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Clinical assessment of renal function in pediatric cases of acute diarrheal disease with dehydration

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Abstract

Most children with diarrhea have no dehydration. However, some can be associated with dehydration. Presence of dehydration can be associated with pre-renal dysfunction and dyselectrolytemias which can adversely affect the outcome. The outcome therefore, rests on early diagnosis and treatment of dehydration. Hence present study was planned for clinical assessment of renal function in paediatric cases of acute diarrheal disease with dehydration.

The study was planned in Upgraded Department of Pediatrics, Patna medical College and Hospital, Patna, Bihar. The study was conducted from the Jan 2015 to Nov 2015. Out of the total 930 childrens admitted to Department 112 cases were diagnosed with the acute diarrhoea. These were evaluated and discussed as follows.

The data generated from the present study concludes that Acute Watery Diarrhea is more common cause for morbidity and associated with more abnormalities in renal function tests and electrolyte levels than Invasive Diarrhea. 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.

Keywords: acute diarrhea; children; dehydration; electrolytes; renal function, etc

Introduction

Diarrhea, also spelled diarrhoea, is the condition of having at least three loose, liquid, or watery bowel movements each day. It often lasts for a few days and can result in dehydration due to fluid loss. Signs of dehydration often begin with loss of the normal stretchiness of the skin and irritable behaviour. This can progress to decreased urination, loss of skin color, a fast heart rate, and a decrease in responsiveness as it becomes more severe. Loose but non-watery stools in babies who are exclusively breastfed, however, are normal [1].

The most common cause is an infection of the intestines due to either a virus, bacteria, or parasite—a condition also known as gastroenteritis. These infections are often acquired from food or water that has been contaminated by feces, or directly from another person who is infected. The three types of diarrhea are: short duration watery diarrhea, short duration bloody diarrhea, and persistent diarrhea (lasting more than two weeks, which can be either watery or bloody). The short duration watery diarrhea may be due to cholera, although this is rare in the developed world. If blood is present, it is also known as dysentery. A number of non-infectious causes can result in diarrhea. These include lactose intolerance, irritable bowel syndrome, non-celiac gluten sensitivity, celiac disease, inflammatory bowel disease such as ulcerative colitis, hyperthyroidism, bile acid diarrhea, and a number of medications. In most cases, stool cultures to confirm the exact cause are not required [2].

Diarrhea can be prevented by improved sanitation, clean drinking water, and hand washing with soap. Breastfeeding for at least six months and vaccination against rotavirus is also recommended. Oral rehydration solution (ORS)—clean water with modest amounts of salts and sugar—is the treatment of choice. Zinc tablets are also recommended. These treatments have been estimated to have saved 50 million children in the past 25 years. When people have diarrhea it is recommended that they continue to eat healthy food and babies continue to be breastfed. If commercial ORS are not available, homemade solutions may be used. In those with severe dehydration, intravenous fluids may be required. Most cases; however, can be managed well with fluids by mouth. Antibiotics, while rarely used, may be recommended in a few cases such as those who have bloody diarrhea and a high fever, those with severe diarrhea following travelling, and those who grow specific bacteria or parasites in their stool. Loperamide may help decrease the number of bowel movements but is not recommended in those with severe disease [2].

About 1.7 to 5 billion cases of diarrhea occur per year. It is most common in developing countries, where young children get diarrhea on average three times a year. Total deaths from diarrhea are estimated at 1.26 million in 2013—down from 2.58 million in 1990. In 2012, it was the second most common cause of deaths in children younger than five (0.76 million or 11%). Frequent episodes of diarrhea are also a common cause of malnutrition and the most common cause in those younger than five years of age. Other long-term problems that can result include stunted growth and poor intellectual development. Diarrhea is defined by the World Health Organization as having three or more loose or liquid stools per day, or as having more stools than is normal for that person. Acute diarrhea is defined as an abnormally frequent discharge of semisolid or fluid fecal matter from the bowel, lasting less than 14 days, by World Gastroenterology Organization [3].

Secretory diarrhea means that there is an increase in the active secretion, or there is an inhibition of absorption. There is little

to no structural damage. The most common cause of this type of diarrhea is a cholera toxin that stimulates the secretion of anions, especially chloride ions (Cl–). Therefore, to maintain a charge balance in the gastrointestinal tract, sodium (Na+) is carried with it, along with water. In this type of diarrhea intestinal fluid secretion is isotonic with plasma even during fasting [4]. It continues even when there is no oral food intake. Osmotic diarrhea occurs when too much water is drawn into the bowels. If a person drinks solution with excessive sugar or excessive salt, these can draw water from the body into the bowel and cause osmotic diarrhea. Osmotic diarrhea can also result from maldigestion, e.g. pancreatic disease or coeliac disease in which the nutrients are left in the lumen to pull in water. Or it can be caused by osmotic laxatives (which work to alleviate constipation by drawing water into the bowels). In healthy individuals, too much magnesium or vitamin C or undigested lactose can produce osmotic diarrhea and distention of the bowel. A person who has lactose intolerance can have difficulty absorbing lactose after an extraordinarily high intake of dairy products. In persons who have fructose malabsorption, excess fructose intake can also cause diarrhea. High-fructose foods that also have a high glucose content are more absorbable and less likely to cause diarrhea. Sugar alcohols such as sorbitol (often found in sugar-free foods) are difficult for the body to absorb and, in large amounts, may lead to osmotic diarrhea. In most of these cases, osmotic diarrhea stops when the offending agent, e.g. milk or sorbitol, is stopped. Exudative diarrhea occurs with the presence of blood and pus in the stool. This occurs with inflammatory bowel diseases, such as Crohn's disease or ulcerative colitis, and other severe infections such as E. coli or other forms of food poisoning [5].

Inflammatory diarrhea occurs when there is damage to the mucosal lining or brush border, which leads to a passive loss of protein-rich fluids and a decreased ability to absorb these lost fluids. Features of all three of the other types of diarrhea can be found in this type of diarrhea. It can be caused by bacterial infections, viral infections, parasitic infections, or autoimmune problems such as inflammatory bowel diseases. It can also be caused by tuberculosis, colon cancer, and enteritis. If there is blood visible in the stools, it is also known as dysentery. The blood is a trace of an invasion of bowel tissue. Dysentery is a symptom of, among others, Shigella, Entamoeba histolytica, and Salmonella [5].

Diarrheal disease may have a negative impact on both physical fitness and mental development. "Early childhood malnutrition resulting from any cause reduces physical fitness and work productivity in adults," and diarrhea is a primary cause of childhood malnutrition. Further, evidence suggests that diarrheal disease has significant impacts on mental development and health; it has been shown that, even when controlling for helminth infection and early breastfeeding, children who had experienced severe diarrhea had significantly lower scores on a series of tests of intelligence [6].

Diarrhea can cause electrolyte imbalances, kidney impairment, dehydration, and defective immune system responses. When oral drugs are administered, the efficiency of the drug is to produce a therapeutic effect and the lack of this effect may be due to the medication travelling too quickly through the digestive system, limiting the time that it can be absorbed. Clinicians try to treat the diarrheas by reducing the dosage of medication, changing the dosing schedule, discontinuation of the drug, and rehydration. The interventions to control the diarrhea are not often effective. Diarrhea can have a profound effect on the quality of life because fecal incontinence is one of the leading factors for placing older adults in long term care facilities (nursing homes) [5].

Proper nutrition is important for health and functioning, including the prevention of infectious diarrhea. It is especially important to young children who do not have a fully developed immune system. Zinc deficiency, a condition often found in children in developing countries can, even in mild cases, have a significant impact on the development and proper functioning of the human immune system. Indeed, this relationship between zinc deficiency and reduced immune functioning corresponds with an increased severity of infectious diarrhea. Children who have lowered levels of zinc have a greater number of instances of diarrhea, severe diarrhea, and diarrhea associated with fever. Similarly, vitamin A deficiency can cause an increase in the severity of diarrheal episodes. However, there is some discrepancy when it comes to the impact of vitamin A deficiency on the rate of disease. While some argue that a relationship does not exist between the rate of disease and vitamin A status, Others suggest an increase in the rate associated with deficiency. Given that estimates suggest 127 million preschool children worldwide are vitamin A deficient, this population has the potential for increased risk of disease contraction [7].

Numerous studies have shown that improvements in drinking water and sanitation (WASH) lead to decreased risks of diarrhoea. Such improvements might include for example use of water filters, provision of high-quality piped water and sewer connections [8].

In institutions, communities, and households, interventions that promote hand washing with soap lead to significant reductions in the incidence of diarrhea. The same applies to preventing open defecation at a community-wide level and providing access to improved sanitation. This includes use of toilets and implementation of the entire sanitation chain connected to the toilets (collection, transport, disposal or reuse of human excreta).

Basic sanitation techniques can have a profound effect on the transmission of diarrheal disease. The implementation of hand washing using soap and water, for example, has been experimentally shown to reduce the incidence of disease by approximately 42–48%. Hand washing in developing countries, however, is compromised by poverty as acknowledged by the CDC: "Handwashing is integral to disease prevention in all parts of the world; however, access to soap and water is limited in a number of less developed countries. This lack of access is one of many challenges to proper hygiene in less developed countries." Solutions to this barrier require the implementation of educational programs that encourage sanitary behaviours [9].

Given that water contamination is a major means of transmitting diarrheal disease, efforts to provide clean water supply and improved sanitation have the potential to dramatically cut the rate of disease incidence. In fact, it has been proposed that we might expect an 88% reduction in child mortality resulting from diarrheal disease as a result of improved water sanitation and hygiene. Similarly, a meta-analysis of numerous studies on improving water supply and sanitation shows a 22–27% reduction in disease incidence, and a 21–30% reduction in mortality rate associated with diarrheal disease [10].

Chlorine treatment of water, for example, has been shown to

reduce both the risk of diarrheal disease, and of contamination of stored water with diarrheal pathogens. Immunization against the pathogens that cause diarrheal disease is a viable prevention strategy, however it does require targeting certain pathogens for vaccination. In the case of Rotavirus, which was responsible for around 6% of diarrheal episodes and 20% of diarrheal disease deaths in the children of developing countries, use of a Rotavirus vaccine in trials in 1985 yielded a slight (2–3%) decrease in total diarrheal disease incidence, while reducing overall mortality by 6–10%. Similarly, a Cholera vaccine showed a strong reduction in morbidity and mortality, though the overall impact of vaccination was minimal as Cholera is not one of the major causative pathogens of diarrheal disease. Since this time, more effective vaccines have been developed that have the potential to save many thousands of lives in developing nations, while reducing the overall cost of treatment, and the costs to society [11].

A rotavirus vaccine decreases the rates of diarrhea in a population. New vaccines against rotavirus, Shigella, Enterotoxigenic Escherichia coli (ETEC), and cholera are under development, as well as other causes of infectious diarrhea. Dietary deficiencies in developing countries can be combated by promoting better eating practices. Zinc supplementation proved successful showing a significant decrease in the incidence of diarrheal disease compared to a control group. The majority of the literature suggests that vitamin A supplementation is advantageous in reducing disease incidence. Development of a supplementation strategy should take into consideration the fact that vitamin A supplementation was less effective in reducing diarrhea incidence when compared to vitamin A and zinc supplementation, and that the latter strategy was estimated to be significantly more cost effective [12].

Breastfeeding practices have been shown to have a dramatic effect on the incidence of diarrheal disease in poor populations. Studies across a number of developing nations have shown that those who receive exclusive breastfeeding during their first 6 months of life are better protected against infection with diarrheal diseases. One study in Brazil found that non-breastfed infants were 14 times more likely to die from diarrhea than exclusively breastfed infants. Exclusive breastfeeding is currently recommended for the first six months of an infant's life by the WHO, with continued breastfeeding until at least two years of age [13].

Most children with diarrhea have no dehydration. However, some can be associated with dehydration. Presence of dehydration can be associated with pre-renal dysfunction and dyselectrolytemias which can adversely affect the outcome. The outcome, therefore, rests on early diagnosis and treatment of dehydration. Hence present study was planned for clinical assessment of renal function in paediatric cases of acute diarrheal disease with dehydration.

Methodology

The study was planned in Upgraded Department of Pediatrics, Patna medical College and Hospital, Patna, Bihar. The study was conducted from the Jan 2015 to Nov 2015. Out of the total 930 childrens admitted to Department 112 cases were diagnosed with the acute diarrhoea. These were evaluated and discussed as follows.

Children more than one month and less than 5 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 [14].

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Following was the inclusion and exclusion criteria for the present study.

Inclusion Criteria: For Patients • Patient with Acute diarrhea defined as 3 or more loose, watery stools in a day, of less than 2 weeks duration) • Age above 18 years.

Exclusion criteria: for patients • Patients already receiving any form of calcium or magnesium therapy • Liver disease • Hypoalbuminemia due to any cause • Patient with pre-existing renal failure, Co-morbid conditions like malignancy, diabetes mellitus, hypertension, malnutrition and wasting, diarrhea attributable to any other systemic illness.

Results & Discussion

Dehydration classically refers to the excessive loss of body water through conditions such as diarrhea, sweating, or urinary losses, but among the lay public dehydration may also refer to the loss of both water and salt leading to a hypovolemic state [15]. Dehydration has multiple effects on the kidney, leading to urinary concentration due to activation of vasopressin that occurs as a result of increase in serum osmolarity due to the loss of body water. Classically dehydration results in a ‘pre-renal state' associated with intrarenal vasoconstriction but with relative maintenance of glomerular filtration rate (GFR). If volume depletion is severe, GFR falls, but it has been thought to be completely reversible with hydration, unless ischemia results in acute kidney injury (AKI). Nevertheless, AKI is thought be largely reversible. Hence, dehydration has not been classically considered a risk factor for chronic kidney disease (CKD).

Table 1: Parameters

Parameters	Acute Watery Diarrhea (AWD)	Invasive Diarrhea (ID)
Age		
Less than 1 years	42	4
1 years to 5 years	35	17
More than 5 years	4	4
Total	81	25
Urea		
Normal	34	12
High	47	13
Total	81	25
Creatinine		
Normal	35	14
High	44	11
Total	81	25
Sodium		
Normal	59	21
High	15	1
Low	7	3
Total	81	25
Potassium		
Normal	75	22
High	2	1
Low	4	2
Total	81	25
Dehydration		
No	7	3
Some	63	21
Severe	11	1
Total	81	25

Table 2: Outcome

Parameters	Acute Watery Diarrhea (AWD)	Invasive Diarrhea (ID)
Malnutrition		
Yes	31	23
No	50	2
Total	81	25
Outcome		
Discharged	80	24
Expired	2	1
Total	81	25

Some children with diarrhoea, especially young infants, develop hypernatraemic dehydration. This reflects a net loss of water in excess of sodium, when compared with the proportion normally found in ECF and blood. It usually results from the ingestion during diarrhoea of fluids that are hypertonic (owing to their content of sodium, sugar, or other osmotically active solutes, such as lactose in whole cow's milk) and not efficiently absorbed, and an insufficient intake of water or other low-solute drinks. The hypertonic fluids create an osmotic gradient that causes a flow of water from ECF into the intestine, leading to a decrease in the ECF volume and an increase in sodium concentration within the ECF.

Children with diarrhoea who drink large amounts of water or other hypotonic fluids containing very low concentrations of salt and other solutes, or who receive intravenous infusions of 50% glucose in water, may develop hyponatraemia. This occurs because water is absorbed from the gut while the loss of salt (NaCl) continues, causing net losses of sodium in excess of water.

Patients with diarrhoea often develop potassium depletion owing to large faecal losses of this ion; these losses are greatest in infants and can be especially dangerous in malnourished children, who are frequently potassium-deficient before diarrhoea starts. When potassium and bicarbonate are lost together, hypokalaemia does not usually develop. This is because the metabolic acidosis that results from the loss of bicarbonate causes potassium to move from ICF to ECF in exchange for hydrogen ion, thus keeping the serum potassium level in a normal or even elevated range. However, when metabolic acidosis is corrected by giving bicarbonate, this shift is rapidly reversed, and serious hypokalaemia can develop. This can be prevented by replacing potassium and correcting the base deficit at the same time.

The higher incidence of diarrhoea had also been reported by other workers [16, 17]. Newborns and infants because of their immature immunological response are particularly susceptible to infection especially if they are not breast fed. Moreover, they are easily prone to dehydration and electrolyte imbalance because of greater water content and increased insensible water loss from their body [18]. The predominance of hyponatremia in dehydrated children with acute diarrhoea has also been reported in other studies. Sharma *et al* found hyponatremia in 52.3% of children with diarrhoea and dehydration, whereas isonatremic dehydration was seen in 47.75% of children [23].

The pathogenesis of hyponatremia in diarrhoea is due to a combination of sodium and water loss and water retention to compensate for volume depletion [19]. In developed countries hypernatremia is commonest electrolyte imbalance in children suffering from diarrhoea with dehydration. Ironside *et al* found hypernatremia in 63% children and hyponatremia in 55% children [20]. This is probably because of concentrated

feeding formula being given to them.

Different studies suggested that hypokalaemia is a common problem in children with acute diarrhoea. Gastric secretions contain up to 20 mEq/L of potassium and diarrheal fluid contains 10–80 mEq/L [21]. Both the metabolic alkalosis which accompanies persistent vomiting and the dehydration resulting from vomiting and/or diarrhoea stimulate aldosterone release. Aldosterone excess further potentiates hypokalemia [22], there by compounding the potassium loss due to vomiting and diarrhoea.

Conclusion

The data generated from the present study concludes that Acute Watery Diarrhea is more common cause for morbidity and associated with more abnormalities in renal function tests and electrolyte levels than Invasive Diarrhea. 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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