International Journal of Health Sciences and Research
Vol.11; Issue: 3; March 2021
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

Undernutrition and Mortality Risk of Children Hospitalized at Brazzaville University Hospital: Comparison of MUAC and Z-Weight-For-Height Z-Score vs PINI

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ABSTRACT

Background: MUAC and the z-score for weight for height are the two anthropometric criteria for assessing undernutrition in community-based studies. The objective of this study was to describe the risk of mortality due to PINI in hospitalized underweight children.
Materials and methods: Cross-sectional study conducted in Brazzaville between October 2018 and April 2019 on 95 malnourished children aged 1-59 months. CRP, orosomucoid, albumin and transthyretin were determined using Roche's Cobas c311, which allowed the calculation of PINI. Software R (Core Team) 3.5.3. 2019 was used for the statistical analysis and the significance level was set at 0.05.
Results: According to MUAC, 29 children were severely malnourished and 23 were normalized, although they had been diagnosed as malnourished by the z-score. In correlation with PINI, although there was no statistically significant difference ($p = 0.431$), 19 of the 23 normonutris were classified at risk of infectious complications by PINI. The z-weight-for-height score (acute undernutrition) affected 55 (57.9%) children, 26 (47.3%) of whom were severely affected. In correlation with PINI, only five were at no risk of infection, compared to six (12%) at high risk, and up to 12 (24%) at risk of mortality.
Conclusion: MUAC and the z-weight for height z-score remain of primary clinical diagnostic interest for hospitalized children in the management of undernutrition. However, PINI classifies the severity of undernutrition and catches up with children who were not detected as malnourished by the first two.

Key Words: Undernutrition, mortality risk, MUAC, z-weight-for-height score, PINI.

CLINICAL RELEVANCY

The diagnosis of severe undernutrition in countries with limited resources such as ours is carried out in the same way in hospitals as in mass epidemiological studies, in particular only by MUAC and the z-score of weight for height, almost never giving room to biology. However, PINI, calculated from markers of undernutrition and inflammation, is reported by several European studies as the "gold standard". This is how we were the first to explore the biology of undernutrition, as a complement to the hospital clinic.

When we independently correlated PINI to MUAC and the z-score of weight for height, we found that there were children classified as normonutris by one or the other but who were caught up by PINI as children potentially at risk of infectious complications, and therefore undernourished, but who benefited from the same therapeutic conduct.

The clinical interest of our study is to contribute to the inclusion of PINI as a biological diagnosis of undernutrition in hospitals in order to clearly distinguish the children most at risk of infectious complications for a better adapted management and follow-up for each case.

INTRODUCTION

Several definitions lend themselves to severe undernutrition, including the one conventionally used by the World Health Organization (WHO), which recommends an absolute circumference of the middle and upper arm (MUAC) < 115 mm or a z-score of weight for height < -3, or the presence of edema as independent criteria for defining severe acute undernutrition in children under five years of age[1]. The definition proposed in recent years by the American Society of Parenteral and Enteral Nutrition (ASPEN), which is better adapted to the hospitalized pediatric population, opts for etiological rather than descriptive terminology and integrates the principles of the inflammatory response[2].

A growing number of studies recognize the importance of acute or chronic inflammation as a key factor affecting the nutritional status of the hospitalized patient [3,4].

In order to be more comprehensive, ASPEN proposes that the new definition take into account the combination of the following six key elements: chronicity, severity, etiology, inflammatory state, pathological mechanisms of undernutrition and impact on growth/development/ functional and clinical parameters of the child[3].

In addition, the recommendation to use the MUAC < 115 mm and z-weight for height < -3 independently was reiterated by WHO in 2013 [5], the absolute use of MUAC as the sole measure is advocated much more in community-based studies for determining the prevalence of undernutrition in order to search for cases of admission to therapeutic feeding programs. Thus, in recent years, MUAC has been increasingly applied by public and private actors in programs for the management of severe acute undernutrition[6, 7].

In hospitals in developing countries, the diagnosis of undernutrition uses the same approach as for mass studies using clinical and anthropometric parameters, in particular the z-score of weight for height as proposed since 2006 by the WHO to replace the 1997 HCNS reference, which expresses the standard deviation between an individual value and the medians of the reference population divided by the standard deviation of the reference population [8].

Although the diagnosis of undernutrition in the hospital setting remains primarily clinical through the measurement of weight loss, which is still not pathognomonic of undernutrition, the clinical examination most often provides the data needed to identify undernutrition or to suspect it and define its severity.

However, the biological assessment of nutritional status must be part of the diagnostic tools used to identify a risk of undernutrition or proven undernutrition, to quantify it and to monitor the evolution of appropriate management [9].

In fact, there is total confusion between the parameters for exploring nutritional status and those for assessing risk, both those specifying undernutrition and the risk of morbidity and mortality related to undernutrition [10].

Indeed, even if undernutrition is associated with a statistical increase in the risk of complications, the indices that allow its evaluation and classification (into moderate and severe) are not clinical aids for diagnosis and the implementation and monitoring of assisted nutrition. In practice, in the hospital setting, these indices make it possible to identify groups of malnourished patients who are most likely to have an unfavorable prognosis [11]. This is the case of the prognostic inflammatory and nutritional index (PINI) proposed by Ingeenblek and Carpentier. This index combines the determination of two markers of inflammation (C - reactive protein and Orosomucoid) and two markers of undernutrition (Albumin and Transthyretin) [12].

The objective of the present study was to describe the risk of mortality due to PINI in hospitalized children with MUAC deficiency or weight-for-height z-score. This was done in order to elicit an approach to the biological diagnosis of undernutrition in hospital settings that would be different from that used in mass or community-based studies.

PATIENTS AND METHOD

This is a cross-sectional descriptive and analytical study conducted at Brazzaville University Hospital between October 2018 and April 2019. The CHU-B is a 3rd level public health facility of reference for the basic and general hospitals of the republic; it thus occupies the top of the pyramid in the national health system and has several specialized care services. As a result of the partnership with the Faculty of Health Sciences, CHU-B ensures the functions of care, teaching and research in health sciences.

The enrolment of children and blood sampling are done in the pediatric-infant department. The biological analysis of the blood samples took place in the medical biology laboratory of the National Reference Center for Sickle Cell Disease "Antoinette Sassou Nguesso".

During the study period, 601 children were admitted to the department for all pathologies, including 95 for malnutrition. The study included children between one and 59 months of age who were clinically malnourished and whose mothers had consented to participate in the study. Children with hematological conditions that could disrupt the inflammatory profile, including sickle cell disease, were not included in this study. The study has been pre-approved by the Health Sciences Research Ethics Board (HSERB).

For all children, sociodemographic and anthropometric characteristics: sex, age, birth weight, weight at the time of the survey, head circumference, absolute circumference of the middle and upper arm (MUAC) or brachial circumference, z-score of weight for age (W/A), weight for height (W/T), and height for age (H/A), presence or absence of edema and the associated diagnosis were collected from the medical record. For each child, four milliliters of blood were drawn in a dry tube for biological tests (CRP, Orosomucoid, Albumin, Transthyretin or Prealbumin), using the Roche/Hitachi Cobas c311 analyzer.

The 95 children were divided into two groups regardless of the assessment criteria used. First using the P/T z-score which distinguishes between non-severe undernutrition (P/T between -2 and -3 z-score, and severe undernutrition (P/T < -3 z-score). Then according to the MUAC for which non-severe undernutrition corresponded to a MUAC between 115 and 125 mm, and severe undernutrition to a MUAC < 115 mm. Undernutrition was considered chronic when there was either stunted growth (z-score of the T/A < -2 z-score. This could be moderate (T/A between -2 and -3 z-score), and severe (T/A < -3 z-score). The biological part consisted in determining the PINI for each child by dividing the inflammatory markers (CRP and Orosomucoid) by the nutritional markers (Albumin and Transthyretin). Children who had a PINI < 1 were not at risk of infectious complications. Those with PINI > 1 were at low, medium, proven or life-threatening risk.

The two anthropometric indices (P/T, T/A) and MUAC were analyzed first independently and then in relation to PINI to assess the risk of mortality from PINI in hospitalized children with MUAC or z-score weight-for-height deficits. The biological part consisted in determining for each child the PINI by dividing the inflammatory markers (CRP and Orosomucoid) by the nutritional markers (Albumin and Transthyretin). Children who had a PINI < 1 were not at risk of infectious complications. Those with PINI > 1 were at low, medium, proven or life-threatening risk.

The database was designed using Excel software and the statistical analysis was performed using R (Core Team) 3.5.3. 2019. Categorical variables were presented as frequency or number (N and n) and proportions (%). The study of the profile of biological markers during undernutrition used Student's t-test. Assessment of the risk of infectious complications by PINI during undernutrition required the application of the chi-square test. In all cases, the significance threshold was set at 0.05.

RESULTS

According to anthropometric criteria, table 1 presents the number of children presenting acute (57.9%) and chronic (42.1), moderate (47.3%) and severe (52.7%) undernutrition.

Table 1. Clinical Characteristics of Severity of Undernutrition

Undernutrition	Aiguë (P/T) n (%)	Chronicle (T/A) n (%)	Total N (%)
Severe	26 (47.3)	37 (92.5)	**63 (66.3)**
Moderate	29 (52.7)	3 (7.5)	**32 (33.7)**
Total	**55 (57.9)**	**40 (42.1)**	**95 (100)**

Boys represented 49.5% of the subjects in our study, with a sex ratio M/F of 1; the mean age was 14.7±10.8 months (1-59 months). The average weight of severely malnourished children at the time of the survey was 6.99±1.96 Kg, the average height was 69.6±11.0 cm and the MUAC was 112±18.2 mm. The characteristics of the subjects are shown in Table 2.

Table 2. Anthropometric characteristics of children

	Staff N=95 (100%)	No severe n=32 (33.7%)	Severe n=63 (66.3%)	O.R. [IC 95%]	P
	X ± ET	X ± ET	X ± ET		
Age (mois)	14.7 ±10.8	13.4 ±7.41	15.3 ±12.2	1.02 [0.97-1.06]	0.346
Sex (%)					0.477
F	48 ±50.5	30 ±54.5	18 ±45.0	Ref,	
M	47 ±49.5	25 ±45.5	22 ±55.0	1.47 [0.65-3.32]	
Birth weight (g)	2936 ±582	2992 ±569	2908 ±591	1.00 [1.00-1.00]	0.57
Survey weight (kg)	6.59 ±1.93	7.54 ±1.46	6.09 ±1.96	0.61 [0.46-0.82]	< 0.001
Height (cm)	70.1 ±9.96	70.9 ±7.60	69.6 ±11.0	0.99 [0.71-0.98]	0.496
Cranial perimeter (cm)	43.3 ±3.15	44.4 ±2.37	42.8 ±3.37	0.83 [0.71-0.98]	0.01
MUAC (cm)	11.8 ±1.83	12.9 ±1.27	11.2 ±1.82	0.48 [0.32-0.70]	< 0.001

Table 3: Risk marker for undernutrition complications or PINI

PINI	Interpretation	n	%
< 1	No risk of complications	10	10.5%
[1-10]	Low Risk	44	28.1%
[11-20]	Medium Risk	7	7.3%
[21-30]	High risk of complications	7	7.3%
>31	Vital prognosis at stake	27	28.4%
Total		**95**	**100%**

Table 3 classifies the study subjects according to biological diagnosis (PINI). A PINI < 1, synonymous with no risk of infectious complications following undernutrition, was found in 10 children (10.5%). Seven children (7.3%) were at risk of proven complications for a PINI between 21 and 30, while 27 children (28.4%) were at risk of death for a PINI above 31.

Table 4 shows the distribution of children's nutritional status by MUAC. It shows that 29 (30.5%) children were severely malnourished and 23 (24.2%) children had normal nutritional status.

Table 4: Undernutrition according to MUAC

	Undernutrition according to MUAC		MUAC and PINI Report			
	n	%	PINI < 1	PINI > 1	O.R	p
MU [11.5-12.5]	43	45.3	3 (30%)	40 (47%)	Ref	0,431
SAU < 11.5	29	30.5	3 (30%)	26 (30.6%)	0.65[0.12-3.47]	
NNS > 12.5	23	24.2	4 (40%)	19 (22.4%)	0.36[0.07-1.75]	
N	95	100%	10 (10,5%)	85 (89.5%)		

MU = Moderate undernutrition, NNS = Normal nutritional status, SAU = Severe acute undernutrition

Table 5 shows that 55 of the 95 children had a z-weight score for low height. Furthermore, the PINI reports that only five of them would not be at risk of infection as a result of undernutrition, compared to six (12%) who would be at high risk, and up to 12 (24%) who would be at risk of mortality.

Table 5: z-weight score for height and PINI

	AU N=55	(No Severe) N=5	(Severe) N=50	p
PINI				<0,001
NR	5 (9,09%)	5 (100%)	0 (0,00%)	Ref
LR	28 (50,9%)	0 (0,00%)	28 (56,0%)	<0,001
MR	4 (7,27%)	0 (0,00%)	4 (8,00%)	0,008
HRC	6 (10,9%)	0 (0,00%)	6 (12,0%)	0,002
VPS	12 (21,8%)	0 (0,00%)	12 (24,0%)	<0,001

AU = Acute undernutrition, HRC = High risk of complications, LR = Low Risk, MR = Medium risk, NR = No risk, PINI = nutritional and inflammatory prognostic index, VPS = Vital prognosis at stake

DISCUSSION

Anthropometric measurements are still of great diagnostic and prognostic interest, especially in very young children [13]. The measures are raw data obtained on individuals [14]. Taking anthropometric measurements is the basis for the development of growth indices and indicators. Any errors misinterpretation of the health status of the individual and the community. Yet, because of their deceptive simplicity, these measures are often poorly done and errors are common. Indeed, any measurement can be tainted by imprecision and inaccuracy [15]. Errors made at this point can result from misreading or incorrect scoring of results.

Assessing the nutritional status of hospitalized children is actually complex. Many factors should be considered when choosing assessment tools or methods. Clinicians need to consider the strengths and limitations of different tools, and the use of multiple nutritional markers in diagnosis is often necessary. In our study, we used two clinical tools (the MUAC and z-score for weight for height) and one biological tool (PINI). According to MUAC, 23 (24.2%) children had normal nutritional status, whereas they were diagnosed as malnourished by the z-score. When these results were correlated with the PINI, although without a statistically significant difference (p = 0.431), it was noted that out of the 23 children classified as normonutrient deficient by MUAC, 19 (22.4%) were classified as PINI deficient (Table 4), which means that they were then likely to develop a risk of infectious complications, and therefore mortality. This indicates that PINI was able to catch up with children diagnosed as malnourished by the z-score, whereas they escaped diagnosis by MUAC. Schwinger's study of community data from three countries (Congo DRC, Senegal, Nepal) on children aged six to 59 months found that children identified as severely malnourished by MUAC and by the z-score for weight for height had a similar risk of mortality, respectively about four times higher than those with normal nutritional status [16]. And being classified as severely undernourished by both the MUAC and the z-score for weight for height multiplied this risk of death by eight, although their method of assessing mortality is different from ours. These results are identical to ours in that they clearly show more undernutrition escape by MUAC compared to the z-weight-for-height score. Hence our approach to consider the z-weight-for-height z-score as the primary tool for assessing the nutritional status of children (being in a hospital setting), rather than MUAC (more appropriate in a community setting).

All in all, MUAC is a method of assessing nutritional status that is at first glance simple to perform, more reproducible, more reliable and less costly. It is often used in emergency situations, rapid assessments and community-based studies. This is certainly true provided that various precautions are taken and that standardization of the procedures implemented is effective and regularly monitored [14]. On the other hand, it is an age- or sex-dependent method, subject to measurement error with the possibility of overestimation in young malnourished infants, and underestimation in older children; hence the recommendation to use z-scores [17].

The assessment of undernutrition in clinical practice should include a paraclinical component in addition to the clinical component. For the latter, our study used the Prognostic Inflammatory and Nutritional Index (PINI). Moreover, the implementation of a nutritional risk development tool is essential and should be done systematically in pediatric hospitalization units [18]. PINI essentially involves the determination of serum proteins of undernutrition and inflammation. Table 5 divides children according to the severity of undernutrition and the grade of PINI. The zero risk of infectious complications following undernutrition concerned only five (9.09%) children, all moderately undernourished. While 50 of the 55 severely undernourished children were at risk of complications and statistically significant at each grade of PINI, six (12%) were at high risk and up to 12 (24%) were life-threatening. This would mean that the z-score for PINI would leave 18 of the 50 children who would normally benefit from initial treatment (the first component of management) with increased undernutrition by recognizing and treating life-threatening problems, correcting deficiencies, correcting metabolic disorders and starting to feed the child after seven days until the child stabilizes and regains appetite [19]. Also, and most importantly, follow-up, which is the third component of management, a process that does not exist in our health program, because after discharge, the child and even his family should be followed up to prevent a relapse or even death and to ensure the child's continued physical, mental and emotional development.

Although we worked on a population of hospitalized children, it is important to remember that the early identification of undernutrition or of children potentially at risk of undernutrition remains the key to the prevention of several pathologies appearing even in adulthood [20]. This raises the problem of post-natal monitoring of children in developing countries, where it is not uncommon to find that the assessment of nutritional status is sometimes neglected. This lack of attention would undoubtedly result in an increase in complications, poorer tolerance to treatment and prolonged hospitalization. The development of various effective interventions and strategies for the early detection and treatment of undernutrition in pediatric wards as well as the support of government policies are of crucial importance in order to avoid or at least reduce the effects of undernutrition.

CONCLUSION

MUAC and the weight-for-height z-score remain of primary clinical diagnostic interest for the assessment of nutritional status and the management of undernutrition in hospitalized children. The PINI catches up with children not detected as malnourished by the two indices; it also distinguishes the severity of the undernutrition for a better adapted management. The systematization of PINI in current clinical practice should allow for early management and thus a reduction in mortality related to undernutrition.

Financial disclosure: None declared.
Conflicts of interest: None declared.

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How to cite this article: Christel Mikolélé-Bilombo, Lucie Charlotte Atipo-Ibara Ollandzobo, Steve Vassili Missambou Mandilou et.al. Undernutrition and mortality risk of children hospitalized at Brazzaville University Hospital: comparison of MUAC and z-weight-for-height z-score vs PINI. *Int J Health Sci Res.* 2021; 11(3): 105-111.

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