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Ferritin in Stunting

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Abstract.

Stunting, as defined by the World Health Organization (WHO), is a form of chronic malnutrition characterized by a child's length or height being more than two standard deviations below the median for their age group. While diagnosing stunting is relatively straightforward, the primary challenge lies in its prevention. Clinical assessment and laboratory investigations play an important role in predicting the risk of stunting. Basic laboratory evaluations include complete blood count, urinalysis, and routine stool examination. In addition, metabolic screening may involve random blood glucose, blood gas analysis, lactate, ammonia, ketone bodies, amino acid profiles, and urinary organic acids. Further investigations can include culture tests, iron profile, electrolyte levels, renal and liver function tests, thyroid hormones, infection screening, and immunoglobulin E (IgE) levels. Iron deficiency is a key contributing factor to stunting; therefore, its prevention is essential. Hemoglobin is a sensitive marker for detecting iron deficiency anemia, but it is not reliable for identifying early iron deficiency. Hemoglobin levels may remain within the normal range even when iron stores begin to decline, which can delay diagnosis if clinicians rely solely on this parameter. Serum ferritin is a more sensitive early marker, as its levels decrease in the initial stages of iron deficiency.

Keywords: *Stunting; Iron Deficiency and Ferritin.*

I. INTRODUCTION

Stunting remains a major chronic nutritional problem and a significant public health challenge, particularly in developing countries. This condition is characterized by impaired linear growth due to prolonged nutritional deficiencies, resulting in a child's height being below the standard for their age. Stunting affects not only physical growth but also cognitive development, immune function, and future productivity. Therefore, stunting prevention has become a priority in national health policies, including in Indonesia, where the prevalence remains high [1].One of the key factors contributing to stunting is iron deficiency. Iron is an essential micronutrient that plays a critical role in various biological functions, including hemoglobin synthesis, energy metabolism, and nervous system development. Iron deficiency disrupts oxygen transport to tissues, leading to impaired cellular function and growth. In addition, it affects myelination and neurotransmission, which are crucial for cognitive development in children. These mechanisms indicate that iron deficiency has both direct and indirect associations with the occurrence of stunting [2].Iron deficiency anemia is the most common type of anemia, accounting for approximately 60-70% of all anemia cases. This condition affects not only children but also adolescent girls and pregnant women, who are key populations in the life cycle. Anemia during pregnancy increases the risk of low birth weight and preterm birth, both of which are major risk factors for stunting. Therefore, early detection and management of iron deficiency are essential strategies in stunting prevention [3], [4].

In clinical practice, hemoglobin measurement is commonly used as the primary indicator for detecting anemia. However, this approach has limitations, as hemoglobin reflects only the late stage of iron deficiency. In the early phase, iron stores may already be depleted while hemoglobin levels remain within the normal range. As a result, early iron deficiency often goes undetected, delaying intervention and increasing the risk of stunting [4]. Ferritin is an iron-storage protein that maintains iron availability in a soluble and non-toxic form within the body. Serum ferritin levels reflect total body iron stores and serve as a more sensitive indicator for detecting early-stage iron deficiency. A decline in ferritin levels occurs before changes in other hematological parameters, making it a valuable early marker in iron deficiency screening

[5], [6]. In the context of stunting, the use of ferritin as a laboratory indicator has strategic value, as it enables early detection of impaired iron status before the development of anemia. This allows timely intervention through nutritional improvement or iron supplementation. However, ferritin interpretation must consider inflammatory conditions, as its levels may increase in the presence of infection or chronic disease [6].Based on these considerations, it is important to further examine the role of ferritin in stunting. This review aims to evaluate ferritin as an early marker of iron deficiency and its implications for stunting prevention based on existing literature.

II. METHODS

Study Type and Design

This study employed a descriptive-analytical literature review approach aimed at comprehensively examining the role of ferritin as an early marker of iron deficiency in the context of stunting. This approach was selected because it enables the integration of findings from previous studies to provide a systematic understanding of the relationship between iron status, ferritin, and growth impairment in children. A literature review allows researchers to evaluate theoretical concepts, biological mechanisms, and clinical implications without direct primary data collection. The study design was qualitative, using a narrative analysis that focused on synthesizing information from various scientific sources. This study not only summarizes previous findings but also compares and interprets evidence regarding the role of ferritin in detecting early-stage iron deficiency before anemia develops. This is important, as most clinical practices still rely on hemoglobin as the primary indicator, which has limitations in early detection [4]. The descriptive approach was used to explain the characteristics of ferritin, its biological functions, and changes in ferritin levels in iron deficiency conditions. Meanwhile, the analytical approach was applied to evaluate the relationship between decreased ferritin levels and increased risk of stunting. Thus, this study design provides a clear framework for understanding how ferritin can be used as a preventive indicator in chronic nutritional problems such as stunting.

Data Sources and Search Strategy

Data sources in this study were obtained from various scientific literature relevant to ferritin and stunting. The literature included national and international scientific journals, hematology textbooks, and reports from official health institutions such as the World Health Organization and the Ministry of Health. Sources were selected selectively based on scientific validity, topic relevance, and direct association with iron deficiency and child growth. The search strategy was conducted systematically using key terms such as “ferritin,” “stunting,” “iron deficiency,” “anemia,” and “iron metabolism.” These keywords were combined to identify literature discussing the relationship between ferritin as a laboratory indicator and the occurrence of stunting. In addition, the search focused on literature explaining the physiological mechanisms of iron, the function of ferritin, and the stages of iron deficiency in the body [2], [5]. The search process was not limited to a single source but was conducted across multiple scientific databases and book references to ensure broad and comprehensive data coverage. Priority was given to sources with high credibility that had undergone peer review. This strategy ensured that the data obtained could provide an accurate overview of the role of ferritin in the context of stunting prevention.

Study Selection Process

The study selection process was carried out in stages to ensure that the selected literature had high relevance to the research topic. The initial stage involved identifying literature based on predefined keywords. This was followed by screening titles and abstracts to assess alignment with the focus of the review, namely the relationship between ferritin, iron deficiency, and stunting. Literature that passed the initial screening underwent further analysis through full-text review. At this stage, the researcher evaluated each article based on several aspects, including research objectives, methods used, and results obtained. Articles discussing ferritin as a biomarker, iron metabolism mechanisms, and the impact of iron deficiency on child growth were prioritized for further analysis [7]. The selection process also considered consistency of findings across studies to minimize interpretative bias. Articles with irrelevant data or those that did not

support the research objectives were excluded. Through this approach, only literature with significant contributions to understanding the relationship between ferritin and stunting was included in the review.

Inclusion and Exclusion Criteria

The inclusion criteria comprised literature that directly addressed ferritin, iron deficiency, and stunting. Selected articles were required to have strong scientific foundations, relevance to the topic, and provide information supporting the analysis of the relationship between ferritin and nutritional status. Literature discussing the physiological mechanisms of iron, the function of ferritin, and the impact of iron deficiency on child growth was also included [5].In addition, sources had to originate from credible scientific publications, such as peer-reviewed journals, academic textbooks, and official reports from health institutions. This ensured the quality and reliability of the data used in the review. Conversely, exclusion criteria included articles that were not relevant to the topic, lacked scientific basis, or did not discuss the relationship between ferritin and stunting. Articles that only addressed anemia in general without discussing ferritin were also excluded. Furthermore, sources with poor or unclear methodological quality were eliminated to maintain the validity of the review findings [8]. By applying these criteria, the study focused on literature that strongly supported the analytical objectives, ensuring accurate and reliable results.

Data Extraction and Summary Presentation

Data extraction was conducted by identifying key information from each selected literature source. Collected data included definitions of stunting, pathophysiology of iron deficiency, the function of ferritin, and the relationship between ferritin and child nutritional status. In addition, data related to laboratory indicators, stages of iron deficiency, and the diagnostic value of ferritin were analyzed in depth.The extracted information was then organized systematically in a narrative format. Data presentation followed a thematic approach, where each section addressed specific aspects such as mechanisms of iron deficiency, the role of ferritin, and its implications for stunting. This approach facilitated readers in understanding the relationships between the discussed concepts [5]. The data were not only presented descriptively but also analyzed to identify patterns and relationships between variables. Therefore, the findings provide not only information but also deeper interpretation regarding the role of ferritin in stunting prevention.

Data Synthesis

Data synthesis was performed by integrating findings from various literature sources to develop a comprehensive understanding of the role of ferritin in stunting. A comparative analysis approach was used, in which results from different studies were compared to identify similarities, differences, and consistent patterns of relationships.The synthesis focused on the relationship between decreased ferritin levels and iron deficiency, as well as its impact on child growth. In addition, the advantages of ferritin over hemoglobin as a laboratory indicator for early detection of iron deficiency were analyzed. The findings indicate that ferritin is a more sensitive marker because it can detect changes in iron stores before anemia develops [2], [6]. However, the synthesis also considered factors that may influence ferritin levels, such as inflammation and infection. This is important to ensure more accurate interpretation in the use of ferritin as a screening tool. Through this approach, the study provides a more comprehensive overview of the potential role of ferritin in preventing stunting through early detection of iron deficiency.

III. RESULT AND DISCUSSION

Iron Deficiency and Its Association with Stunting

Iron deficiency is one of the main factors contributing to stunting in children. Iron is an essential micronutrient that plays a critical role in various physiological processes, including hemoglobin synthesis, energy metabolism, and nervous system development. In the context of child growth, iron is crucial because it supports cell division, DNA synthesis, and tissue development. Iron deficiency can impair oxygen transport to tissues, which disrupts cellular metabolism and linear growth [2]. Stunting is not only caused by deficiencies in energy and protein but is also influenced by micronutrient deficiencies such as iron. Iron deficiency directly affects growth through impaired muscle function and reduced physical capacity. In addition, it impacts cognitive development by disrupting myelination and neurotransmission processes. These findings indicate that iron deficiency has multidimensional effects that extend beyond hematological

aspects to brain development and nervous system function [2].Iron deficiency anemia is the most common type of anemia, accounting for approximately 60-70% of all anemia cases. This condition frequently occurs in vulnerable groups such as children, adolescent girls, and pregnant women. Anemia during pregnancy increases the risk of low birth weight and preterm birth, which are major risk factors for stunting. Therefore, iron status in both mothers and children plays a critical role in the cycle of stunting. Iron deficiency is not only an individual clinical problem but also a public health issue that affects the quality of future generations. Efforts to prevent stunting must include early detection and management of iron deficiency.

Stages of Iron Deficiency and Limitations of Hemoglobin

Iron deficiency develops through several stages that occur gradually and are often unrecognized in the early phase. The first stage is characterized by depletion of iron stores, reflected by decreased ferritin levels. At this stage, hematological parameters such as hemoglobin, hematocrit, and erythrocyte indices remain within normal ranges. This condition is referred to as iron depletion and is often asymptomatic [4]. The second stage is iron-deficient erythropoiesis, where iron supply is insufficient to support red blood cell production. During this phase, serum iron levels decrease, transferrin saturation declines, and total iron-binding capacity increases. However, hemoglobin levels may still remain within the normal range, making this stage difficult to detect without more specific laboratory tests [4], [7].The third and fourth stages are marked by more severe disruption of erythropoiesis, eventually leading to iron deficiency anemia. At this stage, hemoglobin levels begin to decline, and morphological changes in erythrocytes, such as microcytic hypochromic features, become evident. However, detection at this stage is considered late, as body iron stores have already been depleted [4]. The use of hemoglobin as the primary indicator in diagnosing anemia has limitations because it reflects only the late stage of iron deficiency. This leads to delays in diagnosis and intervention. In the context of stunting, such delays may result in already impaired child growth. Therefore, more sensitive indicators are needed to detect iron deficiency at an earlier stage.

Ferritin as an Early Marker of Iron Deficiency

Ferritin is the main iron-storage protein in the body that maintains iron availability in a soluble and non-toxic form. It is found in nearly all body tissues, particularly in the liver, macrophages, and reticuloendothelial cells. A small amount of ferritin is also present in serum and is used as an indicator of body iron stores [5], [6]. Serum ferritin levels are directly correlated with total body iron reserves. A decrease in ferritin levels is the earliest sign of iron deficiency, even before changes occur in hematological parameters such as hemoglobin. This makes ferritin a more sensitive biomarker than hemoglobin for detecting iron deficiency [5].In clinical practice, the use of ferritin as a screening tool enables early detection of iron deficiency before it progresses to anemia. This is particularly important in the context of stunting prevention, as early intervention can be implemented before permanent growth impairment occurs. Ferritin also provides a more comprehensive picture of iron status compared to hemoglobin, which mainly reflects functional iron [6]. However, ferritin interpretation must be approached with caution. Ferritin is an acute-phase protein that can increase in response to inflammation or infection, potentially masking underlying iron deficiency. Therefore, ferritin assessment should ideally be combined with other parameters to improve diagnostic accuracy.

Clinical Implications of Ferritin in Stunting Prevention

The use of ferritin as a laboratory indicator has significant clinical implications in stunting prevention. By detecting iron deficiency at an early stage, healthcare providers can implement timely interventions, such as iron supplementation and dietary improvement. This approach is more effective than waiting until anemia develops, as growth impairment may have already begun at that stage [2]. In a public health context, ferritin screening can help identify high-risk groups, including children, adolescent girls, and pregnant women. Interventions targeting these groups can break the cycle of iron deficiency that contributes to stunting. In addition, ferritin measurement can be used to evaluate the effectiveness of iron supplementation programs [3].Stunting prevention requires a multidisciplinary approach that includes nutrition, maternal health, and environmental factors. Ferritin, as a laboratory indicator, can play an important role in this strategy, particularly in early detection and monitoring of iron status. Integrating ferritin testing into healthcare services can enhance the effectiveness of stunting prevention programs.

Limitations of Ferritin Use

Although ferritin is a sensitive indicator for detecting iron deficiency, its use has several limitations. Ferritin is an acute-phase protein that can increase in conditions such as inflammation, infection, or chronic disease. This can lead to biased results that do not accurately reflect true iron status [6]. In addition, variations in normal ferritin values based on age, sex, and laboratory methods present challenges in interpretation. Each laboratory may have different reference ranges, requiring careful consideration when analyzing results. Other factors, such as liver disease, can also influence serum ferritin levels [8]. Therefore, ferritin should not be used as a single diagnostic indicator. It should be combined with other parameters, such as serum iron levels, transferrin saturation, and inflammatory markers, to improve diagnostic accuracy. This approach ensures that iron deficiency is detected accurately and minimizes the risk of misinterpretation. By understanding these limitations, ferritin can be optimized as a screening tool in stunting prevention while considering the overall clinical condition of the patient.

IV. CONCLUSION

Stunting is a chronic nutritional problem influenced by multiple factors, one of which is iron deficiency. Iron plays a critical role in child growth and development, particularly in hemoglobin synthesis, energy metabolism, and nervous system function. Iron deficiency not only leads to anemia but also contributes to impaired linear growth and cognitive development, thereby increasing the risk of stunting. Iron deficiency develops gradually, beginning with depletion of iron stores before progressing to anemia. In the early stage, hemoglobin levels may still remain within the normal range, making hemoglobin measurement insufficiently sensitive to detect this condition. This presents a challenge in clinical practice, as delayed diagnosis can hinder optimal stunting prevention efforts.Ferritin, as an iron storage protein, plays an important role as an early indicator of iron deficiency.

Serum ferritin levels reflect total body iron stores and decrease in the early stage before changes in hemoglobin occur. Therefore, ferritin can be used as a more sensitive biomarker for early detection of iron deficiency. The use of ferritin in screening allows for earlier interventions, such as iron supplementation and dietary improvement, which can prevent long-term impacts on child growth. However, interpretation of ferritin levels must be done carefully, as they can be influenced by inflammation, infection, and chronic diseases. Therefore, ferritin assessment should be combined with other laboratory parameters and comprehensive clinical evaluation to improve diagnostic accuracy. Overall, ferritin has strong potential as a screening tool in stunting prevention through early detection of iron deficiency. Integrating ferritin testing into healthcare services, particularly for high-risk groups, can enhance the effectiveness of stunting prevention programs and support efforts to improve the quality of human resources in the future.

V. ACKNOWLEDGMENTS

The author expresses sincere appreciation to all parties who have contributed to the preparation of this article. Gratitude is extended to academic institutions and scientific sources that have provided relevant and high-quality references, supporting the systematic development of this review. The author also acknowledges previous researchers whose scholarly work has served as the foundation for understanding the relationship between ferritin, iron deficiency, and stunting. Their contributions have greatly enriched the analysis and strengthened the theoretical framework of this article. It is hoped that this article will contribute to the advancement of knowledge, particularly in the fields of child health and nutrition, and serve as a reference in efforts to prevent stunting through early detection of iron deficiency.

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