Clinical Practice Guidelines

Renal Replacement Therapy for Critically Unwell Adult Patients: Guidelines for best practice and service resilience during COVID-19

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Endorsements

The National Institute for Health and Care Excellence (NICE) has accredited the process used by the Renal Association to produce its Clinical Practice Guidelines. Accreditation is valid for 5 years from October 2020. More information on accreditation can be viewed at www.nice.org.uk/accreditation

Method used to arrive at a recommendation

The recommendations for the first draft of this guideline resulted from a collective decision reached by informal discussion by the authors and, whenever necessary, with input from the Chair of the Clinical Practice Guidelines Committee. If no agreement had been reached on the appropriate grading of a recommendation, a vote would have been held and the majority opinion carried. However this was not necessary for this guideline.

Conflicts of Interest Statement

All authors made declarations of interest in line with the policy in the Renal Association Clinical Practice Guidelines Development Manual. Further details can be obtained on request from the Renal Association.

Nomenclature

The term "Renal Replacement Therapy (RRT)" has been utilised within this guideline as this nomenclature is used routinely by healthcare professionals working within the United Kingdom. It should be noted however that this term is interchangeable with the term "Kidney Replacement Therapy (KRT)", used internationally.[1]

Acknowledgements

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References

1. Nomenclature for kidney function and disease: report of a Kidney Disease: Improving Global Outcomes (KDIGO) Consensus Conference. *Kidney International* (2020) **97**, 1117–1129; https://doi.org/10.1016/j.kint.2020.02.010

Contents

Introduction

Purpose

The purpose of this guideline is to support implementation of the NHS England (NHSE) service specification, which describes the requirements for renal replacement therapy (RRT) as an interdependent service for adult critical care services.[1] Accordingly, this guideline has been produced collaboratively by members of the Renal Association and British Renal Society, and Intensive Care Society, with patient review. The guideline will support critical care RRT resilience in the event of further Coronavirus Disease 2019 (COVID-19) surges or similar emergency states.

Background

Severe acute illness is often complicated by acute kidney injury (AKI) and patients with chronic kidney disease (CKD) are at high risk of critical illness if they develop COVID-19. AKI is more common amongst patients hospitalised with COVID-19 than in patients hospitalised due to other illness. Furthermore patients with COVID-19-associated AKI (C19-AKI) sustain worse outcomes than those who develop AKI associated with other acute illnesses. Intensive Care National Audit and Research Centre (ICNARC) data indicates that 1 in 4 patients admitted to critical care in the United Kingdom due to COVID-19 require RRT with up to 80% mortality amongst these patients, compared to 44% amongst those not treated with RRT. Amongst survivors, RRT is associated with a much longer mean duration of critical care bed occupancy (30 days versus 9 days for those not requiring RRT).

The COVID-19 pandemic revealed national shortages of reserve resources and facilities required to meet surges in critical care RRT. Further COVID-19 surges or emergency states risk overwhelming adult critical care RRT capacity, representing a national patient safety risk.

Although observational data indicates COVID-19 associated renal disease is associated with worse patient outcomes, there is no published evidence to suggest C19-AKI should be managed differently to AKI associated with other illnesses. Innovative and flexible cross-specialty working by renal and critical care multi-professional teams helped to sustain RRT delivery in centres across the UK during the early stages of the COVID-19 pandemic. Such collaborative experience and learning also highlighted opportunities to optimise and streamline routine care of critically unwell patients with renal failure, including in centres without on-site renal services.

The recommendations in this guideline are configured to support the NHSE service specification for RRT for critical care, including delivery of renal capability across the specified three tier renal model of critical care units: units with fully integrated on-site renal support (tier 1), units with flexible on-site renal support (tier 2), units with no on-site renal service (tier 3).[1] There should be a particular focus on supporting tier 3 units.

Aims of guideline

1. Reduce variation in practice and promote quality of care for critically unwell patients who require RRT, through supporting implementation of the NHSE service specification.
2. Enable and sustain RRT resilience across all critical care units in the event of COVID-19 surges or emergency states, including in hospitals without on-site renal services (tier 3).
3. Provide an inventory of RRT options and standards that together can be delivered and sustained across all UK critical care units, including those without on-site renal services.

4. Ensure optimal continuous RRT delivery to minimise inefficient use or preventable loss of consumables and impact upon staff workload and capacity.
5. Provide flexible management plans to ensure responsible use of resources during routine circumstances and responsive capability and resilience during surge circumstances.
6. Provide a training and competency framework for consistent delivery of safe and quality intermittent RRT within critical care units, underpinned by robust governance between renal and critical care services.
7. Provide a management framework to limit and manage C19-AKI outside of critical care units, including measures to mitigate RRT demand and prevent avoidable critical care admission during surges.
8. Provide a management framework to limit and manage C19-AKI within critical care units, including drug safety and optimal nutrition.
9. Provide recommendations for management of patients with dialysis dependent end-stage kidney disease (ESKD) with COVID-19.
10. Provide a management framework for patients with COVID-19 associated kidney disease following critical care discharge, including safe and timely patient follow-up.
11. Ensure prompt and quality care for patients with COVID-19 or other acute severe illness in order to limit their risk of AKI and avoidable critical care admission
12. Provide guidance for safe and timely care transitions for patients requiring inter hospital transfer and / or between critical care, renal and non-renal wards.
13. Promote and sustain regional cross-specialty collaborative working, training and audit, to optimise and streamline multi-professional care of critically unwell patients with renal disease during routine and emergency circumstances.

Scope

This guideline is intended for use by healthcare professionals responsible for the care of adults at risk of severe acute illness, complicated by acute kidney injury (AKI) or end-state kidney disease (ESKD). It includes a focus upon critically unwell patients who may require RRT within Adult Critical Care services during COVID-19 surges or similar emergencies. Adult Critical Care underpins all secondary and specialist adult services and incorporates both intensive and high dependency care units (ICU/HDU), stand alone or combined.

Review of Evidence

The literature was reviewed using multiple database searches, such as PubMed (1960-2020) and Ovid MEDLINE (1946-2020) for all human studies published in English pertaining to COVID-19, Acute Kidney Injury (AKI), Renal or Kidney Replacement Therapy and Critical Care in adults. Websites searches included National Institute for Health and Care Excellence (NICE) and the UK Renal Association.

Currently published literature to guide management of COVID-19 associated renal disease is limited to single and multi-centre observational studies, expert opinion and databases reporting epidemiology and outcome amongst different patient populations. COVID-19 related elements of this guideline have been developed based upon such limited published evidence, alongside unpublished experience and learning to date from multi-professionals managing critically unwell patients with COVID-19 and renal disease across centres in the United Kingdom. Recommendations regarding COVID-19 elements of this guideline will be updated if significant additional evidence emerges.

Format of the Guideline

To facilitate user navigation, this guideline is presented as three main sections and two appendices.

- Section I: Pre and post critical care management of COVID-19 associated renal disease.
- Section II: Intra-critical care management of COVID-19 associated renal disease.
- Section III: Renal Replacement Therapy in critical care during routine and surge scenarios.
- Appendix I: Antimicrobial drug dosing for patients receiving RRT in critical care.

The writing process followed the Renal Association Guideline development manual. The guideline comprises of a series of guideline statements accompanied by supporting evidence and audit measures. The recommendations in each guideline statement have been graded using the GRADE system[2] in evaluating the strength of each recommendation (1 = strong, 2 = weak) and quality of evidence (A= high, B = moderate, C= low, D = very low).

The main guideline layout is aligned with the chapter structure used by the Intensive Care Society and Faculty of Intensive Care Medicine in the joint General Provision of Intensive Care Services (GPICS) framework for UK critical care.[3] Thus both standards and recommendations are included within sections I, II and III of the guideline, where:

1. Standards are a summarised form of what the authors regard as currently accepted practice which should be consistently applied, and

2. Recommendations are a forward-looking set of statements about what the authors think should now be implemented.

References

1. NHS England Appendix to Adult Critical Care specification: Interdependent services – Renal replacement therapy (final version due October 2020): https://www.england.nhs.uk/publication/adult-critical-care-services/
2. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) working group: https://www.gradeworkinggroup.org/
3. Guidelines for the Provision of Intensive Care Services - Edition 2: https://ics.ac.uk/ICS/ICS/GuidelinesAndStandards/GPICS_2nd_Edition.aspx

Summary of Clinical Practice Guideline Recommendations

Section I: Pre and post critical care management of COVID associated renal disease

1. For management of patients with COVID-19 associated Acute Kidney Injury (C19-AKI) outside Critical Care, we recommend:

   1.1 Risk factors for developing COVID-19 associated AKI (C19-AKI) are the same as those for patients developing AKI from other common causes. Patients at high risk of developing C19-AKI should be identified at an early stage and measures instigated to reduce this risk. (1A)

   1.2 Patients who develop COVID-19 should have at least twice daily monitoring of their volume status to avoid hypovolaemia. Kidney function should be monitored daily.(2B)

   1.3 Patients who develop C19-AKI have a very high mortality and therefore it is important for all NHS organisations to have an early recognition and response system in place. (1B)

   1.4 Hypovolaemia is common in patients with COVID-19 and will exacerbate the hypercoagulable state and organ injury including C19-AKI. Volume status must be optimised with the appropriate fluid resuscitation, which should be part of a protocol to restore circulating volume status and haemodynamic stability. (1B)

   1.5 Hyperkalaemia is a medical emergency and should be treated as per local guidelines. Potassium binders (e.g. patiromer and sodium zirconium cyclosilicate (SZC)) can be considered alongside standard care for the emergency management of acute life-threatening hyperkalaemia if indicated. SZC has a faster onset of action and lowers potassium to a greater extent in the first 48 hours. Patiromer and SZC can both be continued if their use controls hyperkalaemia and there are no other indications for emergent RRT. If there are delays in patients receiving RRT due to lack of capacity, potassium binders may be used for an extended period of time with senior medical review and dietitian involvement. (2C)

   1.6 A full medication review should be performed and appropriate adjustments made to drug doses. Pharmacist-led review is strongly recommended for medicine optimisation, including appropriate dosing, avoidance of drugs harmful to the kidneys in the setting of COVID-19 and advice on anticoagulation. (1A)

   1.7 Urinalysis should be performed on all patients with COVID-19 and results recorded. The presence of blood and/or protein in the urine (active urinary sediment) is common in patients with COVID-19 with or without C19-AKI and may indicate underlying kidney disease. Urinalysis should be repeated following the acute illness, no later than 3 months, and if the active urinary sediment persists a renal opinion is recommended. (2B)

   1.8 Rhabdomyolysis may complicate C19-AKI and a creatine kinase (CK) should be checked. Such patients should receive aggressive fluid resuscitation and regular volume status review based on local guidelines. (2B)

1.9 Malnutrition is an independent predictor of in hospital mortality in patients with AKI. Local protocols to screen for malnutrition and to identify patients with AKI at risk of malnutrition should be in place. Health care professionals caring for patients with AKI should consider early dietetic referral where concerns about nutritional status exist. Patients at risk for poor outcomes and higher mortality following infection with COVID -19, namely older adults and polymorbid individuals, should be checked for malnutrition through screening and assessment. (2B)

1.10 Renal referral should be considered where diagnostic uncertainty lies as to the cause of AKI or AKI is worsening despite initial management. COVID-19 has been shown to be associated with some rarer forms of AKI. (1A)

1.11 Local transfer criteria and clear transfer pathways must be developed and disseminated to allow the safe inter hospital transfer of patients from non-specialist renal wards to specialised kidney units. This includes transfer from critical care units within a tier 3 centre when referring to tertiary renal units. Criteria may reflect local provision where transfer to renal level 2 units may have criteria at variance to those without. (2B)

1.12 Referral to critical care (in tier 1-3 centres) or renal (in tier 1-2 centres) for renal replacement therapy (RRT) When it is anticipated that patient will meet usual criteria for renal replacement therapy (RRT). (1A)

2. For management of patients with Chronic Kidney Disease (CKD) and End-Stage Kidney Disease (ESKD) outside of Critical Care, we recommend:

2.1 Those responsible for in-patient care of patients with COVID-I9 should be aware that the development of AKI carries a grave prognosis and therefore early identification may mitigate worsening of AKI. Clinicians must be aware that patients with CKD are at higher risk of developing AKI. (1A)

2.2 There is no evidence currently that the initial supportive management of C19-AKI is different from patients with non C19-AKI. As such treatment should follow established guidelines. (1B)

2.3 Renal advice should be sought promptly if the patient has established CKD Stage 4/5 (eGFR is < 30 ml/min/1.73 m2) or has ESKD and is receiving dialysis, especially in tier 3 centres. (1B)

2.4 In patients with advanced CKD where dialysis is planned then NICE guideline [NG160] COVID-19 (rapid guideline: dialysis service delivery) should be followed. Local transfer criteria and local networking must be developed to allow the safe transfer of patients. (1A)

3. For management of patients with COVID-19 Associated Acute Kidney Injury (C19-AKI) Post Critical Care, we recommend:

3.1 Local transfer criteria and local networking must be developed to allow the safe transfer of patients. (1B)

3.2 Critical care discharge summary must include baseline kidney function prior to admission if known, medications prior to admission, AKI risk factors, cause(s) and severity (highest stage during admission), reason for critical care admission, treatment received, discharge kidney function if

dialysis-independent and the emergent need for dialysis . Some critical care units routinely send ICU discharge letters to Primary Care and this is particularly recommended as good practice in the setting of AKI, as new or worsening chronic kidney disease may develop post hospital discharge. (1C)

3.3 Ensuring the provision of optimal nutrition post ICU is an essential component to support successful long-term rehabilitation. Ongoing nutritional input in the recovery phase should therefore be integral to a patient's multidisciplinary rehabilitation plan. (1B)

3.4 Tier 3 units should seek renal advice in terms of vascular access for dialysis as well as recommencement of regular medication. (1B)

4. For management of patients with COVID-19 Associated Acute Kidney Injury (C19-AKI) post hospital discharge, we recommend:

4.1 Hospital discharge summary must include the baseline kidney function prior to admission if known, medications prior to admission, a list of investigations performed, treatment received, cause of AKI, maximum stage, the need for dialysis (temporary / ongoing), discharge kidney function if dialysis-independent. (1B)

4.2 There must be specific recommendations to the GP, patients, relatives and/or carers on the need for immediate, post-discharge monitoring of kidney function, advice on medications that may have been implicated in the episode of C19-AKI (e.g. continued avoidance or advice on re-introduction). (1B)

4.3 Hospital discharge summary should link to relevant local guidelines, advise on the need for documentation of the AKI in the primary care record and note the need for registration on the primary care CKD register if residual CKD exists at the time of discharge. (1B)

4.4 Formal post-discharge renal review should be arranged within 90 days for those with residual CKD stage G4 at hospital discharge or within 30 days for those with residual CKD stage G5 (non-dialysis-requiring) at hospital discharge. (1B)

Section II: Intra-critical care management of COVID-19 associated renal disease

5. For prevention and management of AKI in critically ill patients, we recommend:

5.1 Prevention and management of AKI in critically ill patients with COVID-19 should follow the same principles as stated for patients in non-critical care wards (as per pre and post critical care (PPCC) guidance, recommendations 1.1 to 1.4). (1A)

5.2 Although there are some differences in pathogenesis between COVID-19 associated-AKI (C19-AKI) and critical illness-associated AKI, management is similar, and should follow NICE guidance where appropriate. (1A)

5.3 There is no direct evidence for optimal fluid resuscitation in COVID-19, though a euvolaemic strategy is recommended (as per PPCC guidance, recommendation 1.4). (1C)

5.4 COVID-19 is a new disease with a rapidly evolving understanding of best clinical management. ICU clinicians should note a significant rotation away from an ARDS-like "dry" approach to lung management in favour of clinical euvolaemia. (1B)

5.5 Pharmacist-led review is strongly recommended for medicine optimisation, including appropriate dosing, avoidance of drugs harmful to the kidneys in the setting of COVID-19 and also advice on anticoagulation (as per PPCC guidance, recommendation 1.6). (1B)

5.6 Acute kidney injury (AKI) is detected by monitoring changes in serum creatinine or reductions in urine output and must be defined using Kidney Disease Improving Global Outcomes (KDIGO) definitions (serum creatinine and urine output criteria) to recognise AKI. (1A)

5.7 The NHS England AKI warning algorithm will identify patients with changes in serum creatinine suggestive of AKI and will identify in real time potential cases of AKI. This should be integrated into current IT systems. (1A)

5.8 All critically ill patients should have urinalysis performed on admission to ICU using multi-signal dipsticks. The results of these tests should be documented in the patient's records contemporaneously. Abnormal results are not infrequent in ICU patients. Patients with COVID-19 and proteinuria and haematuria should be discussed promptly with nephrology. (1A)

5.9 Urinary obstruction is no more common in patients with COVID-19 than in other critically ill patients. A renal US should be ordered according to existing guidance. (1A)

5.10 Consider imaging alongside potential for increased radiology workload and spread of COVID-19 infection. The latter can be mitigated by appropriate infection control precautions and should not delay diagnosis of reversible pathology. (1B)

5.11 It is very unlikely that a native renal biopsy will be required in COVID-19 patients with AKI on critical care. Any potential indications for a renal biopsy should be discussed with a nephrologist. (1A)

6. For non-dialytic management of complications of AKI in Critical Care, we recommend:

6.1 Fluid overload should be avoided. If it occurs, it should be managed with diuretics as long as the patient is diuretic responsive and there are no other life-threatening complications which require RRT. (1B)

6.2 Consider bicarbonate (enteral or intravenous) if no contraindications and worsening metabolic acidosis due to AKI. This may reduce RRT requirement. (1A)

6.3 Hyperkalaemia is a medical emergency and should be treated as per local guidelines. Potassium binders (e.g. patiromer and sodium zirconium cyclosilicate (SZC)) can be used alongside standard of care for the emergency management of acute life-threatening hyperkalaemia if indicated. SZC has a faster onset of action and lowers potassium to a greater extent in the first 48 hours. Patiromer and SZC can both be continued if their use controls hyperkalaemia and there are no other indications for emergent RRT. If there are delays in patients receiving RRT due to lack of capacity, potassium binders may be used for an extended period of time with senior medical review and dietitian involvement (as per PPCC guidance, recommendation 1.5). (1A)

7. For management of patients with Chronic Kidney Disease (CKD) and super-imposed AKI, we recommend:

7.1 Where possible avoid drugs which can cause renal tubular or glomerular toxicity, or induce renal ischaemia, eg. non-steroidal anti-inflammatory drugs (NDSAIDs), SGLT2 inhibitors, aminoglycosides, glycopeptide antibiotics and certain antiviral medications. (1A)

7.2 Ensure regular pharmacist-led medication review to ensure drug safety and avoid potential drug interactions. (1A)

7.3 Blood pressure targets should be individualised to maintain an appropriate mean arterial pressure (MAP) for an individual patient, considering patient age and pre-admission MAP. (1A)

7.4 Consider suspending antihypertensive medication in context of relative hypotension to reduce AKI risk. Consider suspending ACEIs / ARBs during relative hypotension and / or if serum potassium rises above 6.0mmol/l. (1A)

7.5 For kidney transplant recipients, follow Renal Association / British Transplant Society recommendations for COVID-19 disease.

7.5.1 Consider suspending antiproliferative agents (MMF/azathioprine) (1C)

7.5.2 Consider reduction or stopping calcineurin inhibitors (tacrolimus/ciclosporin) (1C)

7.5.3 Consider dexamethasone 6 mg daily for 10 days. (1B)

7.6 If modifying or withholding immunosuppressive medications, ensure there is a plan in place to review this decision regularly. (1A)

7.7 Combinations of lopinavir and ritonavir along with hydroxychloroquine, or dexamethasone and tocilizumab, have not been shown to improve outcomes in renal transplant recipients and should not be used outside of clinical trials. Consider drug interactions with calcineurin inhibitors and appropriate monitoring if using antiviral drugs. (1C)

8. For Nutrition and Dietary management, we recommend:

8.1 Nutritional and dietary intervention should be completed by a dietitian and include assessment of malnutrition, the need for nutritional support, severity and phase of illness, metabolic state (catabolic phase, anabolic phase, recovery phase), metabolic disturbances associated with AKI (such as potassium, phosphate), fluid status, as well as the underlying disease process. (1A)

8.2 Limitation of sodium, phosphate, potassium or fluid intake may be required in individual patients. Protein requirements may need to be increased in critically ill patients requiring RRT based on the dietetic assessment. (1A)

9. For transfer of information (i.e. discharge summary, communication with nephrology and primary care), we recommend:

9.1 Standardised systems of care (including checklists, staffing and equipment) should be used when transferring critically ill patients within or between hospitals. Accuracy and consistency of

communication not only with family, but also internally between clinical teams, is repeatedly identified as being of great importance to patients and families. (1C)

9.2 There should be clear communication between hospital teams and to primary care at all handovers of care including ICU discharge and hospital discharge. When discharged from critical care, the accepting team should be informed if the patient received RRT whilst in intensive care so that appropriate follow-up arrangements can be made. (1B)

9.3 The critical care discharge summary must include the baseline kidney function prior to admission if known, medications prior to admission, AKI risk factors, cause(s) and severity (state the highest stage during admission), reason for critical care admission, treatment received, discharge kidney function if dialysis-independent and the emergent need for dialysis. (1B)

9.4 Some critical care units routinely send ICU discharge letters to GPs and this is particularly recommended as good practice in the setting of AKI, as new or worsening chronic kidney disease may develop post hospital discharge (as per PPCC guidance, recommendation 3.2). (1C)

10. For communication and education of the MDT, we recommend:

10.1 Multi-disciplinary communication and education should engage with the whole team to encourage their involvement in AKI care and include clear allocation of roles. (1B)

10.2 Nurse education and competencies should follow the Step Competency Framework. (1B)

11. For liaison with next of kin, we recommend:

11.1 There should be a process of regular phone updates (usually daily) to a named relative who disseminates information to the rest of the family. (1C)

11.2 Family relationship teams comprised of senior non-critical care medical staff have been utilised successfully. Robust channels of communication between these teams and the clinical care staff ensures an accurate message regarding patient status is conveyed and enables a compassionate means of communication with relatives. (1C)

11.3 Allocate appropriate staff to speak to relatives; this can be a doctor or nurse. (1C)

12. For psychological support in critical care, we recommend:

12.1 Patients should be assessed during their critical care stay for acute symptoms of anxiety, depression, panic episodes, nightmares, delusions, hallucinations, intrusive memories, flashback episodes and underlying psychological disorders, to determine their risk of future psychological morbidity. (1C)

12.2 Psychological support should be provided to aid rehabilitation and recovery in critical care units, on general wards, and in the community. (1B)

12.3 A validated tool such as the intensive care psychological assessment tool (IPAT) should be used by trained critical care staff to detect acute stress and indicate the risk of future psychological morbidity. (1A)

Section III: Renal Replacement Therapy in critical care during routine and surge scenarios.

13. For each critical care unit, we recommend:

13.1 Each critical care unit in the UK should identify a multidisciplinary local leadership team responsible for the provision of renal replacement therapy and development of resilience options. (1A) The local leadership team should:

13.1.1 Include representatives from critical care and renal teams including medical, nursing, pharmacy, dietetic and technical staff. (1B)

13.1.2 Undertake an evaluation of existing RRT capacity on the critical care unit. (1A)

13.1.3 Maintain an inventory of consumables and be prepared to liaise with national bodies in the event of a further surge in demand for RRT. (1B)

13.1.4 Consider the most appropriate local strategies to increase the number of nurses capable of delivering RRT by redeployment of existing dialysis nurses and providing pre-emptive additional training to ICU nurses. (2B)

13.1.5 Consider increasing the number of pharmacists on the ICU to assist with drug dosing for patients receiving RRT. (2B)

13.1.6 Consider contingency planning for delivering RRT to patients in the event of a surge in admissions. Some ICUs were able to develop a service to offer peritoneal dialysis (PD) and intermittent haemodialysis (IHD) during the first pandemic surge. ICUs investigating the feasibility of delivering these RRT options should consider: (2C)

a. the availability of equipment
b. infrastructure (water supply and drainage including quality assurance)
c. staffing (who will prescribe, deliver and monitor these therapies)

14. For each critical care network, we recommend:

14.1 Each critical care network in the UK should identify a representative multidisciplinary team responsible for the regional provision of renal replacement therapy and development of resilience options. (1B) The regional leadership team should:

14.1.1 Evaluate regional facilities for RRT provision. (1B)
14.1.2 Have discussions with local hospitals within the critical care network to establish an agreed regional hub or hubs capable of delivering alternative RRT modalities in the event of a pandemic surge. (1B)
14.1.3 Consider the impact on all critically ill patients when identifying a regional hospital as a hub for alternative RRT provision. (2B)
14.1.4 Ensure decision to transfer patients for RRT is made by the clinical team at the referring and receiving hospitals. (1A)

14.1.5 Liaise with regional partners responsible for transporting critically ill patients between hospitals within the critical care network to ensure appropriate preparations for such transfers are in place. (1B)

15. For critical care CRRT delivery during routine and surge scenarios, we recommend:

15.1 Each critical care unit in the UK should consider implementing this toolkit which suggests measures to maximise currently available CRRT resources. (1B)

15.1.1 The decision to initiate RRT should be based on the overall condition and prognosis of the patient, not on isolated urea or creatinine values. (1A)

15.1.2 Where potentially life-threatening complications of AKI are developing, such as hyperkalaemia, fluid overload, metabolic acidosis or severe uraemia, careful medical management may be considered to temporise or potentially avoid need for RRT in selected patients. Each case should be assessed by a senior nephrologist and/or intensivist. (1B)

15.1.3 Where complications of AKI are refractory to medical therapy or become life-threatening, RRT should be started urgently unless a decision has been made not to escalate therapy. (1A)

15.1.4 Decisions not to provide RRT on grounds of prognosis should involve consultation with a multi-disciplinary team involving senior intensivists and/or nephrologists and be appropriately documented and appropriately communicated to patients and their next of kin. (1A)

15.1.5 Patients with end-stage renal failure with other organ failure as a consequence of COVID-19 may require critical care admission. In such cases, there should be close liaison with the regional renal service regarding appropriate modality of RRT, vascular access and arrangements for step down. (1A)

15.1.6 Continuous and intermittent RRT should be considered as complementary therapies for AKI in COVID-19, but clinicians should be aware of the implications of choice of therapy on fluid balance and pharmacokinetics. Choice of therapy should be based on patient status, expertise of clinical staff and availability of equipment. In order to deliver most effective therapy to the largest number of patients, modality choice may be re-evaluated if changes in clinical condition occur. (1B)

15.1.7 In circumstances where non-ICU staff are re-deployed to critical care areas, appropriate orientation, training and supervision are required to ensure safe, effective delivery of RRT. Staff should not be responsible for delivery of an RRT modality for which they have not been fully trained. (1A)

15.1.8 Dose of RRT should be prescribed at the beginning of the RRT session following local protocols. Standard dose should remain based on KDIGO recommendation of 20-25ml/kg/h. Dose should be reviewed regularly and if required tailored to the needs of the patient. There is no evidence for clinical benefit from enhanced doses of RRT in COVID-19 patients. (1A)

15.1.9 The decision to use anticoagulation to maintain circuit patency and the choice of anticoagulant should be based on the potential risks and benefits in an individual patient, the expertise of the clinical team and the options available. (1A)

15.1.10 As hypercoagulable states are common in in COVID-19, RRT circuit performance should be closely monitored to ensure maximal circuit patency as the initial anticoagulation strategy may not be effective in all patients. Centres should establish a stepwise escalation and/or alternative plan for RRT anticoagulation when circuit lifespan is unacceptable. (1B)

15.1.11 In addition to circuit-anticoagulation emphasis should be placed on best choice of site and length of vascular access to optimise circuit patency. Where CRRT is used, measures to reduce filtration fraction should be considered when providing RRT to COVID-19 patients with hypercoagulable states; this might involve preference for CVVHDF or CVVHD modalities of CRRT where these options are compatible with local protocols. (1C)

15.1.12 In addition to patient-specific considerations, within the limits of patient-safety, adjustments to RRT modality, indications, anticoagulation, and dose may be considered as part of a local response to supply/demand imbalances in order to conserve scarce resources and deliver effective therapy to the greatest number of patients. Any such adjustments should follow clearly developed protocols and must be accompanied by appropriate training and monitoring. (2C)

15.1.13 Continuous RRT is associated with increased protein losses, resulting in the need for increased protein provision to compensate for this. The use of protein supplementation/high protein formulas should be used to meet protein targets. Energy and protein targets for continuous renal replacement therapy should be set as per local critical care practice. The use of citrate containing solutions can also be a source of non-nutritional calories and should be accounted for as per local practice[4-5]. Input from a specialist critical care dietitian and/or renal dietitian should be standard practice alongside frequent monitoring especially if RRT modality is changed.

15.1.14 Patients treated with acute CRRT should receive standard enteral nutrition as long as there are no significant electrolyte abnormalities or fluid overload refractory to RRT. Input from specialised renal and/or critical care dietitians should be standard practice including review if RRT modality is changed. (1B)

15.1.15 After step-down from critical care, the accepting team and GP should be informed that the patient had received RRT for AKI while in intensive care so that appropriate follow-up arrangements can be made. Patients with ongoing need for RRT but not intensive care should be transferred promptly to a regional renal unit with facilities for in-patient RRT. (1A)

15.1.16 Appropriate ICU outreach should be provided to patients discharged from ICU, especially those transferred between sites, to assist in management of ongoing manifestations for critical illness such as delirium and to make proactive decisions about re-escalation if required. (1B)

16. For expanding critical RRT capability during surge circumstances, we recommend:

16.1 Each critical care unit in the UK should consider implementing this toolkit which suggests how to increase RRT capacity including use of modalities not employed as standard in those units such as intermittent haemodialysis (IHD), hybrid therapies and peritoneal dialysis (PD). (2C)

Intermittent haemodialysis (IHD)

16.1.1 Use of IHD on ICU will depend on availability of technical requirements, including existence of permanent water supply suitable for IHD and availability of renal unit medical and nursing staff to advise and deliver the treatment.

16.1.2 Where ICUs are not already equipped to deliver IHD or SLED/SLEDf, adaptation is sometimes possible but requires advanced planning particularly with respect to suitable water supply.

16.1.3 IHD must be prescribed, supervised and delivered by clinicians with appropriate experience and expertise in the modality. Usually this would be nephrologists and renal/dialysis unit nursing staff, ideally working alongside ICU staff to provide integrated care.

16.1.4 If IHD cannot be delivered on ICU for technical reasons, consider delivering it on the renal unit so long as senior ICU and renal medical staff consider that it is safe to do so. This may require escort and supervision of patients by ICU staff for the transfer and duration of the RRT.

16.1.5 Transfer of a patient with COVID-19 from ICU to the renal unit for IHD must comply with renal unit policy for management of patients with confirmed or possible COVID-19 i.e. it should not lead to compromise of a COVID-19 'clean' area.

16.1.6 Clinicians prescribing IHD should choose acid concentrate with appropriate amount of potassium based on the patient's serum potassium levels, to avoid significant hypo- or hyperkalaemia.

16.1.7 Vascular access for acute RRT should comply with local guidelines.

16.1.8 The use of nutrient-dense and low electrolyte/specialist renal feeds may be required in instances where dialysis can only occur on an intermittent basis as a means to help achieve fluid balance goals and management of electrolytes levels. Additional protein supplementation should be considered if needed to meet protein targets. Energy and protein targets for intermittent renal replacement therapy should be set as per local renal and critical care practice.

Extended ('hybrid') therapies (SLED, SLEDf)

16.1.9 Extended therapies such as SLED and SLEDf should be considered only in centres with experience and expertise. The recommendations for IHD apply also to SLED/SLEDf.

16.1.10 Indications and contraindications for extended therapies for patients with COVID-19 and AKI are likely to be similar to those for COVID-19 negative patients with AKI.

16.1.11 Where there is no specific indication for extended therapy (such as haemodynamic instability), IHD should be the preferred intermittent extracorporeal treatment because it generally requires less renal nursing time.

16.1.12 Where extended therapies are used, serum potassium and phosphate should be monitored as per local guidelines, bearing in mind that the extended therapy is a risk factor for hypokalaemia and/or hypophosphatemia.

Acute peritoneal dialysis (PD)

16.1.13 Consider acute PD when RRT capacity is stressed and where suitable outreach expertise can be provided from within the trust or region.

16.1.14 Where PD nurse specialists are not available 24 hours, ICU and renal (PD) teams must agree a protocol for ensuring that all aspects of PD management comply with local/regional standards.

16.1.15 Standard operating procedures for PD should be agreed between the Renal (PD) and ICU teams and documented. Local SOPs should address potential complications particular to ICU and COVID-19 e.g. whether PD should continue in event of proning.

16.1.16 PD should be supervised by an outreach team from local PD unit, including overnight on-call service where overnight PD is anticipated.

16.1.17 Mode and prescription of PD (CAPD vs APD, machine type, PD fluid) should follow local PD protocols with consultation between renal ICU staff.

16.1.18 Each patient should be reviewed at least daily by the PD team to ensure that dialysis adequacy and ultrafiltration are responsive to their individual requirements.

16.1.19 PD tube insertion and maintenance should follow local protocols

16.1.20 Exit site care should be provided by PD specialist nurses following local protocol. Report Twardowski scale when changing exit site dressing. Treat exit site infection per local guidelines.

16.1.21 Surveillance for and treatment of PD peritonitis should follow local protocols and be familiar to ICU staff as well as the PD team.

16.1.22 Caution should be exercised when lifting drain bags, which can weigh up to 7kg. Appropriate PPE should be worn when disposing of PD effluent in patients who have not been de-isolated.

16.1.23 Glucose absorption from dialysate solutions can provide a significant contribution of non-nutritional calories. To avoid overfeeding adjustments to the nutritional plan should be made to account for this. Energy and protein targets for PD should be set as per local critical care/renal practice with protein supplementation/high protein formulas used in those who are unable to meet protein goals. Input from a specialist critical care dietitian and/or renal dietitian should be standard practice. Regular monitoring is essential due to

the frequent changes in patients PD prescription and subsequent glucose content of dialysate solutions.

16.1.24 After discontinuation of PD (e.g. after renal 'recovery'), PD catheters should be removed using local protocol by a clinician experienced in the procedure.

16.2 Each critical care unit should consider how best to provide care of patients with end stage kidney disease requiring respiratory support during a future pandemic surge.

16.2.1 A personalised treatment escalation plan and ceiling of care should be agreed by the renal team and, where possible, the patient. Pre-emptive discussions of wishes and expectations around end of life care are recommended as part of standard outpatient management.

16.2.2 The patient's usual mode of RRT should be maintained unless there is a specific reason to prefer an alternative therapy.

16.2.3 For patients receiving IHD for ESKD, where possible their existing access (AV fistula, graft or tunnelled line) should be used by an appropriately trained clinician (usually a renal/dialysis nurse).

16.2.4 Consider transferring a patient with ESKD requiring respiratory support to a regional renal hub if this is the preferred strategy of the regional renal/ICU network or if it increases the probability of maintaining the patient's usual mode of RRT.

16.2.5 Local ICU, renal and respiratory teams should consider options for providing enhanced respiratory support (such as HFNO and CPAP) on renal wards.

Summary of Audit Measures

The following clinical audit standards have been developed for services to assess the quality of care provided to patients who are critically unwell and have AKI:

1. All patients have pre-morbid kidney function (creatinine and eGFR) documented if available and baseline urine dip and urine albumin creatinine ratio documented.
2. All adults with AKI or Chronic Kidney Disease (CKD) should have a daily medication review to ensure unnecessary nephrotoxic medication is avoided and drug dose adjustments are accurate in respect of kidney function
3. Each critical care unit has a mechanism for real-time assessment of renal replacement therapy (RRT) capacity, including staffing capacity and an inventory of consumables for RRT.
4. Each critical care unit should have a contingency plan in place for delivering RRT to the number of patients seen in that unit in the first surge of COVID-19 (March/April 2020).

Rationale for Clinical Practice Guidelines

The COVID-19 pandemic revealed serious national shortages of reserve resources needed to deliver renal replacement therapy (RRT) to critically unwell patients during such emergency states. Whilst concern initially focused upon critical care bed and ventilator capacity, it soon became clear that limited resources needed to provide renal support for such patients was a concern of similar magnitude and clinical

significance. A further COVID-19 surge or comparable emergency risks overwhelming critical care RRT capacity, representing a national patient safety risk. The primary rationale for these Clinical Practice Guidelines is to support critical care RRT resilience across all centres during further COVID-19 surges, including in hospitals without on-site renal services.

Innovative and flexible cross-specialty working by renal and critical care multi-professional teams was often required to help to sustain critical care RRT delivery during the early stages of the pandemic. Such collaborative experience and learning also highlighted opportunities to optimise and streamline routine care of critically unwell patients with renal failure, including in centres without on-site renal services. A second rationale for these guidelines is thus to utilise cross-specialty multi-professional experience and learning during the pandemic to optimise and streamline patient care during routine and emergency states.

Finally, these guidelines aim to support implementation of the NHS England (NHSE) Service Specification, which describes the requirements for renal replacement therapy (RRT) as an interdependent service for adult critical care services. Because NHS services are configured to meet routine clinical demand to ensure responsible NHS resource use, the NHSE specifications and this guideline incorporate flexibility to ensure appropriate use of resources during routine circumstances and responsive capability and resilience during surge circumstances.

Lay summary

When patients with COVID-19 or other illnesses become critically unwell their kidneys may begin to fail. Kidney failure is a life-threatening problem, especially when associated with COVID-19 because such patients are at high risk of other vital organ failure too. If this happens they may need to be looked after on a critical care unit. Such patients need life-support treatment, including types of kidney dialysis. Dialysis is a treatment that removes dangerous toxins and excess fluid from the body when a patient's kidneys are unable to do so.

Although dialysis can be provided for some patients with kidney failure on standard hospital wards in some hospitals, patients who also have other organ failure can only receive dialysis safely if they also receive other life support treatment in a critical care unit. In addition, some hospitals do not have specialist kidney services to support dialysis on standard wards, and may only be able to provide dialysis in their critical care units.

Equipment and staff needed to provide dialysis in critical care units were set up to meet standard needs during usual circumstances. However the first COVID-19 pandemic wave caused many patients to become critically unwell during a short period of time, therefore the facilities needed to provide dialysis in critical care were almost overwhelmed. Whilst hospitals were initially concerned about running out of critical care beds or ventilators during the pandemic, it soon became clear that exhausting facilities for dialysis was a similar risk to patient safety. Healthcare professionals from critical care and kidney teams across the United Kingdom worked together to help ensure critically unwell patients were able to receive vital dialysis during the first wave of COVID-19. This required staff from these teams to work flexibly in order to find solutions to such challenges associated with COVID-19.

This guideline has been written to help ensure all NHS hospitals are able to provide dialysis treatments for critically unwell patients during further COVID-19 surges or similar national emergencies. It has been written using currently available evidence and also the experience and learning of staff that helped to

provide dialysis for critically unwell patients during the first COVID-19 pandemic wave. This guideline also helps hospitals to meet new NHS England recommendations which direct how critical care and local kidney teams should set up and work together, including in hospitals without on-site kidney specialist teams.

Section I

Management of Patients Pre and Post Critical Care with

COVID-19 Associated Acute Kidney Injury

Aims

1. Produce a management framework for the prevention and treatment of COVID-19 associated acute kidney injury (C19-AKI) outside of the critical care environment appropriate for units level 1-3. Including measures to mitigate demand on renal replacement services under surge conditions.
2. Produce recommendations for the management of patients with end-stage kidney disease (ESKD) and dialysis dependent ESKD with COVID-19.
3. Produce a management framework for patients with COVID-19 associated kidney disease post critical care to ensure efficient use of resources and appropriate patient follow-up.
4. Produce guidance on safe patient inter hospital transfer among critical care, renal units and non-renal wards.

Management of patients with COVID-19 associated Acute Kidney Injury (C19-AKI) outside Critical Care.

Standards

1. Acute kidney injury (AKI) is detected by monitoring changes in serum creatinine or reductions in urine output and must be defined using Kidney Disease Improving Global Outcomes (KDIGO) definitions (serum creatinine and urine output criteria) to recognise AKI.[1]
2. The NHS England AKI warning algorithm will identify patients with changes in serum creatinine suggestive of AKI and will identify in real time potential cases of AKI. This should be integrated into current IT systems.
3. Management of all patients with C19-AKI should follow NICE guidance NG175 : COVID-19 rapid guideline: acute kidney injury in hospital (See Figure 1) as well as NICE guidance NG148 Acute Kidney Injury: prevention, detection and management, and the Renal Association Clinical Practice Guideline on Acute Kidney Injury.[2,3,4]
4. All healthcare workers involved in receiving, assessing and caring for patients who have known or suspected COVID-19 should follow UK government guidance on infection prevention and control. This contains information on using personal protective equipment (PPE), including visual and quick guides for donning and doffing PPE.
5. Discuss the risks, benefits and likely outcomes of treatment options with patients with COVID-19, and their families and carers. This will help them make informed decisions about their treatment goals and wishes, including treatment escalation plans where appropriate. Use decision support tools (when available) and document discussions and decisions clearly.
6. Criteria for the safe inter hospital transfer of patients between non-specialist renal ward and the renal unit must be developed locally.
7. Robust protocols should be in place, which facilitate the transfer of patients with ESKD to their parent renal unit. Transfer should not default to the local tier 3 unit unless clinically appropriate.

Recommendations

1. For management of patients with COVID-19 associated Acute Kidney Injury (C19-AKI) outside Critical Care, we recommend:

   1.1 Risk factors for developing C19-AKI are the same as those for patients developing AKI from other common causes.[1,2,4] Patients at high risk of developing C19-AKI should be identified at an early stage and measures instigated to reduce this risk (see Figure 1).[4] (1A)

   1.2 Patients who develop COVID-19 should have at least twice daily monitoring of their volume status to avoid hypovolaemia. Kidney function should be monitored daily. (2B)

   1.3 Patients who develop C19-AKI have a very high mortality and therefore it is important for all NHS organisations to have an early recognition and response system in place (figure 1). (1B)

   1.4 Hypovolaemia is common in patients with COVID-19 and will exacerbate the hypercoagulable state and organ injury including C19-AKI. Volume status must be optimised to euvolaemia with appropriate fluid resuscitation, which should be part of a protocol to restore circulating volume status and haemodynamic stability with ongoing cardiovascular assessment (figure 1). [5] (1B)

   1.5 Hyperkalaemia is a medical emergency and should be treated as per local guidelines. Potassium binders (e.g. patiromer and sodium zirconium cyclosilicate (SZC)) can be used alongside standard of care for the emergency management of acute life-threatening hyperkalaemia if indicated . SZC has a faster onset of action and lowers potassium to a greater extent in the first 48 hours. Patiromer and SZC can both be continued if their use controls hyperkalaemia and there are no other indications for emergent RRT. If there are delays in patients receiving RRT due to lack of capacity, potassium binders may be used for an extended period of time with senior medical review and dietitian involvement. [6] (2C)

   1.6 A full medication review should be performed and appropriate adjustments made to drug doses. Pharmacist-led review is strongly recommended for medicine optimisation, including appropriate dosing, avoidance of drugs and other substances harmful to the kidneys in the setting of COVID-19, and advice on anticoagulation. (1A)

   1.7 Urinalysis should be performed on all patients with COVID-19 and results recorded. The presence of blood and/or protein in the urine (active urinary sediment) is common in patients with COVID-19 with or without C19-AKI and may indicate underlying kidney disease. Urinalysis should be repeated following the acute illness, no later than 3 months, and if the active urinary sediment persists a renal opinion is recommended. (2B)

   1.8 Rhabdomyolysis may complicate C19-AKI and a creatine kinase (CK) should be checked. Such patients should receive appropriate fluid resuscitation and regular volume status review based on local guidelines. (2B)

   1.9 Malnutrition is an independent predictor of in hospital mortality in patients with AKI. Local protocols to screen for malnutrition and to identify patients with AKI at risk of malnutrition should be in place. Health care professionals caring for patients with AKI should consider early dietetic referral where concerns about nutritional status exist. Patients at risk for poor outcomes and higher mortality following infection with COVID -19, namely older adults and polymorbid individuals, should be checked for malnutrition through screening and assessment.[7, 16] (2B)

1.10 Renal referral should be considered where diagnostic uncertainty lies as to the cause of AKI or AKI is worsening despite initial management. COVID-19 has been shown to be associated with some rarer forms of AKI. (1A)

1.11 Local transfer criteria and clear transfer pathways must be developed and disseminated to allow the safe inter hospital transfer of patients from non-specialist renal wards to specialised kidney units. An example of such a pathway is shown in Figure 2. This includes transfer from critical care units within a tier 3 centre when referring to tertiary renal units. Criteria may reflect local provision where transfer to renal level 2 units may have criteria at variance to those without. (2B)

1.12 Referral to critical care (in tier 1-3 centres) or renal (in tier 1-2 centres) for renal replacement therapy (RRT) When it is anticipated that patient will meet usual criteria for renal replacement therapy (RRT).[2,3] (1A)

Background

C19-AKI is multifactorial in origin and may necessitate admission to the intensive care unit (ICU) and the subsequent use of renal replacement therapy (RRT). The incidence of kidney support is well documented in the English and Welsh ICU population, less is known about the incidence of AKI outside of ICU. In a retrospective cohort of over 5000 patients with COVID-19 from New York 37% suffered C19-AKI at some stage, 53% of which were severe (AKI Stage 2/3).[8] It is suggested that there may be specific renal pathology related to COVID-19 due to a degree of viral tropism and the recognised systemic effects of viraemia, although this is disputed by some groups. However to-date there is no evidence to suggest that management of patients with C19-AKI differs from that of patients with AKI due to other causes such as sepsis and hypovolaemia.[9] Recent evidence suggests that patients with C19-AKI have a worse prognosis than individuals with non-C19-AKI alone hence the management of these patients should follow the National Institute for Health and Care Excellence (NICE) AKI guidelines on AKI management and the NICE accredited Renal Association AKI guidelines.[2,3,6] Risk stratification is important to tailor monitoring and prevention/early treatment strategies for patients who may benefit the most. Initial data suggests that male sex, older age, black race, presence of diabetes mellitus, CKD, hypertension, cardiovascular disease, congestive heart failure, and higher body mass index are associated with an increased risk of AKI.[8,10,11] Rhabdomyolysis, when reported, occurred in 7-20% of patients with evidence of AKI.[12] Hyperkalaemia has been noted in 23% of patients with AKI, and is often associated with metabolic acidosis.[12,13] A large proportion of patients, particularly those who were critically ill and/or had overt AKI, had evidence of haematuria and proteinuria. Where the aetiology is uncertain renal advice should be sought.

Figure 1: Rapid Guideline Summary For C-19 AKI

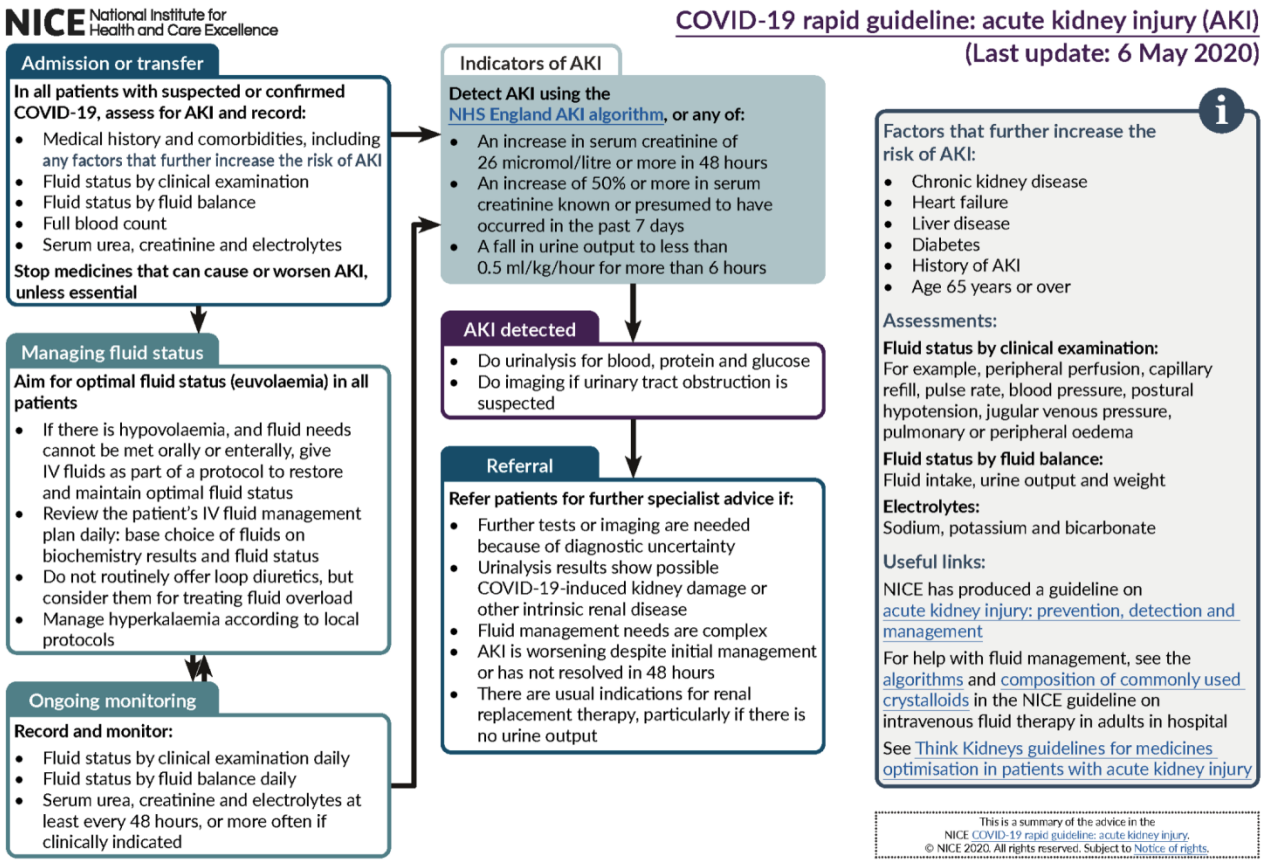


Figure 2: Example of a recommendations for the safe inter hospital transfer of patients from non-specialist renal wards to specialised renal units

HOSPITAL TRANSFER POLICY TO RENAL UNIT FOR PATIENTS WITH AKI

Patient must be clinically assessed using ABCDE just prior to hospital transfer by referring team

Consider P2 referral (discuss with senior nurse)

In addition transfer may only proceed if the following criteria are met

Potassium must be safe

K^+ < 6.5 and No ECG changes

If hyperkalaemia has been treated it must be determined how and when

Hyperkalaemia will recur if transient therapy such as insulin and dextrose has been used and the underlying cause not treated such that K^+ can be excreted via the urine eg obstruction relieved or urine output re-established

Acid-base status must be safe

pH > 7.2

Venous bicarbonate > 12 mmol/L

Lactate < 4 mmol/L

Respiratory status must be safe

Respiratory rate > 11 /min and < 26/min

Oxygen saturation > 94%

Oxygen support not > 35%

If patient required acute CPAP must have been independent of this treatment for 24 hrs

Circulatory status must be safe

HR > 50/min and < 130/min

BP > 100mmHg systolic

MAP > 65mmHg

(lower BP values may be accepted if it has been firmly established these are pre-morbid)

Neurological status must be safe

Alert (AVPU)

IF CRITERIA NOT MET INITIATE EMERGENCY REFERRAL TO LOCAL CRITICAL CARE OUTREACH/ICU

Once patient is stabilised follow ICU to Renal Unit transfer policy

Transfer target post stabilisation < 24 hrs

Management of Patients with Chronic Kidney Disease (CKD) and End-Stage Kidney Disease (ESKD) Outside of Critical Care

Standards

1. AKI is detected by monitoring changes in serum creatinine or reductions in urine output and must be defined using KDIGO definitions (serum creatinine and urine output criteria) to recognise AKI.[1]
2. The NHS England AKI detection algorithm will identify patients with changes in serum creatinine suggestive of AKI and will identify in real time potential cases of AKI. This should be integrated into current NHS IT systems.
3. Management of all patients with C19-AKI should follow NICE guidance NG175: COVID-19 rapid guideline: acute kidney injury in hospital[2] (See Figure 1) as well as NICE guidance NG148 Acute Kidney Injury: prevention, detection and management.[3]
4. All healthcare workers involved in receiving, assessing and caring for patients who have known or suspected COVID-19 should follow UK government guidance on infection prevention and control. This contains information on using personal protective equipment (PPE), including visual and quick guides for putting on and taking off PPE.
5. Discuss the risks, benefits and likely outcomes of treatment options with patients with COVID-19, and their families and carers. This will help them make informed decisions about their treatment goals and wishes, including treatment escalation plans where appropriate. Use decision support tools (when available) and document discussions and decisions clearly.
6. Local renal services should ensure that systems are in place to avoid admission of patients with ESKD patients to Tier 3 units where the only RRT facilities will be on intensive care units.

Recommendations

2. For the management of patients with Chronic Kidney Disease (CKD) and End-Stage Kidney Disease (ESKD) outside of Critical Care we recommend:

   2.1 Those responsible for in-patient care of patients with COVID-I9 should be aware that the development of AKI carries a grave prognosis and therefore early identification may mitigate worsening of AKI. Clinicians must be aware that patients with CKD are at higher risk of developing AKI. (1A)

   2.2 There is no evidence currently that the initial supportive management of C19-AKI is different from patients with non C19-AKI. As such treatment should follow established guidelines.[2,3,6] (1B)

   2.3 Renal advice should be sought promptly if the patient has established CKD Stage 4/5 (eGFR is < 30 ml/min/1.73 m2) or has ESKD and is receiving dialysis, especially in tier 3 centres. (1B)

   2.4 In patients with advanced CKD where dialysis is planned then NICE guideline [NG160] COVID-19 (rapid guideline: dialysis service delivery) should be followed.[7] (1A)

Background

The presence of CKD is a major risk factor for developing AKI and therefore the identification of patients with CKD is of paramount importance.[8,10] Management is similar, however early referral to the renal service is recommended where the need for long term renal support is envisaged. Enhanced Personal Protective

Equipment should be worn by all staff involved in the care of patients receiving haemodialysis who are symptomatic and awaiting a swab result or patients with a positive COVID-19 swab, until they are de-isolated.

Management of Patients with COVID-19 Associated Acute Kidney Injury (C19-AKI) Post Critical Care

Standards

1. Tier 3 units should liaise directly with the local renal unit regarding safe patient inter hospital transfer and provision of RRT and choice of modality prior to the need for discharge. Where possible this should be expedited in order to provide capacity.
2. Tier 1 units with on-site provision for dialysis should be aware of potential transfers with the possibility of stepping down to a level 2 area. This will be governed by local leadership teams who will better understand local resources, infrastructure and staffing.
3. Consideration should be given to minimise cross-infection so that patients can receive dialysis in cohorts based on their COVID -19 status. Consider whether anyone accompanying a patient to the dialysis unit may have COVID -19, and cohort the patient appropriately.[14]

Recommendations

3. For management of patients with COVID-19 Associated Acute Kidney Injury (C19-AKI) Post Critical Care, we recommend:

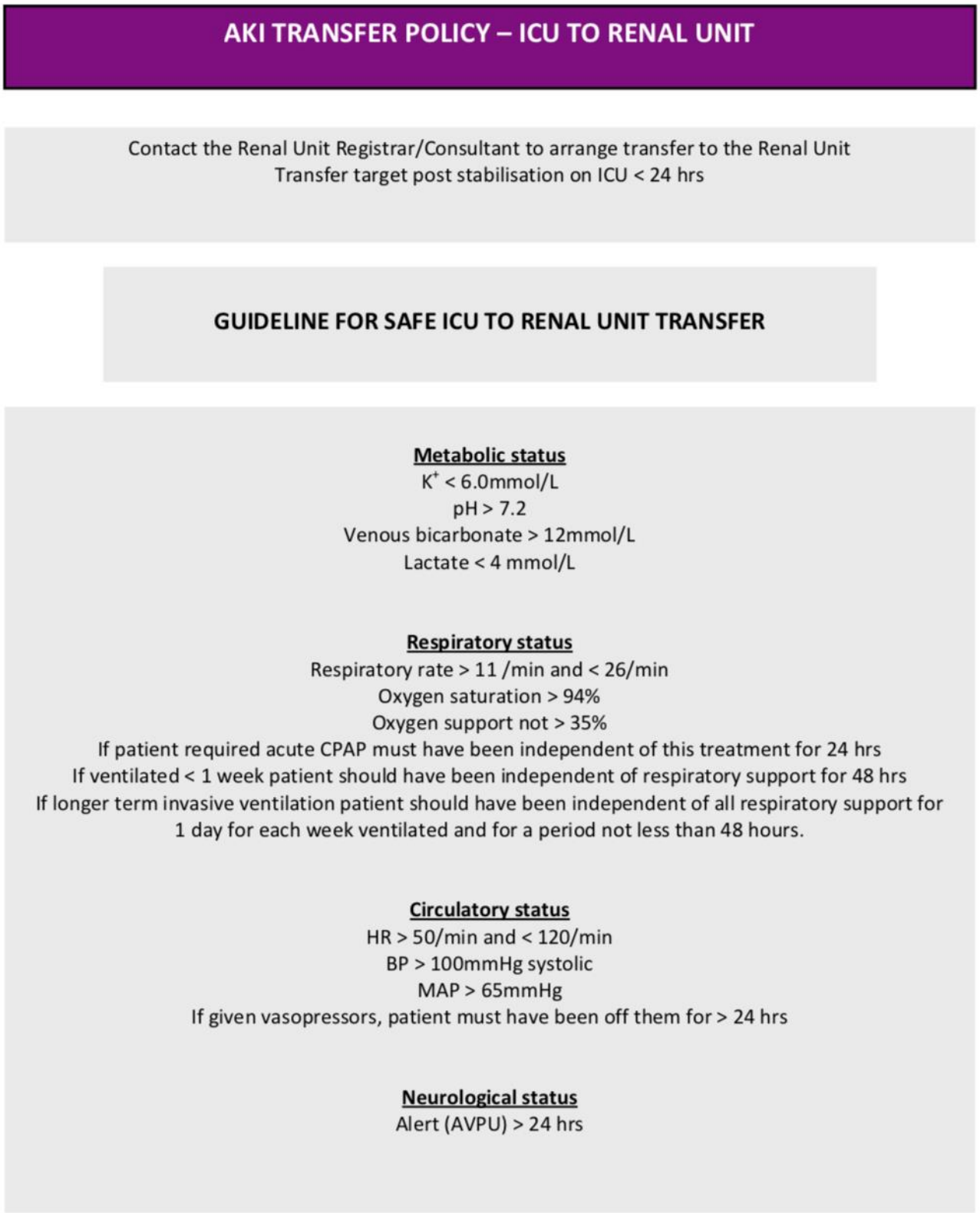
3.1 Local transfer criteria and local networking must be developed to allow the safe transfer of patients (See Figure 3 as example). (1B)

3.2 Critical care discharge summary must include the baseline kidney function prior to admission if known, medications prior to admission, a list of investigations performed, treatment received, cause of AKI, discharge kidney function if dialysis-independent and the emergent need for dialysis. Some critical care units routinely send ICU discharge letters to Primary Care and this is particularly recommended as good practice in the setting of AKI, as new or worsening chronic kidney disease may develop post hospital discharge. (1C)

3.3 Ensuring the provision of optimal nutrition post ICU is an essential component to support successful long-term rehabilitation. Ongoing nutritional input in the recovery phase should therefore be integral to a patient's multidisciplinary rehabilitation plan. (1B)

3.4 Tier 3 units should seek renal advice in terms of vascular access for dialysis as well as recommencement of regular medication. (1B)

Figure 3. Example recommendations for the safe transfer of patients between critical care and the renal unit



Management of Patients with COVID-19 Associated Acute Kidney Injury (C19-AKI) Post Hospital Discharge

Standards

1. Hospital discharge summary must include key information for the continued follow-up and management of the patient.
2. There must be specific recommendations provided to the GP, patients, relatives and/or carers for the continued follow-up and management of the patient to try and avoid further episodes of admission and AKI.
3. Discharge summary should link to relevant local guidelines.
4. Formal post-discharge renal review should be arranged for appropriate patients as per local guidelines.

Recommendations

4. For the management of patients with COVID-19 Associated Acute Kidney Injury (C19-AKI) Post Hospital Discharge, we recommend:

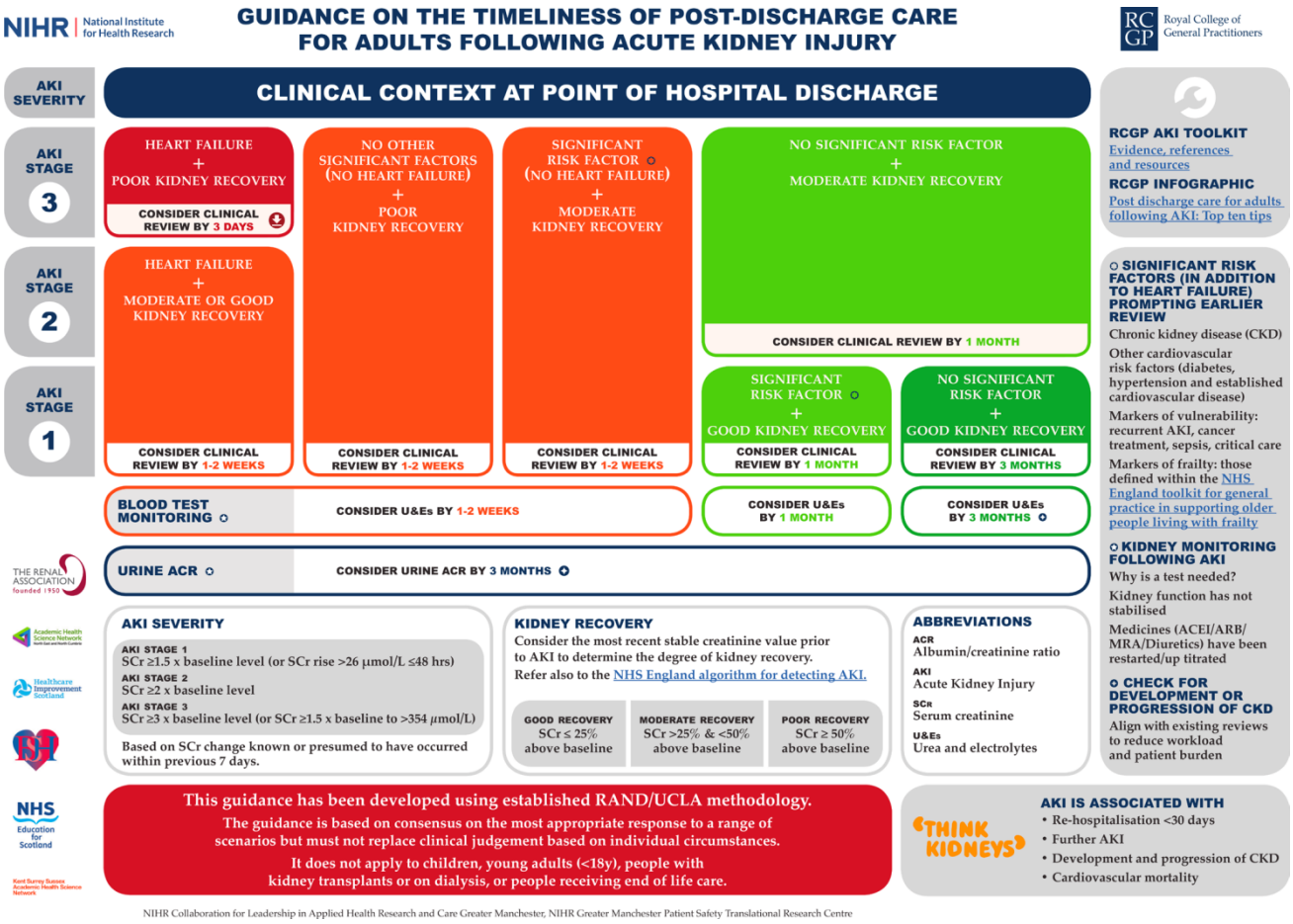
4.1 Discharge summary must include the baseline kidney function prior to admission if known, medications prior to admission, a list of investigations performed, treatment received, cause of AKI, maximum stage, the need for dialysis (temporary / ongoing), discharge kidney function if dialysis-independent (See Figure 4).[15] (1B)

4.2 There must be specific recommendations to the GP, patients, relatives and/or carers on the need for immediate, post-discharge monitoring of kidney function, advice on medications that may have been implicated in the episode of C19-AKI (e.g. continued avoidance or advice on re-introduction). (1B)

4.3 Discharge summary should link to relevant local guidelines, advise on the need for documentation of the AKI in the primary care record and note the need for registration on the primary care CKD register if residual CKD exists at the time of discharge. (1B)

4.4 Formal post-discharge renal review should be arranged within 90 days for those with residual CKD stage G4 at hospital discharge or within 30 days for those with residual CKD stage G5 (non-dialysis-requiring) at hospital discharge. (1B)

Figure 4: Guidelines on the timeliness of post-discharge care for adults following acute kidney injury (From reference 15)



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Section II

Intra-critical care management of COVID-19

associated renal disease

Prevention and management of AKI in critically ill patients

5. For prevention and management of AKI in critically ill patients, we recommend:

5.1 Prevention and management of AKI in critically ill patients with COVID-19 should follow the same principles as stated for patients in non-critical care wards (as per pre and post critical care (PPCC) guidance, recommendations 1 to 4).[1,2,3,4] (1A)

5.2 Although there are some differences in pathogenesis between COVID-19 associated-AKI (C19-AKI) and critical illness-associated AKI, management is similar, and should follow NICE guidance where appropriate. (1A)

5.3 There is no direct evidence for optimal fluid resuscitation in COVID-19, though a euvolaemic strategy is recommended (as per PPCC guidance, recommendation 4).[2,4] (1C)

5.4 COVID-19 is a new disease with a rapidly evolving understanding of best clinical management. ICU clinicians should note a significant rotation away from an ARDS-like "dry" approach to lung management in favour of clinical euvolaemia. (1B)

5.5 Pharmacist-led review is strongly recommended for medicine optimisation, including appropriate dosing, avoidance of drugs harmful to the kidneys in the setting of COVID-19 and also advice on anticoagulation (as per PPCC guidance, recommendation 6). (1B)

Diagnosis of AKI

5.6 Acute kidney injury (AKI) is detected by monitoring changes in serum creatinine or reductions in urine output and must be defined using Kidney Disease Improving Global Outcomes (KDIGO) definitions (serum creatinine and urine output criteria) to recognise AKI.[3] (1A)

5.7 The NHS England AKI warning algorithm will identify patients with changes in serum creatinine suggestive of AKI and will identify in real time potential cases of AKI. This should be integrated into current IT systems. (1A)

Urinalysis

5.8 All critically ill patients should have urinalysis performed on admission to ICU using multi-signal dipsticks. The results of these tests should be documented in the patient's records contemporaneously. Abnormal results are not infrequent in ICU patients. Patients with COVID-19 and proteinuria and haematuria should be discussed promptly with nephrology. (1A)

Caution should be exercised in the interpretation of haematuria in samples taken shortly after catheterisation or in the presence of a UTI (pyuria with positive nitrites) or in patients with long term catheters. In this case, the test should be repeated and discussed with a nephrologist if doubt remains. (1B)

Manufacturer advice with regards to the use of these dipsticks should be followed strictly to minimise false positive/negative readings. (1A)

Imaging of the renal tract

5.9 Urinary obstruction is no more common in patients with COVID-19 than in other critically ill patients. A renal US should be ordered according to existing guidance. (1A)

5.10 Consider imaging alongside potential for increased radiology workload and spread of COVID-19 infection. The latter can be mitigated by appropriate infection control precautions and should not delay diagnosis of reversible pathology. (1B)

Native renal biopsy

5.11 It is very unlikely that a native renal biopsy will be required in COVID-19 patients with AKI on critical care. Any potential indications for a renal biopsy should be discussed with a nephrologist. (1A)

Small case series and post-mortem studies have reported histopathological findings in COVID-19 patients with AKI. Most of these findings were acute tubular injury, endothelial injury and glomerular ischemia. Some samples showed evidence of microthrombi suggestive of a hypercoagulable state. Case series have also shown evidence of glomerular disease (eg collapsing glomerulopathy) and evidence of direct viral infiltration of the kidneys in some patients.

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Non-dialytic management of complications of AKI in Critical Care

6. For non-dialytic management of complications of AKI in Critical Care, we recommend:

6.1 Fluid overload should be avoided. If it occurs, it should be managed with diuretics as long as the patient is diuretic responsive and there are no other life-threatening complications which require RRT. (1B)

6.2 Consider bicarbonate (enteral or intravenous) if no contraindications and worsening metabolic acidosis due to AKI. This may reduce RRT requirement. (1A)

6.3 Hyperkalaemia is a medical emergency and should be treated as per local guidelines. Potassium binders (e.g. patiromer and sodium zirconium cyclosilicate (SZC)) can be used alongside standard of care for the emergency management of acute life-threatening hyperkalaemia if indicated . SZC has a faster onset of action and lowers potassium to a greater extent in the first 48 hours. Patiromer and SZC can both be continued if their use controls hyperkalaemia and there are no other indications for emergent RRT. If there are delays in patients receiving RRT due to lack of capacity,

potassium binders may be used for an extended period of time with senior medical review and dietitian involvement (as per PPCC guidance, recommendation 5).[1,2] (1A)

References

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2. National Institute of Clinical Excellence - Sodium Zirconium Cyclosilicate for treating hyperkalaemia. Technology appraisal guidance [TA599]. September 2019. www.nice.org/guidance/TA599
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Patients with Chronic Kidney Disease (CKD) and super-imposed AKI

7. For management of patients with Chronic Kidney Disease (CKD) and super-imposed AKI, we recommend:
   - 7.1 Where possible avoid drugs which can cause renal tubular or glomerular toxicity, or induce renal ischaemia, eg. non-steroidal anti-inflammatory drugs (NDSAIDs), SGLT2 inhibitors, aminoglycosides, glycopeptide antibiotics and certain antiviral medications. (1A)
   - 7.2 Ensure regular pharmacist-led medication review to ensure drug safety and avoid potential drug interactions. (1A)
   - 7.3 Blood pressure targets should be individualised to maintain an appropriate mean arterial pressure (MAP) for an individual patient, considering patient age and pre-admission MAP.(1A)
   - 7.4 Consider suspending antihypertensive medication in context of relative hypotension to reduce AKI risk[8, 9]. Consider suspending ACEIs / ARBs during relative hypotension and / or if serum potassium rises above 6.0mmol/l[7]. (1A)
   - 7.5 For kidney transplant recipients, follow Renal Association / British Transplant Society recommendations for COVID-19 disease.
     - 7.5.1 Consider suspending antiproliferative agents (MMF/azathioprine). (1C)
     - 7.5.2 Consider reduction or stopping calcineurin inhibitors (tacrolimus/ciclosporin). (1C)
     - 7.5.3 Consider dexamethasone 6 mg od for 10 days. (1B)
   - 7.6 If modifying or withholding immunosuppressive medications, ensure there is a plan in place to review this decision regularly. (1A)
   - 7.7 Combinations of lopinavir and ritonavir along with hydroxychloroquine, or dexamethasone and tocilizumab, have not been shown to improve outcomes in renal transplant recipients and should not be used[10]. (1C)

Background

Patients with CKD are at greater risk of developing AKI during COVID-19[1]. Grading of CKD is based on the estimated glomerular filtration rate (eGFR), which is derived from serum creatinine and the presence of albuminuria as quantified by urinary albumin creatinine ratio (ACR). eGFR is adjusted for individuals of black ethnicity. Whereas eGFR is adjusted for African/Afro-Caribbean patients, there is no corresponding adjustment for South Asians, who may have reduced muscle mass or be vegetarian, so eGFR values may over-estimate true renal function in this ethnic group.

Patients with CKD are at risk of drug toxicity during acute illness, as many drugs are renally excreted and require dose adjustment dependent on excretory kidney function. Many patients with CKD are prescribed antihypertensive medications, including Angiotensin converting enzyme inhibitors or angiotensin receptor blockers (ACEIs / ARBs). These drugs have been shown to reduce proteinuria and rate of renal function decline[2], and also improve outcomes those with cardiac failure[3]. Epidemiological studies have not demonstrated increased mortality risk for patients prescribed ACEIs/ARBs[4,5] and there is only weak evidence that discontinuing such drugs prior to coronary angiography reduces AKI risk[6].

References

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Nutrition and Dietary intervention

Standards

1. Malnutrition in AKI is an important predictor of hospital mortality.
2. From a dietetic point of view AKI should be classified into:
   a. AKI in patients who are not metabolically stressed
   b. AKI in patients who are metabolically stressed.

Recommendations

8. For nutrition and dietary management, we recommend:

   8.1 Nutritional and dietary intervention should be completed by a dietitian and include assessment of malnutrition, the need for nutritional support, severity and phase of illness, metabolic state (catabolic phase, anabolic phase, recovery phase), metabolic disturbances associated with AKI (such as potassium, phosphate), fluid status, as well as the underlying disease process.[1,2] (1A)

   8.2 Limitation of sodium, phosphate, potassium or fluid intake may be required in individual patients. Protein requirements may need to be increased in critically ill patients requiring RRT based on the dietetic assessment.[3,4] (1A)

References

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Transfer of information (i.e. discharge summary, communication with nephrology and primary care)

Standards

1. There must be a standardised handover procedure for medical, nursing and AHP staff for patients discharged from critical care units with a formalised transfer process.
2. The discharge letter should include whether the patient had AKI or not, the most severe AKI stage, urinalysis result, whether RRT was needed, and the results of any diagnostic work-up.
3. The discharge letter should state any particular management strategies, including temporary or permanent medication changes, and whether any investigations should be repeated after discharge.
4. The handover of care should include an agreed individualised structured rehabilitation programme when patients transfer from critical care to a general ward.
5. Where possible and appropriate, adults should be given information about AKI and potential rehabilitation goals before they are discharged from critical care to a general ward.

6. Patients receiving acute RRT, where the cause of AKI is unclear or where RRT is a continuing requirement, must be discussed with the local nephrology team.

Recommendations

9. For transfer of information (i.e. discharge summary, communication with nephrology and primary care), we recommend:

   9.1 Standardised systems of care (including checklists, staffing and equipment) should be used when transferring critically ill patients within or between hospitals. Accuracy and consistency of communication not only with family, but also internally between clinical teams, is repeatedly identified as being of great importance to patients and families.[1,2,3,4] (1C)

   9.2 There should be clear communication between hospital teams and to primary care at all handovers of care including ICU discharge and hospital discharge. When discharged from critical care, the accepting team should be informed if the patient received RRT whilst in intensive care so that appropriate follow-up arrangements can be made.[5,6,7,8](1B)

   9.3 The critical care discharge summary must include the baseline kidney function prior to admission if known, medications prior to admission, AKI risk factors, cause(s) and severity (state the highest stage during admission), reason for critical care admission, treatment received, discharge kidney function if dialysis-independent and the emergent need for dialysis.[9,10,11] (1B)

   9.4 Some critical care units routinely send ICU discharge letters to GPs and this is particularly recommended as good practice in the setting of AKI, as new or worsening chronic kidney disease may develop post hospital discharge (as per PPCC guidance, recommendation 18).[9] (1C)

References

1. Rehabilitation after critical illness in adults (2009) NICE guideline CG83, recommendation 1.12
2. Rehabilitation after critical illness in adults (2009) NICE guideline CG83, recommendation 1.22
3. GPICS2 (2019) 3.1, standard 9
4. GPICS2 (2019) 3.1, standard 10
5. Emergency and acute medical care in over 16s: service delivery and organisation (2018) NICE guideline NG94, recommendation 1.2.11
6. GPICS2 (2019) 4.3, standard 2
7. GPICS2 (2019) 4.3, recommendation 10
8. https://www.thinkkidneys.nhs.uk/aki/wp-content/uploads/sites/2/2016/02/Discharge-summary-minimum-data-content-for-AKI.pdf
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10. Emergency and acute medical care in over 16s: service delivery and organisation (2018) NICE guideline NG94, recommendation 1.2.11
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Communication and education of the MDT

Recommendations

10. For communication and education of the MDT, we recommend:
    10.1 Multi-disciplinary communication and education should engage with the whole team to encourage their involvement in AKI care and include clear allocation of roles.[1] (1B)

    10.2 Nurse education and competencies should follow the Step Competency Framework.[2] (1B)

References

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2. https://www.cc3n.org.uk/step-competency-framework.html

Liaison with family

Standards

1. Good practice in critical care routinely involves continuous assessment of each patient's progress, the likelihood of a good outcome, and the adjustment of treatment plans in light of these issues.
2. Patients receiving acute RRT, where the cause of AKI is unclear or where RRT will be needed on intensive care discharge, must be discussed with the local renal team as per the NICE guideline and discussion clearly documented by the referring or ICU team as appropriate.
3. Where treatment is limited or withdrawn there must be clear and complete documentation of the rationale for any decisions and documentation of discussions with the patient or their representative and any other clinical staff involved. Where treatment is limited or withdrawn, the benefit of involving a palliative care team should be considered, especially if the patient is managed outside the intensive care unit.[3]
4. This decision should be discussed with the patient (or their next of kin) and the decision Patients receiving acute RRT must be cared for by a multi-professional team that is trained and experienced in delivering and monitoring RRT.[3]
5. The COVID-19 pandemic has resulted in restrictions on hospital visits for patients' relatives. This has led Intensive Care Units to explore alternatives to physical visits including videoconferencing.[1,2,3,4]
6. The use of videoconferencing in Intensive Care raises a number of legal and ethical issues whilst having the potential to improve the experience of patients who would otherwise be completely isolated from family and friends.
7. Patients & carers should be told how and why they developed AKI, their risk factors and future precautions. If not done previously, ensure AKI information leaflet given to patient/ carer.[5]

Recommendations

11. For liaison with next of kin, we recommend:[5]
    11.1 There should be a process of regular phone updates (usually daily) to a named relative who disseminates information to the rest of the family. (1C)

    11.2 Family relationship teams comprised of senior non-critical care medical staff have been utilised successfully. Robust channels of communication between these teams and the clinical care staff ensures an accurate message regarding patient status is conveyed and enables a compassionate means of communication with relatives. (1C)

11.3 Allocate appropriate staff to speak to relatives; this can be a doctor or nurse. (1C)

References

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Psychological support in the ITU

Standards

1. A body of evidence is available about the prevalence of acute stress and frightening psychological experiences in the ICU and adverse psychological outcomes post-ICU.
2. Psychological support can be difficult and time-consuming and senior staff and appropriate materials are needed to deliver it.
3. Acute stress in the ICU may be one of the strongest patient risk factors for poor psychological and cognitive outcomes after intensive care.
4. Families of critical care patients also frequently need support to deal with anxiety and fatigue, to comfort them when they learn that a loved one is dying, or after a death. Conflict may arise between family members who have different views on a patient's care, or between families and staff, particularly around withdrawal of support or non-resuscitation orders.[5]
5. Staff in critical care has much higher than average rates of stress and burnout than other hospital staff which may be related to the responsibility of maintaining lives through sophisticated technological interventions; difficult emotions created by caring for patients who are dying or who die, and a culture in which staff may be perfectionist, driving themselves to provide high standards of care, without utilising appropriate self-care strategies.[2,3]
6. Conflict between patients' families who are upset, angry or grieving, and staff who are not trained to deal with these emotions, can also escalate. Excessive stress can lead to staff requiring long-term sick leave or eventually leaving the service. Psychological support should be routinely available for staff.

Recommendations

12. For psychological support in critical care, we recommend:

12.1 Patients should be assessed during their critical care stay for acute symptoms of anxiety, depression, panic episodes, nightmares, delusions, hallucinations, intrusive memories, flashback episodes and underlying psychological disorders, to determine their risk of future psychological morbidity.[2] (1C)

12.2 Psychological support should be provided to aid rehabilitation and recovery in critical care units, on general wards, and in the community.[1] (1B)

12.3 A validated tool such as the intensive care psychological assessment tool (IPAT) should be used by trained critical care staff to detect acute stress and indicate the risk of future psychological morbidity.[4] (1A)

References

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Section III

Renal Replacement Therapy in critical care

during routine and surge scenarios

Aims

1. Produce an inventory of renal replacement therapy (RRT) options and standards that together can be delivered and sustained across all UK critical care units, including those without on-site renal services.
2. Ensure optimal continuous renal replacement therapy (CRRT) delivery to minimise inefficient use or preventable loss of consumables and impact upon staff workload and capacity.
3. Incorporate flexibility to ensure responsible use of resources during routine circumstances and responsive capability and resilience during surge circumstances.

Broad recommendations

13.1 Each critical care unit in the UK should identify a multidisciplinary local leadership team responsible for the provision of renal replacement therapy and development of resilience options. (1A)

14.1 Each critical care network in the UK should identify a representative multidisciplinary team responsible for the regional provision of renal replacement therapy and development of resilience options. (1B)

15.1 Each critical care unit in the UK should consider implementing this toolkit which suggests measures to maximise currently available CRRT resources. (1B)

16.1 Each critical care unit in the UK should consider implementing this toolkit which suggests how to increase RRT capacity including use of modalities not employed as standard in those units such as intermittent haemodialysis (IHD), hybrid therapies and peritoneal dialysis (PD). (2C)

16.2 Each critical care unit should consider how best to provide care of patients with end stage kidney disease requiring respiratory support during a future pandemic surge. (1B)

Detail of broad recommendations

Local provision of renal support during COVID-19 pandemic surge

Introduction

The first pandemic surge stretched the renal support resources of many intensive care units.[1]

Standards

1. Each critical care unit should identify a local leadership team for renal support surge preparations.
2. This local leadership team should have diverse membership to reflect the multidisciplinary team with experience of managing a patient requiring RRT.

Recommendations

13.1 Each critical care unit in the UK should identify a multidisciplinary local leadership team responsible for the provision of renal replacement therapy and development of resilience options. The local leadership team should:

13.1.1 Include representatives from critical care and renal teams including medical, nursing, pharmacy, dietetic and technical staff. (1B)

13.1.2 Undertake an evaluation of existing RRT capacity on the critical care unit. (1A)

13.1.3 Maintain an inventory of consumables and be prepared to liaise with national bodies in the event of a further surge in demand for RRT. (1B)

13.1.4 Consider the most appropriate local strategies to increase the number of nurses capable of delivering RRT by redeployment of existing dialysis nurses and providing pre-emptive additional training to ICU nurses. (2B)

13.1.5 Consider increasing the number of pharmacists on the ICU to assist with drug dosing for patients receiving RRT. (2B)

13.1.6 Consider contingency planning for delivering RRT to patients in the event of a surge in admissions. Some ICUs were able to develop a service to offer peritoneal dialysis (PD) and intermittent haemodialysis (IHD) during the first pandemic surge. ICUs investigating the feasibility of delivering these RRT options should consider: (2C)

a) the availability of equipment
b) infrastructure (water supply and drainage including quality assurance)
c) staffing (who will prescribe, deliver and monitor these therapies)

More detailed information is available in section 15.1 to 16.2 of this document.

Background

Increased admissions to critical care and high rates of AKI together with disease specific factors led to a supply and demand imbalance during the first COVID-19 surge in the UK. Local innovation and leadership were vital in providing RRT during times of increased demand. Local leadership teams will best understand local resources, staffing, infrastructure and patients. Local leadership teams are best placed to understand the challenges that a future pandemic will pose to the continuity of patient care.

The challenges of providing alternative modalities of RRT in ICU should not be underestimated. In particular, it should be recognised that training of ICU nurses to deliver IHD will require time and local contingency plans should be considered in advance of a further COVID-19 spike.

References

1. Speciality guides for patient management during the coronavirus pandemic: Clinical guide for renal replacement therapy options in critical care during the coronavirus pandemic, NHS England, April 2020

Regional provision of renal support during COVID-19 pandemic surge

Introduction

CRRT is the most commonly available renal support treatment in the UK. The first pandemic surge stretched the renal support resources of many intensive care units. Some critical care units with onsite renal services were able to diversify the renal support they were able to offer patients and therefore reduce the demand on the supply of CRRT machines and consumables. Most critical care units in the UK do not currently have access to alternative renal support for critically ill patients.

Standards

1. Each regional network* should identify a regional leadership team with responsibility for regional coordination of renal surge preparations.

2. This regional response leadership team should have diverse membership to reflect the multidisciplinary team with experience of managing a patient requiring RRT. It should have representation from hospitals with and without access to onsite renal services.

** ie NHS England Operational Delivery Networks*

Recommendations

14.1 Each critical care network in the UK should identify a representative multidisciplinary team responsible for the regional provision of renal replacement therapy and development of resilience options. The regional leadership team should:

14.1.1 Evaluate regional facilities for RRT provision. (1B)

14.1.2 Have discussions with local hospitals within the critical care network to establish an agreed regional hub or hubs capable of delivering alternative RRT modalities in the event of a pandemic surge. (1B)

14.1.3 Consider the impact on all critically ill patients when identifying a regional hospital as a hub for alternative RRT provision.[1] (2B)

14.1.4 Ensure decision to transfer patients for RRT is made by the clinical team at the referring and receiving hospitals. (1A)

14.1.5 Liaise with regional partners responsible for transporting critically ill patients between hospitals within the critical care network to ensure appropriate preparations for such transfers are in place. (1B)

Background

In 2000, the Department of Health report 'Comprehensive Critical Care: A review of adult critical care services' recommended that adult critical care networks be formed to deliver a collaborative model of care for critically ill patients within defined geographical regions.[2] The primary aims of integrated operational delivery networks are to improve equity of access, experience and health outcomes to critically ill patients.

The first surge in admissions related to COVID stretched the renal support resources of many critical care units in the UK. CRRT remains the default renal support of the majority of the critical care units in the UK which in the time of a national pandemic led supply and demand imbalance first in machines capable of delivering CRRT then later in the consumables. Some hospitals with onsite renal services were able to deliver RRT by offering alternative renal support with peritoneal dialysis or intermittent haemodialysis.

Most critical care units in the UK do not have access to onsite renal services making diversification of renal support treatments more difficult. However, within each critical care network there will be hospitals with existing infrastructure and resources to offer alternative RRT options or be able to develop such capability. Establishing regional hub or hubs for renal support and agreeing a mechanism to transfer patients will provide more resilience options in the future.

Critical care units agreeing to become regional hubs for the provisional of renal support may experience a higher number of admissions than they would otherwise experience. This may have an impact on that hospital's capacity to provide access to critical care for other patients. For example, those patients requiring

planned admission to critical care following elective surgery. Such factors should be considered when planning which hospitals will act has regional hubs.[3]

Cross-organisational cooperation and collaboration are recognised as priorities to improve the quality of patient care, especially during a time of a pandemic related surge in admissions to critical care.[4]

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Critical Care CRRT delivery during routine and surge scenarios

Introduction

CRRT is the predominant modality of RRT used for the treatment of AKI in UK ICUs. Prior to the COVID-19 pandemic intermittent haemodialysis was available in <10% of UK ICUs and rarely employed in those where it was technically available. While high quality evidence for the benefit of CRRT over IHD is lacking international guidelines suggest that continuous modalities are preferred in critically ill patients with haemodynamic instability. In the event of a further COVID-19 spike, CRRT is likely to continue to provide the mainstay of RRT provision in AKI in the majority of ICUs without onsite expertise and resources to deliver other modalities of RRT and for the sickest patients during multi-organ failure in all centres. There are a number of specific challenges for delivery of effective and equitable provision of RRT in ICUs during a COVID-19 surge (table 1). Optimisation of conventional CRRT delivery will be a core feature of any surge response.

Table 1: Factors impacting ability of centres to deliver RRT in ICU during a COVID-19 surge

Increased RRT Demand	Reduced RRT Capacity
Substantially increased local CRRT demand due to surge in critically ill COVID-19 cases with severe AKI or ESRD	Increased worldwide, national or regional demand impacting supply of CRRT disposables and machines.
Increased CRRT disposables consumption due to COVID-19 specific effects including coagulopathy accelerating circuit loss	Interruption of supply chains due to global emergency
Increased disposables consumption due to effects of surge-response, inexperienced staff, lack of availability of optimal anticoagulation, limited number of machines requiring use of prolonged intermittent therapy using CRRT devices to allow more patients to be treated.	Lack of experienced staff to expand therapy provision and sickness/burn-out in existing trained staff.

Standards

1. Critical care units must maintain necessary facilities and expertise to provide acute RRT for patients with AKI on a 24/7 basis, including response to a COVID-19 surge.
2. During a COVID-19 surge, pathways for involvement of local renal teams and regional renal-hubs in decision-making for and management of RRT patients of should be established.
3. Patients receiving acute RRT should be cared for by a multi-professional team that is trained and experienced in delivering and monitoring the RRT modality employed.
4. Acute RRT for patients with progressive or severe AKI must be started before onset of life-threatening complications associated with renal dysfunction.
5. Local protocols for the prescription, monitoring and delivery of CRRT may need adaptation to specific challenges of a COVID-19 surge.
6. During a COVID-19 surge RRT providers have responsibility to balance conservation of resources to ensure continuity of service delivery and provision of high quality care to all that require it.

Recommendations

15.1 Each critical care unit in the UK should consider implementing this toolkit which suggests measures to maximise currently available CRRT resources. (1B)

15.1.1 The decision to initiate RRT should be based on the overall condition and prognosis of the patient, not on isolated urea or creatinine values. (1A)

15.1.2 Where potentially life-threatening complications of AKI are developing, such as hyperkalaemia, fluid overload, metabolic acidosis or severe uraemia, careful medical management may be considered to temporise or potentially avoid need for RRT in selected patients. Each case should be assessed by a senior nephrologist and/or intensivist. (1B)

15.1.3 Where complications of AKI are refractory to medical therapy or become life-threatening, RRT should be started urgently unless a decision has been made not to escalate therapy. (1A)

15.1.4 Decisions not to provide RRT on grounds of prognosis should involve consultation with a multi-disciplinary team involving senior intensivists and/or nephrologists and be appropriately documented and appropriately communicated to patients and their next of kin. (1A)

15.1.5 Patients with end-stage renal failure with other organ failure as a consequence of COVID-19 may require critical care admission. In such cases, there should be close liaison with the regional renal service regarding appropriate modality of RRT, vascular access and arrangements for step down. (1A)

15.1.6 Continuous and intermittent RRT should be considered as complementary therapies for AKI in COVID-19, but clinicians should be aware of the implications of choice of therapy on fluid balance and pharmacokinetics. Choice of therapy should be based on patient status, expertise of clinical staff and availability of equipment. In order to deliver most effective therapy to the largest number of patients, modality choice may be re-evaluated if changes in clinical condition occur. (1B)

15.1.7 In circumstances where non-ICU staff are re-deployed to critical care areas, appropriate orientation, training and supervision are required to ensure safe, effective delivery of RRT. Staff

should not be responsible for delivery of an RRT modality for which they have not been fully trained. (1A)

15.1.8 Dose of RRT should be prescribed at the beginning of the RRT session following local protocols. Standard dose should remain based on KDIGO recommendation of 20-25ml/kg/h. Dose should be reviewed regularly and if required tailored to the needs of the patient. There is no evidence for clinical benefit from enhanced doses of RRT in COVID-19 patients. (1A)

15.1.9 The decision to use anticoagulation to maintain circuit patency and the choice of anticoagulant should be based on the potential risks and benefits in an individual patient, the expertise of the clinical team and the options available. (1A)

15.1.10 As hypercoagulable states are common in in COVID-19, RRT circuit performance should be closely monitored to ensure maximal circuit patency as the initial anticoagulation strategy may not be effective in all patients. Centres should establish a stepwise escalation and/or alternative plan for RRT anticoagulation when circuit lifespan is unacceptable. (1B)

15.1.11 In addition to circuit-anticoagulation emphasis should be placed on best choice of site and length of vascular access to optimise circuit patency. Where CRRT is used, measures to reduce filtration fraction should be considered when providing RRT to COVID-19 patients with hypercoagulable states; this might involve preference for CVVHDF or CVVHD modalities of CRRT where these options are compatible with local protocols. (1C)

15.1.12 In addition to patient-specific considerations, within the limits of patient-safety, adjustments to RRT modality, indications, anticoagulation, and dose may be considered as part of a local response to supply/demand imbalances in order to conserve scarce resources and deliver effective therapy to the greatest number of patients. Any such adjustments should follow clearly developed protocols and must be accompanied by appropriate training and monitoring. (2C)

15.1.13 Continuous RRT is associated with increased protein losses[1], resulting in the need for increased protein provision to compensate for this [2]. The use of protein supplementation/high protein formulas should be used to meet protein targets. Energy and protein targets for continuous renal replacement therapy should be set as per local critical care practice[3-5]. The use of citrate containing solutions can also be a source of non-nutritional calories and should be accounted for as per local practice[4,5]. Input from a specialist critical care dietitian and/or renal dietitian should be standard practice alongside frequent monitoring especially if RRT modality is changed. (1B)

15.1.14 Patients treated with acute CRRT should receive standard enteral nutrition as long as there are no significant electrolyte abnormalities or fluid overload refractory to RRT. Input from specialised renal and/or critical care dietitians should be standard practice including review if RRT modality is changed. (1B)

15.1.15 After step-down from critical care, the accepting team and GP should be informed that the patient had received RRT for AKI while in intensive care so that appropriate follow-up arrangements can be made. Patients with ongoing need for RRT but not intensive care should be transferred promptly to a regional renal unit with facilities for in-patient RRT. (1A)

15.1.16 Appropriate ICU outreach should be provided to patients discharged from ICU, especially those transferred between sites, to assist in management of ongoing manifestations for critical illness such as delirium and to make proactive decisions about re-escalation if required. (1B)

Background

CRRT provision during a COVID-19 surge

Recent trials and meta-analysis have demonstrated no difference in mortality or renal recovery when treatment is initiated in the absence of emergent indications.[6,7] The decision to initiate RRT for AKI in COVID-19 should be based on individual patient assessment and not solely on AKI stage or renal function. As there is no high-quality evidence that one modality of acute RRT is better than another selection of RRT modality will depend on local availability and training and expertise of nursing medical and technical staff.

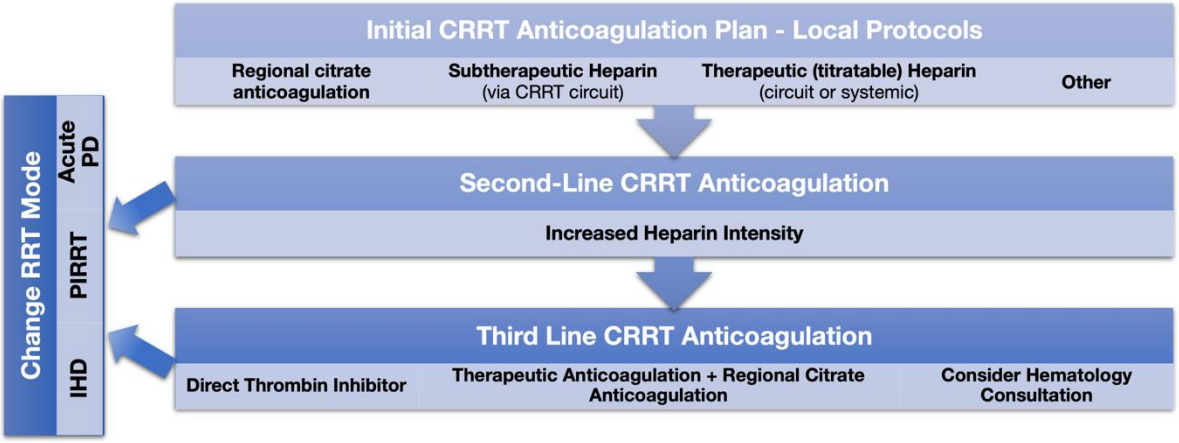
Randomised controlled trials have failed to demonstrate improved survival or recovery of renal function with higher delivered doses in critically ill patients with AKI. In COVID-19 dose of CRRT should remain based on KDIGO recommendation of 20-25ml/kg/h, but may require adjustment in response to changes in clinical, physiology and/or metabolic status. Any role of CRRT as an adjunctive treatment for COVID-19 disease, including removal of inflammatory mediators is unproven, and the earlier use or escalation of dose of CRRT for non-renal indication is not appropriate outside the setting of a clinical trial.

A COVID-19 hypercoagulable state has been described,[8-11] which may contribute to premature CRRT circuit failure.6 Unplanned CRRT interruptions will increase consumption of disposables, staff exposure and time, risk inadequate metabolic and fluid balance control, and interfere with effective drug dosing. Thus, during a COVID-19 surge, monitoring CRRT circuit lifespan is important. Interruption of CRRT due to circuit clotting can have substantial impact on delivered dose and prescription may need to be adjusted to account for this down time.

KDIGO recommends use of anticoagulation for CRRT unless contraindicated, but choice of anticoagulation should depend on local practice and experience and currently limited data is available to inform if any anticoagulation strategy is superior in COVID-19 CRRT. If a patient experiences poor circuit lifespan, a stepwise approach to anticoagulation is recommended to minimize the supply consumption and enable effective treatment (Figure 5). Several anticoagulation strategies can be used in in COVID-19 RRT varying from therapeutic, titratable anticoagulation with unfractionated- or low molecular weight heparins to direct thrombin inhibitors. Several centres are employing enhanced systemic thrombo-prophylaxis or prophylactic therapeutic anticoagulation for hypercoagulable COVD-19 patients in general, and CRRT anticoagulation will need to be integrated with these strategies.[12]

Non-pharmacological strategies are an important adjunct to ensuring circuit patency and are of increased importance in the setting of COVID-19. Attention should be paid to choice of catheter length and position to optimise circuit flow. During CRRT reduction of filtration fraction (by pre-dilution CVVH, CVVHDF or CVVHD) may also enhance circuit performance. Acute PD may also be an effective alternative in patients who are unable to receive effective anticoagulation.

Figure 5 – Potential stepwise strategy for escalation of CRRT anticoagulation (www.ADQI.org)



Organisational steps to conserve CRRT capacity during a COVID-19 surge

Excessive consumption of RRT disposables due both to increased demand and poor circuit performance have the potential to cause critical shortages compromising ability to deliver RRT. Local hospital strategies to optimize efficient use of RRT resources can cut consumption to help avert critical shortages. Early medical management of electrolyte/acid-base disturbances or fluid overload may avoid need for RRT or forestall RRT initiation thereby enabling improved allocation of finite RRT resources. In addition, strategies such as lowering blood flows to reduce citrate consumption, moderating RRT intensity to conserve fluids, or running prolonged intermittent renal replacement therapy (PIRRT) to treat more patients per machine may form part of a local response.[13,14] These responses need to be tailored to the nature of the capacity shortage. Use of PIRRT using CRRT devices can allow a fixed number of machines to treat a larger number of patients on a daily basis, however this comes at the expense of greater consumption of disposables so where circuits are the limiting factor then continued use of CRRT may be preferable. In this setting, transition to intermittent haemodialysis with online generated dialysate, or acute peritoneal dialysis, may be valuable options for clinically appropriate patients in centres with appropriate resources and expertise, conserving CRRT resources for those that need them.

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Expanding critical RRT capability during surge circumstances

Standards

1. All ICUs should liaise with the most appropriate local renal unit to agree on whether an alternative RRT modality delivered on ICU or on the renal unit is a realistic contingency plan in event of COVID - 19 surge.

Recommendations

16.1 Each critical care unit in the UK should consider implementing this toolkit which suggests how to increase RRT capacity including use of modalities not employed as standard in those units such as intermittent haemodialysis (IHD), hybrid therapies and peritoneal dialysis (PD).

Intermittent haemodialysis (IHD)

16.1.1 Use of IHD on ICU will depend on availability of technical requirements, including existence of permanent water supply suitable for IHD and availability of renal unit medical and nursing staff to advise and deliver the treatment. (1A)

16.1.2 Where ICUs are not already equipped to deliver IHD or SLED/SLEDf, adaptation is sometimes possible but requires advanced planning particularly with respect to suitable water supply.[1] (1B)

16.1.3 IHD must be prescribed, supervised and delivered by clinicians with appropriate experience and expertise in the modality. Usually this would be nephrologists and renal/dialysis unit nursing staff, ideally working alongside ICU staff to provide integrated care. (1B)

16.1.4 If IHD cannot be delivered on ICU for technical reasons, consider delivering it on the renal unit so long as senior ICU and renal medical staff consider that it is safe to do so. This may require escort and supervision of patients by ICU staff for the transfer and duration of the RRT. (1B)

16.1.5 Transfer of a patient with COVID-19 from ICU to the renal unit for IHD must comply with renal unit policy for management of patients with confirmed or possible COVID-19 i.e. it should not lead to compromise of a COVID-19 'clean' area. (1C)

16.1.6 Clinicians prescribing IHD should choose acid concentrate with appropriate amount of potassium based on the patient's serum potassium levels, to avoid significant hypo- or hyperkalaemia. (1B)

16.1.7 Vascular access for acute RRT should comply with local guidelines. (1B)

16.1.8 The use of nutrient-dense and low electrolyte/specialist renal feeds may be required in instances where dialysis can only occur on an intermittent basis as a means to help achieve fluid balance goals and management of electrolytes levels. Additional protein supplementation should be considered if needed to meet protein targets. Energy and protein targets for intermittent renal replacement therapy should be set as per local renal and critical care practice.[2,3,4] (1B)

Extended ('hybrid') therapies (SLED, SLEDf)

16.1.9 Extended therapies such as SLED and SLEDf should be considered only in centres with experience and expertise. The recommendations for IHD apply also to SLED/SLEDf. (1B)

16.1.10 Indications and contraindications for extended therapies for patients with COVID-19 and AKI are likely to be similar to those for COVID-19 negative patients with AKI. (1C)

16.1.11 Where there is no specific indication for extended therapy (such as haemodynamic instability), IHD should be the preferred intermittent extracorporeal treatment because it generally requires less renal nursing time. (1C)

16.1.12 Where extended therapies are used, serum potassium and phosphate should be monitored as per local guidelines, bearing in mind that the extended therapy is a risk factor for hypokalaemia and/or hypophosphatemia. (1B)

Acute peritoneal dialysis (PD)

16.1.13 Consider acute PD when RRT capacity is stressed and where suitable outreach expertise can be provided from within the trust or region. (2C)

16.1.14 Where PD nurse specialists are not available 24 hours, ICU and renal (PD) teams must agree a protocol for ensuring that all aspects of PD management comply with local/regional standards. (1C)

16.1.15 Standard operating procedures for PD should be agreed between the renal (PD) and ICU teams and documented. Local SOPs should address potential complications particular to ICU and COVID-19 e.g. whether PD should continue in event of proning. (1D)

16.1.16 PD should be supervised by an outreach team from local PD unit, including overnight on-call service where overnight PD is anticipated. (1C)

16.1.17 Mode and prescription of PD (CAPD vs APD, machine type, PD fluid) should follow local PD protocols with consultation between renal ICU staff. (1C)

16.1.18 Each patient should be reviewed at least daily by the PD team to ensure that dialysis adequacy and ultrafiltration are responsive to their individual requirements. (1C)

16.1.19 PD tube insertion and maintenance should follow local protocols. (1C)

16.1.20 Exit site care should be provided by PD specialist nurses following local protocol. Report Twardowski scale when changing exit site dressing. Treat exit site infection per local guidelines. (1C)

16.1.21 Surveillance for and treatment of PD peritonitis should follow local protocols and be familiar to ICU staff as well as the PD team. (1C)

16.1.22 Caution should be exercised when lifting drain bags, which can weigh up to 7kg. Appropriate PPE should be worn when disposing of PD effluent in patients who have not been de-isolated. (1D)

16.1.23 Glucose absorption from dialysate solutions can provide a significant contribution of non-nutritional calories. To avoid overfeeding adjustments to the nutritional plan should be made to account for this. Energy and protein targets for PD should be set as per local critical care/renal practice with protein supplementation/high protein formulas used in those who are unable to meet protein goals.[6] Input from a specialist critical care dietitian and/or renal dietitian should be standard practice. Regular monitoring is essential due to the frequent changes in patients PD prescription and subsequent glucose content of dialysate solutions. (1C)

16.1.24 After discontinuation of PD (e.g. after renal 'recovery'), PD catheters should be removed using local protocol by a clinician experienced in the procedure. (1D)

Background

There is currently no convincing evidence that, for management of AKI, one form of RRT is better than another. When RRT provision in ICU is under pressure, whether due to staff or equipment shortages, availability of additional modes of RRT may be important.

The range and technical specifications of RRT modalities vary between renal units. Acute IHD is common, SLED and SLEDf less so and acute PD is currently uncommon in the U.K. Choice of RRT modality will depend on local expertise and facilities as well as patient specific factors such as haemodynamic stability.

Where ICUs are not already equipped to deliver IHD or SLED/SLEDf, adaptation is sometimes possible but requires advanced planning particularly with respect to suitable water supply. Delivery of IHD and SLED/SLEDf also requires appropriately trained and experienced nursing staff. It is not realistic to expect ICU staff unfamiliar with IHD to deliver the therapy.

PD is a familiar RRT modality in most renal units for management of ESKD but is rarely used in adults to provide acute RRT. PD tubes can be inserted under local anaesthetic by appropriately trained surgical or nephrology staff, but ongoing care and supervision of RRT requires specialist supervision.

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Care of patients with end stage kidney disease requiring respiratory support during a future pandemic surge

Standards

1. Patients with ESKD and COVID-19 should receive escalation of care, including respiratory support, where considered clinically appropriate based on assessment of the individual patient by ICU medical staff, in consultation with the patient's nephrologists.

Recommendations

16.2 Each critical care unit should consider how best to provide care of patients with end stage kidney disease requiring respiratory support during a future pandemic surge.

16.2.1 A personalised treatment escalation plan and ceiling of care should be agreed by the renal team and, where possible, the patient. Pre-emptive discussions of wishes and expectations around end of life care are recommended as part of standard outpatient management. (1B)

16.2.2 The patient's usual mode of RRT should be maintained unless there is a specific reason to prefer an alternative therapy. (1B)

16.2.3 For patients receiving IHD for ESKD, where possible their existing access (AV fistula, graft or tunnelled line) should be used by an appropriately trained clinician (usually a renal/dialysis nurse). (1B)

16.2.4 Consider transferring a patient with ESKD requiring respiratory support to a regional renal hub if this is the preferred strategy of the regional renal/ICU network or if it increases the probability of maintaining the patient's usual mode of RRT. (1C)

16.2.5 Local ICU, renal and respiratory teams should consider options for providing enhanced respiratory support (such as HFNO and CPAP) on renal wards. (1C)

Background

Patients with ESKD often have significant comorbidities and high risk of cardiovascular disease. The presence of ESKD increases a patient's risk of cardiovascular disease and death many times but patients with ESKD should not be denied treatment (including RRT) in ICU on the basis of a default assumption of poor prognosis. Decisions on escalation or limitation of treatment should be assessed on an individual basis and should involve, where possible, nephrologists familiar with individual patient.

Appendix I

Clinical Guidance for adult critical care units – Antimicrobial drug dosing in different modalities of renal replacement therapy

Introduction

The recent surge in demand for renal replacement therapies (RRT) within intensive care, has resulted in the employment of other forms of RRT including intermittent haemodialysis (IHD), peritoneal dialysis (PD) and sustained low efficiency dialysis (SLED). These additional RRT modalities may be less familiar to the critical care workforce and have an impact on the dosing of drugs and dosing frequency. These rapidly produced supportive suggestions have been circulated as an initial decision support tool for critical care pharmacists and teams in the context of the rapid need to provide RRT under constrained resources. The recommendations given below are a pragmatic guide based on the limited available literature, expert opinion and the balance of effective treatment versus risk of toxicity.

Notes

1. Due to the dynamic clinical picture of patients, the guidance below should be used in the context of the patient being treated. Dosing should always be assessed on an individual patient basis, adjusted in light of susceptibility of the pathogen(s), clinical response as well as the frequency and intensity of RRT and any residual urine output. These recommendations will be kept under close review as clinical experience is gained with use in practice and/or availability of evidence.
2. 'Critical Illness', due for first publication in early 2021 will contain comprehensive recommendations for many antimicrobials used in critical care and include use in renal replacement therapy. Some of the monographs have been made available early through Medicines Complete. Links to those currently available have been placed in this document. When published, it is intended that 'Critical Illness' will supersede this document.
3. In principle, in the acutely critically ill patient, most antimicrobials should be given at full dose for the first 24-48h. Dose reductions should be considered when there is objective evidence the patient is responding to therapy such as improvement in organ function or markers of infection, or if there are concerns relating to potential toxicity. There should be a focus on adequate source control and ensuring microbiology results are used to target therapy based on organism sensitivity, ensuring that dosing strategies are tailored to ensure adequate tissue penetration for the site of infection. Resistant organisms may require a more aggressive dosing strategy.
4. Therapeutic Drug Monitoring (TDM) should be used where possible to ensure PK targets are achieved and limit the risk of toxicity. This is particularly important when extended courses of antimicrobials are required in patients on RRT. If TDM is not possible, symptoms suggestive of toxicity should be closely monitored, and dose reductions considered.
5. It should be noted that IHD, PD and SLED are RRT modalities used in more stable patients, who are less likely to be affected by the PkPd changes that occur in the acutely critically ill patient. They are also less likely to require the high intensity of treatment that might be required in the more acute or initial unstable phase. Therefore if the patient is well enough to tolerate IHD, PD or SLED, a more conservative dosing strategy is likely to be appropriate.
6. For antimicrobials that are well dialysed (e.g. meropenem, piperacillin-tazobactam, co-amoxiclav) the dialysis dose or effluent flow rate should be considered and for CVVHF/CVVHDF/CVVHD, effluent flow rates (dialysis rate +/- ultrafiltration rate) greater than 25mL/kg/hr can be considered to be very approximately equivalent to GFR of 30mL/min.
7. If no administration timing is specified in the table (e.g. pre or post RRT), give dose as per regular dosing frequency of the drug.

8. Where recommended to give a drug pre- or post-RRT session – do this if possible. This may not always be the case, please refer to the doctor or critical care pharmacist if you have any questions. Do not delay starting antibiotics if indicated.
9. Trough levels should be taken pre-dose (as close to the dosing time as practically possible or 4 – 6 hours before the next dose is due where a nomogram is used).
10. Consideration must be given to the rate AND duration at which RRT is running. Many units are now running citrate anticoagulation with improved RRT circuit life, potentially leading to more RRT being delivered and greater drug removal. However, clinicians should consider dose reductions for low continuous RRT rates (e.g. ≤24mL/kg/h).
11. SLED dosing recommendations are based on a daily SLED regimen, e.g. 8-12 hrs of SLED in a 24 hr period every day. In practice, the interval between SLED sessions may vary depending on patient trajectory and RRT availability. We suggest SLED dosing recommendations are based on the interval between SLED sessions. If the interval between SLED sessions is less than 24 hrs, then follow the SLED column recommendation. If the interval between SLED sessions is more than 24hrs, consider reducing the drug dose or frequency on non-SLED days (to account for the fact that there will be reduced clearance while the patient is not receiving RRT).
12. Actual body weight should be used to calculate doses unless specified. Consider using adjusted body weight if BMI>30 Kg/m^2.
13. Where limited evidence and experience have been identified, dosing recommendations have been extrapolated from the RDD, please note that these recommendations have not been extensively studied in the critical care setting and may need to be applied with caution according to the principles outlined above.
14. The list of medicines below is not exhaustive and provides dose guidance on drugs frequently used in critical care. For drugs not listed on the table, considerations may need to be made along similar principles. Please refer to the product of summary of characteristics (www.medicines.org.uk), Critical Illness, the Renal Drug Database or the critical care pharmacy team for guidance.

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.

IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft OR

IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]

**In peritoneal dialysis (PD) patient, and dosing weight consideration should exclude the PD fluid, which may be in the patient. Please check with patient or PD specialist nursing team

Abbreviations

IHD – intermittent haemodialysis (high flux filters are usually used)

HDF – intermittent haemodiafiltration – either pre or post dilution

SLED – sustained low efficiency dialysis

SLED-f – sustained low efficiency dialysis with filtration

CVVH – continuous venovenous haemofiltration

CVVHD – continuous venovenous haemodialysis

CVVHDF - continuous venovenous haemodiafiltration

PD – peritoneal dialysis

RDD – Renal Drug Database

IBW = ideal body weight

ABW = actual body weight

AdjBW = adjusted body weight

EBW = estimated body weight

Antivirals & Antibiotics

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Aciclovir All calculated doses should be based on ABW* Narrow therapeutic window so consider TDM for patients requiring extended courses	IV: 10mg/kg TDS – Max. 800mg TDS	IV: 5-10mg/kg TDS for 24-48 hours then BD. Consider OD dosing if low RRT rate (e.g. ≤24mL/kg/h) Dialysability: dialysed Use higher end of dosing range for confirmed HSV encephalitis or pneumonitis	IV: 5mg/kg OD **(on dialysis days give dose post dialysis session)** Dialysability: dialysed	IV: 2.5-5mg/kg OD Dialysability: not dialysed	For HSV encephalitis or HSV pneumonitis: IV: 10mg/kg (Max 800mg) BD on SLED days. Give OD on non-SLED days.
Amoxicillin Contains Penicillin	IV/PO/Enteral: 1g TDS 2g IV TDS for severe infections 2g every 4h used in certain circumstances (e.g. Listeria meningitis or endocarditis)	Dose as in normal renal function For high dose regimens, consider a maximum dose of 6g/day Dialysability: dialysed 2g every 4h used in certain circumstances (e.g. Listeria meningitis or endocarditis)	Dose as in normal renal function (max 6g per day in endocarditis) Dialysability: dialysed	Dose as in normal renal function (max 6g per day in endocarditis) Dialysability: not dialysed	IV: 1-2g TDS (max 6g per day in endocarditis)

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]

IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft OR
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Amikacin **Daily Levels Required** All calculated doses should be based on ABW* Aminoglycoside dosing will be highly individualised and should be overseen by an experienced critical care pharmacist. Previous administration of an aminoglycoside in patients with AKI may represent an indication for further/ongoing RRT irrespective of other indications For severe infections/refractory shock/MDR organism use higher end of dosage range.	IV: 15-20mg/kg Loading dose (max. single dose 1500mg) Subsequent doses should be tailored following discussion with ICU pharmacist. For severe infections / refractory shock / MDR organism consider 25mg/kg loading dose after discussion with pharmacist	IV: 15-20mg/kg loading dose then adjust dose and frequency according to levels **Daily** trough levels to be taken – aim for <5mg/L Effluent flow rates of 30mL/kg/hr or higher may require 25mg/kg dosing every 48 hrs. Dialysability: dialysed	IV: 5-10mg/kg loading dose then adjust dose and frequency according to daily levels **(on dialysis days give dose post dialysis session)** **Daily** trough level to be taken - aim for <5mg/L (on dialysis days take level **post** dialysis session) Dialysability: dialysed	IV: 5mg/kg loading dose then adjust dose according to daily levels, usually 2mg/kg every 24-48 hours **Daily** trough levels to be taken – aim for <5mg/L Dialysability: dialysed	Should ideally given at start of SLED session, but dose should not be delayed. IV: Loading or initial dose: 15 – 20mg/kg (using the larger loading dose if timed at the beginning of SLED session to optimise peak) Maintenance dose: 7.5 – 15mg/kg (Max. 7.5mg/kg if given outside of SLED session) Levels: - Pre- and post-SLED session(s) or at 24hr (which ever is soonest) - Consider re-dose once level <5mg/L - When re-dosing consider diminished effect through acquired resistance (esp. for Pseudomonas) where doing interval may be <24 hours Dialysability: dialysed

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft OR
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Ceftazidime	IV: 1-2g TDS (increased to maximum of 3g 8-hourly in pseudomonal lung infections)	Give 48 hours at normal dose then reduce frequency to BD Dialysability: dialysed	IV: 1g STAT, then 1-2g every 48 hours **(on dialysis days give dose post dialysis session)** Dialysability: dialysed	IV: 1g OD Dialysibility: dialysed	IV: 2g every 12 hours Where possible, doses should be timed to avoid administration during the SLED session, however do not delay initial dose if urgent treatment is required. Consider reducing frequency on non-SLED days
Ceftazidime/ Avibactam (Zavicefta) **Caution-NOT in severe penicillin allergy**	IV: 2g/0.5g TDS	IV: 48 hours at normal dose then 1g/0.25g to 2g/0.5g TDS Dialysability: dialysed	IV: 0.75g/0.1875g 24-48 hourly (on dialysis days give dose post dialysis session) Dialysability: dialysed	IV: 0.75g/0.1875g 24-48 hourly Dialysability: unknown	IV: 2g/0.5g every 12 hours Where possible, doses should be timed to avoid administration during the SLED session, however do not delay initial dose if urgent treatment is required. Consider reducing frequency on non-SLED days
Ceftriaxone **Caution-NOT in severe penicillin allergy**	IV: 2g OD, increased to 2g every 12 hours in severe or CNS infections	Dose as in normal renal function. IV: 2 g every 12–24 hours Dialysability: unknown	Dose as in normal renal function. Dialysability: unknown Maximum 2g daily.	Dose as in normal renal function. Dialysability: not dialysed. Maximum 2g daily.	Dose as in normal renal function, usual maximum IV: 2 g OD - BD Where possible, doses should be timed to avoid administration during the SLED session, however do not delay initial dose if urgent treatment is required.

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft OR
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Ciprofloxacin Consider interactions with enteral nutrition in context of enteral dosing	IV: 400mg BD-TDS PO: 500mg BD Enteral: 750mg BD Consider TDS dosing in refractory shock or MDR organism or >90kg	IV: Consider TDS dosing in high dose CRRT (30mL/kg/hr), refractory shock, MDR organism or >90kg PO: 500mg BD Enteral: 750mg BD Dialysability: dialysed	IV: 400mg BD Enteral: 750mg BD (Treatment duration up to 2 weeks. If treatment duration is longer then reduce dose to 250mg BD) Dialysability: small amount dialysed PO: 500mg BD (Treatment duration up to 2 weeks. If treatment duration is longer then reduce dose to 250mg BD)	IV: 200mg-400mg every 12 hours Enteral: 750mg BD (Treatment duration up to 2 weeks. If treatment duration is longer then reduce dose to 500mg BD) Dialysability: small amount dialysed PO: 500mg BD (Treatment duration up to 2 weeks. If treatment duration is longer then reduce dose to 250mg BD)	Dose as in normal renal function Consider BD dosing if no RRT to be delivered on a given day Consider the use of moxifloxacin IV/Enteral 400mg daily (administered at the end of SLED) as an alternative fluoroquinolone, if sensitivities allow, in view of the reduced likelihood for its pharmacokinetics to be affected by SLED
Clarithromycin Multiple Drug Interactions – see BNF	IV/PO/Enteral: 500mg BD	Dose as in normal renal function. Dialysability: unknown	Dose as in normal renal function. Dialysability: unknown	Dose as in normal renal function. Dialysability: not dialysed	Dose as in normal renal function
Clindamycin	IV: 150mg-600mg QDS; increase to 1.2g QDS in severe infections. PO/Enteral: 150mg-300mg QDS increase to 450mg QDS in severe infections	Dose as in normal renal function Dialysability: unknown	Dose as in normal renal function. Dialysability: unknown	Dose as in normal renal function. Dialysability: not dialysed	Dose as in normal renal function

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Colistimethate sodium (Colistin) Trough levels should be taken to monitor for accumulation. Aim 2.0 – 4.0 mg/L. First level should be taken in the **morning before the 3rd or 4th dose** (including the loading dose) and further levels to be taken will be dependent on the clinical status of the patient.	IV: 9 million units loading dose then 4.5 million units BD	IV: 9 million units loading dose then 4.5 million units BD Dialysability: dialysed	IV: Loading dose 9 million units Maintenance dose: on Non-HD day – 1.125 million units BD on HD days – 3 million units OD (post dialysis session) Dialysability: dialysed	IV: 9 million unit loading dose then 1.125 million units BD Dialysability: dialysed	IV: 9 million unit loading dose then 3 million units TDS
Co-Amoxiclav **Contains Penicillin**	IV: 1.2g TDS PO/Enteral: 625mg TDS	IV: Give 48 hours at 1.2g TDS and then consider reduction to 1.2g BD. Continue TDS if CRRT rate >24mL/kg/hr OR IN SEVERE SEPTIC SHOCK. PO/Enteral: Dose as in normal renal function Dialysability: dialysed	IV: 1.2g STAT followed by 1.2g BD – to be started 12 hours after stat dose **(on dialysis days give dose post dialysis session)** PO/Enteral: Dose as in normal renal function Dialysability: dialysed	IV: 1.2g STAT followed by 1.2g BD – to be started 12 hours after stat dose PO/Enteral: Dose as in normal renal function Dialysability: dialysed	IV: 1.2g TDS. Reduce frequency to BD on non SLED days

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Co-trimoxazole All calculated doses should be based on ABW* Consider monitoring levels Dose conversion IV to enteral = 1:1 ****Avoid in G-6-PD deficiency and porphyria****	**For PCP treatment:** IV/PO/Enteral: 120mg/kg/day in 2-4 divided doses for 3 days, then reduce to 90mg/kg/day for 18 days **For stenotrophamonas** IV/PO/Enteral 90mg/kg/day in divided doses	**For PCP treatment:** IV/PO/Enteral: 120mg/kg/day in 2-4 divided doses for 3 days then reduce to 60mg/kg/day if RRT dosage rate ≤ 24mL/kg/hr **For stenotrophomonas:** IV/PO/Enteral 60mg/kg/day in divided doses if filter dosage rate <20mL/kg/hr Dialysability: dialysed	**For PCP treatment:** IV/PO/Enteral: 120mg/kg/day in divided doses for 3 days then reduce to 60mg/kg/day. **For stenotrophamonas:** IV/PO/Enteral 60mg/kg/day in divided doses Dialysability: dialysed	**For PCP treatment:** IV/PO/Enteral: 60mg/kg/day in divided doses **For stenotrophamonas:** IV/PO/Enteral 60mg/kg/day in divided doses Dialysability: not dialysed	**For PCP treatment:** IV/PO/Enteral: 120mg/kg/day in divided doses for 3 days then reduce dose. Consider a reduction to 60mg/kg/day in divided doses if adequate initial response. If maintenance dose of 90mg/kg/day used, monitor pre and post dose levels. **For stenotrophamonas:** IV/PO/Enteral 60mg/kg/day in divided doses Dialysability: dialysed More drug is removed via SLED than other forms of RRT
Doxycycline	PO/Enteral: 200mg OD	Dose as in normal renal function Dialysability: unknown	Dose as in normal renal function. Dialysability: unknown	Dose as in normal renal function. Dialysability: not dialysed	Dose as per normal renal function
Flucloxacillin **Contains Penicillin**	IV: 1-2g QDS Endocarditis: Adult (body-weight 85 kg and above) 12 g daily in 6 divided doses.	Dose as in normal renal function Dialysability: not dialysed	Dose as in normal renal function up to a total daily dose of 4g Dialysability: not dialysed	Dose as in normal renal function up to a total daily dose of 4g Dialysability: not dialysed	Dose as in normal renal function up to a total daily dose of 4g

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Gentamicin All calculated doses should be based on ABW* See Critical Illness Monograph: https://www.medicinescomplete.com/#/critical-illness/gentamicin **Daily Levels Required** Aminoglycoside dosing will be highly individualised and should be overseen by an experienced critical care pharmacist. Previous administration of an aminoglycoside in critical care patients with AKI may represent an indication for RRT on the following day irrespective of other indications.	Once daily dosing: IV 5-7mg/kg STAT unless otherwise stated by microbiology. Max single dose 500mg Consider 7mg/kg initial dose in refractory septic shock (max 500mg).	Once daily dosing: IV 5mg/kg STAT then adjust dose according to daily levels **Daily** trough levels to be taken, aim for < 1mg/L Dialysability: dialysed	IV: 2mg/kg STAT then adjust dose according to daily levels **(on dialysis days give dose post dialysis session)** **Daily** trough levels to be taken, aim for < 1mg/L (on dialysis days take level **post** dialysis session) Dialysability: dialysed	IV: 2mg/kg STAT then adjust dose according to daily levels **Daily** trough levels to be taken, aim for < 1mg/L Dialysability: dialysed	Should ideally given at start of SLED session, but dose should not be delayed. IV: Loading or initial dose: 5 – 7mg/kg (using the larger loading dose if timed at the beginning of SLED session to optimise peak) Maintenance dose: 3 – 5mg/kg (Max. 3mg/kg if given outside of SLED session) Levels: - Pre- and post-SLED session(s) or at 24hr (which ever is soonest) - Consider re-dose once level <1mg/L - When re-dosing consider diminished effect through acquired resistance (esp. for Pseudomonas) where doing interval may be <24 hours Dialysability: dialysed

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Levofloxacin Consider interactions with enteral nutrition in context of enteral dosing	IV/PO: 500mg BD	IV/PO: Load with 500mg on day 1 then 250mg – 500mg OD (n.b. resistant pseudomonal lung infections may require 500mg OD until response) Dialysability: not dialysed	IV/PO: Load with 500mg on day 1 then 125mg OD Dialysability: not dialysed	IV/PO: Load with 500mg on day 1 then 125mg OD Dialysability: not dialysed	IV/PO: 250-500mg OD. 20% removed by SLED (high flux filter) Consider reducing to 250mg OD on non SLED days.
Linezolid **Additional comments:** Adverse effects likely to indicate toxicity include leucopenia, thrombocytopenia, bone marrow suppression, serotonin syndrome symptom (alteration of mental status, neuromuscular abnormalities, autonomic instability), LFT derangement. Linezolid is weak non-selective monoamine oxidase inhibitor	IV/PO/Enteral: 600mg BD	Dose as in normal renal function Dialysability: dialysed	Dose as in normal renal function. Dialysability: dialysed.	Dose as in normal renal function. Dialysability: likely to be dialysed	Dose as in normal renal function Where possible, doses should be timed to avoid administration during the SLED session, however do not delay initial dose if urgent treatment is required. If the first dose is administered during SLED an additional dose should be administered at the end of the session and subsequent doses timed to continue every 12 hours from then. Note: 30% removed during 8 hour SLED via low flux filter

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Meropenem Caution-NOT in severe penicillin allergy **Consider extended duration infusions in treating non-CNS MDR organisms**	IV: 1g TDS increase to 2g TDS in CNS infections	If RRT ≤24mL/kg/hour exchange rate: give full dose for 48 hours then consider reducing to BD dosing All other patients: dose as in normal renal function Dialysability: dialysed	IV: 1g OD **(on dialysis days give dose post dialysis session)** Dialysability: dialysed	IV: 1g OD Dialysability: dialysed	IV: 1g every 8 hours Administer each dose as an extended infusion over 4 hours Consider 2g 8 hourly injection for CNS infections. 50-78% removed during 6 hours SLED via high flux filter Consider reduction to OD on non SLED days, if no residual renal function
Metronidazole	IV: 500mg TDS PO/Enteral: 400mg TDS	Dose as in normal renal function Dialysability: dialysed	Dose as in normal renal function. Dialysability: dialysed	Dose as in normal renal function. Dialysability: not dialysed	Dose as in normal renal function.
Piperacillin-Tazobactam (Tazocin) **Consider extended duration infusions in treating MDR organisms** Contains Penicillin	IV: 4.5g TDS (can be increased to 4.5g QDS in severe infections / neutropenic sepsis/ECMO)	Dose as in normal renal function Dialysability: dialysed	IV: 4.5g BD **(on dialysis days, give one additional 2.25g dose post dialysis session if the next dose is not due within 2 hours. Then continue with the next dose at the scheduled time)** Dialysability: dialysed	IV: 4.5g BD Dialysability: not dialysed	Dose as in normal renal function Consider 6-hourly dosing if indication or organism susceptibility warrants Consider frequency reduction on non-SLED days

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Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Teicoplanin Consider adjusting doses based on TDM from day five onwards	IV: Loading dose: 6-12mg/kg BD for 3 doses and then reduce to OD (max 1g) Consider higher doses in streptococcal or enterococcal endocarditis (in combination with another antibacterial), bone and joint infections	Give normal loading dose, then reduce dose on day five to 6-12mg/kg every 48-72 hours or to 30-50% of dose OD. Dose reduction dependent upon anticipated clearance. Dialysability: dialysed	Give normal loading dose, then reduce dose on day five to 6-12mg/kg every 48-72 hours. Dose reduction dependent upon anticipated clearance. Dialysability: dialysed	Give normal loading dose, then reduce dose on day five to 6-12mg/kg every 48-72 hours depending. Dose reduction dependent upon anticipated clearance. Dialysability: not dialysed	
Tigecycline	IV: 100mg loading dose followed by 50mg BD	Dose as in normal renal function Dialysability: unknown	Dose as in normal renal function. Dialysability: dialysed	Dose as in normal renal function. Dialysability: Not dialysed	Dose as in normal renal function

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Vancomycin	As per local policy	As per local policy Dialysability: dialysed	These patients should **not** be started on a continuous infusion. Intermittent dosing as per local policy. Take a level 18 hours post the loading dose and discuss subsequent dosing with the Critical Care consultant, pharmacist and renal teams. Re-dose when level <20mg/L. Affected by dialysate and blood flow rate **(on dialysis days give dose post dialysis session)** Dialysability: dialysed	These patients should **not** be started on a continuous infusion. Loading dose IV: 15mg/kg STAT Take a level 18 hours post the loading dose and discuss subsequent dosing with the Critical Care consultant, pharmacist and renal teams. Re-dose when level <20mg/L. Dialysability: not significantly	These patients should **not** be started on a continuous infusion. Requires consideration on an individual patient basis. Consult critical care pharmacist for advice. IV: 1g Loading dose. If this is administered during SLED session, send level at the end of the session and administer a repeat 1g dose if level reported <20mg/L. If >20mg/L, send level in 12 hours. If administered outside of SLED session, send level at 12 hours post dose. Administer a repeat 1g dose if level reported <20mg/L. If above >20mg/L, send level after a further 12 hours or at the end of the following SLED session (which ever is soonest). Consider higher trough targets in severe infections or as per local policy, 15-20mg/L. 36% of the dose is removed during 8 hours high flux SLED

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Antifungals

*****SEND BETA-D- GLUCAN (BDG) & GALACTOMANNAN ANTIGEN LEVELS PRIOR TO STARTING TREATMENT*****

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Ambisome (Liposomal Amphotericin) All calculated doses should be based on ABW*	IV: 3mg/kg OD (max 5mg/kg). Test dose of 1mg over 10 minutes should be given before starting a new course of treatment.	Dose as in normal renal function	Dose as in normal renal function	Dose as in normal renal function	Dose as in normal renal function
Anidulafungin	IV: 200mg loading dose followed by 100mg OD from day 2 onwards.	Dose as in normal renal function	Dose as in normal renal function	Dose as in normal renal function	Dose as in normal renal function
Caspofungin	IV: 70mg loading dose followed by 50mg daily, increased to 70mg daily if body weight over 80kg	Dose as in normal renal function	Dose as in normal renal function	Dose as in normal renal function	Dose as in normal renal function

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

Drugs	Normal Dosing	Recommended dosing in haemofiltration (CVVH/CVVHDF/CVVHD)	Recommended dosing in haemodialysis (IHD) (HDF/high flux)	Recommended dosing in peritoneal dialysis (PD)	Recommended dosing in slow low efficiency dialysis (SLED)
Fluconazole **Please note multiple drug interactions - see BNF)	IV: Consider 800mg loading dose on day 1. Maintenance dose 400mg daily	IV: Loading dose 800mg on day 1. Maintenance dose, consider 10mg/kg max. 800mg daily for patients on CRRT.	IV: Loading dose 800mg on day 1, followed by 200-400mg OD from day 2 onwards (on dialysis days give dose post dialysis session)	IV: 200mg-400mg OD (no loading dose required)	Treatment – IV: 400mg twice daily Prophylaxis – IV: 100mg twice daily Where possible, doses should be timed to avoid administration during the SLED session, however do not delay initial dose if urgent treatment is required. If the first dose is administered during SLED an additional dose should be administered at the end of the session and subsequent doses timed to continue every 12 hours from then. Reduce frequency to once daily on non-SLED days

*For obese patients (actual body weight>20% over IBW), the adjusted body weight should be used to calculate dose.
Adjusted Body Weight (AdjBW) = IBW + 0.4 [actual body weight (kg) – ideal body weight (kg)]
IBW (kg) with height in feet and inches = [males 50kg, female 45.5kg] + 2.3kg for every inch over 5 ft **OR**
IBW (kg) with height in centimetres = [males 50kg, female 45.5kg] + [(2.3 x height in cm above 152.4)/2.54]

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