Prevention and Management of Acute Kidney Injury Guideline

1 Introduction

- Acute Kidney Injury (AKI), previously known as acute renal failure, is characterised by a sudden decline in kidney function.
- AKI can occur without symptoms and is detected through a routine blood test (serum creatinine) and/or a decrease in urine output (KDIGO, 2012).
- AKI is associated with an increased risk of death, length of hospital stay, risk of chronic kidney disease (CKD) and cost to the NHS.
- It is likely that early AKI currently goes unrecognised and a number of AKI cases in at risk groups / high-risk scenarios are preventable.
- Early detection and appropriate management of AKI can minimise further injury.

1.1 Recognise AKI

AKI is defined according to the KDIGO criteria (KDIGO, 2012) and relies primarily on assessing the change in serum creatinine measurement from a previous baseline. Depending on the availability of previous creatinine measurements, in order of preference, 'Baseline creatinine' is defined as:

a) The lowest serum creatinine measurement in the preceding 7 days
b) The average (mean) of all serum creatinine measurements over the preceding year
c) The upper limit of the age specific reference interval for serum creatinine.

In addition, urine output <0.5 ml/kg/h for ≥8h may indicate AKI and should prompt further investigation.

AKI severity	Serum creatinine
Stage 1	1.5–1.9× baseline OR ≥26 µmol/l increase
Stage 2	2.0–2.9× baseline
Stage 3	3.0× baseline OR Increase in serum creatinine to ≥354 µmol/l) OR Initiation of renal replacement therapy OR Decrease in estimated glomerular filtration rate (eGFR – see Appendix A for calculation) to <35 ml/min per 1.73 m^2

2 Prevention of AKI

2.1 Identify patients at risk for AKI

An audit at Alder Hey identified that our leading causes of AKI are cardiac bypass surgery and nephrotoxic medications.

The BAPN recommends that children meeting any of the following criteria should be considered at risk of AKI:

Children at high risk of AKI include those with:

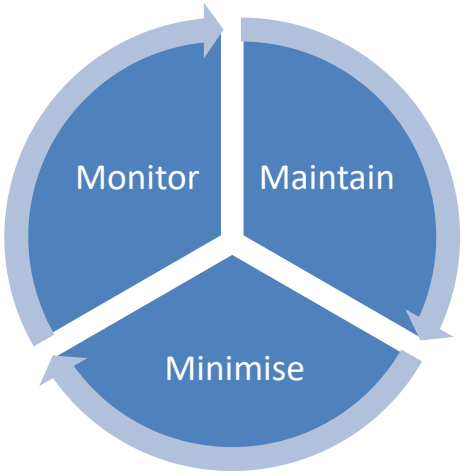
- Nephro-urological, cardiac or liver disease
- Malignancy and/or a bone marrow transplant
- Dependence on others for access to fluids (e.g. gastrostomy fed)
- History of taking medication that may adversely affect renal function (ACEI / ARB, NSAIDs, aminoglycosides, calcineurin inhibitors)

Scenarios in which children can be at high risk of AKI include:

- History of reduced urine output
- Sepsis
- Hypoperfusion or dehydration
- History of exposure to drugs or toxin that may adversely affect renal function
- Renal disease or urinary tract obstruction
- Major surgery

2.2 Prevention: 3Ms

Monitor the following daily in children at high risk of AKI:
- Serum creatinine and electrolytes
- Urinalysis
- Weight
- Fluid balance (including urine output)
- PEWS including blood pressure



Maintain circulation
- Adequate treatment of hypoperfusion

Minimise kidney insults
- Review, monitor and adjust potentially nephrotoxic medications (see section 2.3)

2.3 Medicines Optimisation for prevention of AKI

- Calculate eGFR (see Appendix A)
- Review medication list in liaison with pharmacist (See Appendix B)
- Avoid potential nephrotoxins. For example:
  - Radiocontrast for CT scans (if essential, ensure adequate hydration)
  - Consider temporarily stopping ACE inhibitors in patients with diarrhoea, vomiting or sepsis until their clinical condition has improved and stabilised

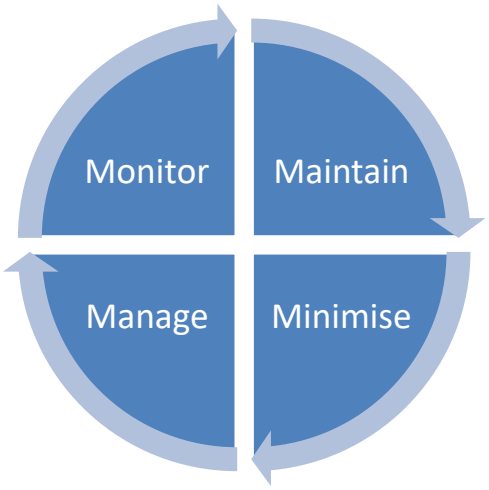
3 Management of confirmed AKI

3.1 Aims

- Recognise AKI early
- Minimise further kidney injury
- Identify and treat the underlying cause

3.2 Management: 4Ms

Monitor the following daily in children with AKI:
- Serum creatinine and electrolytes
- Urinalysis
- Weight
- Fluid balance (including urine output)
- PEWS including blood pressure



Maintain circulation
- Adequate treatment of hypoperfusion

Minimise kidney insults
- Review, monitor and adjust potentially nephrotoxic medications
- See section 3.3 & Appendix B

Manage

Initial investigations:
- Bloods
  - Repeat creatinine & electrolytes (including bicarbonate)
  - Bone profile
  - FBC
- Urine
  - Dipstick
  - Albumin/Creatinine ratio
  - Microscopy
- Urinary tract ultrasound scan
  - within 24 hours
  - unless the cause has been identified and the patient is improving.

Urgent review by a senior member of the patient's primary clinical team.

If an **obstructive cause** is suspected:
- Urgent Urology review
- Urgent urinary tract ultrasound

Further investigations if clinically relevant:
- C3 / C4
- ASOT
- ANA
- ANCA
- Anti-GBM antibodies
- Immunoglobulins
- Blood film
- LDH
- CK

Paediatric Nephrology Referral

AKI Stage 1	**Consider discussion** with nephrology team
AKI Stage 2	**Discuss** with nephrology team
AKI Stage 3	**Refer** to nephrology team (See section 3.3)

3.3 Medicines Optimisation in children with AKI

- Calculate eGFR (see Appendix A)
- Review medication list in liaison with pharmacist
- **Avoid if possible**:
  - ACE inhibitors and ARBs until their clinical condition has improved and stabilised
  - NSAIDs
  - radiocontrast for CT scans (if essential, ensure adequate hydration)
  - Aminoglycoside antibiotics
- For more detailed advice see summary table in Appendix B

3.4 Paediatric Nephrology Referral (excluding patients on Intensive Care)

When referring to nephrology team:

- Notify patient's lead consultant
- Telephone referral to Nephrology team (Registrar bleep 184, Out-of-hours contact on-call consultant via switchboard)
- Also complete Meditech Nephrology referral

Criteria for immediate discussion with nephrology team in any stage of AKI:

- Pre-existing renal condition (e.g. existing CKD 4 or 5 or renal transplant)
- AKI associated with multisystem disease or suspected intrinsic renal disease (e.g. haemolytic uraemic syndrome)
- Potassium >5.5mmol/l (free-flowing, non-haemolysed sample)
- Oligoanuria and/or plasma sodium <125mmol/l
- Fluid overload (Weight gain, peripheral oedema, pulmonary oedema or hypertension)
- Rising plasma urea >20mmol/l unresponsive to fluid challenge

3.5 Referral of patients on Intensive Care to Paediatric Nephrology Team

We recognise that AKI often occurs as part of multisystem illness in critically ill patients, and will usually be managed independently by the intensive care team.

The Nephrology team should be routinely informed of any patient with AKI stage 2 or more for 2 days or more.

Some patients may benefit from additional Paediatric Nephrology input, including:

- Where there is diagnostic uncertainty
- Where intrinsic renal disease is suspected
- Where the patient is likely to require ongoing renal input following stepdown from intensive care.

4 Discharge after AKI

4.1 Discharge summary

- Document AKI episode (including stage and dates) on discharge summary
- Document the likely cause of AKI (e.g. nephrotoxic (state causative agent), dehydration, sepsis, cardiac surgery, etc.)
- Request AKI follow-up with nephrology team for all patients with AKI stage 2 or 3 for 2 days or more:
    - State 'Nephrology AKI follow-up clinic in 3 months' in discharge summary plan
    - Inform Nephrology team of discharge (bleep 184)

4.2 Follow-up

All patients with AKI stage 2 or 3 for 2 days or more will be followed-up by the paediatric nephrology team 3 months after the episode.

5 Contributors

Caroline Jones, Consultant Paediatric Nephrologist
Richard Holt, Consultant Paediatric Nephrologist
Henry Morgan, Consultant Paediatric Nephrologist
Louise Oni, Consultant Paediatric Nephrologist
Tolu Awogbemi, Consultant General Paediatrician

6 References

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Appendix A – Calculation of estimated glomerular filtration rate (eGFR)

$$eGFR(ml/min/1.73m^2) = \frac{36.5 * [Height\ (cm)]}{serum\ creatinine}$$

Appendix B – Selected medications to use with caution or avoid in kidney impairment (Adapted from Dowsett *et al*, 2021)

Please note that this list is not exhaustive. Medications listed in this table are those most commonly used in daily practice. Please refer to the BNFc, renal drug handbook and discuss with a pharmacist for specific advice on dosing adjustments.

Drug Examples	Pharmacology and other information	Impact of kidney impairment	Action
Anti-infectives			
Aminoglycosides • Gentamicin • Tobramycin • Amikacin	• Concentration-dependent, bactericidal agents • Inhibit bacterial protein synthesis • Elimination mainly by glomerular filtration • 50-60% of the dose excreted within 24 hours	• Reduced clearance • Rapid accumulation • Nephrotoxicity • Ototoxicity	• Avoid if possible • Dosing based on eGFR with input from pharmacist • Monitor plasma concentrations (pre-dose levels) • Await results before giving next dose • Adjust dose or dosing interval accordingly
Vancomycin	• Glycopeptide active against the majority of gram-positive bacteria including methicillin-resistant staphylococcus aureus (MRSA) • Predominantly renal clearance • 80-90% recovered unchanged in the urine	• Reduced clearance • Rapid accumulation • Nephrotoxicity • Ototoxicity	• Dosing based on eGFR with input from pharmacist • Monitor plasma concentrations (pre-dose levels) • Await results before giving next dose • Adjust dose or dosing interval accordingly
β-lactam antibiotics • Penicillins • Cephalosporins • Carbapenems	• Time-dependent pharmacodynamics	• Reduced clearance and protein binding leads to higher plasma concentrations. • Central nervous system disturbances including confusion, myoclonus and seizures	• Dosing based on eGFR with input from pharmacist • Reduce the dose and/or dosing interval

Aciclovir	• Predominantly renal clearance	• Increased risk of toxicity including nephrotoxicity and neurotoxicity	• Dosing based on eGFR with input from pharmacist • Reduce the dose and/or dosing interval
Antifungals			
Conventional amphotericin B	• Exhibits concentration-dependent fungicidal activity	• Highly nephrotoxic, permanent kidney impairment may occur in patients including those receiving doses of more than 1mg/kg/day, those with pre-exisiting kidney impairment or on concurrent nephrotoxic drugs.	• Use with caution in kidney impairment • Seek input from pharmacist and/or infectious diseases team • Consider using liposomal amphotericin or an alternative antifungal. Please note although liposomal amphotericin is less nephrotoxic the risk of kidney impairment still exists.
Analgesics			
Opioids • Morphine • Tramadol • Codeine	• This varies for individual opioids therefore it is important to understand the pharmacokinetics of each drug to minimise the risk of toxicity. • Morphine, tramadol and codeine have significant renal clearance.	• Reduced clearance • Accumulation of toxic/active metabolites • Central nervous system and respiratory depression	• Caution in CKD 4 or 5 • Dose reduction in earlier stages of impairment (e.g. reduction of 50-75% for morphine and codeine) • Avoid slow-release preparations • Consider using opiates with lower dependence on renal excretion such as oxycodone and fentanyl. Fentanyl should only be used under the direction of a specialist team. • Consider nurse or parent/patient controlled analgesia rather than continuous infusion

Non-sterodal anti-inflammatory drugs (NSAIDs) e.g: • Ibuprofen • Diclofenac • Celecoxib	• Inhibit prostaglandin synthesis which may result in sodium retention and reduced kidney blood flow	• Increased impact on kidney blood flow, causing further decline of kidney function	• Avoid if possible • If an NSAID is required liaise with a nephrologist and/or specialist pharmacist
Diurectics			
• Furosemide • Spironolactone (potassium sparing diuretic)	• Varies with different diuretics however the ultimate aim is to increase the amount of water in the urine	• Can cause a reduction in GFR if their use results in hypovolaemia.	• Use with caution • Increased risk of hyperkalaemia with potassium sparing diuretics
Angiotensin-converting enzyme (ACE) and Angiotensin receptor blockers (ARBs) Inhibitors			
Examples include: • Lisinopril • Captopril • Losartan	• ACE inhibitors and ARBs inhibit the renin-angiotension-aldosterone system	• May increase the risk of AKI by reducing glomerular perfusion.	• Close monitoring of renal function during therapy. • Monitor for hyperkalaemia • If an episode of AKI occurs– consider omitting treatment until AKI resolves/liaise with a nephrologist
Specialist medications			
Calcineurin inhibitors • Tacrolimus • Ciclosporin	• Immunosuppressants • Used in several kidney conditions as well as post-kidney transplant	• Associated with potential for nephrotoxicity	• Discuss with specialist team/pharmacist

Anti-epileptics	• Varies for individual medications	• Accumulation • Increased CNS effects	• Dose adjustment based on GFR • Discuss with specialist team/pharmacist
Contrast media	• Various compounds for different radiological procedures	• Some associated with potential for nephrotoxicity • gadolinium-based contrast agents associated with nephrogenic systemic fibrosis in kidney impairment	• Avoid if possible in severe kidney impairment. • Discuss with radiologist if suitable alternative imaging modality available • Consider risks and benefits on an individual patient basis. • Consider pre-hydration

Document Control Sheet

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Version	**Date**	**Author**	**Status**	**Comment**
2	June 2022	Stephen McWilliam	Current	
1	February 2019	Stephen McWilliam, Paediatric Nephrologist	Archived	

Review & Amendment Log Record of changes made to document since last approved version			
Section Number	**Page Number**	**Change/s made**	**Reason for change**
2.2	2	Existing text presented as a figure	Improved visibility of information
2.3	2	Addition of medicines optimisation section	Improve clarity of guidance for prescribers
3.2	3	Existing text presented as a figure. Clarification of guidance on ultrasound and management of obstruction	Improved visibility and clarity of information
3.3	4	Addition of medicines optimisation section	Improve clarity of guidance for prescribers
3.4	4	Removed small amount of text to include in figure in section 3.2	Improved visibility of information
4	5	New figure included to highlight referral criteria for AKI follow-up	Improve visibility and clarity of guidance
6	5	Updated versions of original references included and two new references added	Ensure guideline is based on best available evidence
Appendix A	6	Formula updated to more accurate version of Bedside Schwartz	Improve accuracy of eGFR calculation
Appendix B	7	Previous link to guidance removed and replaced with medicines optimisation table for guidance	Improve clarity of guidance for prescribers