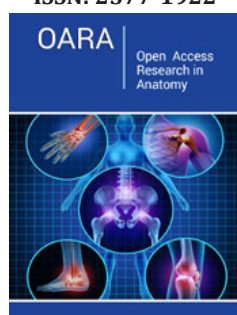


Detection of Variation in Hemoglobin Concentration between Capillary and Venous Blood Samples among Healthy Sudanese Population in Khartoum State

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Abstract

Currently, there are several methods available for hemoglobin screening, such as the spectrophotometric determination of hemoglobin, the spinning microhematocrit determination, and the copper sulphate density method. This cross-sectional comparative (analytical) study was conducted in the Sudan University of Science and Technology faculty of Medical Laboratory Sciences. This study aimed to determine any significant variation in hemoglobin concentration (g/dl) between capillary and venous blood. The sample consists of 100 healthy Sudanese adult volunteers, 41 males (41%) and 59 females (59%), aged 18-24 years, who have been tested. Paired blood samples (EDTA venous & capillary) were collected from each individual and analyzed for hemoglobin concentration by manual technique (HiCN). The result shows there was a significant difference in Hb concentration in capillary blood (mean 13.2g/dl) and venous blood (mean 12.8g/dl) ($P < 0.001$). Hemoglobin concentration is significantly higher in capillary blood compared to venous blood, with a mean difference of +0.4g/dL (13.2 ± 1.53 g/dL vs. 12.8 ± 1.41 g/dL, $P = 0.000$).

Keywords: Hemoglobin; Capillary; Venous blood; Analytical variations; Cyanmethemoglobin; Sudan; Adult health

Introduction

Complete Blood Count (CBC) is a common investigation that is done as a part of the assessment of a variety of medical conditions, mainly diagnosis and follow-up of anemia. Certain blood parameters (e.g., complete blood count) can be measured by samples taken from either site, i.e., venous and capillary. Venous blood and capillary blood are not quite similar. Differences of blood counts in venous and capillary blood, including hematocrit and hemoglobin concentration, have long been recognized, however, controversy remains about the exact aspects or mechanisms of the difference. Blood from a capillary puncture is a mixture of blood from arterioles, veins, and capillaries. therefore, contains some interstitial and intracellular fluid. Although some studies have suggested negligible differences in the free flow of blood. Others have shown definite differences in composition between skin puncture and venous blood samples in neonates, children, and adults. The differences may be exaggerated by cold, with resulting slow capillary blood flow. This study aims to determine the agreement of hemoglobin analysis using capillary blood from a finger stab compared to a conventional venous blood sample analysis at the hospital laboratory [1,2]. Currently, there are a number of methods available for hemoglobin screening, such as the spectrophotometric determination

of hemoglobin, the spinning microhematocrit determination, and the copper sulphate density method. A standardized procedure for hemoglobin screening of donors is not required by the FDA or AABB. In some parts of the United States, the gravimetric copper sulphate method has been in use for many years. Although this approach is simple to use and reasonably priced, it does not yield as reliable results as other hemoglobin screening techniques. The copper sulphate density method depends on a subjective endpoint and does not provide quantitative data [3-5]. Although the spun microhematocrit method is time consuming and less precise than other screening techniques, some institutions employ it for initial screening or as a backup testing method in the event that donors do not pass copper sulphate testing [6,7]. Erythrocyte is the life-giving substance of every red cell, the oxygen-carrying component of the red cell. Each red blood cell is nothing more than a fluid-filled sac, with the fluid being hemoglobin. In 4 months, or 120 days, red cells with normal hemoglobin content submit to the rigors of circulation. Red cells are stretched, twisted, pummeled, and squeezed as they make their way through the circulatory watershed. Each major organ in the human body depends on oxygenation for growth and function, and this process is ultimately under the control of hemoglobin. Oxygen and some carbon dioxide depend almost totally on the presence of red respiratory pigment (hemoglobin) in erythrocytes. Hemoglobin increases the ability of the blood to carry oxygen by 60 fold. Plasma carries 0.3mL of oxygen /100ml, while whole blood carries 20ml/100ml. This vital function makes Hb one of the important constituents of higher organisms [8]. This study aimed to determine the Variation in Hemoglobin Concentration between Capillary and Venous Blood Samples among the Healthy Sudanese Population in Khartoum State

Materials and Methods

This was a cross-sectional, comparative (analytical) study conducted in Khartoum State, Sudan. The study targeted healthy adult individuals aged between 18 and 24 years.

Study population

A total of 100 healthy volunteers (both males and females) were enrolled in the study. All participants were within the defined age range and free from any known medical conditions.

Inclusion criteria

Male and female participants. Age between 18 and 24 years. Clinically healthy and free from any illness.

Exclusion criteria

Presence of any illness, particularly anemia or polycythemia. Smoking. Individuals outside the age group (less than 18 or more than 24 years old).

Test performed

Laboratory analysis was done immediately after collection of samples from capillary and venous, and the hemoglobin estimation was obtained by the manual technique (cyanmethemoglobin) method: Whole blood was diluted using Drabkins solution, which

contains potassium ferricyanide and potassium cyanide, the red cell are hemolyzed by detergent and hemoglobin oxidized by potassium ferricyanide to ferricyanide methemoglobin (unstable color) and then converted by potassium cyanide to stable cyanmethemoglobin (HiCN). The absorption of HiCN solution was measured by a colorimeter in a yellow-green filter, it can also be measured by a spectrophotometer at a wavelength of 540nm, and the density of color is directly proportional to hemoglobin concentration in the sample.

Ethical considerations

The study was approved by the Department of hematology, faculty of medical laboratory sciences, Sudan university of science and technology, and the study was matched to the ethical review committee board. Sample collection was done after signing a written agreement with the participants. The aims and the benefits of this study were explained with the assurance of confidentiality. All protocols in this study were done according to the Declaration of Helsinki.

Data analysis

Data were analyzed using SPSS 25.0, descriptive statistics in terms of frequency, percentages, means, and standard deviations, and the Chi-square test was calculated. A p-value ≤ 0.05 is considered statistically significant.

Results

Venous and capillary blood samples were obtained from 100 healthy adult volunteers, 41 males (41%) and 59 females (59%), whose age was between 18-24 years (Table 1). Mean age of male (21 ± 2.0) and female (20 ± 1.5). Despite higher hemoglobin in males, the capillary-venous difference remained stable (0.4 g/dL), indicating no sex-based variation. Clinical Uncorrected capillary sampling may cause diagnostic misdirection, especially for anemia thresholds (Table 2).

Table 1: Sample distribution by sex and age.

Sex	No	Percentage (%)	Mean Age (Years $\pm$ SD)
Male	41	41%	21 ± 2.0
Female	59	59%	20 ± 1.5

Table 2: Hemoglobin concentration (g/dL) comparison.

Sample Type	Mean $\pm$ SD	P-Value
Capillary	13.2 ± 1.53	0
Venous	12.8 ± 1.41	
Males (Capillary)	14.3 ± 1.05	0
Males (Venous)	13.9 ± 0.95	
Females (Capillary)	12.5 ± 1.36	0
Females (Venous)	12.2 ± 1.27	

Discussion

A key component of the blood donor screening procedure is the quick, precise, and repeatable measurement of donor hemoglobin, which has led to the development of multiple point-of-

care techniques for minimally invasive hemoglobin determination. A drop of blood drawn from capillaries using the fingerstick technique has a different composition from blood drawn from a vessel via venipuncture [9]. The blood from different loop capillaries, tiny arterioles, and venules in the finger is reflected in the fingerstick blood drop. Additionally, the thickness of the skin, its warmth, the lancet's depth of penetration, and the possibility of the phlebotomist "milking" the finger all affect the fingerstick sample. This study shows a statistically significant increase in hemoglobin concentration in capillary blood compared to venous blood (mean difference: +0.4g/dL, P-value=0.000) among healthy Sudanese adults. This finding matches existing research, supporting that capillary sampling consistently results in higher hemoglobin values across different populations [1]. Our results (+0.4g/dL) are similar to studies from Iraq (+0.5g/dL) [2], China [10], Turkey (neonates) [11], Mexico (+0.5g/dL) [12], and Iran (neonates) [13]. This trend holds regardless of age group or method (e.g., HemoCue vs. automated analyzers) [12,14]. Capillary blood contains interstitial fluid and reflects arteriolar composition, which may concentrate cellular components like hemoglobin [1]. Cold-induced vasoconstriction might also increase the differences [1]. Using the cyanmethemoglobin (HiCN) method helped reduce measurement variability [1,15]. This aligns with ICSH guidelines [1,16]. Limiting participants to healthy adults aged 18-24 eliminated confounding factors such as smoking, chronic disease, or age-related blood changes [17]. An unadjusted +0.4g/dL difference could lead to misclassification of 7-10% of anemia cases based on WHO criteria (e.g., females: capillary 12.5g/dL vs. venous 12.2g/dL, anemia defined as <12.0g/dL) [1,15]. To improve the safety of blood donation and the blood supply, a crucial component of this reevaluation of hemoglobin eligibility standards will be paying close attention to the strict training and regular competency evaluations of personnel doing fingerstick hemoglobin assays.

Conclusion

The fundamental purpose of this study is to exhibit precise and accurate measurement of hemoglobin by manual methods. From this study, we conclude that there is a significant difference in hemoglobin concentration between capillary blood and venous blood. The hemoglobin concentration is higher in capillary blood than venous blood by about 0.4g/dl.

Conflict of Interest

The author has affirmed that there are no conflicting interests.

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