ORIGINAL RESEARCH PAPER

Radiology

PREDICTION OF ANEMIA ON UNENHANCED COMPUTED TOMOGRAPHY OF THE THORAX.

KEY WORDS: Unenhanced Computedtomography,CT attenuation, Anemia

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ABSTRACT

Background: Our aim was to investigate the diagnostic value of unenhanced MDCT in anemic patients.
Material and methods: This hospital based correlation study was done on patients who underwent thoracic and abdominal computed tomographic examination in Yenepoya Medical College, Mangaloreduring a period of six months between (June 2016- December 2016) and their hemoglobin levels were assessed no more than 24 from an unenhanced CT of the thorax.
Observations: A total of 50 cases were included in this study. All patients were imaged using a 16 slice CT system (GE bright speed) using 1.25mm thickness, 1.375 pitch, 150-350 mA and 120 kVp. Following image review, circular regions of interest (ROI) were defined within the lumen of the left ventricle. The mean attenuation value is calculated.The mean patient age was 59.6 years (range 18-85 years).
Discussion and Conclusions: A good correlation (r=0.60) was observed between the left ventricular CT attenuation values and the hemoglobin levels in the whole study population. Using a threshold of ≤35 HU for anemia diagnosis, the sensitivity and specificity of left ventricular CT attenuation value were 94% and 88%, respectively, with the largest area under the curve (0.89) among all diagnostic criteria. No male with a left ventricular attenuation value greater than 50HU and no female with a left ventricular attenuation greater than 45HU were found to be anaemic. The results demonstrate a significant correlation between patients' haemoglobin measurement and the derived left ventricular attenuation value. We do not propose this as a method of accurately measuring the patient's haemoglobin; however, we feel that it may be possible for a radiologist at non-contrast enhanced CT examination to note the probable presence of anaemia.

INTRODUCTION

Although anemia is not primarily diagnosed on CT and serum hemoglobin levels can be readily obtained. Experienced radiologists are able to visually appreciate minor variations in density between adjacent tissues on CT images. During interpretation of noncontrast CT scans of the chest or abdomen performed for other indications, some radiologists may comment on the density of the blood within the cardiac chambers or major vessels and may infer an anemic state. It is assumed by many radiologists that one can usually correctly identify anemia (hemoglobin, < 10 g/dL) in patients simply by comparing the attenuation of blood in noncontrast studies with the adjacent vessel wall or myocardium[7]. A study by Powell and colleague[7]revealed that in the anemic state, the right and left ventricular cavities become clearly visible in canine hearts, thus making it possible to distinguish readily the boundaries of the ventricular and atrial cavities, the papillary muscles, the major trabeculae, and the aorta.Identifying such incidental findings may have a considerable impact on patient management and outcome[13,14].

Previously, anemia has been diagnosed when the hyperattenu ating aortic wall is seen against a relatively hypodense aortic blood pool ("aortic ring sign"), or when the dense myocardium or interventricular septum against hypodense left ventricular (LV) cavity ("interventricular septum sign") is clearly visualized on unenhanced CT.(1–5) These observations are a reliable method for detecting severe anemia, but it is an observerdependent process that may be subject to significant interobserver variability[5,6].

Previous studies have shown that the relation between the CT number of the cardiovascular chamber and the peripheral blood hemoglobin level is useful for the objective diagnosis of anemia[4–11].

Some authors have stressed the usefulness of CT attenuation of the abdominal aorta, and some emphasize the difference of CT attenuation between the LV cavity and the interventricular septum. However, the best method for analyzing this relation, and its reliability, is not certain. The measurement parameters of CT attenuation in the presence of anemia include CT numbers of the thoracic/abdominal aorta, inferior vena cava, LV cavity, and interventricular septum and the attenuation difference between the LV cavity and the interventricular septum[12].

Distinguishing the myocardium or interventricular septum as two relatively dense structures from a hypodense left ventricular cavity has been claimed to be a reliable sign for the diagnosis of anemia [1-4]. This approach, however, has been recently shown to be an operator-dependant process that may be subject to significant inter-observer variability[6]. Furthermore, in some diseases such as secondary hemochromatosis and glycogen storage disease, excess cardiac iron or glycogen may result in a relative increase in the interventricular density despite normal hemoglobin levels[1,10].

Similarly, the identification of a hyperattenuating aortic wall has been shown to indicate an underlying anemia [1, 2]. This sign, however, can be easily mimicked by the existence of calcified atherosclerotic plaques. Objective analysis, in contrast, is a more accurate process that can differentiate anemic from nonanemic subjects [6]. This can be established by analyzing the blood pool density of great vessels or cardiac chambers upon unenhanced CT. Hounsfield units (H) are the units of measurement of density on CT. In CT, a number (between –1,000 and 1,000 H) is assigned by computer to represent the difference in X-ray attenuation between a given materials and water (where air is –1,000 H and pure water is 0 H). This number is then used by the computer to assign a gray-scale shade to the represented image. The exquisite contrast resolution of current CT scanners can detect differences in contrast of less than 5 H (< 0.5%). CT density measurements of intravascular blood by Di Giandomenico et al. [9]showed a significant difference in blood attenuation values between healthy subjects and anemic patients.

The study aims to demonstrate a correlation between routine haematological assay of haemoglobin level and the attenuation value measured within the left ventricular cavity at routine unenhanced CT examination. The measured attenuation value is a reproducible physical density measurement, readily obtainable from a standard CT examination. A correlation between attenuation value and plasma haemoglobin may permit the identification of anaemia at CT examination. We attempted to determine if objective (measurement of Hounsfield units within the lumen of the left ventricle) evaluation was sufficiently accurate in predicting anemia.

MATERIALS AND METHODS

This is a hospital based correlationstudy. All the patients who underwent thoracic/abdominal CT fromJune 2016- December 2016 (6 months) in Yenepoya Medical College Hospital, Mangalore meeting the inclusion and exclusion criteria were considered for the study.With the approval of the ethical committee of our hospital, upon arrival at the reception patients were informed in writing that their medical information would be anonymized and used for research, although written consent was waived. The normal reference blood hemoglobin level in our hospital is 14.0–17.0 g/dl in males and 11.5–14.5 g/dl in females.

The peripheral blood examination is done within 24 hours after or before an unenhanced CT scan. The subjects consisted of 21 males and 31 females with a mean age of 59.6 years (18–85 years). The peripheral blood hemoglobin level varied from 5.5 to 17.7 g/dl (mean 12.0 g/dl). The normal reference blood hemoglobin level in our hospital is 14.0–17.0 g/dl in males and 11.5–14.5 g/dl in females.

A total of 52 cases were included in this study (21M, 31F). The mean patient age was 59.6 years (range 18-85 years).Inclusion criteria included any patient who undergoes non enhanced CT of thorax for any indication and exclusion criteria was previously diagnosed case of anemia and patients receiving blood transfusion for anemia.

GE Bright speed 16 slice CT scanner was used for the study. : The whole study underwent unenhanced CT on a 16 slice CT system (GE bright speed) using 1.25mm thickness, 1.375 pitch, 150-350 mA and 120 kvp.

No oral contrast medium was given for any patient either before or during the CT examination.

The acquired images were reconstructed into CT images (thickness 1.25 mm) utilizing the CT image reconstruction function; observation was performed under standard mediastinal settings (window width 400, window level 60).

Blood density was quantified through measuring CT attenuation value (HU) by means of three region of interest (rois) drawn over the lumen of left ventricle .A standard circular ROI measuring 2 cm was applied to the whole study.CT attenuation values were correlated with the hemoglobin levels.

STUDY TOOLS

Patients that meet the inclusion criteria will be considered for the study.

Minimum sample required is 52.
Power =80%
Effect size d =0.4
Sample size calculated using G power software
Level of significance= 5%
Sample size =52

OBSERVATIONS

Thevalues derived from aortic ROIs of patients are, given as mean ± SD.

Variables were compared using thepaired t-test; a P-value of less than 0.05 was consideredsignificant.

Using linear regression analysis, correlation between hemoglobin level and the left ventricular CT attenuation values was evaluated. Receiver-operating characteristic (ROC) curves were generated for objective analysis.

True-positive cases were defined as anemic patients correctly identified.

True-negative cases were defined as nonanemic patients that were correctly identified.

The mean density measured in Hounsfield units for anemic patients was 31.8 H with arange from 19.3 to 47.9 H

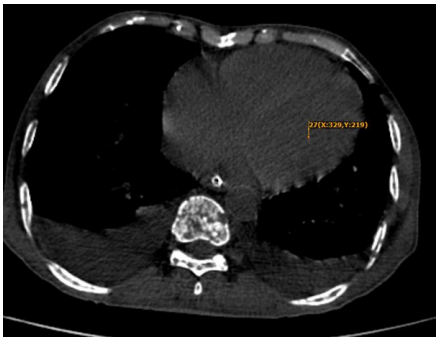
A good correlation was observed between the left ventricular CT attenuation values and Hb (r=0, 71, p<0, 0001).

Value of 42, 2 HU in the left ventricle for men revealed the most accurate results for anaemia detection with sensitivity of 100% and specificity of 86, 7% (AUC=0, 96, p<0, 0001).

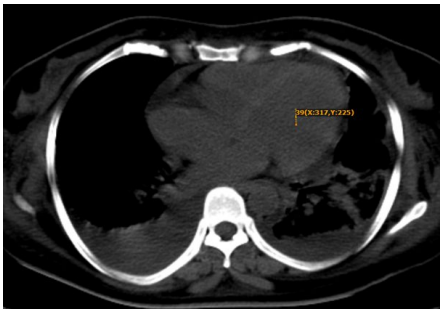
This threshold for women was 41, 8 HU with sensitivity of 100% and specificity of 68, 8% (AUC=0, 89, p<0, 0001).

This threshold for men and women successfully identified anaemic patients.

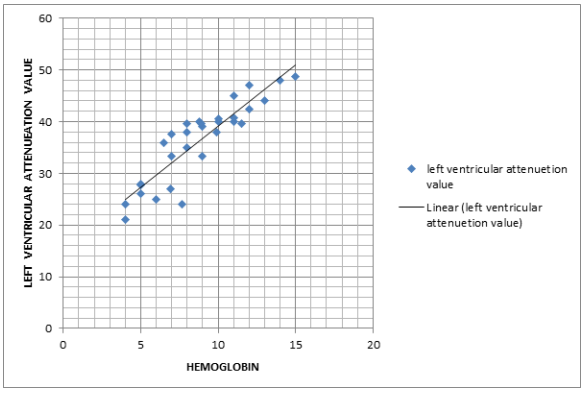
We found that no male patient with aleft ventricular attenuation value greater than 50HU and no female patient with attenuation greater than 45HU were anaemic.



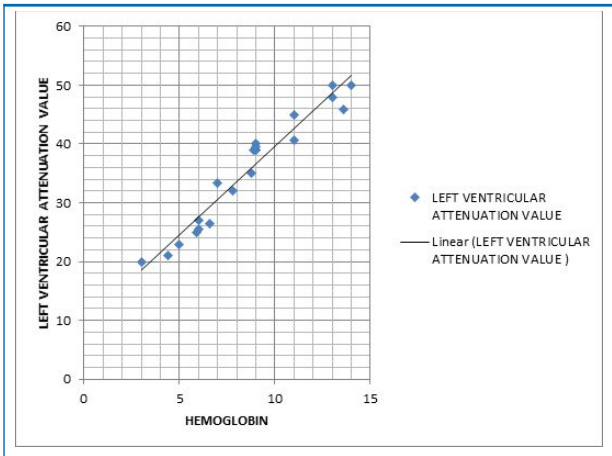
Unenhanced CT at the ventricular level in a woman with severe anemia (hemoglobin, 7.4 g/dl) shows left ventricular attenuation of 27HU and the interventricular septum sign .



Unenhanced CT at the ventricular level in a woman with severe anemia (haemoglobin, 9.4 g/dl) shows left ventricular attenuation of 39 HU and the interventricular septum sign



Graph shows correlation between hemoglobin levels versus density in Hounsfield units in women.



Graph shows correlation between haemoglobin levels versus density in Hounsfield units in me

DISCUSSION

The prevalence of anemia has been recently shown to be more common than is generally considered [15]. Besides its well-known prevalence among oncology and criticalcare patients, the incidence of anemia among aged people is four to six fold greater than generally suspected [15, 16].Recognition and treatment of anemia are important since untreated anemia carries increased risks of morbidity,mortality, and long hospital stay. These can indeed augment the cost of health-care delivery [15]. However, despite these facts, anemia remains a neglected and undertreated diagnosis [15]. Consequently, every effort must be done to identify and treat anemia as early as possible toavoid many unnecessary comorbidities.

Lan H et.al studied that for diagnosing anemia calculating the difference in CT attenuation between the interventricular septum and the LV cavity was definitely superior to measuring the CT attenuation of the LV cavity alone[12].

Foster et al. reported a similar result, but their calculation of the difference in CT attenuation between the LV cavity and interventricular septum was limited to cases in which the hyper attenuated interventricular septum was well visualized and they did not compare the accuracy of the calculation of the difference in CT attenuation between the LV cavity and interventricular septum with the measurement of CT attenuation of the cardiovascular chambers (LV cavity, aorta, inferior vena cava)[4].

Kamel EM1 et al. Investigated the diagnostic value of unenhanced MDCT in anemic patients and revealed that the aortic ring sign was more sensitive than the interventricular septum sign for anemia detection (84% vs. 72%), whereas this latter sign was more specific (100% vs. 92%).

This study revealed that anemia can be predicted by measuring the CT attenuation of the left ventricular cavity .We have not compared the diagnostic accuracy of subjective observation methods ("aortic ring sign" or "interventricular septal sign") with objective quantitative analyses. Previous reports have compared these two methods and they highlighted the integral roles of both subjective and objective radiological analysis for detecting anemia using unenhanced CT alone[4-6].

CONCLUSION

This study aimed to investigate the possibility of deriving a haemoglobin level from this readily available data. The degree of correlation we have demonstrated is not strong enough to give a highly accurate measurement of the plasma haemoglobin but is capable of providing a reliable indicator of the presence of anaemia. We have shown that an averaged left ventricular attenuation value in excess of 50HU in a male and 45HU in a female is consistent with the absence of anaemia.

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