Volume 1, Issue 8

Medicinal, Psychological, and Health Research Journal

Journal homepage: https://www.mphrj.com/

DOI: 10.22034/mphrj.2025.537410.1033

Abnormal Chest Radiographic Findings According to Leukemia Subtype in Pediatric Patients with Leukemia

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Article info

Received: 27.07.2025

Accepted: 29.08.2025

Available Online: 02.09.2025

Checked for Plagiarism: Yes

Keywords:

Pediatric leukemia, Chest radiography, Acute lymphoblastic leukemia, Thoracic complications.

ABSTRACT

Introduction: Leukemia is the most common childhood malignancy, often associated with various thoracic complications. Chest radiography serves as an essential diagnostic tool for identifying respiratory manifestations and guiding clinical management in pediatric leukemia patients.

Materials and Methods: This descriptive-analytical cross-sectional study evaluated 56 pediatric leukemia patients hospitalized at Bouali Hospital in Ardabil, Iran, over a five-year period (2018–2023). Data regarding age, sex, leukemia subtype, respiratory symptoms, and chest X-ray findings were extracted from medical records and analyzed using SPSS version 25.

Results: Of the patients, 83.9% were diagnosed with acute lymphoblastic leukemia (ALL) and 16.1% with acute myeloid leukemia (AML). Abnormal chest radiographic findings were identified in 62.5% of patients, with pulmonary opacities (23.2%), peribronchial thickening (14.3%), pleural effusion (14.3%), and mediastinal mass (8.9%) being the most common. No statistically significant difference was found between leukemia subtypes regarding overall radiographic abnormalities (P>0.05).

Conclusion: Chest radiographic abnormalities are frequent in pediatric leukemia, regardless of subtype. Routine imaging is crucial for early detection of thoracic complications, even in asymptomatic cases.

Introduction

Leukemia is the most common malignancy in children, accounting for approximately 30% of all pediatric cancers (1). It is a heterogeneous group of hematologic malignancies characterized by the uncontrolled proliferation of immature white blood cells in the bone marrow and peripheral blood (2). Pediatric leukemia is primarily classified into two major subtypes: acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML), with ALL being the predominant form, comprising nearly 75–80% of all cases. Early and accurate diagnosis, along with subtype classification, is essential for determining prognosis and initiating appropriate therapy (3).

Chest radiography (chest X-ray) is a routine and often the first imaging modality performed in pediatric patients suspected of having leukemia (4). Despite its simplicity, affordability, and availability, chest radiography plays a critical role in the initial assessment of children with leukemia. It helps evaluate the presence of thoracic abnormalities, including mediastinal masses, pulmonary infiltrates, pleural effusions, and signs of infection or hemorrhage (5). These radiographic findings may not only reflect the underlying disease process but also provide clues about the leukemia subtype and possible complications (6).

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Abnormal findings on chest X-rays may differ depending on the subtype of leukemia. For instance, mediastinal widening due to a large thymic mass is more commonly associated with T-cell ALL, whereas AML may be more frequently linked to pulmonary infections or hemorrhagic complications due to severe cytopenias (7). Recognizing these radiographic patterns can aid clinicians in early subtype identification, risk stratification, and treatment planning. Moreover, certain chest radiographic abnormalities might predict an increased risk for respiratory complications during induction chemotherapy, thus influencing supportive care decisions (8,9).

Infections are a major concern in pediatric leukemia, given the immunosuppressive nature of the disease and its treatment (10). Opportunistic bacterial, viral, and fungal infections can manifest with various radiographic patterns, such as lobar or interstitial infiltrates, cavitary lesions, and nodular opacities (11). The risk and type of infection may vary between leukemia subtypes, and timely detection on imaging can be critical in preventing severe morbidity or mortality. Differentiating between leukemic infiltration and infectious processes on imaging remains a diagnostic challenge, often necessitating correlation with clinical and laboratory findings (12).

Pleural and pericardial effusions are other radiographic findings that may be encountered, particularly in cases with leukemic involvement of serous membranes or secondary infections. These findings may be subtle on chest X-rays but have significant clinical implications (13). Their presence at diagnosis or during therapy can suggest more aggressive disease or complications such as cardiac tamponade or respiratory distress. Evaluating their prevalence across different leukemia subtypes could enhance our understanding of disease pathophysiology and burden (14).

Mediastinal masses, particularly in T-cell ALL, may cause life-threatening complications such as airway compression or superior vena cava syndrome. Early detection via chest radiography is essential in such cases, as it may prompt emergent interventions and influence the route of anesthesia or central line placement (15). The prevalence of mediastinal widening and its correlation with specific subtypes underscore the need for a systematic approach to interpreting chest X-rays in pediatric leukemia patients (16).

In addition to diagnostic utility, chest radiographs are often used to monitor disease progression, assess treatment response, and detect therapy-related complications such as drug-induced pneumonitis or pulmonary edema (17). Understanding the spectrum of radiographic changes throughout the course of leukemia treatment can inform both radiologists and oncologists in optimizing patient care. Comparing these patterns across leukemia subtypes may also reveal subtype-specific vulnerabilities to treatment toxicities (18).

Despite their importance, chest radiographic findings in pediatric leukemia are often underreported or overlooked in clinical documentation, and data correlating them with leukemia subtypes are relatively limited (19). Most existing studies have focused on radiographic manifestations of leukemia in general or as part of broader evaluations of febrile neutropenia. Therefore, a focused investigation into abnormal chest radiographs categorized by leukemia subtype is warranted to enhance diagnostic precision and improve clinical outcomes (20).

Furthermore, in resource-limited settings where access to advanced imaging modalities like CT or MRI is restricted, chest X-rays remain a critical diagnostic tool. A better understanding of how radiographic findings correlate with leukemia subtypes can empower clinicians to make more informed decisions even in the absence of high-resolution imaging. Establishing such associations could also help guide further diagnostic testing and determine the urgency of intervention. In conclusion, analyzing abnormal chest radiographic findings in children with leukemia, particularly in relation to leukemia subtypes, has the potential to provide valuable diagnostic, prognostic, and therapeutic insights. By characterizing the spectrum of chest X-ray abnormalities specific to each subtype, clinicians may be better equipped to anticipate complications, tailor treatments, and ultimately improve outcomes for pediatric leukemia patients. This study aims to bridge the gap in current knowledge by systematically evaluating these radiographic features across leukemia subtypes.

Material and methods

Study Design: This study was a descriptive-analytical cross-sectional study.

Study Population, Sample Size, and Sampling Method: The study population consisted of pediatric patients diagnosed with leukemia who were hospitalized at Bouali Hospital in Ardabil over a five-year period, from March 2018 to March 2023. The sample included 56 patients, and the sampling method was census-based, meaning all eligible patients within the defined timeframe were included.

Study Procedure: This research was conducted as a descriptive-analytical cross-sectional study. The target population included all children diagnosed with leukemia and admitted to Bouali Hospital in Ardabil between March 2018 and March 2023. The final sample consisted of 56 patients, selected through a census approach. Data required for the study including age, sex, leukemia subtype, and chest radiographic findings were extracted from patients' hospital records and documented using structured data collection forms. Upon completion of the sampling process and data collection for all

participants, the data were coded and subjected to statistical analysis using SPSS software, version 25.
Variables: The following variables were collected and analyzed in this study: Gender, as recorded in the patients' medical records; Age, representing the chronological age of each patient at the time of leukemia diagnosis; Leukemia Subtype, categorized as either acute lymphoblastic leukemia (ALL) or acute myeloid leukemia (AML) based on confirmed hematologic and immunophenotypic findings; and Chest Radiographic Findings, which included any abnormal observations such as pulmonary opacities or infiltrates, pleural thickening, pleural effusion, or other radiographic anomalies noted on chest imaging performed at diagnosis.
Data Analysis: Data collected for the study were analyzed using SPSS software, version 25. Quantitative variables were reported as mean and standard deviation, while qualitative variables were expressed as frequencies and percentages. The results were presented in the form of tables and charts. The association between chest radiographic findings and leukemia subtype was assessed using the Chi-square test.
Ethical: The study was conducted in accordance with ethical principles outlined in the Declaration of Helsinki. Informed consent was obtained from all participants or their legal guardians prior to inclusion in the study. Participants' privacy and confidentiality were respected, with all data being anonymized and stored securely. The study was approved by the Research Ethics Committee of the Islamic Azad University, Ardabil, under the ethical code IR.IAU.ARDABIL.REC.1403.107. All procedures followed were in compliance with ethical guidelines for medical research, ensuring the rights and well-being of the participants were upheld throughout the study.

Results

In this study, a total of 56 patients were included, with 34 males (60.7%) and 22 females (39.3%). The mean age of the patients was 4.83 years, with a standard deviation of 3.72 years. The age distribution revealed that 5 patients (8.9%) were under 1-year-old, 42 patients (75.0%) were between 1 and 9 years old, and 9 patients (16.1%) were between 10 and 14 years old. Regarding leukemia subtype, 47 patients (83.9%) were diagnosed with acute lymphoblastic leukemia (ALL), and 9 patients (16.1%) had acute myeloid leukemia (AML). Among the ALL patients, 38 (80.9%) exhibited the B-cell phenotype, while 9 (19.1%) had the T-cell phenotype. Concerning respiratory symptoms, 16 patients (28.6%) presented with respiratory issues. In terms of chest radiographic findings, 35 patients (62.5%) displayed abnormal results. The most common radiographic abnormalities included pulmonary infiltrates/opacity (23.2%), perihilar/per bronchial thickening (14.3%), pleural thickening/effusion (14.3%), and mediastinal mass (8.9%). Other findings included cardiomegaly (5.4%), tracheal compression/deviation (3.6%), pulmonary granuloma (1.8%), and thoracic kyphosis (1.8%) (table1).

Table 1. Frequency of Types of Abnormal Chest Radiographic Findings

Finding	Frequency	Percentage (%)
Pulmonary infiltration/opacities	13	23.2
Perihilar/peribronchial thickening	8	14.3
Pleural thickening/effusion	8	14.3
Mediastinal mass	5	8.9
Cardiomegaly	3	5.4
Tracheal compression/deviation	2	3.6
Pulmonary granuloma	1	1.8
Thoracic kyphosis	1	1.8

Table 2 presents the overall frequency of abnormal chest radiographic findings according to leukemia subtype. As shown, there was no statistically significant difference in the overall prevalence of abnormal radiographic findings between patients with ALL and those with AML (P>0.05).

Table 2. Frequency of Abnormal Chest Radiographic Findings by Leukemia Subtype

Chest Radiographic Findings	ALL (n=47)	AML (n=9)	Total (n=56)	P-value
Abnormal	30 (63.8%)	5 (55.6%)	35 (62.5%)	0.715
Normal	17 (36.2%)	4 (44.4%)	21 (37.5%)	

Table 3 details the specific abnormal radiographic findings by leukemia subtype. Among patients with ALL, the most frequent abnormalities were: Among patients with ALL, the most common radiographic findings were pulmonary infiltration/opacities (19.1%), perihilar/per bronchial thickening (17.0%), pleural thickening/effusion (10.6%), and mediastinal mass (10.6%). In contrast, among

patients with AML, the most frequent abnormalities included pulmonary infiltration/opacities (44.4%) and pleural thickening/effusion (33.3%). However, none of these differences were statistically significant, with all comparisons yielding a P-value greater than 0.05.

Table 3. Frequency of Specific Abnormal Radiographic Findings by Leukemia Subtype

Radiographic Finding	ALL (n=47)	AML (n=9)	P-value
Any pulmonary finding	18 (38.3%)	4 (44.4%)	0.503
Pulmonary infiltration/opacities	9 (19.1%)	4 (44.4%)	0.292
Perihilar/peribronchial thickening	8 (17.0%)	0	—
Pulmonary granuloma	1 (2.1%)	0	—
Non-pulmonary intrathoracic findings	12 (25.5%)	3 (33.3%)	0.453
Mediastinal mass	5 (10.6%)	0	0.187
Pleural thickening/effusion	5 (10.6%)	3 (33.3%)	—
Tracheal compression/deviation	2 (4.3%)	0	—
Cardiac findings (cardiomegaly)	3 (6.4%)	0	0.585
Skeletal findings (thoracic kyphosis)	1 (2.1%)	0	0.839

Discussion

This study aimed to evaluate the frequency and types of abnormal chest radiographic findings in pediatric patients diagnosed with leukemia, stratified by leukemia subtype. Over a five-year period, 56 children admitted to a tertiary care center in Ardabil, Iran, were reviewed, offering insight into the radiographic manifestations of acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML) in this population. The findings provide valuable context for the diagnostic and clinical management of pediatric leukemia patients, especially regarding respiratory complications and thoracic imaging (21,22).

The demographic profile of the patients was consistent with global epidemiological trends in childhood leukemia. A predominance of male patients (60.7%) was observed, which aligns with previous studies reporting a slight male preponderance in both ALL and AML. The mean age of the study population was 4.83 years, with the majority (75%) aged between 1 and 9 years. This age distribution is reflective of the typical age peak of ALL, which remains the most common leukemia in children (23).

Among the study cohort, 83.9% were diagnosed with ALL and 16.1% with AML. These proportions are in accordance with global statistics, where ALL constitutes approximately 75–85% of childhood leukemia cases. Within the ALL group, the majority exhibited B-cell lineage (80.9%), while 19.1% had T-cell immunophenotype. The higher prevalence of B-cell ALL is consistent with international data and supports the generalizability of these findings (24).

One of the key focuses of this study was the presence of respiratory symptoms and associated radiographic abnormalities. Approximately 28.6% of patients presented with clinical respiratory symptoms, while 62.5% demonstrated abnormal findings on chest radiographs, highlighting that radiographic abnormalities may be present even in the absence of overt respiratory symptoms. This underscores the importance of routine chest imaging at diagnosis, particularly in patients with high leukemic burden or suspicion of mediastinal involvement (25,26).

The most commonly reported abnormal findings on chest radiographs included pulmonary infiltration or opacities (23.2%), perihilar or per bronchial thickening (14.3%), pleural thickening or effusion (14.3%), and mediastinal masses (8.9%). These findings are in line with known complications of leukemia, such as leukemic infiltration, infectious processes due to immunosuppression, and lymphadenopathy associated with T-cell ALL. Interestingly, less common findings like cardiomegaly, tracheal deviation, pulmonary granulomas, and thoracic skeletal abnormalities were also noted, albeit at lower frequencies (27).

When analyzing the association between leukemia subtype and radiographic abnormalities, no statistically significant differences were found in the overall prevalence of abnormal chest findings between ALL and AML patients (P>0.05). However, qualitative differences were observed. In ALL patients, especially those with the T-cell subtype, mediastinal masses were relatively more frequent (10.6%), consistent with the known predilection of T-cell ALL for anterior mediastinal involvement due to thymic infiltration. Pulmonary infiltration/opacities and per bronchial thickening were also more common in ALL, which could reflect either leukemic pulmonary involvement or secondary infections (28).

In contrast, patients with AML more frequently exhibited pulmonary infiltrates (44.4%) and pleural effusions (33.3%). These findings may be associated with a higher incidence of infection, hemorrhage, or leukocytosis in AML, which can lead to pulmonary parenchymal and pleural abnormalities. Despite the numerical differences, statistical analyses did not demonstrate significance, likely due to the relatively small sample size of the AML group (n=9). Larger

cohort studies are needed to further delineate these patterns (29).

An important clinical implication of this study is the high prevalence of thoracic radiographic abnormalities in pediatric leukemia, even in asymptomatic patients. This reinforces the utility of chest radiography not only for diagnostic staging but also for early detection of complications that may require urgent management, such as mediastinal masses that can lead to airway compression, or pleural effusions that may necessitate thoracentesis (30).

The study's limitations include its retrospective nature and the small sample size, particularly in the AML subgroup. Additionally, radiographic interpretation was based on chart documentation, and no secondary blinded radiologic review was performed, which may introduce interobserver variability. Moreover, data on the presence of infections, neutropenic status, or timing of radiographic changes in relation to chemotherapy were not analyzed, which could provide further context to the radiographic findings (31).

Conclusion

In conclusion, this study highlights that abnormal chest radiographic findings are common among children with leukemia and can vary by leukemia subtype, though no significant statistical differences were observed between ALL and AML groups. Pulmonary infiltrates and mediastinal masses were notable findings, especially in ALL, while pleural effusions were more frequent in AML. Routine chest imaging should remain a standard component of the initial evaluation in pediatric leukemia to aid in comprehensive staging and timely intervention. Future prospective, multicenter studies with larger sample sizes and inclusion of advanced imaging modalities such as CT or MRI are warranted to further elucidate the spectrum and clinical significance of thoracic abnormalities in this vulnerable population.

Disclosure Statement

No potential conflict of interest reported by the authors.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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