Clinical audit on management of hypernatremia in the Gastroenterology Department of Assiut University Children Hospital

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Received 19 December 2018
Accepted 06 March 2019

Journal of Current Medical Research and Practice
January-April 2019, 4:83–90

Introduction
Hypernatremia is a sodium concentration more than 145 mEq/l, although it is sometimes defined as more than 150 mEq/l. Mild hypernatremia is fairly common in children, especially among infants with gastroenteritis. Hypernatremia in hospitalized patients may be iatrogenic due to inadequate water administration or, by excessive administration of sodium. Moderate or severe hypernatremia has significant morbidity, including the result of the underlying illness, the effects of hypernatremia on the central nervous system, and the risks of rapid correction. Hypernatremia may be mild [Na+] 146–149 mmol/l, moderate [Na+] 150–169 mmol/l or severe [Na+] more than or equal to 170 mmol/l.

Patients and methods
This study was a clinical audit on the management of hypernatremia among children admitted to the Gastroenterology and Hepatology Unit in Assiut University Children Hospital during the period spanning from the 1st of March 2017 to the 31st of August 2017. All children with gastroenteritis who were admitted were investigated, and those with hypernatremia were included in this study.

Results
The present study included 220 children with hypernatremia who were admitted to the Gastroenterology Unit of Assiut University Children Hospital over a period of 6 months. During this period, 2665 patients were admitted in the Gastroenterology Unit; 220 cases of them were hypernatremic (8.25% of admitted cases).

Keywords:
brain edema, hypernatremia, oral rehydration solution, total body water

J Curr Med Res Pract 4:83–90

2357-0121

Introduction

Hypernatremia is a common electrolyte problem that is strictly defined as a hyperosmolar condition caused by a decrease in total body water relative to electrolyte content. Hypernatremia is a 'water problem,' not a problem of sodium homeostasis [1,2]. This deficit in total body water is due to either loss of free water, or infrequently, the administration of hypertonic sodium solutions [2]. Hypernatremia is usually a result of loss of excess free water (renal, enteral, and insensible) in association with decreased free intake (impaired thirst mechanism, lack of access to free water) and inappropriate treatment by using isotonic fluids such as normal saline [3].

Aim of the study

To assess how much the adapted protocols of management of hypernatremia were applied at the Gastroenterology and Hepatology Unit of Assiut University Children Hospital.

Patients and methods

Pediatric patients 1 month to 16 years of age who were admitted to the Pediatric Gastroenterology Unit (1st of March 2017 to end of August 2017) were included in this study.

Inclusion criteria

(1) All children with hypernatremia admitted to Gastroenterology and Hepatology Unit during this period were included in this study.

Exclusion criteria

Cases with gastroenteritis not associated with hypernatremia were excluded.

The following methodology was used for the study:

(1) A clinical audit on the management of hypernatremia was applied according to guideline protocol used in the Gastroenterology and Hepatology Unit of Assiut University Children hospital.
(2) A checklist was used to record demographic clinical and laboratory data of the included children; the data recorded were divided into two categories:
   (a) Audit (whether data were recorded or not).
   (b) Findings (the value of the recorded data).

Results

Demographic data

Table 1 shows the demographic data of the studied cases.

Age, sex, and residence were recorded in all cases. Of the studied cases, 49.1% were male patients and 50.9% were female patients. The majority of cases were infants (85%) followed by patients in the age range of 1–5 years (13.2%), and lastly those aged more than 5 years comprised 1.8%, respectively. Female patients (50.9%) were slightly more than male patients (49.1%) in the studied cases. Most of the cases were from the rural areas (72.2%).

History and presenting symptoms in the studied patients

Table 2 shows that a history of diarrhea and vomiting, history of impaired urine concentration, history of abnormal conscious, and history of poor oral intake were present in 100% of cases. However, history of thirst was recorded in only 60.45% of studied cases.

Clinical findings of the studied cases

Table 3 shows the findings of the examination in the recorded cases. As regards conscious level, 5.9% of the studied cases were disturbed. Pallor was present in 91.36% of studied cases. Jaundice was present in 2.27% of studied cases due to acute hemolytic crisis associated with gastroenteritis. Cyanosis was present in 1.81% due to congenital heart diseases. As regards vital signs, tachycardia was present in 55.26% of the studied cases. Hyperthermia was present in 80.45% of the studied cases. Hypotension was present in 34.37% of the studied cases, while 1.87% of cases were hypertensive. Tachypnea was present in 34.22% of the studied cases. As regards dehydration assessment, mild dehydration was present in 25.90% of the studied cases. Moderate dehydration was present in 64.54% of the studied cases. Severe dehydration was present in 9.54% of the studied cases.

Table 1 The demographic data of studied cases (total number=220)

Demographic data	*n* (%)
Age	
>1-12 months	187 (85)
>1-5 years	29 (13.2)
>5 years	4 (1.8)
Sex	
Male	108 (49.1)
Female	112 (50.9)
Residence	
Rural	160 (72.7)
Urban	60 (27.3)

Table 2 The recorded history of all studied children (total number=220)

History	Recorded [*n* (%)]	Not recorded [*n* (%)]
History of diarrhea and/or vomiting	220 (100)	0 (0.0)
History of thirst	133 (60.45)	87 (39.54)
History of impaired urine concentration	220 (100)	0 (0.0)
History of abnormal conscious level	220 (100)	0 (0.0)
History of poor oral intake	220 (100)	0 (0.0)

Laboratory findings among the studied cases

Table 4 shows that anemia was present in 94.81% of cases, leukocytosis was present in 26.41% of cases, while leukopenia was present in 1.41% of cases, and thrombocytosis was present in 41.5% of studied cases, while thrombocytopenia was present in 1.88% of cases.

As regards serum electrolyte findings, mild hypernatremia was present in 20.9% of cases, moderate hypernatremia was present in 65% of cases, severe hypernatremia was present in 14.1% of cases, hyperkalemia was present in 12.27% of cases, while hypokalemia was present in 3.18% of cases, and hypocalcaemia was present in 6.81% of cases.

As regards kidney function tests, raised kidney function was present in 33.18% of cases. Arterial blood gases were normal in 9.75% of the indicated cases, while compensated metabolic acidosis was present in 48.78% of indicated cases, and uncompensated metabolic acidosis was present in 41.64% of the indicated cases.

Treatment of all studied children

Table 5 shows that shock therapy was given for 100% of indicated cases using normal saline 0.9% to restore intravascular volume, patients with mild and moderate hypernatremia who had good oral intake were managed by oral rehydration therapy (35.45%), while those with moderate hypernatremia and poor oral intake were managed initially with intravenous fluids using half-normal saline in glucose 5% followed by oral rehydration therapy after improvement and

Table 3 History taking in studied children with hypernatremia

History	Yes [*n* (%)]	No [*n* (%)]
Diarrhea only	23 (10.45)	
Watery diarrhea	15 (6.81)	
Bloody diarrhea	6 (2.72)	
Diarrhea with mucous	2 (0.9)	
Acute diarrhea (<15 days)	23 (10.45)	
Chronic diarrhea (more than 15 days)	0 (0.0)	
Frequency 4-6 times	10 (4.54)	
Frequency 6-10 times	9 (4.09)	
Frequency >10 times	4 (1.81)	
Vomiting only	11 (5)	
Vomiting related to meals	9 (4.0) 9	
Vomiting not related to meals	2 (0.9)	
Projectile vomiting	0 (0.0)	
Nonprojectile vomiting	11 (5)	
Bilious vomiting	0 (0.0)	
Nonbilious vomiting	11 (5)	
Diarrhea and vomiting	186 (84.54)	
Watery diarrhea	141 (64.90)	
Bloody diarrhea	12 (5.54)	
Diarrhea with mucous	33 (15)	
Acute diarrhea	186 (84.54)	
Chronic diarrhea	0 (0.0)	
Diarrhea and vomiting (continue)		
Frequency 4-6 times	34 (15.45)	
Frequency 6-10 times	123 (55.9)	
Frequency >10 times	29 (15.59)	
Vomiting related to meals	57 (13.18)	
Vomiting not related to meals	129 (58.63)	
Projectile vomiting	7 (3.18)	
Nonprojectile vomiting	168 (76.36)	
Bilious vomiting	1 (0.45)	
Nonbilious vomiting	177 (80.45)	
Loss from nasogastric or colostomy drainage	0 (0.0)	
History of thirst (drinks eagerly)	89 (66.91)	44 (33.08)
History of impaired urine concentration	43 (19.54)	177 (80.45)
History of neurological impairment	18 (8.18)	202 (91.81)
Disturbed conscious level	13 (5.9)	
Convulsions	5 (2.72)	
History of poor oral intake	73 (33.18)	147 (66.81)

establishment of good oral intake (50.45%). Severe hypernatraemia was managed only by deficit and maintenance intravenous fluids (14.09% of cases) with 0.9% sodium chloride (normal saline) in 5% glucose over 72–84 h at a rate of 1.25–1.5 times the maintenance dose. In the present study, no complications were found during intravenous therapy. Treatment of specific etiology included Nitazoxanide and zinc syrup; Lactobacillus and antiemetics were prescribed in 100% of cases, which is the usual practice in the unit, as most of the cases were diagnosed to have acute gastroenteritis.

As shown in Table 6, 215 (97.7%) cases improved clinically and were discharged, whereas five (2.3%) cases died (Tables 7–10).

Discussion

The present study included 220 children with hypernatremia who were admitted to the Gastroenterology and Hepatology Unit of Assiut University Children Hospital over a period of 6 months. During this period, 2665 patients were admitted to the Gastroenterology Unit; 220 cases of them were hypernatremic (8.25% of admitted cases).

In the present study, the majority of cases were infants (85%). The data of the present study are in concordance with Chouchane *et al.* [4], who mentioned that the majority of cases of hypernatremia were infants. Moreover, Chisti and colleagues mentioned in their retrospective study that most of the children included in their study were young infants; they usually have a larger surface area in relation to height or weight than adults, and they lose relatively more water by evaporative loss, thus increasing the incidence of hypernatremia among patients of this age group [5].

In the present study, most data of the history were fulfilled, except history of thirst, which was recorded in 60.45% of cases. This may be because resident doctors in Assiut University Children Hospital may care to record the history of thirst only in cases with moderate dehydration, as it is a very important history for diagnosis, and may not care to record history of thirst in cases with mild dehydration or shocked cases. In the present study, history of thirst (drinks eagerly) was found in 89 (66.9%) of the recorded cases. Fang *et al.* [6] mentioned in their study that thirst was found in 100% of cases. Thirst is the mechanism to increase water consumption in response to detected deficits in body fluid. Thirst is mediated by an increase in effective plasma osmolality of only 2–3% [7]. Hence, this point must be taken into consideration in future studies. History of thirst must be recorded in all cases, whatever the degree of dehydration.

In the present study, the main complaint was diarrhea and vomiting; this finding is in agreement with the previous studies. El-Bayoumi and colleagues mentioned in their study that diarrhea is a serious condition, which carries the risk of central nervous system injury, both related to illness severity and complications related to treatment [8].

In the present study, most cases were diagnosed to have acute gastroenteritis with hypernatremia; this is in agreement with Robertson and Carrhill who mentioned in their study of 57 children with hypernatremic gastroenteritis who were admitted to a pediatric ICU in Cape Town, South Africa, that all children had hypernatremia with diarrheal disease, but some children had also received excessive sodium due

Table 4 The clinical data of all studied children (total number=220)

Examination	Positive [*n* (%)]	Negative [*n* (%)]
Conscious level	220 (100.0)	0 (0.0)
General look (pallor, jaundice, cyanosis)	220 (100.0)	0 (0.0)
Vital signs		
Heart rate	190 (86.36)	30 (13.36)
Respiratory rate	187 (85)	33 (15.0)
Body temperature	220 (100)	0 (0.0)
Blood pressure	160 (72.72)	60 (27.27)
Head and neck examination		
Anterior fontanelle (number of children <18 months=202)	202 (91.81)	18 (8.18)
Eyes (sunken/normal)	220 (100)	0 (0.0)
Mucous membranes (tongue)	180 (81.81)	40 (18.18)
Upper and lower limbs' examination	220 (100.0)	0 (0.0)
Chest examination	220 (100.0)	0 (0.0)
Cardiac examination	220 (100.0)	0 (0.0)
Abdominal examination	220 (100.0)	0 (0.0)
Neurological examination	190 (86.36)	30 (13.63)
Degree of dehydration	220 (100)	0 (0.0)

to incorrectly prepared formula, or oral rehydration solution, before hospitalization [9]. History of neurological complications was found in 18 (8.81%) cases in the form of disturbed conscious level in 13 (72.22%) cases and convulsions in five (27.77%) cases. All children with convulsions in this study had serum sodium levels more than 160 mmol/l. This is in agreement with Robertson and Carrhill [9] who mentioned in their retrospective study that neurological complications were present in seven (9%) cases of children with hypernatremia. Abu-Ekteish and Zahraa [10] mentioned in their study that 9% of the hypernatremic children developed convulsions. It has been reported that neurological complications occur more often when serum sodium exceeds 160 mmol/l and that death is more likely when it exceeds 185 mmol/l [10]. All children with convulsions in this study had serum sodium levels more than 160 mmol/l. This is in agreement with the present study wherein all children with convulsions had a serum sodium level more than 160 mmol/l.

Assessment of conscious level, general examination, the degree of dehydration, chest examination, and cardiac and abdominal examinations was checked in 100% of cases included in this study, but neurological examination was recorded in 190 (86.36%) cases.

As regards vital signs, there was a defect in the recording of vital signs; only body temperature was recorded in 100% of cases, but heart rate was recorded in 86.36 of cases; respiratory rate was recorded in 85% of cases, and blood pressure was recorded in 72.72% of cases. It is important to check the vital signs of all patients with hypernatremia due to their great role in assessment of degree of dehydration, as signs and symptoms of moderate and severe dehydration can include the following (and they are): tachycardia, orthostatic falls in blood pressure, and deep respirations with or without an increase in respiratory rate [11].

As regards vital signs, tachycardia was present in 55.26% of studied cases. Hyperthermia was present in 177 (80.45%) cases. Abu-Ekteish and Zahraa [10] mentioned in their study that 63% of cases had hyperthermia. Fang *et al.* [6] mentioned in their retrospective study that fever was present in 100% of cases. Hypotension was present in 34.37% of the studied cases. Fang *et al.* [6], mentioned in their study that hypotension was present in 55 (11.34%) cases. Tachypnea was present in 105 (34.22%) cases; this result is in concordance with Chisti *et al.* [5] who mentioned in their retrospective study that tachypnea was present in 35% of the studied cases.

As regards dehydration assessment, mild dehydration was present in 57 (25.90%) cases. Moderate dehydration was present in 142 (64.54%) cases. Severe dehydration was present in 21 (9.54%) cases. Abu-Ekteish and Zahraa [10] mentioned in their prospective study that mild dehydration percentage was 7.5%, moderate dehydration percentage was 59.7%, and severe dehydration percentage was 32.8%. Robertson and Carrhill mentioned in their retrospective study that degrees of dehydration were mild dehydration in 9% of cases, moderate dehydration in 23% of cases, and severe dehydration in 65% of cases. This indicates that hypernatremia may complicate any type of dehydration even in mild dehydration [9].

In the present study, dry mucous membranes were found in 68.88% of cases, depressed anterior fontanelle (in children <18 months age) was found in 81.92% of cases, sunken eyes were present in 60.45% of

Table 5 Findings of examination in studied children (recorded)

Examination	Yes [*n* (%)]	No [*n* (%)]
Disturbed conscious level	13 (5.90)	207 (94.09)
Mild (GCS=13-15)	6 (2.72)	
Moderate (GCS=9-12)	4 (1.81)	
Severe (GCS=3-8)	3 (1.36)	
Pallor	201 (91.36)	19 (8.63)
Jaundice	5 (2.27)	215 (97.72)
Cyanosis	4 (1.81)	216 (98.18)
Pulse	190 (86.36)	30 (13.63)
Tachycardia	105 (55.26)	
Bradycardia	0 (0)	
Normal pulse	85 (44.73)	
Temperature (axillary)	220 (100)	0 (0.0)
Feverish (more than 37.2°C)	177 (80.45)	
Hypothermia (less than 35.6°C)	5 (2.27)	
Normal temperature (35.6-37.2°C)	38 (17.27)	
Blood pressure (according to blood pressure chart by age) (mmHg)		60 (27.27)
Reference: PALS Guidelines (2015)	160 (72.72)	
Hypertension	3 (1.87)	
Hypotension	55 (34.37)	
Normal blood pressure	102 (63.75)	
Respiratory rate	187 (85)	33 (15.0)
Tachypnea	64 (34.22)	
Bradypnea	0 (0.0)	
Normal respiratory rate	123 (65.77)	
Head and neck examination		
Depressed anterior fontanelle	145 (81.92)	32 (18.07)
Sunken eyes	133 (60.45)	87 (39.54)
Dry tongue	124 (68.88)	56 (31.11)
Upper and lower limbs' examination		
Delayed capillary refill time	120 (54.54)	
Normal capillary refill time	100 (45.45)	
Chest examination	220 (100)	0 (0.0)
Respiratory distress b (fine crepitations)	26 (11.81)	
Acidotic breathing	37 (16.81)	
Normal chest examination	157 (71.36)	
Heart examination	220 (100)	0 (0.0)
Pansystolic murmur	3 (1.36)	
Normal heart examination	217 (98.63)	
Abdominal examination	220 (100)	0 (0.0)
Delayed skin turgor	141 (64.09)	
Normal abdominal examination	79 (35.90)	
Neurological examination	190 (86.36)	30 (13.63)
Hyperreflexia, hypertonia	16 (8.42)	
Hyporeflexia, hypotonia	7 (3.64)	
Normal reflexes and muscle tone	167 (87.89)	
Degree of dehydration	220 (100)	0 (0.00)
Mild dehydration	57 (25.90)	
Moderate dehydration	142 (64.54)	
Severe dehydration	21 (9.54)	

cases and delayed capillary refill was found in 54.54% of cases. Fang and colleagues mentioned in their study that dry mucous membranes were found in 100% of cases, depressed anterior fontanelle in 95.6% of cases, sunken eyes in 92.8% of cases and delayed capillary refill time was found in 45.4% of cases. Impaired urine concentration and decreased urine output were found in 19.54% of our studied cases [6].

With regard to investigations, most recommended investigations carried out were serum electrolytes, kidney function tests, and blood gases for indicated cases. Complete blood count was performed for 212 cases who had pallor on clinical examination, and anemia was found in 201 cases of them. It is currently estimated that anemia affects about 25% of the population, and it is estimated that 36% of developing

Table 6 The recorded investigations of all studied children (total number=220)

Investigations	Performed [*n* (%)]	Not performed [*n* (%)]
Complete blood count	212 (96.36)	8 (3.63)
Kidney function tests and electrolytes	220 (100.0)	0 (0.0)
Arterial blood gases	41 (18.63)	179 (81.36)

Table 7 Findings of investigations in studied children (recorded)

Investigations	*n* (%)
Complete blood count	
WBC	212 (96.36)
Leukocytosis	56 (26.41)
Leukopenia	3 (1.41)
Normal leukocytic count	153 (72.16)
Hemoglobin level	212 (96.36)
Anemia	201 (94.81)
Normal hemoglobin level	11 (5.18)
Platelet count	212 (96.36)
Thrombocytopenia	4 (1.88)
Thrombocytosis	88 (41.5)
Normal platelet count	120 (56.60)
Electrolytes: hypernatremia	220 (100)
Mild [Na+] 146-149 mmol/l	46 (20.9)
Moderate [Na+] 150-169 mmol/l	143 (65.0)
Severe [Na+] ≥170 mmol/l	31 (14.1)
K (potassium)	220 (100)
Hyperkalemia	27 (12.27)
Hypokalemia	7 (3.18)
Normal K level	186 (84.54)
Ca (Calcium)	220 (100)
Hypercalcemia	0 (0)
Hypocalcemia	15 (6.81)
Normal Ca level	205 (93.18)
Kidney function tests	220 (100)
Raised kidney function tests	73 (33.18)
Normal kidney function tests	147 (66.81)
Arterial blood gases(HCO3– level)	41 (18.63)
Normal HCO3–	4 (9.75)
Compensated metabolic acidosis	20 (48.78)
Uncompensated metabolic acidosis	17 (41.64)

Table 8 Management steps' recording

Management	Recorded [*n* (%)]	Not recorded [*n* (%)]
Shock therapy in indicated cases (*n*=21)	21 (100.0)	0 (0.0)
Oral rehydration solution	220 (100.0)	0 (0.0)
Intravenous fluids	220 (100.0)	0 (0.0)
Type of fluids used	220 (100.0)	0 (0.0)
Time of correction for IV fluids (*n*=142)	142 (100.0)	0 (0.0)
Rate of correction for IV fluids (*n*=142)	142 (100.0)	0 (0.0)
Treatment of specific etiology of hypernatremia	220 (100.0)	0 (0.0)

Table 9 Treatment of all studied children (total number=220)

Treatment	Yes [*n* (%)]	No [*n* (%)]
Shock therapy by normal saline 20 ml/kg	21 (100.0)	0 (0.0)
Oral rehydration solution only (each sachet in 200 ml water)	78 (35.45)	31 (14.09)
Intravenous fluids on admission (deficit and maintenance)	31 (14.09)	78 (35.45)
Intravenous fluids and ORS	111 (50.45)	
Type of fluids used on admission	220 (100.0)	0 (0.0)
Normal saline (shock therapy)	21 (9.54)	
Oral rehydration solution	189 (85.9)	
Half-normal saline + glucose 5% (deficit and maintenance)	142 (64.54)	
Time of correction	142 (64.54)	78 (35.45)
24 h	7 (4.92)	
48 h	104 (73.23)	
72 h	27 (19.01)	
84 h	4 (2.81)	
Treatment of specific etiology of hypernatremia	220 (100.0)	0 (0.0)

ORS, oral rehydration solution.

countries suffer from this health condition [12]. Infections are a well-recognized cause of mild to moderate anemia. Several studies have demonstrated that even mild infections can cause a significant decrease in serum iron levels [13].

With respect to serum electrolyte findings in this study, mild hypernatremia was present in 20.9% of cases, moderate hypernatremia was present in 65% of cases, and severe hypernatremia was present in 14.1% of cases. Abu-Ekteish and Zahraa [10] mentioned in their study that mild hypernatremia was present in 49.3%, moderate hypernatremia was present in 34.3%, and severe hypernatremia was present in 16.4% of cases. According to the laboratory findings in the present study, 65% of cases had moderate hypernatremia with a mean serum sodium level of 162 mmol/l; the Fang *et al*. [6] study showed that the mean serum sodium level was 164.5 mmol/l at the time of admission. Abu-Ekteish and Zahraa [10] mentioned in their prospective study that the mean serum sodium level of studied cases was 161 mmol/l. Robertson and Carrhill [9] mentioned in their study that median admission sodium was 165 mmol/l.

As regards kidney function tests, raised kidney function was present in 33.18% of our studied cases. Arterial blood gases' tests were performed in cases of severe hypernatremia and children with acidotic breathing. Arterial blood gases' evaluation resulted normal in 9.75% of the indicated studied cases, while compensated metabolic acidosis was present in 48.78% of the indicated cases, and uncompensated metabolic acidosis was present in 41.64% of the indicated cases. Serum bicarbonate was the most useful laboratory test to assess the degree of acidosis with dehydration in children. A value below 17 mEq/l differentiated children with moderate and severe hypovolemia from those with mild hypovolemia [11]. Diarrhea is a frequent cause of nonanion gap metabolic acidosis. Infants are more likely to develop a nonanion gap metabolic acidosis due to losses of excessive bicarbonate

Table 10 Outcome of studied cases was recorded in 100% of cases; the results of management are shown

Outcome	*n* (%)
Clinical improvement and discharge	215 (97.7)
Died	5 (2.3)
Duration of admission	3-14 days

in diarrheal stools. The stool output can contain as much as 70–80 mEq/l of bicarbonate [14].

With regard to treatment, the international guidelines for the management of hypernatremia have been followed by the Gastroenterology and Hepatology Unit of Assiut University Children Hospital in most treatment lines, both in type and rate of fluid intake. The cornerstone of the management of hypernatremia is providing adequate free water to correct the serum sodium level. Hypernatremia is frequently accompanied by volume depletion; therefore fluid resuscitation with normal saline must be instituted before correcting the free water deficit [15].

Children suffering from hypernatremic dehydration with circulatory collapse (hypovolemic shock) have received isotonic solution (shock therapy) [1].

Following initial volume expansion, all children also received maintenance fluid for ongoing watery stool loss; the composition of parenteral fluid therapy depends mainly on the cause of the hypernatremia. Patients with sodium overload or a renal concentrating defect will require a more hypotonic fluid than patients with volume depletion and intact renal ability to concentrate urine. Oral hydration should be established as soon as possible by using oral rehydration solution [15].

The type of fluid recommended for deficit replacement is less controversial; the guideline published by the National Institute of Clinical Excellence of the UK recommends the use of an isotonic solution such as NS, or NS in 5% dextrose, for fluid deficit replacement and maintenance. In all cases, the rate of drop of serum sodium in these children remains crucial, with an average drop of 0.5 mEq/l/h quoted as the maximum safe rate of drop. A rapid drop of serum sodium is associated with the development of cerebral edema and seizures and other neurological complications [16].

Shock therapy in our study was given for 100% of indicated cases using normal saline 0.9% to restore intravascular volume at a correct dose of 10–20 ml/kg over 20 min, and patients with mild and moderate hypernatremia who had good oral intake were managed by oral rehydration therapy (35.45%); each sachet was dissolved in 200 ml water. Those with moderate hypernatremia and poor oral intake were managed initially with intravenous fluids using half-normal saline in glucose 5% followed by oral rehydration therapy after improvement and establishment of good oral intake (50.45%). Severe hypernatremic patients were managed only by deficit and maintenance intravenous fluids (14.09% of cases) with 0.9% sodium chloride (normal saline) in 5% glucose over 72–84 h at a rate of 1.25–1.5 times the maintenance dose, as described in the recent guidelines.

The optimum sodium concentration required to maintain a safe fall in serum sodium has been a matter of debate [9]. Recently, there have been suggestions that solutions with higher sodium content (77–154 mmol/l) should be used in order to prevent a rapid fall in sodium and possible cerebral edema [17]. In the present study, children who were in need of intravenous fluids received a hypotonic intravenous infusion containing 77 mmol/l sodium (half-normal saline in dextrose 5%) according to recent recommendations.

The mortality rate in the present study was 2.3%. Moritz and Ayus [15] observed that delayed treatment of hypernatremia was a significant comorbidity factor that led to death. Different percentages were recorded in previous studies by Funk *et al.* [18] who recorded that mortality rate of hypernatremic children reaches 20–60% and varies according to comorbidities, associated illness, and whether hypernatremia is present at admission or acquired during hospitalization. Chisti *et al.* [5] mentioned in their study that mortality rate was 15%. Abu-Ekteish and Zahraa [10] mentioned in their study that the mortality rate was 3% among their studied cases. Robertson and Carrhill [9], mentioned in their retrospective study that the rate of mortality was 7%. The low mortality rate in the present study in relation to other studies indicates the quality and speed of medical services provided in the Gastroenterology Unit in Assiut University Children Hospital.

Conclusion

Hypernatremic dehydration is the most dangerous form of dehydration because of complications of hypernatremia and of therapy. Hypernatremia can cause serious neurologic damage, including central nervous system hemorrhages and thrombosis. It is important for doctors to realize that hypernatremia is presented with nonspecific symptoms such as irritability, restlessness, weakness, and lethargy. Some infants have a high-pitched cry and hyperpnea. Alert patients are very thirsty, even though nausea may be present.

(1) Determination of a serum sodium level is an important initial step for management, as the rate of correction depends on the initial sodium concentration.

(2) The initial resuscitation of hypernatremic dehydration requires restoration of the intravascular volume with normal saline. To avoid cerebral edema during correction of hypernatremic dehydration, the fluid deficit is corrected slowly.
(3) The international guidelines for the management of hypernatremia have been followed by the Gastroenterology and Hepatology Unit of Assiut University Children Hospital in most treatment lines, and some of the default is due to poor resources, lack of medication, and dereliction of some resident doctors in history taking and examination.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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