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Genetic Blood Disorders in Saudi Arabia

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Abstract

Hereditary blood disorders are identified by any blood related disorders that can passes from parents their offspring. Red blood cell synthesis is decreased, which leads to several blood diseases. When the production of these red blood cells stops, it leads to blood abnormalities in people's bodies and may cause significant diseases since red blood cells do not stay forever within the body and must be regenerated after a period of time. Sickle cell anemia and thalassemia are the most highlighted abnormal hemoglobin disorders caused by genetics. In Saudi Arabia, around 4.2 % of the population possesses the sickle-cell trait, with 0.26 % suffering from sickle-cell disease. The Eastern province has the highest prevalence, with around 17% of the population carrying the gene and 1.2 %suffering from sickle cell disease. The frequency of hereditary blood diseases in KSA varies across the Kingdom. The eastern and southern parts of the Kingdom have the greatest rates, while the center and northern regions have the lowest. Sickle cell anemia is a genetic blood disorder characterized by a lack of the oxygen-carrying protein hemoglobin in red blood cells. In sickle cell anemia, red blood cells become stiff and sticky, producing sickles or crescent moons. These irregularly formed cells can become trapped in small blood arteries, reducing or obstructing blood flow and oxygen to various parts of the body, resulting in symptoms such as acute pain, shortness of breath, and others. The most highlighted symptoms of sickle cell anemia are Periodic periods of pain, known as crises, occur in various sections of the body depending on where sickle-shaped red blood cells break apart and clog micro vessels. Pain, for example, might develop in the belly, joints, or one of the limbs.

Keywords: *genetics, blood, sickle, anemia, disorders*

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الملخص

أمراض الدم الوراثية هي اي اضطرابات تحدث في الدم ويمكن انتقالها من الآباء إلى الأبناء، وانخفاض إنتاج خلايا الدم الحمراء يؤدي إلى العديد من أمراض الدم؛ فعندما يتوقف إنتاج خلايا الدم الحمراء هذه، فإنه يؤدي إلى تشوهات أو اضطرابات في خلايا الدم في أجسام الناس، وقد يسبب أمراضًا كبيرة لأن خلايا الدم الحمراء لا تبقى إلى الأبد داخل الجسم، ويجب تجديدها بعد فترة من النضج، وفقر الدم المنجلي والثلاسيميا هي اضطرابات الهيموغلوبين غير الطبيعية الأكثر تميزًا الناجمة عن علم الوراثة في المملكة العربية السعودية، حيث يمتلك حوالي 4.2٪ من السكان سمة فقر الدم المنجلي، و0.26٪ يعانون من مرض فقر الدم المنجلي، والمنطقة الشرقية لديها أعلى معدل انتشار، حيث يحمل حوالي 17٪ من السكان الجين و1.2٪ يعانون من مرض فقر الدم المنجلي، ويختلف تواتر أمراض الدم الوراثية في المملكة العربية السعودية في جميع أنحاء المملكة، والمناطق الشرقية والجنوبية من المملكة لديها أكبر المعدلات، في حين أن المناطق الوسطى والشمالية لديها أدنى المعدلات، وفقر الدم المنجلي هو اضطراب وراثي في الدم يتميز بنقص الهيموغلوبين البروتيني الحامل للأكسجين في خلايا الدم الحمراء، ففي فقر الدم المنجلي تصبح خلايا الدم الحمراء قاسية ولزجة، وتنتج المنجل أو الأقمار الهلالية، ويمكن أن تصبح هذه الخلايا غير المنتظمة محاصرة في شرايين الدم الصغيرة، مما يقلل أو يعيق تدفق الدم والأكسجين إلى أجزاء مختلفة من الجسم؛ مما يؤدي إلى أعراض مثل الألم الحاد وضيق التنفس وغيرها، وأبرز أعراض فقر الدم المنجلي هي فترات الألم الدورية، والمعروفة باسم الأزمات، وتحدث في أقسام مختلفة من الجسم اعتمادًا على المكان الذي تتفكك فيه خلايا الدم الحمراء المنجلية الشكل وتسد الأوعية الدقيقة مسببةً الألم، على سبيل المثال قد يتطور في البطن أو المفاصل أو أحد الأطراف.

الكلمات المفتاحية: علم الوراثة، الدم، المنجل، فقر الدم، الاضطرابات

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1. Introduction

Genetic disorders are identified as any disease that can passed along from one or both parents to their offspring, Genetic blood disorders are a group of disorders that occurred due to heredity and appeared as abnormal change in the red blood cells composition (Chattoo, 2018). These abnormal changes works to cause function disability to the red blood cells which make them unable to perform their normal role within the body.

Currently, the most highlighted main types of hereditary blood disorders are both sickle cell anemia and thalassemia (Alharbi et al., 2021). As any other genetic disorder, it occur due to the process of passing mutated genes presented on the chromosomes of parents to their children. If both spouses have a genetic abnormality, their kid has a 25% risk of inheriting the condition. Nevertheless, if one person is healthy but the other parent has the characteristic, the sickness may be passed to certain offspring, giving them those mutated genes (Suchdev et al., 2014).

According to Saudi Arabia ministry of health, genetic blood disorders as sickle cell anemia and thalassemia are varies distributed within the kingdom but found mostly within both southern and eastern regions, the ministry of health was officially cited within the “healthy marriage program” that thalassemia incidence was 0.05% while the sickle cell anemia was 0.27%. (Alsaeed et al., 2018) it was also reported that 4.2% of the kingdom population are carrying Sickle cell anemia traits, but only 0.27% have the disease. (SCD) is also spread all over the world in a huge number too (Ali et al., 2018).

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Sickle Cell anemia is a disease caused by the formation of a non-usual type of hemoglobin component that works to bind and link to other unusually formed hemoglobin molecules to cause red blood cells to distortion and change its characteristics. Which leads the RBCs to become sticky in texture, hard, similar to the shape of "C", and not able to pass and move across the tiny blood vessels resulting in vascular bed blockage, and infarction. While normal RBCs are generally rounded in shape, move across any small or tiny blood vessels to transport oxygen molecules all over the body. (Mansour et al., 2015).

2. Sickle cell anemia pathophysiology

Sickle cell anemia generally happened due to a mutation on β - globin gene that is located specifically on the short arm within chromosome 11; the point mutation causes the glutamic acid of β - globin chain to be inserted at the sixth position instead of the hydrophobic amino acid valine. If two mutated subunits of β – globin collaborated they combined to create a hemoglobin S (HbS). During certain conditions as the low presence of O_2 causes lack of polar amino acid of β - globin chain at the sixth position that leads the hemoglobin to go under non covalent polymerization cascade that's by its role make distortion to RBCs, remove their elastic properties, and gave them the sickle shape (Ifeanyi & Ogechi, 2015).

Losing RBCs to their elasticity is the core of the sickle cell anemia pathophysiology, as the healthy RBCs have a pretty good elastic properties that make the deforming and passing throughout capillaries easily. The low oxygen levels within Sickle cell affected RBCs escalate their sickling and put them in a continuous loop of cell membrane damaging which decrease the elasticity too. Sickled cells are not allowed to gain back their normality when the oxygen level is restored again,

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which lead them to become unable to deform while passing through tight capillaries results in Ischaemia and vessel occlusion (Sundd et al., 2019).

The anemia caused by sickle cell disease is mainly occurred when red blood cells destructed in the spleen due to their odd shape (C shape). However the human bone marrow works to compensate this loss by creating and producing new RBCs but it cannot cover the rate of dead damaged cells. As sickled cells only lives from 10-20 days while the healthy RBCs can survive up to 120 days (Shrestha et al., 2016)

3. Genetics of Sickle cell disease

Across heterozygous for Hbs people, the polymerization defects are low, that's due to the ability of normal allele to create above 50 % of the entire hemoglobin. On the other side, homozygous Hbs persons the existence of long and tall chain Hbs polymers causes distortion of red blood cells overall shape and convert it from soft doughnut shape into C spiked shape that give the RBCs fragile properties in addition to become susceptible to damage across capillaries (Muller, 2018).

If the oxygen levels is deprived or when is an emergency dehydration case, the Sickle cells carriers will develop the symptoms. Under ordinary situations, these excruciating crises occur 0.8 times for every patient every year. SCD develops whenever the seventh amino acid called glutamic acid, is substituted by valine to affect the structure and function of the protein (National Heart Lung and Blood Institute, 2017).

The mutated gene defect is caused by a recognized alteration of a single nucleotide (A to T) inside the p-globin gene, resulting in glutamate being replaced by valine at location 6. In contrast to the mature adult HbA, hemoglobin S with this

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alteration is referred to as HbS. The hereditary condition is due to a single nucleotide change, a GAG to GTG codon mutation (Frenette et al., 2017).

It is a harmless abnormality that has no impact on the second, third, or quaternary structure composition of hemoglobin, however, enable for the polymerization cascade of HbS under circumstances of reduced oxygen levels. The hemoglobin deoxy version reveals hydrophobic component among E, F helices. Those patches are later associated to the hydrophobic residues comes from Valine, resulting aggregation in hemoglobin S components in addition to fibrous precipitates (Pace et al., 2012).

4. Heredity of sickle cell anemia

As any other inherited traits like eye color, hair color, or blood type, sickle cell anemia is also inherited from parents. Each individual has a certain type of hemoglobin that produced in the RBCs upon on what genes were passed from parents. If only single parent has sickle cell anemia traits (SA) while the other parent has the traits (SA) the child chance to develop sickle cell disease is 50% (SS) and 50% of having only the trait of the disease (AS). If both spouse have only the traits of sickle cell anemia (AS); the child will have 25% chance for disease inheritance (SS) (Inusa et al., 2019).

5. Types of Sickle Cell anemia

5.1 Hemoglobin SS disease

It’s the most popular sickle cell anemia type and known by its severity and has the worst occurrence symptoms in a higher rates too. The disease starts when the child inherits two copies of the defective gene (hemoglobin S gene) from both parents which causes formation of hemoglobin type called HB SS (Sathi, 2020).

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5.2 Hemoglobin SC disease

This type of sickle cell anemia is occurs when the person has only a slight change in substitution within the genes of β – globin which leads to production of both hemoglobin S and hemoglobin C types. This type might induce similar occurrence symptoms as sickle cell anemia but in a lower rates of anemia as the patients usually has higher levels of blood count (Moll & Orringer, 1997).

5.3 Sickle Beta-Plus Thalassemia

The affected persons with this type of sickle cell anemia are own a substitution in both genes of beta globin, the quantity of healthy beta globin generated determines the severity of the condition. The symptoms are essentially comparable to sickle cell anemia if no beta globin is generated, with severe patients requiring constant blood transfusions (Bhardwaj et al., 2017).

5.4 Sickle Hemoglobin-O Disease

Another form of β – globin substitution element is called Hemoglobin O, it works to interact with the hemoglobin unit of sickle cell. The same symptoms of sickle cell anemia can also represented to people with Hemoglobin-O illness (SO). People of North African, Arabian, and Eastern Mediterranean heritage have a high prevalence risk of Sickle Hemoglobin-O illness (Johnso et al., 2015).

6. Symptoms and signs of Sickle Cell Disease

The most highlighted complication of SCD is starting from the occurred mutation in only on base-pair DNA that is implemented a nearly all systems of body and can cause a premature death in those who has the disease. The clinical features of sickle cell disease are caused by the inability of deoxygenated sickle hemoglobin to dissolve and polymerize. The clinical symptoms starts from the first months and

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approximately year, as when the concentration of fetal Hb drops. Fetal Hb suppresses the polymerization process of deoxy-Hb S in RBCs (Kavanagh et al., 2011).

The indications and symptoms of sickle cell disease differs according to different cases. For example: some have a sickle cell disease in a mild form while other people have extremely severe signs and symptoms so they must need hospitalization care and treatment. In infants; the most highlighted signs of SCD are hands swelling, fever, chest pain, nose bleeding, in addition to upper respiratory infections by frequent times, the symptoms can be chronic, acute or severe, other signs are also presented in many cases such as low back and legs orthopedic complications, jaundice, fatigue, and dyspnea. (Jude Children, 1990).

6.1 Sickle cell crisis "pain crisis"

Pain crises, which occur on a regular basis, are a primary signs of sickle cell anemia. Pain occurs when sickle-shaped RBCs obstruct blood circulation to the abdomen, chest, and joints via small blood vessels. The degree of the pain differs according to persons and might persist from hours to days. Sickle cell crisis also include different types as vaso-occlusive crises, sequestration crises, aplastic crises, and others (Novelli & Gladwin, 2016).

6.1.1. Vaso-occlusive Pain Crises

This type of cries characterized by the presence of a multiple processes starting from initiation phase, then propagation phase, and finally the resolution phase. Reduced deformability of sickled cells and adhesion between erythrocytes and endothelium are two major factors for this crisis to occur and to make the entrapment of RBCs. VPC are considered to be the most highlighted character of SCD as it

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defined by the presence of pain in chest, back, head, etc. that continued for two or maybe more hours; phases of Vaso-occlusive Pain Crises explained as:

A. prodromal phase

According to 58% of patients, this phase appears before the pain onset and they feel symptoms like aches, numbness, in addition to paresthesia. Within this phase, the number of dense cells and irreversibly sickled cells (ISCs) are increased, while the number of erythrocyte deformability is decreased but it depends on the steady state values of each individual (Jacob et al., 2005).

B. Initial phase

It's also known as the first, infective, or evolving phase) it is distinguished by the start of pain, anxiety, anorexia, and fever. There is a drop in platelet count and a proportional rise in ISCs, dense cells, and erythrocyte dispersion width (Paule et al., 2011).

C. Established phase

It's also called post inactive phase and might continue from 4 to 5 days in adulthood. The most highlighted symptoms for this phase are severe continuous pain, leukocytosis, fever, arthralgia, fever, in addition to joint effusion. In most cases, bone infarction develops within established phase. When compared to steady-state values, laboratory examination results in elevated lactate dehydrogenase and Creactive protein, as well as reticulocytosis and a low hemoglobin content (Stuart et al., 1994).

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D. Resolving Phase

Also known as post crisis or healing phase, in this last phase; the pain started to decrease in a gradual way by the passing of one or maybe two days. The count of ISCs, dense cells, and the erythrocyte deformability degree are also returned to their normal value among steady state (Pandey, 2021).

6.1.2. Sequestration crises

Also known as splenic crisis, it's a non-safe type of crisis, as it affects children. It starts by a noticeable decrease in hemoglobin to reach 2g/dL linked to splenomegaly. In this case and because of its role as a blood filter, the spleen is particularly vulnerable to problems from SCD. The spleen is divided into three sections: red pulp, white pulp, and a transitional zone, each has a different purpose in the immune system. A small percentage of blood circulation only entering the spleen (about 10%) is redirected to get out of blood vessels to enter the red pulp parenchyma section, that's where RBCs are directed to form reticuloendothelial cells like macrophages, which sweep away aberrant cells or other infections. RBCs must be squeezed and decreased in size to pass through the small gaps of venous sinuses endothelium to re-enter the circulatory system (Siado & Hernández, 2015).

The spleen white pulp is organized mostly by T-cell per arteriolar sheaths and follicles, which are made up of B cells. B cells plays an important role as they produces IgM antibodies to perform and damage encapsulated types of bacteria as Neisseria meningitides, Haemophilus influenza type B and Streptococcus pneumonia by Opsonization. Due to recurrent bouts of auto scarring and infarction, the spleen rapidly loses size and function in children with SCD throughout the first five years of life (Tavare et al., 2012).

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6.1.3. Aplastic crisis

Its bone marrow inability of RBCs reproduction, this shutdown occurs only in a temporary way. When the bone marrow stops manufacturing red blood cells, a fast reduction in hemoglobin occurs due to the limited red cell lifetime in sickle cell disease patients. Severe aplastic crisis is usually related with parvovirus B19 infections in SCD affected persons (86 percent of cases) “childhood fifth disease”. Other factors might include a viral infection or pharmaceutical usage (Setúbal et al., 2000).

6.2 Acute Chest Syndrome

The sign of this syndrome are chest pain, abdomen pain, dyspnea, leukocytosis, pulmonary infiltrate and fever. This syndrome has nearly 10% risks of mortality. Vaso-occlusion or Infection are the most common causes for this syndrome, however pulmonary remobilization, noncardiogenic pulmonary edema from a bone marrow infarction or distant thrombus, can also cause it. Just what the cause, the most serious threat of acute chest syndrome is hypoxia, which can lead to widespread sidelining and vaso-occlusion, putting the patient at risk of multi-organ failure (Valley et al., 2017).

6.3 Psychological symptoms

According to modern insights into psychosocial pf patients with SCD, they have higher risks of getting depression, social isolation, lack of social relationships, low self-esteem, in addition to their inability to live a normal day. In SCD, there is a link between anxiety, a decreased in life quality, and increased discomfort As a result, it was proven that anxiety and depression in adults with SCD predicted increased daily discomfort and a lower physical quality of life (Edwards et al., 2005).

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6.4 Neurological complications symptoms

More than 25% of SCD patients are suffering from neurological complications such as cerebral infarction, unexplained coma, ischemic attacks, spinal cord infarction or compression, cerebral hemorrhage, vestibular dysfunction, sensory hearing loss, and central nervous system infection. (Mengnjo et al., 2016)

6.5 Bone problems signs and symptoms

Vaso-occlusive bone pain, osteonecrosis, and infections are all orthopedic consequences of (SCD) (osteomyelitis and septic arthritis). SCD patients are functionally a splenic, putting them at risk for life-threatening infections. Other noninfectious bone and joint issues can cause excruciating pain and immobility, limiting one's ability to work and live a normal life. These problems can be difficult to see, especially in people who suffer from persistent vaso-occlusive discomfort. It is, nevertheless, vital to make the accurate diagnosis in order to give suitable therapy. (Ballas, 2018)

6.6 Development and growth symptoms and complications

Children with SCD develops a noticeable retardation in the growth after the age of two, this retardation cause increasing in the weight and lowering the height. But when reaching the adult age, the height goes normal but the weight is still not back to normal. Some children with SCD might has delay in maturation of their skeletal, girls also may have complication within their sexual maturation process occurred in elevated levels of gonadotropin. Boys with intrinsic hypopituitarism, hypogonadism, or hypothalamic deficiency also have a postponed sexual maturity. Dietary supplementation has been able to restore normal development (Côbo et al., 2013).

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7. Diagnosis of SCD

7.1. Complete blood cells count

It's the most primary test to begin with in the process of Sickle cell anemia detection, it uses to characterize and identified different types of anemia. Although, the mutation in hemoglobin is going to affect the parameters of hematology and exposing a variable clear change. In Sickle cell anemia, homozygous and heterozygous (SS) and (S/β) respectfully, the mutations linked to normal hemolytic anemia type as RBCs, hematocrit, and hemoglobin are decreased and present in low amounts. On the other side platelets and WBCs levels are raised and they can fluctuate (Creary & Strouse, 2014).

Reticulocyte numbers, on the other hand, are variable and rely on a variety of parameters, including the degree of anemia induced by cell hemolysis, sequestration, and the bone marrow's reaction to anemia. In SCD patients using hydroxyurea, the mean corpuscular volume (MCV) is frequently higher. Furthermore, owing of the distinct subpopulations of RBCs, SCD patients have a higher red cell distribution width (RDW). CBC is commonly used to characterize hematological parameters as useful information, however it is insufficient to provide a comprehensive picture of a patient's diagnosis (Arishi et al., 2021).

7.2. Peripheral Blood Smear (PBF)

After finding abnormal results related to the presence of SCD in CBC test, a peripheral blood smear test will be conducted. It started by examining blood cells morphology, then looking for any change within the microscopic level, this will give precious information for different types of anemia diagnosis and not only specified for Sickle cell anemia. For Sickle cell anemia, the test detects the presence of

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anisopoikilocyte with a noticeable number in addition to detection of the elongated sickled cells due to oxygen deprivation. The procedure for making these blood samples slides is straightforward, quick, and affordable. However a PBF is a useful hematological test, it is dependent on the pathologist's abilities, and skilled pathologists are scarce. Moreover, due to variations in the cell's border, position, form, and size, blood slides analysis is too difficult. As a result, a computerized approach has been devised to make determining the kind of anemia more accessible. (Alvarez et al., 2015)

7.3. Test of Solubility Sickling

This test is fully dependent on HbS polymerization at the state of deoxygenated. It’s the most used test in our times; the idea of this test was built based on Hbs insolubility when concentrated phosphate buffer is presented, sodium dithionate, and for sure a hemolyzing agent. Those agents caused HbS crystallization and cells precipitation which lead to turbidity occurrence in the solution, the positive and negative control is presented to be compared with. (Okwi et al., 2010).

False-negative findings were recognized in people whom suffers both the severe anemia trait in addition to thalassemia. False positives, were also recorded among the other side, are seen in individuals with severe leukocytosis, erythrocytosis, high serum viscosity, and in some cases of anemia. Furthermore, sickle solubility tests cannot discriminate between sickle cells trait and sickle cell disease, and they are ineffective in detecting hemoglobin AS (HbAS). Because of these drawbacks, they are difficult to utilize in screening programs (Alli et al., 2008).

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7.4. Hemoglobin Electrophoresis test

It's a common chromatography type technique, and known to be one of the most highlighted Hb variants detection method, an electrical field is used in this assay to aid the movement of electrically charged molecules. In 1949, electrophoresis was used for the first time to define the hemoglobin variation Hb-S. Different pH and media are utilized to discover hemoglobin variations, such as cellulose acetate electrophoreses at alkaline pH or citrate agar at acidic PH. Sickle cell anemia and Thalassemia are detected by alkaline electrophoresis at PH 8.4. (Geraldine et al., 2001)

It started by hemolysate preparation from RBCs, secondly; by adding run in buffer and cellulose strip, then constant voltage will be passed into electrophoresis chamber to separate different types of hemoglobin according to their charges and mobility. Hemoglobin electrophoresis can distinguish between the most clinically relevant variations, HbS and HbC. Electrophoresis, on the other hand, does not differentiate between hemoglobin types with similar electrical charges and produces the same migratory patterns as HbG and HbD as they comigrate with HbS (CDC, 2015).

7.5. Isoelectric Focusing technique

Isoelectric focusing (IEF) is a high-resolution approach for protein separation that uses their isoelectric points to separate them (pI). The Hb molecules proceed down a pH gradient unless they reach the isoelectric points, in which they have no net charge. The Hb molecules clump together and form a sharp band. In a high concentration of HbF, this approach can easily identify HbS and HbA. It also

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distinguishes Hb D-Punjab from HbS. In most cases, the result may be obtained in 45 minutes. (Mvundura et al., 2019)

7.6. Polymerase Chain Reaction techniques (PCR)

One of the strongest diagnoses techniques in these days, as certain enzymes are involved in amplification process for a certain genetic material parts to give more than million copy. By applying specific designed primers; PCR can accurately detect the presence of several genes or a well specified genes. The process begins with denaturation phase, annealing phase, and finally elongation phase that repeated in a continuous 20 to 40 thermal cycles. Then gel electrophoresis will sequencing be conducted. After that followed by melting curve analysis. The prenatal and neonatal diagnostic sector has been transformed thanks to the sensitivity and specificity of PCR. Furthermore, selective settings have allowed the detection of heterozygous and homozygous states based on agarose gel electrophoresis band diameters (Vrettou et al., 2004).

The amplification-refractory mutation system (ARMS) is a straightforward method for identifying single point mutations or minor deletions. The ARMS concept states that primers having specified sequences are used to facilitate Amplicons in the existence of the desired allele. As a result, the availability of the PCR product is used to identify the relevant allele. (Yue et al., 2014).

7.7. Genetic testing technique

The genetic study is vital for the exact diagnosis of the many forms of sickle cell disease, based on the detection of -globin abnormalities that contribute to the development of SCD (Gustafson, 2006).

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8. Sickle Cell Treatment

8.1 Treatment by medications

- **Hydroxyurea**

Since the 1980s, clinicians have utilized hydroxyurea to treat persons with sickle cell disease. In 1998, the FDA authorized it for the treatment of people with sickle cell disease. It was authorized by the FDA in 2017 to treat children with SCD. Hydroxyurea expands red blood cells. It keeps them either flexible or rounder, which causes reduction in sickle shape formation. This type of treatment medication achieve this goal by escalating a certain hemoglobin type known as hemoglobin F. Hemoglobin F is also known as fetal hemoglobin since it is seen in newborn newborns. RBCs are less likely to produce difficulties if you have larger amounts of hemoglobin F (Tshilolo et al., 2019).

- **Crizanlizumab**

Crizanlizumab is an intravenous (IV) therapy that patients with sickle cell can use alone or in combination with hydroxycarbamide (popularly called hydroxyurea) to avoid bouts of discomfort and several other problems. Crizanlizumab has been the first novel medication for sickle cell disease in more than 20 years (Boiten, 2003).

- **Endari "L-glutamine oral powder":**

Endari is a kind of amino acid. Chemically, L-glutamine is known as (S)-2aminoglutaramic acid, L-glutamic acid 5-amide, or (S)-2,5-diamino-5-oxopentanoic acid. C5H10N2O3 is the chemical formula, and the molecular weight is 146.15 g/mol. Endari is a white crystalline powder that comes in a 5 gm paper-foil-plastic laminate container for oral route. It is suggested in adult and pediatric

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patients 5 years of age and older to decrease the acute consequences of SCD. (Kaufman, 2017)

8.2. Infection prevention actions

Penicillin is given from the age of 2 months to children suffering from SCD. To prevent many types of infection as pneumonia, that might cause serious complications then leads to death in children with SCD. Then during the adultness phase, they continue on penicillin for the rest of life especially if they conducted spleen removal procedure. Vaccinations at early ages against all kind of infections or diseases are also important. (Elobied et al., 2021).

9. Conclusion

Sickle cell disease (SCD) is an autosomal recessive illness characterized by defective hemoglobin S production and is linked with substantial morbidity and mortality. Although data on the frequency of SCD in Saudi Arabia is sparse and likely overestimated, research have shown that SCD is a very frequent hereditary condition in this region of the world. The frequency of SCD varies greatly across Saudi Arabia, with the Eastern province having the greatest prevalence.

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