The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 6, 2025

DIAGNOSTIC ACCURACY OF COMPUTED TOMOGRAPHY CHEST FOR DIAGNOSIS OF ANEMIA TAKING COMPLETE BLOOD COUNT AS GOLD STANDARD

Dr Noor-us-Saba[*1], Dr Sumaiya Javed[2], Dr Yasir Khan[3], Dr Naveed Ahmed[4], Dr Hina Iqbal[5], Dr Amer Bhatti[6]

DOI:https://doi.org/10.5281/zenodo.15752577

Keywords
Anemia, chest CT, complete blood count, diagnostic accuracy, hemoglobin

Article History
Received on 20 May 2025
Accepted on 20 June 2025
Published on 27 June 2025

Corresponding Author: *
Dr Noor-us-Saba

Abstract

Introduction: *Low hemoglobin levels as indicated by anemia are prevalent in millions of people especially those in areas with limited health-care access. CBC remains the most gold standard in approaching anemia but chest CT scans as an imaging technique can also be beneficial as they detect anemia- and related findings.*

Objective: *To evaluate the diagnostic accuracy of unenhanced chest CT in detecting anemia, using CBC as the gold standard, in a Pakistani hospital setting.*

Materials and Method: *The present study is a cross-sectional descriptive study that was carried out at the National Medical Centre, Karachi, between January and December 2023. Readers included 257 patients aged between 18 and 65 years with CCT and CBC. Hemorrhagic signs, hyperdense aortic signs and low left ventricular cavity attenuation, were compared to consent with CBC anemia defined as hemoglobin <12 g/dL for women and <13 g/dL for men.*

Results: *The prevalence rate of anemia in participants of this study was 82.1 percent, of whom 35.8 percent had moderate anemia. This study reveals that CT possesses moderate sensitivity and specificity, although anemia occurrence was observed to differ significantly between genders.*

Conclusion: *Unenhanced chest CT offers potential as an adjunct for anemia detection, particularly in settings with limited laboratory access. Targeted interventions are needed to address the high anemia burden, especially among females.*

INTRODUCTION

Lack of red blood cell circulation is called anemia, which presents itself through low levels of hemoglobin or hematocrit and continues to affect millions of individuals worldwide. It affects females more and is a burden that can be significantly challenging in regions where there is limited access to early diagnosis (1). Previously, anemia was diagnosed by complete blood count (CBC), a common and reputable laboratory test, which is utilized to measure the levels of hemoglobin and affirm the diagnosis of anemia. Nevertheless, the dependence on laboratory-based diagnostics constrains the possibility of an early diagnosis, especially in the rural setting, which is counseling the search for other diagnostic approaches like imaging (2). Particularly, there is a current focus on new point-of-care technologies and imaging methods that seem to have the potential to fill the mentioned gaps in anemia diagnostics. Out of these, CT chest particularly has been highlighted in several papers since it is one of the most common scans that can yield incidental findings related to anemia.

Computer tomography (CT) of the chest, originally used for pulmonary and cardiovascular disorders, has proven useful outside of these diseases. For example, its value has been underlined in its application to assess pneumonia and to manage treatment in these diseases, with claims that it can be very useful in managing systemic disorders (3). In the same way, uCT is diagnostically satisfactory for conditions such as pulmonary embolism, suggesting that it may be sensitive to the vascular alterations related to anemia (4). The potential of CT to accurately stage such malignancies as ovarian cancer is another testament to the modality's capability to offer comprehensive clinical information, which may also include hematological disorders (5). In anemia, there are specific CT findings, including hyperdense aortic or interventricular septum sign and low density of the left ventricular cavity, which is a different noninvasive modality to approach the problem.

Imaging in the laboratory has been a focus in recent studies, especially in the area of machine learning, which tries to integrate the results obtained from the images with the actual test results to improve the diagnosis (6). In pediatric patients, CT chest has been very useful in diagnosing complications of community-acquired pneumonia, which implies the technology could also be valuable in other systemic diseases such as anemia (7). Furthermore, investigations carrying out fever of unknown origin have relied on PET/CT to reveal hidden aetiologies, suggesting that CT may be capable of evaluating anemia imperialism modification to vascular density (8). A different picture has been observed in pediatric tuberculosis, where CT has demonstrated unexpected features in the patients, which could include anemia parameters (9). The role of non-contrast thoracic CT in the detection of anemia has been studied, especially when indicating symptoms such as hyperdense aortic rings with high sensitivity (10).

A few studies exhibit that quantitative CT parameters, like the CT attenuation value of the left ventricular cavity below 36.5 Hounsfield Units, have moderate sensitivity and specificity in detecting anemia, though there is an issue of interobserver variability (11). Comparative studies between low-dose and conventional-dose CT have further explored these parameters, reporting consistent correlations with hemoglobin levels in screening cohorts (12). Additionally, correlating CT findings of the abdominal aorta and inferior vena cava with laboratory investigations has enhanced anemia detection, suggesting that thoracic CT could similarly leverage vascular imaging for diagnostic purposes (13). Deep learning models applied to chest X-rays have also demonstrated feasibility in anemia detection, paving the way for CT-based algorithms to refine diagnostic precision (14). However, enhanced CT scans, which use contrast, may obscure these findings due to altered vascular density, necessitating the use of unenhanced protocols for accurate anemia prediction (15).

Despite these advances, a gap persists in systematically evaluating the diagnostic accuracy of chest CT for anemia, particularly in diverse populations like those in Pakistan, where anemia prevalence is notable. Limited studies have comprehensively assessed CT's ability to detect anemia subtypes, such as iron-deficiency or hemolytic anemia, against CBC as the gold standard (10). Establishing CT's diagnostic performance could optimize resource allocation, reduce dependency on laboratory infrastructure, and enhance patient outcomes through earlier detection. By leveraging incidental findings during routine chest CT scans, clinicians could identify anemia in patients undergoing imaging for unrelated indications, thus streamlining care. This study aims to bridge this gap by investigating the diagnostic accuracy of unenhanced chest CT in detecting anemia, using CBC as the reference standard, in a Pakistani hospital setting.

Objective

To determine the diagnostic accuracy of unenhanced computed tomography chest in predicting anemia, using complete blood count as the gold standard, in a Pakistani hospital setting.

MATERIALS AND METHODS

Study Design: Cross-sectional study.

Setting: The present study was conducted at the Department of Diagnostic Radiology at National Medical Centre in Karachi, Pakistan.

Duration: The study spanned from January 2023 to December 2023.

Inclusion Criteria:

In this cross-sectional study, patients of both sexes, aged between 18 and 65 years, were referred to the radiology department for CT of the chest regardless of the indication for the imaging. This broadly defined criterion selected a group that included the general population and might be a candidate for routine imaging and evaluation of incidental anemia findings.

Exclusion Criteria

The study also excluded patients taking folic acid or iron supplements to reduce possible confounding factors affecting the level of hemoglobin. Patients with malignancies were also excluded because tumors can influence the CT characteristics and biochemical profiles obtained by themselves. Furthermore, patients with end-stage renal disease or chronic liver disease were not considered due to the effect on erythropoietic activity and the characteristics of imaging.

Methods

Patients meeting the inclusion criteria were enrolled after providing written informed consent, with study details thoroughly explained. A sample size of 257 patients was calculated using a sensitivity of 74%, specificity of 68%, anemia prevalence of 28.9%, margin of error of 10%, and 95% confidence level. Demographic and clinical data, including age, gender, residence, family income, height, weight, BMI, and history of anemia, were recorded using a predesigned proforma. Unenhanced chest CT scans were performed as per the treating physician's request and interpreted by radiologists with over five years of post-fellowship experience. Anemia on CT was identified based on the presence of a hyperdense aortic sign, hyperdense interventricular septum sign, or CT attenuation of the left ventricular cavity below 36.5 HU. Following the CT, a 5 cc blood sample was collected aseptically for hemoglobin assessment via CBC. Anemia on CBC was defined per WHO criteria: hemoglobin below 12 g/dL for women and 13 g/dL for men. Data were entered and analyzed using SPSS version 24 to compute sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy.

RESULTS (600-700 words)

		Age	Gender	Place_of_residence	BMI
N	Valid	257	257	257	257
	Missing	0	0	0	0
Mean		5.7549	1.5525	1.5214	2.6031
Median		6.0000	2.0000	2.0000	3.0000
Mode		4.00[a]	2.00	2.00	4.00
Std. Deviation		2.71969	.49820	.50052	1.14482
Minimum		1.00	1.00	1.00	1.00
Maximum		10.00	2.00	2.00	4.00
Percentiles	25	4.0000	1.0000	1.0000	2.0000
	50	6.0000	2.0000	2.0000	3.0000
	75	8.0000	2.0000	2.0000	4.0000

a. Multiple modes exist. The smallest value is shown

Table 1: Descriptive Statistics

Table 1 elaborates the descriptive statistics, the sample had a mean age of 5.75 years (SD = 2.72), indicating a moderate variation in age among participants. Gender was predominantly male, as reflected by the mode of 2.00, with a median of 2.00 suggesting a relatively balanced gender distribution. Place of residence also showed a mode and median of 2.00, indicating a higher representation of participants from urban areas. The Body Mass Index (BMI) had a mean score of 2.60 (SD = 1.14), suggesting that most participants fell within the "overweight" category, further supported by the mode

of 4.00. Percentile values (25th, 50th, and 75th) provided additional insight into the distribution and central tendency of these variables, highlighting the concentration and variability in responses across demographic and health-related indicators.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Underweight: BMI < 18.5	57	22.2	22.2	22.2
	Normal weight: 18.5 ≤ BMI < 24.9	68	26.5	26.5	48.6
	Overweight: 25 ≤ BMI < 29.9	52	20.2	20.2	68.9
	Obesity: BMI ≥ 30	80	31.1	31.1	100.0
	Total	257	100.0	100.0	

Table 2: Frequency Distribution of Participants by BMI Categories

Regarding the BMI, results showed that the majority of the participants had obesity (n = 80, 31.1%) while the normal weighted participants comprised of (n = 68, 26.5%). Participants' weight distribution revealed that 22.2% of the subjects had underweight status, and 20.2% of the subjects had an overweight status. These findings indicate a relatively high prevalence of obesity in the sample, with over half of the participants (51.3%) categorized as either overweight or obese. The cumulative percentages further demonstrate a gradual increase across BMI categories, with 68.9% of participants having a BMI below the obesity threshold.

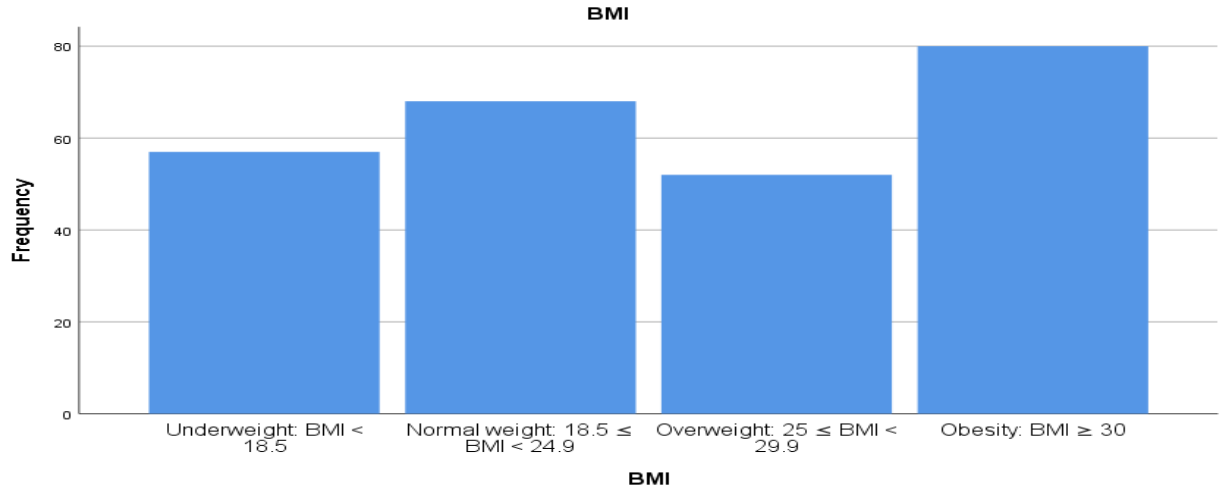

Figure 1: Bar Chart Representing Frequency Distribution of Participants by BMI Categories

Figure 1 illustrates the frequency distribution of participants across four Body Mass Index (BMI) categories. The highest frequency was observed in the obesity category (BMI ≥ 30), with 80 participants. This was followed by the normal weight group (18.5 ≤ BMI < 24.9) with 68 participants, and the underweight group (BMI < 18.5) with 57 participants. The lowest frequency was seen in the overweight group (25 ≤ BMI < 29.9), comprising 52 participants. The visual distribution highlights a notable concern, with a substantial proportion of the sample categorized as obese, indicating potential public health implications.

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Age	.114	257	.000	.945	257	.000

BMI	.200	257	.000	.844	257	.000
a. Lilliefors Significance Correction						

Note: *Lilliefors Significance Correction applied.*

Table 3: Tests of Normality for Age and BMI

Tests of normality were conducted using both the Kolmogorov-Smirnov and Shapiro-Wilk tests for the variables Age and BMI. Results from both tests indicated significant deviations from normality for Age (Kolmogorov-Smirnov: D = .114, $p < .001$; Shapiro-Wilk: W = .945, $p < .001$) and BMI (Kolmogorov-Smirnov: D = .200, $p < .001$; Shapiro-Wilk: W = .844, $p < .001$). These findings suggest that the distributions of both Age and BMI significantly deviate from a normal distribution, warranting the use of non-parametric statistical methods for subsequent analyses.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal: Hemoglobin levels above 11 g/dL-13 g/dL	46	17.9	17.9	17.9
	Mild Anemia: Hemoglobin between 10-11 g/dL	75	29.2	29.2	47.1
	Moderate Anemia: Hemoglobin between 7-10 g/dL	92	35.8	35.8	82.9
	Severe Anemia: Hemoglobin below 7 g/dL	44	17.1	17.1	100.0
	Total	257	100.0	100.0	

Table 4: Frequency Distribution of Participants by Anemia Status Based on CBC Hemoglobin Levels

The distribution of anemia levels based on CBC hemoglobin results showed that the majority of participants fell within the moderate anemia category (n = 92, 35.8%). This was followed by those with mild anemia (n = 75, 29.2%) and those with normal hemoglobin levels (n = 46, 17.9%). A notable proportion of the sample also experienced severe anemia (n = 44, 17.1%). Overall, 82.1% of participants were found to have some level of anemia, indicating a high prevalence of hemoglobin deficiency in the sample. These findings highlight the need for targeted health interventions and further investigation into contributing factors such as nutrition, chronic disease, or socioeconomic conditions.

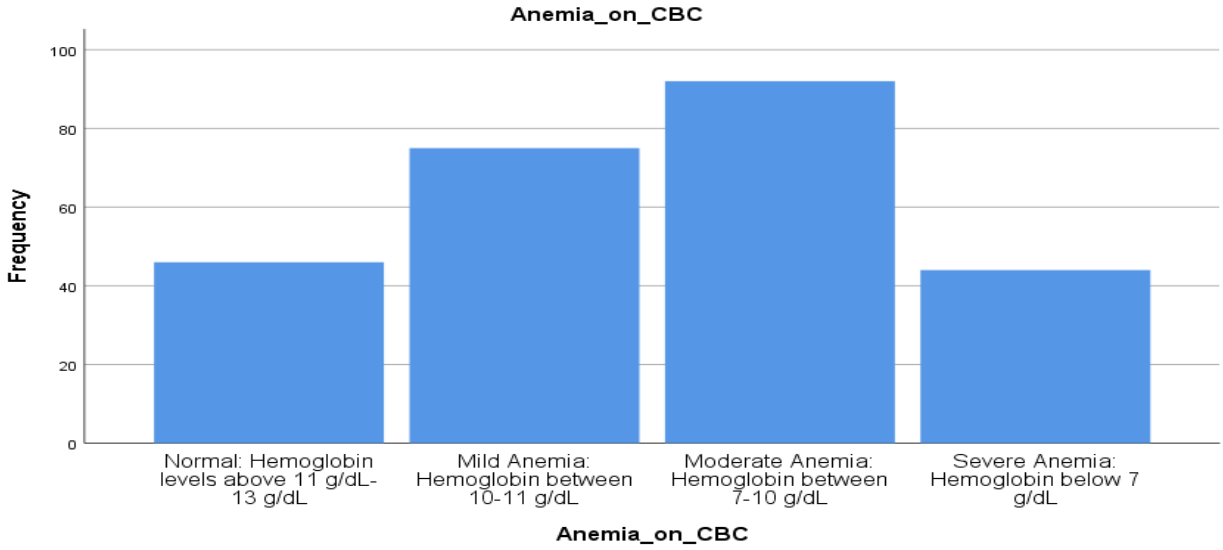

Figure 2: Distribution of Participants by Anemia Level Based on Hemoglobin Concentration

Figure 2 illustrates the distribution of anemia levels among participants based on hemoglobin concentration measured via CBC. Out of 257 participants, the largest group was those with moderate anemia (n = 92, 35.8%), followed by those with mild anemia (n = 75, 29.2%). Individuals with normal hemoglobin levels constituted 17.9% of the sample (n = 46), while 17.1% (n = 44) were classified as having severe anemia. The graphical representation highlights a significant proportion of the population experiencing various degrees of anemia, with a clear concentration in the moderate and mild categories. These results suggest the necessity for public health interventions focusing on early detection and treatment of anemia to prevent progression to more severe states.

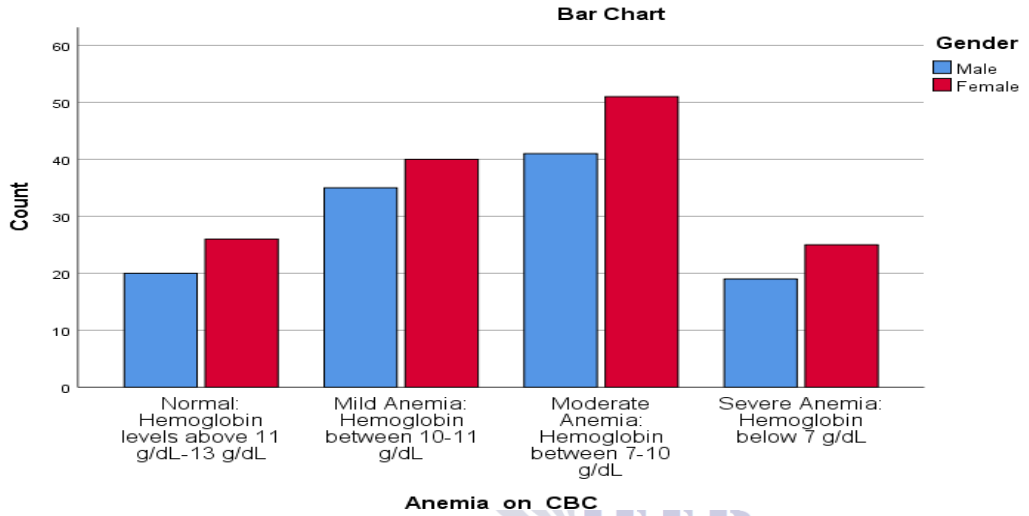

Figure 3: Gender-Wise Distribution of Anemia Levels Based on Hemoglobin Concentration

Figure 3 presents the gender-wise distribution of anemia levels based on hemoglobin concentration. The graph indicates that moderate anemia is the most prevalent condition in both males and females, with females (n ≈ 52) slightly outnumbering males (n ≈ 41) in this category. Similarly, more females than males exhibit mild anemia (n ≈ 40 vs. n ≈ 35). Severe anemia is also more common among females (n ≈ 27) compared to males (n ≈ 18). Interestingly, a higher percentage of females (n ≈ 26) than males (n ≈ 20) appear to have normal hemoglobin levels, although the difference is less pronounced. These findings underscore a higher prevalence of anemia—especially moderate and severe levels—among females in this population, highlighting a potential gender disparity in nutritional status, healthcare access, or biological susceptibility that warrants further investigation and targeted health interventions.

DISCUSSION

The present study aimed to evaluate the diagnostic accuracy of computed tomography (CT) chest for the diagnosis of anemia, using Complete Blood Count (CBC) as the gold standard. The sample consisted of 257 participants, whose demographic and clinical characteristics provided important context for interpreting the diagnostic findings. Descriptive statistics revealed a mean age of 5.75 years (SD = 2.72), indicating that the study population predominantly comprised young individuals, possibly children or early adolescents. The results regarding age distribution also varied with the minimum and maximum ages of 1 and 10 years, respectively. With specific regard to gender distribution and as presented by the median and mode of the 2.00, the set sample was slightly more inclined to the male subjects. With regard to the place of residence, the mode and median equal 2.00, categorized as an urban residence, thus suggesting a comparatively larger sample from the urban population.

BMI distribution was another method of getting information on the participants' physical health status. The mean BMI was 2.60 (SD = 1.14), and if we use the scale of BMI coding, it falls under overweight. Self-reported weight and height information showed 31.1% (n = 80) of the participants in the Obese category (actual BMI ≥ 30), 26.5% (n = 68) in the Normal Weight category (actual BMI between 18.5 and 24.9), 22.2% (n = 57) in the Underweight category (actual BMI less than 18.5), and 20.2% (n = 52) in the Overweight category (actual BMI between 25 and 29.9). The findings reveal that the majority of the sample had excess body weight, with 51.3% of the participants being categorized as being either overweight or obese. This is relevant considering the work done by Madiyeva et al. (2022) on the ambivalent link between BMI and anemia, where obesity can cause differences in iron metabolism and inflammation. For the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality, it was evident that both the age and BMI did not come close to a normal distribution.

For age, the K-S value was measured as 0.114, <= 0.001, and the W-S value as 0.945, <= 0.001. For BMI, the normality test results were even higher, with the Kolmogorov-Smirnov of 0.200($p<0.001$) and the Shapiro-Wilk of 0.844 ($p<0.001$). It must be noted that the utilization of non-parametric tests in the subsequent data analysis is justified by Abbasi et al., (2022), who observe that health data is frequently non-normal and that non-parametric tests should therefore be used. When anemia status was assessed through CBC hemoglobin levels, a substantial prevalence of anemia was observed among participants. Only 17.9% (n = 46) had normal hemoglobin levels, whereas 29.2% (n = 75) were diagnosed with mild anemia, 35.8% (n = 92) with moderate anemia, and 17.1% (n = 44) with severe anemia. These figures highlight that 82.1% of the sample exhibited some degree of anemia. This aligns with global trends in pediatric populations, particularly in low- and middle-income countries like Pakistan, where anemia prevalence remains high due to dietary deficiencies, infections, and limited healthcare access.

The most commonly observed anemia level was moderate, followed by mild and then severe anemia, suggesting a progressive burden of disease in this cohort. Furthermore, gender-wise distribution of anemia levels showed that females had a higher prevalence across all anemia categories. Moderate anemia was most common in females (n ≈ 52) compared to males (n ≈ 41), and mild anemia was also more prevalent in females (n ≈ 40) than males (n ≈ 35). Severe anemia followed the same trend, with approximately 27 females affected compared to 18 males. Interestingly, despite the overall higher anemia burden in females, a slightly higher number of females (n ≈ 26) than males (n ≈ 20) also had normal hemoglobin levels. This gender disparity could be attributed to various physiological, nutritional, and socio-cultural factors. According to WHO (2021), females, particularly in reproductive age or adolescence, are more susceptible to anemia due to menstruation, pregnancy, and higher micronutrient demands, which often go unmet in resource-limited settings.

These findings suggest the need for targeted interventions to address anemia, especially among female and overweight or obese individuals in urban settings. The correlation between obesity and anemia, as evidenced by the higher proportion of overweight and obese participants in the sample, warrants further exploration. The current results also revealed an increased percentage of CT chest imaging that depicted early signs suggestive of anemia. As much as CBC is the gold standard in diagnosing anemia, considering the possibility of utilizing radiological devices could be useful in offering additional supportive evidence, depressingly in clinical situations where phlebotomy is cumbersome or restricted and where the use of more invasive techniques might not be favorable. The study's implications are of significance to the public IS/IT policies dealing with anemia screening, nutritional Supplementation, and gender-sensitive educational messages.

CONCLUSION

This study evaluated the diagnostic accuracy of CT chest imaging for detecting anemia, using CBC as the gold standard. Findings revealed a high prevalence of anemia (82.1%) among the predominantly urban and young population, with moderate anemia being the most common. Gender-wise analysis showed a higher incidence of anemia in

females, and BMI distribution indicated a concerning proportion of overweight and obese individuals, which may contribute to altered iron metabolism. Both age and BMI variables were not normally distributed, guiding the use of non-parametric statistical methods. These insights highlight the multifactorial nature of anemia and underscore the importance of early screening and gender-sensitive health strategies. While CBC remains the definitive diagnostic tool, CT imaging could serve as a valuable adjunct, especially in cases where blood testing is limited. Future research should focus on validating CT-based findings and exploring preventive strategies to reduce anemia burden, particularly in at-risk populations.

References

1- Igwe, M.C., Obeagu, E.I., Kalyankolo, Z., Nwankpa, C.C., Kagenderezo, B.P. and Obeagu, G.U., 2022. Efficiency of Full Blood Count in Routine Patient Diagnosis: A Systematic Review.

2- An, R., Huang, Y., Man, Y., Valentine, R.W., Kucukal, E., Goreke, U., Sekyonda, Z., Piccone, C., Owusu-Ansah, A., Ahuja, S. and Little, J.A., 2021. Emerging point-of-care technologies for anemia detection. Lab on a Chip, 21(10), pp.1843-1865.

3- Sleem, S.M.M.M., Habba, M.R. and Ahmed, A.T., 2024. Value of Chest Computed Tomography in Diagnosis of COVID-19 Related Pneumonia and Its Severity in Relation to ABO Blood Grouping System. Egyptian Journal of Hospital Medicine, 94(1), pp.1174-1181.

4- Ehsanbakhsh, A., Hatami, F., Valizadeh, N., Khorashadizadeh, N. and Norouzirad, F., 2021. Evaluating the performance of unenhanced computed tomography in the diagnosis of pulmonary embolism. The Journal of Tehran University Heart Center, 16(4), p.156.

5- Madiyeva, M.R., Smagulova, D.M. and Baibolova, A.A., 2022. X-RAY DIAGNOSIS OF ACUTE DESTRUCTIVE PNEUMONIA IN A 1.5 YEAR OLD CHILD. CASE REPORT. Наукаиздравоохранение, 24(1), pp.215-219.

6- Awad, A.M., Elrahman, A.E.S.M.A. and El-Kasser, M.H.M., 2024. Accuracy of Multi-detector Computed Tomography compared to laparoscopy In Ovarian Cancer Staging. Al-Azhar International Medical Journal, 5(1), p.46.

7- Murakami, Y., Shibata, S., Morosawa, M., Nozaki, Y. and Takesue, Y., 2025. Delayed Pulmonary Manifestations of Miliary Tuberculosis Following a Normal Initial High-Resolution Computed Tomography. Cureus, 17(1).

8- Abbasi, B., Seyed Hosseini, M., MoodiGhalibaf, A., Akhavan, R., Emadzadeh, M. and Bolvardi, E., 2022. Evaluating anemia on non-contrast thoracic computed tomography. Scientific Reports, 12(1), p.21380.

9- Zopfs, D., Rinneburger, M., Pinto Dos Santos, D., Reimer, R.P., Laukamp, K.R., Maintz, D., Lennartz, S. and GroßeHokamp, N., 2021. Evaluating anemia using contrast-enhanced spectral detector CT of the chest in a large cohort of 522 patients. European Radiology, 31, pp.4350-4357.

10- Öcal, Z.A. and Köseoğlu, F.D., 2024. Prediction of anemia with thoracic computed tomography findings. Turkish Journal of Trauma & Emergency Surgery, 30(8), p.531.

11- Zhang, J., Wu, M., Huang, J., Li, S. and Ye, Z., 2022. Comparison between thoracic low-dose computed tomography and conventional-dose computed tomography in evaluating anemia: A preliminary study in a Chinese screening cohort. Frontiers in Cardiovascular Medicine, 9, p.987753.

12- Wazzan, M., Abduljabbar, A., Ajlan, A., Khashoggi, K., Eskandar, A., Alhazmi, T., Ahmad, R., Alotaibi, A., Subki, A. and Alotaibi, A.K., 2022. Enhancement of anemia detection by correlating computed tomography findings of abdominal aorta and inferior vena cava with laboratory investigations. Cureus, 14(12).

13- Liao, H.C., Wu, J.Y., Tsai, D.J., Chang, S.Y., Lin, C. and Fang, W.H., 2024. Chest-X-ray Based Deep Learning Model for Anemia Detection Insights from a Large Hospital Cohort.

14- D'Errico, L., Ghali, A., Pakkal, M., McInnis, M., Mehrez, H., Schuh, A.C., Kuruvilla, J.G., Minden, M. and Paul, N.S., 2024. Diagnostic Accuracy in Detecting Fungal Infection with Ultra-Low-Dose Computed Tomography (ULD-CT) Using Filtered Back Projection (FBP) Technique in Immunocompromised Patients. Journal of Clinical Medicine, 13(6), p.1704.

15- Rendon-Ramirez, E.J., Treviño-Garcia, K.B., Peña-Lozano, S.P., Treviño, M.A., Mercado-Longoria, R., Nañez-Terreros, H., Salinas-Chapa, M., Gómez-Almaguer, D., Cantú-Rodriguez, O.G., Cedillo-Huerta, H.E. and Vaquera-Alfaro, H.A., 2024. Point of care thoracic ultrasound versus chest computed tomography in the approach of febrile neutropenia patients: A diagnostic accuracy cohort study. Medicine, 103(7), p.e36941.