Kidney basics

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Functions of the kidneys

The kidneys have numerous functions and don’t just produce urine:

- Play a key role in regulating blood pressure
- Produce Erythropoietin that is vital in the production of red blood cells
- Maintain calcium and phosphate balance via the nephrons and through the activation of Vitamin D
- Maintain acid/base balance
- Maintain electrolyte balance, such as potassium and sodium
- Removal of waste products such as urea, creatinine, drugs and toxins
The launderette theory of renal function.....
Pump

Inflow pipes

Blood supply in

Pre

Renal

Damage to kidney itself

Cleaner

Outflow pipes

Post

Drainage of urine
Acute kidney injury

Sudden insult can be largely reversed if treated quickly
Post AKI
Chronic kidney disease
AKI on chronic
Post AKI on CKD
The tea bag.....
Kidney Dysfunction

- Kidney dysfunction can be seen as chronic or acute in nature.
- Chronic Kidney Disease (CKD) is the gradual decline in renal function over months or usually years.
- Acute Kidney Injury (AKI), formally known as acute renal failure, is the sudden deterioration of renal function over hours or days.
- People with CKD can also experience episodes of AKI – known as acute on chronic.
- People with CKD are most at risk of developing AKI.
Drugs affecting blood supply in

- ACE inhibitors (ACEi) / ARBs (ARB)
- NSAIDs
- Diuretics
- Blood pressure tablets
- Spironolactone
Drugs affecting kidney itself

- Gentamicin
- Amphotericin
- Carboplatin
- Lithium

Damage to kidney itself
Drugs to be aware of in kidney failure

- Metformin
- Insulin
- Opioids
- Gabapentin / pregabalin
Acute kidney injury

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The NHS campaign to improve the care of people at risk of, or with, acute kidney injury

In the UK up to 100,000 deaths each year in hospital are associated with acute kidney injury. Up to 30% could be prevented with the right care and treatment.

One in five people admitted to hospital in the UK each year as an emergency has acute kidney injury.

Just one in two people know their kidneys make urine.

About 65% of acute kidney injury starts in the community.

NCEPOD, Adding Insult to Injury, 2009
Ipsos MORI survey, July 2014

Think Kidneys is a national programme led by NHS England in partnership with UK Renal Registry

https://www.thinkkidneys.nhs.uk/aki/
RCGP AKI http://www.rcgp.org.uk/aki
Pump

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Blood supply in

Outflow pipes

Drainage of urine

Pre

Renal

Cleaner

Damage to kidney itself

Post
Consider INSULT and RISK FACTORS

Acute insult

Risk factors

Acute insult

Risk factors
**CAUSES**

- Cardiac causes: MI, acute arrhythmia, acute LV dysfunction
- Dehydration; diarrhoea and vomiting, poor intake, increased stoma output
- Blood loss; trauma, GI bleed
- Sepsis
- Liver failure

**Obstruction:**
- Prostate enlargement: BPH or Ca
- Malignancy; bladder, cervical, uterine, pelvic
- Uterine fibroids
- Bladder stones
- Ureteric stone in single kidney

**RISK FACTORS**

- Cardiac failure, uncontrolled AF, ileostomy, dementia, medication, elderly, immunosuppressed, vascular disease, diabetes, liver disease

**Inflow pipes**

**Cleaner**

- Chronic kidney disease
- Previous AKI

**Outflow pipes**

- Catheter (blocking)
- Known BPH or Prostate cancer
- Stents
Cardiac causes: MI, acute arrhythmia, acute LV dysfunction
Dehydration; diarrhoea and vomiting, poor intake, increased stoma output
Blood loss; trauma, GI bleed
Sepsis
Liver failure

Inflammatory renal disease; vasculitis
Myeloma
Drugs
Rhabdomyolysis
Pre-eclampsia

Obstruction:
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CAUSES

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Inflow pipes

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Ureteric stone in single kidney

Cardiac failure, uncontrolled AF, ileostomy, dementia, medication, elderly, immunosuppressed, vascular disease, diabetes, liver disease

Chronic kidney disease
Previous AKI

Catheter (blocking)
Known BPH or Prostate cancer
Stents
Drugs increasing risk

- ACEin /ARB
- NSAIDs
- Diuretics
- Blood pressure tablets
- Spironolactone
Drugs increasing risk: NEPHROTOXINS

- Gentamicin
- Amphotericin
- Carboplatin

Idiosyncratic; interstitial nephritis

- PPI
- Antibiotics
- NSAIDs
- And many others....

Damage to kidney itself
Drugs to be aware of in kidney failure

- Metformin
- Insulin
- Opioids
- Gabapentin / pregabalin
Detecting AKI
Testing

Blood tests
• Serum creatinine
• Need previous test to compare with
• No eGFR in AKI

<table>
<thead>
<tr>
<th>AKI stage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AKI stage 1</td>
<td>Cr &gt;1.5x baseline or ↑ 26µmol/l in 24 hrs</td>
</tr>
<tr>
<td>AKI stage 2</td>
<td>Cr &gt;2.0x baseline</td>
</tr>
<tr>
<td>AKI 3 stage 3</td>
<td>Cr &gt;3.0x baseline or 1.5x and &gt;354 µmol/l</td>
</tr>
</tbody>
</table>

Urine tests
• Urine dipstick
  • Blood and protein
This algorithm has been endorsed by NHS England and it is recommended that the algorithm is implemented across the NHS. When integrated into a Laboratory Information Management System (LIMS) the algorithm will identify potential cases of AKI from laboratory data in real time and produce a test result. The laboratory system will then send the test result, using existing IT connections to patient management systems.
<table>
<thead>
<tr>
<th>AKI Warning Stage Test Result</th>
<th>Clinical Context Within Which Blood Test Taken#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirm or refute automated AKI Test Result by comparing patient’s current creatinine within clinical context against baseline creatinine</td>
<td>If clinical context is unknown, then assume high pre-test probability until proven otherwise</td>
</tr>
<tr>
<td></td>
<td>LOW Pre-test Probability of AKI Stable Clinical Context</td>
</tr>
<tr>
<td></td>
<td>HIGH Pre-test Probability of AKI Context of Acute Illness</td>
</tr>
<tr>
<td><strong>AKI Warning Stage 1</strong></td>
<td><strong>Consider clinical review ≤ 72 hours of e-alert</strong>*</td>
</tr>
<tr>
<td>Current creatinine ≥1.5 x baseline level (or creatinine rise &gt;26 μmol/L 48 hrs)</td>
<td><strong>If AKI confirmed → manage as per table 2</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Likely Stage 1 AKI → manage as per table 2</strong></td>
</tr>
<tr>
<td><strong>AKI Warning Stage 2</strong></td>
<td><strong>Consider clinical review ≤ 24 hours of e-alert</strong>*</td>
</tr>
<tr>
<td>Current creatinine ≥2 x baseline level</td>
<td><strong>If AKI confirmed → manage as per table 2</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Likely Stage 2 AKI → manage as per table 2</strong></td>
</tr>
<tr>
<td><strong>AKI Warning Stage 3</strong></td>
<td><strong>Consider clinical review ≤ 6 hours of e-alert</strong>*</td>
</tr>
<tr>
<td>Current creatinine ≥3 x baseline level (or creatinine 1.5 x baseline and &gt;354 μmol/L)</td>
<td><strong>If AKI confirmed → consider admission</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Likely Stage 3 AKI</strong></td>
</tr>
</tbody>
</table>

**#Clinical Context**

Why was the blood test taken?
- Routine chronic disease monitoring
- Drug monitoring
- Assessment of acute illness

Creatinine rise within stable clinical context may reflect unstable CKD instead of AKI, especially if longer time period between current and baseline creatinine.

**AKI Risk Factors/Clinical Features Prompting Earlier Review**

- Poor oral intake/urine output
- Evidence of hyperkalaemia, especially if moderate (K+ 6.0-6.4) or severe (K+ ≥ 6.5)￥
- Known history of CKD stages 4 & 5 or history of kidney transplant
- Deficient Immunity
- Frail with co-morbidities (CKD, diabetes, heart failure, liver disease, neurological or cognitive impairment)
- Past history of AKI
- Suspected intrinsic kidney disease
- Suspected urinary tract obstruction
## Management

<table>
<thead>
<tr>
<th>&quot;Think&quot; Cause</th>
<th>&quot;Think&quot; Medication#</th>
<th>&quot;Think&quot; Fluids</th>
<th>&quot;Think&quot; Review¥</th>
</tr>
</thead>
</table>
| History of acute Illness?  
  • Think Sepsis  
  • Think Hypotension | Any medication which could exacerbate AKI?  
  Consider withholding:  
  • NSAIDs  
  • Diuretics  
  • Antihypertensive medication | What is the patient’s volume status?  
If hypovolemia present:  
  • When did patient last pass urine?  
  • Can the patient increase fluid intake?  
  • Is admission for IV fluid replacement and monitoring required? | Does the patient need acute admission?  
If not, when will you review?  
Have you ensured handover?¥ |
| Intrinsic kidney disease?  
(E.g. vasculitis)  
• Think Urinalysis | Any medication which may accumulate and cause harm during AKI?  
Any new medication that may cause AKI?(E.g. drug induced tubulo-interstitial nephritis) | Does the patient have and/or need carer support? | |
| Urinary tract obstruction? | | | |
Tightrope walkers
Heart failure

- Poor pump
- Diuretics
- ACEin / ARB
- Spironolactone
- CKD

Treat the patient and the bloods not just one or the other

Take advice

Just keep the ship steady.....
Mrs AG 83 yr old lady

- Baseline CKD with
  - eGFR 34ml/min.
  - creatinine 135umol/l but fluctuates
- Heart failure on furosemide 80mg daily
- ACE inhibitor: ramipril 5mg daily
- BP 125/50
- Diabetic on gliclazide
- Diarrhoea and vomiting

- Bloods:
  - Creatinine 180umol/l

AKI 1 alert

Action?
Mr PK 65 yr old male

- Baseline CKD last measured 2 years ago
  - creatinine 160 umol/l
  - eGFR 40ml/min
  - ACR 40mg/mmol
- Diabetic. Control not great on metformin
- Hypertension
  - Clinic BP 160/95
- Recheck bloods as in the surgery

- Results:
  - Creatinine 220umol/l
  - (eGFR 28ml/min)
  - ACR 80mg/mmol
- AKI 1 alert
- Action?
83 yr old man

- Renal function checked 1 year ago
  - Creatinine 100umol/l
  - eGFR 66 ml/min
- 12 month history of increased frequency and nocturia
- 1 week history of less urine output
- 2 day history of high fever
- BP 90/50, tachycardic and unwell

- Creatinine 400umol/l
- K 6.5 mmol/l
- AKI 3 alert
- Action?
56 yr old woman

- Renal function checked 2 years ago as borderline hypertensive
  - Creatinine 50 umol/l
  - eGFR >90 ml/min

- 2 month history of non-specific illness with weight loss
- 3 month history of nose bleeds
- Rash: 1 week
- Creatinine 150umol/l
82 yr old male

- Baseline renal function
  - Creatinine 120 umol/l
  - eGFR 53ml/min
- Fell and hurt ribs
- Constipated
- Not so well

- Creatinine 220 umol/l
- Calcium 2.8 mmol/l
- Hb 89g/l
- ESR 120

- Immunoglobulins raised IgG 26g/l, others suppressed
- Serum protein electrophoresis paraprotein IgG
- Serum free light chains
Beware.....

• Protein supplements in young people
• Trimethoprim

• Last renal measure was:
  • In hospital on iv fluids or after long admission / period of poor nutrition
  • In pregnancy
Summary AKI

• It’s common and it increases risk of death
• Balance of insult vs risk factor
• Review reason for blood tests in the first place for speed of review needed
• Repeat if unexpected and patient well

• Restart needed medication promptly on recovery; take advice if needed