Nutrition as Medical Therapy in Pediatric Critical Illness

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In this month's *Clinical Journal of the American Society of Nephrology*, work by Kyle *et al.* titled "Nutrition Support among Critically Ill Children with AKI" found that children in the intensive care unit (ICU), especially those with AKI, have nutritional deprivation before and during their ICU stay (1).

This study evaluated a series of 167 children, of whom 40% had AKI according to the RIFLE (Risk, Injury, Failure, Loss, ESRD) criteria before coming to the ICU. Looking at their nutritional measures, there was a significant component of malnutrition at the time of admission to the pediatric ICU. This seems to be more exaggerated in patients who have chronic illness associated with renal disease.

The authors found that by days 3 and 5 of the hospitalization, the overall group continued to have a component of undernourishment and, when measured, did not meet estimated energy or full protein requirements. There were a variety of perceived obstructions to delivering "full" nutrition. Therefore, this population was behind on nourishment at the time of admission and continued to be behind on nourishment during the first 5 days of ICU care.

Looking outside of North America, we see that many developing countries identify undernourishment as an independent risk factor for morbidity and mortality. Anochie and Eke identified a large group of Nigerian children with AKI who required dialysis (2). There was significant mortality in this population, in part because of the inability to perform dialysis. The authors also pointed out that an independent risk factor for death was the degree of malnourishment at the time of hospital arrival. The recent FEAST (Fluid Expansion as Supportive Therapy) study, published in 2011 in the *New England Journal of Medicine,* found that fluid resuscitation in African children with severe infection can be associated with a high mortality rate (3). It appears that the children with a higher mortality rate in that study were the ones who were much more severely malnourished. This finding suggests that their degree of malnourishment before seeking medical care added to the independent morbidity and mortality associated with fluid resuscitation.

A limitation to Kyle and colleagues' study is that nourishment assessment was estimated. Historically, many programs have used metabolic carts at the bedside to measure carbon dioxide and oxygen expenditure as a true assessment of energy requirements. Further 24-hour protein balances can be accurately assessed by measuring the input and excretion of urinary and stool protein.

Without the precise measurement of energy requirements, perhaps the tools that estimate energy requirements may not be valid. Be that as it may, nutrition as an independent risk factor for morbidity and mortality needs to be considered specifically as a line item, similar to antibiotic delivery in sepsis, for improvement of health care. Individuals have seen time and again that children seek medical care often late in the course of illness. This can be exaggerated if the children have inadequate oral intake and inadequate nutritional intake for some time before medical care. In addition, medical systems often restrict the patient to "nothing by mouth" or slowly advance nutrition because of concerns about risk of refeeding syndrome or intolerance to nutrition.

What Kyle and colleagues have not addressed is that if patients with AKI who have malnourishment require renal replacement therapy, their energy requirements also change. Maxvold and colleagues found that patients receiving continuous renal replacement therapy have substantial protein losses during this period (4). Moreover, in a multicenter study by Zappitelli *et al.* among children who underwent continuous renal replacement therapy, nutrition and protein delivery remained inadequate even by day 5 (5).

Lyle and colleagues' study is a wake-up call for those involved with medical decision-making at the bedside. Clinicians need to identify the proper techniques for measuring nutrition status at the time of hospital admission and implement nutrition as aggressively as we would with antibiotics in the sepsis campaign. In addition, in the face of the changing severity of illness and comorbid conditions common in children in the current ICU era, valid tools must be used to determine energy requirements and delivery. Validation of estimated versus measured nutritional energy intake is necessary to confirm that these tools are accurate in a changing population of patients with more severe multiorgan failure, specifically the pediatric population.

One has to ask, should nutrition delivery be considered part of the therapy in critical illness? Clinicians would suggest that, similar to antibiotics for sepsis and vasopressor agents for hemodynamic compromise, nutrition needs to be front and center as part of health care delivery in these critically ill children. Further use of extracorporeal devices in children (*e.g.*, continuous renal replacement therapy and extracorporeal membrane

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oxygenation) may affect nutritional clearance and needs to be factored into both caloric and nitrogen balance in these children.

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