## 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
- Oligura: 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/hrs for >6 consecutive hours
- Stage 2: Cr ≥2-3 times baseline or UO <0.5 ml/kg/hrs 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
  o 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
  o Interstitial
    ▪ Acute interstitial nephritis: usually caused by a drug-induced allergic reaction
      • Penicillin
      • NSAIDs
    ▪ Autoimmune disease e.g. systemic lupus erythematosus (SLE)
    ▪ Infiltrative disease
      • Lymphoma
      • Sarcoidosis
  o Vascular
    ▪ Hypertensive nephropathy
    ▪ Vasculitides
    ▪ Haemolytic uraemic syndrome (HUS)
    ▪ Thrombotic thrombocytopenic purpura (TTP)
    ▪ Disseminated intravascular coagulation (DIC)
• Post-renal: obstruction to urinary flow
  o 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
  o 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

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
  o When considering urethral catheterisation for urine output monitoring, weigh the benefits of accurate urine output monitoring against the risks of introducing infection
• Renal USS
  o 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):
  o Urine output <0.3 ml/kg for 24 hours
  o Absolute anuria for >12 hours
  o Multi-organ failure
  o Refractory volume overload
  o Complications of uraemia
    ▪ Uraemic encephalopathy
    ▪ Uraemic pericarditis
  o Severe poisoning or drug overdose
  o Severe hypo/hyperthermia
  o Refractory hyperkalaemia >6.5 mM
  o Serum urea >27 mM
  o Refractory metabolic acidosis pH <7.15
  o Refractory electrolyte abnormalities
    ▪ Hyponatraemia <115 mM
    ▪ Hypernatraemia >165 mM
    ▪ Hypercalcaemia
• Types of continuous renal replacement therapy (CRRT):
  o Continuous venovenous haemodialysis (CVVHD)
  o Continuous venovenous haemofiltration (CVVHF)
  o 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
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- Refractory hyperkalaemia >6.5 mM
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