial spin labelling enable non-contrast assessment of regional ventilation and/or perfusion, whereas hyperpolarized gas MRI evaluates ventilation using inhaled noble gases and remains primarily research-oriented.
- Tailored pediatric imaging protocols and preparation strategies allow high-quality scans while minimizing the need for sedation.
- MRI demonstrates diagnostic performance comparable with CT for infections, congenital anomalies, tumors, and vascular diseases, making it a promising tool in pediatric thoracic imaging.
- MRI should be viewed as a complementary or alternative modality rather than a universal replacement for CT, with modality selection guided by the clinical scenario.

small lesions due to partial volume effects. Signal averaging enhances the image quality but increases the acquisition time, limiting routine clinical use.¹³

Susceptibility differences

At air–tissue boundaries, paramagnetic oxygen and diamagnetic tissue create local magnetic field inhomogeneities that cause rapid signal dephasing. The apparent transverse relaxation time (T_2^*) is extremely short—around 2 ms at 1.5 T and even shorter at 3 T—making conventional gradient echo (GRE) imaging challenging and requiring pulse sequences with echo times < 1–2 ms.¹³

Motion-related challenges

Beyond these intrinsic physical limitations, thoracic MRI is further complicated by constant motion from respiration and cardiac pulsation. These induce artefacts that obscure anatomic details, particularly at the lung bases and pericardiac regions. The effect is most pronounced in children, whose irregular breathing patterns hinder reproducibility. Thus, motion control remains essential for acquiring diagnostic-quality images.¹⁷

Strategies for addressing imaging challenges

Key techniques used to optimize lung MRI and minimize motion artefacts are summarized in Figure 1.

1. Optimizing field strength

Lower field strengths, such as 1.5 T, are preferred for thoracic MRI because they reduce susceptibility artefacts and motion distortions compared with 3 T systems. Although 3 T scanners provide a higher SNR and improved lesion contrast, they also amplify field inhomogeneity, producing banding artefacts in sequences such as true fast imaging with steady-state precession. Low-field scanners (< 0.5 T) further minimize susceptibility effects but often at the cost of longer acquisition times.^{10,17}

2. Short echo time sequences

To capture signal from tissues with very short T_2^* values, MRI sequences such as UTE and ZTE are used. These employ radial or center-out k-space trajectories, enabling signal acquisition immediately after excitation and minimizing decay; UTE typically uses echo times < 1 ms, and in ZTE, the echo time is effectively zero.^{1,18}

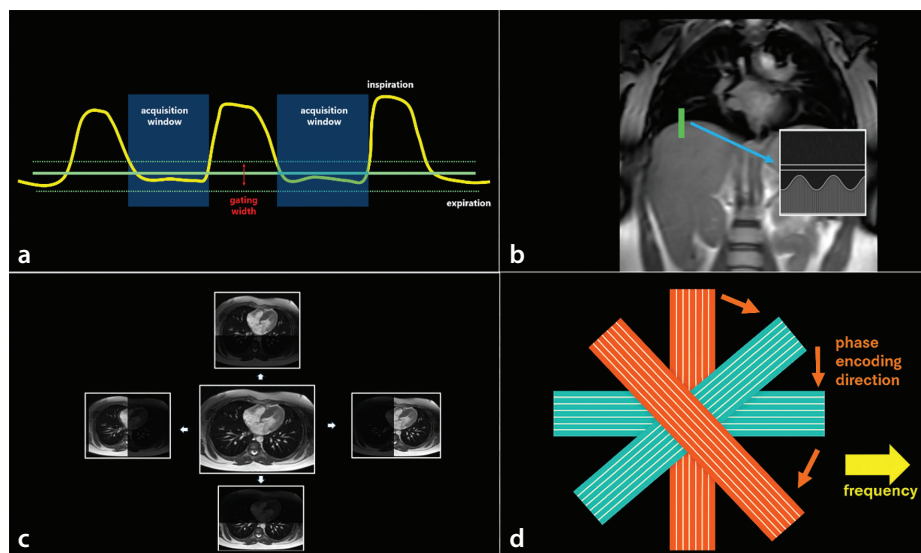


Figure 1. Techniques to optimize lung magnetic resonance imaging: **a)** respiratory gating, **b)** navigator echoes, **c)** parallel imaging, **d)** periodically rotated overlapping parallel lines with enhanced reconstruction.

3. Respiratory gating and navigator echoes

Respiratory gating synchronizes acquisition with the breathing cycle, typically capturing data during end-expiration when motion is minimal. An external respiratory bellows monitors chest wall motion. Navigator echoes further refine this by tracking diaphragmatic position using rapid MR pulses, accepting data only when the diaphragm is within a target window. Although both methods reduce motion artefacts, they prolong scan duration.^{14,19}

4. Parallel imaging

Parallel imaging accelerates acquisition by undersampling k-space and reconstructing the missing data using spatial sensitivity profiles from multiple coils. This reduces the number of phase-encoding steps, shortening breath-hold times, and improving patient comfort—particularly in pediatric or dyspneic patients.¹³

5. Periodically rotated overlapping parallel lines with enhanced reconstruction techniques

Radial k-space sampling techniques, such as periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) and BLADE, are highly effective in mitigating motion artefacts. By rotating radial trajectories and oversampling central k-space, they inherently correct for in-plane motion and provide robust motion averaging. These techniques are especially advantageous for uncooperative or free-breathing children.¹

6. Adjusting lung inflation state

Imaging during expiration enhances the parenchymal signal by increasing the proton density and reducing susceptibility artefacts, whereas full inspiration provides a darker background that improves vascular and nodule contrast. The choice of phase depends on diagnostic goals.³

Current limitations of technical solutions

Despite substantial technical progress, implementation of advanced thoracic MRI remains uneven across institutions. Respiratory gating and navigator-based acquisitions may prolong examinations and can be difficult to apply in young or uncooperative children. Advanced methods may also depend on vendor-specific sequence packages, compatible reconstruction platforms, optional or proprietary software licenses, and dedicated post-processing pipelines. Differences in scanner hardware, acquisition parameters, reconstruction algorithms, and operator expertise consequently limit reproducibility and cross-center comparability. Broader adoption will require improved vendor integration, automated processing, protocol harmonization, and prospective multicenter validation.^{2,6,10,12,13,19}

Evidence maturity of contemporary techniques

The current level of clinical implementation varies substantially across thoracic MRI techniques. Conventional sequences, including fast spin-echo imaging, T1-weighted spoiled GRE, short tau inversion recovery, balanced steady-state free precession (SSFP),

and motion-robust radial techniques, such as PROPELLER/BLADE, are well established and routinely incorporated into pediatric thoracic MRI protocols. Other advanced methods, including contrast-enhanced MR angiography (CEMRA), contrast-enhanced perfusion imaging, diffusion-weighted imaging (DWI), and dynamic functional imaging, are clinically available but are generally applied in selected indications and experienced centers. In contrast, UTE and ZTE imaging should be considered emerging techniques, as their availability and implementation remain variable across vendors and institutions. Non-contrast functional approaches, such as Fourier decomposition and ASL, remain predominantly at the early clinical or investigational stage because of limited standardization, specialized reconstruction and post-processing requirements, and relatively limited multicenter validation. Hyperpolarized gas MRI remains primarily research-oriented and is currently confined largely to specialized centers with the necessary hardware, gas-production infrastructure, regulatory approval, and technical expertise. Accordingly, these techniques should not be interpreted as having equivalent levels of evidence or routine clinical readiness, and further multicenter validation and technical standardization are required before the emerging and investigational approaches can be recommended for widespread clinical adoption.^{2,6,8,19}

Core magnetic resonance imaging sequences in pediatric thoracic imaging and magnetic resonance imaging protocols

Recent advances in MRI technology have enabled detailed lung imaging protocols that minimize motion artefacts while maximizing diagnostic yield. These protocols are divided into standard fast imaging sequences and advanced techniques for both structural and functional assessment.

Standard fast imaging sequences

The T2-weighted single-shot fast spin-echo (SSFSE) sequence is a cornerstone of lung MRI, providing rapid, motion-robust imaging that is particularly useful for evaluating airspace disease. Although SSFSE may depict indirect signs of pulmonary embolism, dedicated techniques, such as CEMRA and perfusion imaging, are required for reliable assessment.^{1,10}

The three-dimensional (3D) T1-weighted spoiled GRE sequence is essential for both pre- and post-contrast imaging. It offers high

spatial resolution for evaluating vascular structures and solid lesions, and its dynamic capability aids assessment of contrast enhancement patterns and disease monitoring.¹

Short tau inversion recovery enhances lesion conspicuity by suppressing fat signals, improving contrast between lesions and surrounding tissue. It is especially useful for detecting edema and mediastinal lymph nodes.^{1,3}

The balanced SSFP sequence provides high signal intensity and excellent tissue contrast with inherent T2/T1 weighting. It is valuable for dynamic studies, such as diaphragmatic motion, cardiac function, and pulmonary embolism evaluation, though it is sensitive to magnetic field inhomogeneity, causing banding artefacts.²

PROPELLER sequences use rotating radial k-space sampling to effectively reduce motion artefacts, making them highly suitable for imaging non-cooperative or pediatric patients.²

Clinically available advanced techniques

CEMRA achieves high temporal resolution using dynamic techniques such as time-resolved imaging of contrast kinetics and time-resolved angiography with interleaved stochastic trajectories, enabling thoracic MRA within a few seconds. These techniques are clinically established for the evaluation of congenital and acquired vascular abnormalities, including anomalous pulmonary venous return, pulmonary embolism, arteriovenous malformations, and aortic pathology. Their implementation nevertheless depends on appropriate contrast administration, temporal coordination, and local expertise in pediatric vascular imaging.^{20,21}

Non-contrast MRA provides an alternative for children requiring repeated vascular assessment and for patients in whom gadolinium administration is undesirable. The most established thoracic technique is electrocardiographic- and respiratory navigator-gated 3D balanced SSFP, which yields high-resolution images of the thoracic aorta and central great vessels without contrast. In congenital heart disease, these measurements show good agreement with CEMRA, and newer free-breathing methods using self-navigation, radial sampling, and compressed sensing further improve motion robustness. However, non-contrast MRA remains limited by longer acquisition times, reduced temporal information, and variable image quality,

particularly for small or fast-flowing vessels, and is therefore best used as a complementary tool in experienced centers; CEMRA or CT may still be required when higher spatial or temporal resolution is needed.^{22,23}

Contrast-enhanced MR perfusion imaging employs time-resolved 3D T1-weighted sequences to assess the first passage of contrast material through the pulmonary circulation. It can demonstrate regional perfusion abnormalities associated with pulmonary embolism, vascular obstruction, and hypoxic vasoconstriction. Although clinically available, its use is generally indication-specific and requires optimization of temporal resolution, contrast timing, and respiratory motion control.^{24,25}

Dynamic functional imaging uses rapid, low-spatial-resolution acquisitions to evaluate respiratory mechanics, diaphragmatic motion, chest wall dynamics, airway collapse, and tumor movement. These methods are particularly useful for functional assessment and radiotherapy planning and can be incorporated into clinical protocols in centers with relevant expertise.^{8,19}

DWI provides qualitative and quantitative information on tissue cellularity and may aid in the characterization of pulmonary, mediastinal, and chest wall lesions. It is most commonly performed using single-shot echo-planar imaging (EPI), which enables rapid acquisition but is prone to susceptibility-related distortion and signal loss, particularly at air-tissue interfaces.²⁶ Alternative approaches, such as readout-segmented EPI and reduced-field-of-view techniques—including vendor-specific implementations, such as ZOOMit—can reduce distortion and improve spatial resolution but at the cost of longer acquisition times, reduced coverage, and limited validation in pediatric thoracic imaging; therefore, they remain optional rather than standard techniques.^{27,28}

Intravoxel incoherent motion (IVIM) extends conventional DWI by using multiple b-values to separate diffusion and perfusion-related effects. Although it may provide additional microvascular information, its parameters show variable diagnostic performance, require complex post-processing, and have not demonstrated consistent superiority over standard apparent diffusion coefficient (ADC) measurements. Accordingly, IVIM is still considered investigational, particularly in children.²⁹

Lesion size markedly affects DWI performance. Sensitivity increases with size, from

approximately 44% for 3–5 mm nodules to 97% for lesions ≥ 10 mm. ADC measurements are less reliable in lesions < 2 cm due to partial-volume effects and a lower SNR. Reported ADC thresholds for malignancy vary widely, and no universal cut-off exists. These data are primarily derived from adult populations and should be applied with caution in pediatric imaging.³⁰

Emerging and investigational techniques

Both UTE and ZTE imaging overcome the rapid signal decay associated with the short T2* of lung parenchyma by using non-Cartesian k-space trajectories and very short or effectively ZTEs. These techniques improve visualization of pulmonary structures and have shown promising performance in the assessment of cystic fibrosis and pulmonary nodules. Nevertheless, UTE and ZTE should currently be regarded as emerging rather than universally established techniques because their availability, sequence implementation, reconstruction methods, and software integration remain vendor- and platform-dependent.^{2,18}

Non-contrast image-decomposition techniques, including Fourier decomposition and related free-breathing approaches, derive regional ventilation- and perfusion-weighted information from respiratory- and cardiac-related signal variations in time-resolved proton MRI data. These techniques do not require intravenous contrast administration or inhaled tracer gases and are therefore attractive for children requiring repeated functional assessment. However, they are not yet widely implemented in routine pediatric practice because they commonly require dedicated reconstruction algorithms, image registration, and specialized post-processing workflows. Protocol heterogeneity, differences in quantitative outcome measures, and limited multicenter validation further restrict direct comparison and widespread adoption. Further technical standardization, automated processing pipelines, and broader vendor integration will therefore be necessary before these methods can be routinely incorporated into clinical protocols.^{7,8,19}

ASL is a non-contrast perfusion MRI technique in which radiofrequency pulses magnetically label inflowing arterial blood water, allowing it to act as an endogenous tracer; subtraction of labelled and control images yields perfusion-weighted maps without gadolinium and enables repeated measurements within a single examination. Pulmonary ASL has shown sensitivity to regional

perfusion gradients and defects, making it attractive for pediatric and serial imaging where contrast agents are undesirable. However, it remains investigational due to low lung proton density, short T2*, motion sensitivity, and dependence on physiological and technical parameters, such as transit time, lung inflation, and labelling efficiency, all of which limit quantification and reproducibility. Current evidence is based mainly on small adult feasibility studies with minimal pediatric validation; therefore, ASL should be considered a promising research tool rather than a clinical alternative to contrast-enhanced pulmonary perfusion MRI.^{31–33}

Hyperpolarized gas MRI enables regional ventilation assessment using inhaled hyperpolarized noble gases, most commonly ¹²⁹Xe and, historically, ³He. Despite its unique functional capabilities, the technique remains primarily research-oriented. It requires specialized hardware, dedicated acquisition and reconstruction software, access to gas-polarization infrastructure, site-specific technical expertise, and compliance with regulatory and licensing requirements. The associated costs and logistical challenges of gas production, storage, and administration currently restrict its use largely to specialized research institutions and tertiary referral centers. Broader clinical adoption will depend on improved commercial availability, regulatory harmonization, protocol standardization, and multicenter outcome-based validation.^{7,8,19}

Future directions

Future progress in pediatric thoracic MRI is likely to depend not only on the development of individual sequences but also on the integration of accelerated acquisition, motion-resolved imaging, and advanced reconstruction methods. Compressed sensing, self-navigated radial or non-Cartesian acquisitions, and artificial intelligence-assisted reconstruction may enable shorter, high-resolution, free-breathing examinations while reducing motion artefacts and potentially decreasing the need for sedation. Deep-learning approaches may also support denoising, automated motion correction, image registration, and reconstruction of respiratory-resolved 3D datasets. However, preservation of subtle pathological findings, reproducibility across scanner platforms, and generalizability beyond the institutions in which these algorithms were developed require prospective multicenter validation before routine clinical implementation.^{34,35}

A parallel area of development is the transition from qualitative image interpretation towards reproducible quantitative imaging biomarkers. Automated segmentation and analysis of the lungs, airways, vessels, and lesions may facilitate longitudinal measurement of structural disease burden, regional ventilation and perfusion abnormalities, diffusion characteristics, and treatment response. Quantitative MRI and radiomics could potentially identify imaging phenotypes that are not apparent through visual assessment alone and support more personalized surveillance strategies. Nevertheless, variations in acquisition parameters, reconstruction methods, segmentation, feature extraction, and patient populations currently limit comparability across studies. Future research should therefore prioritize protocol harmonization, external validation, interpretable quantitative endpoints, and demonstration that these biomarkers provide clinically meaningful information beyond conventional imaging assessment.^{36,37}

Protocol adaptation based on patient demographics and clinical indications

MRI protocols must be tailored to patient age and clinical need. Patient preparation and the need for sedation or feed-and-wrap should be individualized as detailed in the “Procedure Details and Patient Preparation” section.

Conventional sequences (e.g., T1-, T2-weighted, balanced SSFP, PROPELLER) remain central to pediatric protocols. Breath-hold 3D T1-weighted GRE identifies small solid lesions, whereas single-shot two-dimensional T2-weighted imaging is used for larger pathologies. Advanced imaging techniques further enhance diagnostic accuracy.

Serai et al.² proposed standard parameters for currently available techniques; Table 1 summarizes key imaging parameters, and Table 2 demonstrates their implementation by major vendors.

From a practical workflow perspective, motion-robust anatomical sequences should be prioritized early in the examination to ensure that a diagnostically useful core dataset is obtained even if the study is interrupted. Additional structural, functional, vascular, or diffusion-weighted sequences should then be selected according to the clinical question, patient cooperation, and local technical availability. Table 3 provides a pragmatic indication-based framework for sequence prioritization and workflow integration; it is

intended as a practical guide rather than a prescriptive universal protocol.

Clinical decision framework: when should magnetic resonance imaging replace, complement, or follow computed tomography?

Modality selection should be guided by the clinical question, urgency, need for serial imaging, and potential value of functional or soft-tissue information rather than by a binary “MRI versus CT” approach. Tables 4 and 5 summarize the relative strengths of each modality and provide an indication-based framework for imaging selection.^{2,4,6,10}

Situations in which magnetic resonance imaging may replace computed tomography

MRI may serve as a primary imaging modality in selected clinical scenarios where repeated imaging is anticipated and where diagnostic performance approaches that of CT. This is particularly relevant in children with cystic fibrosis, chronic airway disease, complicated pneumonia during follow-up, congenital thoracic malformations, mediastinal masses, and chest wall tumors. In these settings, MRI provides excellent soft-tissue contrast and allows repeated examinations without cumulative radiation exposure. Furthermore, MRI offers functional information regarding ventilation, perfusion, and respiratory mechanics that cannot be obtained from routine CT examinations.^{2,6,9,19}

Situations in which magnetic resonance imaging complements computed tomography

In many clinical settings, MRI should be regarded as complementary rather than competitive to CT. Examples include interstitial lung diseases, complex infections, vascular anomalies, and oncologic imaging. CT frequently provides superior assessment of fine parenchymal detail, whereas MRI contributes additional information regarding tissue composition, inflammatory activity, vascular involvement, treatment response, and functional impairment. Combining both modalities may therefore provide a more comprehensive evaluation than either technique alone.^{4,6,14,24,38}

Situations in which computed tomography remains the preferred modality

Despite substantial technical advances, MRI continues to have limitations that restrict its use in certain scenarios. CT remains the preferred modality when detection of very small pulmonary nodules, subtle interstitial

Table 1. Example parameters used at Dokuz Eylül University Faculty of Medicine, Department of Paediatric Radiology (may vary across vendors)

Parameter	T2-weighted SSFSE or HASTE	T1-weighted	STIR	SSFP	PROPELLER
Pulse sequence type	2D	3D	2D	2D	2D
Matrix	208 × 208	184 × 124	256 × 256	172 × 138	268 × 268
No. of signals acquired	1	1	2	1	1
Acceleration factor	2	2	1.5	2	2
TR/TE	2,500/100	4/2	3,800/60	3.3/1.65	2,200/80
No. of slices	30–40	60–80	40–60	30–40	30–40
Slice thickness (mm)	5	5	4	5	6
Gap (mm)	6	2.5	4.4	5.5	7
Frequency direction					
FOV setting (mm)	250	250	360	250	400
Flip angle (°)	90	10	90	90	90
Acquisition plane	Axial	Axial	Coronal	Axial	Axial
Approximate scan time	50 s	20 s	2 min	1 min 20 s	2 min 40 s

SSFSE, single-shot fast spin-echo; HASTE, half-Fourier acquisition single-shot turbo spin-echo; STIR, short tau inversion recovery; SSFP, steady-state free precession; PROPELLER, periodically rotated overlapping parallel lines with enhanced reconstruction; FOV, field of view; TR, repetition time; TE, echo time; 2D, two-dimensional; 3D, three-dimensional.

Table 2. Equivalent vendor-specific sequence names for commonly used thoracic magnetic resonance imaging protocols in pediatric imaging

Parameter	T2-weighted SSFSE	T1-weighted	STIR	SSFP	PROPELLER
Siemens	HASTE	VIBE (ce) Flash (ang) TWIST (perf)	STIR	TrueFISP	BLADE
Philips	Halfscan FSE	THRIVE (ce) FFE (ang) TRAK (perf)	STIR	bFFE	MultiVane (MVXD)
GE	½ NEX FSE	LAVA (ce) SPGR (ang) TRICKS (perf)	STIR	FIESTA	PROPELLER
Hitachi	Half scan Single shot FSE	TIGRE RF spoiled SARGE TRAQ	STIR	BASG	RADAR
Toshiba	AFI RO	Quick3D FE, FFE DRKS	STIR	TrueSSFP	JET

SSFSE, single-shot fast spin-echo; HASTE, half-Fourier acquisition single-shot turbo spin-echo; VIBE, volumetric interpolated breath-hold examination; ce, contrast-enhanced; ang, angiography; TWIST, time-resolved angiography with stochastic trajectories; perf, perfusion; FSE, fast spin-echo; THRIVE, T1 high-resolution isotropic volume examination; FFE, fast field echo; TRAK, time-resolved angiography; NEX, number of excitations; LAVA, liver acquisition with volume acceleration; SPGR, spoiled gradient recalled echo; TRICKS, time-resolved imaging of contrast kinetics; TIGRE, T1-weighted gradient echo; RF, radiofrequency; SARGE, spoiled acquisition in the reconstructed gradient echo; AFI RO, auto flip angle rocking; FE, field echo; DRKS, driven equilibrium; STIR, short tau inversion recovery; SSFP, steady-state free precession; TrueFISP, true fast imaging with steady-state precession; bFFE, balanced fast field echo; FIESTA, fast imaging employing steady-state acquisition; BASG, balanced SARGE; PROPELLER, periodically rotated overlapping parallel lines with enhanced reconstruction; BLADE, vendor-specific name for PROPELLER (Siemens); MultiVane (MVXD), vendor-specific name for PROPELLER (Philips); RADAR, vendor-specific name for PROPELLER (Hitachi); JET, vendor-specific name for PROPELLER (Toshiba).

abnormalities, or acute traumatic injuries is required. Similarly, emergency situations often favor CT because of its widespread availability, rapid acquisition, and lower susceptibility to motion artefacts. Consequently, MRI should not currently be considered a com-

plete replacement for CT in routine thoracic imaging.^{6,10,12}

Practical approach to imaging selection

From a practical perspective, CT should remain the first-line modality when maxi-

Clinical indication	Prioritized core sequences	Targeted additional sequences	Contrast administration	Motion and workflow considerations	Important limitation or indication for CT
Complicated pneumonia and infection follow-up	Axial and coronal T2-weighted SSFSE/HASTE; motion-robust PROPELLER/BLADE; T1-weighted GRE	DWI for suspected abscess or empyema; post-contrast fat-suppressed T1-weighted imaging for necrosis, abscess, pleural enhancement, or lymphadenopathy	Not routinely required for uncomplicated follow-up; recommended when complications or tissue viability must be assessed	Acquire free-breathing, motion-robust sequences first; add respiratory triggering when initial image quality is inadequate	CT remains preferable for rapid emergency assessment or detailed evaluation of subtle parenchymal abnormalities
Cystic fibrosis and chronic airway disease	T2-weighted SSFSE/HASTE; PROPELLER/BLADE; 3D T1-weighted GRE; balanced SSFP	Contrast-enhanced perfusion MRI; UTE/ZTE when available; dynamic imaging for respiratory mechanics	Optional; determined by the need for perfusion or inflammatory assessment	Use coached breath-hold imaging in cooperative children; prefer free-breathing radial or motion-robust techniques in younger children	CT may still be required for subtle bronchiectasis, small-airway abnormalities, or fine structural detail
Congenital thoracic malformations	Multiplanar T2-weighted imaging; 3D T1-weighted GRE; balanced SSFP	Contrast-enhanced or non-contrast MRA for systemic arterial supply and venous drainage; dynamic imaging when functional assessment is required	Frequently useful when vascular anatomy must be defined; may be avoided when diagnostic non-contrast MRA is available	Feed-and-wrap may be attempted in neonates; sedation or anesthesia may be required when detailed vascular imaging is essential	CT may be complementary when maximal spatial resolution, airway detail, or assessment of calcification is required
Mediastinal masses and cysts	T1-weighted, T2-weighted, STIR, and balanced SSFP imaging in at least two planes	DWI and ADC mapping; chemical-shift imaging for thymic or fat-containing lesions; post-contrast fat-suppressed T1-weighted imaging	Generally recommended for solid masses, suspected invasion, or vascular involvement	Acquire motion-robust anatomical imaging before longer DWI and contrast-enhanced acquisitions	CT may be added for calcification, osseous involvement, or detailed lung assessment
Chest wall tumors and inflammatory lesions	T1-weighted, T2-weighted, and STIR imaging with sufficiently wide anatomical coverage	DWI and ADC mapping; post-contrast fat-suppressed T1-weighted imaging; dynamic contrast-enhanced imaging in selected tumors	Generally recommended for tumor characterization, local staging, abscess, or osteomyelitis	Select an appropriate surface coil and ensure coverage of the entire lesion and adjacent thoracic structures	CT is complementary for cortical bone destruction, mineralization, and calcification
Thoracic vascular abnormalities	Balanced SSFP and multiplanar anatomical imaging	Time-resolved CEMRA; navigator-gated non-contrast 3D SSFP MRA; phase-contrast imaging when flow quantification is required	Determined by the vascular question and feasibility of non-contrast imaging	ECG and respiratory gating may improve image quality but increase examination time; contrast-enhanced techniques may be prioritized when rapid vascular assessment is required	CT angiography may be preferred in emergencies or when assessment of small distal vessels and maximal spatial resolution is essential
Airway, diaphragmatic, and chest wall motion disorders	Dynamic balanced SSFP or other rapid cine sequences; anatomical T2-weighted imaging	Targeted inspiratory and expiratory acquisitions; free-breathing dynamic imaging	Usually not required	Perform imaging during spontaneous respiration when functional collapse or abnormal motion is the primary clinical question	CT or bronchoscopy may remain necessary for detailed assessment of small-airway anatomy
Interstitial lung disease or suspected very small pulmonary nodules	MRI should be used selectively; T2-weighted imaging and UTE/ZTE may be obtained when available	Functional or perfusion imaging may provide complementary information in follow-up or research settings	Usually not required unless another clinical question warrants administration	Avoid prolonging the examination with advanced sequences that are unlikely to answer the primary clinical question	CT remains the reference standard for subtle interstitial abnormalities and pulmonary nodules smaller than approximately 3–4 mm
The suggested sequence priorities represent a pragmatic framework based on current evidence and clinical practice rather than a prescriptive universal protocol. Protocols should be adapted according to patient age and cooperation, the specific clinical question, scanner platform, local expertise, and availability of advanced sequences. ADC, apparent diffusion coefficient; CEMRA, contrast-enhanced MR angiography; DWI, diffusion-weighted imaging; ECG, electrocardiographic; GRE, gradient echo; HASTE, half-Fourier acquisition single-shot turbo spin-echo; MRA, magnetic resonance angiography; SSFP, steady-state free precession; SSFSE, single-shot fast spin-echo; STIR, short tau inversion recovery; UTE, ultrashort echo time; ZTE, zero echo time.					

mal spatial resolution and rapid diagnostic assessment are required. Conversely, MRI should be strongly considered in radiation-sensitive populations requiring serial examinations, in diseases where functional

assessment may influence management, and in situations where superior soft-tissue characterization provides additional clinical value. Suggested imaging strategies for common pediatric thoracic indications are

summarized in Table 5. The optimal imaging strategy is therefore not an “MRI versus CT” approach but rather the integration of both modalities according to the specific clinical scenario.^{4,6,9,10}

Table 4. Comparative diagnostic utility of MRI and CT for thoracic pathologies		
MRI > CT	MRI = CT	MRI < CT
Mediastinal masses	Pneumonia	Pulmonary nodule (< 3–4 mm)
Complex mass (mediastinum-chest wall invasion)	Atelectasis	Interstitial lung disease
Perfusion deficits (embolism, hypoxic ventilation conditions)	Cystic fibrosis	Emphysema
Cystic fibrosis (perfusion imaging)	Pulmonary nodule (> 3–4 mm)	
	Congenital lung anomalies	
	Vascular pathologies (pulmonary embolism, anomalous pulmonary venous return, pulmonary artery aneurysm, arteriovenous malformation, vasculitis)	
	Pleural effusion	
Comparative diagnostic utility of magnetic resonance imaging (MRI) and computed tomography (CT) for thoracic pathologies in pediatric patients, highlighting conditions where MRI outperforms CT, offers equivalent diagnostic value, or is less sensitive than CT.		

Table 5. Suggested imaging strategy for common pediatric thoracic clinical scenarios		
Clinical scenario	Preferred modality	Role of magnetic resonance imaging (MRI)
Small pulmonary nodules (< 3–4 mm)	Computed tomography (CT)	Limited; lower sensitivity than CT
Acute thoracic trauma	CT	Limited role
Complicated pneumonia (follow-up)	MRI	Alternative to CT, particularly for serial imaging
Cystic fibrosis surveillance	MRI	Preferred for longitudinal follow-up and functional assessment
Chronic airway disease	MRI	Valuable for repeated assessment and functional evaluation
Congenital thoracic malformations	MRI ± CT	MRI for anatomical and vascular characterization; CT when high spatial resolution is required
Mediastinal masses and cysts	MRI	Preferred due to superior soft-tissue contrast
Chest wall tumors	MRI	Preferred for local staging and assessment of invasion
Vascular anomalies	MRI/CT	Selection depends on the clinical question and local expertise
Interstitial lung disease	CT	Primary modality; MRI may provide complementary functional information
Suggested imaging strategy based on currently available evidence. Recommendations are intended as a practical framework and should be adapted according to clinical indication, local expertise, scanner availability, and patient-specific factors.		

Overall, current evidence supports a disease-specific and patient-centered imaging strategy. Although CT remains indispensable in many circumstances, MRI has evolved from a niche technique into a clinically relevant modality that can replace or complement CT in an increasing number of pediatric thoracic indications.^{6,8,9,19}

Clinical applications of pediatric thoracic magnetic resonance imaging

The strength of evidence supporting pediatric thoracic MRI varies considerably across clinical indications. Most available studies are observational, frequently single-center, and include relatively small or clinically selected patient cohorts, with substantial heterogeneity in acquisition protocols, comparator techniques, and diagnostic endpoints. The most consistent pediatric evidence supports MRI for the assessment and follow-up of complicated pneumonia, cystic fibrosis, congenital thoracic abnormalities, and mediastinal or chest wall lesions, particularly when avoidance of repeated radiation

exposure is clinically important. In contrast, evidence remains more limited for subtle interstitial lung disease, very small pulmonary nodules, and several advanced functional or quantitative techniques. Accordingly, the following disease-specific applications should be interpreted within the context of variable evidence maturity, and reported equivalence with CT should not be generalized beyond the clinical question, lesion type, and MRI protocol evaluated in the original studies.

• Lung parenchymal pathologies

Pneumonia

Pneumonia is one of the most common causes of illness and hospitalization in children. Although uncomplicated pneumonia can often be diagnosed clinically, imaging becomes crucial when complications are suspected.² MRI offers a distinct advantage in this setting, as inflammation and consolidation result in increased proton density, which enhances signal contrast against the normally signal-poor lung parenchyma.^{39–41}

MRI findings in pneumonia largely mirror those of CT, including consolidation, ground-glass opacities, necrosis, abscess formation, lymphadenopathy, and pleural complications. Consolidation appears as a homogeneous signal intensity, obscuring vascular and bronchial structures—hyperintense on T2-weighted and isointense on T1-weighted images with homogeneous contrast enhancement. Ground-glass opacities manifest as hazy T2-hyperintense regions that do not obscure underlying structures.^{11,39}

Complications such as necrosis and abscesses are well characterized on MRI. Necrosis appears as non-enhancing parenchyma, often T2-hypointense within hyperintense consolidation. Abscesses show T2 hyperintensity, restricted diffusion, and peripheral rim enhancement. MRI can detect air-fluid levels or air locules as signal-void areas.³⁹

Mediastinal and hilar lymphadenopathy is commonly seen, with MRI delineating nodal enhancement and necrosis due to its high contrast resolution. Pleural effusions appear

T2-hyperintense and T1-hypointense; empyemas show pleural thickening, septations, heterogeneous signal, and diffusion restriction, allowing confident differentiation from simple effusions.^{10,39}

In pediatric pneumonia, thoracic MRI has demonstrated diagnostic accuracy comparable with CT for detecting pulmonary consolidation and major complications. Prospective and retrospective studies have shown no notable difference between MRI and CT in identifying pneumonia-related findings, and MRI provides superior depiction of necrosis, abscess formation, and pleural septations without ionizing radiation.^{11,42}

Importantly, thoracic MRI has shown near-perfect interobserver agreement, with reported κ values of approximately 0.95–0.98 for consolidations, pleural effusions, and pulmonary abscesses, indicating robust diagnostic reliability in both acute and follow-up settings.¹¹

Current evidence suggests that MRI may serve as an alternative to CT for the evaluation and follow-up of complicated pneumonia in children, particularly when repeated imaging is anticipated. However, CT may still be preferred when rapid assessment or comprehensive evaluation of the lung parenchyma is required.

In Figure 2, a 4-year-old girl with necrotizing pneumonia demonstrates cavitory consolidation, subcarinal lymphadenopathy, and pleural empyema.

Hydatid cysts

Hydatid disease, caused by the larval form of *Echinococcus*, is a global zoonosis with the lungs as one of the most commonly affected organs, second only to the liver. Within the thorax, hydatid cysts (HCs) most frequently occur in the lung parenchyma, but extrapulmonary involvement, including the pleural space, fissures, mediastinum, diaphragm,

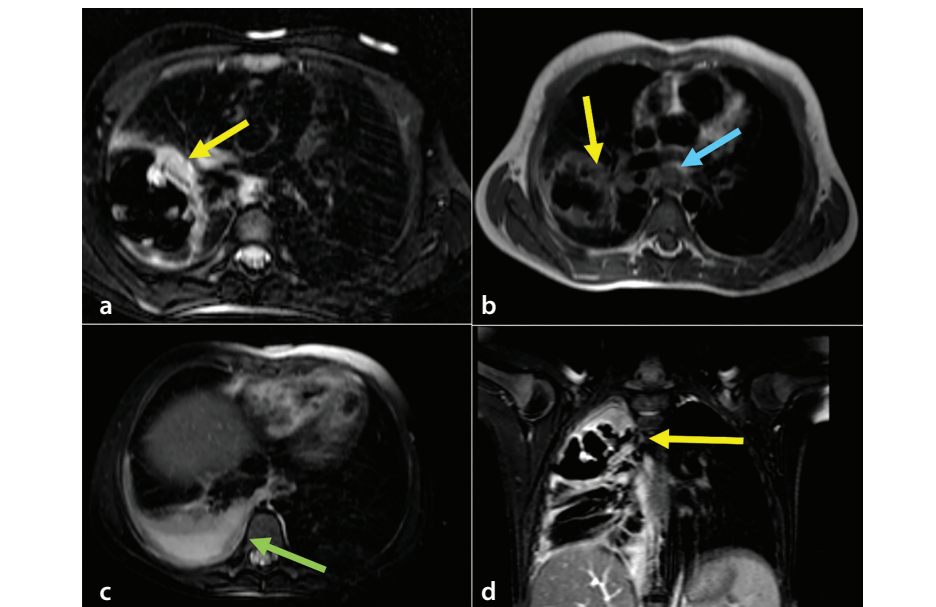


Figure 2. A 4-year-old girl with necrotizing pneumonia. A cavitory lesion with lobulated contours and thick walls is seen in the right upper lobe [a: axial periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER), b: axial T1-weighted, c: axial PROPELLER, d: coronal PROPELLER], consistent with necrotizing pneumonia (yellow arrows). A blue arrow in (b) marks a subcarinal lymph node, and a green arrow in (c) indicates pleural fluid and pleural thickening, consistent with empyema.

chest wall, and even vascular structures, is also possible.^{43,44} MRI is particularly useful for evaluating the extent and complications of thoracic hydatid disease, especially in cases with suspected extrapulmonary involvement.

Although chest radiography and CT are commonly used for initial detection, MRI provides superior soft-tissue contrast and better characterization of cyst contents, including daughter cysts and detached germinal membranes. On MRI, HCs typically appear hypointense on T1-weighted images and hyperintense on T2-weighted sequences. Daughter cysts may vary in signal intensity depending on their contents. MRI's multiplanar capability and tissue contrast make it particularly valuable for identifying extrapulmonary spread and for surgical planning in complex or recurrent cases.⁴⁵

In Figure 3, an 18-year-old girl demonstrates a large multicystic hydatid lesion occupying the mediastinum.

Tuberculosis

MRI has emerged as a useful modality in the evaluation of thoracic tuberculosis, particularly in the pediatric population. Although CT remains the traditional imaging method, MRI offers radiation-free imaging with excellent soft-tissue contrast, which is especially useful for evaluating lymphadenopathy and parenchymal involvement.

Tuberculous lymph nodes show variable signal intensities depending on disease stage and activity. T2-weighted sequences often reveal central hyperintensity corresponding to liquefactive necrosis, and the surrounding parenchyma may appear hypointense on T2-weighted imaging, a pattern seen in

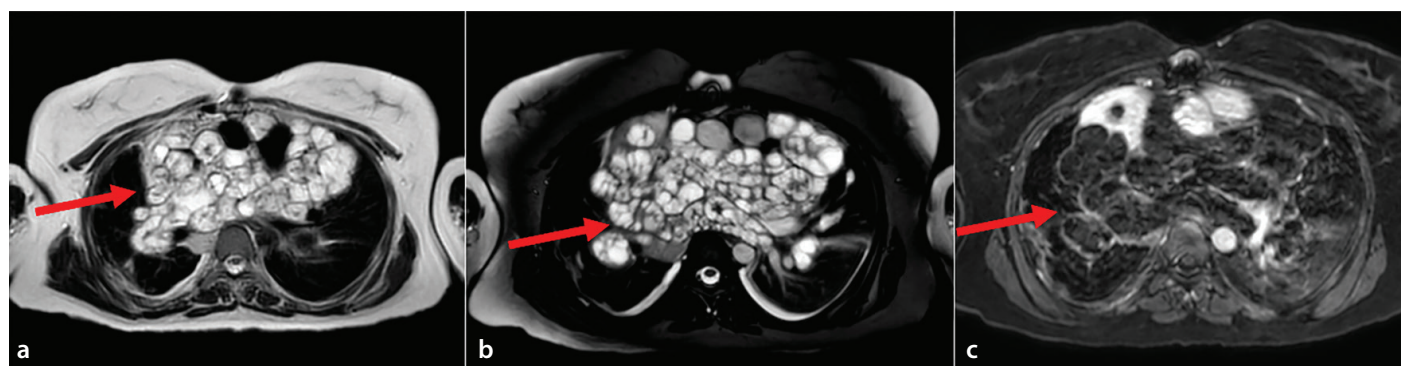


Figure 3. Thoracic hydatid disease in an 18-year-old girl. A large multicystic hydatid lesion occupying the entire mediastinum is seen (a: axial T2-weighted, b: axial steady-state free precession, c: axial periodically rotated overlapping parallel lines with enhanced reconstruction). Red arrows indicate the lesion.

pediatric tuberculosis. Contrast-enhanced MRI can highlight peripheral rim enhancement around necrotic nodes, and DWI can reveal restricted diffusion, suggesting active disease. MRI can also help monitor treatment response and disease progression.^{46,47}

MRI may serve as a useful complementary modality in pediatric thoracic tuberculosis, particularly for characterizing lymphadenopathy and monitoring treatment response, although CT remains the primary modality for comprehensive assessment of pulmonary involvement.

In Supplementary Figure 1, a 9-year-old boy with confirmed tuberculosis demonstrates a nodular, pathologically enlarged right paratracheal lymph node on MRI, along with a hepatic lesion in segment 8.

Cystic fibrosis

Despite its lower spatial resolution compared with CT, MRI is gaining ground in the imaging of cystic fibrosis due to its superior tissue characterization and radiation-free nature. Patients with cystic fibrosis undergo frequent imaging for disease monitoring and management, and MRI offers a safer alternative for long-term follow-up.¹⁴

MRI systems, now being validated against CT-based criteria, assess key features such as bronchiectasis, mucus plugging, parenchymal changes, and lung volumes. Studies have shown these MRI scores to be comparable with CT, allowing for reduced use of ionizing radiation in routine surveillance.⁴¹ In comparative pediatric cohorts, MRI and CT findings of airway consolidations have demonstrated up to 100% concordance, and MRI-based morphological scores have shown a strong correlation with CT scores and pulmonary function tests, with reported correlation coefficients in the range of $r \approx 0.8$ – 0.9 .^{11,48}

In addition to anatomical assessment, MRI provides functional insights that CT cannot offer. T2-weighted hyperintensity within bronchial walls can indicate edema, and contrast enhancement points to active inflammation. Detection of air-fluid levels within the bronchi can signify infection. Moreover, perfusion MRI reveals hypoperfused lung regions due to reflex vasoconstriction in diseased areas—a phenomenon that may precede morphologic deterioration. This combination of structural and functional data makes MRI particularly valuable in the comprehensive evaluation and longitudinal monitoring of cystic fibrosis, particularly in children requiring repeated imaging.^{3,6,48}

Among current pediatric thoracic indications, cystic fibrosis represents one of the strongest use cases for MRI. The combination of longitudinal surveillance requirements, avoidance of cumulative radiation exposure, and the availability of functional imaging makes MRI a particularly attractive modality for disease monitoring. Nevertheless, CT may still be required in selected cases when assessment of subtle structural abnormalities is necessary.^{6,9,48}

In Figure 4, a 2-year-old girl with cystic fibrosis and pneumonia shows consolidations with air bronchograms and bronchial wall hyperintensity suggestive of active inflammation.

Congenital causes

MRI provides detailed anatomical visualization of congenital lung anomalies, including pulmonary sequestration, congenital pulmonary airway malformation, congenital diaphragmatic hernia, and congenital lobar emphysema. Its multiplanar capabilities, combined with contrast-enhanced techniques, allow precise evaluation of both parenchymal abnormalities and associated vascular anomalies, such as aberrant arterial supply, which is crucial for pre-surgical planning.^{2,38} In Figure 5, an 11-day-old girl with a prenatal diagnosis of pulmonary sequestration shows intralobar sequestration in the left lower lobe with systemic arterial supply and venous drainage into the azygos vein. Supplementary Figure 2 demonstrates examples of congenital cystic lesions: a bronchogenic cyst adjacent to the left lower lobe bronchus in a 16-year-old girl, and an intestinal duplication cyst occupying most of the posterior right hemithorax in a neonate.

Interstitial lung diseases

Although interstitial lung diseases (ILDs) are uncommon in pediatric patients, MRI is gaining recognition as a complementary im-

aging tool. CT remains the gold standard for the detection of subtle interstitial abnormalities and fibrotic changes; however, MRI can provide additional information regarding inflammatory activity and may help differentiate active inflammation from established fibrosis. Consequently, MRI may be particularly useful for follow-up imaging and functional assessment while reducing cumulative radiation exposure in children with progressive disease. Despite promising developments, MRI should currently be considered complementary rather than an alternative to CT in pediatric ILD, and further validation is required before routine adoption as a primary imaging modality can be recommended.^{7,49,50}

Airway diseases

MRI is effective in evaluating large airway abnormalities, including masses, stenosis, and congenital conditions such as tracheomalacia. Dynamic sequences captured during respiration can assess airway collapse or obstruction, offering a non-invasive method to evaluate respiratory mechanics and airway patency.¹⁴ In Figure 6, a 15-year-old girl with primary ciliary dyskinesia demonstrates left lower lobe atelectasis and bronchiectatic changes with mucus plugging.

Pleural diseases

MRI is used to assess both isolated pleural conditions and those associated with lung parenchymal diseases. It excels in detecting pleural effusions, empyema, and pleural thickening, providing crucial information on the extent of pleural involvement and differentiating between inflammatory and malignant processes.^{3,51} In Figure 7, a 9-year-old girl with pleuropulmonary blastoma demonstrates recurrent disease more clearly on MRI than on CT, underscoring MRI's superior soft-tissue contrast.

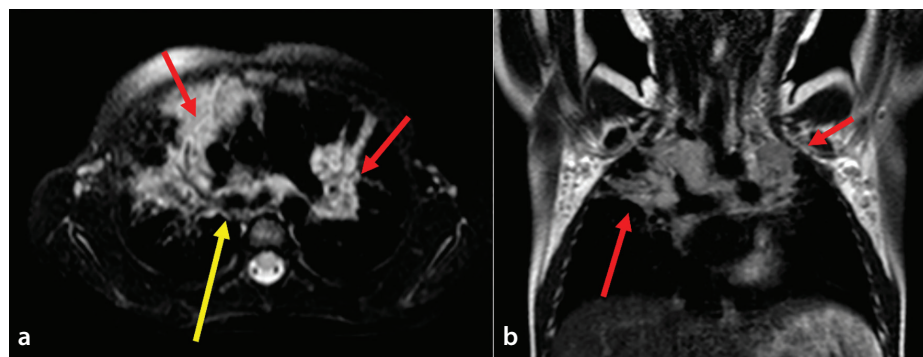


Figure 4. Cystic fibrosis and pneumonia in a 2-year-old girl. Consolidations containing air bronchograms are seen (a: axial periodically rotated overlapping parallel lines with enhanced reconstruction, b: coronal T1-weighted image). Red arrows indicate the consolidations. The yellow arrow indicates bronchial wall hyperintensity, suggestive of active inflammation.

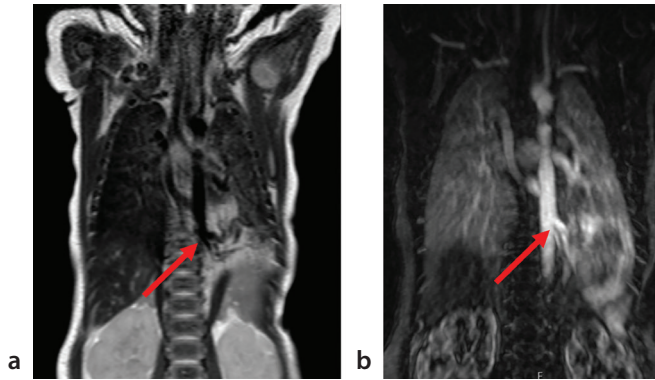


Figure 5. Pulmonary sequestration in an 11-day-old girl with a prenatal diagnosis. Thoracic magnetic resonance imaging demonstrates intralobar sequestration in the lower lobe of the left lung, with arterial supply from the aorta and venous drainage into the azygos vein (a: coronal T2-weighted, b: coronal contrast-enhanced three-dimensional T1-weighted image). Red arrows indicate the lesion and its vascular supply/drainage.

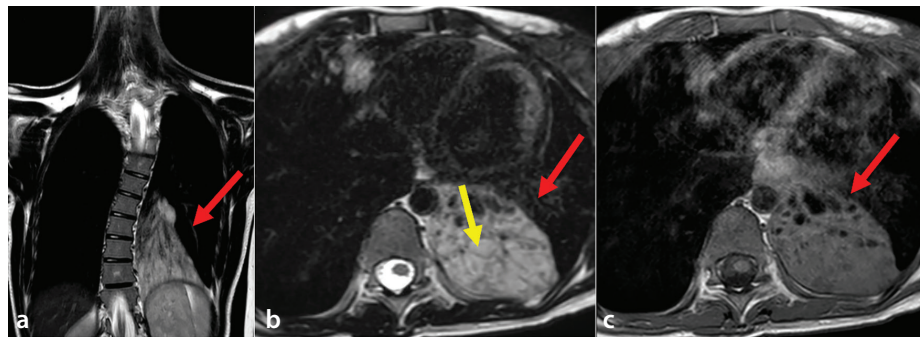


Figure 6. Primary ciliary dyskinesia in a 15-year-old girl. Atelectasis and bronchiectatic changes are seen in the lower lobe of the left lung (a: coronal T2-weighted, b: axial T2-weighted, c: axial T1-weighted image). Red arrows indicate the affected lung parenchyma and bronchiectatic airways. Signal-void areas within the dilated bronchi represent intraluminal air. The yellow arrow indicates a mucus plug within a bronchus.

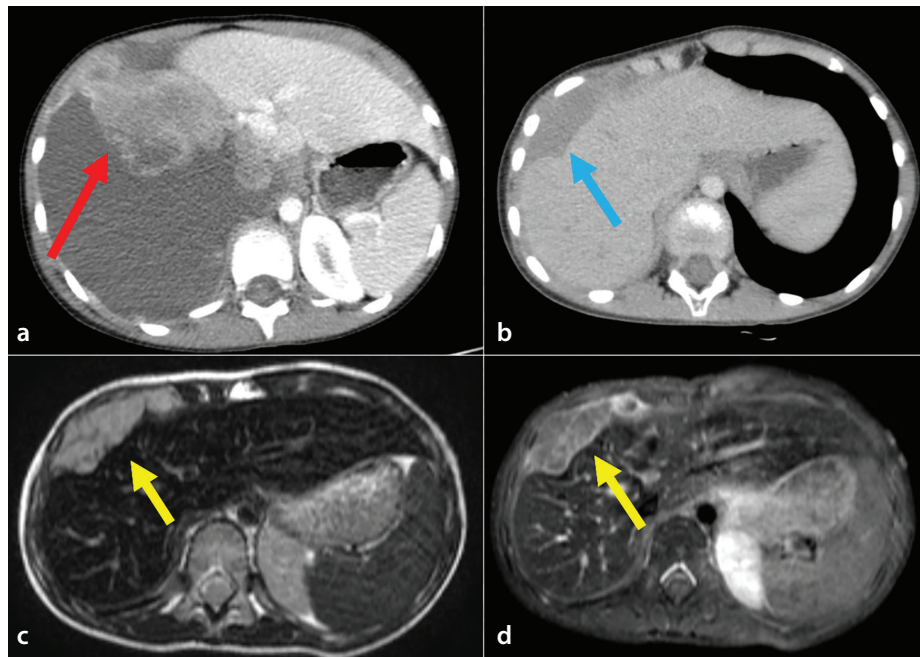


Figure 7. Pleuropulmonary blastoma in a 9-year-old girl. The initial lesion is seen on axial contrast-enhanced computed tomography (CT) performed 1 year before surgical resection (a). Follow-up contrast-enhanced CT demonstrates subtle findings suggestive of recurrence (b), whereas the recurrent lesion is more clearly visualized on magnetic resonance imaging (MRI) (c: T2-weighted, d: contrast-enhanced T1-weighted spectral presaturation with inversion recovery). The red arrow indicates the initial lesion, the blue arrow indicates the subtle recurrent finding on CT, and the yellow arrows indicate the recurrent lesion on MRI, highlighting the superior soft-tissue contrast of MRI.

Systemic pathologies

MRI is effective in evaluating pulmonary manifestations of systemic diseases, such as vasculitis, connective tissue disorders, and hematological conditions. Its ability to demonstrate nodular, cavitory, or infiltrative lesions enhances diagnostic accuracy in these cases. Functional MRI, including perfusion imaging, can also aid in assessing disease severity and monitoring treatment response.⁵² Supplementary Figure 3 shows a 2-month-old infant with pulmonary Langerhans cell histiocytosis, demonstrating multiple bilateral lesions and a cavitory lesion in the left upper lobe confirmed on thoracic MRI.

• Mediastinal pathologies

Lymph nodes

MRI offers high sensitivity in detecting and characterizing mediastinal lymphadenopathy. This is particularly useful in pediatric patients with suspected malignancies, infections, or inflammatory conditions, where non-invasive and radiation-free assessment is preferred.³

Masses and cysts

MRI is comparable with CT in diagnosing mediastinal masses and cystic lesions. Its superior soft-tissue contrast helps differentiate between solid and cystic components, visualize fat content, and assess relationships with vascular structures. Furthermore, MRI is excellent for evaluating local invasion into the pericardium, chest wall, or spinal structures.^{2,53}

In Figure 8, a 15-year-old boy demonstrates an anterior mediastinal dermoid cyst containing fat signal intensity. Figure 9 shows a 5-year-old girl with thymic hyperplasia, characterized by homogeneous anterior mediastinal soft tissue with microscopic fat and no pathological enhancement. Figure 10 depicts a 3-year-old girl with a paravertebral ganglioneuroma extending into the neural foramen, and Figure 11 shows a paravertebral hemangioma with intense enhancement and high ADC values. Supplementary Figure 4 presents a 12-year-old boy with acute myeloid leukemia and granulocytic sarcoma, with a mediastinal mass encasing major vessels and narrowing the superior vena cava.

Vascular pathologies

MRI enables a comprehensive evaluation of congenital and acquired thoracic vascular abnormalities, including anomalous pulmonary venous return, aortic coarctation, pul-

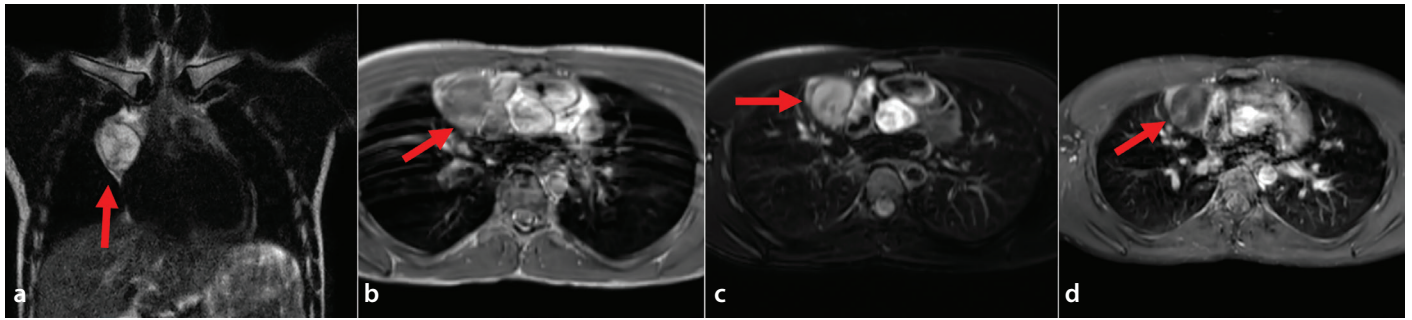


Figure 8. Dermoid cyst in a 15-year-old boy. A well-defined heterogeneous cystic lesion is seen in the anterior mediastinum adjacent to the right atrium (a: coronal T2-weighted, b: axial T1-weighted, c: axial periodically rotated overlapping parallel lines with enhanced reconstruction, d: axial contrast-enhanced T1-weighted spectral presaturation with inversion recovery). Areas of fat signal intensity within the lesion are consistent with a dermoid cyst. Surgical excision confirmed the diagnosis histopathologically.

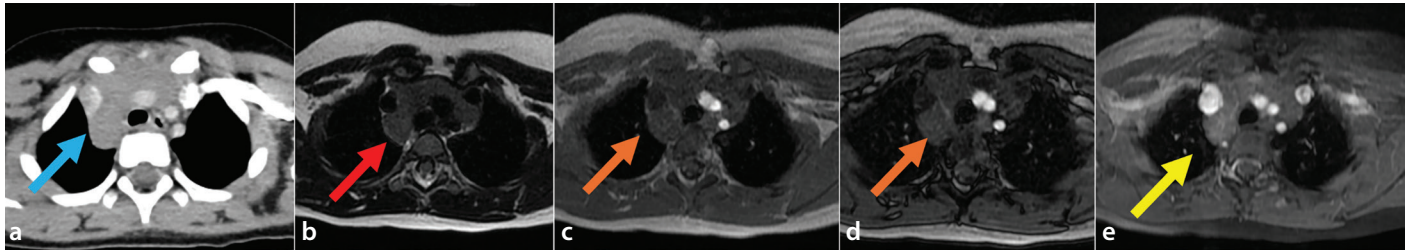


Figure 9. Thymic hyperplasia in a 5-year-old girl. Axial computed tomography (CT) demonstrates a prominent soft-tissue structure in the anterior and superior mediastinum, consistent with thymic tissue (a). Magnetic resonance imaging (MRI) shows homogeneous soft tissue in the anterior mediastinum and bilateral upper paratracheal regions (b-e). Axial in-phase and out-of-phase T1-weighted images demonstrate signal loss on the out-of-phase sequence, indicating microscopic fat (c, d), and the axial contrast-enhanced T1-weighted spectral presaturation with inversion recovery image confirms the absence of pathological enhancement (e). The blue arrow indicates thymic tissue on CT, red arrows indicate the thymus on MRI, orange arrows indicate signal loss on the out-of-phase image, and yellow arrows indicate the absence of pathological enhancement.

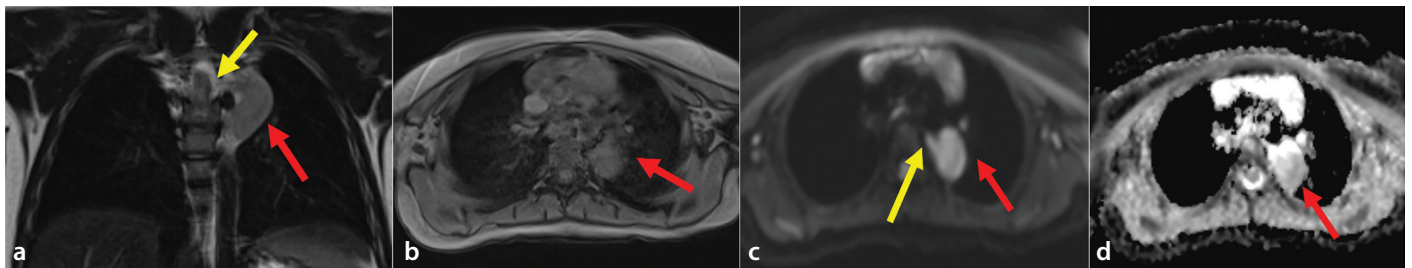


Figure 10. Paravertebral ganglioneuroma in a 3-year-old girl. A well-defined solid mass is seen in the paravertebral region with extension into the neural foramen [a: coronal T2-weighted, b: axial T1-weighted, c: diffusion-weighted image (DWI), d: apparent diffusion coefficient (ADC) map]. Red arrows indicate the paravertebral mass, and the yellow arrow indicates neural foraminal extension. The lesion demonstrates diffusion restriction on the DWI with low signal intensity on the ADC map. Excisional biopsy confirmed the diagnosis of ganglioneuroma.

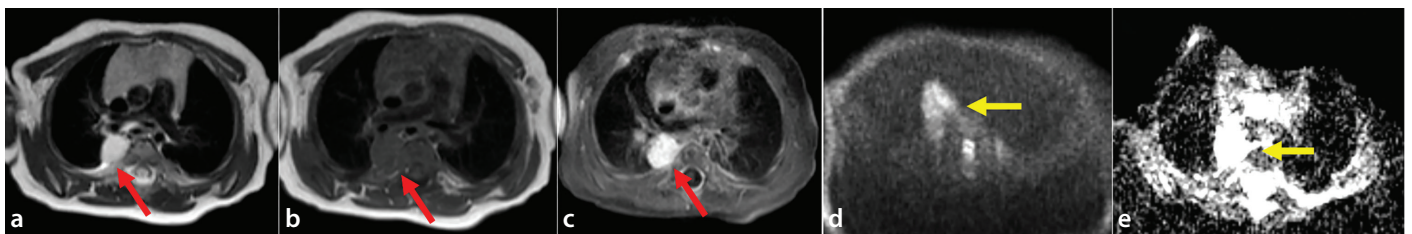


Figure 11. Paravertebral hemangioma in a 10-year-old boy. A well-defined lesion is seen in the right paravertebral region with extension into the posterior mediastinum [a: T2-weighted, b: axial T1-weighted, c: axial contrast-enhanced T1-weighted spectral presaturation with inversion recovery, d: diffusion-weighted image, e: apparent diffusion coefficient (ADC) map]. Red arrows indicate intense homogeneous contrast enhancement, and yellow arrows indicate high signal on the ADC map. Excisional biopsy confirmed the diagnosis of hemangioma.

monary arterial abnormalities, arteriovenous malformations, vasculitis, and systemic venous anomalies. Dynamic CEMRA provides rapid, time-resolved depiction of arterial and venous phases and remains particularly useful when vascular transit, collateral circu-

lation, or complex flow pathways must be assessed. Non-contrast techniques, particularly electrocardiographic and respiratory-gated 3D balanced SSFP angiography, may provide high-resolution anatomical assessment of the thoracic aorta, central pulmonary vessels,

and systemic veins without gadolinium administration. These approaches are especially attractive for children requiring repeated follow-up, although longer acquisition times, motion sensitivity, limited temporal information, and platform-dependent availability

may restrict their use. Selection between CE-MRA, non-contrast MRA, and CT angiography should therefore be guided by the vascular territory, required spatial and temporal resolution, patient cooperation, and local technical expertise.^{2,15,21,23} In Figure 12, MRA in two adolescents demonstrates vascular anomalies, including arterial stenosis in Takayasu arteritis and a right-sided aortic arch.

• Chest wall pathologies

Tumors

MRI is the preferred imaging modality for assessing chest wall tumors and their in-

vasion into adjacent structures. It provides detailed information on tumor size, margins, and internal composition, including septations, fibrous components, and calcifications. Dynamic contrast enhancement can further aid in characterizing tumor vascularity and distinguishing between benign and malignant lesions.^{3,51,54} In Figure 13, an 8-year-old boy with Ewing sarcoma of the rib demonstrates a heterogeneously enhancing mass arising from the left 7th rib. Figure 14 shows a 9-day-old infant with a mesenchymal hamartoma of the chest wall, containing calcifications and heterogeneous enhancement. Supplementary Figure 5 depicts a 3-year-old

boy with a multicystic thoracic wall lymphatic malformation extending into the axilla, without major enhancement.

Abscesses/infections

MRI is useful for detecting infections and abscesses in the chest wall. Its multiplanar imaging capabilities allow for precise localization and characterization of fluid collections, enhancing diagnostic confidence and aiding in procedural planning.^{3,10} In Figure 15, a 6-year-old girl with post-surgical sternal osteomyelitis demonstrates a subxiphoid infected collection and marrow signal changes in the sternum.

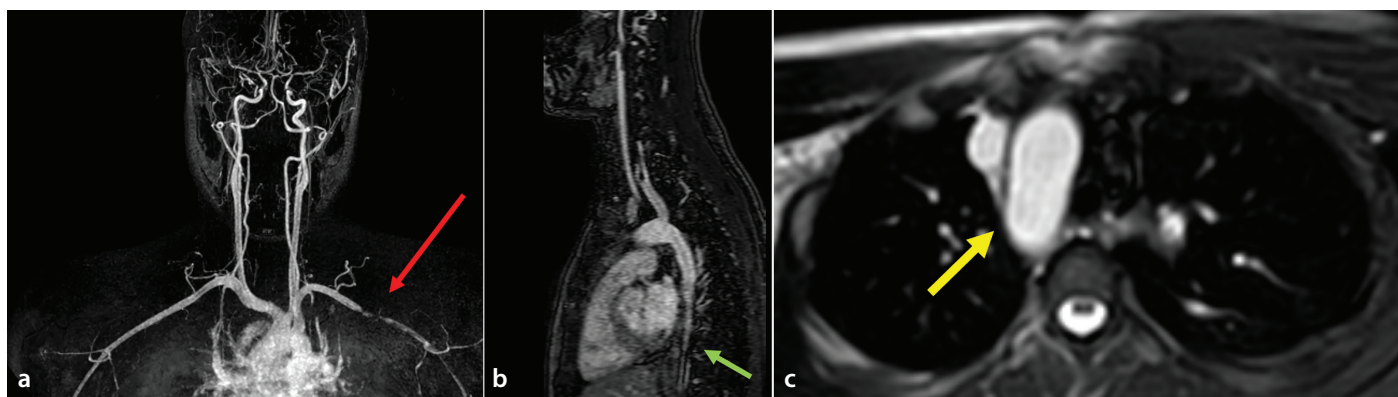


Figure 12. Vascular anomalies in two adolescent boys. Magnetic resonance angiography in a 16-year-old boy with Takayasu arteritis demonstrates stenosis of the left subclavian artery and descending aorta (a, b). Single-shot fast spin echo imaging in an 18-year-old boy demonstrates a right-sided aortic arch (c). The red arrow indicates left subclavian artery stenosis, the green arrow indicates descending aortic stenosis, and the yellow arrow indicates the right-sided aortic arch.

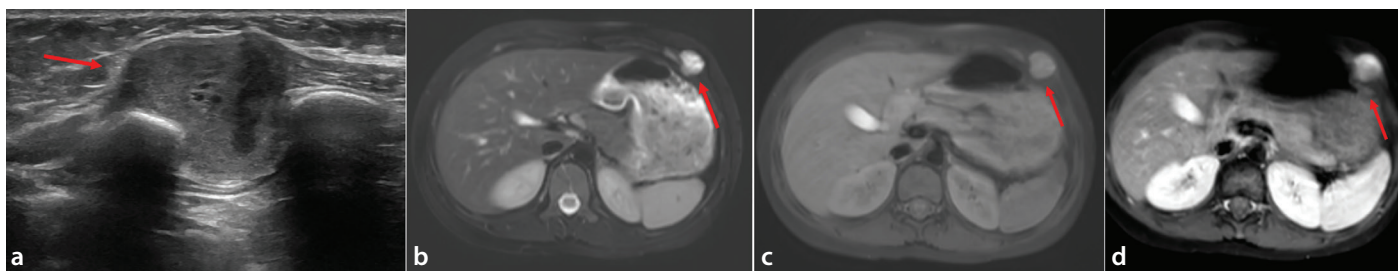


Figure 13. Ewing sarcoma of the rib in an 8-year-old boy. Initial ultrasonography demonstrates a hypoechoic solid mass extending into the intercostal space at the level of the left costal arch (a). Magnetic resonance imaging shows a mass arising from the anterior aspect of the left seventh rib at the level of the costal arch [b: axial periodically rotated overlapping parallel lines with enhanced reconstruction, c: axial T1-weighted spectral presaturation with inversion recovery (SPIR), d: axial contrast-enhanced T1-weighted SPIR]. Red arrows indicate heterogeneous contrast enhancement within the lesion.

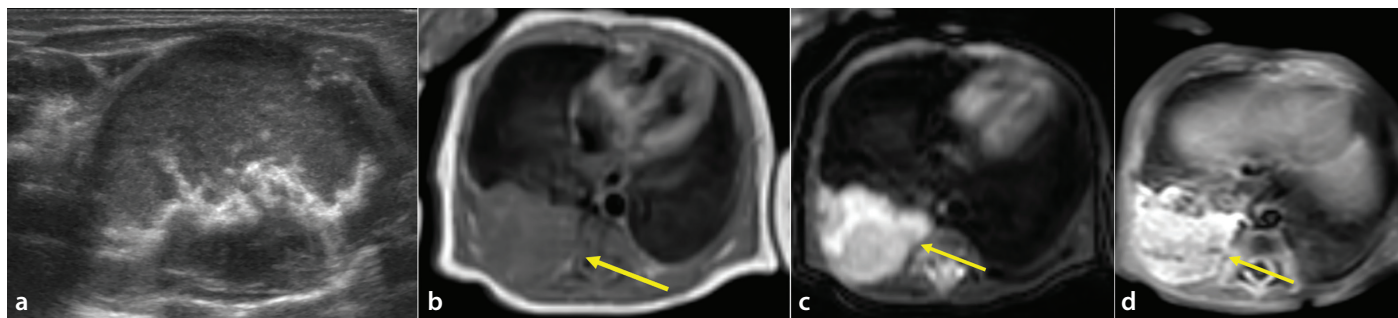


Figure 14. Mesenchymal hamartoma of the chest wall in a 9-day-old infant. Initial ultrasonography demonstrates an expansile mass in the posterior intercostal space containing calcifications (a). Magnetic resonance imaging (MRI) shows a heterogeneously enhancing mass arising from the chest wall in the posterior right hemithorax (b: axial T1-weighted, c: axial periodically rotated overlapping parallel lines with enhanced reconstruction, d: axial contrast-enhanced T1-weighted spectral presaturation with inversion recovery). The blue arrow indicates calcification within the lesion, and yellow arrows indicate the chest wall mass on MRI. Surgical excision confirmed the diagnosis of mesenchymal hamartoma of the chest wall.

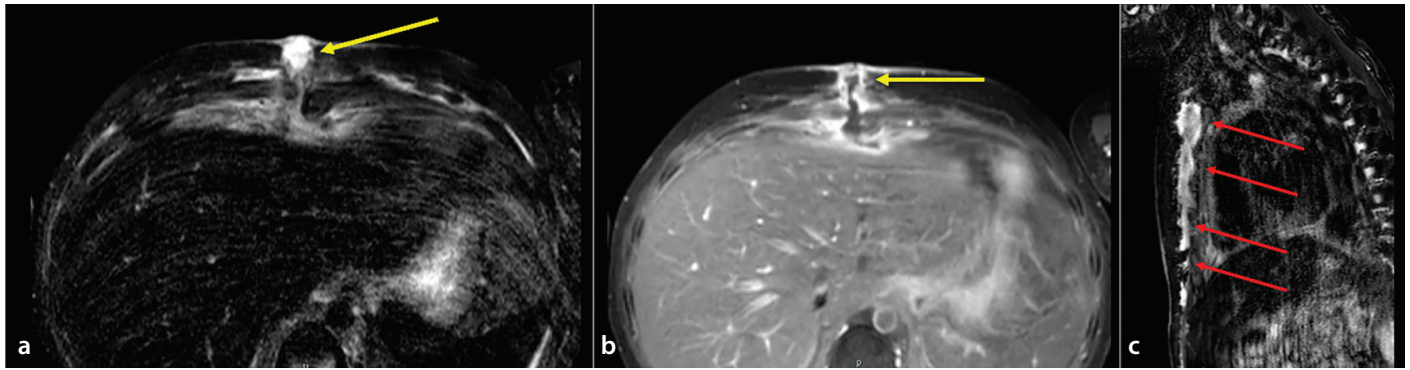


Figure 15. Sternal osteomyelitis in a 6-year-old girl following cardiac surgery. A subxiphoid collection extends from the subcutaneous fat into the supradiaphragmatic region and demonstrates peripheral contrast enhancement, consistent with an infected collection (a: axial fat-saturated T2-weighted, b: axial fat-saturated contrast-enhanced T1-weighted, c: sagittal fat-saturated T2-weighted image). Yellow arrows indicate the infected collection, and red arrows indicate increased signal intensity in the sternum and adjacent subcutaneous fat, consistent with sternal osteomyelitis.

Deformities

MRI is an effective tool for evaluating structural deformities of the chest wall, such as pectus carinatum, pectus excavatum, and Poland syndrome. Its ability to provide high-resolution images without ionizing radiation is advantageous, particularly in young patients. Dynamic imaging can also assess the impact of these deformities on respiratory mechanics and cardiovascular structures.⁵⁵ In Supplementary Figure 6, a case of Poland syndrome demonstrates the absence of the right pectoralis major muscle on MRI.

Overall, available evidence suggests that thoracic MRI achieves diagnostic performance approaching that of CT for most clinically relevant pediatric thoracic diseases, with high reader agreement and added functional information, although it remains limited for the detection of very small nodules and early interstitial abnormalities.^{6,12}

Limitations of thoracic magnetic resonance imaging

Despite substantial technical advances, thoracic MRI continues to have several limitations that restrict its widespread use in routine pediatric practice. Compared with CT, MRI generally offers lower spatial resolution, limiting reliable detection of very small pulmonary nodules (< 3–4 mm). In addition, longer acquisition times and greater sensitivity to motion artefacts remain important challenges, particularly in uncooperative children.⁵

The frequent need for sedation or general anesthesia in younger patients increases procedural complexity and may limit availability in high-volume centers. Furthermore, higher costs, limited scanner accessibility, and vendor-dependent sequence implementations

reduce reproducibility and standardization across institutions.¹²

Consequently, although thoracic MRI provides unique advantages—particularly radiation-free and functional imaging—CT remains the reference standard in many clinical scenarios, and MRI should currently be considered a complementary or alternative modality in selected pediatric indications.^{6,9,12}

Thoracic MRI is increasingly recognized as a valuable imaging modality, offering high-resolution anatomical and functional assessment without ionizing radiation. This makes it particularly beneficial for pediatric patients and other radiation-sensitive populations.² Despite technical challenges, recent improvements in motion-robust acquisition and short-TE imaging have increased feasibility and diagnostic confidence in pediatric practice.^{2,8,14}

Current evidence supports the use of MRI as an alternative or complementary modality in selected indications, including the follow-up of complicated pneumonia, cystic fibrosis and other chronic airway diseases, congenital thoracic abnormalities, mediastinal lesions, chest wall disorders, and selected vascular conditions. However, CT remains the reference standard when rapid acquisition, maximal spatial resolution, or reliable detection of very small pulmonary nodules and subtle interstitial abnormalities is required. MRI should therefore not be regarded as a universal replacement for CT, but rather as part of a disease-specific and patient-centered imaging strategy.³

Although CT remains the gold standard, MRI is emerging as a viable alternative in selected cases due to its superior soft-tissue contrast and growing functional applications. Ongoing innovations in motion com-

pensation, faster acquisition, and functional imaging will further enhance its clinical utility, positioning thoracic MRI as a key tool in modern thoracic imaging, especially in pediatric and radiation-sensitive patients.^{2,19}

Footnotes

Conflict of interest disclosure

The authors declared no conflicts of interest.

Supplementary Figures 1-6: <https://d2v96fxpocvxx.cloudfront.net/cf9d60d6-523c-458a-a2e6-78728d3ffbb0/content-images/da795f40-6959-4920-939f-e2dd607d3483.pdf>

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