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Evaluating the Efficacy of Fluid Therapy in Pediatric Patients Admitted to the Emergency Department

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ABSTRACT: Background and Objective: Fluid therapy is an essential part of treatment of dehydrated pediatric patients. There are few studies conducted regarding fluid therapy errors in hospitalized children. The aim of this study was evaluating the efficacy of fluid therapy in pediatric patients admitted to the emergency departments of three teaching hospitals. Methodology: This study was conducted in 2011 in Haft-e-Tir, Imam Hossein and Mofid hospitals. Dehydrated pediatric patients (under the age of 18) were evaluated for dehydration severity before treatment. Treatment was conducted and the data was collected including fluid type, fluid volume, bolus volume and its frequency, used electrolytes and treatment duration, outcome, length of stay and complications. The data was analyzed using SPSS, Ver. 20.Results: Totally 160 pediatric patients participated in this study. The mean and SD of the age of the patients was 26.2±31.1 months; 51.3% of the subjects were male, 70% of them suffered from moderate dehydration and the rest from severe dehydration; 42.8% of the patients (n=68) received improper fluid therapy in the first 8 hours, 73.3% in the first 16 hours, and 67.6% in the first 24 hours; meanwhile 34.5% of children had received inadequate bolus treatment. All of the ICU patients had received proper fluid therapy. Conclusion: Improper fluid therapy is a common error in dehydrated pediatric patients; however, patients with severe conditions received fluid therapy more properly. Improvement of the knowledge of healthcare team can play an important role in prevention from and reduction of the fluid therapy errors.

Key words: Fluid therapy, Medical Errors, Pediatric patients, Dehydration, Emergency department.

ORIGINAL ARTICLE

INTRODUCTION

The health of the patients of is one of the main issues in medicine and is a priority for research. According to the literature, annually a large number of patients are harmed due to medical errors, while a significant number of such harms are preventable, and their number can be greatly reduced by identifying and understanding their causes (Colletti et al., 2010). Nowadays, dehydration is one of the causes of morbidity and mortality in the world, especially in children aged less than 5 years due to hypoxia and ischemia, which can cause physical and mental disabilities and may lead to permanent disabilities. With proper treatment of dehydration, however, the mortality and morbidity rate due to insufficient amount of fluids can be reduced (Karpas et al.. 2009).The aim of fluid therapy is compensating the lost water and electrolytes in order for achieving a normal balance of these factors and improving the patient's condition. Clinical dehydration scales are based on a combination of findings of the physical examinations and are the most sensitive and specific tools for diagnosis of dehydration in dehydrated pediatric patients and for classification of the severity of the disease. Diagnosis of this condition in a timely manner can save patients, while misdiagnosis or delayed diagnosis can be a cause of increased morbidity (Goldman et al., 2008).

Dehydration is one of the important causes of admission of the pediatric patients (those who aged less than 18 years) to emergency departments and one of the causes of morbidity and mortality in the world, particularly in children aged less than 5 years. Children are at higher risk of dehydration and subsequent risk of morbidity and mortality because they have higher extracellular fluid volume (Holliday et al., 2008, Han et al., 2005). In recent years, numerous studies have been conducted on fluid therapy of pediatric patients in emergency departments, but they have mainly focused on the value of scoring systems, the severity of the dehydration and oral rehydration vs. intravenous administration for dehydration treatment (Jemma et al., 2007). In our country, little research has been performed concerning the errors in fluid therapy. The aim of this study was evaluating the efficacy of fluid therapy in pediatric patients admitted to the emergency departments of three hospitals, namely Haft-e-Tir, Imam Hossein and

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Mofid, so that the results may help us to take a small step towards reducing morbidity and mortality rates of patients.

METHODS AND MATERIALS

This cross-sectional study was conducted on dehydrated patients younger than 18 years admitted to the emergency departments of three teaching hospitals, namely Haft-e-Tir, Imam Hossein and Mofid at 3 stages and in the year 2012. Patients whose CDS (Clinical dehydration scale) score was zero and those who could not receive fluid therapy orally, via NG tube or intravenously were excluded. At first stage, CDS was used and the patients were examined in terms of dehydration severity before treatment, then their baseline data including age, gender, vital signs, apparent symptoms, ocular symptoms, symptoms of dried mucus and lacrimation symptoms were recorded. Secondly, the carried out fluid therapy was recorded in terms of fluid type, fluid volume, bolus volume and its frequency, used electrolytes and duration of treatment, without the intervention of the researcher. During the third stage, outcome of the patients was examined including recovery and discharge, length of stay, intubation, ICU stay, complications and mortality. Then the data of the first and second stages were presented to the pediatricians who were not informed of the outcomes and the patients and the patients were divided into two groups based on their opinions, namely well-managed and miss-managed groups. The collected data was analyzed using a statistical software program, i.e. SPSS Ver. 11.05. Some statistical tests such as independent sample T-test, Mann-Whitney U test and chi square test and Pearson's' and Spearman's correlation coefficients were used. The level of statistical significance was considered to be $p < 0.05$.

RESULTS

In this study, 160 pediatric patients aged from 1-170 months, with mean and SD of 26.2±31.1 months was examined. Of these, 82 patients (51.3%) were male and the rest were female. Their average weight was 12±8.5 kg. Underlying cause for dehydration included diarrhea in 128 patients (80%), vomiting in 125 patients (78%), polyuria in 10 subjects (6%), fever in 33 patients (20%) and diabetic ketosis in 4 subjects (2%) whether alone or in combination with other symptoms. The accompanied symptoms included food intolerance in 43 patients (26%), polydipsia in 5 patients (3%), and infection (sepsis) in four subjects (2%) alone or in combination with other symptoms. In terms of level of consciousness (GCS), 135 patients (84.4%) were conscious, and 25 subjects (15.6%) had some degrees of unconsciousness. Mean and SD of weight of the samples was 12±8.5 kg. Table 1 represents the patients' appearance and the severity of dehydration in them.

Table1: Patients' appearance and the severity of dehydration in them

Items		Number	Percent
The patient's appearance	Normal	13	8.1
	Thirst, restless, lethargic but sensitive to touch	132	82.5
	Sleepy, cold, sweating, comatose, limp	15	9.4
Eye response	Open	9	5.6
	Lethargic	106	66.3
	Sharply sinking and lethargic	45	28.1
Dryness of mucous	Wet	12	7.5
	Adhesive	38	23.8
	Dry	110	68.8
Lacrimation	Natural	64	40
	Reduced	52	32.5
	None	44	27.5
Dehydration severity	Low (below 4%)	0	0
	Medium (4 to 9%)	112	70
	High (above 9%)	48	30

The mean and SD of calculated needed bolus in order to overcome dehydration were 236.6 ±164.2 ml. The mean and SD of received bolus to eliminate dehydration were 177.3±183.2 ml, respectively. The number (percentage) of those who received appropriate fluid bolus was 105 (65.6%).The mean and SD of number of received bolus were 1.6±1, and 74 patients (59.7%) received one bolus, 34 patients (27.4%) were given two boluses, 13 subjects (10.5%) received three boluses, 2 subjects (1.6%) were given 4 boluses and finally 1 patient (0.9%) received nine boluses, meanwhile 36 cases (22.5%) received no bolus at all. The mean and SD of the needed fluid for patients in the first 8 hours of treatment was 916.3±480.7 ml, respectively. The mean and SD of the received fluid during the first 8 hours were 657.8±351.6 ml, while 18 patients did not receive any fluid or were stayed less than

8 hours in the emergency department. The number (percentage) of the patients who received insufficient fluid during the first 8 hours was 68 (42.8%). The mean and SD of the fluid requirements in the first 16 hours by patient were 1245.3±670.4 ml, while the mean and SD of the received fluid by patients during the first 16 hours amounted to 1168.2±721.4 ml and 54 subjects did not receive any fluid or were stayed less than 16 hours in the hospital.

The number (%) of the patients who received inadequate fluid in the first 16 hours was 74 (73.3%), while the length of stay of 59 people was not enough so that the fluid needed for the first 16 hours can be calculated for them. The mean and SD of the total fluid intake by patients in the first 24 hours were 2742.2±2775.5 ml, respectively. The mean and SD of total fluid needed by patients in the first 24 hours were 2169.5±1189.5 ml. The number (percentage) of the patients who received insufficient fluid in the first 24 hours was 69 (67.7%), while length of stay of 58 people was not enough so that the fluid needed for the first 24 hours can be calculated for them. Fluid and electrolytes were prescribed alone or in combination with other fluids and electrolytes, and therefore the final percentage is greater than 100%. The mean and SD of duration of treatment and length of stay were 53.4±57.3 and 61±78.3 hours, respectively. Intubation was needed in four cases (2.5%) and hospitalization at ICU was occurred for four cases (2.5%). The mean and SD of length of stay at ICU were 0.3± 3.1 hours. Complications include hypovolemic shock in three patients (1.9%), intussusception and abdominal surgery in 2 cases (1.2%), ATN in one case (0.6%) and resistance to treatment in 1 case. Outcome of patients included recovery and discharge in 147 cases (91.9%), death in one case (0.6%) and referral to another medical center in 12 cases (7.5%). The percentage of the people with hyponatremia (sodium level less than 135 mg/dl) and hypernatremia (sodium level greater than 145 mg/dl) was 12.4% and 15.9 respectively. The percentage of those with hypokalemia (potassium level less than 3.5 mg/dl) or hyperkalemia (potassium level greater than 5.5 mg/dl) was 4.4% and 3.5 respectively. Percentage of subjects with abnormal level of urea (above 20 mg/dl) was 26% and percentage of the children who had creatinine higher than 1mg/dl was 5.5%.

Table 2: Assessment of dehydration in pediatric patients based on the Clinical Dehydration Scale (CDS) scoring system

CDS score of pediatric patients	Number	Percent
1	1	0.6
2	8	5
3	27	16.9
4	41	25.6
5	28	17.5
6	35	21.9
7	17	10.6
8	3	1.9

Bolus fluid therapy in males (62 boys (75.6%) was better than the therapy in females (43 girls (55.1%)) (p = 0.006). Of those who had dried mucus, 79 patients (71.8%) had appropriate fluid bolus therapy while 31 patients (28.2%) had inappropriate fluid bolus therapy. This difference was statistically significant (p = 0.049). Among those without lacrimation, 32 patients (74.4%) had received adequate 8-hour fluid therapy, and 11 patients (25.6%) experienced poor 8-hour rehydration (less than the required amount) and this difference was statistically significant (p = 0.019). Dehydration severity was significantly correlated with appropriate fluid bolus therapy (p = 0.001), as 41 patients (85.4%) of those with severe dehydration, also received adequate fluid bolus therapy. Dehydration severity was also significantly correlated with 8-hour fluid therapy (p = 0.013), as 34 of those with severe dehydration (72.3%), received appropriate fluid bolus therapy. Among people who were not hospitalized at ICU, 30.3% had received proper 24-hour fluid therapy, while among those patients who were hospitalized at ICU, the figure was 100% (p = 0.032). Treatment type was also associated with proper fluid therapy (p = 0.032), as among the people who received symptomatic treatment, 18 patients (72%) had adequate 8-hour fluid therapy, while among those who were treated for infection (were given at least one antibiotic as a part of the treatment), for 11 patients (42.3%) such treatment was sufficient. Among those who had received bolus more than once (n = 18, 51.4%), the level of adequate received 24-hour bolus was higher, which was statistically significant (p = 0.028), than those who received a single bolus (n = 13, 27.7%). People whose CDS scores were greater than four (n = 64, 77.1%) received adequate fluid bolus therapy compared with those whose CDS scores were equal to or less than four (n = 41, 53.2) and the difference was statistically significantly (p = 0.001). Length of stay (p = 0.05) and treatment duration (p = 0.012) were related with outcomes of patients and this was statistically significant. The number of received blouses (p = 0.009), CDS score (p< 0.001), age (p = 0.011) and weight (p = 0.037) were significantly correlated with the amount of lacrimation. CDS score (p < 0.001) was significantly correlated with

the degree of mucosal dryness. Mean level of creatinine ($p = 0.014$), CDS score ($p < 0.001$), mean systolic blood pressure ($p = 0.001$) and weight ($p = 0.031$) were significantly associated with ocular conditions. Length of stay ($p = 0.033$), CDS score ($p< 0.001$), mean systolic blood pressure ($p = 0.016$) and mean respiratory rate ($p = 0.001$) were correlated with the appearance of the patients.

This study aimed to evaluate the adequacy of fluid therapy in pediatric patients admitted to the emergency departments of Haft-e-Tir, Imam Hossein and Mofid hospitals. The results of this study showed that patients who had more severe dehydration, received fluid therapy more favorably, while those patients who were better and had been discharged received inefficacious fluid therapy. Fluid therapy is an essential part of treatment for patients who are hospitalized. Assessment of the electrolytes and fluid conditions of the patients generally depends on the medical history, the patient's condition, vital signs, body weight changes, fluid balance chart (intake and output), hemodynamic and autonomic responses, properties of skin and mucous membrane, and physical and biochemical assessment of serum and urine (Han et al. 2005).

Choosing the wrong type of fluid, its volume and concentration and error in infusion rate of fluid can lead to patients' morbidity and mortality. Clinical complications such as pulmonary edema and heart failure have been reported due to these errors. Hypotonic fluid therapy can result in hyponatremia in patients (Rooker et al. 2007; Gorard 2007). Additionally, fluid therapy errors can increase the cost of treatment. In the literature review, few studies was found regarding the assessment of fluid therapy in patients, all of which cited infusion rate error as the most common error with fluid therapy (Gladstone et al. 1995).In a previous study (18), the level of error in fluid intake in patients was 30%. Rocker's study reported the error in the amount of infused fluid in a fifth of patients. In another study, the incidences of errors in IV bolus doses have been reported from 10.3 to 49 percent (Taxis et al. 2003).In this study, in 68 patients (42.8%), 8-hour fluid intake was assessed as insufficient and 74 subjects (73.3%) received inadequate fluid in the first 16 hours, while 69 patients (67.6%) received wrong amount of fluid in the first 24 hours. The percentage of the patients in the present study who were assessed with unsuitable adequacy of fluid therapy was greater than the percentage of errors in previous studies, i.e. 20-%30%, 10.3%-49% (111). Moreover, 34.5% of people also received inappropriate bolus. The study by Han et al showed that the risk of error significantly increased with hydration time (Bruce et al. 2001). In the current study, inappropriate fluid therapy in the first 8 hours (42.8%) was significantly less than the fluid therapy in the first 16 hours (73.3) and the first 24 hours (67.6), and the difference was statistically significant ($p <0.01$).

Comparison of efficacy of 8-hour, 16-hour and 24-hour fluid therapy after treatment showed that adequacy of the received fluid by patients was not similar at these durations and at 8-hour period, more patients had received required fluids.

DISCUSSION

This result indicates that in the first hours of hospitalization of the dehydrated patients, fluid therapy has been conducted more appropriately. The patients were in the emergency department for the first 6 hours of hospitalization, and more severity led to better treatment and fluid therapy. When patients were hospitalized in other departments, the percentage of improper fluid therapy was significantly increased that can also be explained as a result of better general conditions of the patients, which result in receiving less attention. Despite the fact that fluid therapy in the first 8 hours, i.e. in the emergency department, was better than the following hours, the level of inappropriate fluid therapy (42%) is very high and special attention should be paid in this regard. One of the problems in emergency departments of teaching hospitals is overcrowding and the major reason for it is insufficient number of beds in them. The majority of the patients who had inadequate fluid therapy were discharged in the first 8 hours. The general conditions of these patients were determined as "good" and they could be discharged in order for preventing from overcrowding of emergency departments and reducing health care costs before completion of the process of fluid therapy. In the present study, 30.3% of people who were not hospitalized at ICU had suitable 24-hour fluid therapy. Meanwhile, all those who had been admitted to ICU had received proper therapy in the first 24 hours. The findings of this study also suggest that proper fluid therapy occurred in people who were less sick. These findings are also true regarding the received bolus, i.e. the received 24-hour suitable bolus for people who had received bolus more than once ($n = 18$, 51%) was significantly more than those who were received a single bolus ($n = 13$, 27.7%).

Our findings that poor fluid therapy increases with longer duration of treatment is consistent with the findings of the previous studies (Hartley et al. 1998), and the improved general conditions of the patients were accompanied with the less time for monitoring them by the treatment team (Moritz et al., 2007). However, the patients who had a more serious condition, such as those who needed intensive care were assessed more frequently by the treatment team. Evaluation of patients with dehydration is one of the main problems we are faced with in emergency departments, and patients' vital signs, hemodynamic parameters, levels of electrolytes, serum and urine biochemistry, daily intake and output, kidney function tests and physical examination findings are mainly used in the emergency departments of the hospitals

for evaluation of dehydrated patients. In a previous study, 25% of errors were related to assessing the amount of fluid in dehydrated patients, while in the present study, we did not have such problem and fluid intake was calculated correctly in all patients.

In the current study, treatment type was also associated with proper fluid therapy ($p = 0.032$), as among the people who received symptomatic treatment, 18 patients (72%) had adequate 8-hour fluid therapy, while among those who were treated for infection (were given at least one antibiotic as part of the treatment), such treatment was sufficient only for 11 patients (42.3%). These findings illustrate the importance of treatment for dehydrated patient, so that appropriate and timely treatment can play a vital role in improving the conditions of these patients. Among patients participating in the study, 19 patients were referred to other medical centers due to lack of enough bed at ICU. One of the patients died and the remaining patients recovered, and were discharged.

Generally, following the use of hypotonic fluids, hyponatremia happens in hospitalized patients. Hypotonic fluids are the most common IV fluids used for both hospitalized children and adults (Moritz et al. 2007). Hypernatremia, hyponatremia and hypoglycemia sometimes complicate severe dehydration. Considering the patient's underlying medical condition such as diabetes, hypertension and kidney disorders is critical for fluid therapy and proper treatment of dehydration and therefore these patients need to be closely monitored.

CONCLUSION

The results of this study indicate a high rate of inappropriate fluid therapy in dehydrated pediatric patients. In teaching hospitals, such as the hospitals included in this research, residents are also among the members of the treatment teams. Lack of knowledge and experience of residents can be one of the causes of error in treatment. Promoting knowledge, awareness and attention of the treatment team regarding assessment of the these patients, evaluation of hydration severity, deciding about the required fluid and choosing the right type of intake fluid and careful monitoring of the patients' hemodynamic and laboratory parameters are necessary to prevent from and to reduce fluid therapy errors in pediatric patients.

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