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Prediction of Anaemia in Non-Contrast Computed Tomography of Chest

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Abstract: ***Anaemia is an extensive and a common problem all over India. Direct haemoglobin estimation for assessment of anaemia is a relatively easy modality however Computed Tomography (CT) can detect few changes that suggest anaemia. These incidental findings can aid in the management of the patient. A cross-sectional study was carried out in100 patients. From August 2022 to December 2022, the subjects who had undergone thoracic CT at the D.Y. Patil medical college and hospital in Kolhapur, India, were included. For males the normal reference blood haemoglobin was 14g/dL and 11 g/dL for females. The blood investigation was performed within 24 hours after or before the non-contrast CT scan. For the research, a 128-slice CT scanner was used. Our results showed that the blood parameters revealed anaemia in a total of 61% of patients. Aortic ring sign was found in 62% of patients overall, whereas hyperdense interventricular (IV) septum sign was found in 66% of patients. It was therefore concluded that when the interventricular septum is visible on a CT thorax without contrast, it indicates the presence of underlying anaemia and has to be investigated to better care and lessen patient morbidity.***

Keywords: Interventricular septum, haemoglobin, aortic ring sign, Hounsfield units, Computed Tomography

1. Introduction

There have been various incidental findings seen on CT assessment of the chest. Identifying these incidentally picked-up findings can have a significant impact on the management of the patient. One such incidental detection can be anaemia. Usually, anaemia is diagnosed on the basis of plasma haemoglobin levels but recognising such unseen discoveries, especially in emergency situations aids in giving the patient the best care possible.[1]On CT we can also comment on the blood viscosity in the heart chambers and in the blood vessels and this may help in possibly predicting anaemia but this usually requires an experienced radiologist.

Previous studies in the past reported the incidental finding of anaemia on non-contrast CT with IV septum sign which implies that the myocardium or the interventricular septum appear as dense structures when compared to the density in the cavity of the left ventricle. Additionally, diseases like secondary hemochromatosis and glycogen storage disease can show increased IV septum density because of excess iron or glycogen even though haemoglobin levels are normal. Yet another sign was the Aortic ring sign i.e. the wall of the thoracic aorta appears hypodense in comparison to the blood within it.[2,3,6]Atherosclerotic plaques that are calcified can also mimic this sign. The above two methods were reliable in finding severe anaemia but were however an operator-dependent procedures and thus had inter-observer variability.

Some publications emphasise the value of the abdominal aorta's CT attenuation, while others focus on the distinction between the Left Ventricular (LV) cavity and the IV septum's CT attenuation.

Taking into the above consideration we decided to diagnose anaemia on the basis of IV septum sign and Aortic ring sign in our hospital setting. The study also evaluates if the measurement of density in HU values of IV septum and left ventricular cavity helps in predicting anaemia.

2. Literature Survey

There were previous studies conducted which showed that prediction of anaemia on contrast and non-contrast CT thorax was feasible by the presence of the Aortic ring sign and interventricular septum sign. A study conducted by Michelle Foster concluded that the presence of interventricular septum on unenhanced CT helps in the diagnosis of anaemia.[4]

By using CT density measurements of intravascular blood, Di Giandomenico E et al. demonstrated that there is a considerable variation in blood attenuation values between healthy people and anaemic patients. However, it is unclear which approach to use to analyse this relationship and how reliable it is. [7]

3. Methods

A cross-sectional study was conducted on a total of 100 patients. From August 2022 to December 2022, all patients who received thoracic CT at the Dr. D.Y. Patil medical college and hospital and Research Institute in Kolhapur, India, were included as subjects. The sample size was calculated by using the following formula:

$$\mathbf{n} = \frac{(\mathbf{Z_\alpha})^2 \mathbf{p_1}(\mathbf{1} - \mathbf{p_1})}{(\mathbf{d})^2}$$

where Z_α is the critical value of the normal distribution at α (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96, **p1** is the prevalence(Proportion) of CT thorax and d is the Margin of error. Taking, p_1 = 15% = 0.15 (from MRD of Dr. D. Y. Patil Hospital, Kolhapur) and d = 7% = 0.07
100 samples were required as the minimum number.

3.1Inclusion criteria

Patients (both male and non-pregnant female) between age 20-75 years who got non-contrast CT chest for any indication.

3.2 Exclusion criteria

Known case of anaemia or those undergoing blood transfusion for anaemia were excluded from the study.

3.3 Study Procedure

The patients fulfilling the inclusion criteria were studied. GE Optim 660 128 slice CT scan machine was used. The reference value for normal blood haemoglobin was considered as 14g/dL for males and 11g/dL for females. The plasma Haemoglobin was assessed within 24hrs after or before the CT scan was performed. The CT scan was interpreted by experienced Radiologist in the department of Radiology. The interpreter was not aware of the value of the patient's plasma haemoglobin. In all of the cases, the soft tissue window was utilised during interpretation (WW:200 HU; WL:55 HU).[10]

True positives- Those cases where both the haemoglobin measurement and the CT findings were suggestive of anaemia.

True negatives- Those cases where the results of the CT scan and the haemoglobin measurement were not suggestive of anaemia.

False positive-Those cases with positive CT scans suggesting anaemia but negative haemoglobin estimation results showing no evidence of anaemia.

False negative- Those cases had no finding suggestive of anaemia on CT but the levels indicate anaemia based on haemoglobin estimate.

3.4 Statistical analysis

Version 23.0 of the statistical package Statistical Package for the Social Sciences (SPSS) was used to analyse the data for Positive Predictive Value (PPV) and Negative Predictive Value (NPV). Categorical variables that were provided as percentages and frequencies were subjected to the chi-square test for association. The p-value of 0.05 was considered as significant.

4. Results and Discussion

100 subjects were examined by using the aortic ring sign and IV septum objectively out of which 56 were females and 44 were males. 61 patients among 100 were diagnosed with anaemia on blood parameters. The Aortic ring sign was seen in 62% of the patients and 66% had a hyperdense interventricular septum.

Table 1: Distribution of variables(N=100)

Parameters		Count (N)	Percentage (%)
Anaemia	Present	61	61
	Absent	39	39
Age (in years)	30 and below	8	8
	31-50	31	31
	51-70	48	48
	Above 70	13	13
Gender	Male	44	44
	Female	56	56
Aortic ring sign	Present	62	62
	Absent	38	38
Interventricular septum	Present	66	66
	Absent	34	34

Frequency, percentage, PPV, and NPV were used as the basis for the analysis. Anaemia was detected in 61% of the total patients in this study, which had a predominance of female patients. [Table 1]. In comparison to patients who had the aortic ring sign, a greater number of patients had the hyperdense IVS sign [Table-1]. 9 patients with the positive aortic ring sign were given the wrong diagnosis of anaemia (false positive), while 8 patients with anaemia were not given the correct diagnosis because they didn't show the aortic ring sign (false negative).Likewise, 10 patients with hyperdense IVS sign were misdiagnosed to have anaemia (false positive) and 5 patients with anaemia did not demonstrated the hyperdense IVS sign (false negative). The hyperdense IVS sign was found to have higher sensitivity and negative predictive value (NPV) than the aortic ring sign, but the aortic ring sign had higher specificity and positive predictive value (PPV) than the hyperdense IV septum sign. [Table 2, 3].

Table 2: Analysis of presence of interventricular septum

Interventricular Septum Sign	
Parameters	Percentages (%)
Sensitivity	91.8
Specificity	74.3
Positive likelihood ratio	3.57
Negative likelihood ratio	0.11
Positive predictive value	84.8
Negative predictive value	85.2

Table 3: Analysis of presence of aortic ring sign

Aortic Ring Sign	
Parameters	Percentages (%)
Sensitivity	86.8
Specificity	76.9
Positive likelihood ratio	3.75
Negative likelihood ratio	0.17
Positive predictive value	85.4
Negative predictive value	78.9

Table 4: p value of the CT signs (p-value <0.05 is significant)

Anaemia (absent/present)	p-Value (Chi-square)
Aortic ring sign	<0.001*
Interventricular septum	<0.001*

In comparison to the calculated 22.0 odds ratio for the aortic ring sign (p-value<0.001), the odds ratio for the hyperdense IVS sign was 32.48. (p-value<0.001) [Table 4, 5].

Table 5: Odds ratio of the radiological signs

Odds Ratio Values	
Parameters	Value
Gender	1.92
Aortic ring(absent/present)	22.0
Interventricular septum(absent/present)	32.48

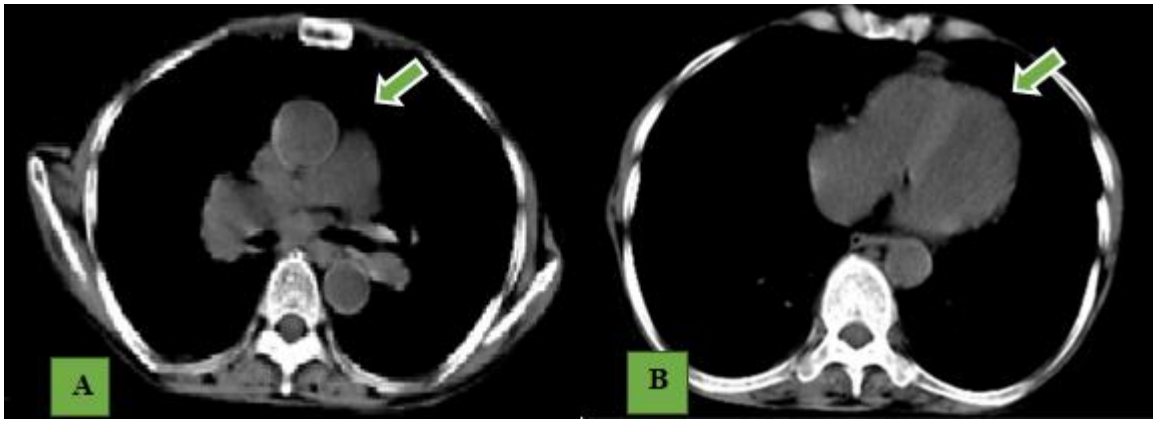

Figure 1: 65-year-old male patient underwent CT Chest for complains of shortness of breath. Her haemoglobin level was 9.4g/dL. A)Non contrast CT chest shows aortic ring sign(arrow) at the level of right pulmonary artery. B) Non contrast CT chest shows interventricular septum sign (arrow) at the ventricular level.

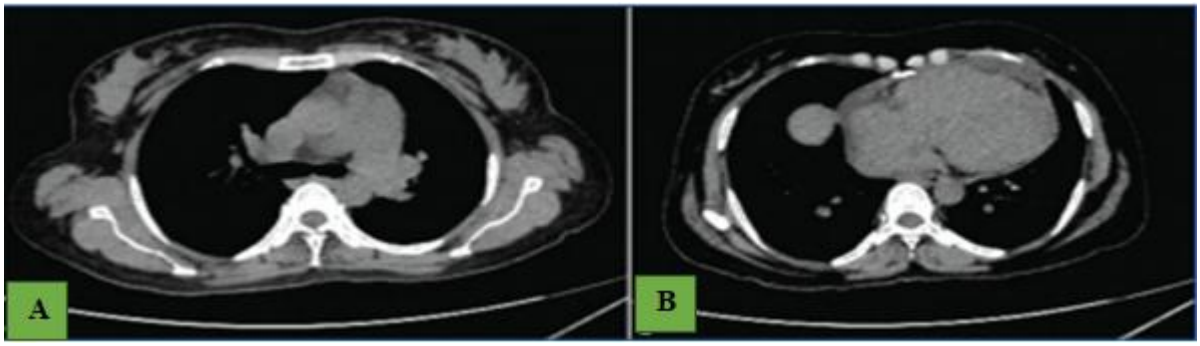

Figure 2: 58-year-old female patient underwent CT Chest for complains of cough. Her haemoglobin level was normal. A) Non contrast CT chest shows normal appearance of aorta at the level of bifurcation of pulmonary artery. B) Non contrast CT chest shows normal appearance of the myocardium at the ventricular level.

Recently, it has been discovered that anaemia, which is typically thought to be rare, is actually more prevalent. Anaemia is common among oncology and critical care patients, but it is actually four to six times more common than thought among the elderly. Because untreated anaemia increases the risk of morbidity, death, and prolonged hospital stays, it is crucial to identify it and treat it. In this study the hyperdense IV septum sign shows a sensitivity of 91.8% and a specificity of 74.3%. Considering that the aortic ring sign shows a sensitivity of 86.8% and a specificity of 76.9%.

According to research by Lan H et al., assessing the CT attenuation of the LV cavity alone was clearly inferior to estimating the difference in CT attenuation between the IVS and the LV cavity for identifying anaemia. [5]

When Kamel EM et al. studied the diagnostic value of unenhanced MDCT in anaemic patients, aortic ring sign was more specific than the IVS sign for detecting anaemia (100% vs. 92%), but the latter was more sensitive (84% vs. 72%). [4] The IVS sign was more effective at identifying anaemia, while Patil NG et al. found that the CT attenuation value of the aortic ring was more sensitive with a strong association (r=0.63). They came to the conclusion that an

alternate basis for determining anaemia is provided by the attenuation values of the aorta, the aortic ring sign, and the IVS sign on an unenhanced CT scan of the thorax. [8]

Haemoglobin concentration and CT attenuation of IVS-LV were found to have an obvious parallel association, according to Zhou QQ et al. (the determination coefficient was 0.818; p-value0.001). When the CT value was greater than 13.5 HU, the sensitivity and specificity for diagnosing severe anaemia were good in both sexes (94.6% and 82.8% in men; 81.9% and 82.1% in women). However, the threshold of CT attenuation of IVS-LV was low, the specificity for diagnosing mild anaemia was low, while the sensitivity was very high. [Table 6]. As hematologic laboratory studies are lacking, they came to the conclusion that the CT attenuation of IVS-LV may accurately predict the degree of anaemia with good sensitivity and specificity, adding value to clinical practise and, more significantly, improving patient care. [9]

Table 6: IVS-LV HU values in both genders with their sensitivity and specificity.(Adapted form [9])

IVS-LV HU Value	Gender	Sensitivity (%)	Specificity (%)
5.5-9.5	M	100	85.7
5.5-9.5	F	100	86.2
9.5-13.5	M	93.3	75.1
9.5-13.5	F	94.1	63.4
>13.5	M	94.6	82.8
>13.5	F	81.9	82.1

This study shows that the IVS CT attenuation can be used to predict anaemia. When the interventricular septal sign or the aortic ring sign's diagnostic effectiveness is compared to that of objective quantitative analysis, it is discovered that the IVS sign is more successful at spotting anaemia on plain CT.

Male or female anaemia could still exist, despite the absence of IVS visualisation. The study's sensitivity and specificity are 96.61% and 80.49%, respectively, with an IVS hyperdensity cut-off value of 38.15 HU. Patients with diseases including glycogen storage disorders and iron overload who have many blood transfusions may exhibit a rise in the IVS hyperdensity on a CT scan even when their haemoglobin levels are normal. We did not find any patients with aberrant glycogen or storage during this investigation.

5. Conclusion (s)

Predicting anaemia on non-contrast CT Chest is possible as there was a significant correlation between the values of haemoglobin and the presence of hyperdense IVS. Among the IVS sign and aortic ring sign, the former has better sensitivity and PPV when compared to the latter. Therefore, visualisation of hyperdense IVS sign and aortic ring sign in a CT thorax scan can suggest the diagnosis of anaemia which can be further evaluated for better patient outcomes.

6. Future Scope (limitations)

The limitation of this study is due to the operator dependence of this study, inter-observer variability makes it more error-prone. In patients with mild anaemia, the chances of a false negative are more. Another limitation was the small sample size. The wide range of X-ray tube currents used for CT in patients who had variable body mass indices was yet another drawback of the study.

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