GUIDELINE

# Fluid Balance and Elimination

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| **Scope (Staff):** | Nursing and Medical Staff |
| **Scope (Area):** | NICU KEMH, NICU PCH, NETS WA |

**Child Safe Organisation Statement of Commitment**

CAHS commits to being a child safe organisation by applying the National Principles for Child Safe Organisations. This is a commitment to a strong culture supported by robust policies and procedures to reduce the likelihood of harm to children and young people.

**This document should be read in conjunction with this disclaimer**

## Contents

## Aim

The aim of the fluid balance and elimination guideline is to describe normal neonatal fluid balance and passing of urine and meconium, describe how fluid status can be monitored, and discuss possible complications of under- and overhydration.

## Risk

Risks of not adhering to this guideline include missing the diagnosis of pathological conditions if urine and meconium are not passed appropriately, and inappropriate management of fluid balance.

## Key points

- Newborn infants should pass urine in the first 24 hours. Failure to do so should prompt a detailed history, full examination, assessment of fluid intake and additional investigations as indicated.
- Meconium should be passed in the first 48 hours of life. Failure to pass meconium can be due to imperforate anus, microcolon, mucous or meconium plug, or another cause of intestinal obstruction, and requires a full history, clinical examination and additional investigations as indicated. Passage of a meconium plug may be associated with Hirschsprung's disease and meconium ileus is strongly associated with cystic fibrosis.
- Neonates usually lose 5 – 10% of birth weight in the first week of life.
- Both under and overhydration can be harmful.
- Preterm infants are at increased risk of fluid and electrolyte imbalance and their fluids need to be carefully managed.

## Background

- Neonates have different physiological and body composition characteristics compared to older children and adults. These include higher basal metabolic rate (BMR), increased body surface area and increased total body water (TBW), which is distributed between intra- and extracellular (ECW) spaces.
- Fluid requirements are higher per kg body weight, the ability to concentrate and acidify urine is decreased, and renal handling of sodium is immature. Neonates also undergo changes in fluid balance after birth as they transition from intra- to extra-uterine life.
- ECW volume contracts due to increased renal blood flow and subsequent diuresis at 48 – 72 hours of life which results in up to 10% weight loss in term infants. Fluid loss is affected by gestational age, antenatal steroid exposure, renal function and transepidermal losses, which can increase under radiant warmers and with phototherapy.
- Under- and overhydration can be harmful, too little fluid resulting in dehydration, decreased renal blood flow and acute kidney injury, and overhydration associated with increased risk of chronic lung disease (CLD), patent ductus

arteriosus (PDA), intraventricular haemorrhage (IVH), and necrotizing enterocolitis (NEC).

## Assessment of Fluid Status

Fluid status is monitored via measurements of body weight, urine output, urine electrolytes and specific gravity, BP measurements, serum sodium, and physical examination.

- **Weight** is affected by gestational age, intrauterine growth, maternal fluid balance in labour/delivery, postnatal age and health of an infant. Daily weights are needed for at least the first 7 days in infants requiring intensive care if the infant is sufficiently stable.
- **Urine output** from 12-24 hours should be at least 0.5 mL/kg/hour, after which it ranges from 1 - 5 mL/kg/hour.
- **Cardiovascular signs** including heart rate, capillary refill time and blood pressure.
- **Physical examination** of skin (decreased skin turgor or oedema), mucous membranes, anterior fontanelle, and hepatomegaly in fluid overload.
- **Urinalysis** including urine electrolytes and specific gravity (SG). Urine electrolytes can be used to assess renal concentrating ability, sodium excretion, spilling of glucose and ability to acidify the urine. Normal SG varies with gestational and postnatal age but is usually 1.008-1.020 (table 1). This can be increased if the infant is receiving insufficient fluid.
- **Blood investigations** including serum electrolytes (specifically sodium and potassium), urea, creatinine and acid-base status.
- **Clinician performed functional ultrasound** can be used to assess intravascular volume and cardiac output.

## Fluid Requirements

- **Maintenance fluid**: Insensible losses, urine and stool output and fluid required for nutritional support. Recommended maintenance fluid volumes can be accessed in the clinical guideline Nutrition: Volume and Nutritional Requirements
- **Replacement of deficit or ongoing losses:** Ongoing losses from loose stools, nasogastric drainage or other gastric and stoma losses; third spacing (eg sepsis-related); polyuria; inadequate intake.

## Fluid Balance in Extremely Preterm Infants

Extremely preterm infants (<28 weeks gestation) are at particularly high risk of fluid and electrolyte imbalance due to their high TBW content and immaturity of renal function and skin barriers.

- **Water content**: Extremely premature infants have a larger TBW than term infants (80 – 86% vs 70 – 75%) and a greater proportion of their TBW is ECW (54% vs 44%). In addition, the degree of postnatal contraction of ECW is inversely proportional to gestational age and is greater in SGA compared with AGA infants. Preterm infants can lose up to 15% of birth weight as a result.
- **Renal function:** Renal function is immature in extremely premature infants leading to low GFR and poor tubular function. Preterm infants are unable to concentrate urine beyond ~500mOsm/L postnatally and have high urinary sodium losses. Renal function is further compromised by low renal perfusion, cardiovascular instability, hypotension, and exposure to nephrotoxic substances.
- **Skin barrier:** The skin consists of only 3 – 4 layers and the stratum corneum, responsible for the barrier function of the skin, is not well developed. This results in high evaporative water losses from the body surface (transepidermal water loss (TEWL)). There is an inverse relationship between gestational age and TEWL. The skin matures rapidly after birth and there is a 50% decrease in TEWL by the end of the first week of life. TEWL is higher with the infant nursed on a radiant warmer and lower in a humidified incubator.
- Preterm infants should be nursed in an appropriate thermal environment with consideration of incubator humidification. Fluid regimes that allow for contraction of ECW and a degree of weight loss, with avoidance of hypernatremia, likely result in optimal outcomes. Maintenance fluids should be commenced at 80 – 100mL/kg/day and adjusted according to urine output, serum sodium and body weight.

## Urinalysis

Urinalysis, either at the bedside using a reagent strip or in the laboratory, provides important information regarding the physicochemical properties of an infant's urine. Urinalysis can be used to identify urinary tract infection (UTI), haematuria, proteinuria, glycosuria, and to determine specific gravity and urine pH.

**Haematuria:** Defined as >5 red blood cells (RBCs) per high-power field. It can be misdiagnosed when a female infant has had a small vaginal bleed, when pink urate crystals are in the nappy, and in cases of myoglobinuria and haemoglobinuria, and should therefore always be confirmed on urinalysis. Common causes include acute tubular or cortical necrosis, renal artery or vein thrombosis, coagulopathy, trauma following catheterisation or suprapubic aspiration, nephrocalcinosis, urologic abnormalities, and UTI.

**Proteinuria:** Mild proteinuria is not uncommon in the first week of life but persistent proteinuria >250mg/m$^2$/day requires investigation. Proteinuria may be due to vascular or tubular injury from sepsis, HIE or hypotension or, rarely, due to congenital nephrotic syndrome.

**Table 1: Normal urine and renal values in preterm and term infants (1)**

| | Preterm infants <34 weeks | Term infants at birth | Term infants at 2 weeks | Term infants at 8 weeks |
|---|---|---|---|---|
| **GFR (ml/min/1.73m$^2$)** | 13 - 58 | 15 - 60 | 63 - 80 | |
| **Bicarbonate threshold (mmol/L)** | 14 - 18 | 21 | 21.5 | |
| **Protein excretion (mg/m$^2$/24 hours) (mean +/- 1SD)** | 60 +/- 96 | 31 +/- 44 | | |
| **Maximum concentration ability (mOsmol/L)** | 500 | 800 | 900 | 1200 |
| **Maximum diluting ability (mOsmol/L)** | 25 - 30 | 25 - 30 | 25 - 30 | 25 - 30 |
| **Specific gravity** | 1.002 – 1.015 | 1.002 – 1.020 | 1.002 – 1.025 | 1.002 – 1.030 |
| **Urinalysis reagent strip:**<br>**pH**<br>**Protein**<br>**Glucose**<br>**Blood**<br>**Leukocytes** | 5.0 – 8.0<br>Neg to ++<br>Neg to ++<br>Neg<br>Neg | 4.5 – 8.0<br>Neg to +<br>Neg<br>Neg<br>Neg | 4.5 – 8.0<br>Neg<br>Neg<br>Neg<br>Neg | 4.5 – 8.0<br>Neg<br>Neg<br>Neg<br>Neg |

GFR: Glomerular filtration rate; SD: standard deviation; Neg: Negative.

# Acute Kidney Injury (AKI)

Is an abrupt decrease in glomerular filtration and staged according to serum creatinine and urine output (table 2). AKI in the neonatal period is common and affects approximately 30% of neonates admitted to NICU. Specific sub-populations are at particularly high risk, including preterm and low birth weight infants, infants with congenital heart disease, hypoxic-ischaemic encephalopathy (HIE), NEC and exposure to nephrotoxic medications.

**Table 2: Definition of acute kidney injury (AKI) (2)**

| AKI stage | Serum creatinine (SCr) criteria | Urine output criteria |
|---|---|---|
| **0** | No change in SCr or SCr rise <0.3mg/dL | ≥0.5 ml/kg/hr |
| **1** | SCr rise ≥ 0.3 mg/dL rise within 48 h or SCr rise ≥ 1.5–1.9 × baseline SCr | <0.5 ml/kg/hr x 6-12 hrs |
| **2** | SCr rise ≥ 2.0–2.9 × baseline SCr | <0.5 ml/kg/hr for >12 hrs |
| **3** | SCr rise ≥ 3 × baseline SCra or SCr ≥ 2.5 mg/dL or Kidney support therapy utilization | <0.3 ml/kg/hr for ≥24 hrs or anuria for ≥12 hrs |

## Epidemiology

1. **Pre-renal**
   - Inadequate intravascular volume: dehydration, third-spacing, blood loss, excess GIT losses.
   - Inadequate perfusion pressure: hypoxia/ischaemia, hypotension, sepsis, PDA.

2. **Renal (intrinsic)**
    - Acute tubular necrosis: hypoxia/ischaemia, nephrotoxic drugs (eg. gentamicin).
    - Vascular: renal vein thrombosis, aortic / renal artery thrombosis.
    - Congenital abnormalities: Multicystic / polycystic kidney disease, renal agenesis.
3. **Post-renal (obstructive)**
    - Urethral obstruction: Posterior urethral valves, urethral stricture.
    - Ureterocoele
    - Ureteropelvic / ureterovesical obstruction
    - Megacystis or megaureter
    - Neurogenic bladder

## Evaluation and Management

Evaluation of AKI should begin with a comprehensive history and clinical examination. Further investigations may include:

- Urinalysis: microscopy, culture and biochemistry.
- U&Es and FBC.
- Fractional Excretion of Sodium (FENa) reflects the balance between glomerular filtration rate and sodium reabsorption and is calculated as follows:
    - $FENa = \frac{\text{Urine Na x Plasma Creatinine}}{\text{Plasma Na x Urine Creatinine}}$
- Blood culture.
- Blood gas analysis.
- Ultrasound scan of the renal structures as indicated.

Management should be directed towards the specific cause of AKI. General measures include:

- **Fluid management**: Strict fluid intake and output monitoring is required which may require insertion of an indwelling urinary catheter (refer to Urethral Catheterisation. Management should be based on the patient's fluid status and assessment of ongoing losses. In the absence of dehydration and high output states, fluid replacement should be limited to insensible losses and urine output.
- Cease or adjust dosing of nephrotoxic medications.
- Manage complications such as hyperkalaemia and acid-base disturbances.
- Ionotropic support may be required in the face of hypotension and antihypertensive agents in the face of hypertension.

- Renal replacement therapy (dialysis) may be required in cases of AKI refractory to medical therapy. This should occur in consultation with the paediatric renal team at PCH.

## Fluid overload

Fluid overload in neonates has been associated with increased mortality, CLD, IVH, PDA and NEC. Provision of appropriate fluids should balance prevention of dehydration with maintenance of adequate tissue perfusion, while avoiding fluid overload. There are several causes of fluid overload including:

- Congenital cardiac conditions and/or cardiac failure
- Oliguric kidney failure
- Abdominal compartment syndrome
- Shock (sepsis, NEC, hypoxic ischaemic injury)
- Hypoalbuminemia
- Syndrome of inappropriate ADH secretion
- Iatrogenic (excess fluid and/or sodium administration administration)

### Evaluation and Management

Evaluation should begin with a comprehensive history and clinical examination which should be used to determine the underlying cause and direct further investigations. The principles of investigation and management include:

- Blood investigations, urinalysis and imaging studies.
- Monitoring fluid intake and output. Limiting fluids according to output and maintenance requirements. An estimated “dry weight” should be determined for drug dosing and fluid calculations.
- Medications and nutrition may need to be concentrated to restrict fluids and achieve fluid balance.
- Assess intravascular volume and tissue perfusion. Blood pressure support may be required (ionotropes +/- hydrocortisone).
- Consider frusemide.
- Consider albumin infusion if hypoalbuminaemic.

| Related CAHS internal policies, procedures and guidelines |
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| CAHS Neonatal Guidelines<br>• Urethral Catheterisation<br>• Nutrition: Volume and Nutritional Requirements |

## References and related external legislation, policies, and guidelines


1. Eichenwald EC, Hansen AR, Stark AR, Martin C. Cloherty and Stark's manual of neonatal care. 8th ed. Philadelphia: Wolters Kluwer, 2017.
2. Coleman C, Tambay Perez A, Selewski DT, Steflik HJ. Neonatal Acute Kidney Injury. Front Pediatr. 2022 Apr 7;10:842544. doi: 10.3389/fped.2022.842544. PMID: 35463895; PMCID: PMC9021424.
3. Weaver LJ, Travers CP, Ambalavanan N, Askenazi D. Neonatal fluid overload-ignorance is no longer bliss. Pediatr Nephrol. 2023 Jan;38(1):47-60. doi: 10.1007/s00467-022-05514-4. Epub 2022 Mar 29. PMID: 35348902; PMCID: PMC10578312.
4. Segar JL. A physiological approach to fluid and electrolyte management of the preterm infant: Review. J Neonatal Perinatal Med. 2020;13(1):11-19. doi: 10.3233/NPM-190309. PMID: 31594261.


This document can be made available in alternative formats on request.

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