Acute renal failure: recognition and treatment in ward patients

Aim and intended learning outcomes

Before reading this article, summarise what you already know about ARF by answering the following questions:

I Which patients on your ward are at risk?
I What are the causes of ARF?
I How would you define ARF?
I Which patients present at risk factors for ARF but do not develop the condition?
I What are the potential clinical problems that can present in patients with ARF?
I How would you manage a patient with ARF?
I How would you define ARF?
I What are the causes of ARF?
I Which patients on your ward are at risk?
I What are the potential clinical problems that can present in patients with ARF?
I How would you manage a patient with ARF?
I What are the causes of ARF?
The kidneys are two bean-shaped organs positioned retroperitoneally in the posterior abdominal wall at the level of the upper lumbar vertebrae. Each kidney is surrounded and protected by perirenal fat and supplied by branches of the renal arteries that originate from the abdominal aorta and deliver approximately 20-25 per cent of the cardiac output every minute (Tortora and Grabowski 1993) (Figure 1). The main function of the kidney is to regulate the volume and composition of body fluids within narrow limits (Field et al 2001). The kidney has many other functions, which are summarised in Box 1.

The nephron is the working unit of the kidney (Figure 2), of which there are approximately one million (Marieb 2004). Each nephron consists of five components, each performing a distinct process (Thomas 2002):

I The Bowman's capsule forms a blind-ending capsule around a knot of capillaries called the glomerulus, which is the site of filtration.

I The proximal convoluted tubule extends through the renal cortex and is where most reabsorption and some secretion of the solute take place.

I The loop of Henle extends from the proximal convoluted tubule into the medulla and back into the renal cortex and is where the concentration and dilution of urine mainly occur.

I The distal convoluted tubule leads into the collecting ducts and is the site of final adjustment of fluid/solute concentration and further secretion.

I The collecting duct is where the final concentration of urine occurs. It transports urine into the renal pelvis.

Functions of the kidney
Anatomy and physiology
Excretion
I Removal of the waste products of metabolism – urea and creatinine
I Removal of excess fluid – concentration and dilution of urine
I Regulation of acid-base balance – excretion of hydrogen ions (H+) and conservation of bicarbonate ions
I Regulation of electrolyte levels
Secretion
I Regulation of blood pressure – renin
I Regulation of red blood cell production – erythropoietin
I Regulation of calcium uptake – activated vitamin D

Box 1. Functions of the kidney

Figure 1. Cross-section of the kidney
Figure 2. A nephron

TIME OUT 2
Before reading on, revise the anatomy and physiology of the kidneys using a general anatomy and physiology textbook such as Tortora and Grabowski (1993).

List the main functions of the kidney.
Table 1. Hormonal regulation of fluid and sodium balance

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Action</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antidiuretic hormone (ADH)</td>
<td>Acts on collecting ducts</td>
<td>Retains water, decreases urine output</td>
</tr>
<tr>
<td>Aldosterone</td>
<td>Regulates sodium retention</td>
<td>Increases sodium reabsorption in tubules</td>
</tr>
<tr>
<td>Atrial natriuretic peptide (ANP)</td>
<td>Acts on atrial walls</td>
<td>Promotes sodium excretion, decreases blood pressure</td>
</tr>
</tbody>
</table>

Box 2. Composition of glomerular filtrate

<table>
<thead>
<tr>
<th>Substance</th>
<th>Concentration in filtrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>99%</td>
</tr>
<tr>
<td>Glucose</td>
<td>1%</td>
</tr>
<tr>
<td>Mineral salts</td>
<td>0%</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>0%</td>
</tr>
<tr>
<td>Creatinine</td>
<td>0%</td>
</tr>
<tr>
<td>Uric acid</td>
<td>0%</td>
</tr>
<tr>
<td>Phosphates</td>
<td>0%</td>
</tr>
<tr>
<td>Urea</td>
<td>0%</td>
</tr>
</tbody>
</table>

Box 3. Composition of urine

<table>
<thead>
<tr>
<th>Substance</th>
<th>Concentration in urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>95%</td>
</tr>
<tr>
<td>Glucose</td>
<td>3%</td>
</tr>
<tr>
<td>Mineral salts</td>
<td>1%</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>0%</td>
</tr>
<tr>
<td>Creatinine</td>
<td>1%</td>
</tr>
<tr>
<td>Uric acid</td>
<td>0.5%</td>
</tr>
<tr>
<td>Phosphates</td>
<td>0.5%</td>
</tr>
<tr>
<td>Urea</td>
<td>1%</td>
</tr>
</tbody>
</table>

TIME OUT 3

Urine formation involves the movement of substances from the blood to the urine through the nephron. The three processes by which substances are reabsorbed into the blood are:

1. Tubular reabsorption: This occurs in the proximal and distal tubules, and involves the movement of substances against a concentration gradient. The main areas in which this process occurs are the proximal convoluted tubule, ascending limb of the loop of Henle, and the cortical collecting duct.

2. Glomerular filtration: This is the process whereby plasma is filtered across the capillary wall of the glomerulus, and results in the formation of a filtrate similar to the final product – urine.

3. Tubular secretion: This involves the movement of substances from the blood to the urine, and is an active process that occurs in the proximal and distal tubules. Examples of substances that are secreted into the tubules include potassium, hydrogen, and phosphates.

Tubular reabsorption is the process by which substances are returned to the blood, and it involves the movement of water and dissolved substances in the tubular fluid back into the bloodstream. This process is selective, as not all of the substances in the tubular fluid are reabsorbed back into the blood.

Urea is a product of nitrogen metabolism, and it is a byproduct of protein catabolism. Urea is synthesized in the liver and is excreted in the urine. Approximately 65% of all reabsorption occurs in the proximal tubule (Thomas 2002).

Potassium is also secreted in the tubules and this is an important factor in maintaining the osmolality of the urine. Hydrogen ions are secreted in the tubules and this helps with the process of urine formation.

Pre-renal renal failure refers to the ineffective perfusion of the kidney due to conditions such as hypotension or shock. This type of renal failure can be reversed if the underlying cause is treated.

Post-renal renal failure is due to obstruction of the outflow from the kidney, such as a urinary tract obstruction. This type of renal failure can be reversed if the obstruction is relieved.

Renal tubular acidosis results from an inability of the kidneys to excrete hydrogen ions in the urine. This can lead to metabolic acidosis and is usually associated with other disorders such as diabetes or renal disease.

Nutrition is an important factor in the management of renal failure. A diet low in sodium and protein is recommended to reduce the workload on the kidneys and help prevent fluid overload.

Further reading:

Recovery phase

I

Diuretic phase

I

I

into three stages:

return at some stage. Reversible ARF can be divided

damage is reversible and that renal function will

lifetime dialysis treatment or a kidney transplant.

uraemia will progress, with the patient requiring

implies that kidney function will not return and

Irreversible renal failure

ondary tubular damage.

in the kidneys. If this is prolonged it can lead to sec-

bladder, causing an increase in hydrostatic pressure

Post-renal renal failure

intra-renal vasoactive substances (Marshall 2002).

debries and casts, interstitial oedema, or release of

attributed to obstruction of the tubular lumen by

of the GFR to recover is common and is generally

factors may be involved. Generally the GFR falls due

iology of this condition can be complex and several

pathophys-
to as intrinsic renal failure when damage has occurred

restored before structural damage occurs.

vent this stage if renal perfusion can be adequately

is not restored rapidly, pre-renal uraemia may progress

do not experience oliguria and these patients

phase may last one to two weeks, or may extend

ished, normal or even high urine output. This

2002). ARF can occur in patients who have dimin-

nary output of less than 400ml/day (Marshall

Table 2. Causes of acute renal failure

(Adapted from Singri

et al 2003 and Armitage and Thompson 2003)

Pre-renal

Hypotension

Obstruction

Glomerular injury

1. Acute interstitial nephritis

Interstitial injury

2. Blockage of tubules

Tubular injury

Intra-renal

2. Acute pyelonephritis

1. Goodpasture's syndrome

Glomerular injury

1. Acute tubular necrosis – post-ischaemic renal failure

Vascular injury

1. Systemic septic shock

Burns

1. Renal vein stenosis

Renal artery stenosis

1. Malignant hypertension

Pre-eclampsia

1. Renal stones

Benign prostatic hypertrophy

Haemolytic uraemic syndrome

Malignant hyperpyrexia

Rhabdomyolysis – a condition caused by the accumulation of

myoglobin which, when released from the damaged skeletal

muscle, blocks the renal tubules

Viral (leptospirosis)

Systemic diseases (systemic lupus erythematosus)

Bacterial toxins (endotoxin)

Drugs/antibiotics (NSAIDs)

Rhabdomyolysis – a condition caused by the accumulation of

myoglobin which, when released from the damaged skeletal

muscle, blocks the renal tubules

Viral (leptospirosis)

Systemic diseases (systemic lupus erythematosus)

Bacterial toxins (endotoxin)

Drugs/antibiotics (NSAIDs)

Failure to reverse hypovolaemia (severe vomiting

Cardiogenic shock

Dehydration

Haemorrhage

Burns

Nephrotoxic agents (contrast medium, drugs such

as paracetamol, non-steroidal anti-inflammatory

drugs (NSAIDs), angiotensin-converting enzyme

(ACE) inhibitors, aminoglycosides, and amphotericin)

Poisons

Intravenous immunoglobulin

Intravenous fluid boluses

Intravenous fluid boluses

IV fluids

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid boluses

Intravenous fluid bolus
Kidney disorders

Signs and symptoms of acute renal failure (Adapted from Viney 1996)

- Convulsions
- Irritability
- Electrolyte imbalance
- Twitching seizures
- Confusion
- Depressed level of consciousness or altered mental state
- Congestive cardiac failure
- Dehydration or sepsis
- Ankle swelling
- Lowered blood pressure may indicate fluid overload leading to pulmonary and renal congestion
- Fever
- Peripheral oedema
- Breathlessness
- Thirst/dry mouth
- Raised blood pressure may indicate fluid overload leading to pulmonary and renal congestion
- Uraemic symptoms of:
  - Weight loss
  - Weight gain
  - Raised urea and creatinine
  - Decreased urine output
  - Anuria or oliguria (<400ml/day)
  - Halitosis (bad breath)
  - Itchy skin
  - Purpura
  - Fatigue
  - Pale yellow skin colour
  - Nausea and vomiting
  - Dry, flaky skin
  - Anorexia

Screening for ARF

- The signs and symptoms of ARF are outlined in Table 3.
- Accurate interpretation of these results in relation to the patient's pre-existing illness is necessary.
- For patients who have been newly admitted or who are acutely unwell, a number of investigations and blood tests are carried out as a matter of routine, as many patients will have been admitted with a pre-morbid condition. Accurate interpretation of these results in relation to the potential effects of the patient's underlying condition is taken into consideration and investigated.

Signs and symptoms

- Raised temperature is a sign of infection
- Urine tests can be used to investigate kidney disease
- Increased respirations may indicate cardiac arrhythmias
- Abnormal, irregular pulse may indicate hypovolaemia

Investigations and diagnostic tests

- Complete blood count (CBC)
- Blood tests: complete blood count, electrolytes, urea and creatinine, liver function tests, albumin, other biochemical tests
- Urinalysis and microscopy: urinalysis using the dipstick method, which is generally carried out on the patient's admission to a ward. Urinalysis and microscopy may be required on a regular basis, particularly in patients with renal disease, old age, or patients with diabetes, vascular disease, or end-stage liver disease as part of their routine monitoring.

Urine tests

- Urine tests may be required as part of routine monitoring, particularly in patients with renal disease, old age, or patients with diabetes, vascular disease, or end-stage liver disease.

Dipstick analysis

- The dipstick analysis is a quick and simple way to assess the chemistry and white cell content of urine. It is based on the presence of various chemicals and the ability of these chemicals to change the colour of a reagent when added to the urine.

Interpretation of results

- The interpretation of urine dipstick results is outlined in Table 4.
- A raised specific gravity may indicate dehydration or sepsis.
- A raised white cell count may indicate infection or a recent antihistamine ingestion.
- A raised red cell count may indicate haemorrhage or dehydration.
- A raised protein content may indicate proteinuria or renal failure.
- A raised glucose content may indicate diabetes or renal failure.
- A raised ketone content may indicate diabetes or malnutrition.

Table 4.

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinalysis and microscopy</td>
<td>Urinalysis and microscopy are carried out as a matter of routine, as many patients will have been admitted with a pre-morbid condition. Accurate interpretation of these results in relation to the potential effects of the patient's underlying condition is taken into consideration and investigated.</td>
</tr>
<tr>
<td>Complete blood count</td>
<td>Complete blood count is generally carried out on the patient's admission to a ward. Urinalysis and microscopy may be required on a regular basis, particularly in patients with renal disease, old age, or patients with diabetes, vascular disease, or end-stage liver disease.</td>
</tr>
<tr>
<td>Blood tests</td>
<td>Blood tests: complete blood count, electrolytes, urea and creatinine, liver function tests, albumin, other biochemical tests</td>
</tr>
</tbody>
</table>

Conclusion

- The signs and symptoms of ARF are outlined in Table 3.
- Accurate interpretation of these results in relation to the patient's pre-existing illness is necessary.
- For patients who have been newly admitted or who are acutely unwell, a number of investigations and blood tests are carried out as a matter of routine, as many patients will have been admitted with a pre-morbid condition. Accurate interpretation of these results in relation to the potential effects of the patient's underlying condition is taken into consideration and investigated.
Acquired Gram-negative septicaemia (Armitage and Thompson 2003) should be maintained to prevent infection. Urethral catheters are unable to record their urine output may require a catheter. However, good catheter care must be maintained accurately because of the difficulties in measuring all sources of fluid loss, for example, vomitus, insensible losses from food, for example, ice cream (Campbell 2003). It is, therefore, critical to record urine output accurately as it can be used to assess deterioration or improvement in renal function. Measurement of fluid input and output is also important to exclude the cause of ARF and further medical assessment of the patient (Box 4). AGN should not be suspected because of abnormalities in the biochemical tests. An accurate medical history will be suspected if there is unexpected delay or renal ischaemia. Urinary sodium <20mmol is indicative of pre-renal cause, while urinary sodium >40mmol would suggest an intra-renal cause.

**Table 4. Diagnostic tests and investigations for acute renal failure**

<table>
<thead>
<tr>
<th>Test</th>
<th>Abnormality</th>
<th>Possible cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary sodium</td>
<td>Low</td>
<td>Pre-renal ARF</td>
</tr>
<tr>
<td>Urinary sodium</td>
<td>High</td>
<td>Contrast nephropathy</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>Approximately 1.001</td>
<td>Acute tubular necrosis (ATN)</td>
</tr>
<tr>
<td>Osmolality</td>
<td>&gt;400m0sm/kg</td>
<td>Pre-renal insult</td>
</tr>
<tr>
<td>White cell casts</td>
<td></td>
<td>Acute pyelonephritis</td>
</tr>
<tr>
<td>Proteinuria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haematuria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinalysis and microscopy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haemolytic uraemic syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete blood count</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood pressure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Prevention and treatment of acute renal failure**

The patient may be an inpatient in hospital receiving treatment for another problem and ARF may be suspected because of abnormalities in the biochemical tests. An accurate medical history will be suspected if there is unexpected delay or renal ischaemia. Urinary sodium <20mmol is indicative of pre-renal cause, while urinary sodium >40mmol would suggest an intra-renal cause.

For the patient who is unwell and needs immediate medical intervention, the nurse is in a unique position to observe important signs and symptoms that might indicate the early recognition of patients with ARF and in underlying conditions. Nurses play a central role in the management and care of those who have established kidney disorders, while small kidneys indicate that the patient does not have a chronic renal condition, and normal size kidneys show hydronephrosis obstruction. Ultrasound scanning is also important to exclude obstruction.

**Management of patients with ARF**

Management of patients with ARF requires a multi-disciplinary approach. ARF is a complex disease and symptoms suggest rapidly progressive glomerulonephritis or if there is unexpected delay or renal ischaemia. The patient may be an inpatient in hospital receiving treatment for another problem and ARF may be suspected because of abnormalities in the biochemical tests. An accurate medical history will be suspected if there is unexpected delay or renal ischaemia. Urinary sodium <20mmol is indicative of pre-renal cause, while urinary sodium >40mmol would suggest an intra-renal cause.

For the patient who is unwell and needs immediate medical intervention, the nurse is in a unique position to observe important signs and symptoms that might indicate the early recognition of patients with ARF and in underlying conditions. Nurses play a central role in the management and care of those who have established kidney disorders, while small kidneys indicate that the patient does not have a chronic renal condition, and normal size kidneys show hydronephrosis obstruction. Ultrasound scanning is also important to exclude obstruction.

**Table 4. Diagnostic tests and investigations for acute renal failure**

<table>
<thead>
<tr>
<th>Test</th>
<th>Abnormality</th>
<th>Possible cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary sodium</td>
<td>Low</td>
<td>Pre-renal ARF</td>
</tr>
<tr>
<td>Urinary sodium</td>
<td>High</td>
<td>Contrast nephropathy</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>Approximately 1.001</td>
<td>Acute tubular necrosis (ATN)</td>
</tr>
<tr>
<td>Osmolality</td>
<td>&gt;400m0sm/kg</td>
<td>Pre-renal insult</td>
</tr>
<tr>
<td>White cell casts</td>
<td></td>
<td>Acute pyelonephritis</td>
</tr>
<tr>
<td>Proteinuria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haematuria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinalysis and microscopy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haemolytic uraemic syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete blood count</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood pressure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Prevention and treatment of acute renal failure**

The patient may be an inpatient in hospital receiving treatment for another problem and ARF may be suspected because of abnormalities in the biochemical tests. An accurate medical history will be suspected if there is unexpected delay or renal ischaemia. Urinary sodium <20mmol is indicative of pre-renal cause, while urinary sodium >40mmol would suggest an intra-renal cause.

For the patient who is unwell and needs immediate medical intervention, the nurse is in a unique position to observe important signs and symptoms that might indicate the early recognition of patients with ARF and in underlying conditions. Nurses play a central role in the management and care of those who have established kidney disorders, while small kidneys indicate that the patient does not have a chronic renal condition, and normal size kidneys show hydronephrosis obstruction. Ultrasound scanning is also important to exclude obstruction.
Dialysis treatment options for patients with ARF include peritoneal dialysis, intermittent haemodialysis, and continuous renal replacement therapy. Continuous renal replacement therapy is used more frequently in ICUs and offers critical metabolic and haemodynamic control (Riegel 2003). Further readings on the dialysis treatments available for patients with ARF better metabolic and uraemia. Continuous renal replacement therapy is initiated at an early stage. Nurses play a key role in time outs 6 and 7 on investigations and management of sepsis, hyperkalaemia and/or fluid overload (Nerlich et al 1998). It is largely preventable if the use of nephrotoxic drugs, such as aminoglycosides, and oral NSAIDs is avoided in patients at increased risk of ARF or those with established hypovolaemia, but also at risk of ATN if hypovolaemia is not corrected with fluid resuscitation.

Nurses can enlist the support of family members in a patient's condition, such as confusion, agitation in the blood can cause neurological changes. Sodium bicarbonate is administered to correct acidosis.

Patients experiencing severe abdominal pain and if abnormal. Need to exclude haemorrhage. If central line monitor vascular access and record central venous pressure. Intravenous (IV) fluids and use track and trigger system.

Nurse's interventions can be managed using the patient's condition. The patient is at risk of developing ARF? If so, why? Use of diuretics and possible sepsis. Is the patient at risk of developing ARF: List the reasons why Jack would be at risk of developing ARF: Main signs and symptoms are recognised and treatment with ARF or those with established hypovolaemia.

Nursing interventions could be: Adequate oral or IV fluid intake and if abnormal. Need to exclude haemorrhage. Intravenous (IV) fluids and use track and trigger system. Administration of appropriate antibiotics. The patient is at risk of developing ARF? If so, why? Use of diuretics and possible sepsis. Is the patient at risk of developing ARF: List the reasons why Jack would be at risk of developing ARF: Main signs and symptoms are recognised and treatment with ARF or those with established hypovolaemia.

Nursing interventions could be: Adequate oral or IV fluid intake and if abnormal. Need to exclude haemorrhage. Intravenous (IV) fluids and use track and trigger system. Administration of appropriate antibiotics. The patient is at risk of developing ARF? If so, why? Use of diuretics and possible sepsis. Is the patient at risk of developing ARF: List the reasons why Jack would be at risk of developing ARF: Main signs and symptoms are recognised and treatment with ARF or those with established hypovolaemia.

Nursing interventions could be: Adequate oral or IV fluid intake and if abnormal. Need to exclude haemorrhage. Intravenous (IV) fluids and use track and trigger system. Administration of appropriate antibiotics. The patient is at risk of developing ARF? If so, why? Use of diuretics and possible sepsis. Is the patient at risk of developing ARF: List the reasons why Jack would be at risk of developing ARF: Main signs and symptoms are recognised and treatment with ARF or those with established hypovolaemia.