# RENAL FAILURE

## DEFINITION

- Failure of the kidneys to maintain metabolic stability in relation to fluid balance, electrolyte balance and excretion of nitrogenous waste
- Serum creatinine shortly after birth is a reflection of maternal renal function

## MAIN CAUSES

**Prenatal injury/vascular damage**

- Maternal use of:
- ACE inhibitors, angiotensin 2 receptor antagonist
- NSAID

**Congenital renal disorders**

- Renal agenesis
- Renal dysplasia/hypoplasia
- Polycystic kidney disease
- Congenital nephrotic syndrome (Finnish type)

**Postnatal renal disease**

***Pre-renal***

- Decreased intravascular volume/tissue perfusion
- perinatal haemorrhage
- dehydration
- hypotension
- third space losses (sepsis, NEC)
- congestive cardiac failure
- pericardial tamponade

***Intrinsic renal***

- Acute tubular necrosis
- Perinatal asphyxia
- Drug induced
- aminoglycosides
- amphotericin B
- IV contrast media
- NSAID
- ACE inhibitors
- Renal artery/vein thrombosis

***Post-renal/obstructive***

- Posterior urethral valves
- Obstruction in a single kidney
- Spinal cord pathology – neurogenic bladder
- Inappropriate ADH in ventilated babies causes transient oliguria
- will correct spontaneously as lung compliance improves

## HISTORY AND EXAMINATION

- Evaluate to differentiate between pre-renal, intrinsic or post-renal problem
- Detailed clinical history
- assessment of gestational age
- antenatal ultrasound scans

- maternal medications (nephrotoxic)
- birth history
- fetal heart rate monitoring
- resuscitation
- postnatal events (e.g. hypotension, nephrotoxic medications)
- Clinical assessment for volume status
- signs of depletion/hypovolaemia
- cold peripheries
- delayed capillary refill
- tachycardic
- oliguric (<1 mL/kg/hr) or anuric
- Clinical signs of hypervolaemia/volume overload
- tachypnoeic
- oedema
- excessive weight gain
- raised blood pressure
- gallop rhythm
- hepatomegaly

# INVESTIGATIONS

**Blood**

- FBC with red cell morphology
- Coagulation screen
- Serum U&E, calcium, phosphate, total protein, albumin, magnesium
- Blood gases
- Blood culture and CRP

**Urine**

- Dipstick for blood and protein
- Osmolality
- Culture and sensitivity
- Electrolytes
- Random urine protein:creatinine ratio
- Fractional excretion of sodium – (urine Na × plasma creatinine)/(urine creatinine × plasma Na) × 100
- may not be useful in preterm infants
- Renal failure index (urinary Na/urinary creatinine) × 100

**Imaging**

- Ultrasound scan of urinary tract
- If UAC in place, abdominal X-ray to check position of tip
- ensure tip not close to vertebra L1 (origin of renal artery)

# DIAGNOSTIC INDICES

| Indices | Pre-renal | Intrinsic |
|---|---|---|
| Urine osmolality | ≥400 | <400 |
| Urine analysis | Normal | >5 RBCs |
| Urine sodium mmol/L | 31 +/- 19 | 63 +/- 35 |
| Urine protein/creatinine ratio | 29 +/- 16 | 10 +/- 4 |
| Fractional excretion of Na | <2.5 | ≥2.5 |
| Renal failure index | <3 | ≥3 |

# PREVENTION

- Ensure adequate fluid intake particularly in very preterm babies with excessive transepidermal water loss (see **Fluid balance** below)
- Extra care required when using radiant heaters in contrast to high humidification in incubator (see **Hypothermia** guideline)
- Maintain a safe blood pressure (see **Hypotension** guideline)

# MONITORING

- Weigh 12-hrly
- BP 12-hrly
- Cardiac monitor to detect arrhythmias
- Strict documentation of fluid input and output
- Daily:
- cumulative fluid balance
- evaluate medications
- monitor drug levels

***Urine***

- Dipstick (proteinuria; sediment, e.g. blood, casts, tubular debris, indicate intrinsic problem; WBC and nitrites suggest infection)
- Microscopy and culture
- Electrolytes, urea, creatinine, osmolality

***Blood***

- U&E, creatinine 12-hrly (monitor Na and K on blood gas when possible)
- Blood gases, pH 4–8 hrly
- Glucose 4-hrly
- Daily:
- calcium
- phosphate
- magnesium
- albumin
- FBC

***Typical biochemical changes in acute renal failure (ARF)***
*Increased urea, creatinine, $K^+$, $PO_4^{3-}$*
*Reduced $Na^+$, $Ca^{2+}$, $HCO_3^-$ pH*

- Increasing urine output generally first sign of recovery
- Monitor serum electrolyte levels during polyuric phase
- Creatinine estimation often misleading in first few days (in-utero creatinine is cleared by placenta)
- after delivery creatinine production by muscles is not stable and can be influenced heavily by muscle damage resulting from delivery/hypoxia/sepsis
- >48–72 hr, it can be used, but trend much more valuable than absolute concentration
- Urea estimation
- can be influenced by tissue breakdown (e.g. bruises/swallowed blood)
- little produced when protein intake compromised

# TREAMENT

**Correct underlying cause**

***Pre-renal failure***

- Correct hypovolaemia – avoid over-hydration in established renal failure
- sodium chloride 0.9% 10–20 mL/kg IV

- if blood loss known/ suspected: give 10–20 mL/kg packed red cells
- if hypotensive in absence of fluid depletion: start inotrope infusion (see **Hypotension** guideline)
- Open duct in duct-dependent circulation in congenital heart disease (see **Cardiovascular** guidelines)
- Antibiotics for sepsis

***Intrinsic renal failure***
- Goal is to limit further renal damage
- Management of fluid and electrolyte imbalance and hypertension
- In majority of cases kidneys will recover in 24–48 hr

***Post-renal failure***
- Surgical approach to obstructive uropathy unless very poor prognosis (e.g. Potter's syndrome)
- Post-renal obstruction (e.g. posterior urethral valves) can be temporarily relieved by indwelling catheter until definitive surgical treatment considered

**Supportive**
- If possible, stop all nephrotoxic drugs (e.g. aminoglycosides, vancomycin, furosemide), or monitor levels if need to continue
- Assess fluid status regularly

**Fluid balance**
- If baby hypovolaemic/hypotensive it is important to correct this before instituting fluid restriction (see above)
- If signs of fluid overload consider trial of furosemide
- Restrict fluid intake to minimal maintenance fluids
- Calculate maintenance fluid:
- maintenance fluid = insensible losses + urine output + GIT losses
- insensible losses (if nursed in incubator):
  - <1000 g: 60−80 mL/kg/day
  - 1000−1500 g: 40−60 mL/kg/day
  - >1500 g: 20 mL/kg/day
  - for babies in well-humidified incubator or receiving humidified respiratory support, use lower figure
- Replace maintenance fluid as glucose 10–20% (electrolyte-free)
- If electrolyte losses ongoing (e.g. diarrhoea, fistula), electrolytes required
- Weigh twice daily
- change in body weight best guide to change in hydration
- stable weight indicates over-hydration and need to reduce fluid intake further
- aim to achieve 1% loss of body weight daily

**Hyperkalaemia**
- See **Hyperkalaemia** guideline

**Acidosis**
- Monitor pH 4–8 hrly
- If metabolic acidosis present with pH <7.2 or $HCO_3$ <12 mmol/L, give sodium bicarbonate
- Monitor ionised calcium levels to prevent seizures/tetany

**Hyponatraemia**
- Low sodium more likely to indicate fluid overload than deficit in body sodium

- Unless evidence of dehydration, treatment should be fluid restriction with maintenance sodium intake of 2–3 mmol/kg/day
- If severe (Na <120 mmol/L) and associated with neurological symptoms, e.g. seizures, can use hypertonic saline (sodium chloride 3%) 4 mL/kg over a minimum of 15 min: check serum sodium immediately after completion of infusion
- If baby still fitting, dose can be repeated **after** assessing serum sodium concentration
- Amount of Na required = (desired Na – actual Na) × 0.6 × weight
- sodium chloride 3% contains 0.5 mmol/mL of sodium
- Correct serum Na concentration cautiously (maximum daily correction 8–10 mmol/L) to avoid development of neurological sequelae
- During recovery phase, babies rarely become polyuric, when sodium chloride 0.45% is typically required, although this will depend on measurement of urinary sodium concentration

**Calcium and phosphate imbalances**

- Hyperphosphataemia and hypocalcaemia are known complications in neonates
- Correct symptomatic hypocalcaemia using calcium gluconate 10% 0.5–1 mL/kg IV over 5 min under ECG monitoring
- Correct hyperphosphataemia by restricting phosphate in PN or milk formulas

**Nutrition**

- Attention to nutrition is essential to prevent excessive tissue breakdown
- If baby tolerating oral feeds: give EBM or renal formula to give low renal solute load and low phosphate
- If oral feeds **not** tolerated: parenteral nutrition 50 kcal/kg/day and protein 1–2 mg/kg/day

**Dialysis**

- Hardly ever used in neonates due to technical difficulty and poor prognosis
- Only applicable to term babies with treatable renal problem
- Indications:
- severe metabolic acidosis
- persistent metabolic abnormalities e.g. hyperkalaemia
- intractable fluid overload
- Discuss with paediatric nephrology team

# CONCLUSION

- Outcome dependent on cause and extent of renal damage
- Vast majority of cases of renal failure will recover if the underlying cause is addressed and supportive management provided to maintain fluid and electrolyte balance until recovery takes place, normally over 24–48 hr
- If there is no improvement, discuss with paediatric nephrologist