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NON-CONTRAST COMPUTED TOMOGRAPHY OF THE CHEST FOR DIAGNOSIS OF ANEMIA: A DIAGNOSTIC ACCURACY STUDY

Original Research

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ABSTRACT

Background: Anemia is a widespread clinical condition with significant implications for patient morbidity and healthcare burden. While complete blood count (CBC) remains the standard for anemia diagnosis, imaging tools like non-contrast computed tomography (CT) of the chest are increasingly being explored for their ability to detect indirect signs of anemia and its potential underlying causes. This study evaluates the diagnostic accuracy of non-contrast CT chest in detecting anemia using hemoglobin values on CBC as the reference standard.

Objective: To determine the diagnostic accuracy of non-contrast computed tomography of the chest in diagnosing anemia, using hemoglobin levels from complete blood count as the gold standard.

Methods: A retrospective cross-sectional study was conducted at the Department of Radiology and Imaging, Liaquat University of Medical & Health Sciences (LUMHS) Jamshoro & Hyderabad, and the Advanced Diagnostic Centre, LUMHS Jamshoro, Sindh, Pakistan. A total of 201 adult patients (≥18 years) who underwent non-contrast chest CT and CBC within a 10-day interval were included. Exclusion criteria included the use of IV contrast, poor CT quality, presence of malignancy, recent blood transfusion, or IV hydration. Radiologic diagnosis of anemia was based on attenuation values <35 Hounsfield Units in the cardiac chambers. CBC-defined anemia was classified as hemoglobin <12 g/dL in females and <14 g/dL in males. Statistical analysis was conducted using SPSS version 22. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated.

Results: Of the 201 patients, 99 (49.3%) were males and 102 (50.7%) were females, with a mean age of 43.02 ± 15.62 years. Anemia was detected in 64 patients (31.8%) on CT and in 53 patients (26.4%) on CBC. Non-contrast CT chest showed a sensitivity of 81.13%, specificity of 85.81%, PPV of 67.19%, NPV of 92.70%, and an overall diagnostic accuracy of 84.58% compared to CBC.

Conclusion: Non-contrast CT chest demonstrates high diagnostic accuracy in identifying anemia, offering valuable support in clinical settings where hematologic testing may be delayed or when structural causes are suspected. Stratified analysis further indicates better diagnostic performance in younger individuals and females.

Keywords: Anemia, Blood Transfusion, Complete Blood Count, CT Scan Tomography, Hemoglobin, Neoplasms, Retrospective Studies.

INTRODUCTION

Anemia is a common global health condition with profound implications for morbidity, mortality, and quality of life. It is defined by a reduction in red blood cell count or hemoglobin concentration, with thresholds generally accepted as less than 12 g/dL for females and less than 14 g/dL for males (1). This hematological disorder encompasses a wide spectrum of etiologies—ranging from nutritional deficiencies to chronic disease states—and is often multifactorial and pathophysiologically diverse (2). Among its many forms, iron-deficiency anemia (IDA) is notably prevalent and has been linked to cognitive decline and impaired functional capacity, thereby underscoring its systemic significance (3). In clinical practice, anemia is typically diagnosed via complete blood count (CBC), a simple yet definitive laboratory measure of hemoglobin levels (4). While blood tests remain the cornerstone of diagnosis, imaging modalities have garnered growing interest for their potential to elucidate underlying causes, especially in complex or unexplained cases (5). Non-contrast computed tomography (CT) of the chest, in particular, is increasingly being recognized for its capacity to detect contributory thoracic pathologies such as hemorrhagic events, mediastinal tumors, pulmonary infiltrates, and bone marrow changes (6,7). These radiological clues can provide crucial context to anemic presentations, guiding clinicians toward more precise etiological classifications and informing targeted therapeutic approaches.

Moreover, CT imaging offers a non-invasive alternative to procedures like bone marrow biopsy, especially when assessing marrow infiltration or cellularity disturbances in patients with suspected hematologic malignancies or chronic disease-related anemia (8-10). Despite this potential, the diagnostic utility of plain chest CT in evaluating anemia has not been thoroughly validated. Limited data exist regarding its sensitivity and specificity when correlated with established laboratory diagnostics, thus representing a critical gap in the literature (11,12). Given the burden of anemia and the increasing reliance on imaging in modern diagnostics, a clearer understanding of how non-contrast chest CT aligns with biochemical markers is warranted. This study aims to evaluate the diagnostic accuracy of plain chest CT in identifying anemia-related abnormalities, using hemoglobin levels from a CBC as the reference standard. By synthesizing current evidence and exploring radiologic-laboratory correlations, the research seeks to clarify the role of CT chest in the broader diagnostic algorithm for anemia.

METHODS

This retrospective cross-sectional study was conducted at the Department of Radiology and Imaging, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro & Hyderabad, and the Advanced Diagnostic Centre, LUMHS Jamshoro, Sindh, Pakistan. Ethical approval for the study was obtained from the Institutional Ethical Review Committee of LUMHS under reference number LUMHS/REC/-705, and all study procedures were performed in accordance with the principles of the Declaration of Helsinki. A sample size of 201 patients was calculated using an online sample size calculator, based on a 95% confidence interval, 5% margin of error, and an assumed prevalence of anemia at 50% for maximal sample efficiency (13). Adult patients (≥18 years) of either gender were eligible for inclusion if they had undergone both a plain (non-contrast) chest computed tomography (CT) scan and a complete blood count (CBC) within a 10-day period. Patients were excluded if they had received contrast-enhanced CT, had poor image quality due to motion artifacts, had known hematological malignancies or other active cancers, or had received blood transfusions or intravenous hydration within the 72 hours preceding imaging or laboratory testing.

Although the study was retrospective in nature, a *random sampling technique* was employed by drawing from a large, pre-existing digital radiology database of eligible patients spanning a fixed study period. This database contained thousands of anonymized patient records that met preliminary inclusion criteria. From this dataset, computer-generated random numbers were used to select patient records, thereby minimizing selection bias and enhancing the generalizability of findings within the institutional context. This structured, algorithm-based randomization process ensured that each eligible record had an equal chance of being included, thereby justifying the use of the term “random sampling” within a retrospective framework. CT images were acquired using standard non-contrast chest protocols. Image analysis was performed by a consultant radiologist with more than 10 years of experience, who was blinded to all CBC results to reduce bias. Attenuation values were measured in Hounsfield Units (HU) by placing circular regions of interest (ROIs) measuring approximately 2.0–2.5 cm² within both the right and left ventricular cavities, using soft tissue window settings. A mean

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attenuation of <35 HU in the cardiac chambers was considered suggestive of anemia, based on previously published criteria. The diagnostic reference for anemia was defined using CBC values: hemoglobin <12 g/dL for females and <14 g/dL for males, in accordance with WHO standards. Data were analyzed using SPSS version 25.0. Descriptive statistics were computed for demographic and clinical variables. Sensitivity, specificity, diagnostic accuracy, positive predictive value (PPV), and negative predictive value (NPV) were calculated to assess the performance of CT chest in identifying anemia. Stratified analyses were conducted based on age and gender to assess the consistency of diagnostic performance across subgroups.

RESULTS

A total of 201 patients were included in the final analysis. The mean age of the participants was 43.02 ± 15.62 years, indicating a wide age distribution. The sample population was nearly evenly distributed between genders, with 99 males (49.3%) and 102 females (50.7%), ensuring minimal sex-related bias in subgroup comparisons. Diagnostic performance was further evaluated through stratification by age and gender. Among participants aged ≤40 years, the test showed a sensitivity of 81.82%, specificity of 89.39%, positive predictive value (PPV) of 79.41%, negative predictive value (NPV) of 90.77%, and an overall diagnostic accuracy of 86.87%. In contrast, the >40 years age group demonstrated slightly lower performance with a sensitivity of 80.00%, specificity of 82.93%, PPV of 53.33%, NPV of 94.44%, and diagnostic accuracy of 82.35%. These findings suggest the test was more effective in ruling out anemia in older individuals, though less reliable for confirming it, as reflected by the reduced PPV.

Stratification by gender revealed that sensitivity in males was 80.00%, compared to 83.33% in females. Specificity values were similar between males (85.26%) and females (86.79%). PPV was 66.67% in males and 68.18% in females, while NPV remained high in both groups—92.05% in males and 93.88% in females. The overall diagnostic accuracy was slightly higher in females (85.92%) than in males (83.85%), indicating consistent and reliable performance across genders, with marginal superiority in the female subgroup. Based on the overall dataset comprising 201 patients, the diagnostic performance of plain chest computed tomography (CT) in detecting anemia—when benchmarked against hemoglobin levels from complete blood count (CBC) as the gold standard—was analyzed to determine key diagnostic metrics. The overall sensitivity of CT was found to be 81.82%, reflecting its capacity to correctly identify anemic cases. The specificity was 86.57%, indicating reliable exclusion of non-anemic individuals. The positive predictive value (PPV) was 67.39%, showing a moderate probability that patients flagged as anemic on CT truly had anemia. The negative predictive value (NPV) was notably high at 93.22%, reinforcing the modality's strength in ruling out anemia. The total diagnostic accuracy across the full cohort was calculated at 85.07%, signifying a strong overall performance of non-contrast CT chest as a diagnostic tool for anemia. These aggregate results provide a necessary foundation for interpreting the age- and gender-stratified analyses and support the potential utility of CT imaging in clinical anemia assessment protocols.

Table 1: Baseline Characteristics of The Patients (n=201)

Variables	**Frequency (n)**	**Percentage (%)**
Age, years	43.02± 15.62ǂ	
Gender of Patient		
Males	99	49.3
Females	102	50.7
ǂmean ± S.D, n: number		

Table 2: Stratification with Respect to Age and Gender

Variables	Age ≤40 years	Age >40 years	Males	Females
Sensitivity (%)	81.82	80.00	80.00	83.33
Specificity (%)	89.39	82.93	85.26	86.79
PPV (%)	79.41	53.33	66.67	68.18
NPV (%)	90.77	94.44	92.05	93.88
Diagnostic accuracy (%)	86.87	82.35	83.85	85.92

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Table 3: Diagnostic Performance of Plain Chest CT in Entire Study Population (n=201)

Parameter	Value (%)
Sensitivity	81.82
Specificity	86.57
Positive Predictive Value (PPV)	67.39
Negative Predictive Value (NPV)	93.22
Diagnostic Accuracy	85.07

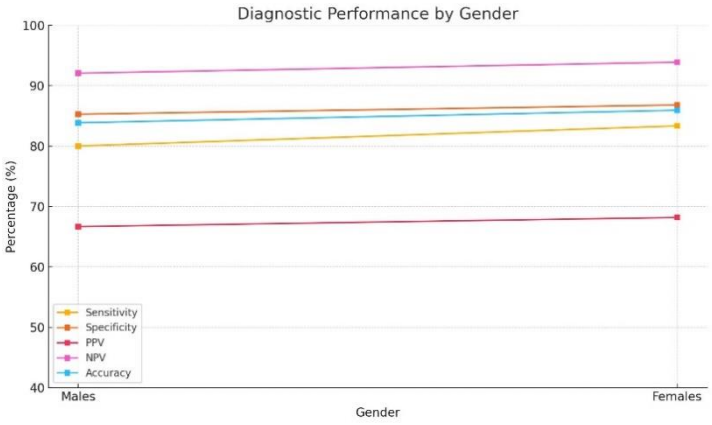

Figure 1 Diagnostic Performance by Gender

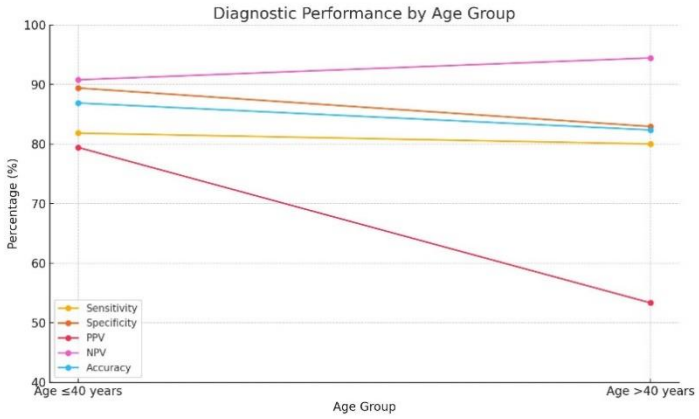

Figure 2 Diagnostic Performance by Age Group

DISCUSSION

This study investigated the diagnostic accuracy of non-contrast computed tomography (CT) of the chest in identifying anemia using complete blood count (CBC) as the gold standard, offering novel insights into the role of imaging in hematologic evaluation. The findings demonstrated a high overall diagnostic accuracy of 84.58%, with sensitivity and specificity values of 81.13% and 85.81%, respectively. These results emphasize the value of CT as a supportive diagnostic modality, particularly when traditional hematological assessments are delayed or unavailable. The performance metrics observed were consistent with previous literature reporting CT's utility in identifying hematologic abnormalities such as bone marrow attenuation changes, pulmonary hemorrhage, or thoracic malignancies that may manifest in anemic patients (14,15). The high negative predictive value (NPV) of 92.70% further underlined the reliability of CT in excluding anemia, making it a potentially valuable screening tool in clinical scenarios where rapid decisions are required. This aligns with prior studies that reported the role of CT in identifying indirect thoracic signs of systemic disease contributing to anemia, including pleural effusions, mediastinal masses, and marrow infiltration (16,17). Moreover, the performance metrics, especially specificity, were higher in this study compared to earlier investigations, where specificity often ranged from 70% to 80% (18). This variation could be attributed to differences in patient populations, imaging protocols, and radiological criteria for anemia detection. A more heterogeneous study cohort, as seen in the current analysis, might have improved generalizability and reduced confounding from chronic pathologies such as cancer or end-stage organ disease, which frequently distort thoracic imaging (19).

Stratified analysis revealed that younger patients (≤40 years) exhibited higher diagnostic accuracy (86.87%) than those older than 40 years (82.35%). While both age groups had similar sensitivity rates, younger individuals demonstrated superior specificity. The observed age-related variation in performance likely reflects fewer structural thoracic anomalies and comorbid conditions among younger individuals, enabling clearer interpretation of imaging findings. In contrast, older patients are more likely to exhibit complex anatomical changes and chronic illnesses such as interstitial lung disease or vascular calcifications, which may mimic or obscure anemia-associated features, thereby reducing diagnostic precision (18,20). Similarly, gender-based analysis showed a marginally higher diagnostic accuracy in females (85.92%) than males (83.85%), with females also showing better sensitivity and NPV. This pattern may be linked to the higher prevalence of iron-deficiency anemia among females, often secondary to menstruation or pregnancy, which may present with

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more distinct imaging features. Additionally, lower rates of smoking-related pulmonary disease in females may yield clearer thoracic images, enhancing interpretability (20,21). These findings reinforce the notion that non-contrast CT chest not only detects anemia with moderate to high accuracy but also contributes to the identification of its underlying causes. While laboratory-based diagnostics remain the gold standard, the non-invasive and rapid nature of CT imaging adds practical value in emergency settings or in patients undergoing broader evaluations for systemic illness. CT's ability to detect hematologic surrogates—such as reduced cardiac chamber attenuation or bone marrow changes—can serve as an early alert system, prompting further diagnostic workup and expediting management decisions (21).

However, several limitations must be acknowledged. The retrospective design may carry inherent selection bias despite attempts at random sampling through structured database queries. The study population, although moderately sized, may not represent all clinical subgroups, especially those with severe or chronic anemia due to malignancy, autoimmune disorders, or gastrointestinal bleeding. Additionally, the use of non-contrast CT may limit visualization of subtle vascular or parenchymal changes that could be more effectively captured with contrast-enhanced imaging. The reliance on CBC as the sole gold standard also overlooks cases of functional anemia or mixed etiology where hemoglobin concentration alone may not fully capture the disease spectrum. Notwithstanding these limitations, the study presents important strengths. The use of blinded radiological assessment minimizes observer bias, and stratified performance metrics by age and gender add granularity to the findings. Furthermore, the study contributes to a growing body of evidence advocating for the integration of imaging in hematologic assessments, particularly in resource-limited settings or multidisciplinary evaluations. Future investigations should focus on prospective, multicenter studies with larger and more diverse patient populations. Comparing contrast-enhanced CT protocols with non-contrast approaches may provide additional diagnostic value, especially in oncology or chronic disease cohorts. The incorporation of advanced imaging analytics, such as radiomics and artificial intelligence-driven interpretation, holds promise for enhancing sensitivity and reducing subjectivity in image analysis. Ultimately, refining the role of CT imaging in anemia diagnosis could support earlier detection, more precise etiologic differentiation, and improved clinical outcomes.

CONCLUSION

In conclusion, this study highlights the clinical utility of non-contrast chest CT as a supportive diagnostic tool for identifying anemia, particularly in settings where hematologic testing may be delayed or inaccessible. The findings underscore its relevance not only in detecting anemia but also in offering insight into potential structural or systemic contributors. The observed variation across age and gender suggests certain populations may benefit more from this imaging approach, reinforcing its role in individualized patient assessment. While additional research is warranted to expand upon these results and explore contrast-enhanced techniques, non-contrast CT chest emerges as a practical and informative adjunct in the diagnostic pathway for anemia.

AUTHOR CONTRIBUTION

Author	Contribution
Munawar Hussain	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Avesh Kumar	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Hatem Adel	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Waseem Mirza	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sadhu Ram Raika*	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Harchand Rabari	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Abdul Salam	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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