

An Overview on Micronutrient Deficiency in Critical Condition: A Review of Thalassaemia

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Abstract: Thalassaemia is a hereditary disorder that disrupts normal hemoglobin synthesis, resulting in anemia and various systemic complications. Classified into two main types, alpha-thalassaemia and beta-thalassaemia, the disorder varies in severity based on the genetic mutation. Managing thalassaemia involves blood transfusions, iron chelation therapy, and addressing micronutrient deficiencies, which collectively impose a substantial healthcare burden. This review highlights the critical role of micronutrients in managing thalassaemia-related complications, emphasizing their importance in optimizing patient outcomes.

In this review, secondary data is collected and accordingly ascertain which micronutrient deficiency is common. Iron is a key component of hemoglobin and plays a crucial role in oxygen transport. Folic acid and vitamin B12 are essential for DNA synthesis and red blood cell production. Zinc and copper are involved in various enzymatic processes related to red blood cell development and function. Vitamin C enhances iron absorption, while antioxidants protect cells from damage caused by oxidative stress. Strategies for effective management include iron chelation therapy, tailored nutritional counseling, and regular monitoring of micronutrient levels. Emphasis is placed on a balanced diet rich in essential nutrients to mitigate oxidative stress, support red blood cell production, and improve patient outcomes.

Keywords: Chelation, haemoglobin, micronutrients, thalassaemia, and transfusion

INTRODUCTION

This overview will delve into the complexities of micronutrient deficiencies in individuals with thalassaemia. It explores the prevalence, impact, and causes of these deficiencies, ultimately highlighting strategies for effective management as this study uncovers the critical interplay between thalassaemia and micronutrient status. Thalassaemia is a genetic disorder that affects the production of hemoglobin, the protein responsible for carrying oxygen in red blood cells. There are two main types: Alpha-thalassaemia and Beta-thalassaemia. Each type has different subtypes based on the severity of the genetic mutation.

Thalassaemia affects millions of people worldwide, with a particularly high prevalence in Mediterranean, Southeast Asian, and African regions. Individuals with thalassaemia often experience lifelong health complications, including anemia, fatigue, bone deformities, and an increased risk of infections. The treatment and management of thalassaemia pose a significant burden on healthcare systems, requiring regular blood transfusions and iron chelation therapy.

MATERIAL AND METHOD

This review is based on an extensive analysis of existing literature, focusing on the roles of micronutrients, their deficiencies in thalassaemia patients, and potential management strategies. Literature was retrieved from major scientific databases, including PubMed, Scopus, Web of Science, Embase and Cochrane Library. A concise summary of the key findings from the ten cited studies:

1. Nutritional Deficiencies in β -Thalassaemia Major: Over 30% of thalassaemia patients experience deficiencies in key micronutrients, even with adequate dietary intake, due to increased needs or losses.
2. Iron Overload and Micronutrient Deficiencies: Iron overload from transfusions contributes to deficiencies in vitamins C, D, and zinc, requiring focused management.
3. Thalassaemia Survival and Nutritional Challenges: Advances in care have improved survival, but micronutrient deficiencies remain a persistent issue in β -thalassaemia.
4. Supplementation During COVID-19: Immune-related vitamins and minerals (C, D, and zinc) were highlighted as critical supplements for β -thalassaemia patients during the pandemic.
5. Anemia and Micronutrient Deficiencies in Ghana: Found high anemia and micronutrient deficiency

rates in regions with hemoglobinopathies, underscoring the need for interventions.

6. Inadequate Dietary Intake in Adults with β -Thalassemia: Dietary patterns often fail to meet micronutrient needs, leading to deficiencies and health complications.
7. Biomarkers of Micronutrient Deficiency: Significant deficiencies in vitamins (A, C, E, B12, folate) and antioxidants were identified in children with β -thalassemia major.
8. Systematic Review on Nutrition in Thalassemia: Nutritional deficiencies are common and linked to morbidities such as iron overload and diabetes, requiring tailored management.
9. Hepcidin and Iron Dysregulation: Low hepcidin levels in β -thalassemia patients exacerbate iron overload, indirectly affecting micronutrient balance.
10. Comprehensive Review of Micronutrient Deficiencies examined clinical implications of deficiencies and recommended strategies for improving outcomes in thalassemia patients.

The studies collectively emphasize the prevalence of micronutrient deficiencies in thalassemia patients, often exacerbated by iron overload, increased metabolic demands, and dietary inadequacies. Regular assessment and individualized supplementation are vital for improving patient outcomes.

Micronutrients are essential vitamins and minerals required in small amounts for normal growth, development, and overall health. These nutrients play a vital role in various bodily functions, including energy production, cell growth, and immune system function. In the context of thalassemia, certain micronutrients are particularly important due to their impact on red blood cell production and overall health. Iron is a key component of hemoglobin and plays a crucial role in oxygen transport. Folic acid and vitamin B12 are essential for DNA synthesis and red blood cell production. Zinc and copper are involved in various enzymatic processes related to red blood cell development and function. Vitamin C enhances iron absorption, while antioxidants protect cells from damage caused by oxidative stress.

Iron is an essential component of hemoglobin, the protein responsible for carrying oxygen in red blood cells. In thalassemia, the body's ability to produce hemoglobin is impaired, leading to iron deficiency.

This deficiency can further worsen the symptoms of thalassemia, leading to increased fatigue, pallor, and shortness of breath. However, iron overload is a common problem in individuals with thalassemia who receive regular blood transfusions. Blood transfusions increase the body's iron stores, leading to iron accumulation in organs like the liver, heart, and pancreas. This iron overload can cause serious complications, such as heart failure, liver damage, and diabetes. Therefore, managing iron levels is crucial in thalassemia. Regular blood tests are used to monitor iron levels, and chelation therapy is often employed to remove excess iron from the body.

Folic Acid and Vitamin B12 are essential for DNA synthesis and red blood cell production. These vitamins are crucial for the formation of new red blood cells, which are particularly important for thalassemia patients who experience reduced red blood cell production. Deficiencies in folic acid and vitamin B12 can lead to megaloblastic anemia, a condition characterized by the production of large, abnormal red blood cells. This anemia can worsen the symptoms of thalassemia, leading to increased fatigue and pallor.

Adequate intake of folic acid and vitamin B12 is vital for thalassemia patients to support red blood cell production and overall health. Dietary sources of folic acid include leafy green vegetables, legumes, and fortified cereals. Vitamin B12 is found in animal products, such as meat, poultry, fish, and dairy products.

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Zinc and Copper are essential minerals involved in various enzymatic processes related to red blood cell development and function. These minerals play critical roles in the formation of enzymes involved in hemoglobin synthesis, red blood cell maturation, and overall cell growth and repair. Deficiencies in zinc and copper can impair red blood cell production and function, potentially worsening the symptoms of thalassemia. Zinc deficiency can lead to delayed growth and development, weakened immune function, and impaired wound healing. Copper deficiency can result in anemia, bone abnormalities, and neurological problems.

While zinc and copper deficiencies are less common in thalassemia than iron overload or folic acid deficiency, their impact on red blood cell function and

overall health highlights the importance of maintaining adequate levels of these essential minerals.

Vitamin C, also known as ascorbic acid, is an important antioxidant and plays a crucial role in iron absorption. Vitamin C enhances the absorption of non-heme iron, the type found in plant-based foods, by promoting the conversion of ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}), the form more readily absorbed by the body.

In individuals with thalassemia, iron absorption can be particularly important due to the increased need for iron to compensate for the reduced hemoglobin production. Adequate vitamin C intake can help improve iron absorption and reduce the risk of iron deficiency, which can further worsen the symptoms of thalassemia.

Good sources of vitamin C include citrus fruits, berries, tomatoes, and leafy green vegetables. Incorporating these foods into the diet can help enhance iron absorption and contribute to overall health in thalassemia patients.

Antioxidant Micronutrients, such as vitamin C, vitamin E, and selenium, help protect cells from damage caused by free radicals. These antioxidants may contribute to improved health outcomes in thalassemia by reducing oxidative stress and inflammation.

Oxidative stress is a process that occurs when the body produces more free radicals than antioxidants. Free radicals can damage cells, leading to inflammation and cell death. Oxidative stress is exacerbated in thalassemia due to the increased breakdown of red blood cells and the release of free radicals. However, incorporating a diet rich in antioxidants may be beneficial for managing the condition.

Understanding the Underlying Causes

Frequent blood transfusions can overload the body with iron, leading to iron accumulation and potentially iron deficiency. Thalassemia-related conditions can affect the absorption of key nutrients, including iron, zinc, and folate, in the gastrointestinal tract. Thalassemia patients have increased nutrient requirements due to increased red blood cell turnover and other metabolic demands.

Consequences of Micronutrient Deficiencies

Exacerbated Anemia- Further worsens anemia, leading to increased fatigue and reduced quality of life.

Compromised Immune System- Increases susceptibility to infections, delays wound healing, and hinders overall health.

Growth Retardation- Impacts growth and development, especially in children and adolescents.

Bone Complications- Contributes to bone fragility and osteoporosis, increasing the risk of fractures.

Heart Failure- Iron overload can lead to heart damage and heart failure.

Strategies for Effective Management

Nutritional Counseling- Providing tailored nutritional guidance, including dietary recommendations and supplements.

Iron Chelation Therapy- Administering medications to remove excess iron from the body, reducing the risk of iron overload.

Regular Monitoring- Closely monitoring micronutrient levels through blood tests and adjusting treatment plans as needed.

Dietary Recommendations for Thalassemia Patients

A balanced diet that includes a variety of foods rich in micronutrients is essential for individuals with thalassemia. This diet should emphasize iron-rich foods, such as red meat, poultry, fish, beans, and lentils. It should also include good sources of folic acid, vitamin B12, zinc, copper, and vitamin C.

Some specific dietary recommendations for thalassemia patients are:

- Consume iron-rich foods, such as red meat, poultry, fish, beans, and lentils.
- Include foods rich in folic acid, such as leafy green vegetables, legumes, and fortified cereals.
- Eat foods rich in vitamin B12, such as meat, poultry, fish, and dairy products.
- Incorporate zinc-rich foods, such as oysters, beef, nuts, and beans.
- Consume copper-rich foods, such as shellfish, nuts, and legumes.
- Eat foods rich in vitamin C, such as citrus fruits, berries, tomatoes, and leafy green vegetables.

It is crucial to consult with a registered dietitian to develop an individualized meal plan that meets the specific nutritional needs of each patient.

CONCLUSION AND RECOMMENDATIONS

Micronutrients play a vital role in managing thalassemia, a complex genetic blood disorder characterized by reduced hemoglobin production. Adequate intake of iron, folic acid, vitamin B12, zinc, copper, and vitamin C is crucial for supporting red blood cell production, minimizing oxidative stress, and improving overall health outcomes.

Prompt and accurate diagnosis of thalassemia is crucial for timely interventions. Tailored management plans should address the individual needs of each patient. Involving healthcare professionals from various specialties for comprehensive care. Empowering patients with knowledge about their condition and treatment options. By understanding the complexities of micronutrient deficiencies in thalassemia, we can enhance treatment strategies and improve the lives of those affected by this disorder.

While current research highlights the importance of these micronutrients in thalassemia, further research is needed to fully understand the optimal intake of each micronutrient, potential interactions, and long-term health benefits. It is essential to work closely with healthcare professionals to manage iron levels and obtain necessary micronutrients through a balanced diet or supplements as recommended. Through ongoing research, improved nutritional management, and personalized care, we can strive to improve the quality of life for individuals with thalassemia and manage this lifelong condition effectively.

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