Overview on Fluid, Electrolyte and Nutrition Management of the Newborn and Pre-term Newborns

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Often in extremely preterm newborns in the early postnatal daysproblems in fluid and electrolyte balance occur Due to excessive insensible water loss and renal immaturity. The dietary care of newborn newborns is challenged by the demands of growth and organ development. The stress of a serious disease makes it much more difficult to get enough nourishment. Newborns andespecially premature newborns must be assessed thoroughly for fluid and electrolytes balance. Calculating the fluid and electrolyte demand for sustaining metabolic activities, replacing losses (evaporative, third space, external), and considering pre-existing fluid imbalance are all part of effective fluid and electrolyte management. When a neonate's size or condition prevents them from receiving enteral nutrition, parenteral nutrition can help them grow and thrive. Although eating through the gastrointestinal tract is the recommended method of nutritional management, some situations necessitate the use of PN as an adjuvant or sole treatment. In this article we discuss fluid electrolytes and Nutritional management using parenteral nutrition.

1. INTRODUCTION

Because most newborns in a neonatal intensive care unit (NICU) require intravenous fluids (IVFs) and undergo fluid changes between intracellular, extracellular, and vascular compartments, fluid, electrolyte, and nutrition management is critical. As a result, fluid and electrolyte balance must be carefully monitored. Fluid and electrolyte imbalances can lead to significant morbidity if the wrong fluids are given. Growth failure, premature osteopenia, and other problems result from inadequate nutrition during the newborn era [1].

Due to excessive insensible water loss and renal immaturity, problems in fluid and electrolyte balance occur often in extremely preterm newborns in the early postnatal days. Hypernatraemia and hyperkalaemia, which induce neurological impairment and cardiac arrhythmia, respectively, might result from this imbalance. Other issues might arise as a result of a delayed removal of interstitial fluid from the extracellular fluid compartment, which is clinically indicated by postnatal weight loss. Respiratory morbidity, patent ductus arteriosus, and necrotising enterocolitis are all linked to persistent growth of the extracellular fluid compartment and retention of interstitial fluid [2-12].

The dietary care of newborn newborns is challenged by the demands of growth and organ development. The stress of a serious disease makes it much more difficult to get enough nourishment. Enteral feeding provides a number of advantages over parenteral nutrition (PN), including the maintenance of the gut mucosa and a lower risk of sepsis caused by bacterial translocation. Although gastrointestinal feeding is the ideal method for nutritional management, there are times when PN as an adjuvant or sole treatment is required to address nutritional demands.It is feasible to give comprehensive nutritional support for critically sick newborn newborns when precise attention is paid to the requirements of hydration, calory, protein, and fat, as well as monitoring the metabolic condition of patients [13].

The following losses should be included when calculating daily fluid requirements: (1) urinary water losses, (2) gastrointestinal losses, (3) insensible water losses, and (4) surgical losses (drains). Water makes up 70-80% of a typical neonate's and preterm baby's body weight, respectively. The amount of total body water (TBW) is inversely proportional to the amount of fat in the body, therefore prematures have smaller fat deposits.

TBW is divided into two compartments: extracellular fluid (ECF) and intracellular fluid (ICF). With sodium as the main cation and chloride and bicarbonate as anions, the ECF compartment is one-third of the TBW.Potassium is the main cation in the ICF compartment, which is two-thirds the size of the TBW compartment. The metabolic rate of a newborn is high, and extra energy is required to maintain body warmth and development. When the foetus leaves the womb and enters his new life outside of the womb, his body water changes.The extracellular fluid compartment and body water compartment gradually diminish, whereas the intracellular fluid compartment increases. Premature delivery causes this transition to be disrupted [14].

1.1 Objective

In this article we discuss fluid electrolytes and Nutritional management using parenteral nutrition.

2. PARTICIPANTS AND METHODS

Study Design: Review article.

2.1 Study duration Data were Collected between 1 July and 30 October 2021

Data collection Medline and PubMed public database searches have been carried out for papers written all over the world on immune thrombocytopenic purpura. The keyword search headings included "Fluid, Electrolyte, Nutrition, Newborn, Pre-term newborns, neonate", and a combination of these were used. For additional supporting data, the sources list of each research was searched.

Criteria of inclusion: the papers have been chosen based on the project importance, English language, and 20 years' time limit. Criteria for exclusion: all other publications that did not have their main purpose in any of these areas or multiple studies and reviews were excluded.

2.2 Statistical Analysis

No predictive analytics technology has been used. To evaluate the initial results and the methods of conducting the surgical procedure, the group members reviewed the data. The validity and minimization of error were double revised for each member's results.

2.3 Assessing Fluid and Electrolyte Status

Maternal history: The fluid and electrolyte state of a baby mirrors the mother's condition to some extent. Excessive oxytocin administration or hypotonic IVF in the mother, for example, might result in hyponatremia in the newborn.Intrauterine growth can be harmed by placental malfunction (for example, due to hypertension during pregnancy). Infants who are born with growth retardation (10th percentile for gestational age) may struggle to thrive unless their nutritional needs are met after delivery. The degree of postnatal catch-up growth is influenced by the severity and duration of severe intrauterine malnutrition [1]. Angiotensin-converting enzyme (ACE) inhibitors, such as captopril, can cause acute renal failure in newborns if used by the mother during pregnancy. Other drugs given to the mother, such as indomethacin, furosemide, and aminoglycosides, may influence the neonate's renal function [1].

History of a newborn: Congenital renal failure, such as renal agenesis, polycystic kidney disease, or posterior urethral valves, may be linked to oligohydramnios. Acute tubular necrosis can result from severe in utero hypoxia or birth asphyxia.When a newborn lacks spontaneous urination or has a weak urine stream and dribbling, posterior urethral valves should be investigated. The bladder is frequently full.

Body weight: Extremely preterm newborns and other unwell neonates should be weighed at least once or twice daily in neonatal intensive care units. Weight loss of 5-10% of birth weight in term newborns and 10-15% of birth weight in preterm infants is expected and necessary in the first week of life, depending on the degree of maturation. The daily weight loss should be 1-2 percent of body weight in term newborns and 2-3 percent of body weight in preterm infants when planning maintenance fluid treatment [15].

Clinical fluid status assessment: Excessive Insensible Water Loss (IWL) can be detected by an inability to keep an infant sufficiently warm. Cooling occurs with IWL owing to the latent heat of evaporation, comparable to cooling caused by sweating in older children and adults. Sudden weight fluctuations in a newborn are usually due to a shift in body water. The impacted compartment is determined by the gestational age, as well as any complications (e.g., respiratory distress syndrome, sepsis, necrotizing enterocolitis) and clinical treatment [13].

Tachycardia can be caused by a reduction in intravascular volume, a reduction in stroke volume, or an inadequate cardiac output. This might be independent of the ECF volume, which is higher in congestive heart failure and lower in dehydration. Although delayed capillary refill is evident in newborns with peripheral vasoconstriction due to cold stress or acidosis, it may also be seen in infants with peripheral vasoconstriction due to cold stress or acidosis. With mild or moderate hypovolemia, blood pressure (BP) values are frequently within the reference range due to an infant's compensatory

mechanisms. Hypotension is nearly always evident in severe hypovolemia [1].

Fluid treatment for preterm newborns has unique requirements, including a cautious approach, consideration of body weight variations, salt balance, and ECF tonicity. They are prone to sodium loss as well as sodium and volume excess. Left ventricular failure, respiratory distress syndrome, bronchopulmonary dysplasia, and necrotising enterocolitis can all be caused by high intravenous treatment [14].

Clinical criteria such as body weight, tissue turgor, palpation of peripheral pulsations, fontanelle depression, dryness of the mouth, and urine production can be used to determine the degree of dehydration. Additional parameters to assess the patient's reaction include blood urea nitrogen, haematocrit, serum sodium, serum potassium, serum chloride levels, and urine osmolality. IV fluids are changed accordingly [14].

Urine production and density: On the first day of life, urine output should be 0.5-1 mL/kg/hr, increasing to 2-3 mL/kg/hr thereafter. Urinary output is frequently measured by weighing nappies. It should be noted, however, that due to the evaporation of urine and increased density, this procedure may produce erroneous findings. The volume of urine produced should be measured every 4 to 8 hours and documented. Although a urine osmolality of 200-400 mOsmol/kg suggests adequate fluid consumption, urine density testing is more widely utilised due to its convenience. However, there was a weak association between urine density and osmolality as determined by pee sticks. It's important to remember that high urine density can be caused by glucose or protein in the urine of ill premature newborns [15].

Laboratory Assessment: The levels of serum electrolytes, urea nitrogen, creatinine, and plasma osmolality should all be measured. Remember that the findings of these tests, particularly the creatinine levels, may still reflect maternal values beyond the first 12-24 hours. Although serum creatinine levels usually fall after birth, pre-term birth newborns may have a delay in this process. Total urine output and total fluid consumption can be accurately measured. Diapers should be weighed promptly after voiding in newborns who do not have urinary catheters or urine bags to avoid evaporation error. Acute kidney damage can occur in infants with decreased urine production and a blood

creatinine level that does not decrease or rises postnatally [1,16,17].

PH Balance: The equilibrium of hydrogen ion (H+) concentration in physiological fluids is known as the acid-base balance. Enzyme activity, electrolyte levels, organ functioning, and proper growth are all affected by changes in H+ concentration in body fluid. In babies, the ECF pH level is maintained in a restricted range, similar to adults. Acidosis is defined as a pH below 7.35, while alkalosis is defined as a pH above 7.45. The body's buffer systems, respiratory system, and kidneys all work together to keep pH levels within acceptable limits. Perinatal events, weather conditions, diet, and the baby's gestational week all impact the acid-base balance in the first 24-48 hours of life [6,18-20].

Hypernatremia and Hyponatremia: The most common cause of hypernatremia in newborns is changes in water homeostasis rather than sodium homeostasis. Total body sodium levels may be normal, high, or low. Concentrated urine and a high sensation of thirst are two preventive mechanisms against hypernatremia. Hypernatremia is more likely in newborns who have limited urine concentration capacity and are unable to communicate thirst. Increased water loss, insufficient water intake, and high salt consumption are the three primary causes of hypernatremia [6]. Hyponatremia is defined as a sodium level in the blood that is less than 135 milliequivalents per litre. Although a blood sodium level of less than 130 mEq/ L is commonly used to identify hyponatremia, studies in newborns reveal that hyponatremia is an independent predictor of poor neuromotor development [15].

2.4 Management

Calculating the fluid and electrolyte demand for sustaining metabolic activities, replacing losses (evaporative, third space, external), and considering pre-existing fluid imbalance are all part of effective fluid and electrolyte management. Premature newborns' daily fluid needs are 120-150ml/kg/24 hours, neonates (term) 100ml/kg/24 hours, and infants >10 kg body weight 1000ml+50ml/kg/24 hours [14].

Management Objectives for Fluid and Electrolyte: Fluid and electrolyte control is performed by continuous monitoring of fluid intake and outflow, as well as basic laboratory

chemistry monitoring. Maintaining the proper ECF volume, ECF and ICF osmolality, and ionic concentrations are the major objectives.The initial loss of ECF, as measured by weight loss, must be tolerated while preserving normal intravascular volume and tonicity, as measured by heart rate, urine output, and electrolyte and pH values. As a result, maintain water and electrolyte balance while meeting body development requirements. The clinical approach must be individualized, with benchmarks for gestational age and birth weight serving as a guide.

Total fluid requirements: The sum of urine production and insensible water loss is the maintenance fluid requirement. Fecal fluid loss is relatively restricted in the first few days of life, especially in preterm newborns. Intravenous infusion treatment aims to keep you hydrated while allowing you to lose weight naturally. The amount of maintenance fluids can be raised or lowered depending on the baby's particular needs [15]. Maintenance (IWL + urine + stool water) plus growth needs equal total fluid requirements. IWL (Insensible Water Loss) accounts for the majority of fluid loss in the first few days. Later, as the renal solute load grows, the quantity of water required to excrete the load increases (80-120cal/kg/day equals 15-20mOsm/kg/day, implying that 60-80mL/kg/day is required to eliminate wastes). The typical stool need is 5-10mL/kg/d. To maintain proper ECF and ICF levels, newborns must add water as they add tissue. Because water makes up 70% of weight gain, a newborn developing 30-40 grammes per day requires an additional 20-25 millilitres of water each day [1].

Fluid needs are affected by a variety of factors: The IWL diminishes as the skin grows after birth. IWL is increased by higher body and air temperature. IWL is increased by 50% with radiant heaters, phototherapy may also enhance IWL, and using a plastic heat shield decreases IWL by 10% to 30%. IWL from the skin and respiratory mucosa is reduced by up to 30% when the environment is humidified.IWL to the afflicted region is correspondingly increased by skin breakdown and skin abnormalities (e.g., omphalocele). Antenatal steroids result in a decreased IWL and improved diuresis in infants [1].

Electrolytes Requirements: Supplemental sodium, potassium, and chloride are typically not needed during the first 24 hours. Starting at 24 hours of age, the newborn requires 1-2 mEq/kg/day of potassium and 1-3 mEq/kg/day of sodium, provided that urine output is adequate. Sodium acetate, rather than sodium chloride, may be beneficial to pre-term newborns who develop metabolic acidosis. According to some research, metabolic acidosis in premature newborns is caused mostly by insufficient NH_4^+ excretion and bicarbonate loss in the urine. After the first week of active growth, the demand for potassium may rise to 2-3mEq/kg/day, while the need for sodium and chloride may rise to 3-5mEq/kg/day. Because of the limited capacity of the kidneys to retain salt, a few of the smallest pre-term newborns have sodium needs of up to 6-8mEq/kg/day [1,21,22].

Symptoms of hypovolemic shock in newborn newborns with hypernatremia: Because intravascular volume is maintained, tachycardia and hypotension are hardly encountered in hypernatremia dehydration. If the newborn displays shock signs such lethargy, circulatory collapse, prolonged capillary refill time (> 3 sec), oliguria, hypotension, or anuria, 10-20 mL/kg 0.9 percent NaCl should be administered within 10-20 minutes. This dose may be repeated if symptoms persist [15].

Newborn infants with mild hypernatremia: Serum sodium levels can be adjusted within 24 hours by giving breastmilk via the enteral route (oral/nasogastric tube) in mild hypernatremic dehydration owing to poor breastfeeding/feeding and without hypovolemia. For newborns with gastroenteritis and mild-to-moderate hypernatremia, oral rehydration fluids are typically sufficient. By summing the shortfalls in the maintenance fluid, the total quantity is determined. Physiologic weight loss (average 5% body weight) should be deducted from the deficit volume when estimating fluid deficits in the first 10 days after delivery; if the newborn is older than 10 days, this correction is not required.For example, if a newborn loses 15% of its body weight on the seventh day after birth, the deficit volume should be 10% of body weight (100 mL/ kg), but if the baby is 15 days old, it should be 15% of body weight (150 mL/ kg) [15].

2.5 Parental Nutrition

When a neonate's size or condition prevents them from receiving enteral nutrition, PN can help them grow and thrive. Although eating through the gastrointestinal tract is the recommended method of nutritional

management, some situations necessitate the use of PN as an adjuvant or sole treatment. Due to the immaturity of the gastrointestinal system, enteral feeding cannot be established in very low birth weight (VLBW) preterm newborns in the first few days of life. In severely unwell newborns, neonates with extended diarrhoea, and neonates who have had extensive gastrointestinal surgery, PN can successfully satisfy nutritional needs [13].

Carbohydrate requirements: Because glucose is easily accessible to the brain, it is the most often utilised intravenous carbohydrate for newborns. Because a preterm newborn has a greater glucose requirement, early glucose administration is critical. Non-protein calories must be balanced between carbs and lipids, with a 2:1 ratio advised. Excess glucose consumption causes lipogenesis, CO_2 generation, and hyperglycemia, which leads to osmotic diuresis. Starting glucose infusion at a rate of 4-6 mg/kg permin (6-8 g/kg per day) and gradually increasing to 12-15 mg/kg per min (16-20 g/kg per day) for 2-3 weeks after delivery will help to reduce hyperglycemia during PN [13,23,24].

Protein requirements: Giving proteins has the purpose of limiting catabolism, preserving endogenous protein reserves, and providing enough energy and protein to promote growth. Early PN administration has been found to be safe and effective, with minimal metabolic side effects. The daily nitrogen requirement for parenteral nutrition is 30-35 mmol/kg, or 3.0-3.5 mg/kg amino acids. Nine essential amino acids are present, as well as cysteine, tyrosine, taurine, and arginine, which are semi-essential amino acids.A preterm newborn catabolizes 1 g/kg of its own body protein every day to fulfil its metabolic demands in the absence of an exogenous protein supply. Excess protein consumption results in elevated blood urea, ammonia, and potentially hazardous amino acids such phenylalanine. For very low birth weight (ELBW) newborns, we normally start amino acids (1 g/kg per day) on the second day of life and gradually increase to 3 g/kg per day with 1 g/kg daily increments. Protein should be supplied with a maximum of 15% calories [13,25,26].

Needs for lipids: Lipid is a key non-protein energy source that also has a nitrogen sparing effect. Lipid is a primary source of non-protein energy and has a nitrogen-sparing impact, as it contains important fatty acids and Long Chain Polyunsaturated Fatty Acid LCPUFA. To emulsify

and modify glycerin tonicity, commercial intravenous lipid emulsions are aqueous solutions comprising neutral triglycerides sourced from soybean, safflower oil, and egg yolk. Hepatic and lipoprotein lipase hydrolyze triglycerides, resulting in the production of free fatty acids. Free fatty acids in circulation can be utilised as an energy source or they can enter adipose tissue and be re-esterified to create triglycerides [13].

3. CONCLUSION

Newborns and especially premature newborns must be assessed thoroughly for fluid and electrolytes balance. Calculating the fluid and electrolyte demand for sustaining metabolic activities, replacing losses (evaporative, third space, external), and considering pre-existing fluid imbalance are all part of effective fluid and electrolyte management. Precise calculations and assessment is the key for management for both electrolytes and also nutritional management.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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