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Effects of pre-injury nutritional status on post-burn growth in prepubescent Children

Javeria Junaid[1], Heriberto Juarez[2], Clark Anderson[1], Celeste C. Finnerty[1,2,] David N. Herndon[1,2], Walter J. Meyer[3]
[1]Department of Surgery, University of Texas Medical Branch and Shriners Hospitals for Children, Galveston, Texas.
[2]Department of General Surgery, University of Texas Medical Branch, Galveston, Texas.
[3]Departments of Pediatrics and Psychiatry University of Texas Medical Branch, and Shriners Hospital for Children, Galveston, Texas.

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Corresponding Author:
ORCID 0009-0009-9296-212X

ABSTRACT

Malnutrition is a major problem in the developing world and has disastrous effects on a child's health and ultimate growth. This study was undertaken to elucidate a possible contributing factor to the altered growth observed and to assess the impact of preinjury malnutrition on growth delay in severely burned children. A retrospective chart review for 89 patients with burn admission dates from 2002 to 2013 at Shriners Hospital for Children, Galveston was done. Only pre-pubertal children were enrolled. These patients were followed in the outpatient clinics for 2 years, and their height, weight, and bone age data were collected at 6-month intervals post discharge. All of the patients were given the standard of care at Shriners Hospital with nutritional supplementation and support. This data was used to determine growth velocities at admission, discharge and each follow-up visit. Weights were also collected on post-surgical day 5 (dry weight) and these were used to calculate the Body Mass Index (BMI) for the patients. These were plotted on standardized Chi Squared analysis and t-tests were used to compare the information for any statistical significance. Of the original 89 patients, 26 (29%) patients were lost to follow-up. Sixty-three patients were assessed via anthropometric standards for malnutrition post-burn injury. The overall prevalence for malnutrition among males was 12% (95% Agresti-Coull CI from 7% to 20%), and amongst females was 25% (95% CI from 14% to 40%) (Figure 1). At the year one-time point, 22 (35%) of patients had abnormal growth velocities, out of these 22 patients, 14% were found to be malnourished prior to injury (p=0.76). At year two only 15(24%) of the patients failed to achieve adequate growth velocity for age, and 33% of these were found to be malnourished (p=0.02) (Table 2).Although malnutrition is a significant problem in the admissions to any burn unit, preinjury malnutrition in pre pubertal children does not have any detrimental effects on the ability of burns survivors to gain normal growth parameters when appropriate nutritional supplementation is achieved

Keywords: Pre pubertal growth, pediatric burns, delayed growth, growth velocities, pre injury malnutrition, dry weight.

Introduction

Severe malnutrition adversely affects wound healing and growth in children.[i] The earlier in life that malnutrition occurs, and the more severe and protracted the malnourished state is, the more likely it is that the adult stature of the child will be negatively impacted(Dukhi, 2020; Muhammad et al., 2020). Severe burn victims suffer a heightened and prolonged metabolic response post injury, which is more severe and prolonged in comparison to other forms of trauma; this response may persist for several months or even years after the initial injury. These effects are mediated by increased serum concentrations of inflammatory mediators that induce significant weight loss, poor weight gain, and post burn growth retardation(H. M. U. Abid et al., 2024; Akhlaq et al., 2024). Following a burn injury, decreases in growth velocity and reductions in peak bone age may also occur without any identifiable mechanism(S. Abid et al., 2024; Naz, Khan, et al., 2024) This study was undertaken to elucidate possible contributing factors to the altered growth velocities seen in such a population, and to assess the impact of preinjury malnutrition on the growth delay frequently observed in children with large surface area burn injuries(Pandey et al., 2022; Usman Abid et al., 2023).

Methodology:

An Institutional Review Board approval was obtained to conduct a retrospective chart review for 89 patients with burn admission dates from 2002 to 2013 at Shriners Hospital for Children, Galveston. These patients were followed in the outpatient clinics and their height, weight, and bone age data was collected at 6-month intervals from the date of discharge. The patients were followed for a total of two years post injury. Inclusion criteria included the following; to avoid confounding by the pubertal growth spurt, age at admission was limited to between 4.0 to 10.9 years. Total body surface area (TBSA) of burns; greater than 30%, out of this 50% were full thickness, third degree (TBSA 3rd) burns. Only children who were admitted within 10 days after burn injury were included in the study so that post injury weight measurements could reflect their preinjury nutritional status, as preinjury data was not available. All the patients with less than two follow up time points were excluded, excluding 26 patients. All of the patients were given the standard of care at Shriners Hospital for Children and resuscitated via the Galveston formula (a total of 5000 mL/m2 total body surface area burned + 2000 mL/m2 total body surface area of lactated Ringer solution was given during the first 24 hours). For all patients, burn wound excision and placement of autograft or allograft was performed within 48 hours of admission. Height, weight and bone age data was collected to determine growth velocities at admission, discharge and each follow up visit. Weights were also collected on post-surgical day 5, so as to adequately reflect the patient's 'dry weight' and negate any confounding due to the initial fluid resuscitation or 'water weight'. Post-surgery day 5 weights were then used to calculate the Body Mass Index (BMI) for the patients according to their age and gender. These were plotted on standardized World Health Organization (WHO), BMI for age charts by gender. This was used to reflect the preinjury nutritional status of the children. The anthropometric WHO BMI for age graphs have percentile plots corresponding to the 97th, 85th, 50th, 15th and 3rd percentiles which represent (positive and negative) two standard deviations from the mean, respectively.[ii] All patients who fell below the 3rd percentile (negative 2 standard deviations from the mean) were considered Malnourished (MN) and the rest were labelled Adequately Nourished (AN). These two groups were then compared in terms of demographic data, total area of burn (TBSA), and gender and growth

velocities at 1 year and 2-year post discharge (Table 1). During the hospital stay and for the entire follow-up time all the patients received the same standard of care. Upon discharge they were nutritional supplementation was given 3 times per day with Boost (Nestle Healthcare Nutrition, Nestl´e S.A., Vevey, Switzerland; 41 g of carbohydrate, 10 g of protein, and 4g of fat). Supplementation was continued until a nutritionist confirmed that a regular diet met the patient's recommended caloric requirements of 1.4 times the resting energy expenditure.[iii]

Agresti-Coull confidence intervals were used to compare the percentile proportions of the population under question to the general US population as most of the admissions to our center are predominantly Hispanic. Chi Squared analysis and t tests were used to compare the information for any statistical significance. For this set of patients, to assess the probability of improvement (catching up to normal for age growth rates) from year one to year two among the populations, a variable "delta" was defined which was 0 if there was no change in percentile group between 1 year and 2 year time points, 1 if the patient changed from abnormal to normal, and -1 if the patient changed from normal to abnormal percentile ranges. Ordinal logistic regression, with verified proportional odds assumption, modeled the relation between delta and age at burn and the BMI percentile associated with that age.

Results:

Adherence to a strict criterion for age and time between burn and admission, limited the number of patients that could be assessed in this study. Many patients admitted to our center have already been given primary treatment elsewhere prior to transfer to our burn unit. This additional delay adds to their lag time and post injury weights cannot be depended upon to reflect the true preinjury status in these cases. Of the originally 89 patients who were enrolled in the analysis, 26 (29%) patients were lost to follow up as they did not complete both 1 year and 2-year follow-ups. Sixty-three patients were assessed via anthropometric standards for malnutrition post burn injury. The overall prevalence for malnutrition amongst males was 12% (95% Agresti-Coull CI from 7% to 20%), and amongst females was 25% (95% CI from 14% to 40%) (Figure 1). Mean age at the time of admission for males was 6.5±2.4 years, and females were 7.2±2.3 years. Average time lag from burn to admission for males was 3±3 days, and for females were 3±2 days. Mean weights for males was 24.5±10.5 kgs, and for females was 22.3±5.7 kgs at admission. Total body surface area of burns (TBSA) was 62±16% in total, (for males 65±16% and females were 60±16%). Third degree burns (TBSA 3rd) or full thickness burns were 55±19% (males 57±21% and females 57±19%) at admission (Table 1)(Naz, Akhtar, et al., 2024). At the year one time point, 22 (35%) of patients had abnormal growth velocities, out of these 22 patients, 14% were found to be malnourished prior to injury ($p=0.76$). At year two only 15(24%) of the patients failed to achieve adequate growth velocity for age, and 33% of these were found to be malnourished ($p=0.02$) (Table 2). Between the first and the second year the probability of the malnourished children to improve (being able to regain their normal growth velocity by year two), was not significant in terms of BMI for age ($p=0.50$). No statistically significant relationship could be found between preinjury malnutrition and retarded growth velocity at years 1 and 2 post injury.

Discussion:

Malnutrition has long term detrimental effects on childhood development. Among hospitalized children, malnutrition negatively influences the response to therapy and prolongs the time till discharge. When a nutritionally deficient body experiences the added stress of a significant injury like burns, delayed or

retarded growth is a likely outcome. This is commonly seen in patients with severe and protracted illness. Severe burn victims suffer heightened and prolonged metabolic responses post injury. That may persist for several months even years after the initial injury. Burned children exhibit a two- to three-fold elevation in both heart rate and catecholamine levels, leading to the digestion of peripheral muscles to support the need for building materials necessary to heal wounds. These effects are primarily mediated by increased serum concentrations of inflammatory mediators that induce significant post burn weight loss, poor weight gain and growth retardation despite adequate fluid and caloric supplementation. Following a burn injury, a decrease in growth velocity and possibly a reduction in peak bone age may occur without any identifiable mechanism. In patients with severe burn injuries covering more than 40% TBSA, the metabolic rate at a thermally neutral temperature reaches 180% of the basal rate during the acute phase. It becomes 150% at full healing of the burn wound and 140%, 120% and 110% at 6, 9, and 12 months post burn respectively. Protein synthesis by itself is unable to compensate for this markedly activated catabolic state, leading to the characteristic loss of muscle mass seen after severe burns. If the patient in question suffers protein energy malnutrition then it is possible that the detrimental effects of the injury would have long and varied consequences. Malnutrition is a common problem in developing countries. Undernutrition, for example, affects 20% of children in the developing world and the causes and consequences of their poor nutrition are multifaceted. Recently a new approach to malnutrition has been taken in developing countries. Malnutrition is now treated as a pathological process similar to intestinal malabsorptive diseases the causal relationship has yet to be established but there is significant evidence that intestinal infections lead to malnutrition, and that malnutrition worsens intestinal infections. As our patient population includes a large cohort from South American and Mexican regions further research into intestinal health may be warranted.

Our study population is more malnourished than the population of the United States for the same age bracket as assessed by Agresti Coull confidence intervals (Figure 1). Therefore standard CDC weight for age charts could not be used to assess the nutritional status of our study patients. Hispanic populations from Mexico and South America have different height and stature when compared to a US population. As a result BMI for age was chosen as a better anthropometric measure and the international WHO charts of BMI for age for children were used to plot post-surgery day 5 (dry) weights. The anthropometric WHO BMI for age graphs have percentile plots developed from consensus data gathered between 1997 and 2003 across six countries. This data is the standard defining how healthy children should grow under optimal environmental conditions, regardless of ethnicities and geographic boundaries(Azeem et al., 2023).

The fifth day post-surgery weight was used as a measure of the patient's preinjury status in order to minimize the confounding factor of over/under resuscitation and water weight. Since our center is rarely the first point of intervention for the majority of the burn's cases seen here, obtaining pre resuscitation weights are rarely an option. Currently fluid resuscitation formulas developed over 30 years ago, have been accepted as guidelines, but ongoing studies are focusing on the growing concerns that burn patients are being over or under fluid resuscitated, often with indistinct and inappropriate end-point targets.

BMI was chosen as a measure of the nutritional status instead of biochemical markers as in the acute setting, hormonal and biochemical assessment parameters are predominantly useful as markers of disease severity and not nutritional status per set the best of our knowledge no one has tried to find a relationship between the preinjury nutritional status of burnt children and their ultimate inability to catch up to normal

growth parameters before this. While several studies have assessed the nutritional status of burn patients most of these have focused on the recovery period or post-acute phases only.

Our study showed that more females were malnourished upon admission when compared to males. On average female patients weighed less as well. These early deficiencies did affect the patient's ability to attain normal growth parameters once their diets were supplemented with adequate nutritional support. The recommended nutritional supplementation, and the fact that post injury the children get better health and nutritional care, seem to negate the influence of any pre injury under/malnutrition in the population as even 1 to 2 years post injury, the patients were no different than the non-burned comparator group. A limitation of this study was that this data was only collected for two years, so most patients had not reached their adult height. We suggest that a long term follow up is required to unmask weather malnutrition in an early age affects the ultimate growth of these patients(Aleem et al., 2020).

In conclusion, although malnutrition is a significant problem in the admissions to any burn unit, preinjury malnutrition in children does not have any long-term detrimental effects on the ability of burns survivors to achieve normal growth parameters when adequate nutritional supplementation is achieved.

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Data Availability Statement: The associated data is available upon request from the corresponding author.

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Tables and Figures:

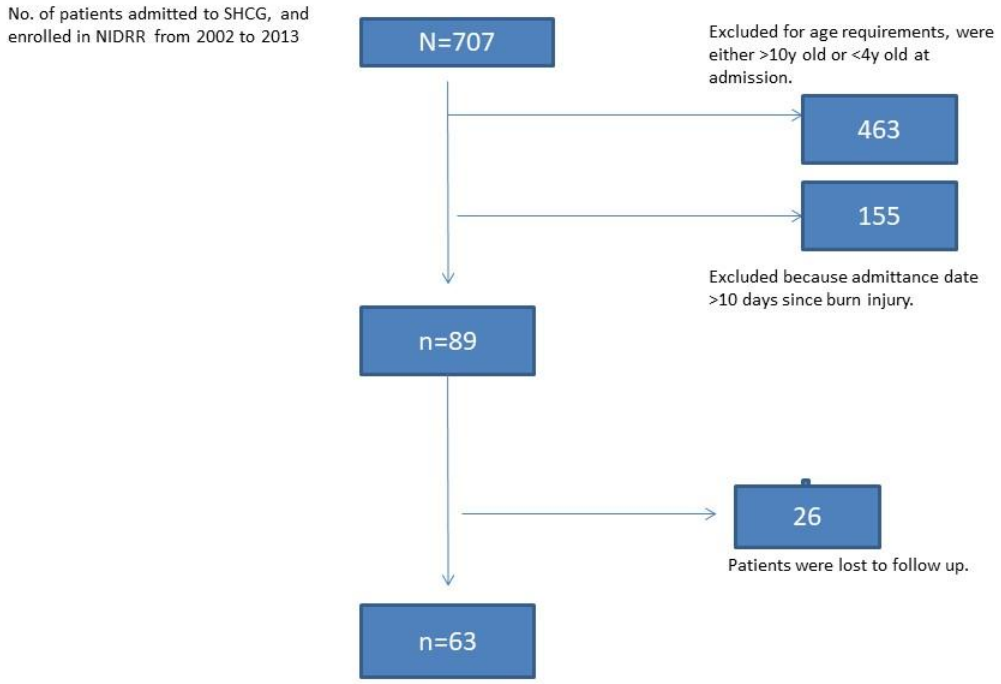
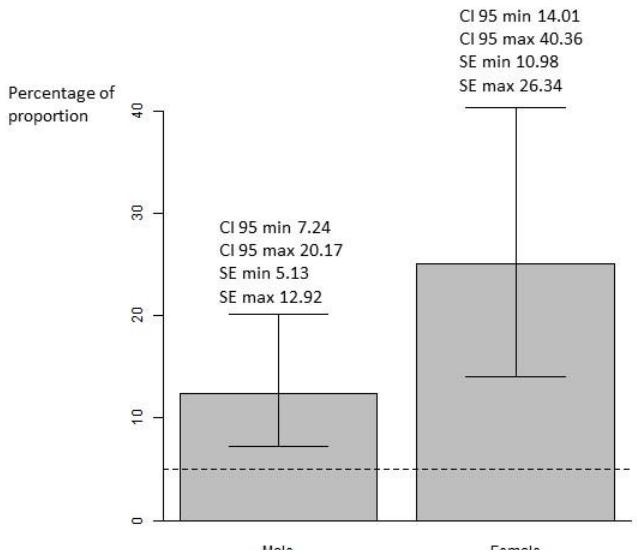


Figure 1. Consort diagram for patient enrolment in the study.



Figure

		Males	Females
Number		47	16
Prevalence of MN (%)		12	25
Age at admission (years)		6±2	7±2
Time from burn to admission (days)		3±3	3±2
Weights at admission (kg)		25±10	22±6
TBSA (%) burned		65±16	60±16
TBSA (%) with third degree burns		57±21	57±19

Table 1. Demographics data.
MN: Malnutrition, kg: Kilograms, TBSA: Total body surface area.

		year 1	year 2
Abnormal GV for age		34.9% (23)	23.8% (16)
Normal GV for age		63.4% (40)	74.6% (47)
Malnourished for age		13.6% (3)	33.3% (5)
p value		0.76	0.02

Table 2. Comparison of malnourished patients with those who were seen to have delayed growth velocity for age at year 1 and year 2 follow up.
GV: Growth Velocity.

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