Original Article

Clinical Profile and Electrolyte Abnormalities in Hospitalized Under-Five Children with Acute Gastroenteritis in a Tertiary Health Facility

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Abstract

Background: Electrolyte abnormalities constitute the leading causes of morbidity and mortality in younger children with acute gastroenteritis. The aim of the study was to determine the clinical profile and pattern of electrolyte abnormalities in under-five children hospitalized for acute gastroenteritis from November 1, 2014, to January 31, 2015. **Methodology:** This was a cross-sectional descriptive study among hospitalized under-five children with acute diarrhea who were consecutively recruited from November 1, 2014, to January 31, 2015. Relevant clinical data were obtained, while the physical examination was done on all subjects. Serum electrolytes values were determined using the ion-selective electrode system and compared with standard reference ranges. The data were analyzed using SPSS version 21.0 with the level of statistical significance set at $P < 0.05$. **Results:** A total of 108 under-five children were studied. The majority (101; 93.5%) were <24 months of age, while 41 (38%) of low socioeconomic class background. Metabolic acidosis was the most common electrolyte abnormality followed by hyponatremia and hypokalemia occurring singly or in combination. The case fatality rate was 13 (12.0%). The electrolyte derangements associated with mortality were hypokalemia and acidosis: 11 (84.6%) each, 9 (69.2%) had hyperchloremia, while 6 (46.2%) were reported to have hyponatremia. **Conclusion:** Electrolyte derangements are common in under 5 years children with acute diarrhea with increased mortality in those with severe acute malnutrition. Proper health education is needed to ensure adequate nutrition and timely use of low-osmolar oral rehydration solution as well as early referral of cases with persistent gastrointestinal losses in order to save lives.

Keywords: Acute gastroenteritis, electrolyte abnormalities, under-five children

Introduction

Acute watery diarrhea is a leading cause of morbidity and mortality in under-five children, particularly in sub-Saharan Africa countries. The data from the World Health Organization (WHO) and the United Nations Children's Fund showed that there are about 2 billion cases of diarrheal diseases reported annually worldwide, accounting for the deaths of over 1.9 (18%) million children under 5 years of age mostly from developing countries annually.[1]

About 151,700 annual deaths due to diarrhea occur in Nigeria annually making it the second country out of fifteen accounting for over two-thirds of diarrhea related mortality in children globally. In addition, the 2013 Nigeria National Demographic and Health Survey has highlighted the huge burden of childhood diarrheal disease in all regions of Nigeria.[2-5]

In general, electrolyte abnormalities tend to be more common in younger children with acute diarrhea. The most severe threat posed by acute watery diarrheal disease is dehydration. During a diarrheal episode, water and electrolytes (sodium,

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chloride, potassium, and bicarbonate) are lost through liquid stools, vomit, sweat, urine, and breathing.[6] Also, different pathophysiological mechanisms, including abnormal fluid and electrolyte transport, decreased absorption, and increased secretion,[7] could be involved in children with acute diarrhea.

Studies have shown that hyponatremia, hypokalemia, and metabolic acidosis are among the common electrolyte abnormalities in children with acute diarrhea and dehydration are often responsible for mortality.[8-11]

In addition, hypokalemic acute kidney injury is one of the most significant complications in children hospitalized with severe acute watery diarrhea as they tend to experience prolonged hospitalization as well as higher mortality.[12]

Several etiological agents including rotavirus infections responsible for most cases of severe dehydrating gastroenteritis have been implicated in acute diarrheal diseases in under-five children in our setting.[13] The severity of acute gastroenteritis is linked to its possible etiology and rotavirus being the most severe infectious agent is frequently associated with dehydration.[14] The Na+ loss in stool depends on the infecting microorganisms. Stool Na+ can be as high as 90 mmol/L in cholera and 40–60 mmol/L in rotavirus diarrhea.[7] Dehydration generally reflects the severity of acute diarrhea and should be monitored by established scoring systems in affected children.[14]

Active management may reduce the duration and severity of diarrhea. Effective interventions include administrations of specific probiotics such as *Lactobacillus* GG OR *Saccharomyces boulardii*, dosmectite, or racecadotril,[14,15] early and correct use of oral rehydration solution (ORS) which has been associated with a dramatic decrease in mortality in children.[7,16,17]

A meta-analysis of randomized controlled trials of reduced osmolarity ORS versus standard WHO ORS in children with noncholera diarrhea reported that the use of a reduced osmolarity ORS was linked with a reduction in the need for unscheduled intravenous fluids (defined as the clinical requirements for intravenous fluids once oral rehydration has commenced); a trend toward reduced stool output to about 20%; and reduction in the incidence of vomiting in the range of about 30%.[16] *In vitro* studies have alluded that water absorption is increased from hypotonic ORS when compared to isotonic ORS.

In general, hypernatremic dehydration, a major cause of mortality in acute gastroenteritis has also become much less common with the use of improved use of ORS in acute childhood diarrhea.[16]

The WHO has recommended the use of zinc supplementation also in young children with acute diarrhea in our setting. However, a recent Cochrane systematic review concluded that zinc might be of benefit in children 6 months and older with acute diarrhea particularly in areas where the prevalence of zinc deficiency or malnutrition is high,[18] meaning that children in our setting will likely benefit from concomitant zinc therapy.

Diarrhea may be associated with up to 95% of all hospitalizations of children younger than 5 years of age. The primary goals in treating acute gastroenteritis are preventing and reversing ongoing dehydration and minimizing the nutritional consequences of mucosal injury as diarrhea, malnutrition, and intestinal integrity have a close complex relationship.[7]

Nutritional deficits caused by diarrhea are known to affect growth, fitness, cognition, and academic performance of the child, and it has been projected that each diarrheal episode a child suffers in the months preceding the 2nd year of life increases the likelihood of stunting by 5%.[19]

The clinical features of these electrolyte abnormalities may be unrecognized and result in morbidity and mortality. Timely recognition, a high index of suspicion and a thorough understanding of the common electrolyte abnormalities in children with acute watery diarrhea, is necessary to ensure their adequate corrections.

The target of reducing under-five mortality by two-thirds globally between 1990 and 2015 recorded substantial progress; however, despite this progress, we are still faced with the challenge to attain the new sustainable development goal target of 25 or fewer deaths per 1000 live births by 2030. Diarrheal-related death is still a major contributor to under-five mortality in our setting.[20]

There is a need therefore to ascertain the pattern of complications of the acute diarrheal disease including electrolyte abnormalities and malnutrition in younger children in our setting so that rational recommendations could be made to save lives.

Also, with the recent introduction of rotavirus immunization into the national program on immunization in Nigeria,[21] it is expected that the prevalence of acute watery diarrhea will reduce considering that rotavirus induced diarrhea is the most common cause of infectious/acute diarrhea in younger children.[13]

The research questions were to ascertain the pattern of electrolyte abnormalities, any association between severity of malnutrition and electrolyte abnormalities as well as the association between electrolyte derangements and survival outcomes in hospitalized under-5 years children with acute diarrhea in our setting.

Hence, the objectives of the study were to determine the clinical profile and electrolyte abnormalities in hospitalized under-five children with acute watery diarrhea in Enugu metropolis, Nigeria.

Methodology

Study design

This was a cross-sectional descriptive study of hospitalized under-five children with acute watery diarrheal disease

presenting to the pediatric emergency unit of the Enugu State University of Science and Technology (ESUT) Teaching Hospital, Park Lane, Enugu.

Ethical approval for the study was obtained from the Health Research Ethics Committee of the University of Nigeria Teaching Hospital, Enugu, while written permission was obtained from the management of ESUT Teaching Hospital, Park Lane, Enugu. Also, written informed consent was obtained from the parent/caregiver of each selected child.

Subjects were recruited consecutively over a 3 month period (November 1, 2014–January 31, 2015).

Information sought from the subjects included biodata: age (in months), sex, highest educational attainment of the parents as well as their present occupation, and relevant clinical data.

The social class of each child was determined using the protocol advanced by Oyedeji.[22]

In this method, the social class of each child was determined based on the educational attainment and occupational status of both parents.[22]

Thorough clinical examination was done in each patient including symmetrical/bilateral pitting edema, hydration status (with each child classified as no dehydration, mild, moderate and severe dehydration ± shock), weight, length/height, mid-upper arm circumference (MUAC) were determined using standard protocols.

Nutritional status of the children was determined using the WHO classification into well-nourished, moderate acute malnutrition (MAM), and severe acute malnutrition (SAM).

MAM was defined as weight-for-height z-score (WHZ) between − 2 and − 3 or MUAC between 115 mm and <125 mm and no symmetrical/bilateral edema,[23] while SAM was defined as WHZ <−3 or MUAC <115 mm or the presence of bilateral pitting edema.[24]

The data were captured using a datasheet designed for the study.

Procedure

About 5 ml of venous blood was obtained from each selected child and put into a plain bottle. The blood was allowed to clot and retract before centrifuging at 3000 revolutions per minute for 5 min to obtain the serum at the chemical pathology department of the hospital. All laboratory analyses were done on the day of sample collection.

Biochemical assay

The serum sodium, potassium, bicarbonate, and chloride were analyzed using the ion-selective electrode system (4000).[25]

The following serum values stated below were considered normal electrolyte ranges:[26]

- Sodium: 135–145 mmol/L
- Potassium: 3.5–5.0 mmol/L
- Chloride: 98–108 mmol/L
- Bicarbonate: 18–25 mmol/L.

Data analysis

The data were analyzed using statistical package for social science version, IBM SPSS version 21.0 (Chicago, Illinois, USA).

Continuous variables were presented as mean ± standard deviations. The differences in mean were compared using the Student's *t*-test. Further statistical analysis using the logistic regression model was applied. The differences in proportions were tested using the Chi-square with the level of significance set at $P < 0.05$.

Results

A total of 108 under-five children were studied out of which 103 (95.4%) were found to have electrolyte and acid-base disturbances while 5% had no derangement. Majority of the children 101 (93.5%) were <24 months of age. Similarly, the majority of the subjects were males, 59 (54.6%) with a male-to-female ratio of 1.02:1. Forty-one (38%) of the children were of lower socioeconomic class, as shown in Table 1.

Majority of the subjects had normal nutritional status 84 (77.8%), while 11 (10.2%) and 13 (12.0%) had moderate and severe acute malnutrition respectively.

Forty-three (39.8%) of the children were well hydrated, while 17 (15.7%), 29 (26.9%), 10 (9.3%), were mildly, moderately, severely dehydrated and 9 (8.3%) were in shock on presentation respectively.

Table 2 shows the distribution of the ranges of the various serum electrolyte values.

Table 1: Sociodemographic characteristics of subjects

Variables	Frequency (%)
Age (months)	
0-<12	51 (47.2)
12-<24	50 (46.3)
24-<36	4 (3.7)
36-<60	3 (2.8)
Total	108 (100.0)
Sex	
Male	59 (54.6)
Female	49 (45.4)
Socioeconomic class	
Upper	40 (37.0)
Middle	27 (25.0)
Low	41 (38.0)
Total	108 (100.0)

Table 2: Serum electrolytes pattern among subjects

Electrolyte (*n*=108)	Normal, *n* (%)	Low, *n* (%)	High, *n* (%)
Sodium	55 (50.9)	49 (45.4)	4 (3.7)
Chloride	55 (50.9)	11 (10.2)	42 (38.9)
Potassium	61 (56.5)	42 (38.9)	5 (4.6)
Bicarbonate	32 (29.6)	73 (67.6)	3 (2.8)

The various electrolyte derangements involving sodium, potassium, chloride and bicarbonate with normal, low and high values respectively were as shown in Table 2.

Metabolic acidosis was the most common electrolyte abnormality followed by hyponatremia, hypokalemia, hyperchloremia, hypochloremia, and hypernatremia either isolated or in combination.

Apart from acidosis, which was significantly seen in infants compared to older children with diarrhea, there was no statistically significant relationship between the ages of the children and electrolyte derangement, as shown in Table 3.

When electrolyte derangement was compared with the duration of diarrhea, hyponatremia was significantly more common when the duration of diarrhea is more than 7 days [Table 4].

With regard to the outcomes of the 108 hospitalized cases of under-five children with acute diarrhea, 13 (12.04%) of them died giving a case fatality rate of 12% out of which 4 (30.8%) were males and 9 (69.2%) females. In addition, 6 (46.2%) out of the 13 fatality cases recorded were of lower socioeconomic background.

Also, 5 (38.5%) of the children that died were dehydrated, 2 (40%) moderately dehydrated while 3 (60%) were severely dehydrated) on arrival.

Table 3: Relationship between age and electrolyte derangement in children with diarrhea

	Age group		*P*	OR	95% CI for OR
	<12, *n* (%)	≥12, *n* (%)			
Sodium					
Normal	22 (43.1)	33 (57.9)			
Hyponatremia	27 (52.9)	22 (38.6)	0.125	1.841	0.844-4.015
Hypernatremia	2 (3.9)	2 (3.5)	0.696	1.500	0.196-11.454
Potassium					
Normal	26 (50.9)	35 (61.4)			
Hypokalemia	24 (47.1)	18 (31.6)	0.149	1.795	0.811-3.972
Hyperkalemia	1 (2.0)	4 (7.0)	0.343	0.337	0.035-3.191
Chloride					
Normal	25 (49.0)	30 (52.6)			
Hypochloremia	5 (9.8)	6 (10.6)	1.000	1.000	0.273-3.670
Hyperchloremia	21 (41.2)	21 (36.8)	0.657	1.200	0.537-2.683
Bicarbonate					
Normal	9 (17.6)	23 (40.3)			
Acidosis	40 (78.4)	33 (57.9)	0.014*	3.098	1.262-7.603
Alkalosis	2 (4.0)	1 (1.8)	0.205	5.111	0.411-63.595

OR: Odds ratio, CI: Confidence interval, *Significant

Table 4: Relationship between duration of diarrhea and electrolyte derangements

	Duration of diarrhea		*P*	OR	95% CI for OR
	≤7 days, *n* (%)	>7 days, *n* (%)			
Sodium					
Normal	53 (54.1)	2 (20.0)			
Hyponatremia	41 (41.8)	8 (80.0)	0.044*	0.193	0.039-0.960
Hypernatremia	4 (4.1)	0 (0.0)	-	-	-
Potassium					
Normal	58 (59.2)	3 (30.0)			
Hypokalemia	36 (36.7)	6 (60.0)	0.113	0.310	0.073-1.319
Hyperkalemia	4 (4.1)	1 (10.0)	0.213	0.207	0.017-2.470
Chloride					
Normal	49 (50.0))	6 (60.0)			
Hypochloremia	9 (9.2)	2 (20.0)	0.505	0.551	0.096-3.174
Hyperchloremia	40 (40.8)	2 (20.0)	0.289	2.449	0.468-12.802
Bicarbonate					
Normal	27 (27.6)	5 (50.0)			
Acidosis	69 (70.4)	4 (40.0)	0.101	3.194	0.797-12.800
Alkalosis	2 (2.0)	1 (10.0)	0.451	0.370	0.028-4.903

OR: Odds ratio, CI: Confidence interval, *Significant

All the children that died were exclusively breastfed for a period of 6 months.

The electrolyte abnormalities associated with the fatalities were as follows: 11 (84.6%) had hypokalemia and acidosis while 9 (69.2%) had hyperchloremia, 6 (46.2%) showed hyponatremia, 2 (15.4%) hyponatremia, 2 (15.4%) hypochloremia, respectively, either singly or in combination as shown in Table 5.

In Table 6 though majority of the subjects with normal nutritional status had normal electrolyte pattern, a couple of them with either MAM or SAM had hyponatremia (MAM 7 [15.6%]; SAM 4 [9.5%]), hypokalemia (MAM 5 [15.2%]; SAM 9 [24.3%]), hyperchloremia (MAM 4 [10.8%]; SAM 5 [13.2%]), acidosis (MAM 10 [15.6%]; 9 [14.3%]) among others as shown in Table 6.

In terms of clinical outcome of subjects with respect to the nutritional status, 80 (95.2%) with normal nutritional status survived while 4 (4.8%) demised. Among subjects with MAM, 8 (72.7%) survived while 3 (27.3%) died. Most of the mortality was recorded among children with SAM as 6 (46.2%) out of 13 that died. However, there was no statistical relationship between survival outcome and nutritional status among subjects ($\chi^2 = 4.192$, $P = 0.123$).

Discussion

Most of the cases seen in the current study were children under 2 years of age. This is in keeping with the incidence of diarrhea which has been reported to be highest in children aged 6 months–2 years.[27]

Most of the study subjects were dehydrated 65 (60.2%) and had electrolyte as well as acid-base disturbances 103 (95.4%) thus reflecting a high burden of fluid and electrolyte/acid-base disturbances in them.

Metabolic acidosis was the most common abnormality observed in the study subjects which corroborates the finding in a similar study in Calabar, South-South, Nigeria, by Odey *et al*.[9] In a similar study by Shah *et al*. in Nepal,[8] all the subjects were found to have developed acidosis. This further shows that metabolic acidosis is a common metabolic derangement in younger children with acute watery diarrhea. It also underscores the need for prompt determination of blood gases and serum electrolytes, urea and creatinine so that adequate fluid and electrolyte therapy could be instituted in order to correct the metabolic derangements in affected children.

The current study also shows that age was significantly associated with acidosis ($P = 0.014$). Children less than 12 months of age were three times more likely to have acidosis (odds ratio = 3.098) than those above 12 months. This may be related to the high body surface area in the younger infants, thereby predisposing them to greater loss of fluid and electrolytes. Also, some of the children that had acidosis could have had severe sepsis which causes vasodilatation

Table 5: Logistic regression of the outcome in subjects according to their characteristics

Variables	Outcome		*P*	OR	95% CI for OR
	Survived, *n* (%)	Died, *n* (%)			
Hyponatremia					
Yes	43 (46.5)	6 (54.5)	0.603	1.395	0.398-4.894
No	50 (53.8)	5 (45.5)			
Hypernatremia					
Yes	2 (3.8)	2 (28.6)	0.037*	10.000	1.148-87.133
No	50 (96.2)	5 (71.4)			
Hypokalemia					
Yes	31 (8.3)	11 (91.7)	0.004*	21.290	2.627-172.564
No	60 (91.7)	1 (8.3)			
Hyperkalemia					
Yes	4 (6.2)	1 (50.0)	0.072	15.000	0.784-286.823
No	60 (93.8)	1 (50.0)			
Hypochloremia					
Yes	9 (14.5)	2 (50.0)	0.095	5.889	0.733-47.300
No	53 (85.5)	2 (50.0)			
Hyperchloremia					
Yes	33 (38.4)	9 (81.8)	0.221	2.661	0.555-12.772
No	53 (61.6)	2 (18.2)			
Metabolic acidosis					
Yes	62 (67.4)	11 (84.6)	0.221	2.661	0.555-12.772
No	30 (32.6)	2 (15.4)			
Metabolic alkalosis					
Yes	3 (9.1)	0	0.999	0.000	0.000-N/A
No	30 (90.9)	2 (100.0)			

OR: Odds ratio, CI: Confidence interval, *Significant

Table 6: Relationship between nutritional status and electrolytes among subject

Nutritional status	Hyponatremia	Normal	*P*
Normal	38 (84.4)	43 (91.5)	
MAM	7 (15.6)	4 (8.5)	0.349
SAM	4 (9.5)	8 (15.7)	0.537
Nutritional status	**Hypernatremia**	**Normal**	***P***
Normal	3 (100.0)	43 (91.5)	
MAM	0 (0.0)	4 (8.5)	1.000
SAM	1 (25.0)	8 (15.7)	0.522
Nutritional status	**Hypokalemia**	**Normal**	***P***
Normal	28 (84.8)	52 (91.2)	
MAM	5 (15.2)	5 (8.8)	0.353
SAM	9 (24.3)	4 (7.1)	0.031*
Nutritional status	**Hyperkalemia**	**Normal**	***P***
Normal	4 (80.0)	52 (91.2)	
MAM	1 (20.0)	5 (8.8)	0.410
SAM	0 (0.0)	4 (7.1)	1.000
Nutritional status	**Hypochloremia**	**Normal**	***P***
Normal	11 (100.0)	40 (85.1)	
MAM	0 (0.0)	7 (14.9)	0.327
SAM	0 (0.0)	8 (16.7)	0.330
Nutritional status	**Hyperchloremia**	**Normal**	***P***
Normal	33 (89.2)	40 (85.1)	
MAM	4 (10.8)	7 (14.9)	0.748
SAM	5 (13.2)	8 (16.7)	0.652
Nutritional status	**Acidosis**	**Normal**	***P***
Normal	54 (84.4)	27 (96.4)	
MAM	10 (15.6)	1 (3.6)	0.163
SAM	9 (14.3)	4 (12.9)	1.000
Nutritional status	**Alkalosis**	**Normal**	***P***
Normal	3 (100.0)	27 (96.4)	
MAM	0 (0.0)	1 (3.6)	1.000
SAM	0 (0.0)	4 (12.9)	1.000

MAM: Moderate acute malnutrition, SAM: Severe acute malnutrition, *Significant

and capillary leakage with the release of cytokines and other inflammatory mediations which cause derangement of the microcirculation producing anaerobic cellular respiration that results in metabolic acidosis in addition to acute kidney injury and coexisting hypokalemia.[28-30]

Other electrolyte derangements that were observed in the present study were hyponatremia (45.4%) and hypokalemia (38.9%).

With regard to the outcomes of the 108 hospitalized cases of under-five children with acute diarrhea; a case fatality of 12% was recorded. This is higher than 5% recorded by Shah *et al*.[8] in Nepal. Significant case fatality was seen in patients with hypernatremia as well as hypokalemia.

Though all the causes of mortality in the current study occurred in children that were exclusively breastfed, studies have shown that breastfed babies are more protected against diarrheal diseases as human breastmilk contains glycans including human milk oligosaccharides which are part of the immunological mechanism that accounts for the way in which human milk protects breastfed infants in addition to the fact that breastfeeding reduces the exposure to contaminated foods and contributes to adequate nutrition and hence, nonspecific immunity.[31]

Hyponatremia was significantly associated with increased duration of diarrhea ($P = 0.044$) among patients. Hence the longer the onset of the diarrhea prior to hospitalization, the higher the likelihood of possible development of electrolyte derangement particularly, hyponatremia.

This may suggest that early presentation and prompt correction of this electrolyte derangement may reduce the duration of diarrhea and by extension associated mortality as corroborated by other studies.[32,33]

However, this finding is at variance with the study by Singh *et al*.,[34] who reported that hyponatremia was not associated with prolonged duration of symptoms prior to hospital presentation in their study cohort. Reason for this discrepancy is not obvious. However, hyponatremia in this study was not associated with increased mortally ($P > 0.05$). This may, therefore, suggest that with adequate correction, mortality could be averted in patients with this frequently common electrolyte derangement in childhood acute diarrheal disease.

Hypokalemia, on the other hand, was associated with significant mortality in this study. This finding corroborates the report by similar studies[8,9,32] and hence underscores the need for proper evaluation and adequate management of this electrolyte derangement.

Also, hypernatremia was reported in 3.7% of the cases and was associated with significant mortality ($P = 0.037$). This further reflects the need for proper clinical evaluation including quick determination of arterial blood gases and serum electrolytes to know the baseline electrolyte derangements in such children to guide an institution of appropriate fluid and electrolytes management.

A close complex relationship exists between diarrhea, malnutrition and intestinal integrity as malnourished children have a greater susceptibility to infections, particularly gastrointestinal tract. Hence, with each diarrheal episode anorexia, reduced absorptive function, and mucosal damage, as well as nutrient exhaustion, occur. A significant proportion of the case fatality in the current study were children whose index illness of diarrhea coexited with various forms of malnutrition.

Most of them had associated electrolyte derangements which complicated their diarrhea.[7,35,36]

No reported cases of established acute kidney injury in the present study. Volume depletion/dehydration is known to increase the likelihood of nonsteroidal anti-inflammatory drugs (NSAIDs) associated with acute kidney injury. Though the study did not intend to study the association of NSAIDs used for symptomatic treatment of fever and renal insufficiency, it is recommended that cautionary measures be taken in the use of NSAIDs for the treatment of fever in children with associated dehydration to avoid the development of renal insufficiency.[37]

Conclusion

Electrolyte derangements are common in under 5 years children with acute diarrhea with increased mortality in those with severe acute malnutrition.

Proper health education is needed to ensure adequate nutrition and timely use of low-osmolar ORS as well as early referral of cases with persistent gastrointestinal losses in order to reduce the incidence of fluid and electrolyte abnormalities in them.

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Conflicts of interest

There are no conflicts of interest.

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