ACUTE RENAL FAILURE

Definition

Abrupt rise in serum creatinine level and decreased glomerular filtration rate resulting in inability of the kidneys to regulate fluid and electrolyte balance. Acute renal failure (ARF) is also known as acute kidney injury (AKI).

Clinical features

- of underlying cause.
- oliguria (< 300 ml/m²/day in children; < 1 ml/kg/hour in neonates)
- non-oliguric.
- clinical features arising from complications of ARF
  e.g. seizures, acute pulmonary oedema

Table 1. Common causes of acute renal failure

Pre-renal	**Renal, or intrinsic**
hypovolaemia dehydration, bleeding, *third space loss* nephrotic syndrome, burns *distributive shock* dengue shock, sepsis syndrome *cardiac* congestive heart failure cardiac tamponade **Post-renal** posterior urethral valves acute bilateral ureteric obstruction acute obstruction in solitary kidney	*glomerular* infection related systemic lupus erythematosus acute glomerulonephritis *tubulointerstitial* acute tubular necrosis from - hypoxic-ischaemic injury - drugs e.g. aminoglycosides, chemotherapy toxins e.g. myoglobin, haemoglobin venom e.g. bee sting tumour lysis, uric acid nephropathy infection, pyelonephritis *vascular* ACE-inhibitors, vascular lesions

footnote:
- important to consider pre-renal failure as a cause of oliguria.
- In pre-renal failure, the kidney is intrinsically normal and the tubules are working to conserve water and sodium appropriately.
- In acute tubular necrosis (ATN) the damaged tubules are unable to conserve sodium appropriately

MANAGEMENT

Fluid balance

In Hypovolaemia

- fluid resuscitation regardless of oliguric / anuric state
- give crystalloids e.g. isotonic 0.9% saline / Ringer's lactate 20 ml/kg fast (in < 20 minutes) after obtaining vascular access.
- transfuse blood if haemorrhage is the cause of shock.
- hydrate to normal volume status.
- if urine output increases, continue fluid replacement.
- if there is no urine output after 4 hours (confirm with urinary catheterization),
- monitor central venous pressure to assess fluid status

Refer to section on shock for details of management.

In Hypervolaemia / Fluid overload

Features of volume overload include hypertension, raised JVP, displaced apex beat, basal crepitations, hepatomegaly and increasing ventilatory requirements.

- if necessary to give fluid, restrict to insensible loss (400 ml/m²/day or 30ml/kg in neonates depending on ambient conditions)
- IV frusemide 2 mg/kg/dose (over 10-15 minutes), maximum of 5 mg/kg/dose *or* IV frusemide infusion 0.5 mg/kg/hour
- dialysis if no response or if volume overload is life-threatening

Euvolaemia

- once normal volume status is achieved, give insensible loss plus obvious losses (urine / extrarenal)
- monitor fluid status: weight, BP, heart rate, nutritional needs, intake/output.

Table 2. Recommended investigations

Blood
full blood count
urea, electrolytes, creatinine
blood gas
serum albumin, calcium, phosphate
Urine
biochemistry, microscopy
Imaging
renal ultrasound scan (urgent if cause unknown)
Other investigations
as determined by cause

Hypertension

- usually related to fluid overload and/or alteration in vascular tone
- choice of anti-hypertensive drugs depends on degree of BP elevation, presence of CNS symptoms of hypertension and cause of renal failure. A diuretic is usually needed

For further details on drug therapy, refer to section on hypertension in 'post-infectious acute glomerulonephritis'.

Metabolic acidosis

- treat if pH < 7.2 or symptomatic or contributing to hyperkalaemia
- *bicarbonate deficit = 0.3 x body weight (kg) x base excess (BE)*
- ensure that patient's serum calcium is > 1.8 mmol/L to prevent hypocalcaemic seizures with sodium bicarbonate therapy.
- replace half the deficit with IV 8.4% sodium bicarbonate (1:1 dilution) if indicated
- monitor blood gases

Electrolyte abnormalities

Hyperkalaemia

- definition: serum K^+ > 6.0 mmol/l (neonates) and > 5.5 mmol/l (children).
- cardiac toxicity generally develops when plasma potassium > 7 mmol/l
- regardless of degree of hyperkalaemia, treatment should be initiated in patients with ECG abnormalities from hyperkalaemia

Table 3. ECG changes in hyperkalemia

i. tall peaked T waves
ii. prolonged PR interval
iii. widened QRS complex
iv. flattened P wave
v. sine wave (QRS complex merges with peaked T waves)
vi. VF or asystole

Treatment

- do 12-lead ECG and look for hyperkalaemic changes
  - if ECG is abnormal or plasma K+ > 7 mmol/l, connect patient to cardiac monitor and give the following in sequence:

IV 10% calcium gluconate 0.5 – 1.0 ml/kg (1:1 dilution) over 5 – 15 mins
(immediate onset of action)
IV dextrose 0.5 g/kg (2 ml/kg of 25%) over 15 – 30 mins
± IV insulin 0.1 unit/kg
(onset of action 30 mins)
IV 8.4% sodium bicarbonate 1 ml/kg (1:1 dilution) over 10 – 30 mins
(onset of action 15 – 30 mins)
Nebulized 0.5% salbutamol 2.5 – 5 mg
(0.5 – 1 ml : 3 ml 0.9% sodium chloride)
(onset of action 30 mins)
Calcium polystyrene sulphonate 0.25g/kg oral or rectally 4 times/day (max 10g/dose)
(Calcium Resonium / Kalimate)

[give rectally (NOT orally) in neonates 0.125 – 0.25g/kg 4 times/day]
OR
Sodium polystyrene sulphonate 1g/kg oral or rectally 4 times/day (max15g/dose) (Resonium)

  - in patients with serum potassium between 5.5 - 7 mmol/L *without* ECG changes, give calcium or sodium polystyrene sulphonate
- dialyse if poor or no response to the above measures

Hyponatraemia

- usually dilutional from fluid overload
- if asymptomatic, fluid restrict
- dialyse if symptomatic or the above measures fail

Hypocalcaemia

- treat if symptomatic (usually serum Ca^{2+} < 1.8 mmol/L), and if sodium bicarbonate is required for hyperkalaemia, with IV 10% calcium gluconate 0.5 ml/kg, given over 10 – 20 minutes, with ECG monitoring

Hyperphosphataemia

- phosphate binders e.g. calcium carbonate or aluminium hydroxide orally with main meals

Nutrition

Optimal intake in ARF is influenced by nature of disease causing it, extent of catabolism, modality and frequency of renal replacement therapy.
Generally, the principles of nutritional requirement apply except for:

- avoiding excessive protein intake
- minimizing phosphorus and potassium intake
- avoiding excessive fluid intake (if applicable)
- if the gastro-intestinal tract is intact and functional, start enteral feeds as soon as possible
- total parenteral nutrition via central line if enteral feeding is not possible; use concentrated dextrose (25%), lipids (10 – 20%),protein (1.0 – 2.0g/kg/day)
- if oliguric and caloric intake is insufficient because of fluid restriction, start dialysis earlier

Table 4. Dosage adjustment in renal failure for some common antimicrobials

drug	creatinine clearance[1]	dose	dose interval
Crystalline/benzylpenicillin	10 – 50	Nil	8 – 12
	< 10	Nil	12
Cloxacillin	< 10	Nil	8
Amoxicillin/clavulanic acid (Augmentin)	10 – 30	Normal dose initially then half-dose 12-hourly.	
	< 10	Normal dose initially then half-dose 24-hourly.	
Ampicillin/sulbactam (Unasyn)	15 – 29	Nil	12
	5 - 14	Nil	24
Cefotaxime	< 5	Normal dose initially, then 1/2 dose, same frequency	
Cefuroxime	> 20	Nil	8
	10 – 20	Nil	12
	< 10	Nil	24
Ceftriaxone	< 10	Dose not > 40mg/kg (maximum 2g)/day	
Ceftazidime	30 – 50	50-100%	12
	15 – 30	50-100%	24
	5 – 15	25-50%	24
	< 5	25–50%	48
Cefepime	30 – 50	50mg/kg	12
	11 – 29	50mg/kg	24
	< 10	25mg/kg	24
Imipenem	40	75%	8
	10	25%	12
	anuric	15%	24
Meropenem	25 – 50	100%	12
	10 – 25	50%	12
	< 10	50%	24
Ciprofloxacin	40	Nil	12
	10	50%	24
	anuric	33%	24
Metronidazole	< 10	Nil	12
Acyclovir (iv infusion)	25 – 50	Nil	12
	10 - 25	Nil	24
Acyclovir (oral)	10 – 25	Nil	8
	< 10	Nil	12
Erythromycin	< 10	60%	Nil
Gentamicin	Avoid if possible. If needed, give 5mg/kg, check trough level 24 hours later, and peak 1 hour post-dose.		
Amikacin	Avoid if possible, If needed, give initial dose, take trough sample immediately before next dose, and peak 1 hour post-dose.		
Vancomycin	Give initial / loading dose, take trough sample immediately before next dose and peak, 1 hour after completion of infusion		

[1]Note:
It is difficult to estimate GFR from the serum creatinine levels in ARF. A rough estimate can be calculated using the formula below once the serum creatinine level remains constant for at least 2 days.

Calculated creatinine clearance (ml/min/1.73m²) = $\frac{\text{height (cm) x 40}}{\text{serum creatinine (micromol/l)}}$

Assume creatinine clearance of < 10ml/min/1.73m² if patient is on dialysis or anuric.

Dialysis

Dialysis is indicated if there are life-threatening complications like:

- fluid overload manifesting as
  - pulmonary oedema
  - congestive cardiac failure or
  - refractory hypertension
- electrolyte / acid-base imbalances:
  - hyperkalaemia (K+ > 7.0)
  - symptomatic hypo- or hypernatraemia or
  - refractory metabolic acidosis
- symptomatic uraemia
- oliguria preventing adequate nutrition
- oliguria following recent cardiac surgery

The choice of dialysis modality depends on:

- experience with the modality
- patient's haemodynamic stability
- contraindications to peritoneal dialysis e.g. recent abdominal surgery

Refer to section on 'acute peritoneal dialysis' for further details.

Medications

Avoid nephrotoxic drugs if possible; if still needed, monitor drug levels and potential adverse effects. Check dosage adjustment for all drugs used.

ACUTE PERITONEAL DIALYSIS

Introduction

The purpose of dialysis is

- to remove endogenous and exogenous toxins and
- to maintain fluid, electrolyte and acid-base equilibrium until renal function returns

Peritoneal dialysis (PD) is the simpler modality in infants and children as it is technically simpler and easily accessible even in centers without paediatric nephrologists.

Contraindications to Acute PD

- abdominal wall defects or infection
- bowel distension, perforation, adhesion or resection
- communication between the chest and abdominal cavities

Types of Catheter Access

- a *soft PD catheter* implanted percutaneously or surgically (preferred)
- a *straight rigid catheter* if a soft PD catheter is not available

Table 1. Indications for dialysis

Acute renal failure
pulmonary oedema
refractory hypertension
oliguria following recent heart surgery
symptomatic electrolyte or acid-base imbalance
- hyperkalaemia (K^+ > 7.0)
- hypo- or hypernatraemia
- acidosis (pH<7.2, or <7.3 with hyperkalaemia)
uraemia
Inborn errors of metabolism
encephalopathy
hyperammonaemia
severe metabolic acidosis