EFFECTS OF CONSULTATION AND SUPPLEMENTAL EDUCATION FOR THALASSEMIA PATIENTS ON EFFECTIVE TREATMENT AND CARE

By

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Abstract:

Thalassemia is a genetic disorder that is characterized by abnormal hemoglobin within red blood cells of the body. If not diagnosed early and treated with proper care, this disorder is fatal. Once considered rare, this disorder's rise in prevalence is now of concern to many health professionals because it does not receive the same level of attention as other, more common blood disorders. Due to its chronic treatment course and recent advancements in treatment, thalassemia still remains primarily a pediatric disorder not having many cases of patients living into adulthood at this point in time [1]. Seeing this shortcoming in thalassemia advocacy we find it useful to take certain steps to bring more public awareness of it. We hope to share information about this debilitating disorder, its management/ treatment course and most importantly, its prevention through genetic testing. We conducted a patient quality improvement study at the Pediatric Hematology/Oncology/BMT clinic at Banner University Medical Center Tucson, AZ to assess the effectiveness of consultations and supplemental education on the treatment and care of thalassemia patients. The focus of the project revolved around patients with the most prominent thalassemias, beta and alpha.

Introduction:

The thalassemias are a family of genetically inherited blood disorders which originate from the Mediterranean area. Although it's origins were around the Mediterranean region, thalassemia is now observed globally. Thalassemia, also called Cooley's Anemia after American doctor Thomas Cooley who first clinically described the disorder's symptomology in 1927, is a disorder that results in improper red blood cell function. The two predominant forms of thalassemia are alpha and beta thalassemia. Thalassemia also has variable expressivity. There are three broad types (severities) of thalassemia: major, minor, and intermediate [2].

Thalassemia is characterized as a hemoglobinopathy meaning that it's pathophysiology arises due to faultiness in the hemoglobin protein found in red blood cells (RBCs). More specifically, gene mutations that code for the alpha and beta globin chains which constitute the quaternary structure of hemoglobin produce alpha and beta thalassemia respectively. Improper hemoglobin structure eventually leads to improper oxygen loading and offloading of hemoglobin. Consequently, to compensate for the anemia, thalassemia leads to blood transfusion dependency for patients who become affected by the disorder. There are multiple sources of mutations that can cause beta thalassemia. These include gene deletions of the beta globin chain, or mutations that lead to faulty transcription, processing, and translation of the beta globin gene [3]. The only mutation type that gives rise to alpha thalassemia, however, are gene deletions specifically in the alpha globin chain gene.

Beta thalassemia: Major, Minor, Intermediate:

In patients with beta thalassemia, there are three severities that the disorder presents clinically. Beta thalassemia major, or just, thalassemia major, is the full form of the disorder. Patients with thalassemia major, to some varying degree, display all the common symptoms associated. Thalassemia major patients are anemic and blood transfusion dependent. Thalassemia minor is another name for the carriers of this disorder. These individuals have the thalassemia trait but do not express all of the primary symptoms and thus live otherwise healthy, normal lives. Thalassemia intermediate patients have the same mutation as thalassemia major patients, having inherited both recessive alleles for the beta globin chain gene but do not show the same severity of symptoms as thalassemia major patients [4]. Thalassemia intermediate patients may require occasional blood transfusions, if any, in their lives and will typically maintain otherwise normal lives [2]. In the study, our focus was on the beta thalassemia major and minor patients.

Pathophysiology

Beta thalassemia pathogenesis and pathophysiology occurs in three ways. The first is that there is ineffective red-blood cell formation or erythropoiesis along with destruction of parts of the red blood cell precursors [3]. Secondly, mature erythrocytes, due to an overabundance of alpha globin chains, tend to lyse easily and die [3]. Third, there is overall reduced size and hemoglobin content in the erythrocytes that are produced [3]. Thus the main constituent to beta thalassemia pathophysiology is caused by damage to erythrocyte cell membrane. Because there is an overabundance of alpha globin chains in the erythrocytes, they form clusters of alpha globin chain. These clusters then react with certain membrane proteins and cause dysfunction, damaging the integrity of the cell membrane. Additionally, the free iron that is also abundant in the erythrocytes can react to form reactive oxygen species which then also contribute to the

structural damage of the cell membrane [3]. Ultimately the lysis of the red blood causes hemoglobin precipitates to pool in the bone marrow. This causes destruction of erythrocyte precursors within the bone marrow [3].

Inheritance of beta thalassemia

Beta thalassemia major is an autosomal recessive trait. This means that both of the recessive copies of the beta globin chain gene need to be inherited from the mother and father in order for the offspring to be affected by thalassemia, in other words, the child will have beta thalassemia major. Like-wise, if only one copy of the recessive gene is inherited, which can either be passed on from mother or father, then the offspring will be at most, a carrier of the disease, also known as beta thalassemia minor. **Figure 1** provides a table indicating the inheritance pattern observed in beta thalassemia. Note, both parents have to be carriers of the beta thalassemia trait in order for there to be any probability of having an affected child with beta thalassemia major. There is a 25 % chance of conceiving a child with beta thalassemia major and a 50 % chance of conceiving a child with beta thalassemia trait, and 25 % chance of conceiving a child without any thalassemia at all**.** **Figure 2** further explains the probabilities and associated phenotypes of beta thalassemia present in the offspring of two beta thalassemia trait/carrier parents.

	Parent (carrier)		
		B	b
Parent (carrier)	B	BB	Bb
	b	Bb	bb

B: Dominant, unaffected allele for beta globin chain synthesis
b: Recessive, affected allele for beta globin chain synthesis

Figure 1: The inheritance of beta thalassemia is shown in this figure. Beta thalassemia follows basic Mendelian genetics. If both parents are heterozygous for the trait of beta hemoglobin chain, there is a 25 % chance of conceiving a child with beta thalassemia major (Major Child), a 50 % chance of conceiving a child with beta thalassemia trait (Carrier Child), and 25 % chance of conceiving a child without any beta thalassemia (Normal Child).

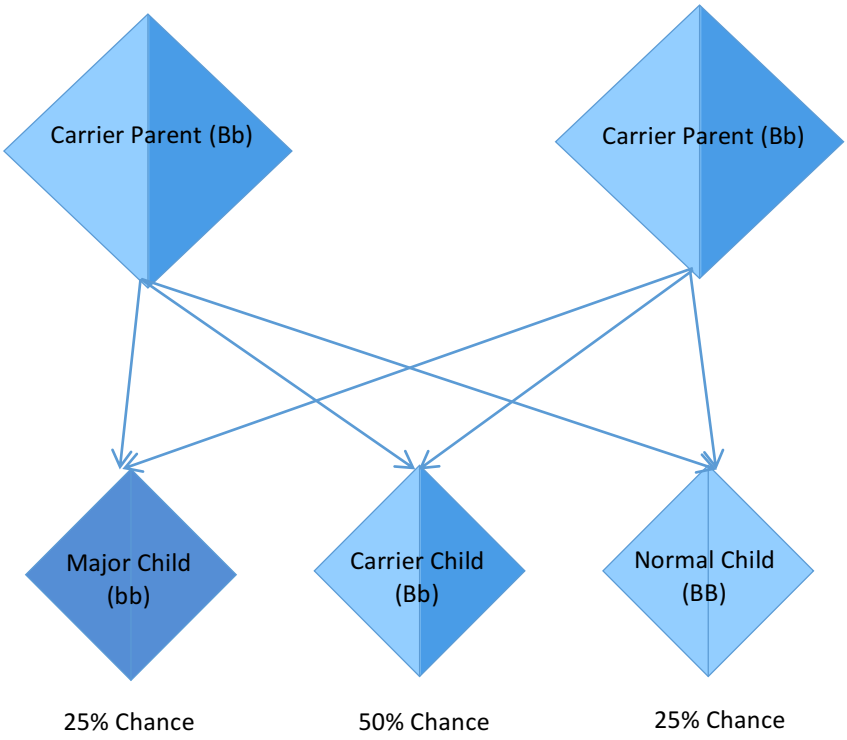

Figure 2: The figure is another representation indicating the inheritance of beta thalassemia. This figure depicts the relative genotypic and phenotypic probabilities of the children born to two beta thalassemia trait/carrier parents.

Alpha thalassemia: Trait, Hemoglobin H disease, Hb Bart hydrops fetalis:

Pathophysiology

Unlike beta thalassemia in which the primary issue is ineffective formation/maturation of erythrocytes due to damage to the cell membrane of the erythrocytes, in alpha thalassemia, the primary issue is not due to inefficient erythropoiesis [3]. In the case of alpha thalassemia, pathogenesis/pathophysiology results more-so due to reduced efficiency of the erythrocytes after they mature, their damage to surrounding circulation, and due to reduced life. In alpha thalassemia, because the production of the beta globin chain is unaltered, when erythrocytes mature, there are excess beta globin chains within the erythrocytes. The conglomeration of beta globin chains without the alpha chains leads to improper hemoglobin quaternary structure and thus leads to a mutant version of hemoglobin called hemoglobin H a homotetramer of four beta globin subunits. This form of hemoglobin is soluble in the marrow thus it does not lead to any bone marrow damage [3].

Inheritance of alpha thalassemia

The genetic inheritance of alpha thalassemia is more complex than that of beta thalassemia. There are four genes that are responsible for the normal production of the alpha globin chain, the second major component of the hemoglobin tetramer. Alpha thalassemia arises with the varying number of deletions in the four genes accountable for alpha globin chain production. If a patient is born with only one of four genes missing, the patient is known as a silent carrier of alpha thalassemia ($\alpha\alpha/\alpha$-). Clinically, the patient will maintain a healthy and normal lifestyle with no major complications associated with alpha thalassemia besides mild anemia. If a patient is born with two of the four genes, the patient is known as alpha thalassemia

trait. An alpha thalassemia trait mutation is classified as either a cis-mutation (αα/--) or a trans-mutation (α-/α-) [5]. When three of the four genes are knocked out (--/-α), a condition called hemoglobin H disease results. This condition can be analogous to a patient having beta thalassemia major. With hemoglobin H disease, the patient presents with all the primary symptoms of alpha thalassemia [6]. The last scenario occurs when all four genes associated to alpha globin chain synthesis are missing (--/--). This is known as Hb Barts hydrops fetalis and is incompatible with life [6]. **Figure 3** includes three broad and predominant genotypic crosses leading to alpha thalassemia, indicating the relative genotypic and phenotypic probabilities of the offspring having some form of alpha thalassemia described above. A) shows a cross between two parents who are both silent carriers of alpha thalassemia. When conceiving a child, the phenotypes include 25 % chance of a normal child free of alpha thalassemia, 50 % chance of a child who is a silent carrier like the parents, and 25 % chance of a child with alpha thalassemia trait. B) depicts a cross between two parents who are both inflicted with hemoglobin H disease themselves. When conceiving a child, they can expect the following phenotypes: 25 % chance of a child with alpha thalassemia trait. A 50 % chance of a child with hemoglobin H disease like the parents, and finally 25 % chance of a child who will have hydrops fatalis and will not survive past birth. Lastly, cross C) represents a cross between two parents who both are alpha thalassemia traits. The resulting children would be expected to have phenotypes: 25 % chance of being normal, 50 % chance of having alpha thalassemia trait, and 25 % chance of having a child with hydrops fetalis, which is again, incompatible with life.

A)

Silent Parent

Silent Parent		AA	A-	
	AA	AA/AA	AA/A-	50% Silent Carrier
	A-	AA/A-	AA/--	25% Trait

25% Normal

B)

HbH Parent

HbH Parent		A-	--	
	A-	AA/--	A-/--	50% HbH
	--	A-/--	--/--	25% Hydrops Fetalis

25% Trait

C)

Trait Parent (cis)

Trait Parent (cis)		AA	--	
	AA	AA/AA	AA/--	50% Trait
	--	AA/--	--/--	25% Hydrops Fetalis

25% Normal

A: Alpha globin gene present	**– : Alpha globin chain gene deletion**

Figure 3: The inheritance of alpha thalassemia is shown above in the figure. There are four genes that correspond to alpha globin chain production and mutations in any can lead to some form related to alpha thalassemia. The figure describes the common phenotypic and genotypic combinations clinically observed in alpha thalassemia. A) shows a cross between two parents who are silent carriers of alpha thalassemia. B) shows a cross between two parents with hemoglobin H disease, and C) shows a cross between two parents who are each alpha thalassemia traits. The genotypic and phenotypic probabilities of the offspring are provided for each cross.

Patient Quality Improvement Study – Pediatric Hematology/Oncology/BMT clinic at Banner University Medical Center Tucson, AZ:

Due to its low prevalence world-wide, thalassemia often goes overlooked in the public health community. A relatively recent study indicated that the incidence of thalassemia births was estimated at 1 in 100,000 world-wide [1]. However, "population migration and intermarriage between different ethnic groups has introduced thalassemia in almost every country of the world, including Northern Europe where thalassemia was previously absent" [1]. The lack of education and medical knowledge is cause of concern for patients and care providers. Additionally, because the disorder is still very much a pediatric disorder, only very specialized caregivers are able to properly monitor and provide adequate care to patients. This makes it difficult for patients to receive appropriate care and intervention early in life because too often the disorder is misdiagnosed or lacks early intervention causing medical issues later in life.

Aim

In light of the fact that there is a shortage of education regarding thalassemia, we were intrigued to see the effects of implementing a patient quality improvement study in the local Pediatric Hematology/Oncololgy/BMT clinic at the Banner University Medical Center in Tucson, AZ. The aim of this study was to implement and evaluate education provided to patients referred for thalassemia to the pediatric hematologist.

Hypothesis

Through the implementation of this education quality improvement project, our goal was to determine if thalassemia education provided at the clinic was effectively comprehended,

reproducible and could be reiterated by patients via analysis of a pre- and post-survey by the patients and/or their families at the hematology clinic.

Inclusion Criteria- Abnormal newborn screen for thalassemia, ability to speak, read, and understand the English language.

Exclusion Criteria- Patients with other hemoglobinopathies such as sickle cell disease, sickle cell trait, HbC disease, HbSC disease, inability to speak, read, or understand the English language.

Methods

To provide education, we did a literature search on beta thalassemia major, beta thalassemia trait (minor), hemoglobin H disease, and alpha thalassemia trait (the most common thalassemia referrals to the pediatric hematology service). An evidence based education packet with references was created for each diagnosis (see pgs 19-27). In addition, pre-education and post-education surveys were prepared for each patient with five questions that were addressed in the education packet. The packet contained information about the specific thalassemia diagnosis the patient was referred for based on their blood work, outpatient or newborn screening results. This packets included information about the diagnosis, its inheritance, and what it meant for the patient to have that particular diagnosis.

At patients' arrival to clinic, vitals were done by clinic RN, history and physical exam were performed by Dr. Bhasin and the quality improvement education goals were explained to the family. Soon after, patients were given a brief survey consisting of five questions related to their respective proposed diagnosis. They were told to answer the questions to their best knowledge. This was collected as the pre-survey (see pgs 28-31).

After completing the pre-survey questions, Dr. Bhasin and I educated the family about their specific hemoglobinopathy and reviewed the information included in their education packets. The education packets were then handed to the patient and the families were asked to review the information and ask any questions for clarification if needed. Once education was completed, patient families were given the post-survey (pgs 28-31) which consisted of the same exact questions as those on the pre-survey.

All pre- and post-surveys were completed by parents/guardians of the patients given we were dealing with the pediatric population. Families were allowed to consult with family members present when attempting the pre- and post surveys and look through their education packets during this time. We requested the same family member to complete both the pre and post survey for consistency.

Results

The pre- and post-surveys of all the patients were collected to be analyzed. All the families spoke and understood English well. Study population included, two patients with alpha thalassemia trait (2 gene mutation), and one patient with beta thalassemia trait. Pre- and post-surveys were scored based on how many of the questions the patients answered correctly and given a percent correct value. Two families (both alpha thalassemia trait diagnoses) scored 100% on their pre- and post-surveys. One family (beta thalassemia trait) scored 80 %on the pre-survey and 100% on the post survey (see **Table 1**).

Conclusions

In attempts to improve our study, we tried to reflect back on what limitations we noticed. Firstly, because all three of the patients were referred to see a hematologist based off their new born screenings, they may have had prior knowledge of the disorder which may have resulted in

higher scores on the pre-survey. Another thing we want to consider for the future is the difficulty and consistency in the type of questions we ask. We wanted to ensure that we did not burden the patients with an extensive list of questions, or make the questions unnecessarily difficult in attempts to make the patients feel more relaxed and comfortable during their initial consultation. Although we did not keep track of the time it took the patients to complete the pre- and post-surveys, we noticed that all patient families were able to complete the five questions in relatively short periods of time and even shorter when taking the post-surveys (matter of minutes). We may therefore need to reassess the difficulty of questions to understand whether it is conducive to providing a reasonable assessment of education and retention of the consultation. Another thought may be to switch the order of questions presented between the pre- and post-surveys in order to eliminate any potential serial effects of the survey questions. Additionally, it might also be useful to make the pedigrees and inheritance sections of the education regiment more interactive to promote discussion between the clinicians and patients. Doing so, it can provide immediate feedback to the hematologists whether the education is helpful, giving them the opportunity to clarify any confusion or misunderstandings, while instilling a better connection and trust with the patients.

Due to our small sample size (3 patient families), it is hard to ascertain any significant and relevant information. Because of the small sample size and since we did not attain any information on two of four diagnoses (beta thalassemia major, and hemoglobin H disease), the study possessed limitations. The study is still a work in progress and we will continue our data collection beyond the time frame of this thesis project until we reach of goal of 15 patients in order to do statistical analysis.

Future Direction

Previous initiatives in other modalities of healthcare have indicated the beneficial effects of the patient quality improvement model. A 2009 patient quality improvement initiative done through the Veterans Affairs–Tennessee Valley Healthcare System among patients with hypertension showed a that blood pressure control was improved in 4.2 % in the patient population in only one year of intervention [7]. Similar effects were observed in a 2001 patient quality improvement study conducted on patients of chronic illness. The researchers used "The 'collaborative' approach--the Breakthrough Series (BTS) and the "Chronic Care Model" to assess the effects of patient quality improvement on effective care. The study indicated that more than fifty healthcare systems are using these models in conjunction to treating chronic illness like diabetes, depression, asthma, and congestive heart failure [8].

We aim to continue providing education to future patients as that is a crucial aspect to making sure the patients who visit the clinic feel reassured and safe that they will receive proper and effective medical care after their diagnoses. We hope that over time, with more patients, we can gather useful, relevant, and significant data to analyze our education efficacy for the patients of this patient quality improvement study. Prevention is an important precaution in pediatrics and this project aims to educate families about seeking genetic counseling when planning future pregnancies to avoid these serious disorders that can lead to life-long complications or death. Genetic counseling is especially important in inherited disorders such as thalassemia in order to assure that families, when planning to have children can do so safely without risking the chances of having children who become inflicted with the chronic and painstaking disorders. The implementation of this study design and the results we can gain from this are critical components

which can be supplemented with genetic counseling to promote a healthier and safer future for patients' families.

The long term goal of the study is that eventually, the BMT clinic will adopt the design of this patient quality improvement study and use this style of practice as a standard protocol with its newly referred patients. In doing so, the clinic can ensure that its doctors and other medical staff are providing the patients all the necessary education and health support (efficiently and consistently) needed when diagnosing and treating for thalassemia. Once this patient care procedure is well grounded for thalassemia patients, the clinic looks to extend this approach and patient quality improvement methodology to other hematological disorders beyond thalassemia.

Patient (Diagnosis)	Pre-survey Score (Questions scored correctly out of total five)	Pre-survey Score (Percentage correct)	Post-survey Score (Questions scored correctly out of total five)	Post-survey Score (Percentage correct)
1 (Beta thalassemia trait)	4	80 %	5	100 %
2 (Alpha thalassemia trait)	5	100 %	5	100 %
3 (Alpha thalassemia trait)	5	100 %	5	100 %

Table 1: The table above indicates the scores of the patients on the pre- and post-surveys during the study. There were only three patients that were part of the study, whose scores are reflected above. Note, all surveys were attempted by a parent/guardian of the patient due to pediatric patient population and the survey-taker was asked to take both the pre- and post-surveys.

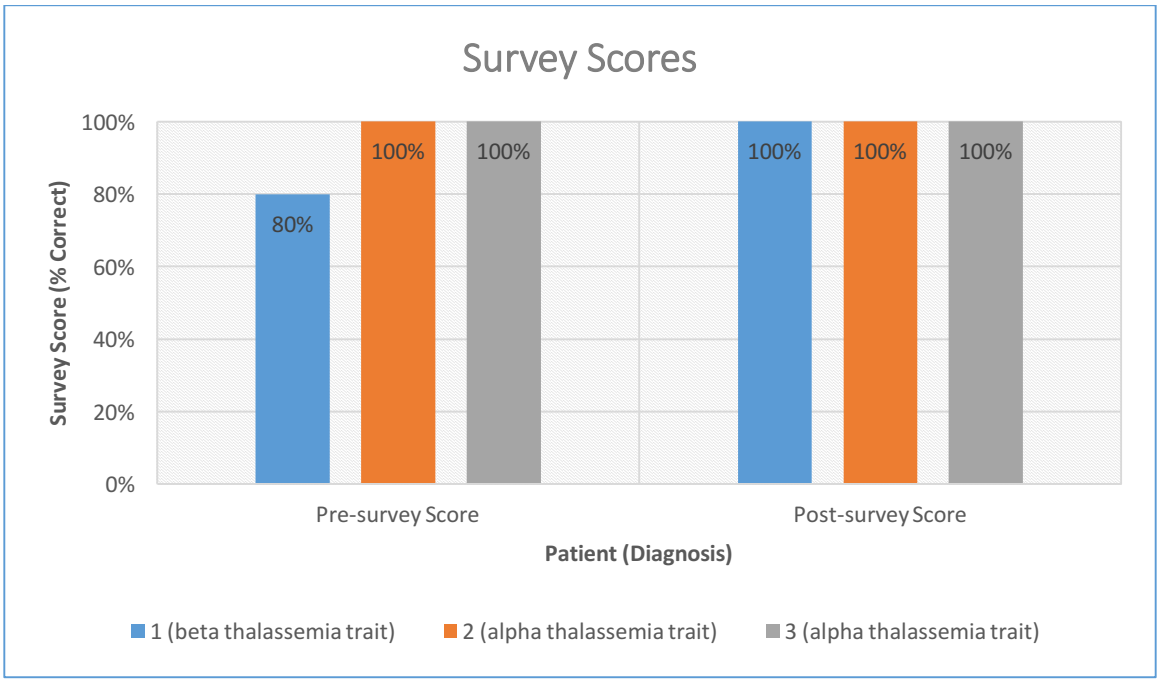

Figure 4: This graph indicates the survey scores of the three patient families included in the study. The per-survey and post-survey scores are shown. The only patient family that had differing scores between the pre- and post-surveys was patient 1 (beta thalassemia trait).

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Reflection:

Doing this thesis project was particularly intriguing to me because of a personal connection to thalassemia. I myself am a patient of beta thalassemia major. Because of this, thalassemia is a topic near and dear to me. I have a unique perspective—that of a patient. Having grown up with and living with the disorder, I experience the daily challenges associated to living with a chronic illness like thalassemia. Over the years, I realized that much of the problem that existed with thalassemia was the lack of education and awareness of the disorder. This lack of education is present not only in the public, but also amongst primary care providers, who often do not have the proper knowledge on how to care for thalassemia with appropriate effectiveness. Due to thalassemia's chronic nature, effective care and management starts with early diagnosis and effective management during the early stages of life. Thus, it is important that doctors are adequately rehearsed in diagnosing and effectively treating thalassemia.

I wanted to try to understand how education could directly be improved and manipulated so that it was most effective for the patients and families afflicted with thalassemia. It is humbling to know I had the opportunity to help contribute to starting a patient quality improvement study alongside Dr. Bhasin. I was able to learn the clinical and medical aspects of thalassemia to a greater extent while spending time in the clinic and working on this project. I look forward to continuing my work at the BMT clinic and giving structure to this patient quality improvement study.

Supplemental Education Packets and Surveys:

Alpha thalassemia trait

Alpha thalassemia is a genetic blood disorder that causes the body to make improper red blood cells. Red blood cells carry the oxygen that we breathe and need to sustain life. Alpha thalassemia trait is caused by a mutation in a protein called hemoglobin causing low levels of this protein. Hemoglobin carries the oxygen in our blood. Because the disorder is genetic, it means that the only way to be affected by it is to inherit it. In the case of patients with alpha thalassemia trait however, the body is still able to make sufficient hemoglobin protein to not require any major medical interventions.[1]

What this means for you or your child

With alpha thalassemia trait, patients will not require any sort of medical treatments. Because the patient's body naturally produces adequate amounts of proper functioning hemoglobin, blood transfusions are not required unlike in patients with hemoglobin H disease who are truly affected by alpha thalassemia. Fortunately, though, patients with alpha thalassemia trait such as yourself or your child have no need to take any medicines, as you/your child do not require regular blood transfusions[2].

Inheritance of Alpha thalassemia trait

When it comes to living with a genetic disorder, there are many aspects of life that are involved and need to be considered. In addition to taking good care of your health and well being, it is important to understand that because disorders like thalassemia are genetic, they are inherited and can be passed onto future generations. For patients with alpha thalassemia trait, it is very important to find a partner who is not affected by the disorder his/her self. It is also very important to consult a genetic counselor prior to having children, who can best assist in understanding the potential options and outcomes. To understand how alpha thalassemia trait is inherited please refer to the diagram below which shows the probability of children that will be affected or unaffected by thalassemia when you plan to have kids together.

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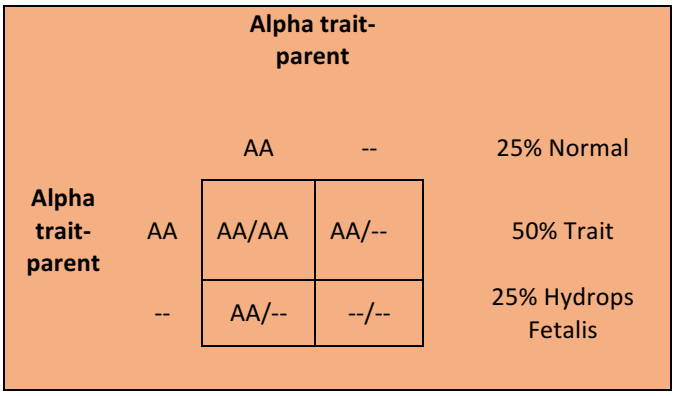
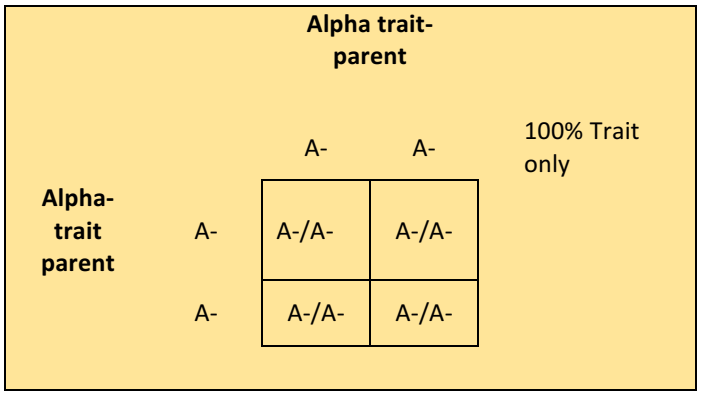
Inheritance Diagram





Beta thalassemia major

Beta thalassemia major is a genetic blood disorder that causes the body to make improper red blood cells. Red blood cells carry the oxygen that we breathe and need to sustain life. Beta thalassemia major is caused by a mutation in a protein called hemoglobin. Hemoglobin carries the oxygen in our blood. Because the disorder is genetic, it means that the only way to be affected by it is to inherit it. In the case of patients with beta thalassemia, a specific part of the hemoglobin protein (the beta chain) is mutated and cannot carry oxygen around your body, causing anemia[1]. The only definitive cure for thalassemia that exists is bone marrow transplant. However, because it is a highly risky procedure, life long treatment is what doctors will often suggest instead.

What this means for you or your child

With beta thalassemia major, patients will require regularly scheduled blood transfusions to compensate for the anemia and lack of proper hemoglobin. Therefore, it is very important to monitor hemoglobin levels routinely and receive transfusions if hemoglobin levels fall below a certain level established by your doctor. Blood from donors lasts in your body temporarily, therefore regular transfusions are needed for survival. Due to low hemoglobin levels, patients often feel tired easily and weak especially when closer to transfusion dates. Other symptoms include pale or opaque skin. Several transfusions over time lead to excess iron in your body that the body cannot excrete. Iron overload is what makes thalassemia a potentially fatal disorder when it is not effectively treated. For this reason, medications are needed to bind excess iron in the body so it does not get deposited abnormally in your heart, liver etc. where it is not needed. These medications are called 'chelation therapy' and can be taken by mouth or via subcutaneous (injected under the skin) routes. To monitor thalassemia health, patients must have regular labs drawn at the time of each transfusion to insure anemia is improving, excess iron is not getting deposited, and chelation therapy is effective. Two of the most common iron chelation medicines are called Exjade and Jadeu. Patients should understand the side effects of these medicines and understand the importance of being extremely compliant in taking them daily, to maintain good thalassemia health[2].

Patients are also highly recommended to visit one of the several thalassemia specialty clinics in U.S. to establish individualized and more comprehensive thalassemia care. Doctors at these clinics will keep a close eye on several body functions that are relevant in thalassemia health. Comprehensive exams are important to assess iron overload. Bone health and endocrine health is also monitored for these patients.

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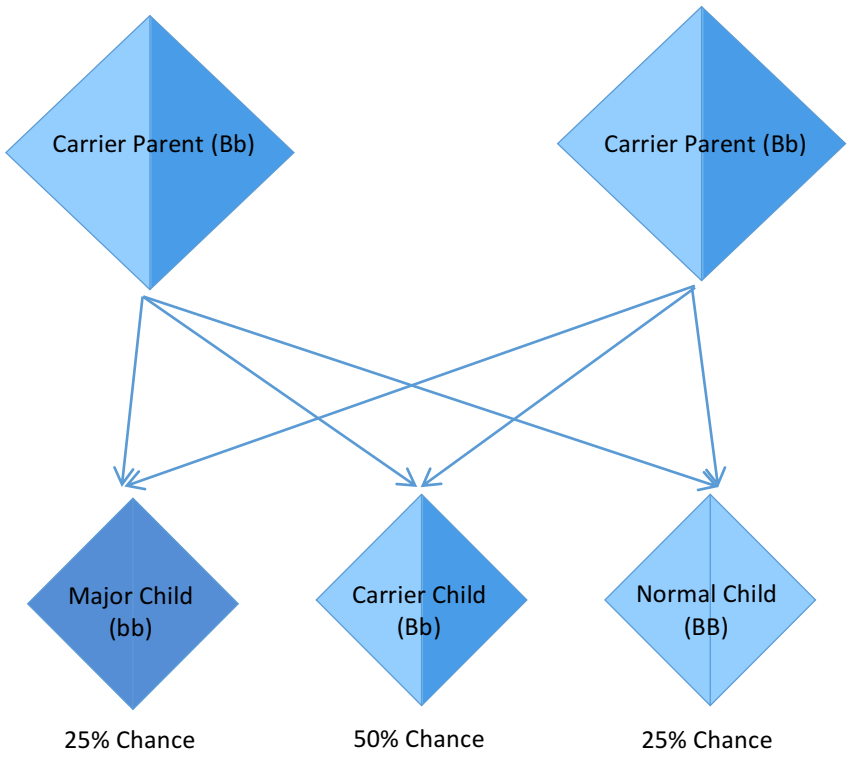
Inheritance of Beta thalassemia major

When it comes to living with a genetic disorder, there are many aspects of life that are involved and need to be considered. In addition to taking good care of your health and well being, it is important to understand that because disorders like thalassemia are genetic, they are inherited and can be passed onto future generations. For patients with beta thalassemia major, it is very important to find a partner who is not affected by the disorder his/her self and is also not a carrier for the mutation. It is also very important to consult a genetic counselor prior to having children, who can best assist in understanding the potential options and outcomes. To better understand how beta thalassemia major is inherited please refer to the diagram below which shows the probability of children that will be affected or unaffected by thalassemia when you plan to have kids together.

Inheritance diagram



Beta thalassemia trait

Beta thalassemia is a genetic blood disorder that causes the body to make improper red blood cells. Red blood cells carry the oxygen that we breathe and need to sustain life. Beta thalassemia trait is caused by a mutation in a protein called hemoglobin. Hemoglobin carries the oxygen in our blood. Because the disorder is genetic, it means that the only way to be affected by it is to inherit it. In the case of patients with beta thalassemia trait however, the body is still able to make sufficient hemoglobin protein to not require any major medical interventions[1].

What this means for you or your child

With beta thalassemia traits, patients will not require any sort of medical treatments. Because the patient's body naturally produces adequate amounts or proper functioning hemoglobin, blood transfusions are not required unlike in patients with beta thalassemia major who are truly affected by beta thalassemia. Fortunately, though, patients with beta thalassemia trait such as yourself or your child have no need to take any medicines, as you/your child do not require regular blood transfusions[2].

Inheritance of Beta thalassemia trait

When it comes to living with a genetic disorder, there are many aspects of life that are involved and need to be considered. In addition to taking good care of your health and well being, it is important to understand that because disorders like thalassemia are genetic, they are inherited and can be passed onto future generations. For patients with beta thalassemia trait, it is very important to find a partner who is not affected by the disorder or has the trait his/her self. It is also very important to consult a genetic counselor prior to having children, who can best assist in understanding the potential options and outcomes. To understand how beta thalassemia trait is inherited please refer to the diagram below which shows the probability of children that will be affected or unaffected by thalassemia when you plan to have kids together.

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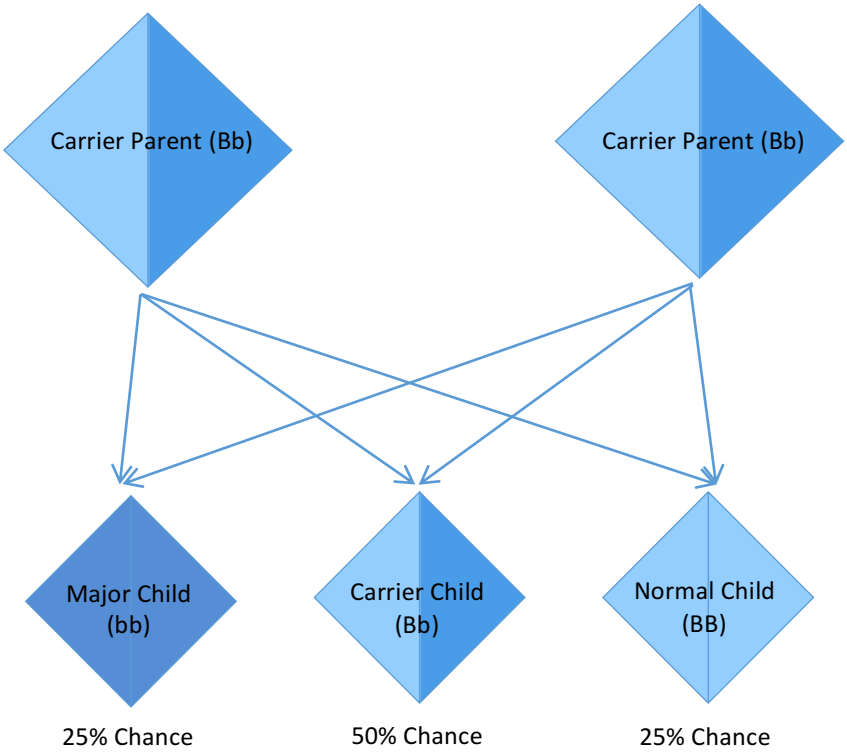
[1] Bunn, H. F. & Aster, J. C. (2011). *Pathophysiology of Blood Disorders*. Retrieved from http://accessmedicine.mhmedical.com.ezproxy1.library.arizona.edu/book.aspx?bookid=1191

[2] Northern California Comprehensive Thalassemia Center. (2012). *What is Thalassemia?*. Retrieved from http://thalassemia.com/what-is-thal-beta.aspx#gsc.tab=0

Inheritance diagram



Hemoglobin H disease

Hemoglobin H disease, a form of alpha thalassemia, is a genetic blood disorder that causes the body to make improper red blood cells. Red blood cells carry the oxygen that we breathe and need to sustain life. Hemoglobin H disease is caused by a mutation in a protein called hemoglobin. Hemoglobin carries the oxygen in our blood. Because the disorder is genetic, it means that the only way to be affected by it is to inherit it. In hemoglobin H disease, a specific part of the hemoglobin protein (the alpha chain) is mutated and cannot carry oxygen around your body well causing anemia[1]. The only definitive cure for thalassemia that exists is bone marrow transplant however, because it is a highly risky procedure, life long treatment if needed, is often what doctors will suggest instead.

What this means for you or your child

Some patients with hemoglobin H disease require frequent blood transfusions to compensate for the anemia while others do not. Therefore, it is very important to monitor hemoglobin levels routinely and receive transfusions if hemoglobin levels fall below a certain level as established by your doctor. Blood from donors lasts in your body just temporarily so regular transfusions are needed for continued anemia throughout a lifetime. Regular blood contains proper concentrations of hemoglobin protein. Due to low hemoglobin levels, patients often feel tired easily and weak especially when closer to transfusion dates. Other symptoms include pale or opaque skin. Several transfusions over time lead to excess iron in your body that the body cannot excrete. Iron overload is what makes thalassemia a potentially fatal disorder when it is not effectively treated. For this reason, medications are needed to bind excess iron in the body so it does not get deposited abnormally in your heart, liver, etc. where it is not needed. These medications are called 'chelation therapy' and can be taken by mouth or via subcutaneous (injected under the skin) routes. To monitor thalassemia health, patients must have regular labs drawn at the time of each transfusion to insure anemia is improving, excess iron is not getting deposited, and chelation therapy is effective. The two more common chelation medicines used are Exjade and Jadenu. Patients should understand the severity of these medicines and understand the importance of being extremely compliant in taking them daily, to maintain good thalassemia health[2].

Patients are also highly recommended to visit one of the several thalassemia specialty clinics in U.S. to establish individualized and more comprehensive thalassemia care. Doctors at these clinics will keep a close monitor on several body functions that are relevant in thalassemia health and care. Of these main comprehensive exams/checkups, thalassemia patients are vitally examined for liver iron overload. Aside from the main focus on thalassemia care, other periodic checkup routines that

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[1] Bunn, H. F. & Aster, J. C. (2011). *Pathophysiology of Blood Disorders*. Retrieved from http://accessmedicine.mhmedical.com.ezproxy1.library.arizona.edu/book.aspx?bookid=1191

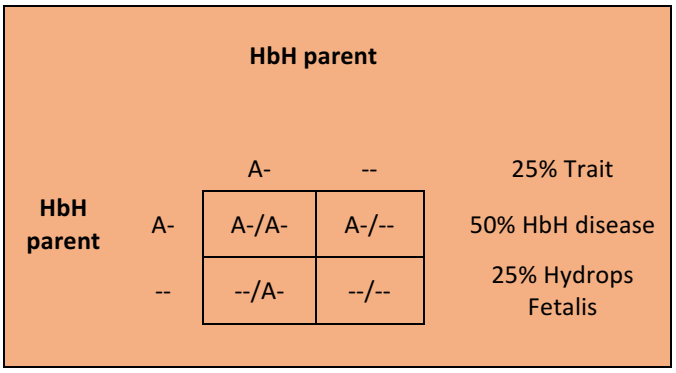
[2] Lal, A. (2012). *Treating Thalassemia: Hemoglobin H Disease.* Retrieved from http://thalassemia.com/treatment-HbH-Lal.aspx#gsc.tab=0

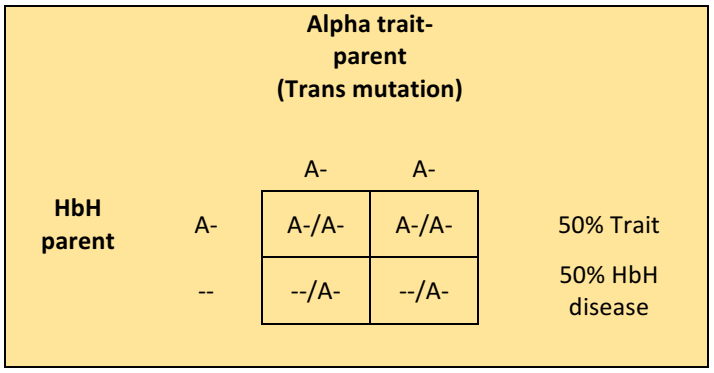
doctors will request include bone health and endocrine health as hemoglobin H disease has long-term adverse affects on other parts of the body as well.

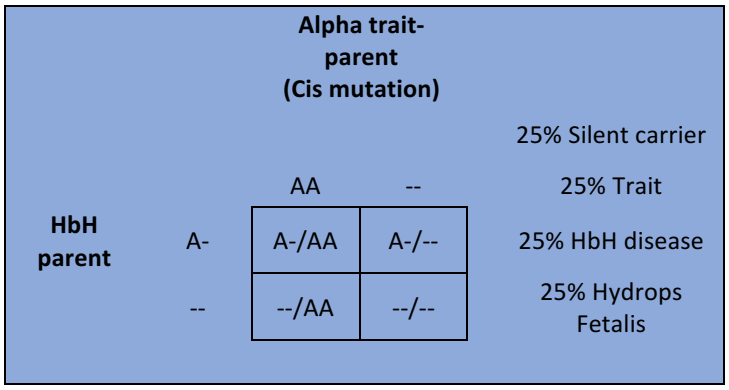
Inheritance of hemoglobin H disease

When it comes to living with a genetic disorder, there are many aspects of life that are involved and need to be considered. In addition to taking good care of your health and well being, it is important to understand that because disorders like thalassemia are genetic, they are inherited and can be passed onto future generations. For patients with hemoglobin H disease, it is very important to find a partner who is not affected by the disorder his/her self and is also not a carrier for the mutation. It is also very important to see a genetic counselor prior to having children when you have hemoglobin H disease who can best assist in understanding the potential options and outcomes. To understand how hemoglobin H disease is inherited please refer to the diagram below which shows the probability of children that will be affected or unaffected by thalassemia when you plan to have kids together.

Inheritance Diagram







Alpha thalassemia trait questionnaire

What type of disorder is thalassemia?

A. Hemoglobin
B. Platelets
C. Bone
D. Stomach

Do patients with alpha thalassemia **trait** need medication for their thalassemia?

A. Yes
B. No

Thalassemia trait patients will have low ___ levels, but will not require intervention?

A. Hemoglobin
B. Sodium level
C. Calcium level
D. Creatinine

What should you do when planning to have children?

A. Heart transplant
B. Consult a genetics counselor
C. Bone marrow transplant
D. Vaccinations

How can you get thalassemia trait?

A. Its contagious
B. Spread through blood
C. Only inherited from generation to generation
D. Sharing food/drinks

Beta thalassemia major questionnaire

What type of disorder is thalassemia?

A. Blood
B. Cancerous
C. Bone
D. Gastric

What is the major treatment course for patients with beta thalassemia major?

A. Chemotherapy
B. Insulin pump
C. Blood transfusions
D. Dialysis

Which of the following blood tests are usually checked during clinic visits?

A. Hemoglobin
B. Sodium level
C. Calcium level
D. Creatinine

How likely is it to have a child with thalassemia major if both parents are carriers or traits of the disorder?

A. 40%
B. 25%
C. 50%
D. 100%

What is the only cure for thalassemia at this point, but is highly risky?

A. Heart transplant
B. Gastric bypass
C. Bone marrow transplant
D. Vaccinations

Beta thalassemia trait questionnaire

What type of disorder is thalassemia?

A. Blood
B. Cancerous
C. Bone
D. Gastric

Do patients with beta thalassemia **trait** need medication for their thalassemia?

A. Yes
B. No

Thalassemia trait patients will have low ___ levels, but will not require intervention?

A. Hemoglobin
B. Sodium level
C. Calcium level
D. Creatinine

What should you do when planning to have children?

A. Heart transplant
B. Consult a genetics counselor
C. Bone marrow transplant
D. Vaccinations

How can you get thalassemia trait?

A. Its contagious
B. Spread through blood
C. Only inherited from generation to generation
D. Sharing food/drinks

Hemoglobin H disease questionnaire

What type of disorder is thalassemia?

A. Blood
B. Cancerous
C. Bone
D. Gastric

What is the major treatment course for some patients with Hemoglobin H disease?

A. Chemotherapy
B. Insulin pump
C. Blood transfusions
D. Dialysis

Which of the following blood tests is usually checked during clinic visits?

A. Hemoglobin
B. Sodium level
C. Calcium level
D. Creatinine

How can you get hemoglobin H disease?

A. Its contagious
B. Spread through blood
C. Only inherited from generation to generation
D. Sharing food/drinks

What is the only cure for thalassemia at this point, but is highly risky?

A. Heart transplant
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