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Research Article

Paediatric Fluid Balance: Important Concern for Care of Paediatric Sick Patients

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Abstract

Fluid therapy is an essential component of paediatric medicine throughout the world. Paediatric sick patients undergo changing hemodynamic. Care of these hemodynamically unstable patients often is complicated further by disruption in fluid balance. Therefore, prompt identification of this disruption with maintaining of fluid challenge is an important skill for paediatrician. The cornerstone of such treating process is essential to understand the patho-physiology of body fluids. Fluid therapy is based on gross estimates of daily maintenance requirements, deficit replacement and supplementation of ongoing abnormal losses. The specific needs in each of the three areas of fluid therapy is equally important. In practical evidence, percent deficit is often overwhelmed. Justified therapeutic interventions must be clinically assessed in each step of the way. If the patient is under or over hydrated after oral or parenteral fluid therapy, the therapy must be readjusted and individualized accordingly. Easy monitoring is done at bed side with physical examination and evaluate associated change of recent body weight in aspect of intake and output. To achieve proper therapeutic drug concentration, hydration status must be needed otherwise risk for dose toxicity. This article approach to provide a review of the principles of fluid balance for care of paediatric sick patients.

Keywords: *Fluid Therapy; Paediatric Sick Patients; Care*

Introduction

Fluid is an essential component for care of hospitalized sick children. Through systematic and organized fashion as maintenance, deficit, and replacement requirements with clinical monitoring for response to therapy makes justified manageable of fluid therapy. The content of body fluid is water and solute. Water, the most abundant (50% - 80% of total body weight) solvent in the body, plays a vital role in certain physiological processes as digestion, absorption, use of nutrients, distribution, waste excretion, perfusion and overall maintenance of hemodynamic [1,2]. Among the solutes, electrically charged electrolytes (e.g., Na^+, K^+) called star of body fluid (Table 1), very much essential to maintain daily living systems, the other solute is non-electrolytes (e.g. glucose and urea). It is essential in appreciating hemodynamic changes of fluid during critical necessities with justified implication of fluid therapy. Fluid homeostasis also affect the pharmacokinetics of medications through virtue of hydration status [3].

Ion	ECF*(plasma) concentration (mmol/l)	ICF** concentration (mmol/l)
Cations		
Sodium	142	10
Potassium	4.0	145
Calcium	2.5	0.001
Magnesium	1.0	40
Anions		
Chloride	104	5
Bicarbonate	25	10
Phosphate	1.1	100
Sulphate	0.5	20
Organic anions	3.0	0
Protein**	1.1	8

Table 1: *Ionic composition of body fluids.*

Note:

- *ECF*: Sodium is the major cation; chloride and bicarbonate are the major anions.*
- *The plasma has a similar ion composition to that of interstitial fluid except that it contains a much higher concentration of dissolved proteins.*
- *ICF**: Potassium and magnesium are the major cations; phosphate and sulphate are the major anions.*

Fluid compartments

Total body water is separated by semi-permeable membranes into ECF and ICF compartments

Extracellular fluid (ECF): Complex fluid compartment, composed of interstitial (tissue) fluid, plasma, lymph and transcellular fluid. 75% of ECF is in the interstitial fluid compartment (i.e. between cells in the extravascular) with 25% circulating intravascularly (Figure 1). Transcellular fluid (TCF) is low (1.5% - 2.5% of TBW) (e.g. synovial, pleural, pericardial, intraocular, CSFs) and does not significantly contribute to fluid losses [2]. Lymph is a clear-to-white fluid made of White blood cells especially lymphocytes, the cells that attack bacteria in the blood. Fluid from the intestines called chyle, which contains proteins and fats. Lymph is transported through the lymphatic vascular system which help rid the body of toxins, waste and other unwanted materials.

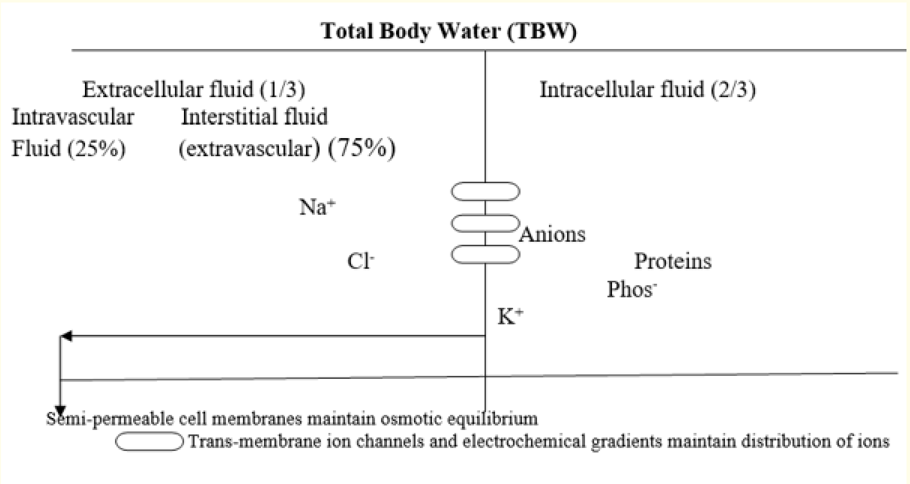

Figure 1: *Body distribution of fluid [water and solutes as electrolyte (e.g. Na+, K+) and non-electrolyte (e.g. proteins)] in adolescence/adult.*

Intracellular fluid (ICF): largest isolated fluid compartment in the body contained within cell membranes and contains water, electrolytes, protein (Figure 1). Potassium, magnesium and phosphate are the three most common electrolytes in the ICF (Table 1).

Physiologic changes of fluid compartments

Total body water (TBW) content varies from one individual with age, gender, skeletal muscle mass and fat content to another and changes drastically since before birth until one year of age.

At 24 weeks of gestational age: TBW→80% of body weight [4] (Table 2).

Neonate (% body weight)	Infant (% body weight)	1yr (% body weight)	Adolescent/adult (% body weight)
TBW			
23-27 wk GA: 85-90	70	60	60 (male) 55 (female)
28-32 wk GA: 50-60			
36-40wk GA: 71-76			
Extracellular fluid			
23-27 wk GA: 60-70	70	55	30
28-32 wk GA: 50-60			
36-40wk GA: 40			
Intracellular fluid			
23-27 wk GA: 30-40	30	45	70
28-32 wk GA: 40-50			
36-40wk GA: 60			

***Table 2:** Age related changes in TBW.*
GA: Gestational Age, TBW: Total Body Water.

At Birth: TBW→70% to 75% of body weight. More than half of the newborn infant's body weight is ECF.

After Birth, neonates are expected to loose body weight during the first 3 or 4 days of age up to a maximum of 10% of the birth weight. The weight remains stationary for the next 4 to 5 days, then the babies start gaining at the rate of 20 - 40 gm per day. They regain their birth weight by the end of 2nd week of life. Excessive weight loss, delay in regaining the birth weight or slow weight gain suggest that either the baby is not being fed adequately or he is sick may have sepsis or renal dysfunction and needs immediate attention.

Premature neonates have the highest percentages of TBW (Table 2). Physiologically with more being lost birth weight in premature low birth weight infants [5,6].

At 3 Months: ECF decreases and ICF increases.

At 1yr: ECF and ICF ratio becomes nearby in equal volume. At 3 yrs: ECF of approximately 25% to 30% and an ICF of 50% to 60%.[7]Body fluid components more closely resemble those of adolescence/adult.

At Aolescence: more changes occur because of lower water content of fat (adipose tissue).

Most adults: TBW→ 50% and 60% of total body weight.[5]TBW% of Women is less than in Men.

Body fluid dynamics

Semi-permeable membranes separate each fluid compartment and maintain osmotic equilibrium through permit the constant movement of water and certain solutes between the compartments. This equilibrium is achieved by several physiological processes as osmosis, filtration, diffusion and active transport until an inequality in concentration:

- **Osmosis:** Movement of water from an area of lower solute concentration to→ higher solute concentration.

  Importance: Moving of important materials (e.g. water, nutrients and other solutes) inside and out of cell.

- **Filtration:** Movement of water from an area of increased hydrostatic pressure to→ lower hydrostatic pressure.

  Importance: Moving fluids out of the arterial end of the capillaries.

- **Diffusion:** Movement of particles through a solution or gas from an area of higher concentration to→ one of lower concentration.

  Importance: More concentration gradient, faster the rate of diffusion.

- **Active transport:** Movement of particles against a concentration gradient is required energy to move particles through the process of active transport. Example: Na^+–K^+ pump.

  Importance: Participates a vital role to maintain the unique composition of ECF and ICF.

Control of fluid flow

Physiological control of fluid flow between plasma and interstitial compartments by three principles

Hydrostatic pressure

Pressure difference across the capillary endothelium results in fluid flow from vascular to tissue space but the retention of proteins within vasculature.

Importance: Its ability to increase circulation and assist venous return to help deoxygenated blood cells (that no longer have oxygen) return back to the heart and lungs to pick up more oxygen.

Oncotic pressure

The retained protein within vasculature exert a retarding force termed as plasma oncotic pressure. Proteins in the interstitial space produce a force causing outward filtration of fluid from the vasculature space.

Importance: As a balance the plasma protein reduces interior permeability, less plasma fluid can exit the vasculature. So plasma oncotic pressure is an important vascular fluid retention force. When depleted there is an increased risk of interstitial oedema.

Capillary permeability

Characterizes the capacity of a blood vessel wall to allow the flow of small molecules in and out of the vessel. Blood vessel walls are lined by a single layer of endothelial cells.

Importance: Increased capillary permeability increases interstitial fluid volume causing oedema.

In normal tissues, proteins that are leaked out from capillaries are reabsorbed by lymphatic micro-vessels nearby.

The factors which control of Fluid flow between plasma and interstitial compartments are

A) Semi-permeable membranes: maintain osmotic equilibrium. Cellular membranes are relatively impermeable to large anions and proteins but are freely permeable to water.

B) Trans-membrane ion channels and electrochemical gradients: Can be either gated or ligand-gated channels (pores formed by protein complexes within lipid bi-layer).

Both maintain distribution of ions. By any disturbance of the two factors does not maintain osmotic equilibrium leading either hypo or hyper-osmolality.

Osmolality

Number of particles (osmoles) of solute dissolved in one kg of solution (i.e. mOsmol/kg) [1]. Usually measured on an analytical instrument called an osmometer. Osmoles are sodium, glucose and urea are the primary osmoles in blood participate for calculating plasma osmolality.

Calculated plasma osmolality: 2 [Na^+] + Glucose (mg/dl) /18+ BUN (mg/dl)//2.8 [8]. Normal values are 275 - 295 m Osm/kg.

Hypo-osmolality (serum osmolality < 275 m Osm/kg); secondary to raised total body water or depletion of body solutes or a combination of two.

Causes- Syndrome of inappropriate antidiuretic hormone secretion (SIADH), salt-losing nephropathy, diuretic use, nephrotic syndrome, mineralocorticoid deficiencies, heart failure and cirrhosis.

Treatment

Restriction of free water.

Repletion of sodium deficits (if present).

Administration of diuretics to offset the effects of vasopressin.

Hyper-osmolality (serum osmolality > 295 m Osm/kg) results from a relative deficiency of water to solute in the ECF or if water excretion is increased.

Causes-diabetes insipidus, acute tubular necrosis, burns, GI illness and iatrogenic causes. Treatment: Salt restriction.

IV fluid replacement.

IV insulin given to lower blood glucose levels.

Potassium and Sodium Phosphate (sometimes) IV given to maintain cells function correctly.

Deamino-d-arginine vasopressin an ADH analogue used in Central Diabetes Insipidus.

Fluid imbalance and regulation

Fluid balance is between intake and output. Intake is derived primarily from three sources: Ingested water, water contained in food, and water produced from oxidation of carbohydrates, proteins, and fats. Losses occur in the urine and stool water, as well as during perspiration and respiration. Alterations in plasma osmolality even 1% - 2% are sensed by osmoreceptors in the hypothalamus. These receptors affect water intake via thirst and water excretion via antidiuretic hormone to return plasma osmolality to normal.

Hypervolemia

↑TBW→↓ serum osmolality→↓AVP concentrations [2]→↓thirst and ↑excretion of water by the kidney.

Hypervolemia caused by kidney or liver failure, heart failure, sepsis, and syndrome of inappropriate antidiuretic hormone secretion.

Clinical manifestation- an increased of serous nasal discharge followed by chemosis and finally pulmonary congestion leading to pulmonary oedema (terminal event of hypervolaemia).

Hypovolemia

↓TBW→↑serum osmolality→↑release of two hormones: AVP and aldosterone [1].

AVP→↑free water reabsorbtion. Aldosterone→ Na^+ and water reabsorption in distal convoluted tubules of the kidneys [1]. By such, hypovolemic state overwhelms the body's natural process for regulating volume [9]. Hypovolemia include blood loss, vomiting and/or diarrhea, burns, excessive sweating or diuresis, and diabetes insipidus.

Clinical manifestation- headache, fatigue, nausea, profuse sweating, dizziness.

Fluid imbalance may also occur when less intake of fluid than body demand (e.g. dysphagia, impaired thirst mechanism, prolonged NPO status). Another important fluid volume deficit through third spacing other than usual space of ECF and ICF develops during ascites, burns, peritonitis, sepsis, intestinal obstruction and pancreatitis.

Excess fluid volume deficit (severe dehydration) in critically paediatric sick patients causing cardio-respiratory de-compromise and renal dysfunction [7]. Evaluate of this deficit on basis of clinical manifestations as severity (mild, moderate, severe) (Table 3).

Mild fluid deficit	Moderate fluid deficit	Severe fluid deficit
Clinical manifestations		
Look at		
General Condition		
Well, alert	*Restless, irritable*	Lethargic, somnolent or unconscious, floppy*
Thirst		
Drinks normally, not thirsty	*Thirsty, drinks eagerly*	*Drinks poorly or unable to drink*
Tears		
Present	Present or absent	Absent
Mouth and tongue		
Moist	Dry	Very dry
Fontanel and eyes		

Normal	Slightly depressed	Severely sunken
Urine output		
Normal	Oliguria	Oliguria or anuria
Respirations		
Normal	Normal to rapid	Deep and rapid
Feel		
Capillary refill		
3 - 5s	> 5s	> 8s
Radial pulse		
Normal rate and strength	Rapid and weak	Rapid, feeble, sometimes impalpable
Heart rate		
Normal/mild tachycardia	Tachycardia	Severe tachycardia may progress to bradycardia
Systolic blood pressure		
Normal	Orthostatic hypotension	Severe hypotension
Skin elasticity		
Pinch retracts immediately	*Pinch retracts slowly*	*Pinch retracts very slowly (>3 sec)*
Decide		
The patient has no sign of Dehydration	If patient has two or more signs including at least one *sign, there is some dehydration	If patient has two or more signs including at least one *sign, there is severe dehydration
Body weight loss (%)		
3 - 5	6 - 9	10
Estimated fluid deficit (ml/kg body wt.)		
30 - 50	60 - 90	100

Table 3: *Severity of fluid volume deficit.*

Note:

- *General Condition and Thirst are the key sign of water deficit (dehydration). Skin pinch also the key sign but may be less useful in patients with obesity or marasmus and kwashiorkor.*
- *Tear is a relevant sign only for infants and young children. Sunken fontanel is an additional useful sign only in infants.*
- *Dryness of mouth can be palpated with a clean finger. Mouth may always be dry in a child with habitually breaths by mouth and may be wet in a dehydrated patient due to vomiting or drinking.*
- *In children older than 5 years, other signs for severe dehydration are: absent radial pulse, low or undetectable blood pressure, cold moist extremities and CNS changes (lethargy, stupor, coma) with oliguria or anuria.*
- *Weighing the patient is useful for estimating the fluid requirements according to the extent of dehydration. However, treatment should never be delayed because weight machine is not readily available.*

Types of dehydration

Types of dehydration is a reflection of the relative net loss of water and electrolyte and is based on serum sodium concentration or plasma osmolality. Approximately 70% - 80% of pediatric dehydration is isotonic, rest 10% - 15% of the population hyponatremic and hypernatremia dehydration each occur (Table 4).

Types of dehydration (% Population)	Electrolyte Status (Serum Na^+ mEq/L)	Loses	Associated condition
Hypotonic or Hyponatremic (10% - 15%)	< 130 mEq/L	Solute >Water loss	Cerebral salt wasting Overaggresive diuresis
Isotonic or Isoonatremic (70% - 80%)	130 - 150 mEq/L	Water=Solute loss	Secretory diarrhea
Hypertonic or Hypernatremic (10% - 15%)	➢ 150 mEq/L	Water>solute loss	Viral gastroenteritis Poor breastfeeding Diabetes Insipidus

Table 4: *Types of dehydration.*

Note:

- *Although often used interchangeably, dehydration and volume deficit are not synonyms.*
- *Dehydration refers to loss of total body water producing hypertonicity, which now is the preferred term in lieu of dehydration. Whereas, Fluid volume deficit refers to a depletion in extracellular fluid volume.*
- *In particular, hypertonicity implies intracellular volume contraction. Whereas, volume depletion implies blood volume contraction.*

Fluid therapy

Special concern to fluid therapy for care of pediatric sick patient. There are three necessities of fluid therapy: Maintenance requirements, Deficit as hydration and Replacement for ongoing abnormal losses. Each component of fluid therapy should be paid careful attention, choosing type of fluid and volume to be administered.

Maintenance fluids

Maintenance fluids are required for all paediatric sick patients to compensate for daily normal ongoing losses [10].

Route: Intravenous line or can also be given orally (if able to tolerate).

Division: Divided into Sensible losses ($2/3^{rd}$) and Insensible losses ($1/3^{rd}$).

Sensible losses can be measured, include urine output and fecal water, make up the majority of ongoing losses, with additional contributions from insensible losses.

Insensible losses are normal but are not easily quantified, losses during respiration and perspiration [11].

Requirements for children are higher than adults for following reasons:

a) Higher metabolic rate [10].

b) Higher body surface area to weight ratio relatively more water loss from skin

c) Higher respiratory rates [12]→ higher insensible losses from the respiratory tract.

These factors require a greater caloric expenditure as well as more fluid loss resulting higher fluid requirements.

There are additive factors which may alter the daily fluid requirement as follows

Factors, increase fluid requirement

1. If metabolic rate is increased.
2. Fever (add 7% fluid for each degree rise of temperature above 100F).
3. Hypermetabolic states like salicylism, hyperthyroidism (increase by 25%).
4. Hyperventilation.
5. Hyperactivities.
6. Abnormal fluid losses like diarrhea, vomiting etc.
7. Congenital abdominal wall defects such as omphalocele and gastroschisis can lead to higher evaporative losses before surgical correction and thus careful attention should be paid to fluid balance and electrolytes.

Factors, decrease fluid requirement

1. If metabolic rate is decreased.
2. Hypothermia (decrease by 7% for each degree below 98.6%).
3. Hypothyroidism (decrease by 10%).
4. Very high humidity.
5. Restricted movements, e.g. in unconsciousness.
6. Presence of cerebral edema (meningitis, encephalitis etc.), bronchiolitis, pneumonia, kwashiorkor etc.
7. Fluid retention (oliguria, cardiac failure, anuria).

When considering fluid requirements in hospitalized children, potential increased or decreased needs should always be kept in mind. The most commonly used technique to calculate maintenance fluids for children is the Holliday-Segar method (Table 5).

Holliday-Segar (daily requirement)	
0-10 kg	100 mL/kg/day
>10 kg to ≤20 kg	[1000 mL + (50 mL x each kg > 10 kg)]/day
> 20 kg	[1500 mL + (20 mL x each kg > 20 kg)]/day
4-2-1 (hourly requirement)	
0-10 kg	4 mL/kg/hr
> 10 kg to ≤ 20 kg	40 mL/hr + (2 mL/hr x each kg > 10 kg)
> 20 kg	60 mL/hr + (1 mL/hr x each kg > 20 kg)

Table 5: *Maintenance fluid requirements in sick paediatric patients (common methods to estimate).*

Fluid requirements in infancy and childhood (Table 6)

In a newborn full term baby then total body water is approximately 75% of the body weight, while in older children and adults it is about 60 - 65%. Maintenance of fluid balance in this period is very important. After the first week of life, the average maintenance fluid need during early infancy varies from 150 - 200 ml/kg/day to maintain positive water balance.

Age	Fluid requirement ml/kg/day
1^{st} day	60 ml
2^{nd} day	80 ml
3^{rd} day	100 ml
4^{th} day	120ml
5^{th} day	140 ml
6^{th} and 7^{th} day onwards	150 ml
Up to 9 months	150 - 160 ml
12 months	120 - 150 ml
2 years	100 - 120 ml
4 years	90 - 100 ml
8 years	70 - 90 ml
12 years	60 - 70 ml

Table 6: *Daily fluid requirement in infancy and childhood.*

Neonatal fluids requirement: Different consideration

Impairments of fluid balance in the care of sick neonates are the most commonly encountered problems. Proper understanding of physiological changes in body water and solute after birth to ensure fluid management of normal and sick newborn babies [13]. Literatures of peculiarities of newborns in terms of body fluid are ever growing. Neonates have a decreased capacity to concentrate or dilute their urine in response to changes in intravascular fluid status and are risk of developing dehydration or fluid overload [14].

The fluid requirements of LBW (Low Birth Weight) babies are relatively higher during first week of life (Table 7). Their insensible water loss is more due to large surface area and thin vascular skin. The newborn kidney is half as effective in concentrating urine with its maximum concentrating ability of 600 - 700 mOsm/kg (c.f.1200 mOsm/kg in adult). Therefore, high solute (protein) load results in increased urine flow demanding higher intake to maintain fluid balance.

Day	1000 gm	1001-1500	> 1500 gm
1st and 2nd	100 - 120	80 - 100	60 - 80
3rd and 4th	130 - 140	110 - 120	90 - 100
5th and 6th	150 - 160	130 - 140	110 - 120
7th and 8th	170 - 180	150 - 160	130 - 140
9th onwards	190 - 200	170 - 180	150 - 160

Table 7: *Fluid requirements of LBW babies (ml/kg/day).*

Note: *Higher side of the range refers to larger infants.*

Neonatal kidneys are immature and function and cannot excrete excess fluid and electrolytes because of tubular immaturity [15]. Overload of the fluid in the first week may result in conditions like PDA (patent ductus arteriosus) [16,17] NEC (necrotizing enterocolitis) [18], ICH (intracranial hemorrhage) associated with poor neurodevelopmental outcomes [19].

Continued changes from fetal life to postnatal period in proportion of TBW, ECF, ICF distribution of Sodium, potassium in different fluid compartments.

Physiological changes of TBW in newborn period

- First 48 hours of life: ↑ Serum Na^+ (due to fluid deprivation + Insensible water loss not corrected by kidney. Sodium efflux from ICF→ECF→↑Serum sodium→↑ECF [20,21].
- 72 hours of life: salt and water dieresis with loss of excess ECF [22,23].

  ↓

  Physiological weight loss [22]
- 1st weak of life: Term infants are expected to lose 10% of birth weight as compared to 15% in preterm neonates [13].

Failure to loss the ECF may be associated with over-hydration syndrome (e.g., PDA, BPD, NEC, ICH etc) in preterm neonates [14].

Deficit fluids

Returning the patient's fluid status become to normal which lost prior to medical care termed as deficit fluid volume include significant blood loss, vomiting and diarrhea, and inadequate intake of fluids over a period of time. The deficit fluid volume as degree of dehydration is an estimate amount based on clinical signs of dehydration as increased thirst, dry mucous membranes and decreased urine output (Table 3) [24] or % of dehydration as recent pre-illness weight (if recorded) and recent illness weight loss of a dehydrated paediatric sick patient both measurement are fairly participate to estimate% of dehydration (Table 8).

Degrees of dehydration		
Body weight loss (%)		
3 - 5 (mild)	6 - 9 (moderate)	10 (severe)
Estimated fluid deficit (ml/kg body wt.)		
30- 50 (mild)	60 - 90 (moderate)	100 (severe)
% dehydration =		
[pre-illness weight(kg) - illness weight(kg)] x 100 pre-illness weight(kg)		
Fluid deficit(L)= % dehydration x pre-illness weight(kg)/100		

Table 8: *Dehydration status (degree and percent).*

Management of dehydration

Mild to moderate: Oral rehydration.

Moderate to severe: IV rehydration generally required.

Rehydration is divided into three phases (Phase I, II, III).

Patients with hypotonic or isotonic dehydration are given fluids using the same technique to calculate fluid amount and rate: Calculating Rehydration Fluid in Isotonic or Hypotonic Dehydration.

Rehydration phase: Fluid Volume.

Phase I: Emergency phase

20 mL/kg Fluid over 60 minutes [25].

A bolus of fluid (isotonic) is used to provide rapid volume expansion in the plasma and extracellular fluid and to ensure adequate perfusion of critical organs, such as the brain [25]. May repeat if necessary to maintain adequate perfusion.

Fluid choice: Isotonic; either normal saline or lactated ringers solution

Phase II and phase III

The fluid volume given during phase I should be subtracted from the deficit fluid.

Phase II: First 8 hours

1/3 (one third) daily maintenance + ½ (one half) remaining deficit.

Fluid choice: 5% dextrose with 0.45% sodium chloride (½ strength normal saline) with 20 - 30 mEq/L of potassium chloride added (if patient has voided).

Phase III: Next 16 hours

2/3 (two third) daily maintenance + ½ (one half) remaining deficit.

Fluid choice: 5% dextrose with 0.225% sodium chloride ($1/4^{th}$ strength normal saline) with 20 - 30 mEq/L of potassium chloride added (if patient has voided).

Phases II and III are simply maintenance fluid plus deficit fluid, given over 24 hours with half of the deficit fluid given in the first 8 hours, and the second half of the deficit fluid given in the last 16 hours.

Treatment of Hypotonic or Hyponatremic dehydration is similar to that for Isotonic or Isonatremic dehydration except that the extra loses of sodium should be taken into account.

The extra sodium loss can be calculated from the following formula:

Sodium deficit [mEq] = [Desired S_{Na} – Actual S_{Na}] x Total body water (TBW)

(TBW = 0.6 x weight in Kg)

Actual S_{Na} = Measured Serum Sodium. Desired S_{Na} = Targeted Serum Sodium.

Administrating the extra sodium over 12 - 24 hour (Don`t correct sodium faster than 12 - 15 mEq/l/24 hr), so that gradual correction of the Hyponatremia is accomplished as the volume is expanded.

Fluid choice: 3% NaCl solution, Isotonic saline or Common salt [1 gm NaCl= 17 mEq of Na^+ ions]. In severe symptomatic hyponatremia: A bolus of 100 – 150 ml of hypertonic 3% saline can be given.

In hypertonic or hypernatremic dehydration

The approach to patients with hypertonic dehydration is quite different due to the hyperosmolar state of their circulating blood (Fluid shifts from ICF to ECF). The deficit fluid volume should be added with maintenance fluid volume needed for 48 hours. Then 'The Total' should be administered over 48 hours, otherwise administering the deficit fluid faster causes osmotic fluid shifts, which can result in cerebral edema and convulsions [26]. For this reason, serum sodium should be corrected by not more than 10 mEq/L/24 hrs [26].

Fluid choice

Must account for serum sodium as well as free-water deficit by dextrose 5% in ½ to 1/4th physiological saline (5% dextrose in 0.225% or 0.45% NS). Suitable regimen: 60 - 75 ml/kg/24 hour of a 5% dextrose solution containing 25 mEq/L of sodium as a combination of the bicarbonate and chloride.

If acute symptoms e.g. seizure = Anticonvulsants + 3 -5 ml/ kg of a 3% NaCl solution IV, or by hypertonic mannitol. Serum sodium should be checked every 2 to 4 hours to ensure that rehydration is not occurring so quickly leading to an overly rapid decrease in serum sodium. Amount of maintenance fluid and sodium should be reduced by about 25% during this phase of therapy, high levels of ADH release resulting in low volume urine. Look at calcium level. If hypocalcemia, occur occasionally during treatment of hypernatremic dehydration, may require IV calcium.

Replacement fluids

Replacement fluids are given to replacing ongoing abnormal losses or continuing losses volume even medical care ongoing include uncontrolled vomiting, continuing diarrhea, patients with chest tubes in place or externalized cerebrospinal fluid shunts.

Each example demonstrates a situation, where there is an ongoing abnormal losses which would not be met by only 'Maintenance fluids'. 'Replacement fluids' differ from 'Deficit fluids' in that they are abnormal ongoing, as opposed to a loss of fluid (deficit volume) that occurred prior to receiving medical treatment.

Crystalloid and colloid fluid (Table 9)

	Na^+	K^+	Cl-	Ca^+	Lactate	Acetate
Crystalloid						
Hartman's	131	5	111	2	29	
Normal saline [isotonic](0.9% NaCl)	154		154			
Dextrose saline (4% dextrose in 0.18% saline)	30		30			
Half strength Baby saline (.45% NaCl)	77		77			
Quarter strength Baby saline (.225 % NaCl)	38.5		38.5			
D_5W+.45% NaCl (Dextrose 5g/100ml)	77		77			
D_5W+.225 % NaCl (Dextrose 5g/100ml)	38.5		38.5			
Ringer's lactate [isotonic]	130	4	109	1.5	28	
Cholera saline	113	13	98			48

Re-So-Mal (Rehydration Solution for Malnutrition)	45	40				
Colloid						
Albumin 5% albumin: Osmotically equivalent to an equal volume of plasma. 25% albumin: Osmotically 5 x greater than an equal volume of plasma	130-160					
Dextran (water soluble glucose polymer) Can be in D_5W (5% dextrose in water) or NaCl Expands plasma for 5-6hr (Dextran70), 3-4 hr (Dextran40)						

Table 9: *Paediatric fluid (infusion) [Crystalloid and Colloid].*

Note:

- *Normal saline and lactated Ringer's both are isotonic (same osmotic pressure as blood). Both may used in replace to one another.*
- *Ringer's lactate doesn't last as long in the body as normal saline does, a beneficial effect to avoid fluid overload.*
- *Ringer's lactate also contains additive sodium lactate. The body metabolizes this lactate into bicarbonate by the liver, which can help correct metabolic acidosis. For this reason, Ringer's lactate may use in child sepsis, in which the body becomes very acidic.*
- *Ringer's lactate also preferred over normal saline for replacing lost fluid in trauma patients.*
- *Cholera saline contains acetate which is converted to bicarbonate and is required for correction of acidosis.*
- *Compared with crystalloids, higher proportion of the administered colloid stays within the vasculature, can pull more water from the extravascular space into the vasculature volume expansion.*
- *Of the colloids, albumin is the most commonly used especially in neonates and infants.*

Crystalloid fluid

Commercially available intravenous fluid therapy contains mineral salts and other small, water-soluble molecules. Isotonic to human plasma, easily across semi-permeable membrane and do not exert an osmotic effect *In vivo.*

Colloid fluid

A dispersed mixture solution chosen when intravascular volume expansion is desired for acute resuscitation.

Different preparation of intravenous (IV) fluids

Different% of baby saline

- 12% Baby saline: 5% Baby saline 65 ml + 25% Glucose 35 ml.
- 10% Baby saline: 5% Baby saline 75 ml + 25% Glucose 25 ml.
- 7.5% Baby saline: 5% Baby saline 87 ml + 25% Glucose13 ml.

Different% of cholera saline

- **½strength Cholera saline: Cholera saline 50** ml + 5% DA 40 ml + 25% Glucose 10 ml.
- 5% Cholera saline: Cholera saline 80 ml + 25% Glucose 20 ml.

Fluids in children: Effects on drug distribution

Appropriate fluid therapy for paediatric sick patients is an essential implication on drug therapy through basic pharmacokinetics by applying physiological fluid volume differences. The large percentage of total body water in neonates has a great impact on therapy with water-soluble drugs (e.g. aminoglycosides). The increased volume of distribution requires a large dose. Therefore, in a dehydrated sick children having a smaller volume of distribution, giving a standard dose for the patient's age may result in a toxic serum concentration [3]. Therefore, hydration status can have an important effect on drug therapy and should be careful monitoring.

Monitoring fluid therapy

Monitoring parameters for parenteral fluid therapy.

Physical signs and symptoms of dehydration (Table 3):

- Weight chart for weight changes.
- Oral intake.
- Fluid balance (intake-output) chart.
- Urine volume and specific gravity.
- Serum electrolytes.

Monitor patient fluid status and electrolytes and adjust the rate and fluid type accordingly.

Practice points

- All pediatric bags come in 500 ml volumes as ideal.

  Calculation of amount of fluid: drops per minute x 4 = ml of fluid per hour.

  Micro-burette used as ideal in neonates.1 ml = 15 drops. 1 drop = 4 micro drops.

- Give a bolus of 10 - 20 ml/kg of 0.9% sodium chloride (normal saline) over 60 minutes. Repeat bolus may be given if needed. This fluid volume don't include in any subsequent calculations. Body fluid secretion or discharge collection after procedure should be replaced by normal saline.
- Fluid which mixed or diluted with medication must be taken into total fluid account.
- Urine output should be: <2 yrs old >2 ml/kg/hr; > 2 yrs old > 1 ml/kg/hr.

  Oliguria→urine is < 1 ml/kg/hr. Anuria→ total suppression of urine.

  In VLBW neonates oliguria may be normal in the first 24 hrs of life.
- Different consideration for Premature infants: require more fluids.

  If < 1.5 kg extra 20 ml/kg; if < 1 kg extra 40 ml/kg (empirically). If body weighs less than their birth weight, use birth weight to calculate their fluid requirement.

  Weight < 1 kg, measure electrolyte twice or thrice for 3 - 4 days then daily.

  Weight > 1.5 kg, measure electrolyte (e.g., Na^+, K^+) daily.

  Electrolyte requirement in neonates: Sodium (Na^+) = 3 mEq/kg/day, Potassium (K^+) = 2 mEq/kg/day.

Conclusion

Fluid balance disruption is an important concern for paediatric sick patient. A fundamental understanding the patho-physiology of body fluids as well as clinical assessment with careful monitoring as systematic fashion are needed for determining organized fluid therapy. Prompt and skillful management ensure optimal care to improve the outcome in order to reduce the mortality and morbidity, pertains an absolute best fluid therapy practice in paediatric sick patient's care.

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