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Enteral Nutrition In Non-Ventilated Critically Ill Infants and Children

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Abstract: Provision of optimal nutritional support to children in PICU is important for optimizing nutritional management, yet challenging because of a variety of factors. Previous nutritional status, degree of malnutrition, and variability in disease states differ significantly among PICU patients (1) Furthermore, optimal nutritional delivery sustains function of the cardiovascular, respiratory, and immune systems until the acute phase inflammatory response resolves [(2)] The provision of optimal nutritional care is based on accurate estimations of patients' resting energy expenditure. The latter can be calculated with the use of predictive equations or measured with indirect calorimetry (IC). Owing to their ease of use, mathematical equations have largely replaced IC in clinical practice [(3)]. **Objectives:** The objective of this work is to evaluate Schofield equation for calculation of resting energy expenditure in non-ventilated critically ill infants and children. **Methods:** 40 non-ventilated critically ill infants and children given their caloric needs according to Schofield equation with multiplying by stress and activity factors and nutritional assessment that included anthropometric measurements and laboratory investigations was done weekly for 3 weeks. **Conclusion:** Enteral nutrition does not require special preparation, and it can be started and modified at any time with minimal complications. Moreover, Schofield equation as a predictive equation for estimating energy expenditure in critically ill children with multiplying by stress and activity factors under-estimated the energy requirements during the first week of critical illness and accurately estimated the energy expenditure during the second week and the 3rdweek of critical illness.

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Key words: Enteral nutrition, critical ill, Schofield equation.

1. Introduction:

Baseline malnutrition prevalence in hospitalized patients has been Estimated at around 40%, and is most likely even higher among critically ill patients. Principal factors are the metabolic response to critical illness, and the failure to provide optimal nutrition support **(4).** There are three different phases of stress response probably applies to critically ill children: the acute phase, the stable phase and the recovery phase**.** The energy expenditure is thought to be lower during the first phase. During the stable and recovery phase, inclining caloric and protein requirements allow for a more aggressive feeding approach, together with mobilisation, to enable recovery, rehabilitation and catchup growth (5)**.** Enteral nutritional support stimulate intestinal growth and function, both intra-luminally, and indirectly, Enteral nutrition seems to present benefits in comparison with parenteral nutrition, such as a lower number of infectious complications, non-infectious complications and associated costs. [(6)]

Aim of the work:

The objective of this work is to evaluate Schofield equation for calculation of resting energy expenditure in non-ventilated critically ill infants and children.

2. Subjects and Methods:

The present study was carried out on 40 non-ventilated critically ill infants and children. This study was carried out at pediatric ICU, Tanta University. The study was approved by the Ethical Committee of Faculty of Medicine, Tanta University. The patients were enrolled after obtaining an informed consent from their parents.

Duration of the study:

one year (from 5/2018 till 5/2019)

Inclusion criteria:

* infants, child above the age of one month to the age of 5 years, not ventilated, critically ill.

Exclusion criteria:

Care was taken to exclude patients with:

1-non-functioning gastro intestinal tract due to paralytic ileus.

2-Diabetes Mellitus.

3-chemotherapy, radiotherapy.
4-haemodialysis and peritoneal dialysis.
5-Heaptic and Renal failure.
6-Intractable vomiting and diarrhea.
7-Infants who have history of prematurity or low birth weight.

Methods:

All the subjects included in this study were subjected to the following:

1- **Severity of illness scoring system**:

by PRISM III [7] in the first 24 hours of admission and maintenance intra-venous (IV) fluid was given (pediament), till stability of hemodynamics and Arterial blood gases (ABG). Maintenance IV fluids were given through either a peripheral cannula or central line in amount (100ml/kg (1st 10kg), 50 ml / kg (10-20 kg), 20ml/kg (20-30kg)

2-Nutritional Assessment:

1-**Full history taking:** that included past, present, medical, surgical, developmental and dietetic histories.

2-**Physical examination**: that included Complete Examination and Anthropometric Measurement that include Body Weight, Length / Height, Head Circumference (HC), Body Mass Index (BMI), Triceps Skin Fold Thickness (TSSFT) Mid Upper Arm Circumference (MUAC)

Both Growth and anthropometry were compared to the Egyptian growth charts [8,9], while TSFT and MUAC were compared to the WHO growth charts (10) due to non-availability of these charts in Egyptian growth charts and to identify malnourished children and their degree of malnourishment weight for length (WFL) was compared to the growth charts on admission and also was compared to the growth charts after 3 weeks.

3-**Laboratory Investigations:** that included Serum Prealbumin and Total Lymphocytic Count (TLC).

According to WFL or BMI that was compared to growth charts at first day of admission patients were divided into 2 groups**: (I) well-nourished patients, (II) Malnourished patients** and nutritional assessment that included anthropometric measurements and laboratory investigations was monitored weekly for 3 weeks, patients received maintenance fluid to give them their fluid requirements supplemented with enteral feeding. IV fluids were decreased with concomitant increase of the enteral feeding till full enteral support took place. Bolus feeding given where Bolus feedings divided every 3hr (if less than 6 months of age) or every 4 hours (if more than 6 months of age) was given and advances in feeds (by Increasing each feeding by 25% volume until goal reached) was according to the tolerance of the patients assessed by vomiting, diarrhea, abdominal distension, and gastric residual (less than 5ml/kg) was encouraging to advance in feeding [11].

All patients (group I, II) received age appropriate formula and Patients were given their caloric needs according to Schofield equation [12] Both stress factors and activity factors were added [13].

Total energy expenditure (TEE) was calculated by: TEE= REE × stress factor × activity factor Protein requirements was calculated as 1.5-2.5g/kg/day with minimum protein requirement 1.5g/g/day [14].

Statistical Analysis

Statistical presentation and analysis of the present study was conducted, using the mean, standard deviation, median, student t- test, Paired t-test, Chi-square, by SPSS V20.

3. Results:

The data of the patients were statistically analyzed and the results were summarized and tabulated in the following tables and figures the results of the present study are shown in the following tables and figures.

Table (1) and figure (1) show age distribution among the studied groups in group I the age of the patients ranged between 4- 60 months with median age 8 months and in group II the age of the patients ranged between 4-24months with a median age 9.50 months. There was no statistically significant differences between the two groups as regard to the age ($P < 0.05$)

Table (1): Age in the Studied Groups

Age (Months)	Groups				Mann-Whitney Test	
	Group I (n=20)		Group II (n=20)		Z	P-value
Range	4 -	60	4 -	24	0.177	0.860
Median (IQR)	8	16.50	9.50	7.38		

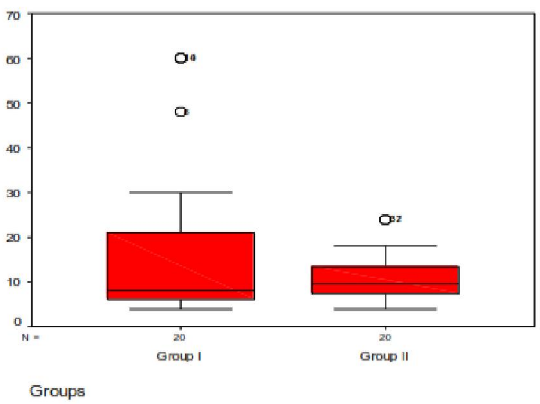

Figure (1): Age in the Studied Groups

Table (2) show sex distribution among the studied groups Group I included 12 males (60%) and 8 females (40%) and group II included 9 males (45%) and 11 females (55%) and there was no statistically significant difference between the two groups as regard to the sex (P< 0.05)

Table (3) shows the severity of illness of the patients assessed by Pediatric Risk Mortality score (PRISM III) in group I ranged between (2- with a mean value of 4.250 ±1.970 while in group II ranged between (2-with a mean value of 5.500 ± 2.328and there was a statistically non-significant difference between the two groups as regard to the PRISM III score (P < 0.05)

Table (2): Sex in the Studied Groups

Sex	Groups						Chi-Square	
	Group I (n=20)		Group II (n=20)		Total			
	N	%	N	%	N	%	X^2	P-value
Male	12	60.00	9	45.00	21	52.50	0.902	0.342
Female	8	40.00	11	55.00	19	47.50		
Total	20	100.00	20	100.00	40	100.00		

Table (3): PRISM III in the Studied Groups

PRISM III	Groups						T-Test	
	Group I (n=20)			Group II (n=20)			t	P-value
Range	2	-	7	2	-	8	-1.833	0.075
Mean ±SD	4.250	±	1.970	5.500	±	2.328		

Table (4): Different Diagnosis in the Studied Groups

Diagnosis	Groups						Chi-Square	
	Group I (n=20)		Group II (n=20)		Total			
	N	%	N	%	N	%	X^2	P-value
Bronchial asthma (BA)	4	20.00	5	25.00	9	22.50	6.444	0.489
Bronchopneumonia (BP)	8	40.00	4	20.00	12	30.00		
Bronchiolitis	4	20.00	2	10.00	6	15.00		
Lobar pneumonia	0	0.00	2	10.00	2	5.00		
Supraventricular tachycardia (SVT)	1	5.00	1	5.00	2	5.00		
Septicemia	0	0.00	2	10.00	2	5.00		
Acute hemolytic anemia	1	5.00	2	10.00	3	7.50		
Others	2	10.00	2	10.00	4	10.00		
Total	20	100.00	20	100.00	40	100.00		

Group I included 4 patients with acute bronchial asthma (20%), 8 patients with bronchopneumonia (40%), 4 patients with bronchiolitis (20%), one patient with supraventricular tachycardia (5%), one patient with severe acute haemolytic anemia (5%) and two patients with operated epidural hemorrhage (10%). while group II included 5 patients with bronchial asthma (25%), 4 patients with bronchopneumonia (20%), 2 patients with acute bronchiolitis (10%), 2 patients with lobar pneumonia with parapneumonic effusion (10%), 1 patient with supra ventricular tachycardia (5%), 2 patients with septicemia (10%), 2 patients with severe acute haemolytic anemia (10%), one patient with operated right diaphragmatic hernia and (5%) one patient with operated vein of Galen aneurysmal malformation (5%). and there was no statistically significant difference between the two groups as regard to the diagnosis as shown in the following table (4)

The results of the anthropometric measurements are shown in the following figures (2-4)

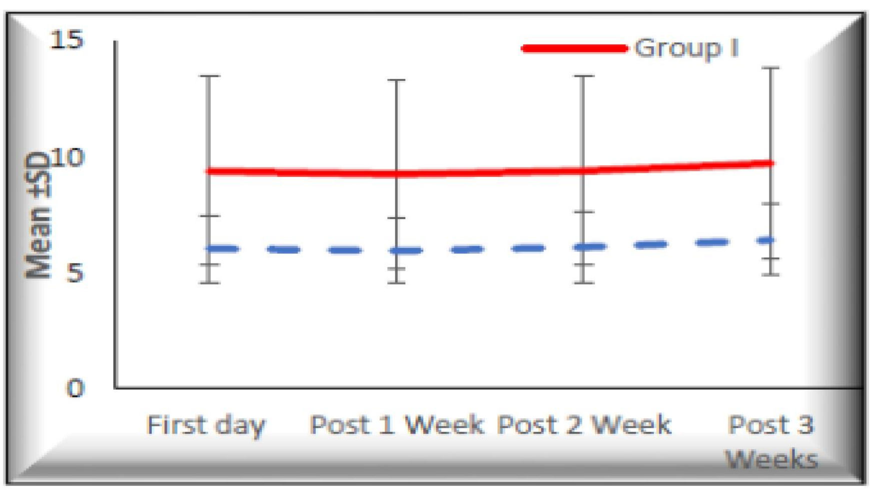

Figure (2): weight in the studied groups

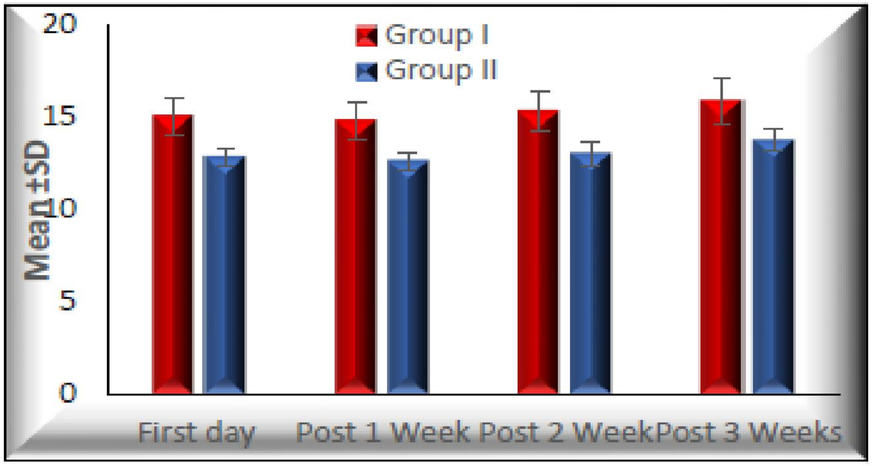

Figure (3): MUAC in the Studied Groups

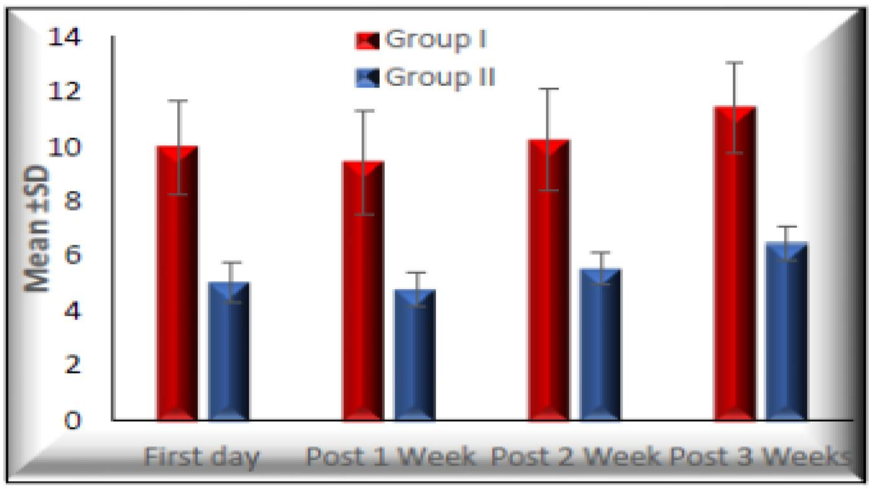

Figure (4): TSSFT in the studied groups

There were statistically non-significant decrease in the Wt, TSSFT and MUAC after one week after admission and there was a statistically non-significant increase after 2 weeks and there were statistically significant increase in the weight, TSSFT and MUAC as compared to the admission Wt, TSSFT and MUAC in both groups and there were statistically significant increase in the Wt, TSSFT and MUAC in the patients of group I when compared to group II at either admission or after one week, 2 weeks, 3 weeks from admission.

Also, there were statistically non-significant change in the height (Or length) or head circumference after one week or 2 weeks or 3 weeks from admission when compared to the admission height (or length) and head circumference in both groups and there were statistically non-significant increase in the height (or length) and head circumference in group I when compared to group II at either admission or after one week, 2 weeks or 3 weeks from admission.

As regard to the lab investigations there was a statistically no n-significant increase in the prealbumin level at one week after admission and there was a statistically significant increase in the pre-albumin level after 2 weeks and after 3 weeks from admission as compared to the admission level and there was a statistically significant increase in pre-albumin level in the patients of group I when compared to the patients of group II at either admission or after 1 week, 2 weeks and 3 weeks from admission as shown in the following table (5)

Table (5) Prealbumin Level in the Studied Groups

Prealbumin		Groups		T-Test	
		Group I (n=20)	Group II (n=20)	t	P-value
First day	Range	7.8 - 13.2	2.2 - 7.3	9.940	<0.001*
	Mean ±SD	10.315 ± 1.873	4.865 ± 1.582		
After 1 Week	Range	7.8 - 13.22	2.22 - 7.31	9.935	<0.001*
	Mean ±SD	10.322 ± 1.873	4.874 ± 1.583		
After 2 Weeks	Range	15.6 - 30	6.8 - 21	5.636	<0.001*
	Mean ±SD	21.465 ± 5.124	13.120 ± 4.195		
After 3 Weeks	Range	17.6 - 32	8.8 - 23	5.636	<0.001*
	Mean ±SD	23.465 ± 5.124	15.120 ± 4.195		
F-P1	Differences	-0.007 ± 0.023	-0.009 ± 0.023		
	Paired Test	0.185	0.108		
F-P2	Differences	-11.150 ± 3.696	-8.255 ± 2.746		
	Paired Test	<0.001*	<0.001*		
F-P3	Differences	-13.150 ± 3.696	-10.255 ± 2.746		
	Paired Test	<0.001*	<0.001*		

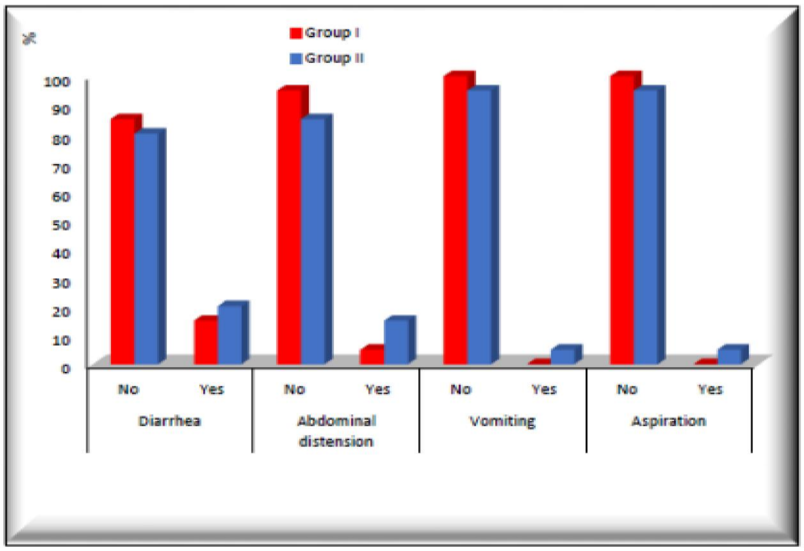

Figure (5): Gastro-intestinal Complications in the Studied Groups.

Regarding TLC there was a statistically non-significant decrease in the TLC at one week after admission and there was a statistically non-significant increase in total lymphocytic count after 2 and 3 weeks from admission in group I as compared to the admission TLC and there was statistically non-significant decrease in the TLC at one week after admission and there was a statistically non-significant increase in the TLC after 2 weeks from admission and there was a significant increase in the TLC after 3 weeks from admission in group II and there was a statistically significant increase in the TLC in the patients of group I when compared to the patients of group II at either admission or after 1 week, 2 weeks or 3weeks from admission.

As regard to gastrointestinal complications the well-nourished patients in group I had a statistically non-significant lower rate of gastrointestinal complications when compared with the malnourished patients in group II as shown in the following figure (5).

Limitations:

Our study evaluated the equation mainly by changes in the anthropometric measurements and biochemical markers and some measurements were very difficult to be assessed due to the critical illness of the patients. Also, it is difficult to determine whether changes in nutrition status have taken place, because anthropometric measurements can be influenced by many factors, (e.g., edema, fluid shifts). However, anthropometric evaluation, including nutrition assessment, is still important for a critically ill patient and nutirion therapy especially enteral nutrition in the PICU is a challenge because it is common to discontinue feeding for diagnostic and therapeutic procedures and also because some patients have digestive intolerance**.**

4. Discussion:

In the present study that was done over 40 infant and/ or children who were divided into two groups, the median age of the patients in group I was 8 months and in group II was 9.50 months without statistical significance. Group I included 12 males (60%) and 8 females (40%) and group II included 9(21%) males and 11(55%) females without significant statistical difference in respect to sex which agreed with **Sánchez C. et al 2005**[15] and **Oosterveld M.J. et al 2006**[16].

In the present study there was a statistically non-significant decrease in the weight after one week from admission and a statistically non-significant increase in the weight after 2 weeks and a statistically significant increase in the weight after 3 weeks from admission as compared to the admission weight in both groups and this agreed with **Abo El-ezz A.A 2002**[17]**, Zamberlan P. et al 2011**[2] and **Delgado A.F. et al 2000**[18]**,** but didn't agree with **Sánchez C. et al 2005** [15] This can be explained as in the previous study transpyloric enteral feeding was used which to a large extent skipped some GI complications including vomiting, abdominal distension and aspiration which minimized feedings interruptions [19]. That's why they kept a nearly constant weight with no reduction or increase, also in the study some children received infant formula, others received normocaloric or hypercaloric nutritional preparations, and others received protein hydrolysate In the present study there was a statistically non-significant change in the height (or length) either one week, 2 weeks or 3 weeks of admission when compared to the admission height (or length) and this agreed with **Delgado A.F. et al 2000** [18] and **Huslt et al 2004** [19]. This finding may be due to the short duration of the nutrition, making significant changes in the height unlikely. In the present study, there was a statistically non-significant decrease in the TSSFT and MUAC after one week from admission and a statistically increase after 2 weeks and a statistically significant increase after 3 weeks from admission as compared to the admission TSSFT and MUAC in both groups. And this agreed with **Abo El-ezz A.A 2002** [17] and **Abou El-Yazid D.A. 2006**[20], but didn't agree with **Hejazi N. et al 2016** [21]. This can be explained by the increase in inflammation since it helps accelerate the degradation of muscle proteins. Also, Immobilization is another important factor in muscle myopathy among hospitalized patients. In addition to the inadequate intake of energy and protein in their patients.

According to laboratory evaluation the results of the present study showed that there was a statistically non- significant increase in the prealbumin level after one week from admission and there was a statistically significant increase in the prealbumin level after 2 and 3 weeks from admission as compared to the admission prealbumin level in both groups and this agreed **with Tekgüç. H. et al 2018**[22]. This may be because serum prealbumin can be good nutritional indicator in the critical patient, as they reflect the capacity for incorporation of amino acids into hepatic protein synthesis, it has a short half-life relative to albumin, its concentration fall rapidly during acute illness and it recover in a short space of time **El-Nawagy A.G. 2017** [23] This can be explained as the patients of the previous study were severely traumatized with severe traumatic brain injury with intense metabolic stress and may have developed more GI intake compared to the requirements. The results of the present work also showed statistically non-significant decrease in the TLC after 1 week from admission and there was a statistically non-significant increase after 2 and 3 weeks from admission as compared to the admission TLC in group I and There was a statistically non-significant decrease in the TLC after one week from admission and there was a statistically non-significant increase after 2 weeks and there was a statistically significant increase after 3 weeks from admission as compared to the admission TLC in group II. This results agreed with **Hejazi N. et al 2016** [21]. This may be because lymphocyte count is not a good nutritional indicator when the nutrition is assessed for a short period of time.

According to the results of our study diarrhea occurred in 7 patients (17.5%), Abdominal distention occurred in 4 patients (10%), Vomiting occurred in 1 patient (2.5%) Aspiration occurred in 1 patient (2.5%) and The well-nourished patients in group I had a statistically non-significant lower rate of gastrointestinal complications when compared with the malnourished patients in group II that was in agreement with **Sánchez C. et al 2005** [15] who their results were Three (7.1%) patients presented with diarrhea and one (2.3%) of these patients also developed abdominal distension; No relationship was found between the incidence of gastrointestinal complications and any of the anthropometric or biochemical parameters.

So we conclude that Schofield equation underestimated energy expenditure during the first week of admission (acute phase) which was proven by the reduction in anthropometric parameters (the Body Weight, TSFT and MUAC) laboratory parameters (TLC) and this agreed with **Chaparro C.J. et al 2017**

[24] who performed a secondary analysis study on REE measured in a previous prospective study on protein and energy needs in pediatric intensive care unit. Included 75 ventilated critically ill children (median age, 21 months) in whom 407 indirect calorimetry measurements were performed. Fifteen predictive equations were used to estimate REE including the Scofield equation. This equation underestimated resting energy expenditure in young children. We also conclude that the equation accurately estimated the energy expenditure during the second and the third week of critical illness which was proven by normalization or even increase in the anthropometric parameters (Body Weight, TSFT, MUAC) and laboratory parameters (Prealbumin and TLC) and this agreed with **Oosterveld M.J. et al 2006**(16) and **Leung J. et al 2019**[25], but The results of this study was not in agreement **Mehta N.M. et al 2011** [26].

During the acute phase, endogenous energy production can cover a substantial (up to 75%) part of energy requirements, irrespective of the exogenous energy provision. In the recovery phase, REE values are the optimal guide for determining energy requirements. If possible, targeted indirect calorimetry is recommended in critically ill children with specific conditions however, in most clinical settings the lack of availability of indirect calorimetry means that prediction equations have to be used [27].

Reasonable values for REE can be derived from Schofield's prediction equation for REE using the actual weight of the patient. Because in contrast to the acute phase, the recovery phase does necessitate to add stress and activity factors to REE to account for tissue repair, growth, and for catch-up growth and physical activity during mobilization [28]

5. Conclusion:

From this study we conclude that enteral nutrition does not require special preparation, and it can be started and modified at any time with minimal complications. Moreover, Schofield equation as a predictive equation for estimating energy expenditure in critically ill children with multiplying by stress and activity factors under-estimated the energy requirements during the first week of critical illness and accurately estimated the energy expenditure during the second week and the 3rd week of critical illness as it is necessary to add stress and activity factors to resting energy expenditure especially during the recovery phase of critical illness to allow tissue repair and catch-up growth and physical activity during mobilization and pre-albumin as a blood biomarker is a good indicator for evaluation of the nutritional status in the critically ill child within one week, weight as well as triceps skin fold thickness and mid-arm circumference are also considered good indicators for evaluation of nutritional status of critically ill children within three weeks, unlike height, head circumference and total lymphocytic count which aren't considered good indicators for evaluation of nutritional status in critically ill children within three-week duration.

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