ORIGINAL RESEARCH

Protein Feeding in Pediatric Acute Kidney Injury Is Not Associated With a Delay in Renal Recovery

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Objective: Critically ill children with acute kidney injury (AKI) are at high risk of underfeeding. Newer guidelines for nutrition support recommend higher protein intake. Therefore, the study evaluated the effects of protein feeding on the resolution of AKI and compared energy and protein intake in patients with and without AKI after implementation of Nutrition Support guidelines.

Design: Retrospective study.

Subjects: Five hundred twenty critically ill children from October 2012 to June 2013 and October to December 2013.

Main Outcome Measure: Energy and protein intake in patients with no AKI, resolved, or persistent AKI. Energy and protein intake was documented for days 1-8 of Pediatric Intensive Care Unit stay and in the postimplementation versus preimplementation period of nutrition support guidelines. AKI was defined by modified pRIFLE. Persistent AKI was defined as patients who did not resolve their AKI during the study period.

Results: A higher percentage of patients with resolved and persistent AKI met ≥ 80% of protein needs versus no AKI. After adjustment for Pediatric Risk of Mortality Score, the odds ratio for protein intake of ≥ 80% compared to <80% of estimated protein needs was not significant, which suggests that higher protein intake was not associated with nonresolution of AKI. There were significant improvements in the cumulative protein gap in patients with no AKI in the postimplementation (−1.0 [−1.7 to −0.6] g/kg/day) compared to preimplementation period (−1.3 [−1.7 to −0.9] g/kg/day, $P = .001$) and persistent AKI in the postimplementation (−0.8 [−1.4 to −0.1] g/kg/day) compared to preimplementation (−1.3 [−1.7 to −0.9] g/kg/day, $P = .03$).

Conclusions: Higher protein intake was not associated with a delay in renal recovery in patients with AKI after adjustment for severity of illness. Protein intake was improved in critically ill children with no AKI, resolved, and persistent AKI after implementation of Nutrition Support Guidelines, but underfeeding persisted in these patients.

Introduction

HOSPITAL UNDERNUTRITION IS a known risk factor for morbidity and mortality in children, adolescents, and adults,[1-3] and malnutrition has been shown to adversely affect patient outcome. In addition, suboptimal nutrient provision contributes to the deterioration of nutritional status and has been shown to increase the risk of multiorgan failure, length of stay (LOS), and mortality.[4,5] Critically ill children are underfed early in their Pediatric Intensive Care Unit (PICU) stay,[6] and this may contribute to worse outcome.

Acute kidney injury (AKI) occurs in 10% of all PICU admissions and in up to 3/4 of patients with cardiorespiratory failure.[7] The risk of acute and chronic malnutrition is high in patients with AKI, and the presence of malnutrition in the context of AKI has been associated with more severe clinical deterioration and organ dysfunction.[8-11] Derangements in substrate metabolism and body composition[12] as a result of physiological changes due to AKI can lead to hypercatabolism,[13] hypoalbuminemia, loss of lean body mass, and depletion of adipose tissue, even with adequate ingestion of nutrients.[14] Maintenance of protein balance in such conditions requires that at least adequate energy and protein intake be provided during acute illness.

Nutrition support is often deferred in critically ill children, until they are medically stabilized, which delays adequate nutrition support for several days due to fluid restriction, digestive intolerance, and interruption of feeding for diagnostic and therapeutic procedures.[15] Pediatric patients are highly dependent on nutritional support due to their intrinsic high anabolic drive and lower nutrient reserves, when compared to adults. AKI patients are at higher

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risk due to fluid restriction and concerns about protein loading leading to worsening uremia. In fact, due to the catabolic nature of the illness associated with AKI, it is now suggested that standard recommendations for energy and protein are appropriate for intensive care patients with AKI.[16-18] Nutrition Support Guidelines were developed and implemented for Texas Children's PICU because of previous reports[6,19-21] of underprescription and underdelivery of nutrition support among critically ill children, including patients with AKI.[22]

There is evidence that increased protein provision might protect the kidney from ischemic injury and may preserve glomerular filtration rate in critical illness[23] and may lead to faster recovery from severe AKI.[24-26] Studies linking achievement of protein requirements to outcome are lacking in children with AKI. The purpose of this study was to evaluate the effect of protein feeding on the resolution of AKI and to compare energy and protein intake in AKI compared to no AKI patients after implementation of Nutrition Support Guidelines.

Subjects and Methods

Five hundred ninety patients aged 0-18 years admitted to the Texas Children's Hospital PICU for >48 hours between October 2012-June 2013 (preimplementation) and October-December 2013 (postimplementation) were eligible. Patients were excluded if they were admitted to the PICU more than 72 hours after hospital admission (n = 51), had more than one PICU admission (n = 18), or had a diagnosis of end-stage renal disease, requiring renal replacement therapy or had received a kidney transplant (n = 10).

Data collected included age, sex, height, admission weight, admission diagnosis, duration of mechanical ventilation, medications, intravenous (IV) fluids, duration of time in PICU and hospital LOS, severity of illness, and survival. Recumbent length of children younger than 24 months was measured using a length board. For patients who were unable to stand due to severity of illness, knee/heel measurements were obtained by using knee/heel calipers and converted to height using the previously validated formulas.[27] Weight was obtained with digital scales (hoist if nonambulatory; Scaletronix Inc, Wheaton, IL) and digital infant scales.

Patients were classified as AKI, and further stratified as risk (R), injury (I), and failure (F) by pRIFLE creatinine criteria.[7] Urine output data were not available. Resolution of AKI was defined as any stage of AKI present during the period of observation and subsequently transitioning to no AKI. Persistent AKI was defined as patients who did not resolve their AKI during the first 8 days of PICU stay.

Weight wasting (moderate/severe) was defined as weight-for-height ≥ -2 z-scores and height stunting (moderate/severe) as height-for-age ≥ -2 z-scores, using World Health Organization[28] and 2000 Center for Disease Control growth charts[29] for children <2 and ≥2 years, respectively. Severity of illness was assessed on the day of admission with the Pediatric Risk of Mortality Score (PRISM III)[30,31] and organ dysfunction with the Pediatric Logistic Organ Dysfunction score (PELOD).[32,33]

Estimated energy and protein needs were determined according to the Schofield prediction equation (basal metabolic rate)[34] (without correction factors) and American Society for Parenteral and Enteral Nutrition guidelines for critically ill children,[35] respectively (protein recommendations 0-2 years: 2-3 g/kg; 2-13 years: 1.5-2 g/kg; >13 years: 1.5 g/kg).

Enteral, parenteral nutrition, and IV-glucose containing solutions were collected. For enteral nutrition, enteral formula provided and the volume given for each 24 hours was collected for each day. For IV and parenteral nutrition, the volume and concentration of all IV fluids were collected. Continuous renal replacement therapy (CRRT) fluids were not included in the calorie and protein calculations. The actual energy and protein intakes were calculated in a spreadsheet for each 24 hours for the first 8 days or until oral intake was initiated. The cumulative gap or deficit was defined as the differences between actual energy (kcal/kg/day) or protein (g/kg/day) intake minus recommended intake based on Schofield equation[3] or American Society for Parenteral and Enteral Nutrition guidelines,[4] respectively, for the time the patients remained in the PICU.

In July and August 2013, the Texas Children's Hospital Nutrition Support Team implemented Nutrition Support Guidelines to improve feeding practices in our PICU. The implementation of Nutrition Support Guidelines consisted of a 45-minute training session for all PICU clinical practitioners as well as written guidelines, made available on the hospital intranet. The changes in energy and protein intakes were also evaluated in the postimplementation compared to preimplementation of Nutrition Support Guidelines. In order to assess the effects of the energy and protein intake on the resolution of AKI, a cutoff of ≥ 80% was used.

The study was approved by the Baylor College of Medicine Institutional Review Board, with a waiver of consent.

Statistics

Continuous variables were classified as normally or nonnormally distributed based on an analysis of frequency distribution graph. Normally distributed continuous variables, reported as mean (standard deviation), were compared using paired and unpaired *t* test. Nonnormally distributed variables were expressed as median with interquartile ranges. For dependent samples, Wilcoxon Signed Rank tests and for independent samples Mann-Whitney U nonparametric tests were performed. Pearson's chi-square or Fisher's exact test was used for independent observations to determine differences between groups of