

Acute kidney injury (AKI)

Definition of acute kidney injury:

- Acute kidney injury (AKI): a sudden deterioration in renal function leading to an inability to maintain fluid, electrolyte and acid-base balance
 - AKI has replaced the term acute renal failure (ARF) which nephrologists disliked because it implied complete failure of renal function
- Oliguria: reduced urine output; defined variously as <0.5 ml/kg/hour, <30 ml/hour or <400 ml/day
- Anuria: complete absence of urine output

Staging of acute kidney injury:

- Stage 1: creatinine (Cr) ≥ 1.5 -2 times baseline or urine output (UO) <0.5 ml/kg/hours for >6 consecutive hours
- Stage 2: Cr ≥ 2 -3 times baseline or UO <0.5 ml/kg/hours for >12 hours
- Stage 3: Cr ≥ 3 times baseline or UO <0.3 ml/kg/h for ≥ 24 hours or anuria for >12 hours
- Patients should be staged according to their worst criterion

Epidemiology of acute kidney injury:

- Common
- Often accompanies other acute medical or surgical problems due to its wide range of causes

Causes of acute kidney injury (AKI):

- Pre-renal: inadequate blood supply to the kidneys
 - Hypovolaemia
 - Inadequate fluid intake
 - Excess fluid loss
 - Vomiting
 - Diarrhoea
 - Diuresis
 - Early sepsis
 - Haemorrhage
 - Burns
 - Reduced cardiac output
 - Acute coronary syndrome (ACS)
 - Cardiac arrhythmia eg atrial fibrillation (AF)
 - Valvular heart disease
 - Hypertension
 - Cardiomyopathy
 - Cardiac tamponade
 - Late sepsis
 - Renal artery disease
 - Renal artery stenosis
 - Vasculitis
- Intrinsic renal: direct damage to the kidneys
 - Glomerular
 - Proliferative glomerulonephritis

- Typically presents as nephritic syndrome characterised by haematuria (with red cells casts on microscopy), mild proteinuria (<3.5 g/day), hypertension, oedema, elevated Cr and oliguria
 - Non-proliferative glomerulonephritis
 - Typically presents as nephritic syndrome characterised by severe proteinuria (>3.5 g/day), hypoalbuminaemia and oedema
- Tubular
 - Acute tubular necrosis (ATN)
 - Usually occurs secondary to the ischaemia of pre-renal AKI
 - Nephrotoxic drugs
 - Angiotensin converting enzyme inhibitors (ACEIs)
 - Angiotensin receptors blockers (ARBs)
 - Non-steroidal anti-inflammatory drugs (NSAIDs)
 - Aminoglycosides eg gentamicin
 - Radiological contrast
 - Rhabdomyolysis
 - Multiple myeloma
- Interstitial
 - Acute interstitial nephritis: usually caused by a drug-induced allergic reaction
 - Penicillin
 - NSAIDs
 - Autoimmune disease e.g. systemic lupus erythromatosus (SLE)
 - Infiltrative disease
 - Lymphoma
 - Sarcoidosis
- Vascular
 - Hypertensive nephropathy
 - Vasculitides
 - Haemolytic uraemic syndrome (HUS)
 - Thrombotic thrombocytopenic purpura (TTP)
 - Disseminated intravascular coagulation (DIC)
- Post-renal: obstruction to urinary flow
 - Ureters
 - Luminal
 - Ureteric calculi
 - Vesicoureteric reflux
 - Mural
 - Tumour e.g. transitional cell carcinoma
 - Extrinsic
 - Compression from abdominal/pelvic mass
 - Complication of abdominal/pelvic surgery
 - Retroperitoneal fibrosis
 - Bladder
 - Luminal
 - Bladder calculi
 - Mural
 - Tumour e.g. bladder carcinoma
 - Extrinsic
 - Neurogenic bladder
 - Diabetes mellitus
 - Multiple sclerosis
 - Spinal cord compression

- Cauda equine syndrome
- Anticholinergic drugs
- Sympathomimetic drugs
- Urethra
 - Luminal
 - Blocked urethral catheter
 - Mural
 - Urethral stricture
 - Extrinsic
 - Benign prostatic hypertrophy (BPH)
 - Prostatic carcinoma
 - Pain

Risk factors for acute kidney injury (AKI):

- Age >75 years
- Chronic kidney disease (CKD)
- Cardiac failure
- Peripheral vascular disease (PVD)
- Hypertension
- Hepatic disease
- Diabetes mellitus
- Nephrotoxic medications

History in acute kidney injury:

- Symptoms of dehydration
 - Thirst
 - Light-headedness
 - Dry mouth
 - Dark urine
- Symptoms of excess fluid loss
 - Vomiting
 - Diarrhoea
 - Diuresis
 - Haemorrhage
 - Burns
- Symptoms of cardiac failure
 - Fatigue
 - Worsening dyspnoea progressing from an exercise tolerance of dyspnoea on exertion to at rest
 - Orthopnoea
 - PND
 - Cough productive of pink, frothy sputum
 - Ankle swelling
- Symptoms of sepsis
 - Fever
 - Rigors
 - Symptoms of the focus
- Symptoms of malignancy
 - Cachexia
 - Anorexia

- Night sweats
- Symptoms of the focus
- Symptoms of ureteric obstruction
 - Severe, colicky loin to groin pain
- Symptoms of bladder obstruction
 - Complete
 - Painful suprapubic mass
 - Anuria
 - Partial
 - Painful suprapubic mass
 - Urinary frequency
 - Hesitancy
 - Poor stream
 - Terminal dribbling
 - Strangury
- Drug history
 - Angiotensin converting enzyme inhibitors (ACEIs)
 - Angiotensin receptors blockers (ARBs)
 - Non-steroidal anti-inflammatory drugs (NSAIDs)
 - Aminoglycosides eg gentamicin
 - Anticholinergic drugs
 - Sympathomimetic drugs
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Examination of the patient with acute kidney injury:

- Signs of hypovolaemia
 - Cold, pale peripheries
 - Prolonged capillary refill times (CRT >2 s)
 - Decreased skin turgor
 - Reduced jugular venous pressure (JVP)
 - Sunken eyes
 - Dry lips, mouth and tongue
 - Tachycardia
 - Postural hypotension
 - Absolute hypotension
 - Dark urine
- Signs of cardiac failure
 - Respiratory distress
 - Tachypnoea
 - Bibasal crepitations
 - Cardiac wheeze
 - Tachycardia
 - Displaced apex beat
 - Third heart sound
 - RV heave
 - Raised JVP
 - Hepatomegaly
 - Peripheral oedema
- Signs of sepsis
 - Pyrexia
 - Tachypnoea

- Tachycardia
- Altered mental state
- Hypotension in septic shock
- Signs of the focus
- Signs of malignancy
 - Cachectic
 - Signs of the focus
- Signs of ureteric obstruction
 - Unable to get comfortable
 - Tender loin
- Signs of bladder obstruction
 - Tender suprapubic mass that is dull to percussion; palpation may generate the urge to urinate
 - Enlarged prostate on digital rectal examination

Investigation of acute kidney injury:

- Urea & electrolytes (U&Es)
 - Although there may be prior clinical suspicion, comparison of current Cr to previous values will make the diagnosis, grade the severity and identify any accompanying electrolyte abnormalities
- Full blood count (FBC)
 - May reveal elevated white cell and neutrophil count suggesting infection
- Venous blood gas (VBG)
 - May reveal a metabolic acidosis and will provide certain electrolytes faster than laboratory blood tests
- Urinalysis
 - Proteinuria may be part of nephrotic syndrome and should be quantified with a urinary protein:creatinine ratio (PCR)
 - Haematuria may be part of nephritic syndrome and should prompt a nephritic screen
 - Leucocytes and nitrites suggest infection and should prompt a urine culture
- Urinary & plasma osmolality and sodium: may help distinguish between pre-renal AKI and ATN
 - Pre-renal AKI: kidney is functioning maximally to retain salt and water; urinary osmolality is high (600-900 mosm/L) and urinary sodium is low (<10 mM)
 - ATN: kidney is functioning inadequately and is unable to retain salt and water; urinary osmolality approaches that of plasma (280 mosm/L) and urinary sodium rises (>30 mM)
- Bladder scan
 - Will reveal the volume of urine in the bladder and suggests retention if >600 ml
 - If the patient is able to pass urine, perform a post-void bladder scan: if the volume is still significant, this suggests incomplete voiding and partial retention
- Renal ultrasound scan (USS)
 - May reveal the source of any post-renal obstruction

Initial management of acute kidney injury (AKI):

- Stop/avoid nephrotoxic drugs;
 - If they are absolutely necessary adjust dosages accordingly
- Fluid resuscitation
- Monitor fluid balance with input/output chart and daily weights
- Daily U&Es
- Urinary osmolality and sodium
- Urinalysis +/- culture, urinary PCR or nephritic screen

- Urethral catheterisation to relieve bladder outflow obstruction and/or accurately monitor urine output
 - When considering urethral catheterisation for urine output monitoring, weigh the benefits of accurate urine output monitoring against the risks of introducing infection
- Renal USS
 - Consider if suspicious of post-renal obstruction, especially if not resolved by urethral catheterisation
- Treat the cause
- Treat any complications

Further management of acute kidney injury (AKI):

- Indications for renal replacement therapy (RRT):
 - Urine output <0.3 ml/kg for 24 hours
 - Absolute anuria for >12 hours
 - Multi-organ failure
 - Refractory volume overload
 - Complications of uraemia
 - Uraemic encephalopathy
 - Uraemic pericarditis
 - Severe poisoning or drug overdose
 - Severe hypo/hyperthermia
 - Refractory hyperkalaemia >6.5 mM
 - Serum urea >27 mM
 - Refractory metabolic acidosis pH <7.15
 - Refractory electrolyte abnormalities
 - Hyponatraemia <115 mM
 - Hypernatraemia >165 mM
 - Hypercalcaemia
- Types of continuous renal replacement therapy (CRRT):
 - Continuous venovenous haemodialysis (CVVHD)
 - Continuous venovenous haemofiltration (CVVHF)
 - Continuous venovenous haemodiafiltration (CVVHDF)

Complications of acute kidney injury:

- Hyperkalaemia
- Hypo/hypernatraemia
- Hypercalcaemia
- Metabolic acidosis
- Pulmonary oedema
- Hypertension
- Uraemic encephalopathy
- Uraemic pericarditis

Prognosis of acute kidney injury:

- When mild and treated promptly and aggressively, AKI is usually reversible
- When severe and/or unrecognised and/or treated inadequately, there is usually at least an element of chronic renal impairment

Common questions concerning acute kidney injury (AKI):

- Define the terms acute kidney injury (AKI), oliguria and anuria
 - AKI: sudden deterioration in renal function leading to an inability to maintain fluid, electrolyte and acid-base balance
 - Oliguria: reduced urine output; defined variously as <0.5 ml/kg/hour, <30 ml/hour or <400 ml/day
 - Anuria: complete absence of urine output
- Outline the criteria for staging AKI
 - Stage 1: Cr ≥ 1.5 -2 times baseline or urine output (UO) <0.5 ml/kg/hours for >6 consecutive hours
 - Stage 2: Cr ≥ 2 -3 times baseline or UO <0.5 ml/kg/hours for >12 hours
 - Stage 3: Cr ≥ 3 times baseline or UO <0.3 ml/kg/h for ≥ 24 hours or anuria for >12 hours
- List three broad categories of AKI
 - Pre-renal
 - Intrinsic renal
 - Post-renal
- List four types of nephrotoxic drugs that you would stop/avoid
 - ACEIs
 - ARBs
 - NSAIDs
 - Aminoglycosides e.g. gentamicin
- When assessing fluid status, what signs would you look for on examination that suggest a patient is hypovolaemic?
 - Cold, pale peripheries
 - Prolonged capillary refill times (CRT >2 s)
 - Decreased skin turgor
 - Reduced jugular venous pressure (JVP)
 - Sunken eyes
 - Dry lips, mouth and tongue
 - Tachycardia
 - Postural hypotension
 - Absolute hypotension
 - Dark urine
- How can urinary & plasma osmolality and sodium help in determining the cause of AKI?
 - Pre-renal AKI: kidney is functioning maximally to retain salt and water; urinary osmolality is high (600-900 mosm/L) and urinary sodium is low (<10 mM)
 - ATN: kidney is functioning inadequately and is unable to retain salt and water; urinary osmolality approaches that of plasma (280 mosm/L) and urinary sodium rises (>30 mM)
- Outline the possible complications of AKI
 - Hyperkalaemia
 - Hypo/hypernatraemia
 - Hypercalcaemia
 - Metabolic acidosis
 - Pulmonary oedema
 - Hypertension
 - Uraemic encephalopathy
 - Uraemic pericarditis
- List the indications for commencing CRRT in AKI
 - Urine output <0.3 ml/kg for 24 hours
 - Absolute anuria for >12 hours
 - Multi-organ failure

- Refractory volume overload
- Complications of uraemia
 - Uraemic encephalopathy
 - Uraemic pericarditis
- Severe poisoning or drug overdose
- Severe hypo/hyperthermia
- Refractory hyperkalaemia >6.5 mM
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