Dietary Intake and Clinical Response of Hospitalized Patients with Acute Diarrhea

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Dietary intake and clinical response of hospitalized patients with acute diarrhea

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Abstract

Background. *Diarrhea and malnutrition remain major health problems among children of developing countries. During diarrhea, the patient's dietary intake and absorption of nutrients are reduced while nutritional requirements are increased.*

Objective. *To determine the relationship between food intake and clinical response during the hospital stay of patients with acute diarrhea.*

Methods. *A hospital-based longitudinal study was conducted in 118 patients with acute diarrhea aged 6 to 59 months who required treatment for at least 3 days in the in-patient ward in Dhaka Hospital of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B). Daily food intake was measured and anthropometric measurements were taken to assess nutritional status. Daily stool weight and clinical records were collected. The data were analyzed with SPSS/PC+, version 10, and EPI STAT, version 3.2.2.*

Results. *The duration of diarrhea was 50% greater in patients with lower energy intake (less than 50% of the recommended dietary allowance [RDA]) than in those with higher energy intake (6 vs. 4 days,* $p = <.001$*). Patients with lower energy intake had 22% greater stool output than those with higher energy intake (122.65 vs. 100.37 mL/kg body weight/day,* $p = .04$*). Among patients with lower energy intake, the weight-for-age and weight-for-height z-scores (WAZ and WHZ) at discharge from the hospital were higher than those at admission (−3.53 ± 1.25 vs. − 3.67 ± 1.31 and 1.95 ± 1.23 vs. −2.14 ± 1.22, respectively;* $p = .001$ *for both comparisons), but these scores did not differ at admission and discharge among patients with higher energy intake. The Kaplan–Meier survival function showed that 80% of well-nourished children (WAZ ≥ −2), as compared with 58% of malnourished children (WAZ < −2), recovered by the 4th day of treatment (*$p < .01$*). The length of the recovery period was related negatively with total energy intake (*$p = <.001$*) and mid-upper-arm circumference (*$p = .004$*) and positively with stool weight.*

Conclusions. *Food intake was reduced in the hospitalized children because of severe illness. Patients with lower energy intake as a percentaqe of RDA had delayed clinical recovery and higher stool output.*

Key words: Body weight, diarrhea, energy intake, hospital stay, malnutrition, RDA

Introduction

Acute diarrhea is a major cause of morbidity and mortality among children in developing countries; rotavirus and enterotoxigenic *Escherichia coli* (ETEC) are among the most frequent etiologic agents [1, 2]. Children in developing countries suffer from an average of 2.2 episodes of acute diarrhea per year, leading to 1.4 milion deaths [3]. Inadequate water supplies, poor sanitation, overcrowding, and malnutrition are the main factors in the spread and severity of diarrheal diseases [4]. The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) operates the Dhaka Hospital, which treats about 110,000 patients for diarrheal disease each year [5]. Diarrhea and malnutrition remain major health problems among children of developing countries. The prevention of diarrhea is critical, especially in areas where limited access to health care and financial constraints prevent prompt treatment, as is the case in much of the developing world [6, 7]. It has been well documented that diarrhea is a major cause of malnutrition [8, 9], and malnourished children are

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at greater risk for infection and severe illness. On the other hand, it has been widely accepted that infection adversely affects nutritional status through reductions in dietary intake and intestinal absorption, increased catabolism, and sequestration of nutrients that are required for tissue synthesis and growth [10].

Diarrhea is accompanied by malabsorption of sugars, nitrogen, fats, and micronutrients. The mechanisms by which acute diarrheal diseases produce malabsorption have not been studied adequately. The nutritional costs of malabsorption may pose a major threat if diarrhea becomes chronic or recurrent [11].

Nutrient absorption is reduced by about 30% during acute diarrhea [12]. Excessive fecal loss of nutrients from the intestine, particularly nitrogen, fat, and carbohydrate, leads to malnutrition. Diarrhea precipitates symptoms including abdominal pain, anorexia, nausea, and vomiting, leading to reduced dietary intake [13, 14]. Because of frequent passage of stool with water, electrolytes, and nutrients, children lose body weight. In addition, inadequate nutrient intake due to anorexia leads to growth faltering during diarrhea.

During the last two decades, remarkable progress has been made on the development of oral rehydration and intravenous electrolyte solutions [15, 16]. There are differences in the loss of fluid and electrolytes in diarrhea due to different pathogens [17]. However, the electrolyte composition of oral rehydration solution (ORS), consisting of sodium, chloride, bicarbonate, and potassium, is uniform for any type of diarrhea. Recent developments in the carrier ingredients of ORS have led to better fluid absorption than that of earlier ORS [18, 19]. The World Health Organization (WHO) recommendation for management of acute diarrhea is to continue usual feeding and maintain hydration with intravenous or oral rehydration fluid.

Adequate feeding is a critical issue to ensure weight gain of children during diarrhea. It is important to identify the factors that predict the clinical outcome of diarrhea to guide appropriate management. We undertook a study to assess the influence of dietary energy intake and nutritional status on the clinical outcome of acute diarrhea in children.

Methods

Study design and subjects

This longitudinal study was conducted in the long-stay unit of Dhaka Hospital of the ICDDR,B. The study included 118 children of both sexes aged 6 to 59 months who required treatment for acute diarrheal illness for at least 3 days in the hospital. Most of the study subjects came from families of low socioeconomic status. The study was approved by the ethical review committee of ICDDR,B. The consent form was read and explained to the mothers of the children, and both written and verbal consent were obtained.

Clinical procedures

On admission, dehydration was assessed according to WHO guidelines [20] and corrected within 4 hours with either intravenous polyelectrolyte solution or WHO/UNICEF-recommended ORS. Body weight after rehydration was measured with a weighing scale with a precision of 20 g on the day of admission and daily thereafter between 9 and 10 A.M. Supine length was measured on a locally constructed length board to a precision of 1 mm. Mid-upper-arm circumference was measured at the midpoint of the hanging left arm with a TALC (Teaching Aid at Low Cost) tape with a sensitivity of 2 mm on admission and at discharge. Weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), and height-for-age z-score (HAZ) were calculated from the measurements taken on admission. Patients were classified into lower and uppper nutritional groups according to whether their z-scores were < –2 SD or ≥ 2 SD of NCHS standards.

Stool output was measured accurately with the use of cholera cots. A cholera cot, which is specially designed for patients with diarrhea, is a bed covered with a plastic sheet with a central hole through which all liquid stool drains into a container under the cot. Urine is separated with pediatric urine collecting (PUC) bags. Stool weights are expressed as milliliters per kilogram of body weight per day. Food intake was also measured every 8 hours by trained dietitians and expressed as kilocalories per kilogram of body weight per day. All mothers stayed with their children throughout hospitalization. Breastfeeding was encouraged, but breastmilk intake was not measured.

The following outcomes were evaluated: duration of diarrhea (calculated from the time of admission until the end of diarrhea, i.e., passage of normal stool), total weight of diarrheal stools during hospitalization, frequency of diarrheal stools, fluid intake, frequency of vomiting, daily body weight, and difference in body weight between admission and discharge.

Nutritional status was determined according to whether WAZ and WHZ scores were below or above –2 SD of the National Center for Health Statistics (NCHS) standards. Energy intake was calculated as the difference between the recommended dietary allowance (RDA) and actual intake as percentage of RDA, and patients were then classified into low- and high-intake groups (< 50% and ≥ 50% of the RDA). Information on socioeconomic status, feeding history, and immunization was obtained from the mother or caretaker. Socioeconomic status was determined on the basis of the total monthly income of the family, the educational background of the parents, type of water source, and hygiene practices.

Statistical analysis

Data were recorded on questionnaires, and data cleaning, validation, and analysis were performed with SPSS/PC+ (Windows 10.0) and Epi Info (version 3.2.2, nutrition). Student's *t*-test was used to compare means of normally distributed data, and the nonparametric Mann–Whitney U test was used for non-normally distributed data. Regression analysis was performed to test for associations. Time to clinical recovery was compared between the groups by Kaplan–Meier survival analysis. Statistical significance was accepted at the 5% probability level.

Results

Table 1 compares admission characteristics and clinical outcomes in patients with low and high energy intakes. There were no significant differences between the groups in age, prehospital duration of diarrhea, WAZ, WHZ, or HAZ. The recovery period, defined as the period required for stool consistency to improve to soft, differed significantly between the groups. The duration of the recovery period was 50% greater in patients with lower energy intake than in those with higher intake (6 vs. 4 days, p = <.001). Patients with lower energy intake had 22% greater stool output than those with higher energy intake (122.65 vs. 100.37 mL/kg body weight/day, p = .04). The daily intake of protein from the diet during the hospital stay was also higher among patients with higher energy intake (p = .000). More patients in the lower-energy-intake group than in the higher-energy-intake group had < −2 WAZ (94% vs. 56%, p = <.001).

All children consumed less than the RDA of energy during the hospital stay. Among patients with lower energy intake, WAZ and WHZ were higher at discharge from the hospital than at admission (−3.53 ± 1.25 vs. −3.67 ± 1.31 and −1.95 ± 1.23 vs. −2.14 ± 1.22, respectively; p = .001 for both comparisons), but these scores did not differ at admission and discharge among patients with higher energy intake (**table 2**).

TABLE 2. Change in nutritional status of all children during hospitalization (mean ± SD)

Nutritional status[a]	Admission	Discharge	p^b
WAZ			
Higher energy intake (N = 41)	−2.22 ± 1.19	−2.16 ± 1.22	.43
Lower energy intake (N = 77)	−3.67 ± 1.31	−3.53 ± 1.25	.001
WHZ			
Higher energy intake (N = 41)	−1.80 ± 0.94	−1.73 ± 1.06	.38
Lower energy intake (N = 77)	−2.14 ± 1.22	−1.95 ± 1.23	.001

WAZ, weight-for-age z-score; WHZ, weight-for-height z-score.
a. Lower and higher energy intakes are defined as < 50% and ≥ 50% of the recommended dietary allowance (RDA), respectively.
b. Paired *t*-test.

TABLE 1. Comparison of admission characteristics and clinical outcomes in patients with lower and higher energy intakes[a]

Variable	Lower energy intake (N = 77)	Higher energy intake (N = 41)	p^b
Admission characteristics			
Age (mo)—median (25th, 75th centile)	10 (7, 18)	9 (7, 12)	.09
Mother's education (yr)—median (25th, 75th centile)	3 (0, 6)	4 (0, 7)	.18
Monthly family income (Tk)—median (25th, 75th centile)[c]	3,250 (3,000, 4,500)	3,500 (3,000, 5,000)	.34
Prehospital duration of diarrhea (days)—median (25th, 75th centile)	3 (2, 6)	3 (2, 7)	.55
WAZ—median (25th, 75th centile)	−3.75 (−4.49, −2.94)	−2.25 (−3.12, −1.22)	<.001
WHZ—median (25th, 75th centile)	−2.45 (−2.99, −1.49)	−1.91 (−2.44, −1.27)	.04
HAZ—median (25th, 75th centile)	−2.76 (−3.95, −1.87)	−1.11 (−1.86, −0.22)	<.001
WAZ ≥ −2—no. (%)	5 (6)	18 (44)	<.001
WAZ < −2—no. (%)	72 (94)	23 (56)	<.001
Clinical outcomes			
Recovery period (days)—median (25th, 75th centile)	6 (4, 7)	4 (3, 5)	<.001
Stool output (mL/kg/day)—median (25th, 75th centile)	122.65 (76.12, 180.36)	100.37 (29.67, 148.51)	.04
Total energy intake (kcal/kg/day)—median (25th, 75th centile)	37.0 (31.89, 42.83)	71.27 (65.45, 82.17)	<.001
Total protein intake (g/kg/day)—median (25th, 75th centile)	0.80 (0.69, 0.96)	1.57 (1.4, 1.79)	<.001

HAZ, height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score
a. Lower and higher energy intakes are defined as < 50% and ≥50% of the recommended dietary allowance (RDA), respectively.
b. Chi-square test.
c. US$1.00 = 59.53 taka.

In comparison with boys, girls were more underweight (WAZ, −3.36 ± 1.50 vs. −2.81 ± 1.24; $p = .04$) and shorter (HAZ, −2.63 ± 1.12 vs. −1.84 ± 0.26; $p = .03$) (**table 3**). The median duration of diarrhea was 67% greater in girls than in boys (5 vs. 3 days, $p = .04$). Mothers of boys had more years of schooling than mothers of girls (median, 5 vs. 2; $p = .03$).

Figure 1 shows that 80% of well-nourished children (WAZ ≥ −2) and 58% of malnourished children (WAZ < −2) recovered by the 4th day of treatment ($p < .01$, log-rank test, Kaplan–Meier survival functions). **Figure 2** shows that 71% of children with higher energy intake and 27% of those with lower energy intake recovered by the 4th day of treatment ($p = <.001$, log-rank test, Kaplan–Meier survival functions).

Table 4 shows the coefficients of multiple regression. When the recovery period was taken as a dependent variable, stool output per kilogram of body weight per day ($p = <.001$) showed positive relationships with recovery, whereas energy intake ($p = <.001$) and the nutritional indicator mid-upper-arm circumference showed a significant negative relationship with period of recovery ($p = .01$).

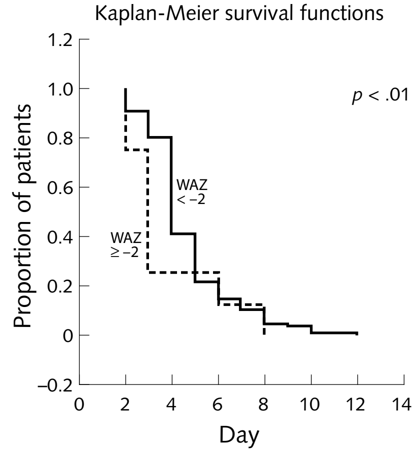

FIG. 1. Proportion of children with continuing acute diarrhea according to nutritional status. WAZ, weight-for-height z-score

Discussion

Our study clearly demonstrated that dietary intake has a positive effect on early recovery from acute diarrheal illness. Before admission to the hospital, the children were sick from diarrhea, and anorexia could reduce food intake and cause delay in treatment and care. In addition, water and electrolyte deficits could cause dehydration and aggravate anorexia. The subjects might have lost body weight from diarrhea. After admission to the hospital, they received diets that were adequate in carbohydrate, protein, fat, and micronutrients, including vitamin A and zinc. During hospitalization, the group with lower dietary intake had greater improvement in nutritional status, since most of them were malnourished. In ICDDR,B hospital practice, diets for patients with acute diarrhea contain less lactose than milk-based formulas [18]. Full-strength feeding began after diarrhea improved. Food was given in small amounts at frequent intervals [21].

Several earlier studies have shown that diarrhea causes malnutrition [22–24]. The major mechanisms by which diarrhea causes malnutrition are reduced food intake during acute diarrhea [25, 26], increased endogenous protein loss from the gastrointestinal

TABLE 3. Comparison of admission characteristics and clinical outcomes in male and female patients

Variable	Boys ($N = 77$)	Girls ($N = 41$)	p^a
Admission characteristics			
Mother's education (yr)—median (25th, 75th centile)	5 (1, 8)	2 (0, 5)	.03
Monthly family income (Tk)—median (25th, 75th centile)[b]	3,500 (3,000, 4,500)	3,500 (3,000, 5,000)	.81
Prehospital duration of diarrhea (days)—median (25th, 75th centile)	3 (2, 7)	5 (1.5, 7)	.49
WAZ—mean ± SD	−2.81 ± 1.24	−3.36 ± 1.50	.04
WHZ—mean ± SD	−1.86 ± 0.49	−2.13 ± 1.02	.22
HAZ—mean ± SD	−1.84 ± 0.26	−2.63 ± 1.12	.03
Clinical outcomes			
Recovery period (days)—median (25th, 75th centile)	3 (2, 6)	5 (4, 7)	.04
Stool output (mL/kg/day)—median (25th, 75th centile)	125.92 (69.84, 194.23)	130.84 (82.41, 170.6)	.82
Total energy intake (kcal/kg/day)—median (25th, 75th centile)	40.20 (26.55, 67.99)	40.30 (23.27, 70.64)	.86

HAZ, height-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score
a. Student's *t*-test (mean ± SD)
b. US$1.00 = 59.53 taka.

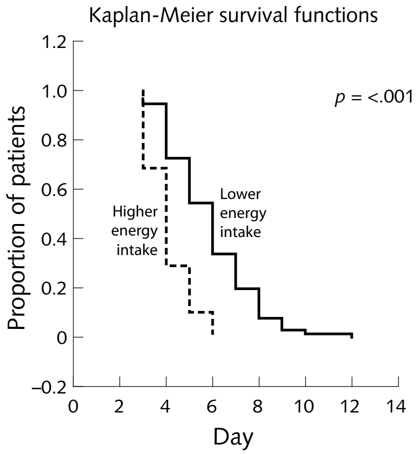

FIG. 2. Proportion of children with continuing acute diarrhea according to energy intake. Lower and higher energy intakes are defined as < 50% and ≥ 50% of the recommended dietary allowance (RDA), respectively

TABLE 4. Coefficient of multiple regression with period of recovery as dependent variable for patients with acute diarrhea

Variable	B	se B	Beta	*p*
Log MUAC (cm)	−0.06	0.02	−0.16	.01
Log energy intake (kcal/kg/day)	−0.36	0.04	−0.60	.000
Log stool weight (mL/kg/day)	0.15	0.03	0.37	.000
Constant	−0.51	0.08	—	.000

B, regression coefficient; se *B*, standard error of regression coefficient; beta, standardized regression coefficient; MUAC, mid-upper-arm circumference

tract, and increased tissue breakdown during infection [9] when the energy cost of diarrhea can be high [9]. Most of the subjects had WAZ scores below −2 SD. Some studies have shown that thin children are likely to have more frequent diarrhea [27] and may also have a higher incidence of diarrhea [28]. The prevalence and duration of diarrhea are greater in undernourished children [9, 27, 29, 30]. After discharge from the hospital, the risk of death in children treated for diarrhea is 14 times greater for malnourished than for well-nourished children [31]. Several surveys have reported that malnutrition is one of the major health problems in Bangladesh, as well as in other countries in the developing world. Malnourished childen may be unable to remain in energy balance when food intake is insufficient. Micronutrients such as vitamin A and zinc are lost in diarrheal stool [32]. Micronutrient malnutrition is associated with impaired immunity, which may subsequently cause increased morbidity, leading to deterioration of nutritional status [32].

Mothers of boys were better educated, and boys had better nutritional status and also recovered earlier than girls. Discrimination against girls is prevalent in Bangladesh. During hospitalization, however, boys and girls received the same dietary allocation. Nutritional status has been shown to influence the frequency of diarrheal attacks and the duration and severity of diarrhea [21, 27, 29].

The patients who failed to recover earlier were suffering from more severe malnutrition than those who recovered later from diarrhea in the hospital. It was not known whether systemic infection or nutrient malabsorption was responsible for clinical failure in patients with acute diarrhea, but failure to thrive is the ramification of these factors, including lower caloric intake and less effective acute-phase management [33]. Although the patients received the same care, treatment, and diet, because of the pathology of malnutrition [34], immunological defects, reduced rate of mucosal recovery, and reduced nutrient absorption [35, 36], malnourished children and those with lower energy intake recovered later than well-nourished children and those with higher energy intake.

The length of the recovery period was correlated positively with stool weight and negatively with energy intake and mid-upper-arm circumference. It appears that mid-upper-arm circumference may serve as an important prognostic factor for absorption of nutrients, which may in turn influence the period of recovery from diarrhea [37]. Anorexia is associated with any severe illness, including gastroenteritis, which causes abdominal pain and nausea resulting in low dietary intake [38]. Our study indicates that during hospital treatment, children may be at risk for reduced dietary intake, which leads to prolonged suffering and delayed recovery from diarrhea.

Further in-depth studies are required to identify risk factors for reduced dietary intake during acute diarrhea.

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