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Correlation between Blood Groups and Severe Anemia among Anemia Patients in Sana'a City, Yemen

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Abstract

Background: Blood is a specialized connective tissue with a complete and unchangeable identity. It provides one of the means of communication between cells of different parts of the body and the external environment. In modern medicine, blood transfusion is an important procedure to replace blood loss. At least 30 common antigens and hundreds of other rare antigens have been found in human blood cells and shown to be linked to anemia and other diseases.

Objective: To determine the frequency of different types of anemia among patients who visit the three main specialized hospitals in the city of Sana'a and to determine the association of severe anemia with different blood types and Rh factors, as well as the association with gender and age groups with severe anemia.

Subjects and methods: A cross-sectional study was carried out among 391 patients suffering from anemia in Sana'a City from 1st October 2023 to the end of February 2024. Data on socio-demographics, clinical presentations, blood samples for hemoglobin level, and other blood markers were collected and tested by automated methods. Blood groups were deter-

mined using the glass slide method using antisera A, B, and D. Using SPSS version 25, descriptive statistical analysis and adjusted odds ratios were used to determine the associated factors.

Results: The male patients counted 61.1%, and the female patients counted 38.9%. The mean age of our patients was 17.3 years, with an SD of 18.7 years, and their ages ranged from 1 to 91 years. Most of our patients were in the age group of 1–5 years (30.4%), followed by the group of 11–15 years (18.7%). The mean hemoglobin level of our patients was 6.8 mg/dL and ranged from 3.0 to 10.8 mg/dL. Very severe anemia (<6.1 mg/dL) was reported in 26.1% of all patients. The predominant blood group was the O blood group (60.1%), followed by A (28.9%), while B and AB counted 7.9% and 3.1%, respectively. Considering Rh antigens, 91.3% of total patients were Rh+ and only 8.7% were Rh-. The most common anemia was thalassemia (30.2%), followed by sidroplastic anemia (22.8%), neonatal anemia (21%), and sickle cell anemia (16.1%). However, a low rate of anemia for chronic diseases (7.2%), pernicious anemia (1%), and aplastic anemia (0.6%) were recorded. There was no significant association between severe anemia and any blood groups or Rh factor. Also, there was no association between severe anemia occurrence and sex or age groups.

Conclusion: We can conclude that blood group O was dominant among our patients, and thalassemia, sidroplastic anemia (cortical anemia), neonatal anemia, and sickle cell anemia were the most common anemias in Sana'a city. There was no significant association between severe anemia and any blood group or Rh factor or the sex or age of the patients. There is a need to develop a good system for better detection, diagnosis, management, and treatment of anemia. Finally, anemia in this region has been shown to be a public health problem.

Keywords: anemia; associated factors; blood group; hemoglobin; prevalence; Sana'a city; severe anemia; Yemen

Introduction

Blood is a unique type of connective tissue that has an absolute identity. It offers one way for the cells in various bodily components to communicate with the outside world [1]. Blood transfusions are a crucial part of modern medicine's strategy to replace lost blood [2]. Human blood cells have been shown to have hundreds of uncommon antigens in addition to at least 30 frequently occurring ones, particularly on the membrane surfaces of the cells. Since the majority of antigens are weak, their main significance comes from researching gene inheritance to determine paternity. Blood transfusion responses are far more likely to be caused by two specific antigen types than by the others. These are the Rh system and the O-A-B antigen system [3].

The two blood group antigens that are known to be clinically important are ABO and Rh. The fourth system to be identified was the rhesus blood group system [1]. ABO blood group people are classified into four primary blood groups based on the presence of agglutinins and antigens: A, B, AB, and O. Blood types A and B have type A and type B antigens, respectively, but blood types O and O have neither type A nor type B antigens. Rhesus antigen, named for the monkeys who originally discovered a similar antigen, is present in 85%-90% of human red blood cells. Because Rh negative blood donors or those who are pregnant can be immunogenic to this blood type, it is the second most important blood group system. In addition to having RhD antigen on the surface of their red blood cells and organ transplants, people who are Rh positive are also associated with certain illnesses such as duodenal ulcer, diabetes mellitus, urinary tract infections, and neonatal Rh incompatibility [1-3]. According to the World Health Organization's statistics on anemia worldwide, 1.62 billion individuals (95%), or 24.8% of the population, suffer from anemia. Additionally, according to WHO estimates, 20% of maternal and neonatal deaths in underdeveloped nations are caused by anemia [4, 5]. A disorder known as anemia is characterized by a low reduction in either the total hemoglobin level or the number of red blood cells. Anemia is defined by the World Health Organization (WHO) as Hb<130 g/L in men over the age of 15, 110 g/L in pregnant women, and <120 g/L in women who are not pregnant but older than 15 [6, 7]. A - clinical disease known as anemia is characterized by a drop in blood hemoglobin concentration that is below the average for the

patient's age [2]. It is a widespread issue that primarily affects the impoverished in developing nations [2, 3]. Adolescent anemia has a serious negative impact on a person's physical and mental development, as well as their ability to behave and think clearly, be physically fit, perform well at work, and even have a negative impact on the outcome of a pregnancy [1]. Although oral iron supplements are frequently administered to treat anemia, they should only be used in cases when dietary interventions have proven ineffective. Additionally, an iron supplement helps treat anemia brought on by an iron deficit [4]. In addition, oral iron supplements have the potential to exacerbate pre-existing ulcers and ulcerative colitis, as well as induce gastrointestinal issues such as nausea, vomiting, diarrhea, and constipation. Chronic iron supplementation may also contribute to heart disease. Due to decreased oxygen delivery and cellular oxidative capability, anemia may even be detrimental to athletic performance [6, 8]. Therefore, it would be preferable to treat those who are more susceptible to anemia in order to combat anemia. It would be simpler to recommend particular dietary recommendations to stop the occurrence of anemia in a group if the specific demographic that is susceptible to or resistant to anemia has been identified.

Anemia can cause a variety of subtle symptoms, including weakness, fatigue, headaches, shortness of breath, and decreased activity capacity [9]. Acute anemia symptoms can include dizziness, a sense of impending death, unconsciousness, and increased thirst [9]. Before a person gets visibly pale, their anemia must be severe. The rate at which hemoglobin depletes determines the symptoms of anemia [10]. Depending on the underlying cause, other symptoms could appear [9]. The likelihood of requiring a blood transfusion after surgery can be elevated by preoperative anemia [11]. Anemia can be mild to severe and be either transient or chronic [12]. Blood loss, a reduction in red blood cell formation, and an increase in red blood cell destruction can all lead to anemia [9]. Inflammation of the stomach or intestines, bleeding during surgery, severe injuries, and blood donation are among the causes of bleeding [9]. Reduced production can be caused by thalassemia, iron shortage, vitamin B12 deficiency, and certain bone marrow cancers [9]. Genetic conditions including sickle cell anemia, infections like malaria, and several autoimmune diseases are among the factors contributing to higher breakdown [9]. The size of the red blood cells and the quantity of hemoglobin in each cell can also be used to categorize anemia. Anemia with small cells is known as microcytic anemia; anemia with large cells is known as macrocytic anemia; anemia with normal-sized cells is known as normocytic anemia. A hemoglobin level of less than 130 to 140 g/L (13 to 14 g/dL) for men and less than 120 to 130 g/L (12 to 13 g/dL) for women is required for the diagnosis of anemia [9, 13]. Then, additional testing is necessary to identify the cause [9, 14]. Several individuals with chronic disease-related anemia do not exhibit any active inflammation or dietary problems at the time of diagnosis. These include numerous with reduced limb loading, such as individuals with spinal cord injuries, space travelers, elderly people with restricted mobility, bedridden patients, and participants undergoing experimental bed rest [15]. Iron supplementation is advantageous for preventive purposes for some populations, including pregnant women [9, 16]. It is not advised to take dietary supplements without first identifying the exact cause. Usually, a person's indications and symptoms determine whether or not blood transfusions are necessary. They are not advised for those who are asymptomatic unless their hemoglobin levels are 60 to 80 g/L (6 to 8 g/dL). Some patients who have severe bleeding may also benefit from following these suggestions. Agents that stimulate erythropoiesis should only be used in cases of severe anemia [9, 17].

People with thalassemias are primarily linked to those from Mediterranean descent, Arabs (particularly Palestinians and those descended from them), and Asians. According to estimates, the prevalence is 1% in Thailand, 16% in Cyprus, and 3-8% in populations from Bangladesh, China, India, Malaysia, and Pakistan[18]. An estimated 80–90 million individuals worldwide, or 1.5% of the total population, are estimated to be carriers of β-thalassemia [17]. However, precise information on carrier rates in many groups is lacking, especially in poor nations where a high incidence is predicted or known to occur [19, 20]. Due to the disease's prevalence in nations where thalassemia is not well understood, getting a good diagnosis and treatment can be challenging [21].

Sickle cell illness usually manifests symptoms between the ages of 5 and 6 months. Numerous health issues could arise, including anemia, bacterial infections, stroke, hand and foot edema, and pain episodes (sometimes referred to as sickle cell crises). As

people age, chronic discomfort may occur [22, 23]. In the developed world, the typical lifespan is between 40 and 60 years. Sickle cell illness affects every important organ. The sickle cell's aberrant actions and improper passage through the small blood channels can also cause harm to the liver, heart, kidneys, gallbladder, eyes, bones, and joints. A person with sickle cell disease receives two faulty copies of the β-globin gene, one from each parent, which produces hemoglobin [24]. It is found on chromosome [11]. Depending on the precise mutation in each hemoglobin gene, there are a number of subtypes. Variations in temperature, stress, dehydration, and high altitude can all trigger an attack [22]. Millions of people worldwide suffer with sickle cell disease, with a higher frequency in sub-Saharan Africa, the Western Hemisphere's Spanish-speaking nations (South America, the Caribbean, and Central America), Saudi Arabia, India, and Mediterranean nations like Turkey, Greece, and Italy [25].

This study aimed to determine the frequency of different types of anemia among patients who visit the three main specialized hospitals in the city of Sana'a and to determine the association of severe anemia with different blood types and Rh factors, as well as the association with sex and age groups with severe anemia.

Subjects and Methods

Study Design

A cross-sectional study was carried out among 391 patients suffering from anemia in Sana'a City from 1st October, 2023 to the end of February 2024.

Sample Size

A sample size of 391 was calculated using the following parameters: confidence level=95%, margin of error =3.81%, and frequency of anemia among general population in similar areas=18% [9, 11].

Data Collection

Individual data were collected in a pre-designed questionnaire, including, clinical data, demographic data, and laboratory results.

Statistical Analysis

By using Epi Info statistical program version 6 (CDC, Atlanta, USA), the analysis of the data was performed. Expressing the quantitative data as mean values, or standard deviation (SD), when the data was normally distributed. Expressing the qualitative data as percentages. Associated factors were calculated by 2X2 tables to find odds ratio, confidence interval, X^2 and p value.

Ethical Consideration

Prior to gathering data, the institution's ethical review committee gave its approval. All participants or/and their guardians received an explanation of the study's goals and advantages prior to involvement, and their verbal informed agreement was obtained. Participants and their families were also told that their participation was optional and that they might decline it without giving a reason.

Fields and Laboratory Works

From 1st October 2023, to the end of February 2024, a cross-sectional study centered in selected tertiary hospitals in Sana'a city was carried out, enrolling 391 anemia patients. Direct interviewing and review of medical records were used to gather socio-demographic and clinical data. Each participant provided a venous blood sample to determine blood markers and for blood

group detection.

Results

Table 1 shows sex and age distribution of anemia patients attending the main tertiary hospitals in Sana'a city. The male patient's counts 61.1% and female patients was 38.9%. The mean age of our patients was 17.3 years with standard division (SD) equal to 18.7 years and ages ranged from 1-91 years. Most of our patients were in the age group of 1-5 years (30.4%), followed by the group of 11-15 years (18.7%), while other age groups were less frequent.

Table 2 shows the hemoglobin level in anemia patients whom attending hospitals, Sana'a city, Yemen. The mean hemoglobin level of our patients was 6.8 mg/dL, the SD level was 1.3 mg/dL and the level ranged from 3.0 to 10.8 mg/dL. Very severe anemia (<6.1 mg/dL) was reported in 26.1% of all patients.

Table 3 shows the frequency of different blood groups in anemic patients in Sana'a city. The predominant blood group was O blood group counted 60.1%, followed by A blood group counted 28.9%, while B blood group only counted 7.9% and AB was 3.1%. Considering Rh antigens 91.3% of total patients were Rh+ and only 8.7% were Rh-.

Table 4 shows the frequency of different types of anemia diagnosed among our study group at a tertiary hospitals in Sana'a city. The most common anemia was thalassemia (30.2%), followed by sidroplastic anemia (22.8%), neonatal anemia (21%) and sickle cell anemia (16.1%). However low rate of anemia of chronic diseases (7.2%), pernicious anemia (1%) and aplastic anemia (0.6%) were recorded.

Table 5 shows the association between blood groups and sever anemia, there was no significant association between severe anemia and any blood groups and Rh factor.

Table 6 shows severe anemia associated risk factors with sex and age groups. Considering sex as associated factors, there was no association between sever anemia occurrence and sex. Also, there was no significant association between severe anemia occurrence and any age groups.

Table 1: Sex and Age distribution of anemia patients in Sana'a city

Characters	N (%)
Sex	
Male	239 (61.1)
Female	152 (38.9)
Age groups (years)	
1-5	119 (30.4)
6-10	64 (16.4)
11-15	73 (18.7)
16-20	32 (8.2)
>20	103 (26.3)
Total	**391 (100)**
Mean age	17.3 years
SD	18.7 years

Median	11 years
Mode	1 year
Min-Max	1-91 years

Table 2: Hemoglobin (HGB) level of anemic patients at a tertiary hospital in Sana'a city

Characters	**Total N (%)**
HGB (mg/dL)	
Less than 6.1	102 (26.1)
6.1-7	120 (30.7)
7.1-8	105 (26.9)
8.1-9	45 (11.5)
9.1-10	15 (3.8)
>10	4 (1.02)
Total	**391 (100)**
Mean	6.8 mg/dL
SD	1.3 mg/dL
Median	6.9 mg/dL
Mode	6.1 mg/dL
Min-Max	3.0-10.8 mg/dL

Table 3: The frequency of different blood groups in anemic patients in Sana'a city

Blood groups	**N (%)**
A+	103 (26.3)
A-	10 (2.6)
Total A	**113 (28.9)**
B+	27 (6.9)
B-	4 (1.02)
Total B	**31 (7.9)**
AB+	12 (3.1)
AB-	0 (0.0)
Total AB	**12 (3.1)**
O+	215 (55)
O-	20 (5.1)
Total O	**235 (60.1)**
Rh +	357 (91.3)
Rh -	34 (8.7)
Total	**391 (100)**

Table 4: The frequency of different types of anemia diagnosed among the study group at a tertiary hospitals in Sana'a city

Type of anemia	N (%)
Aplastic anemia	2 (0.6)
Anemia of chronic diseases	28 (7.2)
Neonatal anemia	82 (21)
Pernicious anemia	4 (1)
Severe acute malnutrition	1 (0.3)
Sickle cell anemia	63 (16.1)
Septicemia anemia	1 (0.3)
Sidroplastic anemia	89 (22.8)
Thalassemia	118 (30.2)
Others	3(0.9)
Total	**391 (100)**

Table 5: Severe anemia associated with blood groups and Rh factor

Blood groups	N (%)	Severe anemia (n=102)	OR	95% CI	X^2	*P* value
A+	103 (26.3)	25 (24.3)	0.8	0.5-1.4	0.2	0.6
A-	10 (2.6)	0 (0.0)	0	0-0.9	3.6	0.06
Total A	**113 (28.9)**	**25 (22.1)**	**0.78**	**0.4-1.2**	**1.15**	**0.2**
B+	27 (6.9)	6 (22.2)	0.79	0.3-2	0.2	0.63
B-	4 (1.02)	2 (50)	2.8	0.3-20	1.1	0.27
Total B	**31 (7.9)**	**8 (25.8)**	**0.99**	**0.25-3.6**	**0.007**	**0.92**
AB+	12 (3.1)	3 (25)	0.9	0.25-3.5	0.007	0.93
AB-	0 (0.0)	0 (0.0)	0	0.0-1.13	3.1	0.07
Total AB	**12 (3.1)**	**3 (25)**	**0.9**	**0.2-3.5**	**0.007**	**0.13**
O+	215 (55)	61 (28.4)	1.1	0.8-2.1	1.2	0.25
O-	20 (5.1)	5 (25)	0.94	0.33-2.6	0.01	0.91
Total O	**235 (60.1)**	**66 (28.1)**	**1.3**	**0.8-2.1**	**1.2**	**0.2**
Rh+	357 (91.3)	95 (26.6)	1.3	0.56-3.3	0.58	0.44
Rh-	34 (8.7)	7 (20.6)	0.7	0.3-1.6	0.5	0.44
Total	**391 (100)**	**102 (26.1)**	-	-	-	-

Table 6: Severe anemia associated risk factors (sex and age).

Characters	Severe Anemia (n=102)N (%)	OR	CI	X^2	*p*
Sex					
Male (n=239)	64 (26.8)	1.1	0.6-1.9	0.15	0.63
Female (n=152)	38 (25)	0.9	0.5-1.4	0.15	0.69

Age groups (years)					
1-5 (n=119)	38 (31.9)	1.3	0.8-2	1.3	0.24
6-10 (n=64)	18 (28.1)	1.1	0.6-2.0	0.16	0.68
11-15 (n=73)	23 (31.5)	1.39	0.79-2.4	1.3	0.24
16-20 (n=32)	4 (12.5)	0.3	0.1-1.1	3.3	0.06
>20 (n=103)	19 (18.4)	0.66	0.38-1.2	2.0	0.15

Discussion

We found that the O blood group accounted for 60.1% of the total blood count, followed by the A blood group at 28.9%, the B blood group at 7.9%, and the AB blood group at 3.1%. These results were differ from those of Reshmarani *et al.* [26] in India, where blood group B had the highest distribution (34.3%), followed by blood groups O and A (31% and 22.7%, respectively), and blood group AB (11%), which had the lowest percentage frequency.

In our study, blood group O had the highest prevalence of severe anemia (28%), followed by blood group B (25%). A study by Reshmarani *et al.* found and documented a different pattern in the prevalence of blood types (B>O>A>AB) among anemic individuals [26]. Blood type O has been reported to be the most often occurring blood group with anemia in numerous other research. In our analysis, there were 8.7% Rh-ve and roughly 91.3% Rh+ve.

In other investigations, where Rh+ counts for more than 90% of all blood types, similar distribution patterns were also noted [1-4]. According to these findings, different populations have different frequencies of ABO and rhesus blood groups depending on their ethnic backgrounds [3-7]. However, no such correlation was found between the Rh factor and the incidence of anemia in the populations listed above. Adolescent anemia has a detrimental effect on many areas of life, including behavior, cognitive development, physical fitness, employment performance, and even the risk of an unfavorable pregnancy outcome. Mild anemia is known to lower immunological competence and has a negative impact on productivity.

In the current study, thalassemia (30.2%) was the most common type of anemia detected in our patient population. Thalassemia is inherited blood illness, which cause abnormal hemoglobin [27]. Depending on the kind of thalassemia, symptoms might range from mild to severe [22]. Because thalassemia can impact both the formation and lifespan of red blood cells, mild to severe anemia (few red blood cells or hemoglobin) is frequently present [22].

Yemen and other Mediterranean peoples are home to a high prevalence of beta type thalassemia[28] 25,000 people died from thalassemia in 2013, compared to 36,000 in 1990 [29].

South Asians, who live far from the Mediterranean, are also impacted; the Maldives has the greatest concentration of carriers worldwide (16–18% of the population) [30]. People of Mediterranean descent, Arabs (particularly Palestinians and those descended from them), and Asians are disproportionately linked to thalassemia [31]. The incidence is believed to be 16% in Cyprus, 1% in Thailand, and 3-8% in Bangladeshi, Chinese, Indian, Malaysian, and Pakistani populations [18]. An estimated 80-90 million persons worldwide, or 1.5% of the total population, are estimated to be βthalassemia carriers [19.]

According to the current study, sidroplastic anemia affected 22.8% of Yemenis. When the bone marrow creates ringed sideroblasts instead of healthy red blood cells (erythrocytes), the condition known as ideal bolastic anemia, also known as sideroachrestic anemia, occurs [32]. Anemia of prematurity stems from both intrinsic and iatrogenic factors, leading to over 80% of extremely preterm infants requiring red blood cell transfusions within the first month of life. In the first few weeks of life,

preterm newborns frequently suffer from anemia and significant blood losses as a result of repeated laboratory tests [33, 34].

Sickle cell anemia ranked as the fourth most frequent kind of anemia in the current survey, accounting for 16.1% of cases. This substantial rate of sickle cell anemia reflects the disease's widespread distribution worldwide and specifically in our region [35]. Millions of people suffer from sickle cell disease worldwide; sub-Saharan Africa, Spanish-speaking areas of the Western Hemisphere (South America, the Caribbean, and Central America), Saudi Arabia, India, and Mediterranean nations like Yemen, Turkey, Greece, and Italy have higher rates of the disease [36]. It caused roughly 114,800 fatalities in 2015 [37].

In this study, there were 2 (0.6%) cases of aplastic anemia. The severe hematologic disorder known as aplastic anemia is caused by the body's inability to produce enough red blood cells [38]. Numerous cancer syndromes and cancer are linked to aplastic anemia. Stem cells that live in the bone marrow create blood cells [39]. Red blood cells, white blood cells, and platelets are all in low quantity as a result of aplastic anemia [40]. The elderly are also prone to it, but those in their teens and twenties experience it most frequently. It may be brought on by immunological disorders, toxins, medications, radiation, or hereditary factors. However, in about half of cases, the cause is unknown [40, 41].

Study Limitations

A number of constraints need to be noted. First, generalizability to different healthcare settings may be limited by the single--center architecture. Second, cytogenetic and molecular analyses which are becoming more and more crucial for a thorough hematological diagnosis were left out. Third, there was no rigorous evaluation of inter-observer heterogeneity in PBF interpretation. Fourth, because only patients undergoing BMA were included, selection bias might be present. Although recent studies have examined the prevalence of pancytopenia among HIV patients [42], red blood cell allografting and autoimmunity in patients with transfusion-dependent sickle cell anemia [43], evaluation of complete blood count parameters in pregnant women with preeclampsia [44], and evaluation of serum zinc levels among Yemeni patients with sickle cell anemia [45]. Additionally, the recovery time course of peripheral blood counts during induction therapy for acute lymphoblastic leukemia in children, the trends and causes of morbidity in a portion of children in Sana'a City, Yemen [46, 47], and the correlation between hemodialysis patients' hepcidin levels, serum iron status, and markers of micro-inflammation [48]. This is the first study discussed the blood groups and anemia in Yemen.

Conclusion and Recommendations

We conclude that blood group O was dominant among our patients, and thalassemia, sidroplastic anemia (cortical anemia), neonatal anemia, and sickle cell anemia were the most common anemias in Sana'a city. There was no significant association between severe anemia and any blood group or Rh factor or the sex or age of the patients. There is a need to develop a good system for better detection, diagnosis, management, and treatment of anemia. Finally, anemia in this region has been shown to be a public health problem.

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