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# THALASSEMIA: INSIGHTS INTO GENETIC DETERMINANTS AND PATHOPHYSIOLOGICAL CONSEQUENCES

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## Abstract

*Thalassemia is a heterogeneous group of hereditary hematological disorders characterized by various errors in globin-chain synthesis, leading to chronic anemia and multisystem involvement. The basic pathophysiology depends on the subtype: β-thalassemia most often involves mutations, rarely deletions, of the β-globin gene on chromosome 11; α-thalassemia is most commonly due to deletions involving the HBA1 and HBA2 genes or the surrounding regulatory regions. These genetic defects disturb the balance between the production of α- and β-globin chains, ultimately leading to ineffective erythropoiesis, hemolysis, iron overload, and a wide range of bone deformities and cardiometabolic complications. Further, myelofibrosis, vitamin B12 deficiency, porphyria cutanea tarda, increased liver enzymes, left ventricular hypertrophy, and chronic thromboembolic pulmonary hypertension are some of the secondary diseases associated with thalassemia, increasing its clinical spectrum even more. Advanced molecular diagnosis and detailed hematological investigations are crucial for better early detection and characterization of mutations. Treatment options include regular blood transfusions, hydroxyurea, and iron chelation to prevent organ injury, whereas newer thalidomide, sirolimus, antioxidant supplementation, bone marrow transplantation, and gene-based therapies hold promise for long-term disease modification. The combined review brings forth various complex pathophysiological mechanisms, diagnostic modalities, and changing treatment approaches that go on improving outcomes in patients with thalassemia.*

## INTRODUCTION

Thalassemia is a major health problem in most parts of the world. It is a genetic disease that occurs in blood cells. It refers to the group of haemoglobin disorders (Meri et al . , 2022).It is caused by the gene mutations that encode the globin chains of haemoglobin, resulting in the reduced production of alpha or beta chain. This imbalance causes disruption in the production of normal haemoglobin and causes disease like hemolytic anemia and erythropoiesis ( Hossain et al . , 2025).

This disease follows an autosomal recessive inheritance pattern. There are two types of thalassemia alpha and beta. Alpha-thalassemia is caused with the deletion of HBA1/HBA2 genes while beta-thalassemia is caused by point mutations of the HBB genes.Thses conditions can progress from carriers to life-threatning with the need for lifelong transfusion ( Wilder, 2024).

The pathophysiology of thalassemia centers on the imbalance of globin chain which produces unmatched chains in excess amount that accumulate

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in the erythroid precursors, which results in marrow hyperplasia, anemia or skeletal deformities (Li 2025). Taken together, the thalassemia collectively appear to be the most frequent inherited disorders in the world. In point of fact, certain allelic variant gene frequencies in the thalassemia reach levels of 30-40% in some Southeastern Asian populations, which are about the same as the frequency of the blood group A+ phenotype in the USA. In certain other areas of the globe, it is clear that the more severe forms of thalassemia constitute important public health concerns, and more significantly, a major source of human suffering (Benz, E. J., & Sankaran, V. G. 2023).

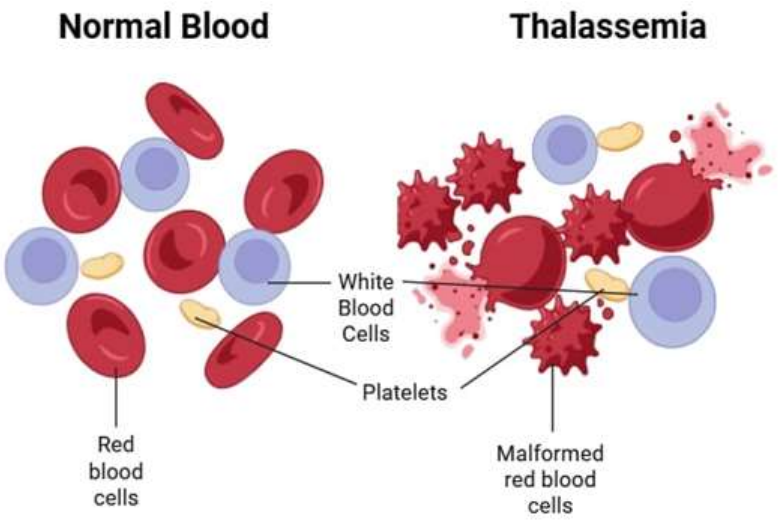


**Fig. 01: Blood cells of normal and affected person**

**2. Which population are at risk?**

Thalassemia is an inherited hemoglobin disorders that is widely spread all over the world with varying levels of prevalence. This is attributed to geographical, environmental factors, among other considerations (Tuo et al., 2024). An increase in the number of carriers of thalassemia is found in the Mediterranean region which include Greece, Italy, Cyprus, the Middle East which involves Iran, Saudi Arabia, South Asia like India, Pakistan, Bangladesh, or Southeastern or East Asia which is China, Thailand (Tuo et al., 2024)

In South Asia, the thalassemia belt conists Bangladesh with a 10.9-13.3% carrier prevalence rate; this translates to millions of carriers with high numbers at risk of births with β-thalassemia. (Hossain et al., 2025). Furthermore, the recent data from research carried out in Pakistan showed that there is a high frequency of β-thalassemia carriers among some of the local communities there, clearly indicating the high genetic load with respect to India (Haq et al., 2025). A high prevalence is also found in East/Southeast Asia; for example, East Asia showed the highest age-standardized prevalence rates of thalassemia in the world in 2021. This is attributed to the significant number of people affected by this condition, as well as the genetic diversity of the region. (Zhang et al., 2024) There is a substantial number of couples of childbearing age found to be carriers of either α- or β-thalassemia in China. (Li et al., 2025).

In Africa, it is thought that the frequency of carriers of β-thalassemia is around 5-10%, while alpha-thalassemia could be more widespread. Moreover, the risk of these conditions is often underrated by current screening practices (Saretta et al., 2025; Obeagu, 2025). Some ethnic communities are also at a higher risk for thalassemia by virtue of genetic founders' effects and consanguineous marriage practices that significantly increase the chances of both parents being carriers with a resulting progeny with thalassemia. Such social factors of inheritance continue to accentuate higher risk pockets in other areas of low prevalence (Musallam et al., 2023).

Children under five years of age are also a high-risk group for thalassemia as well as mortality, given the

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severe presentation of major forms of the disease, adding further emphasis for prenatal screening high-risk communities (Zhang et al., 2024) In general, the geographic populations at the greatest risk for thalassemia include Mediterranean, Middle East, South Asia, Southeast/Eastern Asia, as well as Sub-Saharan Africa, for whom the factors of previous malarial exposures, the number of carriers, as well as unequal accessibility to extensive genetic testing, overlap (Tuo et al., 2024; Hossain et al., 2025).

**3. Classification of Thalassemia:**

**3.1. Alpha Thalassemia:**

Alpha thalassemia results from partial are complete failure in α-globin chains, production leading to microcytic hypochromic anemia. Mild forms are often discovered by chance, through routine blood tests showing microcytosis. In contrast, more serious forms of disease can effect people differently whereas, other may suffer from serious and even dangerous conditions like hydrops fetalis .(Songdej & Fucharoen, 2022). Changes within the α-globin gene cluster strongerly influence how much α-globin is produced.These variations often lead to a reduction in α-globin chain production, it can worsen or alter the severity of conditions like β-thalassemia and sickle cell disease.The α-globin protein is encoded by two almost identical genes , HBA1 and HBA2, found on chromosome 16.( Traeger Synodinos et al., 2024).

α-thalassemia includes conditions marked by insufficient α-global chain production in hemoglobin.This imbalance causes excess β-like chains, producing Hb Bart's in fetuses and HbH in adults. Mild cases involve minimal anemia, whereas moderate forms lead to HbH disease. The most severe form, with little or no α-global production, result in Hb Bart's hydrops fetalis, which is fatal if untreated (Harteveld & Higgs, 2010). α-thalassemia developed due to the genetic changes that interfere with the normal hemoglobin formation, leading to insufficient synthesis of α-globin genes. In its most severe form , the disorder result in the severe fetal complications, known as hemoglobin Bart's hydrops fetalis which usually causes death before birth. Many high risk pregnancy are not detected due to the lack of screening and parental diagnosis.New techniques such as Doppler ultrasound and intrauterine transfusion have improved outcome, but they also raise ethical concerns.(Vichinsky,2009).

**3.2. Silent Carriers:**

Identifying silent carriers of a-thalassemia is challenging while using traditional phenotype based on screening techniques.This limitation can be tackled by applying LC-MS/MS techniques, which may helps in the discovery of new and previously unrecognisable biomarkers..(Ren et al., 2023).

**3.3. Hemoglobin H (Hb H) Disease:**

The very frequent form of thalassemia intermediate, presents several challenges in patient management. Most of the cases arise from double heterozygosity, where the deletions remove both α-globin genes on one chromosome (α0-thalassemia) combined with deletion of single α-globin gene (-/-α,α+ Thalassemia) patterns lead to the characredtic features of Hb H disease. (Funcharoen & Viprakasit, 2009). In individuals with three inactive a-globin genes, only one functional gene remains , causing moderate anemia and smaller , paler red blood cells. An imbalance in globin chain production causes extra β-globin chains to join, resulting Hb H disease, a process often resulting in hydrops fetalis and death during the second or third trimester, or shortly after birth. ( Chui, et al., 2003 ).

**3.4. Hydrops-fetalis:**

A condition in which access fluid accumulates in the fetus's tissues or body cavities, leading to swelling called Hydrops fetalis. This can involve edema of the fetus and placenta, as well as fluid in the abdomen (ascites), chest (pleural effusions), or around the heart (pericardial effusions). Most cases are caused by severe erythroblastosis fetalis due to Rh incompatibility, referred to as immune hydrops fetalis (IHF).(Hamad et al., 2025). Fetal hydrops occurs when fluid abnormally accumulates in more than one fetal compartments. It can be classified according to its cause immune or non immune as well as by the availability of additional anomalies and by the fatal age at which it occurs, including the first, second, or third trimester.(De Luca et al., 2025).

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**3.5. Alpha Thalassemia Major:**

One of the most severe type of alpha thalassemia is Alpha thalassemia major (ATM), affecting thousands globally each year, historically cause that before or at birth in most cases. Recent advances, including early and repeated intrauterine transfusions, have improved survival rates, fewer birth defects, and enhanced brain development in affected children (Winger et al., 2025).

Alpha thalassemia is clinically classified as mild intermediate, or severe, based on the intensity of anemia. Severe cases occurs in homozygous individual lacking both a0 alleles, resulting in a total loss of four a-globin genes. This leads to Hemoglobin Bart's hydrops fetalis, a fatal in utero condition caused by hemoglobin's in ability to transport oxygen properly ( Xu et al., 2025). Thalassemia major is an inherited disorder that poses a major public health challenge. Which can be reduced through effective screening programs. Irregular blood transfusions and Iron therapy can cause physical changes, often leading to anxiety and other psychological problems ( Mediani & Fuadah, 2025).

**4. Beta-Thalassemia**

The reduction in the formation of beta-globin chain results in beta-thalassemia. In 1925, Cooley & Lee defined this term for the first time. Beta-thalassemia is caused by the substitution on the basis of introns, axons and on the promoter areas of beta-globin genes. On the other hand; alpha-thalassemia is caused by the cancellation that remove the alpha-gene, then it is classified according to reduced (β+) or absent (β0) globin chain formation. Microcytic hypochromic anaemia and a large range of syndromic forms can occur (Ali et al., 2021).

The missing beta-chain generation is caused by molecular changes in beta-thalassemia. The formation of alpha-chain stays unaffected and because of this there is an unbalanced concentration of globin-chain race, that cause an unbalance of alpha-chain. If their normal partners and the participate in the red blood cells predecessors are absent, they are not stable. As a result, it causes an ineffective erythropoiesis (Shafique at el., 2021). Generally, there are main three categories of beta-thalassemia: that are explained below.

**4.1. Beta thalassemia major**

Thalassemia major is genetic blood disease that is caused by parents to offspring. Affected people need regular blood transfusion for survival. Because this disease is very dangerous, early treatment and diagnosis is very important for affected people. This condition results in pale red blood cells like, iron shortage anaemia, sideroblastic anaemia, some genetic blood disorders. For correct diagnosis, chose right treatment and avoiding mistakes (Gupta, A. 2024). Beta-thalassemia major damage heart, liver, lungs and hormone producing glands. These problems mainly occur due to the long-standing anaemia and excess iron rise in the body and caused by often blood transfusion. There are some physical health problems such as, emotional, mental and social challenges because the disease occur from birth to death (Tarim & Oz, 2022).

**4.2. Thalassemia intermediate:**

In intermediate thalassemia; patient need blood transfusion only during pregnancy or at a time of illness. Intermediate thalassemia is the moderate form of the disease. There are some complications occur during intermediate thalassemia like; the formation of clarify red blood cells increased. Additional causes include; thrombophilia, leg ulcers, splenectomy, iron overload and infertility. Heart disease is also cause of death rates (Mahmoud at el., 2024).

**4.3. Beta-Thalassemia Minor**

Minor thalassemia cause due to the single chain defect and in this situation; patients do not show any symptoms. But during daily blood tests; simple anaemia show. Beta-thalassemia minor is the third and last type of beta-thalassemia (Meri et al., 2022).

**4.4. Genetic counselling of β-thalassemia:**

B-thalassemia major and β-thalassemia intermedia follow autosomal recessive pattern. This means that; both parents have faulty gene and child must adopt it to develop the disease. If they have one normal gene and one faulty gene means that both parents are carriers; then each pregnancy has, 25% risk of stricken child, 50% risk of carrier and 25% risk that child will be completely normal. If one parent has thalassemia disease and one is carrier; then each

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child will be 50% affected and 50% carrier. Normally carriers do not show any symptoms and transfer the faulty gene to their children. Therefore, genetic counselling is very important before marriage or pregnancy to help the families to understand about the risks of genetic disease (Origa, R. 2021).

**5. Etiology:**

Thalassemia occur due to the less production of at least one globin polypeptide chain like α, β, γ and delta from which the synthesis of Hb becomes unbalanced. Thalassemia is recessive inherited disease. Beta thalassemia occur due to the less production of beta-polypeptide chains (Singh & Akhtar, 2025). There are two types of thalassemia that includes, Heterozygotes are the pathways and do not have the symptoms of initial to intermediate microcytic anaemia that is also known as Thalassemia minor and Thalassemia Major in which Homozygotes can cause the severe anaemia and bone marrow hyperactivity. Homozygotes are also known as Beta-thalassemia major or Cooley's anaemia (Meri et al., 2022).

Thalassemia caused due to the variations or cancellations of the Hb genes, which results in decreased production of alpha-globin or beta-globin chains. About 200 variations are considered as the major causes of thalassemia. The removal of alpha-globin genes can cause alpha-thalassemia and the variations in splice area and promoter regions of beta-globin gene on chromosome can cause beta-thalassemia (Hamza Bajwa & Hajira Basit, 2023). The variations in HBB gene can result in thalassemia. The deletion of genetic material i.e, HBB gene cause this disease in damn rare situations. The instructions provided by the gene perform important functions in body. The faulty protein product may be formed, when gene variations occur. Based on the role of protein it can affect the organ systems of body. The people having beta-thalassemia minor have variations in HBB gene. People with beta-thalassemia major have variations in both HBB genes (Muncie, H. L. 2023).

**6. Factors Contributing to Thalassemia:**

There are many factors contributing to thalassemia from which we will discuss some of the factors; like

**6.1. Iron overloaded:**

Excessive iron accumulates in our organs and causes serious complications. The reason that, the intestine absorbes its frequent amount upto toxic level. To overcome this problem, a therapy is done to secrete the excessive iron from body called Chelation Therapy. On the other hand, there are some risks in this therapy which includes disfunction of kidneys, gastrointestinal imbalances and high level of toxicity in stomach. All these symptoms can make the clinical picture more complicated. So, this is necessary to understand all the complications above mentioned to optimize the care for patients of thalassemia (Eman M Mansory et al., 2025).

**6.2. Genetic Mutations:**

The severity of disease will be determined by different types of variations, substitutions, cancellation and frameshifts. There are more than 200 beta-globin variations, which affects how much globin is produced (Abbas et al., 2023).

**6.3. Number of Affected Globin Genes:**

The damaged alpha or beta genes determine severity of disease. The severe forms of thalassemia are HbH or hydrops fetalis. These forms of thalassemia are caused by losing more alpha-globin genes (Ali & Saqib, 2023).

**6.4. Inheritance Pattern:**

This disease is autosomal recessive. Children inherited by the disease only when both parents have defected genes. Carriers like heterozygotes may looks like healthy but they can transfer the disease to the next generation (Al Hamadiny et al.,2024).

**6.5. Geographic and Ethnic Factors:**

In the Mediterranean region, Middle East, South Asia, and Africa the thalassemia is more common. Consanguineous marriages, which increases the chance of inheriting two defective genes, increases the risk of thalassemia (Haq et al., 2025).

**6.6. Genetic Modifiers and Transcription Factors:**

KLF1 variations, high fatal haemoglobin (HbF), and other gene regulators can make symptoms mild or acute on the base that how they affect globin genes (Zhang et al., 2024).

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**7. Symptoms of Thalassemia:**

When the number of red blood cells decreased, then they cause signs of thalassemia, depending upon the severity of condition (Abid & Najim, 2023). This disease causes long-lasting anaemia, making the person very tired and weak, along with slow growth and swelling of the liver and spleen. It can also change the shape of bones, especially in the face and skull, which may change the person's outlook. The severity of anaemia depend on the affection of one or both genes. Sometimes, the body makes blood cells outside the bone marrow, forming lumps in the liver, spleen, chest, spine, or lymph nodes, which can press on nearby tissues and cause problems. People with this disease may also develop weak bones, leg sores, and have a higher risk of blood clots (Alqurashi & Alquraishi, 2025)

**7.1. Asymptomatic:**

If there is absence of alpha-gene then you will not see any symptom. But if two alpha-genes are absent or one beta-gene is not found then this may cause mild anaemia. For example: Fatigue (Abbas et al., 2023).

**7.2. Initial and Intermediate Signs of Thalassemia:**

There are many forms of intermediate thalassemia presents with mild to moderate form. When red blood cells break; the urine from lighter yellow converted into dark brown. Thalassemia may lead the brittle and prone to fracture bones. The production of red blood cells increased due to low haemoglobin that cause thalassemia, that lead an enlarged and hyperactive spleen. Thalassemia slow down the growth of your children (P Bhandari et al., 2025)

**7.3. Symptoms of Thalassemia Major:**

Patients with thalassemia major frequently face emotional and social problems because of their illness. Physical problems like bone changes, enlarged liver and spleen, slow growth, yellowish skin, and a different facial outlook can make them feel different and it lowers their confidence. The patients stop participating in social activities and they pass through the loneliness feel, which affects their mental health and personality. The long-lasting disease, the need for frequent blood transfusions, and other complications also affects their physical health, independence, relationships, and daily routine, which makes it difficult for them to enjoy the life like a normal person (Al Hamadiny et al.,2024).

**7.4. Symptoms of Intermediate Thalassemia:**

Thalassemia intermedia can show a number of symptoms. Patients often have ongoing anaemia, an enlarged spleen, abnormal growths outside the bone marrow, iron buildup in the body, jaundice, and delayed growth. Common symptoms include short height, pale and small red blood cells means microcytic hypochromic anaemia, high levels of unconjugated bilirubin, and a swollen spleen. Some people may experience joint pain, noticeable paleness, a prominent forehead and cheekbones, and deposits called tophi. Complications can include leg sores, a tendency to form blood clots, and bone deformities (Sadiq et al.,2024). In children between six months and two years, symptoms may start to appear even if they receive fewer blood transfusions. Their growth and mental development can slow down. Problems with red blood cells, such as premature death of cells or decreased production, can lead to acute anaemia even with limited transfusions. Other issues that may occur include blood clotting problems means thrombophilia, leg ulcers, iron overload, infertility, osteoporosis, joint pain, and bone pain due to bone deformities. Heart disease is one of the major cause of death in these patients (Mahmoud et al.,2024).

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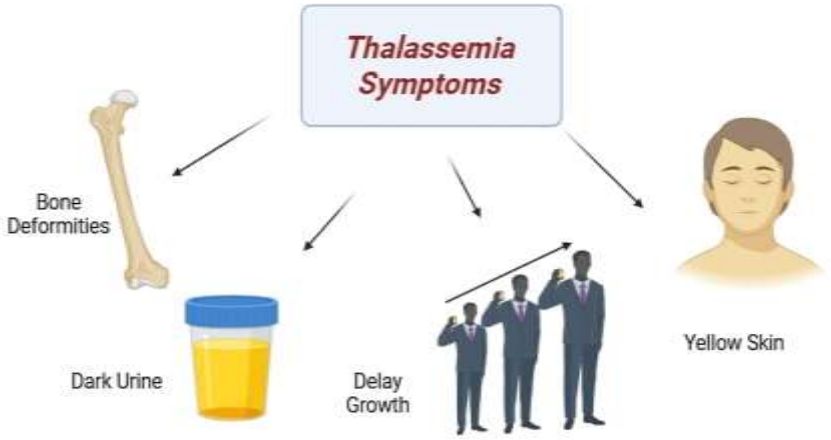


**Fig. 02: Common Symptoms of Thalassemia**

**7.5. Symptoms of Thalassemia Minor:**

Thalassemia trait, also known as thalassemia minor, is a common blood disorder in which a person contains the gene for thalassemia but it does not exhibit the severe symptom. The symptoms can be severe if some other blood problems, like iron deficiency anaemia or abnormal forms of haemoglobin also occurs. It is significant to differentiate thalassemia trait from other problems that cause small and pale red blood cells means microcytic hypochromic anaemia, including iron deficiency anaemia, and anaemia related to chronic illnesses (Gupta, A. 2024).

**7.6. Severe Symptoms of Thalassemia:**

People with haemoglobin H disease or Beta-thalassemia major have severe symptoms of thalassemia. Due to Severe anaemia, skin look pale and due to increased breakdown of red blood cells, skin look yellow. The first symptom of anaemia is tiredness. Due to anaemia, child feel tired, listless, and fussy. Due to beta-thalassemia major, children do not grow and gain weight as expected, and they

do not have the expected growth spurt during puberty (P Bhandari et al., 2025).

**8. Complications:**

Thalassemia affected people can expertise many health problems due to their condition and its treatments. The most common problem all over the world is that, due to the high level of bilirubin in the blood; jaundice and gallstones will happen. When the body produce blood outside the bone marrow; bones become thin and deformed, a process that is known as extramedullary haematopoiesis. Heart problems are a serious trouble in thalassemia. Severe anaemia can lead to high-output heart failure, cardiomyopathies, and irregular heartbeats, and heart-related issues are one of the major causes of death in these patients (Osataphan et al., 2023).

The liver and spleen often become large in size due to both extramedullary haematopoiesis and repeated blood transfusions that accumulate extra iron in the body. With the time, this iron increase and can cause problems alike to hemochromatosis, affecting the endocrine system, joints, and skin. Thalassemia also affect the nervous system, sometimes causing peripheral nerve problems, and can slow growth and delay puberty because of hormone and gland issues (Hamza Bajwa & Hajira Basit, 2023).

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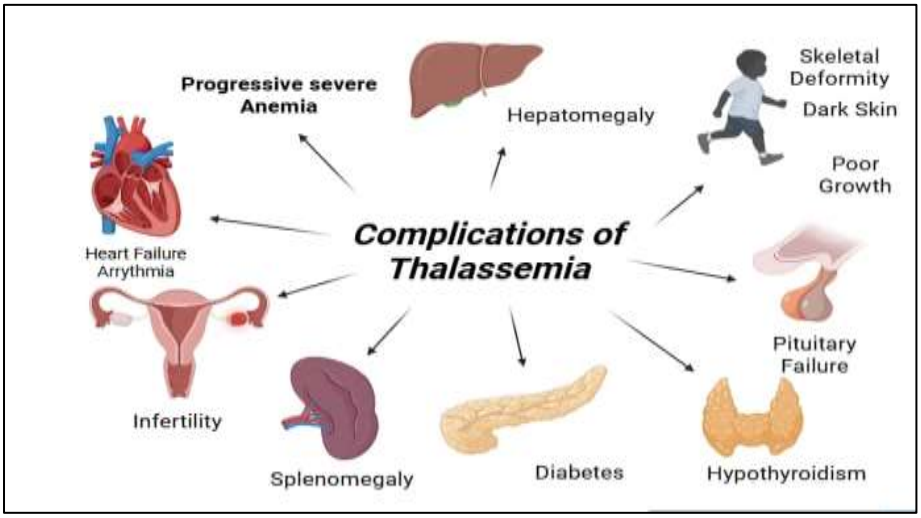


**Fig. 03: Major Complications related to Thalassemia**

Severe thalassemia are needed to manage the frequent blood transfusion, that can cause iron overload, damaging to heart, liver, and glands. Bone deformities, especially in the face and skull, can occur due to overactive bone marrow, making bones fragile and thin. Osteoporosis is also common, particularly in patients with low sex hormones (Meri et al., 2022).

Chronic transfusions occur due to allergic reactions, immune responses against transfused blood means alloimmunization, and other complications. Because thalassemia is relatively rare, following standardized guidelines can be challenging, so patients need to understand their treatment and communicate clearly with healthcare providers (Patterson et al., 2022).

**8.1. Iron overload:**

A serious issue for patients who receive regular transfusions is iron overload, from which the patient can experience the issues related to heart, liver including the endocrine gland (Bhandari et al., 2025).

**8.2. Hypersplenism:**

Another complication is hypersplenism, where the spleen becomes excited and destroys too many blood cells. In such cases, removing the spleen means splenectomy may be necessary. Signs of this include requiring the large amounts of transfused blood, having a very enlarged spleen, or undergo severe low blood counts (Osataphan et al., 2023).

**9. Diagnosis**

To diagnose thalassemia the combination of some laboratory tests like RBCs indices measured by automated hematology analyzer involved. Sometimes quantification of HbA2 and HbAF . To distinguish between thalassemic diseases and carrier the Capillary zone electrophoresis and high-performance liquid chromatography plays an important role. Both quantitative and qualitative analysis of Hb components is given by these systems with the best and also reproducibility. With the help of this thalassemia diagnosis within few minutes. Sometimes precise type of this disease can also be discovered by analysis of DNA and some other methods for the detection of special type of mutation which is point mutation (Fucharoen, S., & Paiboonsukwong, K. (2020).

Different strategies applied to diagnose this disease which can be divided into two main groups. It includes changes of single nucleotides and some deletions and insertions. These variants are specific to specific populations. Each population showing detected alleles. It includes the loss of big segments of a DNA and also includes the copies of a large segment. Functions of genes can also be affected by these changes (S. S., & Seong, M. W. (2021).

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Clinical and laboratory are directly involved in diagnosis of Beta-Thalassemia. Screening tests and confirmatory tests are necessary for diagnosis of HBE. Methods that are basic and comparatively low cast are called as initial screening tests. Usually, they show the possibility that they are suffering from this disease. These tests must involve rapid sample preparation and least sample treatment. They should require any special instrument. Mostly they lead to moderate cost and increasing sample throughout examination, but these tests can't give exact data on the same thalassemia kind of positive person (Tatu, T. (2020).

Laboratory tests, clinical evaluation and a analysis of a gene to verify that disease is present and to indicate its intensity is usually involved in diagnosing thalassemia. Appropriate management and treatment planning need accurate diagnosis. It may become challenging to evaluate thalassemia. Due to its overlapping system with other hematologic disorders (Hassan, H. A. (2024).

Family planning is important in at risk couples' potential parents having parental and maternal alpha-thalassemia mutations need proper counseling related to early genetics. As counseling part, it is necessary to differentiate carriers of alpha-thalassemia that usually carry mutation trans (a-/a-) versus in cis (-a/aa). The parents having mutations in cis are at risk stage mostly of having offsprings with ATM (-/-). All the couples at risk need awareness of disease results. Parental Diagnosis should be offered to a couple getting pregnant which was at risk. Through chorionic villus sampling usually done between 10-14 weeks fetal samples to evaluate for alpha-thalassemia can be obtained during pregnancy and the next to be done after 15 weeks. Gestational age is amniocentesis FBS known as fetal blood sampling is to be done at 18 weeks (Ajayi, A., & Vichinsky, E. (2025).

**10. Treatment**

Currently thalassemia has no definite cure but some treatment methods which are used in clinical practice are mostly symptomatic. These methods include blood transfusion, splenectomy hematopoietic stem cell transplantation and hydroxyurea but luspatercept and iron restricting agent are used for therapeutic research, and these are mature methods. (Huang, W., & Bian, Q. (2025). Some errors that occur in (HBB) which are hemoglobin beta genes result in the removal of production of Beta-globin production. Their production led to deficiency of hemoglobin and this result in hemolysis and deficiency in the production of WBCs due to imbalance of alpha and beta proteins. To maintain their balance, it is strategy to treat beta-thalassemia. (Morgan, M. & Schambach, A. (2025).

Every country has their own guidelines to treat this disease like if we talk about Thailand, they use process for RBCs transfusion in patients with TDT. Overloading iron can be treated with MRI. The difference in their access depend on their earnings. (Agostini, V., & Omert, L. (2023).

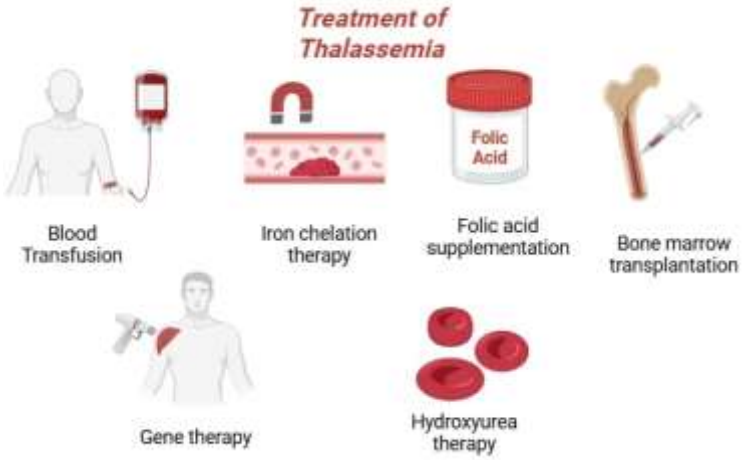


**Fig. 04: Possible Treatments of Thalassemia**

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**11. Prevention:**

Genetic disease thalassemia should be blocked by the help of prenatal diagnosis, which is useful for future incidence and also sometime for decreasing prevalence of thalassemia. During the 11 weeks of pregnancy, the test that is known as "Chorionic Villus Sampling" has been conducted which helps in removing the piece of placenta for evaluation. Health Education Awareness plays a main role in reducing genetic disorders especially from European countries (Meri et al., 2022).

Around counseling and heterozygous carrier detection the basic preventive approach is to prevent the marriage between carriers. All over the world, the premarital testing for thalassemia is being increasingly prevented. Several barriers like, religious issues and sociocultural are considered, when it comes to premarital screening. The screening programs effectiveness is decreased by religion related faiths. By believing on the faith that gods decide their fate; some people accept the possibilities of sick child. By the fear that they are going against the god's desire, they decline the premarital screening program (Suresh et al., 2023).

**12. Conclusion:**

Thalassemia is a genetic inherited disease that need a proper treatment means that regular blood transfusion is very important for affected people. Proper treatment helps the patient avoid from severe complications and is useful for the survival of affected person. For understanding the disease development that how it develop at the genetic and biological level; is help out the doctor to improve the affected person treatment. Regular blood transfusion, iron chelation therapy, Folic acid supplementation, Bone marrow transplantation, Gene therapy and low iron diet is very important for affected person treatment. New therapies like, Gene therapy and Bone marrow transplantation create hope for future. To control the severity of this disease, early detection is very important. Some important tests, like genetic counseling and prenatal test helps to cure the disease at the early stages. Therefore, it is very important to understand the genetic counseling before marriage or before pregnancy. For more effective treatment; research on this disease is very important. With proper management, healthcare provides better support to patients and improve their quality of life.

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