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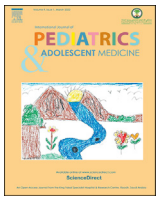

Original article

Outcomes and predictors of early emergency department discharge among children with acute gastroenteritis and moderate dehydration

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ABSTRACT

Background: Gastroenteritis is one of the most common diseases that affects children and remains a leading cause of morbidity and mortality around the world. There is conflicting evidence regarding the effect of rapid intravenous fluid regimen on the clinical outcome of patients with acute gastroenteritis. This study aimed to assess the current practice of intravenous hydration on the clinical outcomes of pediatric patients with acute gastroenteritis and determine the predictive factors for early discharge and emergency department (ED) revisit.

Methods: A cohort study was carried out among children aged from 1 month to 14 years who presented to the ED in a tertiary care hospital between September 2015 and September 2017. Children diagnosed with acute gastroenteritis and moderate dehydration who require intravenous hydration were included in the study. The patients were followed up until discharge from ED, admission to the hospital or revisit to the ED. Collected variables were demographics, presenting symptoms, biochemical marker, amount of intravenous fluid (IVF) received and prescription of anti-emetics. Descriptive statistics were summarized as mean, standard deviation for continuous variables and proportions for categorical variables. Logistic regression was used to identify risk factors.

Results: Out of 284 patients, 148 (52%) were males, 20 (7%) were infants, 80 (28%) were toddlers, 90 (32%) were in preschool, 88 (31%) were in school and 6 (2.1%) were adolescents. No significant difference was observed in the admission rate, discharge within 12 h or less and ED revisits for those who received IVF ≥40 ml/kg as compared to those who received <40 ml/kg. Patients with bicarbonate level closer to normal are more likely to be discharged after 4 h (odds ratio (OR) 1.2 and 95% CI 1.12−1.43). Patients presenting only with vomiting/diarrhoea were less likely to revisit ED (OR 0.33 (95% CI 0.143 - 0.776), while patients with an increase in CO_2 level (OR 1.19 and 95% CI 1.0 -1.436) and anion gap (OR 1.29 and 95% CI 1.08−1.54) were more likely to revisit within 1 week post discharge.

Conclusion: This study did not show any additional benefits of receiving IVF ≥ 40 ml/kg over 4 h neither in early discharge nor in reducing the ED revisit. CO_2 closer to normal was a significant predictor for early discharge in 4 h where the closer level of CO_2 and AGAP were associated with an increase in the chance of a revisit to the ED within 1 week after discharge.

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1. Introduction

Acute gastroenteritis is one of the most common diseases that affects pediatric patients and remains a leading cause of pediatric morbidity and mortality around the world, particularly when it is complicated by dehydration [1]. Usually, it is manifested by vomiting, fever, abdominal pains, nausea and diarrhea. The disturbance in the secretion and absorption processes in the small and large intestines leads to dehydration [2,3].

In the United States, children who are under the age of 5 years account for more than 1.5 million outpatient visits, 200,000 hospitalisations and around 300 deaths annually, with a direct cost of $250 million and around $1 billion in total costs to the community [4–6].

Worldwide, around 2 million deaths are estimated to occur annually among children aged less than 5 years [5]. The American Academy of Pediatrics and the World Health Organization suggest that the treatment of gastroenteritis should be according to the degree of dehydration; mild to moderate dehydration can be rehydrated with Oral Rehydration Solutions (ORS) [7,8], but in case of failure of oral rehydration or severe dehydration, intravenous rehydration is typically used, starting with normal saline or lactated ringer's solution with a rate of 20 ml/kg over 1 h [7].

Physicians use both types of intravenous fluids (IVF), slow over 24 h and rapid rehydration regimens over 1–4 h. It is stated that rapid rehydration regimens might minimise the time of recovery and the length of stay in ED in addition to treatment costs [9]. Generally, it is the usual practice in the treatment of rapid fluid resuscitation to give 40–60 ml/kg of IVF over 1–4 h to replenish circulating intravascular fluid volume [7,10,11]. However, there is still not enough evidence to establish a standard protocol due to wide variation in volume and infusion rates of fluid solution, which are recommended by different emergency department (ED) guidelines [8,12].

Also, in moderately dehydrated children who received IVF therapy, electrolyte levels should be measured initially and as therapy progresses [1]. The most essential serum marker is bicarbonate, which is used to improve physician assessment of dehydration severity and to influence the determination of patient disposition [6–8]. The reason underlying that is the fact that with symptoms of gastroenteritis and dehydration like vomiting and diarrhoea, patients will have an anion gap (AGAP) acidosis from ketosis, which may result in an increase in the severity of symptoms [13,14].

Previous studies, therefore, were not consistent and showed variant results and clinical outcomes of rapid intravenous rehydration with limitation to identify the optimal rapid IV treatment regimen [11,12]. This study aimed to assess the current practice of rapid intravenous rehydration in a tertiary care hospital and the clinical outcomes among pediatric patients who were moderately dehydrated as a result of acute gastroenteritis as well as to determine the predictive factors of early discharge and ED revisit.

2. Methods

A retrospective cohort study was conducted to assess the rapid rehydration over a 4-h impact on the outcome of pediatric patients who visited the ED of a tertiary care hospital in Saudi Arabia from September 2015 to September 2017. All children who were of the age from 1 month up to 14 years, presented with acute gastroenteritis, with moderate dehydration diagnosed by using the Gorelick scale and who required intravenous rehydration were included [15]. Patients with severe chronic systemic disease such as (cardiology, nephrology, metabolic and hematoncology on treatment), bilious or bloody vomit, presence of blood in stool or hematemesis, sepsis or severely ill patients who had a suspected surgical condition and patients with electrolyte level abnormalities (Na (sodium) > 150 mmol/L or < 130 mmol/L and K (potassium) > 5.5 mmol/L or < 3 mmol/L) were excluded.

The demographic and baseline clinical data included age, sex, vital signs, presenting symptoms, biochemical markers, laboratory tests such as sodium, chloride, potassium, creatinine, urea, random plasma glucose, bicarbonate, AGAP and the use of antiemetic medication. The main outcome consisted of variables, including fluid amount, length of stay in the ED, the need of admission and ED revisits. The patients were followed up until discharge (classified as either discharge at 4 or 12 h) or admission to the hospital. Those who were discharged were followed up for any subsequent ED revisit within one week. The classification of administered IVF was: $\geq$ 40 ml/kg or <40 ml/kg.

Demographic characteristics were summarised and reported in terms of mean, standard deviation for continuous variables and proportions with percentage for categorical variables. Chi-square/Fisher's exact test was used to compare the presenting symptoms across age categories, while ANOVA test was utilised to compare continuous variables across age categories. Logistic regression was carried out to identify the predictors of discharge from ED at 4 h and ED revisit within 1 week after discharge. Results were reported as odds ratio, 95% CI and corresponding *P* values. Significance was declared at alpha less than 0.05. All analyses were performed by using the SAS version 9.4 (SAS Institute, Cary, NC, USA).

3. Results

In total, 284 patients met the inclusion criteria age ranging: 20 (7.04%) infants, 80 (28.15%) toddlers, 90 (31.69%) pre-school age, 88 (30.95%) school age and 6(2.11%) adolescents. In all, 52.1% (148) were male patients. The presenting symptoms such as vomiting ($P = .004$) and abdominal pain ($P = .0001$) were significantly different across different age groups (Table 1).

3.1. Discharge from ED and revisit to ED

The patients' discharge rate at 4 h ($P = .553$), discharge rate at 12 h ($P = .335$), admission to the ward ($P = .069$) or rate of ED revisits ($P = .890$) was not statistically different between patients who had received <40 ml/kg vs. $\geq$ 40 ml/kg IVF (Table 2).

3.2. Predictors of discharge at 4 h

The potential risk factors of discharge at 4 h among patients admitted with gastroenteritis and moderate dehydration are summarised in Table 3. Among the explored factors using logistic regression: gender, presenting symptoms, use of anti-emetic, laboratory parameters (anion gap, BUN and random glucose) and amount of the IVF (<40 ml/kg vs. $\geq$ 40 ml/kg) were not statistically significant predictors of discharge at 4 h. The increment in CO_2 is a significant predictor of discharge at 4 h ($P = .0001$).

3.3. Predictors of ED revisit within one-week of discharge

The potential risk factors of revisits among patients who were discharged from ED are summarized in Table 4. Among the explored predictors: gender, use of anti-emetic and laboratory parameters were not statistically significant predictors of revisit after discharge. The only significant factors of ED revisit within 1 week post discharge were CO_2 ($P = .049$) and AGAP ($P = .003$).

Table 1
Demographic and baseline characteristics of the study groups.

	Infant (1–12 months) *n = 20*	Toddler (1–2 years) *n = 80*	Preschool (3–5 years) *n = 90*	School (6–12 years) *n = 88*	Adolescent (13–14 years) *n = 6*	*P* value
Gender *n(%)*	9 (45)	43 (53.75)	44 (48.89)	48 (54.55)	4 (66.67)	.811[a]
Male						
Females	11 (55)	37 (46.25)	46 (51.11)	40 (45.45)	2 (33.33)	
Weight *(Mean ± SD[a])*	7.42 ± 1.88	10.77 ± 1.61	15.46 ± 3.63	27.1 ± 9.07	51.35 ± 11.45	-
Presence of Symptoms yes *n(%)*						
Vomiting	16 (80)	77 (96.25)	89 (98.89)	86 (97.73)	5 (83.33)	.004[b]
Diarrhoea	18 (90)	65 (81.25)	73 (81.11)	68 (77.27)	5 (83.33)	.808[b]
Abdominal pain	0 (0.0)	2 (2.5)	23 (25.56)	49(55.68)	5 (83.33)	<.0001[a]
Fever	12 (60)	45 (56.25)	47 (52.22)	45 (51.14)	2 (33.33)	.771[a]
Vital Signs *(Mean ± SD)*						
HR (min)	151.20 ± 23.63	142.65 ± 19.45	127.13 ± 13.70	116.22 ± 17.52	112 ± 13.07	–
RR (min)	37.65 ± 6.41	31.83 ± 4.05	28.31 ± 2.97	25.43 ± 3.03	23 ± 3.79	–
Temperature (°C)	37.22 ± 0.52	37.16 ± 0.66	37.11 ± 0.64	37.22 ± 0.72	36.98 ± 0.35	–
SBP (mmHg)	99.75 ± 10.34	102.85 ± 9.54	103.84 ± 10.74	108.24 ± 9.74	119 ± 10.25	–
DBP (mmHg)	62.60 ± 11.04	61.39 ± 12.27	62.93 ± 10.74	64.3 ± 9.71	67.2 ± 8.76	–
Electrolytes *(Mean ± SD)*^						
Sodium (mmol/L)	139.55 ± 3.32	136.67 ± 2.85	135.69 ± 2.57	136.66 ± 2.59	135.5 ± 2.66	<.0001
Potassium (mmol/L)	4.38 ± 0.55	4.25 ± 0.48	4.11 ± 0.41	4.05 ± 0.40	4.03 ± 0.23	.006
Chloride (mmol/L)	109.75 ± 6.04	104.95 ± 3.59	103.67 ± 2.83	104.15 ± 3.00	103 ± 2.61	<.0001
Random glucose (mmol/L)	4.59 ± 0.91	4.32 ± 1.41	4.37 ± 1.62	5.12 ± 1.21	5.05 ± 1.02	.001
BUN (mmol/L)	4.58 ± 1.71	5.16 ± 1.97	4.96 ± 1.86	4.66 ± 1.46	4.35 ± 0.64	.321
Creatinine (μmol/L)	38.5 ± 4.57	41.32 ± 4.36	45.50 ± 5.98	51.60 ± 5.86	60.67 ± 6.74	<.0001
CO2 (mmol/L)	16 ± 3.81	15.78 ± 3.14	16.52 ± 3.42	19.22 ± 3.38	19.17 ± 3.25	<.0001
AGAP (mmol/L)	18.3 ± 3.10	20.24 ± 3.56	19.58 ± 3.79	17.40 ± 3.61	17.33 ± 2.42	<.0001

a *P* value is based on chi-square test.
b *P* value is based on Fisher's exact test.
c *P* value is based on ANOVA.
Abbreviations: SD: Standard deviation. BUN (blood urea nitrogen). AGAP (Anion Gap).
The reported percent is column percentage.

Table 2
Primary outcomes and amount of IVF.

Outcomes	IVF <40 n(%)	IVF ≥ 40 n(%)	*P* value [a]
Discharge at 4 h *(yes) n = 81*	66 (81.48)	15(18.52)	.553
Discharge at 12 h *(yes) n = 141*	115 (81.56)	26(18.44)	.335
Admission to ward *(yes) n = 62*	44(70.97)	18(29.03)	.069
ED revisit within 1 week after discharge *(yes) n = 34*	25(75.53)	9 (26.47)	.382

IVF: Total amount of intravenous fluid (ml/kg).
ED: Emergency department.
The reported percent is a row percent.
[a] *P* value is based on the chi-square test.

4. Discussion

This study assessed the relation between the amount of IVF and the early discharge of the patient at 4 and 12 h after receiving intravenous hydration. Failure to discharge at 4 or 12 h led the patient to be admitted. We found that more amount of intravenous fluid hydration, specifically ≥40 ml/kg over 4 h did not facilitate discharge in 4 h as compared to patients who received <40 ml/kg over 4 h. These results were similar to other studies that reported no significant differences between the

Table 3
Risk factors of discharge at 4 h after presenting to ED.

Risk Factors	Estimate(SE)	OR(95% CI)	*P* value
Gender (female *vs. male*)	−0.161 (0.285)	0.851 (0.487–1.488)	.572
Symptoms (abdominal pain/fever with vomiting and diarrhea *vs. vomit & diarrhea alone)*	−0.265(0.304)	0.767(0.422–1.393)	.383
Anti-emetic (yes *vs. no)*	−0.391 (0.299)	0.676 (0.376–1.215)	.191
CO_2	0.239 (0.061)	1.270 (1.127–1.432)	**.0001**
Anion gap	0.020 (0.062)	1.020 (0.903–1.153)	.747
BUN	0.127 (0.090)	1.135(0.951–1.356)	.160
Random blood glucose	−0.160 (0.133)	0.825 (0.656–1.105)	.227
IVF (more than or equal 40 *vs. less than 40*)	0.027 (0.365)	1.028 (0.503–2.103)	.939

OR: Odd ratio, CI: Confidence Interval, SE: Standard Error and IVF: intravenous fluids.
The reference groups are italicised.
The model is based on probability of discharge at 4 h.

Table 4
Risk factors for ED revisit within 1 week post discharge.

Risk Factors	Estimate (SE)	OR (95% CI)	*P* value
Gender (female *vs. male*)	−0.485 (0.421)	0.616 (0.269–1.406)	.250
Symptoms (abdominal pain/fever with vomiting and diarrhea *vs. vomiting and diarrhea)*	−1.099 (0.431)	0.333 (0.143–0.776)	**.011**
Anti-emetic (yes *vs. no)*	0.075 (0.463)	1.079 (0.435–2.673)	.870
CO_2	0.181 (0.092)	1.199 (1.000–1.436)	**.049**
Anion gap	0.261 (0.089)	1.299 (1.089–1.548)	**.003**
BUN	−0.079 (0.137)	0.923 (0.705–1.210)	.563
Glucose random	0.017 (0.180)	1.018 (0.715–1.450)	.921
IVF (≥40 *vs.* < *40*)	−0.322 (0.542)	0.725 (0.250–2.098)	.553

OR: Odd ratio, CI: Confidence Interval, SE: Standard Error and IVF: intravenous fluids.
The reference groups are italicised.
The model is based on the probability of revisit within 1 week of discharge from ED.

amount of IVF in relation to the length of stay in ED and the ED revisit rate [12].

A literature review reveals that many studies support less IVF for a better clinical outcome. As reported in a study, one of the variables significantly associated with the successful discharge was 'less intravenous fluids administered'; the analysis identified that the volume of IVF administered (mL/kg) was negatively associated with successful discharge (95% CI 0.76–0.93 and $P < .001$) [14].

Despite the lack of supporting evidence and the view that there is too much dependence in North America on laboratory tests, many physicians base their decisions on laboratory parameters [16,17].

Several studies examined the relation between serum electrolyte and different treatment outcomes such as the need for admission, discharge from ED and suspecting revisit to ED later. A review of the literature shows several publications with conflicting results regarding the value of these laboratory parameters in predicting the outcome, in which the studies have reported that serum CO_2 has an impact on discharge or revisit.

Our study has shown clearly that serum values of CO_2 and AGAP were useful in the anticipation of the clinical outcome of early discharge from ED or ED revisit with a positive association as with each unit increase in the CO_2 level, there is a more likely chance for the patient to get discharged in 4 h. In a recent prospective study, low serum bicarbonate (<20 mmol/L) was the most commonly cited reason (around half) of failure of discharge and needed for hospitalisation among children with gastroenteritis treated with intravenous rehydration [18].

Another prospective study for children with gastroenteritis treated with intravenous rehydration showed that those with a baseline metabolic acidosis (bicarbonate < 16 mmol/L) were more likely to be hospitalised (38% vs. 15% and $P < .001$); however, this study demonstrated that ED revisits are associated with closer level to normal of serum bicarbonate [14], which was in accordance with the current study results. Furthermore, a recent case-control study similarly found that serum bicarbonate was not associated with return visits to ED. Also, it is shown that there is no difference in mean serum bicarbonate levels among patients with or without return visits who require admission or who received further medical treatment and those who did not receive further medical treatment [13,14,19].

Another laboratory finding, which is AGAP, showed a significant result (95% CI 1.070–1.484) as with each unit increase in AGAP, a patient is more likely to revisit ER within 1 week after discharge, which was opposite to another study, as they found no relation between ED revisit within 7 days and AGAP ($P = 0.54$) [14].

Vomiting is a major cause of dehydration and distress among children, hence anti-emetics are used commonly for children. In a national survey in the United States, around 80% of emergency physicians would prescribe anti-emetics to treat vomiting in children with gastroenteritis [20,21]. On the other hand, anti-emetics are not recommended in the majority of international guidelines because of the self-limited nature of the disease, a shift away from an appropriate fluid and electrolyte, in addition to the potential side effects of older medications [22–24].

The primary aim of using anti-emetics is to reduce vomiting episodes, allow effective oral rehydration and decrease time in ED to avoid hospital admission [20,22,23].

In a recent prospective, double-blind, randomised comparison of using antiemetic and placebo, a single dose of antiemetic reduced vomiting and facilitated oral rehydration, but the rates of hospitalisation and return visits to the ED (19% and 22%, $P = .73$) did not differ significantly between the groups [25], which was similar to our study finding.

4.1. Limitations

This study has several limitations. Although the number of ED visits studied was acceptable, the findings were based on a single center. Besides, the observational nature of this study may affect the validity of the results, as we did not have full information on other confounders that could lead to early discharge or revisit to ED. Despite these limitations, to our knowledge, this study represents an initial investigation on assessing using rapid intravenous rehydration at the national level with assessing other predictive factors of early discharge from ED and ED revisiting.

5. Conclusions

This study did not show any additional benefits in patients who received ≥40 ml/kg over 4 h regarding early discharge or the reduction of ED revisits. Co_2 level closer to normal was a significant predictive factor for early discharge in 4 h; at the same time, a closer level to normal of Co_2 and AGAP were associated with an increase in the chance of revisiting the ED within 1 week after discharge. None of the other characteristics, laboratory parameters and the use of anti-emetics had a significant impact on the clinical outcome.

Authors' contributions

MKM, AMS and BHQ planned and designed the study, NTS and NAS conducted the data collection. NailaS conducted the data analysis and interpretation, AMS and BHQ wrote the first draft of the manuscript and MKM and NailaS edited the manuscript draft to its final stage. All authors have read and approved the final manuscript.

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Ethical statement

The study (RC17/199/R) was approved by the King Abdullah International Medical Research Center Institutional Review Board (IRB). As the data were of retrospective nature, patient consent was not applicable. However, no identifier was used, and privacy and confidentiality of patients were completely protected.

Declaration of competing interest

The authors declare that they have no competing interests.

Visual abstract

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpam.2021.03.003.

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