Kidney Disease

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The Kidney has 2 main functions:

- Maintaining a constant extracellular environment
  - Removing toxins and excess fluid

- Hormone production
  - Red cell production (erythropoietin)
  - Vitamin D
  - Blood pressure control
What happens when the Kidneys Fail?

- Swelling, fluid accumulation
- Loss of energy, appetite, itch
- Anaemia (low blood count)
- High blood pressure
- Osteoporosis (bone disease)
However......

- None of these occur until there has been significant kidney damage.

- Kidney failure is silent until significant irreversible damage has occurred.
Some Myths Relating to the Kidneys

- Alcohol does not affect the kidneys
- Drinking large amounts of fluid does not improve how the kidneys work
- The amount of urine or the manner of passing urine does not reflect how the kidneys work
- Diseases affecting the kidneys affect both kidneys at the same time, not just one
- When kidney damage occurs, it will generally never recover.
Measuring Kidney Function

- Blood tests (creatinine)
- Urine tests (single urine sample or a 24 hour collection)
- X rays and ultrasound scans
Creatinine is a marker of kidney function

![Graph showing the relationship between creatinine (sCr) and eGFR (eGFR)](image-url)
Serum Creatinine: Be Careful!

- Age
- Gender
- Body weight
- Muscle mass
- Race

sCr 120 µmol/L ≠ 120 µmol/L
GFR 30 mL/min 130 mL/min
eGFR: A Description of Kidney Function

- Cockcroft-Gault formula:
  \[
  \frac{(140-\text{age}) \times \text{lbw} \times 1.2}{\text{Plasma creatinine}} \times (x 0.85 \text{ female})
  \]

- MDRD formula

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Weight</th>
<th>Creatinine</th>
<th>eGFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>25</td>
<td>100</td>
<td>120</td>
<td>115</td>
</tr>
<tr>
<td>Female</td>
<td>80</td>
<td>50</td>
<td>120</td>
<td>21</td>
</tr>
</tbody>
</table>
## Stages of CKD by eGFR

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>eGFR (mL/min/1.73m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kidney damage with normal or ↑ eGFR</td>
<td>&gt;90</td>
</tr>
<tr>
<td>2</td>
<td>Mild ↓ eGFR</td>
<td>60-89</td>
</tr>
<tr>
<td>3</td>
<td>Moderate ↓ eGFR</td>
<td>30-59</td>
</tr>
<tr>
<td>4</td>
<td>Severe ↓ eGFR</td>
<td>15-29</td>
</tr>
<tr>
<td>5</td>
<td>Kidney failure</td>
<td>&lt;15 or Dialysis</td>
</tr>
</tbody>
</table>

Epidemic of chronic kidney disease

Stage 5
Stage 4
Stage 3
Stage 2
Stage 1

Clinical Practice Guidelines for CKD  AJKD 2002
Diabetic kidney disease is now the most common cause of end stage kidney failure.
"Would you like a bypass with that?"
Mean life expectancy at age 49 on dialysis is 7 years; 5 year survival in diabetics on dialysis is 20% (similar to lung cancer)
Diabetic Nephropathy (Diabetic Kidney Disease)

Nodules

*Diabetic nephropathy* Light micrograph showing diffuse and nodular (N) glomerulosclerosis in diabetic nephropathy. Note the dense appearance of the deposits and the rim of cells around the nodules, which distinguish this disorder on light microscopy from fibrillary glomerulonephritis or amyloidosis. Courtesy of Helmut Rennke, MD.
Protein in the Urine in Diabetes

A

Years after Diagnosis of Diabetes

Prevalence of Proteinuria (%)

Type 1

Type 2

B

Years after Onset of Proteinuria

Prevalence of Renal Failure (%)

Type 1

Type 2
The measurement of protein in the urine is the Albumin/Creatinine Ratio (ACR)

Normal <2.5

Changes in the ACR reflect progress of diabetic kidney disease

‘ACR’
Management Issues in CKD

- General considerations
- Calcium and phosphate
- Anaemia
- End stage disease
Modifying Progression Factors to Slow CKD

- Strict BP control
- ACE inhibitors, angiotensin II receptor blockers (ARBs)
- Cholesterol and lipids
- Diabetes control
- Avoid nephrotoxic agents
- Use of statins
- Lifestyle adjustment (smoking cessation)

Calcium and Phosphate Abnormalities In CKD

Triad

• Low calcium (Low vitamin D levels)
• Raised Phosphate
• Raised Parathyroid Hormone level
CVD Is a Major Cause of Mortality in ESRD

Cardiovascular Mortality in the General Population (NCHS) and in ESRD Treated by Dialysis (USRDS)

- GP Male
- GP Female
- GP Black
- GP White
- Dialysis Male
- Dialysis Female
- Dialysis Black
- Dialysis White

Sarnak and Levey
AJKD 2000,
35:S117-131
Coronary Artery Calcification in a Haemodialysis Patient
# CKD Blueprint

<table>
<thead>
<tr>
<th>CKD Stage</th>
<th>eGFR</th>
<th>Issue</th>
<th>Treatment</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt;90</td>
<td><strong>Detection</strong> <em>(Urine ACR)</em></td>
<td><strong>BP/diabetes</strong></td>
</tr>
<tr>
<td>2</td>
<td>60-90</td>
<td><strong>Progression</strong></td>
<td><strong>BP control, ACEi/ARB</strong></td>
</tr>
<tr>
<td>3</td>
<td>30-60</td>
<td><strong>Calcium and phosphate</strong></td>
<td><strong>Vitamin D, phosphate binders</strong></td>
</tr>
<tr>
<td>4</td>
<td>15-30</td>
<td><strong>Anaemia</strong></td>
<td><strong>Erythropoietin</strong></td>
</tr>
<tr>
<td>5</td>
<td>&lt;15</td>
<td><strong>Preparation</strong></td>
<td><strong>Dialysis</strong></td>
</tr>
</tbody>
</table>
Acute Kidney Injury (AKI)

(no longer ARF)

• Loss of renal function over hours or days
• Expressed clinically as the retention of nitrogenous waste products in the blood
Definitions

- **Azotemia**: The accumulation of nitrogenous waste products
- **Uraemia**: Symptomatic renal failure
- **Oliguria**: Urine output < 400-500ml/24 hrs
- **Anuria**: Urine output < 100 ml/24hrs
Mortality in AKI

![Bar chart showing mortality in AKI](chart.png)

Star R: Kidney Int 1998; 54: 1817-1831
### Acute Kidney Injury Classification

<table>
<thead>
<tr>
<th>Stage</th>
<th>Creatinine Criteria</th>
<th>Urine Output Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>X 1.5-2</td>
<td>&lt; 0.5ml/kg x 6 hours</td>
</tr>
<tr>
<td>Stage 2</td>
<td>X 2-3</td>
<td>&lt;0.5ml/kg x 12 hours</td>
</tr>
<tr>
<td>Stage 3</td>
<td>&gt;3 fold</td>
<td>&lt;0.3ml/kg x 24 hours</td>
</tr>
</tbody>
</table>
Causes of AKI

Prerenal

Intrinsic

Acute tubular necrosis
Acute interstitial nephritis
Acute GN
Acute vascular syndromes
Intratubular obstruction

Postrenal
Postrenal AKI – ‘Obstruction’
Aetiology of Obstruction

• Upper tract obstruction
  – Intrinsic eg blood clot, stone
  – Extrinsic eg malignancy

• Lower tract obstruction
  – Prostate
  – Bladder TCC
  – Urethral stricture
  – Neurogenic bladder
Prerenal AKI

- Normal perfusion pressure
  - Afferent arteriole
  - Efferent arteriole
  - Glomerulus
  - Tubule
  - Normal GFR

- Decreased perfusion pressure
  - Increased vasodilatory prostaglandins
  - Increased angiotensin II
  - Low GFR

- Decreased perfusion pressure in the presence of NSAIDs
  - Decreased vasodilatory prostaglandins
  - Increased angiotensin II
  - Low GFR

- Decreased perfusion pressure in the presence of ACEi or ARB
  - Slightly increased vasodilatory prostaglandins
  - Decreased angiotensin II
  - Low GFR


ACEi/ARB

NSAIDs
In Practice

- Clinical suspicion (not post renal etc)
- Assess the volume status (skin turgor, JVP, tongue, chest signs, oedema)

- Trial of IV saline – but be careful!
  then

- Re-establish normal circulating volume, remove offending medications, deal with the underlying problem and wait.
Intrinsic acute renal failure

- Acute tubular necrosis
- Acute interstitial nephritis
- Acute glomerulonephritis
- Acute vascular syndromes
Acute Tubular Necrosis

Denuded epithelium

Urinalysis

‘Muddy Brown Casts"
Pathophysiological Mechanisms of Ischemic Acute Tubular Necrosis

Phases of Ischaemic ATN

GFR vs. Time

- Prerenal
- Initiati
- Extension
- Maintenance
- Recovery
Dialysis

Haemodialysis
Peritoneal Dialysis

Peritoneal dialysis
Continuous Renal Replacement Therapy
(‘Prismaflex’)
Indications for Dialysis

- Volume overload
- Metabolic acidosis
- Hyperkalaemia
- Encephalopathy
- Pericarditis
The ‘Achilles Heel’ of Dialysis

Achilles and his Mother
‘Perm caths’
**Arteriovenous Fistula**

*Figure 30-1A Methods of vascular access for hemodialysis. (A) Arteriovenous fistula.*

‘A Work in Progress’

- Epidemic of renal disease, often unrecognised
- Serum creatinine is the best measure of estimating kidney function, expressed as the eGFR (‘percentage’ renal function)
- Chronic kidney disease has a higher cardiac morbidity and mortality
- Diabetes is the most common cause of chronic kidney disease
- Acute kidney injury
- Dialysis – haemodialysis, peritoneal dialysis, ICU dialysis
- Vascular access difficulties remain
A busy day in the dialysis unit

"Pull out, Betty! Pull out!... You've hit an artery!"