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Tips for anemia on unenhanced computed tomography of the thorax in the elderly: Subjective and objective assessment

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Abstract

Objective: To obtain information on whether blood attenuation values are correlated with hemoglobin levels, besides visualization of the interventricular septum and aortic wall signs, in this way providing to estimate the severity of anemia in the elderly.

Subjects and Methods: 169 patients over 65 years old who applied for various reasons in the first three months of 2019 were selected for this study if they had undergone unenhanced thorax CT and their hemoglobin levels had been assessed within 24 hours. Radiologists identified the presence or absence of the interventricular septum and aortic ring signs. Blood density was measured as ROIs. One each ROIs were placed on the left ventricular cavity, the aortic arc, also on the pulmonary arteries, the ascending and descending aortas.

Results: All statistical analysis was performed with the SPSS 22. The specificity was calculated as 100% for IVS, the sensitivity was 57.1%. These values were 51.7% and 91.8%, respectively, for the AR. The correlation between hemoglobin values and blood densities was evaluated by pearson correlation analysis and there was a strong correlation. The cut off HU value for aorta was 36.4, with 69.4 sensitivity and 88.3 specificity. The cut off HU value for the pulmonary artery was 35.2, with 61.2 sensitivity and 87.5 specificity. The cut off HU value for the left ventricle was 37.6, with 77.5 sensitivity and 75.8 specificity.

Conclusion: Interpretation of an anemic situation on the unenhanced thorax CT of the elderly by making subjective and objective assessments will guide the clinician.

Keywords: anemia, aged, blood, thorax, tomography

Introduction

Anemia is a worldwide public health problem affecting all the countries. It may occur at any ages of the life. Anemia in the elderly (defined as people aged > 65 years) is common and increasing as the population ages¹. Nowadays, anemia is acknowledged as a risk factor for a series of negative consequences in the elderly, including hospitalization, morbidity, and mortality^[2]. In spite of its clinical importance, anemia in the elderly is an overlooked diagnosis^[1]. So the diagnosis of anemia is critical. Although anemia is mainly diagnosed with serum hemoglobine levels, Computed Tomography (CT) may evoke awareness about underlying anemia. During evaluation of unenhanced CT images of the thorax, radiologists may point out on anemia.

Radiologists can assess the presence of the visible signs which are interventricular septum (IVS) and the aortic ring (AR) and also make an objective analysis on unenhanced thorax CT. The interventricular septum may be visible on CT with severe anemia^[3]. However one should not ignore that in some diseases are due to excess iron accumulation, such as secondary hemochromatosis, relative density increase can be seen in the interventricular septum while hemoglobin levels are normal^[4, 5, 6]. The visualization of a hyperattenuating aortic wall is another subjective sign because the density of blood is decreased in patients with low hemoglobine levels, and the arterial wall density appears to be higher compared to the blood^[4, 7]. However, it should be kept in mind that atherosclerosis may cause similar appearance^[7]. Additional objective analysis may be more accurate for differentiating anemic situations by measuring the blood density of great vessels lumens or left ventricle lumen on unenhanced CT.

Our purpose in this study was to indicate the correlation between hemoglobine values and blood attenuation values, besides visualization of the IVS and AR signs, hereby help in increasing the clinicians' awareness about anemia that is a challenge for life quality in the elderly.

Subjects and Methods

Patients who applied to our hospital for various reasons in January, February, and March 2019 were selected for this study if they had undergone unenhanced CT of the thorax and their hemoglobin levels had been assessed on the day the CT scan was done. The patients are excluded who were under 65 years old or at the risk of possible acute hemoglobin levels change as in trauma. 169 patients (89 male, 84 female), from 65 to 92 years have the above mentioned criteria were included in the study. Anemia was described as a hemoglobin level below 13 g/L for males and below 12 g/L for females^[8]. Unenhanced Thorax CT scans were obtained from 16 slice PHILIPS MDCT scanner. The preset soft tissue window (window with =350 HU, window level = 50 HU) was used to evaluate the images.

For each patient, two radiologists at least 5 years experienced noted the presence or absence of hyperdense

interventricular septum (interventricular septum sign) and hyperdense aortic wall (aortic ring sign) to make subjective analysis (Fig 1). All radiologists were unaware of the laboratory findings during interpretation. The images with artifacts and the patients with ambiguous findings were excluded for the accuracy of statistical analysis. For quantification analysis the blood attenuation was assessed by measuring the regions of interest (ROIs) on CT images. HU measurements of selected ROIs on each examination were recorded. A circular ROI measuring approximately 1 cm² was applied on all images. A single region of interest were placed on the left ventricular lumen. One ROIs was placed on the aortic arc (Fig 2). At the pulmonary trunk level, one each ROIs were placed on the main, right, and left pulmonary arteries, on the ascending, and the descending aortas (Fig 3).

All statistical analysis was performed with the SPSS 22 (Statistical Package for Social Sciences) program. The correlation between hemoglobin values and densities was evaluated by pearson correlation analysis. The sensitivity and specificity by taking arithmetic mean for ascending aorta, descending aorta, and arcus aorta measurements were also calculated to make an objective analysis.

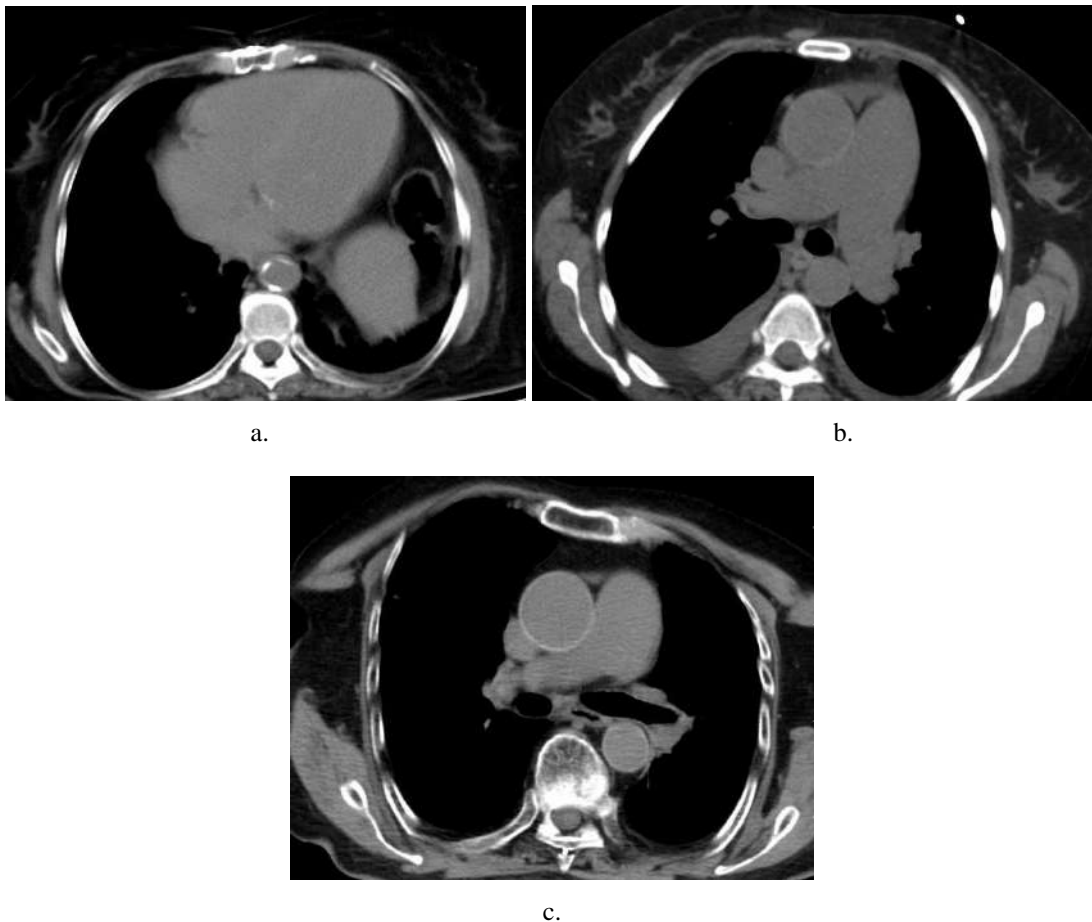


Fig 1: a. Relatively hiperdense interventricular septum against ventricular cavities in an anemic patient. b. Relatively hypendense aortic wall against aorta blood lumen in an another patient with anemia. c. False positive aortic sign because of the faint mural calcification in a non-anemic patient.

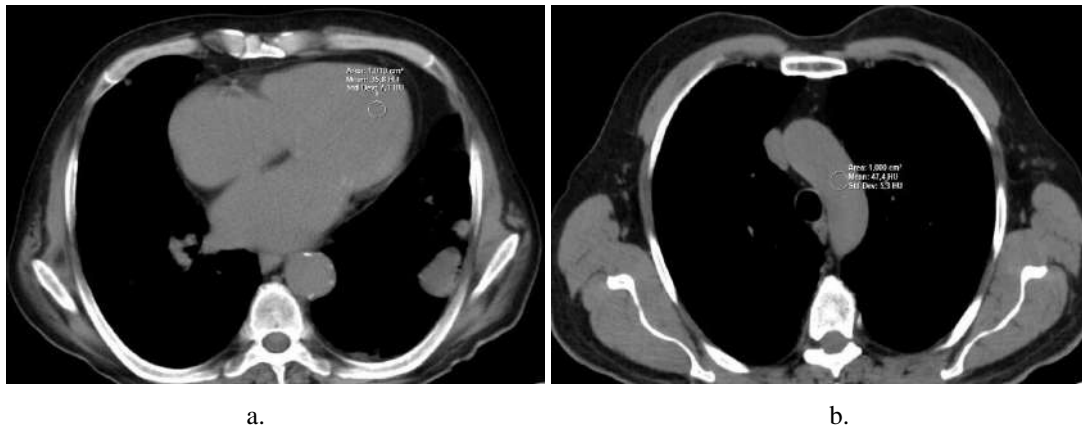


Fig 2: Blood density measurements as ROIs of the left ventricular cavity (a), and arcus aorta (b).

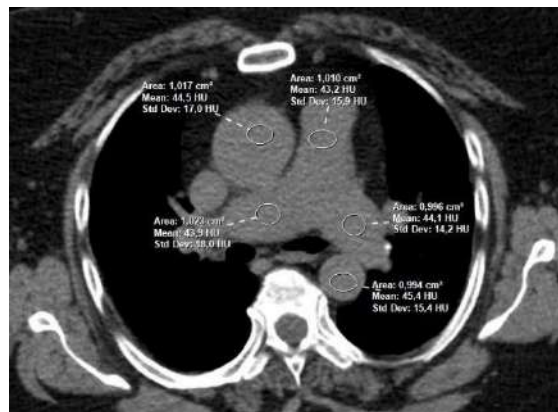


Fig 3: HU measurements of the pulmonary arteries, the ascending aorta and the descending aorta at the pulmonary trunk level.

Results

169 patients aged 65 and over were between 65 and 92 years of age. 88 of the patients were female (52.1%) and 81 were male (47.9%). The lowest hemoglobin level was 7.4, the highest level was 20.0, and the average hemoglobin level was 13.3. 49 patients (29%) had anemia in our patient population. The interventricular septum was present in 28 patients (16.6%), by the way aortic ring was present in 103 (60.9%) patients. Atherosclerosis was detected in 131 patients (77.5%).

The specificity was calculated as 100% for the IVS, whereas the sensitivity was 57.14%. The positive predictive value (PPV) was 100%, the negative predictive value (NPV) was 85.11%, and the accuracy was 87.57% for the IVS. These values were 51.24% and 93.75%, respectively, for the aortic ring. The PPV was 43.27%, the NPV was 95.38%, the accuracy was 63.31%.

There was a strong correlation between left ventricular density and hemoglobin value ($r = 0.619$). There were also strong correlations between main great vessels densities and hemoglobin levels. The r values were 0.543 for the main

pulmonary artery, 0.576 for the right pulmonary artery, 0.544 for the left pulmonary artery, 0.618 for the ascending aorta, 0.642 for the arcus aorta, 0.615 for the descending aorta. The average r values were 0.573 for pulmonary arteries and 0.644 for aortas. $p < 0.05$ was found for all.

We also calculated the sensitivity and specificity by taking arithmetic mean for ascending aorta, descending aorta, and arcus aorta measurements. The cut off HU value for aorta was 36.4, and according to this value the sensitivity was 67.35, the specificity was 89.17. The PPV was 71.74%, the NPV was 86.99%, and the accuracy was 82.84%.

We did the same calculation for the main, right and left pulmonary arteries. The cut off HU value for the pulmonary arteries was 35.2, and according to this value the sensitivity was 61.22, the specificity was 85.00. The PPV was 62.50%, the NPV was 84.30%, and the accuracy was 78.11%.

The cut off HU value for the left ventricle was 37.6, according to this value the sensitivity was 77.55, the specificity was 75.83. The PPV was 56.72%, the NPV was 89.22%, and the accuracy was 76.33% (Table 1).

Table 1: The sensitivity and specificity values, PPVs, NPVs and the accuracy values of the each subjective sign and objective measurements

	Sensitivity	Specificity	PPV	NPV	Accuracy
Interventricular septum	57.14%	100.0%	100.0	85.11	87.57
Aortic Ring	93.75%	51.24%	43.27	95.38	63.31
Aorta HU ($\leq 36,4$)	67.35%	89.17%	71.74	86.99	82.84
Pulmoner Artery HU ($\leq 35,2$)	61.22%	85.00%	62.50	84.30	78.11
Left Ventricle HU ($\leq 37,6$)	77.55%	75.83%	56.72	89.22	76.33

Discussion

Although anemia is more common in oncology and critical care patients, the incidence of anemia among elderly is greater than generally suspected [4, 9]. Anemia in the elderly is especially important because it has some serious outcomes. Anemia has been associated with a high incidence of heart diseases, mental impairment, loss of physical performance and, consequently, quality of life [1]. Moreover, presence of anemia is notably associated with an increased risk of mortality, especially, related to cardiovascular disease [1, 10, 11]. Remarkably, anemia may be an early sign of an undiagnosed malignancy [12]. Anemia of the elderly is a burden for individuals and healthcare providers. The diagnosis and treatment of anemia lies in the ability of doctors [1, 2, 9].

This study demonstrates a correlation between hemoglobin levels and blood density values, besides visualization of the IVS and AR in the elderly patients. Hemoglobin levels can be predicted with the density difference visualization between the IVS and the ventricles. In most patients with both normal and abnormal hemoglobin levels the IVS is invisible because of the similar density values of blood and cardiac muscle as were found in our study about the elderly. In our study, the IVS sign's specificity and the PPV were 100 %, the NPV and the accuracy were over 85%, but the sensitivity was 57.1%. This may have been related to our excluding criterias rejected the ambiguous patients and the images with artifacts. We did not detect any patients had glycogen or iron storage diseases in this study group leading to false positives with recognition of the interventricular septum [5, 12].

Invisibility of the interventricular septum did not rule out the presence of anemia in this study. 49 patients had anemia in total 169 patients in this study. There were 28 patients with IVS and all of them had anemia (100 %). There were 141 patients without IVS and 21 of them had anemia (14.9%). As a result, IVS was detected in 28 of 49 anemic patients. This could possibly be caused by our hemoglobin levels criteria according to WHO and the interventricular septum may be clearly visible with severe anemia [3]. Hemoglobin levels decrease with age and whether these values apply to older people are discussed. However most clinicians think that the normal hemoglobin range should not be reduced for the elderly because it is associated with hospitalization, morbidity, and mortality [1]. Commenting on a suspected anemia upon the unenhanced thorax CT may be guiding the clinician, even if hemoglobin levels are not revealed.

The AR sign's sensitivity was 91.8%, the NPV was 95.38 whereas the specificity was 51.7%, the PPV was 43.27, the accuracy was 63.31. The higher sensitivity of the AR sign may be due to the greater contrast difference between the vascular wall and lumen, since its wall mainly consists of collagen and elastin fibers [13]. The lower statistical ratios of this sign can be clarified with the presence of calcifications due to atherosclerotic changes as we often see in the elderly patients.

We also assessed the sensitivity, specificity, PPV, NPV and, the accuracy of the objective analysis of anemia with HU measurements as discussed in previous studies which had been done on all age groups [4, 6]. The results of this study displayed a strong correlation between density values of the left ventricle or great vessels and hemoglobine levels in distinguishing anemic state. In the evaluation of the density

of blood in the left ventricular cavity on CT images, a threshold value of 35 HU was found best discriminatory for an anemic states in a study [6]. We found an average threshold density value for left ventricular cavity in elderly as 37.6 HU in the elderly patients. We also found an average cut off HU value for the aorta and the pulmonary artery in this age group. The value for the aorta was 36.4, while for the pulmonary artery was 35.2.

Subjective findings of anemia is usually clearly visible with the severe anemia which may be late to intervene, and it usually shows interobserver variability. So it is recommended that besides interpreting the visual findings of anemia, objective measurements of density values in HU of the ventricular or the aortic luminal blood is provided for more reliable diagnosis [6, 14]. In our study we found the IVS sign is the most specific method with high PPV whereas the AR sign is the most sensitive with high NPV. The density measurements of the left ventricular and great arteries lumens besides these subjective signs may provide a more confident diagnosis through increasing sensitivity and spesifity.

The two radiologists in this study evaluated each CT examination for particularly analyzing the images of the heart and great vessels to notice of an anemic state. It should be noted that in daily clinical practice since CT scanning is usually performed for other indications. The doubt of anemia may rise only if an interpreter recognizes a remarkable contrast between ventricular cavity and interventricular septum or visualization of the hyperdense aortic wall. It should also be considered that many indeterminate cases may be overlooked in clinical practice [6]. However, a radiologist may make a comment on an anemic state by measuring density of blood in the lumens of left ventricle or great vessels as ROIs, and correlating it with the subjective findings.

Conclusion

As thinking that anemia is described as a risk factor for a number of negative consequences in the elderly patients, commenting on an anemic state by making both subjective and objective assessments on the CT will raise the awareness of the clinician about anemia.

Competing interests

The authors declare that they have no competing interest.

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