The management of acute kidney injury

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Abstract

Acute kidney injury affects up to 15% of in patients in the acute hospital setting. Although accurate history-taking, careful physical examination and meticulous monitoring of volume balance are essential, there is, to-date, little evidence supporting any intervention that may reverse this process. Acute kidney injury presents a unique set of metabolic derangements that, if untreated, will result in death. We outline the initial management of acute kidney injury as well as specific treatments that may be required. Some consideration is also given to the use of renal replacement therapies.

Keywords Acute kidney injury; glomerular filtration rate; haemofiltration; hyperkalaemia; metabolic acidosis; uraemic encephalopathy; uraemic pericarditis

Introduction

In 2004, the Acute Dialysis Quality Initiative group (ADQI) proposed the RIFLE classification of acute kidney injury (AKI) encompassing two separate criteria, the calculated glomerular filtration rate (GFR) and urine output.[1] The previously adopted acronym RIFLE provides diagnostic definitions for the three grades of increasing severity of AKI and the two outcome variables of loss (L) and end-stage renal disease (E). The grades of severity of injury include the stage at which injury can be prevented (risk, R), when the kidney has already been damaged (injury, I) and when renal failure has occurred (failure, F). In 2007, the Acute Kidney Injury Network (AKIN) modified the RIFLE criteria.[2] The AKIN criteria refer to the same stages (risk, injury and failure) but the time frame for diagnosis of AKI is reduced to 48 hours, and a lower threshold for the rise of serum creatinine from baseline to peak value is used. Both sets of criteria have been validated for in-hospital mortality in numerous studies and can offer prognostic information based on the stages of AKI.[3,4] More recently, the Kidney Disease: Improving Global Outcomes (KDIGO) Work Group has integrated the RIFLE and AKIN criteria, including patients under 18 with a decrease in eGFR to less than 35 ml/min in the stage 3 category.[5] (see Table 1 of Assessment and initial management of acute kidney injury on pages 440–445 of this issue).

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General management of AKI

Early recognition and treatment of AKI saves nephrons and prevents further decline in GFR. It is important to remember that measured serum creatinine may not rise appreciably until GFR has fallen significantly. This is of particular relevance in individuals of small build, vegetarians and the undernourished, such as patients with hepatic failure, in whom a serum creatinine in the normal range can be misleading. Tubular secretion of creatinine is increased as GFR falls, and this may also lead to an overestimation of renal function in AKI.[6] Treatment in AKI is aimed at minimizing further damage to the kidney while providing support until there are signs of functional recovery. This includes restoration of the circulating volume, relief of outflow obstruction if present, removal of tubular toxins and specific treatment of glomerular disease. Early restoration of renal perfusion in precipitant AKI due to presumed acute tubular necrosis is essential. Recovery of GFR depends on the number of remaining functional nephrons that will increase their filtration to maintain GFR. However, continued hyperfiltration may result in progressive glomerular sclerosis and nephron death, leading to end-stage renal failure. (See Assessment and initial management of acute kidney injury on pp 440–445 of this issue.)

Specific problems

Volume resuscitation

In hypovolaemia, volume expansion is recommended. However, uncontrolled volume substitution may result in clinical deterioration with an increased risk of morbidity and mortality in patients with AKI and should be avoided. Isotonic crystalloids remain the mainstay of volume replacement therapy. Crystalloids expand plasma volume by about 25% of the infused volume, correcting sodium depletion as well as restoring solute and water diuresis. However, large-volume infusion of sodium chloride can lead to so-called 'hyperchloraemic acidosis', which may be associated with renal vasoconstriction and gut hypoperfusion.[7] Colloids, such as albumin, gelatins and hydroxyethyl starch, result in volume expansion approximate to the infused volume but, if administered in isolation in AKI, can lead to osmotic nephrosis (osmotic tubular damage). Hydroxyethyl starches are highly polymerized sugars characterized by their molecular weight, grade of substitution and concentration. They are degraded through hydrolytic cleavage, the remnants of which are excreted by the kidney, and should be avoided in AKI particularly when this has resulted from sepsis.

Volume overload

The volume status of a patient with AKI should be assessed carefully. Although somewhat unfashionable, careful bedside examination including assessment of the venous pressure, capillary refill time, pulse and postural blood pressure changes are elementary tools for assessing volume status. Hourly urine-output and accurate fluid-input charts need to include all fluid

losses, including estimated insensible losses, drain/stoma output and nasogastric losses where appropriate. If possible, patients should be weighed daily. A central venous catheter and an arterial cannula can be helpful where multi-organ failure (MOF) is imminent. In established MOF, absolute measurement of central venous pressure can be misleading, especially in the ventilated patient in whom high intrathoracic pressures may be present, and further invasive monitoring may be required.

Where volume overload is encountered in the setting of AKI, symptoms can be alleviated by high-flow oxygen. Where pulmonary oedema is refractory to pharmacological management while preparing the patient for urgent RRT, continuous positive airway pressure ventilation (CPAP) should be considered. Trials using diuretics, such as furosemide and mannitol, and 'low-dose' dopamine have yielded inconsistent results in AKI.[8,9] Although loop diuretics may promote diuresis in oliguric renal failure, there is little evidence that they influence outcome,[10] and the large doses of furosemide often required for diuresis in AKI can result in ototoxicity. Similarly, the use of dopamine does not reduce mortality or accelerate the recovery of renal function and, in the critically ill, dopamine use can lead to peripheral vasoconstriction, causing gut ischaemia, tissue necrosis and digital gangrene.

Hyperkalaemia

This life-threatening complication arises through cellular shifts of potassium or release from lysed cells, together with decreased renal excretion of potassium, and requires immediate treatment. Acidosis, hyponatraemia and hypocalcaemia all potentiate the harmful effects of hyperkalaemia on cardiac function and must also be corrected. Muscle weakness may be present and, if severe, can lead to flaccid paralysis, although symptoms are rarely apparent until the serum potassium exceeds 7.0 mmol/litre. The most serious effect is on cardiac conduction, which classically presents as a shortened QT interval with a tall peaked T wave on the electrocardiogram (ECG). Without treatment, progressive lengthening of QRS duration and PR interval ultimately lead to a 'sine wave' appearance, followed by ventricular standstill or fibrillation. A variety of other conduction disturbances may occur, including bundle-branch block, bifascicular block and advanced atrioventricular block. Asymptomatic patients with serum potassium <6.5 mmol/litre, or whose ECG does not manifest signs of hyperkalemia, should be treated with a low potassium diet; additional sources of potassium intake should be withheld and any potentiating drugs discontinued. (Specific treatment of hyperkalaemia is set out in the article Assessment and initial management of acute kidney injury (Table 3) on pages 440–445 of this issue.)

Acidosis

Metabolic acidosis in AKI results from increased acid production, increased acid retention and decreased renal reabsorption of bicarbonate. Acidosis is exacerbated by sepsis, malnutrition and some drugs, and is very common among critically ill patients and acute admissions. Metabolic acidosis is easily detected by measuring venous serum bicarbonate in the above patient groups when requesting routine blood tests. (Specific treatment of acidosis is set out is set out in the article Assessment and initial management of acute kidney injury (Table 3) on pages 440–445 of this issue.)

Uraemic pericarditis

Uraemic pericarditis is observed in 6–10% of patients with advanced renal failure, resulting from inflammation of both the visceral and parietal membranes of the pericardial sac. Pericarditis in AKI presents with fever and pleuritic chest pain, characteristically worse in the recumbent position. A pericardial rub may be heard on auscultation, although the ECG does not show the typical diffuse ST and T wave elevations observed with other causes of acute pericarditis. The development of pericarditis in a patient with AKI is an indication to institute RRT, unless there are signs of cardiac tamponade due to a pericardial effusion. Under such conditions, heparin-free haemodialysis or haemofiltration should be used because of the risk of increased bleeding into the pericardial sac with anticoagulation.

Uraemic encephalopathy

Like uraemic pericarditis, uraemic encephalopathy tends to be related to the degree of uraemia. Early clinical features include rambling speech, disorientation, lethargy, irritability, hallucinations and, more rarely, coma. Commonly encountered signs include tremor, myoclonus and asterixis, which tend to occur with deterioration in mental status. Transient focal signs, such as hemiparesis or reflex asymmetry, occur rarely but resolve with treatment, although mental state may not improve for up to 48 hours. If the signs do not resolve, other pathologies should be excluded.

Renal replacement therapy

Renal replacement therapy (RRT) does not cure acute kidney injury but it is a safe and efficient way of replacing renal function while the kidneys recover from disease or injury. Historically, single-organ AKI has been treated with either peritoneal or intermittent haemodialysis, which are the mainstay of chronic renal replacement therapy. Hospitals with acute nephrology services will perform haemodialysis in haemodynamically stable patients, although RRT is most commonly performed acutely in a level 2 or 3 facility employing haemodialysis or more commonly continuous therapies such as haemofiltration or haemodiafiltration. However, more recently there has been a trend towards using hybrid therapies such as prolonged intermittent renal replacement therapy (PIRRT). Although superficially similar, the mechanisms by which the composition of the blood is altered differ markedly.[11,12] In haemodialysis, blood flows along one side of a semipermeable membrane as a solution of crystalloids (the dialysis fluid) is pumped against the direction of the blood flow along the other side of the membrane. Molecules diffuse across the membrane from higher to lower concentrations driven by the law of mass action. The composition of the dialysis fluid allows as near normalization of the plasma as possible. The dialysis-fluid compartment is under lower pressure, generating a transmembrane pressure gradient enabling the removal of salt and water. Haemofiltration in its simplest form involves the passage of blood under pressure passing down one side of a highly permeable membrane, allowing water and other molecules up to a size of about 20 kDa to pass through the membrane by convection. Thus, filtrate is discarded and replaced by an idealized buffered replacement fluid, the crystalloid components of which are at physiological concentration. Haemodiafiltration as the name implies is a combination of the two therapies