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# Relationship of Renal Function Tests and Electrolyte Levels with Severity of Dehydration in Acute Diarrhea

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## ABSTRACT

**Background:** Acute diarrheal illness constitutes a major cause of morbidity and mortality in children in developing countries. Most of the complications of diarrhea occur due to excessive fluid and electrolyte loss; adverse complications are seen more with increasing severity of dehydration. This study was conducted to identify the relation of renal function and electrolyte abnormalities in children with varying severity of dehydration.

**Methods:** This study was carried out in Manipal Teaching Hospital, Pokhara, Nepal over duration of one year. The aims were to find out the association of renal function and electrolyte disturbances with type of diarrhea, severity of dehydration and their relation to outcome. All children more than one month and less than 15 years with acute diarrhea were included in the study. Data were entered and analyzed by SPSS version 19. Statistical analysis applied was Chi-square test. A p-value of $<0.05$ was taken as significant.

**Results:** Acute watery diarrhea was the commonest type of diarrhea in children. Dehydration was associated more with Acute Watery Diarrhea than with Invasive Diarrhea. Renal function and electrolyte abnormalities were seen more in Acute Watery Diarrhea with increasing levels of blood urea, serum creatinine and abnormal levels of serum sodium seen with increased severity of dehydration.

**Conclusions:** Abnormalities in renal function and electrolytes correlated significantly with severity of dehydration. The outcome of patients correlated with severity of dehydration with mortality occurring in 18.1% of patients with Severe dehydration, 0.8% of Some dehydration with no mortality in the No dehydration group.

**Keywords:** Acute diarrhea; children; dehydration; electrolytes; renal function.

## INTRODUCTION

Diarrhea is a leading cause of death in children world-wide, second only to pneumonias, especially in developing countries. Every year, one in five child deaths is due to diarrhea, leading to a loss of 1.5 million lives a year.[1] Almost 80% of the diarrheal deaths occur in the African and South-East Asian sub-continent.[1] In Nepal, a survey conducted by the Nepal Demographic Health Survey (NDHS) in 2006, showed 12% of children under five years of age suffer from diarrhea and 5% die due to it.[2]

Most children with diarrhea have no dehydration.[3,4] However, some can be associated with dehydration.[5-10] Presence of dehydration can be associated with pre-renal dysfunction and dyselectrolytemias which can adversely affect the outcome.[5,7] The outcome therefore, rests on early diagnosis and treatment of dehydration.

This study was conducted to establish the relation between abnormalities in renal function and electrolytes with severity of dehydration and type of diarrhea and also their relation to outcome.

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## METHODS

This was a prospective hospital-based study conducted in the Pediatric intensive care unit and Pediatric ward from January 2013 till December 2013. Children more than one month and less than 15 years of age admitted with a diagnosis of acute diarrhea were included in the study. Diarrhea was defined as an increase in stool frequency or loosening of stool consistency, as compared to previous habits, with three or more episodes per day. It was defined as acute when it had an onset within 14 days. Acute diarrhea was classified as Acute Watery Diarrhea (AWD) and Invasive Diarrhea (ID), based on the clinical features, gross stool appearance and microscopy. Dehydration was divided into No dehydration, Some dehydration and Severe dehydration, according to World Health Organization-Integrated Management of Childhood Illnesses (WHO-IMCI) protocol.[11] Practice of hand-washing after visiting the toilets and before preparation of oral saline was noted. Knowledge regarding preparation and administration of oral rehydrating saline (ORS) was assessed on the basis of the caretaker's educational status and her understanding of the correct method of preparing and feeding it to the child. Infants less than one month of age, diarrhea of more than 14 days, presence of severe systemic infections, known immunocompromised states and surgical causes of loose stool were excluded. Verbal consent was taken from the patients' attendants. Ethical clearance was taken from the hospital ethical committee.

We first tried to see the relation of various variables like age, severity of dehydration, renal function tests and electrolytes to the type of diarrhea. Then we compared the renal function and electrolytes against the severity of dehydration. Finally certain variables were assessed to see their relation to outcome like age, sex, presence of malnutrition, type of diarrhea and dehydration, intake of ORS and source of water for drinking.

Data were collected and entered into Microsoft Excel. Laboratory values were categorized into normal and abnormal based on age.[12] Analysis was done by SPSS version 19. Statistical method used was Chi-square test. A p-value of < 0.05 was considered significant.

## RESULTS

Out of a total of 1807 admissions in Pediatrics ward of Manipal Teaching Hospital, 222 (12.1%) were admitted with the diagnosis of acute diarrhea. Out of them, 34 cases (15.3%) were excluded due to associated systemic infections in 7(3.1%) and incomplete records in 27(12.1%) cases.

The median age of the participants was 9 months (IQ range 10.8 months). Male: Female ratio was 1.6:1. In 126 (67%) cases, the primary caregiver had an average knowledge about Oral Rehydration Solution; while 30 (16%) mothers had very poor knowledge of ORS. In 38.3% cases, ORS had been given to the child prior to hospitalization. Routine handwashing with soap and water after going to the toilet was practiced in 139 (73.9%) cases. The main source of water for drinking was direct tap water in 132 (70.2%) while in 47 (25%), water was treated prior to drinking. Acute Watery Diarrhea (AWD) was seen in 150 (79.8%) while Invasive Diarrhea (ID) was seen in 38 (20.2%) cases. 122 (64.9%) cases were children below one year of age **(Table 1).** Malnutrition was seen in 39 (20.7%) cases.

**Table 1. Relationship with type of diarrhea.**

| Variables | Type of Diarrhea | | df‡ | p-value |
|---|---|---|---|---|
| | AWD* n (%) | ID† n (%) | | |
| **Age** | | | | |
| < 1 year | 107 (87.7) | 15 (12.3) | | |
| 1-5 Years | 40 (69) | 18 (31) | 2 | **<0.001** |
| >5 years | 3 (37.5) | 5 (62.5) | | |
| **Urea** | | | | |
| Normal | 65 (72.2) | 25 (27.8) | 1 | **0.013** |
| High | 85 (86.7) | 13 (13.3) | | |
| **Creatinine** | | | | |
| Normal | 53 (71.6) | 21 (28.4) | 1 | **0.025** |
| High | 97 (85.1) | 17 (14.9) | | |

| | | | | |
|---|---|---|---|---|
| **Sodium** | | | | |
| Normal | 106 (77.4) | 31 (22.6) | 2 | **0.035** |
| High | 29 (96.7) | 1 (3.3) | | |
| Low | 15 (71.4) | 6 (28.6) | | |
| **Potassium** | | | | |
| Normal | 136 (81) | 32 (19) | 2 | 0.499 |
| High | 4 (66.7) | 2 (33.3) | | |
| Low | 10 (71.4) | 4 (28.6) | | |
| **Severity of Dehydration** | | | | |
| No | 26 (60.5) | 17 (39.5) | 2 | **0.001** |
| Some | 103 (83.7) | 20 (16.3) | | |
| Severe | 21 (95.5) | 1 (4.5) | | |

***AWD= Acute watery diarrhea ; †ID= Invasive diarrhea**

**‡df= degree of freedom**

Severe dehydration was seen in 22 (11.7%); 123 children (65.4%) had Some dehydration while 43 (22.9%) had No dehydration. Dehydration was isonatremic in 137 (72.9%), hypernatraemic in 30 (16%) and hyponatraemic in 21 (11.2%) cases. Dehydration, both Some and Severe, were more in the group with AWD than in ID (p=0.001) **(Table 1)**

Abnormal renal function tests were seen in 135 (71.8%) and electrolyte abnormality in 63 (33.5%) cases. The commonest electrolyte abnormality was hypernatraemia in 30 (16%) followed by hyponatraemia in 21(11.2%) cases. Hypokalaemia was seen in 14 (7.4%) cases. High blood urea was seen in 85 (56.6%) cases of AWD as compared to 13 (34.2%) of ID **(Table 1)**. This finding was statistically significant (p=0.013). Similarly, serum creatinine was higher in the group with AWD as compared to ID (p=0.025).Serum sodium was seen to be abnormal more in the group with AWD than with ID (p=0.035); with hypernatremia seen more commonly in AWD (19.3%) and hyponatraemia more in ID group (15.7%). There was no statistically significant difference in the serum potassium in the two groups (p=0.499) **(Table 1)**.

**Table 2. Relation of severity of dehydration with renal function and electrolytes.**

| Variables | Dehydration | | | df‡ | p-value |
|---|---|---|---|---|---|
| | No n (%) | Some n (%) | Severe n (%) | | |
| **Urea** | | | | | |
| Normal | 28 (65.1) | 60 (48.8) | 2 (9.1) | 2 | **<0.001** |
| High | 15 (34.9) | 63 (51.2) | 20 (90.9) | | |
| **Creatinine** | | | | | |
| Normal | 26 (60.5) | 44 (35.8) | 4 (18.2) | 2 | **0.002** |
| High | 17 (39.5) | 79 (64.2) | 18 (81.8) | | |
| **Sodium** | | | | | |
| Normal | 35 (81.4) | 93 (75.6) | 9 (40.9) | 4 | **0.003** |
| High | 3 (7) | 18 (14.6) | 9 (40.9) | | |
| Low | 5 (11.6) | 12 (9.8) | 4 (18.2) | | |
| **Potassium** | | | | | |
| Normal | 39 (90.7) | 110 (89.4) | 19 (86.4) | 4 | 0.866 |
| High | 2 (4.7) | 3 (2.4) | 1 (4.5) | | |
| Low | 2 (4.7) | 10 (8.1) | 2 (9.1) | | |

**‡df= degree of freedom**

High blood urea was found in 20 (90.9%) of Severe dehydration as compared to 63 (51.2%) of Some and 15 (34%) of No dehydration (p=<0.001). Similarly, high serum creatinine was found in 18 (81.8%) of Severe, 79 (64%) of Some and 17(39.5%) of No dehydration (p=0.002) **(Table 2)**. Serum sodium abnormalities were seen in 13 (59%) of Severe dehydration as compared to 30 (24.3%) of Some and 8 (18.6%) of No dehydration (p=0.003); in both Some and Severe dehydration, hypernatraemia was more common than hyponatraemia. However, serum potassium levels did not vary significantly with the severity of dehydration (p=0.866).

**Table 3. Relationship of selected variables with outcome**

| Variables | Outcome | | | df‡ | p-value |
|---|---|---|---|---|---|
| | Discharged n (%) | LAMA§ n (%) | Expired n (%) | | |
| **Age** | | | | | |
| <1year | 116 (95.1) | 2 (1.6) | 4 (3.3) | 4 | 0.788 |
| 1-5 years | 57 (98.3) | 0 (0.0) | 1 (1.7) | | |
| >5 years | 8 (100) | 0 (0.0) | 0 (0.0) | | |

| | | | | | |
|---|---|---|---|---|---|
| **Malnutrition** | | | | | |
| Yes | 37 (94.9) | 0 (0.0) | 2 (5.1) | 2 | 0.436 |
| No | 144 (96.6) | 2 (1.3) | 3 (2) | | |
| **Type of diarrhea** | | | | | |
| AWD | 145 (96.7) | 1 (0.7) | 4 (2.7) | | |
| ID | 36 (94.7) | 1 (2.6) | 1 (2.6) | 2 | 0.573 |
| **Dehydration** | | | | | |
| No | 43 (100) | 0 (0.0) | 0 (0.0) | | |
| Some | 120 (97.6) | 2 (1.6) | 1 (0.8) | 4 | **<0.001** |
| Severe | 18 (81.8) | 0 (0.0) | 4 (18.2) | | |
| **ORS before admission** | | | | | |
| Yes | 68 (94.4) | 0 (0.0) | 4 (5.6) | 2 | 0.084 |
| No | 113 (97.4) | 2 (1.7) | 1 (0.9) | | |
| **Knowledge about ORS** | | | | | |
| Good | 32 (100) | 0 (0.0) | 0 (0.0) | | |
| Average | 123 (97.6) | 1 (0.8) | 2 (1.6) | 4 | **0.046** |
| Poor | 26 (86.7) | 1 (3.3) | 3 (10) | | |
| **Source of water** | | | | | |
| Tap water | 126 (95.5) | 1 (0.8) | 5 (3.8) | | |
| Treated tap water | 47 (100) | 0 (0.0) | 0 (0.0) | 4 | **0.022** |
| Others | 8 (88.9) | 1 (11.1) | 0 (0.0) | | |

***AWD= Acute watery diarrea; †ID= Invasive diarrhea; ‡ df= degree of freedom**

**§LAMA= Leave against medical advice**

181 (96.1%) of the children were discharged while 5 (2.7%) cases died during treatment. Among the children who died, four were less than one year of age, AWD was seen in 4 (80%), duration of diarrhea was more than three days and less than 14 days in 3 (60%) cases, frequency of loose motions were more than ten times a day in 3(60%) cases and vomiting was present in all cases. Four (18.1%) cases had Severe dehydration and one (0.8%) had Some dehydration (p=<0.001) (Table 3). Malnutrition was present in two (40%) cases.

## DISCUSSION

In 2000, the Millenium Development Goals were defined; the aim being to reduce by two-thirds, the mortality rate of under-five children by 2015. A recent survey by the Department of Health Services, Ministry of Health and Populations, Government of Nepal found incidence of diarrhea per 1000 under-five children has increased from 500 in 2010/11 to 528 in 2011/12.[13] However, the same study found the percentage of Severe dehydration cases among children under-five years has decreased from 0.37 in 2010/11 to 0.26 in 2011/12.[13]

Our study shows a hospital prevalence of 12.2% of acute diarrhea in children less than 15 years. Other studies have quoted a prevalence rate of 6-35%.[14-16] 122 (64.9%) cases were less than one year of age. Similar to our findings, other studies have found diarrhea to be more common in children less than 1 year of age.[6,16] In our study, AWD was more common than ID; similar to a study conducted in Jordan.[15] Dehydration was associated more with AWD than ID; with 68.6% having Some and 14% Severe dehydration. This is most likely explained by the fact that there is larger fluid loss in AWD.

ORS has been considered the "gold standard" of oral rehydration therapy. However, a Cochrane review which included seventeen trials (1811 participants) did not show a significant advantage of ORS over intravenous hydration in the outcome in dehydration associated with diarrhea in children.[17] According to Nepal Demographic Health Survey (NDHS) 2011, the percentage of children treated with ORS has increased from 29% in 2006 to 39% in 2011.[18] In our study, ORS had been given to the child in 72 (38.3%) cases prior to hospitalization. Among the children who received ORS, 68 (94.4%) were discharged while 4 (5.5%) died. Out of the 72 children who had been on ORS prior to admission, hypernatraemia was seen in 14 (19.4%) and hyponatraemia in 6(8.3%); as compared to 13.8% and 12.9% respectively in those who had not been on ORS.

Abnormalities in blood urea (p=<0.001), serum creatinine (p=0.002) and serum sodium (p=0.003) showed a strong correlation with increasing severity of dehydration. This finding is similar to that quoted in other studies.[5,7] But serum potassium levels did not correlate with the dehydration severity. The outcome of the child depended upon the severity of dehydration; with an adverse outcome associated more with increased severity

of dehydration (p=<0.001). Other studies have found similar results.[8] Abnormality in electrolyte levels have been associated with an adverse outcome in several studies.[6,19] We found abnormal sodium levels in 4 (80%) and abnormal potassium levels in 1 (20%) of the cases who died. Among the four ORS-receivers who died, serum sodium levels were high in two and low in one of them. The fifth child who died had not been on ORS and his sodium levels were low. In three of these cases, the mother had poor knowledge about ORS preparation, likely leading to improper dilution.

In our study, out of the children who died, 4(80%) were cases of AWD; this finding is similar to that found by other authors.[15] Four out of the five children who died were below nine months of age. The fifth child who died was 36 months old and had ID, malnutrition and a sodium level of 128 mEq/ L.

The NDHS 2011 survey shows that 82% of the general households in Nepal do not treat drinking water, more so in rural settings than in urban settings.[18] All the children who died, consumed direct tap water without treatment (p=0.022). The relation of water source to cause of death is not exactly clear but it was seen that 81% of the children who consumed untreated tap water developed AWD and had Some (64%) and Severe dehydration (12.8%) as compared to 22.7% of No dehydration. They could also have ingested some organisms which could not be detected due to lack of facilities. These factors could have contributed to death in these children. This highlights the importance of improving the water sources in the country, educating the general public regarding the importance of drinking treated water and urging the government to improve the water and sanitation systems at their level. Similarly, knowledge about ORS had a weakly significant relation with outcome (p=0.046); death occurred more in the group with poor knowledge. However, there was no significant relation between outcome and use of ORS before admission.

## CONCLUSIONS

Acute diarrhea is an important cause for hospital admission in children. AWD is more common cause for morbidity and associated with more abnormalities in renal function tests and electrolyte levels than ID. Derangements in renal function tests and serum sodium levels are seen with increasing severity of dehydration. In presence of clinical signs of dehydration, blood urea, serum creatinine and electrolytes mainly serum sodium levels should be assessed.

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