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The Effect of Thalassemia and its correlation with Hemoglobin A and A2 in both genders across different age groups

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تأثير مرض الثلاسيميا (انيميا البحر المتوسط) وعلاقته بالهيموجلوبين (أ) و(أ2) لدى الجنسين في مختلف الفئات العمرية

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Abstract:

Thalassemia is one of the diseases of anemia, and anemia defined as a disease in which there is decrease in the number of red blood cell, (Mediterranean anemia) is one of the most important hereditary blood disorder genetic that effect in the human body because hemoglobin mainly consist of two different types of protein alpha globin and beta globin with hemi pigment to form the complete hemoglobin molecule. **The aim** of this study to assess the gender and age distribution of the patient population. And to evaluate the levels of HbA2 and HbA in patients with thalassemia and to compare among HbA2 and HbA levels across different gender and age groups. In **Material and Methods**, The research sample was taken from laboratory records at Tripoli Medical Hospital. **The result** showed that The gender distribution was relatively balanced with a slight predominance of male patients was reported (52.1%) compared to female patients that were reported (47.9%). ages of the patients ranged from one month to 71 years. Most of the cases were children and infants (58.7%), while adolescents constituted 9.9%. Adults aged 20-40 constituted 21%, while the elderly over 40 years of age constituted 10.5%. Hemoglobin A2 and HbA levels in thalassemia patients the normal hemoglobin A2 levels was (2-3.5%): The majority of patients (88.6%) have normal hemoglobin A2 levels, indicating effective treatment for most patients. High hemoglobin A2 levels (>3.5%): A smaller proportion of patients (11.4%) still have high hemoglobin A2 levels, which is consistent with beta thalassemia. **We recommend** conducting a study on this topic, especially since there is a diversity in the spread of this genetic disease in different age groups. Further studies on this topic are needed in other regions of Libya. There is also a need for more studies on anemia and to pay close attention to cases of the disease. As is known, thalassemia is a genetic disease, and there are traditional societies in our country where marriage between relatives is common, which gives a great opportunity for this disease to appear and be passed down through generations. Therefore, we can only pay attention to the patients and conduct studies and focus on the younger age groups. **In conclusion**, the study result indicated that children and infants had the highest infection rate, while the lowest infection rate was recorded in adolescents and the elderly, with a very slight difference and a predominance of the elderly, indicating that a small but significant number of patients live with thalassemia until adulthood.

Key words: thalassemia, Hemoglobin A and A2, gender, age groups.

الملخص:

الثلاسيميا (فقر دم البحر الأبيض المتوسط) هو أحد أمراض فقر الدم، ويُعرَّف فقر الدم بأنه مرض ينخفض فيه عدد خلايا الدم الحمراء. الثلاسيميا هو أحد أهم اضطرابات الدم الوراثية التي تؤثر على جسم الإنسان لأن الهيموغلوبين يتكون بشكل أساسي من نوعين مختلفين من بروتين ألفا غلوبين وبيتا غلوبين مع جزيء الهيم الذي يشكل جزيء الهيموغلوبين الكامل. **الهدف من هذه الدراسة:** هو تقييم مستويات الهيموغلوبين A2 (HbA2) والهيموغلوبين A (HbA) في مرضى الثلاسيميا ومقارنتها عبر مختلف الفئات العمرية والجنس وتوزيعها في مجتمع المرضى. **المواد وطرق العمل:** تم أخذ عينات البحث من سجلات المختبر في مستشفى طرابلس الطبي. **النتائج:** أظهرت النتائج أن توزيع الجنس كان متوازناً نسبياً مع اغلبية طفيفة للذكور المرضى حيث كانت نسبتهم (52.1%) مقارنة بالإناث المريضات واللاتي كانت نسبتهم (47.9%). وتراوحت أعمار المرضى الذين تم حصرهم من شهر واحد إلى 71 عاماً. وكانت معظم الحالات من الأطفال والرضع بنسبة (58.7%)، بينما شكل المراهقون اعمارهم بين 10- ≤ 20 عاما نسبة 9.9%. وشكّل البالغون

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الذين تتراوح أعمارهم بين ≤ 20 و 40 عاماً نسبة 21%، بينما شكّل كبار السن الذين تزيد أعمارهم عن 40 عاماً نسبة 10.5%. كانت مستويات HbA و HbA2 في مرضى الثلاسيميا ضمن مستويات الهيموغلوبين A2 الطبيعية (2-3.5%)، مما يشير إلى أن غالبية المرضى (88.6%) لديهم مستوى طبيعي من الهيموغلوبين A2، مما يدل على فعالية العلاج لمعظمهم. ولا يزال لدى نسبة أصغر من المرضى (11.4%) مستويات عالية من الهيموغلوبين A2 (>3.5%)، وهو ما يتوافق مع ثلاسيميا بيتا. **نوصي** بإجراء دراسة حول هذا الموضوع، لا سيما مع وجود تباين في انتشار هذا المرض الوراثي بين مختلف الفئات العمرية. كما أن هناك حاجة إلى مزيد من الدراسات حول هذا الموضوع في مناطق أخرى من ليبيا. كذلك، ثمة حاجة إلى مزيد من الدراسات حول فقر الدم، مع إيلاء اهتمام دقيق لحالات هذا المرض. وكما هو معلوم، فإن الثلاسيميا مرض وراثي، وتنتشر في بلادنا مجتمعات تقليدية حيث يشيع زواج الأقارب، مما يُهيئ بيئة خصبة لظهور هذا المرض وانتقاله عبر الأجيال. لذا، لا يسعنا إلا أن نولي اهتمامًا خاصًا بالمرضى، وأن نجري دراسات تركز على الفئات العمرية الأصغر.. **الخلاصة:** أشارت الدراسة إلى أن الأطفال والرضع لديهم أعلى معدل إصابة، في حين تم تسجيل أدنى معدل إصابة في المراهقين وكبار السن، مع اختلاف طفيف جداً وهيمنة لكبار السن، وهذا ما يشير إلى أنه عدداً قليل من المرضى يعيشون بالثلاسيميا حتى سن البلوغ.

الكلمات المفتاحية: الثلاسيميا، الهيموغلوبين A، الهيموغلوبين A2، الجنس، الفئات العمرية.

Introduction

Thalassemia is one of the diseases of anemia, defined as a disease in which there is a decrease in the number of red blood cells, the amount of hemoglobin in the blood, and the size of the red blood cells. The most prominent symptoms of anemia are paleness, fatigue, and thalassemia, a severe type of anemia. For years, it was condemned as a disease that inflicted death at an early age due to the lack of treatment, Palit 2012. Genetic disorders of human hemoglobin that fall within the category of single gene disorders (single gene disorder) are a common disorder that affects about 5% of the world population who carry one or more mutations in the genes responsible for manufacturing hemoglobin, David et al 2006. Thalassemia (Mediterranean anemia) is one of the most important hereditary blood disorders because it affects the human body since hemoglobin mainly consists of two different types of protein: alpha globin and beta globin, with heme pigment to form the complete hemoglobin molecule, Taher et al 2018. In this study, we discussed a genetic disease transmitted through genes from parents, and it is also known as Cooley's anemia, named after the American physician Thomas Cooley, who first described it in 1927, Khan and Shaikh 2023. It is also known as Mediterranean anemia, as it was previously believed that this disease was limited to residents of the Mediterranean basin, as in the Mediterranean region, every newborn must undergo this examination months after its birth to find out if it is pregnant or has thalassemia. Any genetic defect that hinders the production of these proteins in the body sufficiently for one or both proteins will lead to the blood cells becoming unable to transport sufficient oxygen, resulting in anemia which occurs in early childhood and continues throughout life. The reason for the occurrence of thalassemia is due to a reduction in the production rate of one or more of the polypeptide chains of blood globin, which represents abnormal quantitative changes in production of hemoglobin. Therefore, it differs from hemoglobinopathies which represent disorders of the quality of hemoglobin. Depending on the type of genetic defect and the type of gene affected, there can be several types of thalassemia. The most common and clinically important types are alpha-thalassemia and beta-thalassemia (and beta-gamma thalassemia). Through studying the distribution of thalassemia in the world, it appears that, in addition to the cities in the Mediterranean Sea, cases of thalassemia were initially recorded and the disease was named after them. It is noted that the disease is widespread in most parts of the world, including our Arab countries. In addition to the ongoing migration of some human communities from one region to other parts of the world, Anemia is a significant contributor to the global disease burden, of which thalassemia is the most common hereditary anaemic disease, Yuanyuan et al 2024, which helps spread the disease, a random survey was conducted on 100 people with thalassemia who visited the hematology department at Tripoli Medical Hospital and private clinics in the region during the period from January of 2018 The results showed that the majority of cases were in the age category from 1-15 years, especially those with blood type B. The results also showed that the infection rate in males is higher compared with females, and this is due to several different factors, the most important of which are the prevalence of consanguineous marriage and lack of health awareness.

Problem statement

The research problem lies in the fact that Thalassemia is an inherited genetic disease that is transmitted due to the decline in screening resulting from the prevailing culture in our society, where a high rate of infection with this disease has been observed by reviewing patient records and many previous studies conducted in this area. Therefore, we conducted this study, attempting to reach results that directly clarify the rate of spread of this disease among females and males across different age groups, as a solid starting point for preparing a more comprehensive study to serve those affected by this disease.

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Objectives of this study:

To assess the gender and age distribution of the patient population, evaluate the levels of HbA2 and HbA in patients with thalassemia, and compare HbA2 and HbA levels across different gender and age groups.

MATERIAL AND METHODS

Samples collection

The samples were collected from Tripoli Medical Hospital, and the total number of cases were 334, divided into 174 males and 160 females. This statistical study for effect of a number of criteria on thalassemia patients in Tripoli by reviewing the records of the hematology center in Tripoli Medical Hospital and concluding relationships statistical and inferential data obtained from these records.

Clinical examinations

Clinical examinations depend on the type of thalassemia. If it is of the simple type (thalassemia minor), the patient may not show any symptoms, or slight signs of paleness may appear on him due to mild anemia during the first year of life. As for thalassemia inter media, the patient may show signs of anemia. Blood at late times, which may reach the second decade of life. As for thalassemia major, it results in severe anemia, and death is the fate of the patient. In addition to other symptoms such as a change in the shape of the bones. There is also poor appetite, delayed growth, repeated infections, and enlargement of the liver and spleen, which can be identified. By clinical examination.

Laboratory tests

Blood tests: The Initial test includes counting red blood cells; complete blood count; solubility tests and quantitative estimation of HBF, HbA2. If the hemoglobin is abnormal, it is diagnosed using techniques recommended for this purpose. These techniques include electrophoresis at pH (2.6-6), globin chain attachment (IEF) and İso Electric Focusing, in addition to tests including stability and temperature tests to examine unstable HBS or HBS with a change In oxygen a finite. Complete blood cell count: includes the (CBC) examination: estimation of hemoglobin level, red blood cell count (RBC, RDW, (RED CELL DİSTRİBUTİON WİDTH, mean corpuscular volume (MCV), red blood cell number),; in general, infection with thalassemia reduces the rates of MCV index: Studies have suggested that an MCV of 72 is the most appropriate and acceptable diagnosis for thalassemia syndromes. The extent of distribution of red cells: It is a measure of the degree of change In the extent of distribution of red cells. For example, some of the causes of microcytic anemia are iron deficiency, which Is characterized by an increase in RDW, while in thalassemia it tends to produce a population of small red cells to the same degree and without the increase In RDW in thalassemia. Minor, but this examination is not the most practical indicator in diagnosis, so the Rbc count is used as a diagnostic supplement because thalassemia produces micocytic anemia with an increase in the Rbc number, and a discrepancy occurs In the concentration of hemoglobin according to the degree of the disease. Another blood laboratory test is HBH inclusions, which indicates an insoluble hemoglobin tetramer consisting of four beta globin chains. In the case of alpha thalassemia, where there is a deficiency in the production of alpha globin chains, it leads to an increase in HBH, and the reason for this deposition is the oxidation of hemoglobin, which makes it visible microscopically. This test can be conducted in the laboratory invitro by fixing it and using staining of the cells with dyes such as new methylene blue or brilliant cresyl blue, as the blood samples examined for the disease infected with alpha thalassemia contain at least one body inclusion for every 1000-10000 cells.

Hemoglobin electrophoresis

This test is used to determine hb variants (hb varientl) such as hbA, hbF, hbE, hbD, hbC, hbA2 or such as hbH Symmetric electrophoresis is an electrophoresis technique used to determine and measure the quantity of HBS. This technique is time-consuming, but it is classified as superior insulating, and the narrow beams obtained from it allow for a more precise and specific quantitative measurement than standard electrophoresis. Highly effective liquid chromatography is an excellent method for primary deficiency of hemoglobin variants and hemoglobin disorders, including alpha and beta thalassemia. It determines the amounts of hbc, hbs, hbh, hbA2, hbF, hbE in adults, children, newborns, and parents who are carriers of the disease. This method Is sensitive and accurate for testing hemoglobin. Unnatural and depends on an automatic separation device using ion exchange separation called Varian.

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Genetic tests

molecular tests based on PCR technologic When conducting important tests in diagnosing thalassemia, the goal is to Identify the type of mutation or deletion present in the gene responsible for the production of the globin

protein (globin gene), by obtaining DNA samples from white blood cells or blood lines from the placenta or from any tissue that can It is used for diagnosis, and the mutations it searches for that cause alpha-beta thalassemia syndromes are mainly point mutations. Polymerase chain reaction technology and allele-specific primers have been widely used using special probes (PCR) to diagnose allele specific primers. There are several molecular techniques based on PCR can be used to diagnose Thalassemia / 1 Amplification Refracting Mutation System (ARMS), a common technique used to check for mutations Thalassemia Beta 2. Denataring Gradiant Electrophoresis (DGGE) This technology used in a lack of beta and unknown beta and unknown mutations 3 – This technique has been applied to diagnose the events in the alpha and beta and duplication of different in and the duplication of different or deletions are also used to diagnose blood threats such as diagnosis (HB Leper) Restriction Enzyme Analysis of Pcr Product This technique used to diagnose causative mutations and prenatal and pre-delivery and use in diagnosis of blood thorough and prepared a secondary method in some History Allele specific oligonucleotide \ this technique to diagnosis thalassemia mutation beta or alph and used to diagnose hemoglobin disease. Non pcr based analysis (Pcr) \ 1hybridization 2 southern nlotting 3 dot slot blotting 4 DNA sequencing.

Statistical study

The analytical study was conducted through data collection and subsequent statistical analysis**,** the statistical study that were detected of the effect of a number of criteria on thalassemia patients in Tripoli by reviewing the records of the hematology center in Tripoli medical hospital and concluding relationships statistical and inferential data obtained from these records. The data analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, version 25. Simple descriptive statistics were utilized, including the mean and standard deviation for quantitative variables, and frequency with percentage for categorical variables. Inferential statistics were also employed to draw meaningful conclusions from the data.

RESULT

The primary objectives of this study were to analyze the demographic characteristics and hematological profiles of patients with thalassemia at Tripoli University Hospital.

Independent samples t-tests were used to compare the mean HbA2 and HbA levels between male and female patients. Additionally, Analysis of Variance (ANOVA) tests were conducted to compare the mean HbA2 and HbA levels across different age groups. A p-value of less than 0.05 was considered statistically significant for all tests, indicating a high likelihood that the observed differences are not due to random chance.

Demographic characteristic of studied group:

Gender distribution

The gender distribution is relatively balanced, with a slight predominance of male patients 174 (52.1%) compared to female patients 160 (47.9%). As shown in table (1) and figure (1).

Table 1: Distribution of patients according to gender.

Variable			Frequency	Percentage
Gender		Male	174	52.1%
		Female	160	47.9%
		Total	334	100.0%

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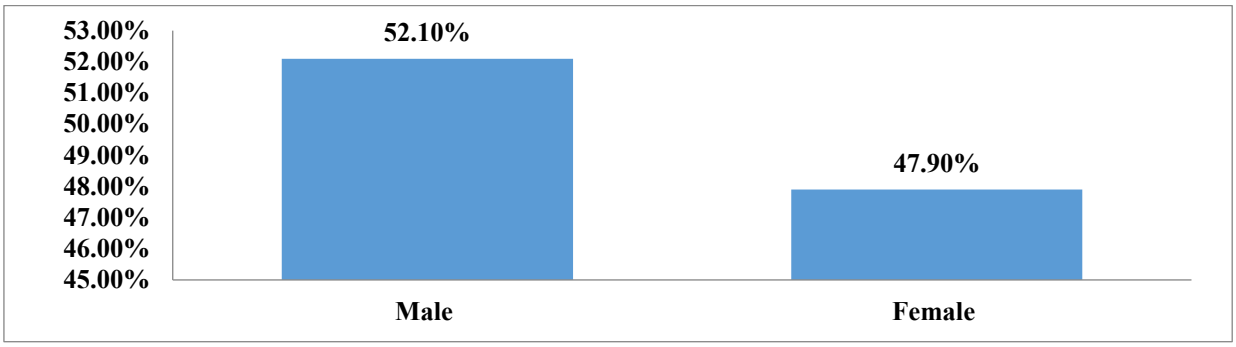

Figure 1: Distribution of patients according to gender

Age of the patients

The ages of the patients ranged from 2 months to 71 years old.

Age group distribution

Table (2) revealed that the majority of the study population were infants and children (<10 years), accounting for 58.7%. Teenagers (10 - < 20 years) represented 9.9% of the study population, a smaller group compared to children. Adults (20-30 years) comprised 21.0% of the study population, while older adults (> 30 years) represented 10.5%, indicating that a smaller, yet significant, number of patients are living with thalassemia into older adulthood.

Table 2: Distribution of patients according to age

Age group	Frequency	Percentage
Infants and Children (< 10 years)	196	58.7%
Teenagers (10 - < 20 years)	33	9.9%
Adults (20-30 years)	70	21.0%
Older adult (> 30 years)	35	10.5%
Total	**334**	**100.0%**

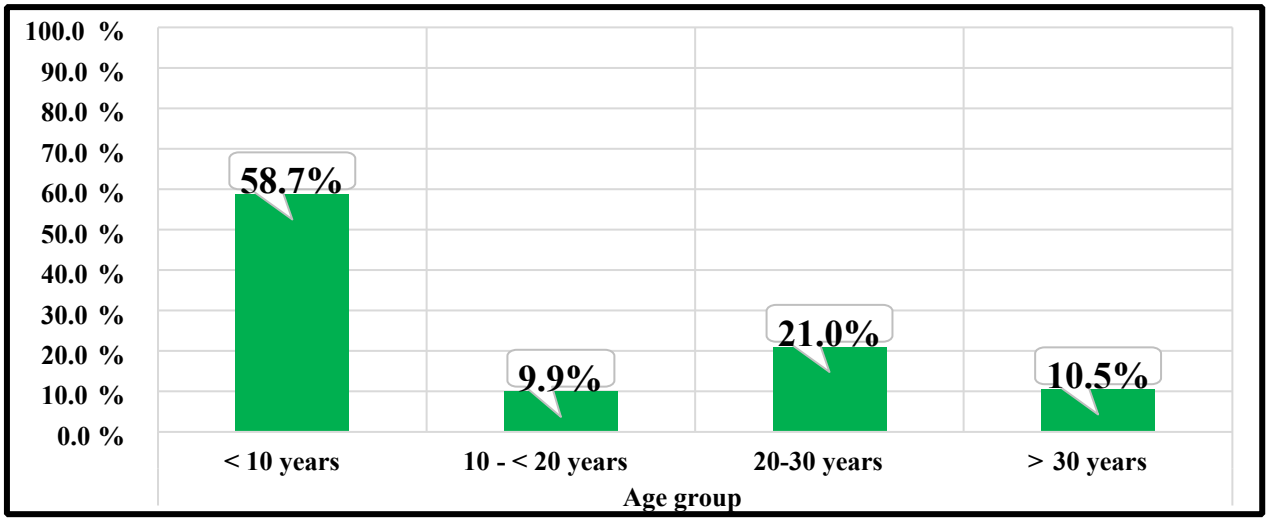

Figure 2: Distribution of patients according to their age

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HbA2 and HbA levels in patients with thalassemia

HbA2 Levels:

Normal HbA2 Levels (2-3.5%): The majority of patients (88.6%) have normal HbA2 levels, indicating effective treatment for most patients. Elevated HbA2 Levels **(>3.5%)**: A smaller proportion of patients (11.4%) still have elevated. HbA2 levels, consistent with beta-thalassemia.

Table 3: Distribution of HbA2 levels in patients with thalassemia

Parameter	Range	Number of patients	Percentage
Normal HbA2 Levels	2-3.5%	296	88.6%
Elevated HbA2 Levels	>3.5%	38	11.4%
Total		**334**	**100%**

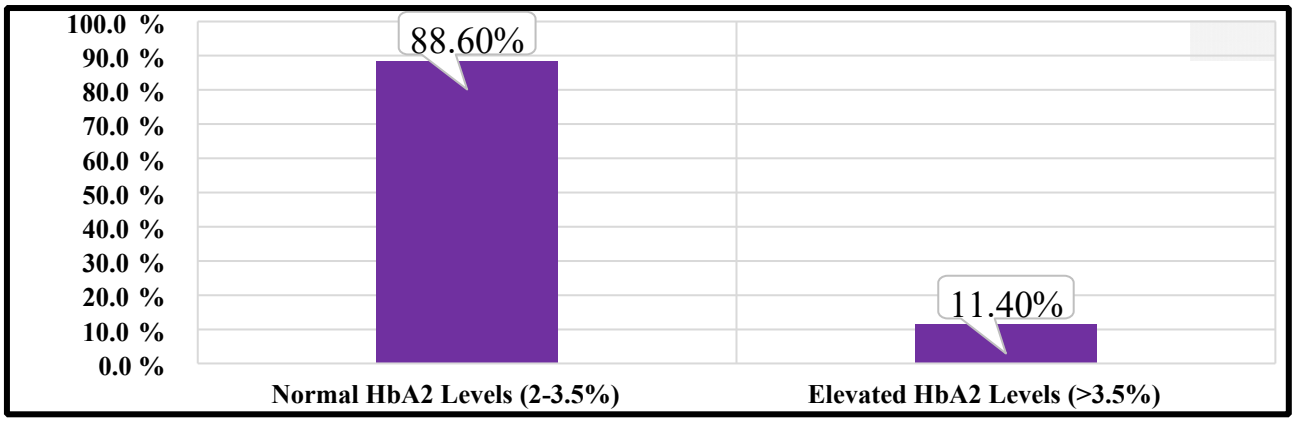

Figure 3: Distribution of HbA2 levels in patients with thalassemia

HbA Levels:

Normal HbA levels (95-98%): More than half of the patients (56.3%) have normal HbA levels post-treatment, indicating significant improvement. Slightly reduced HbA (90-95%): A significant portion of patients (40.7%) have slightly reduced HbA levels, suggesting partial improvement. Greatly reduced HbA (less than 10%): A small number of patients (3.0%) have greatly reduced. HbA levels, indicating severe thalassemia or poor treatment response.

Table 4: Distribution of HbA levels in patients with thalassemia

Parameter	Range	Number of Patients	Percentage
Normal HbA Levels	95-98%	188	56.3%
Slightly Reduced HbA	90-95%	136	40.7%
Greatly Reduced HbA	<10%	10	3.0%
Total		**334**	**100.0%**

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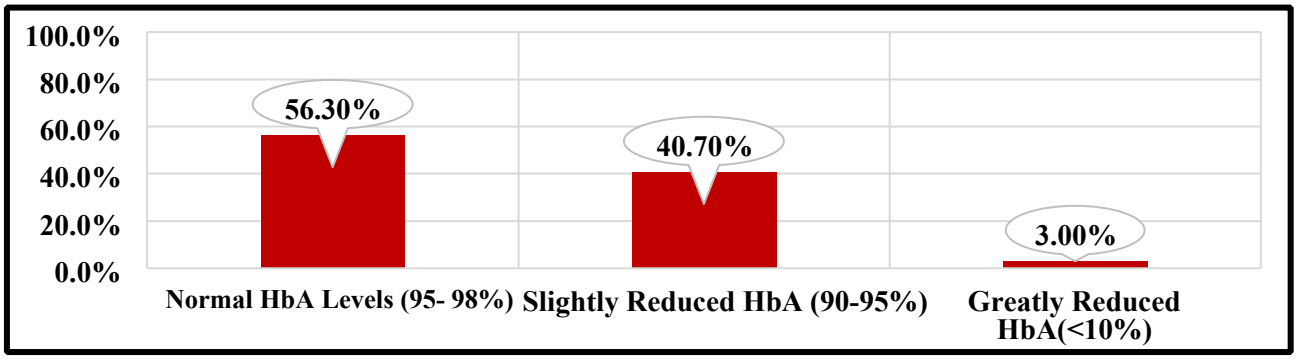

Figure 4: Distribution of HbA Levels in Patients with Thalassemia

Compare HbA and HbA2 levels across gender

HbA2 Levels across gender:

The mean HbA2 level for males is 2.86 with a standard deviation of 1.150, and the mean HbA2 level for females is 2.94 with a standard deviation of 1.190.The t-test shows p-value = 0.579, indicating no significant difference in HbA2 levels between males and females.

Table 5: Comparative analysis of HbA2 in males and females with thalassemia

Gender	N	Mean	Std. Deviation	t	p-value
Male	174	2.86	1.150	-0.555	0.579
Female	160	2.94	1.190		

HbA Levels across gender:

The mean HbA level for males is 82.15 with a standard deviation of 23.27, and the mean HbA level for females is 78.80 with a standard deviation of 25.650.The t-test for shows p-value = 0.212 indicating no significant difference in HbA levels between males and females.

Table 6: Comparative analysis of HbA in males and females with thalassemia

Gender	N	Mean	Std. Deviation	t	p-value
Male	174	82.15	23.278	1.250	0.212
Female	160	78.80	25.650		

Compare HbA and HbA2 levels across different age group

HbA2 Levels across different age groups

The analysis of HbA2 levels across different age groups reveals the following results. For children aged > 13 years, the mean HbA2 level is 2.82 with a standard deviation of 1.21. Teenagers aged 13-19 years have a mean HbA2 level of 2.73 with a standard deviation of 0.878. Adults aged 2040 years exhibit a mean HbA2 level of 3.12 with a standard deviation of 1.229. Finally, older adults aged 40 years and above have a mean HbA2 level of 3.04 with a standard deviation of 0.989. The ANOVA results shows that there is no significant difference in the mean HbA2 levels among infant, children, teenagers, adults, and older adults. The p-value of 0.215 suggests that age does not significantly influence HbA2 levels in patients with thalassemia.

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Table 7: Comparative Analysis of HbA2 across different age group with Thalassemia

Age Group	Mean	Std. Deviation	F	p-value
Children (< 13 years)	2.82	1.211	1.489	0.215
Teenagers (13-< 20 years)	2.73	0.878		
Adults (20-40 years)	3.12	1.229		
Older Adults (4> 0 years)	3.04	0.989		

HbA level across different age groups

The analysis of HbA levels across different age groups reveals that children aged < 13 years have a mean HbA level of 79.72 with a standard deviation of 25.496. Teenagers aged 13-19 years exhibit a mean HbA level of 84.35 with a standard deviation of 26.247. Adults aged 20-40 years show a mean HbA level of 81.57 with a standard deviation of 19.832. Finally, older adults aged 40 years and above have a mean HbA level of 79.49 with a standard deviation of 25.797. These results indicate that while there are slight variations in mean HbA levels across different age groups, the levels remain relatively consistent, with standard deviations indicating variability within each group. The ANOVA results shows that there is no significant difference in the mean HbA levels among infants, children, teenagers, adults, and older adults. The p-value of 0.753 suggests that age does not significantly influence HbA levels in patients with thalassemia.

Table 8: Comparative Analysis of HbA across different age group with thalassemia

Age Group	Mean	Std. Deviation	F	p-value
Children (<13 years)	**79.72**	**25.496**		
Teenagers (13- < 20 years)	**84.35**	**26.247**		
Adults (20-40 years)	**81.57**	**19.832**		
Older Adults (> 40 years)	**79.49**	**25.797**	**0.400**	**0.753**

DISCUSSION

The results that were obtained in the present study were recorded are as follows, with an attempt to find the reasons for the variables and compare these results with other previous studies, The gender distribution was relatively balanced with a slight predominance of male patients (52.1%) compared to female patients (47.9%). Patients ranged in age from 1 month to 71 years. Most cases were children and infants (58.7%). This significant increase is explained by the low immunity in early life and some die in their thirties, which explains the low proportion in adults, while adolescents constituted 9.9%, comparing with other previous studies conducted by (Tou et al 2024. adults aged 20-30 years constituted 21%, while the elderly over 30 years constituted 10.5%. In a 2024 study examining the global burden of thalassemia between 1990 and 2021, researchers found that mortality rates per 100,000 population were higher among female and male patients (0.17 vs 0.10) in the 15- to 19-year-old age group. In addition, rates of disability-adjusted life years (DALYs) were higher in females (62.67) compared to males (56.86) among individuals under 5 years and among those aged 15 to 19 years (13.05 vs 8.19) These results are consistent with the findings of the current study. When studying the levels of hemoglobin A2 and HbA in thalassemia patients, the levels of hemoglobin A2 were normal (23.5%): the majority of patients (88.6%) had normal levels of hemoglobin A2, indicating effective treatment for most patients. Elevated hemoglobin A2 levels (>3.5%): A smaller proportion of patients (11.4%) still had elevated hemoglobin A2 levels, consistent with beta-thalassemia, Other studies have confirmed the results of this study, conducted through (Urschel et al 2009, and

Chapel et al 2008), HbA2 and HbA levels in patients with thalassemia, normal HbA2 levels (2-3.5%): The majority of patients (88.6%) had normal HbA2 levels, indicating effective treatment for most patients, elevated HbA2 levels (>3.5%): A smaller proportion of patients (11.4%) still had elevated HbA2 levels, consistent with beta-thalassemia that were fully consistent with the study conducted by (Galanello and Origa 2010, Stacy et al 2022 and Premawardhena et al 2005) . The results of the current study are consistent with some other studies, including this study conducted by Yang et al 2009 that were recorded the prevalence of elevated hemoglobin A2 measured by the capillarys System as follwes, hemoglobin (Hb) A2 electrophoresis has been used for prenatal screening for the β-thalassemia trait (βTT). They retrospectively reviewed Hb capillary electrophoresis performed in our laboratory. They found that of the 122 cases showing elevated HbA2 levels, 79 cases were due to hemoglobin apathies, mostly Hb. Review of the RBC indices suggested that 3 of 36 cases with elevation of HbA2 in the HbAA-pregnancy group had βTT and 29 had normal RBC indices; data were not available for 4 patients. Among 7 cases with elevation of HbA2 in the HbAA-other group, 5 had βTT and 2 were normal. Yang et all 2011 carried out the study on Elevated hemoglobin A2 as a marker for \beta-thalassemia trait in pregnant women, the number of patients with HbA2 elevation in the pregnant group was significantly higher than that in the non-pregnant group. When a higher HbA2 cutoff (3.5%) was used, only 3 pregnant patients without βTT had HbA2 elevation, similar to the non-pregnant group. they found that a significant number of pregnant women with mild HbA2 elevation had no evidence of βTT, compared with the non-pregnant group, The increase in infection cases among different age groups is clearly evident in children and infants, which is completely consistent with the current study.

conclusion

In conclusion, the study result indicated that The study results indicated that children and infants had the highest infection rate, while the lowest infection rate was recorded in adolescents and the elderly, with a very slight difference and a predominance of the elderly, indicating that a small but significant number of patients live with thalassemia until adulthood.

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