Renal replacement therapy in the paediatric intensive care unit

Rajalakshmi Iyer
Nalaayeni Kanesan
Oluwaseun Ajayi
Arun Ghose

Abstract

Acute kidney injury (AKI) and chronic kidney disease (CKD) are significant concerns in paediatric intensive care units (PICUs), with AKI affecting up to 50% of critically ill children. Renal replacement therapy (RRT) is essential for managing these conditions, with available modalities including intermittent haemodialysis (IHD), continuous renal replacement therapy (CRRT), and peritoneal dialysis (PD). This article defines AKI and CKD based on the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines and outlines the key indications for RRT, such as severe electrolyte abnormalities, fluid overload exceeding 10%, metabolic acidosis and toxin clearance. The fundamental principles of solute clearance in RRT—including diffusion, ultrafiltration, convection, and adsorption—are explained. Additionally, the article reviews essential considerations such as vascular access, anticoagulation strategies and the unique challenges of RRT in neonates and children requiring extracorporeal life support (ECLS). CRRT allows precise and gradual solute and fluid removal, making it ideal for haemodynamically unstable patients. However, it requires an extracorporeal circuit, large-bore vascular access and anticoagulation which can pose challenges, particularly in neonates. In contrast, PD can be initiated quickly via a percutaneous catheter, avoiding the risks associated with central venous access (thrombosis and bleeding). Conversely PD solute and fluid clearance rates are less effective than CRRT, and it is unsuitable for patients with recent abdominal surgery or congenital anomalies. The choice of RRT modality depends on the child's clinical condition, available resources, and institutional expertise. This review highlights the need for individualised RRT strategies to improve outcomes and survival in critically ill children.

Rajalakshmi Iyer ***MBBS MD MRCPCH DNB DM (Paediatric Critical Care)*** *PICM Grid Trainee, Birmingham Children's Hospital, Birmingham, UK. Conflicts of interest: none declared.*

Nalaayeni Kanesan ***MB BCh BAO (Ire) MRCPCH*** *PICM Grid Trainee, Birmingham Children's Hospital, Birmingham, UK. Conflicts of interest: none declared.*

Oluwaseun Ajayi ***MBBS MRCPCH*** *Paediatrics Trainee, Birmingham Children's Hospital, Birmingham, UK. Conflicts of interest: none declared.*

Arun Ghose ***MBChB Dip in Critical Care FRCPCH*** *Consultant Paediatric Intensivist, Birmingham Children's Hospital, Birmingham, UK. Conflicts of interest: none declared.*

Keywords Acute kidney injury (AKI); chronic kidney disease (CKD); continuous renal replacement therapy (CRRT); peritoneal dialysis (PD); PICU

Introduction

Various renal replacement therapies (RRTs) are available for managing severe acute kidney injury (AKI); these include intermittent haemodialysis (IHD), continuous renal replacement therapy (CRRT) and prolonged intermittent renal replacement therapy (PIRRT). Decisions about technique are dictated by the dialysis indication, clinician preference, outcome data and, most importantly, hemodynamic status. CRRT emerges as a preferred modality particularly in paediatric intensive care units (PICUs). CRRT comprises techniques that manage solute removal and substitution while maintaining a desired fluid balance continuously over 24 hours. This involves filtering blood through a semipermeable membrane using various solute transport mechanisms. The goal of RRT is to support or replace the impaired renal function, thus preventing further complications and improving survival rates in these young patients.

This article explores the prevalence and incidence of CKD and AKI in children, particularly in paediatric intensive care units (PICUs), and discusses definitions based on the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines.

Definitions based on KDIGO guidelines

The KDIGO guidelines provide standardized definitions and classifications for both AKI and CKD, which are crucial for diagnosis, management, and research.[1]

Acute kidney injury (AKI)

KDIGO defines AKI as a sudden decrease in kidney function, characterized by an increase in serum creatinine levels by 0.3 mg/dL within 48 hours or a 50% increase in baseline serum creatinine within 7 days. Additionally, a reduction in urine output to less than 0.5 mL/kg/hours for 6 hours is also indicative of AKI. KDIGO further classifies AKI into three stages, with stage 1 being the mildest form and stage 3 the most severe, often requiring RRT.

Chronic kidney disease (CKD)

According to the KDIGO guidelines, CKD is defined as abnormalities in kidney structure or function that persist for more than three months, with implications for health. CKD is classified into five stages based on the estimated glomerular filtration rate (eGFR). Stages 1−3 represent mild to moderate kidney damage, while stages 4 and 5 indicate severe kidney impairment and are associated with a higher risk of progression to end stage renal disease (ESRD).

These KDIGO definitions and classifications are instrumental in guiding clinical practice, enabling healthcare providers to make timely and accurate diagnoses and implementing appropriate interventions to mitigate the adverse effects of CKD and AKI in children.

Background

Acute kidney injury in paediatric intensive care units

Acute kidney injury (AKI) is a growing global health burden. Worldwide, 1 in 5 adults and 1 in 3 children experience AKI

 © 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

during a hospital admission with high comorbidity rate, high mortality and prolonged hospital stay. Advances in our understanding of the epidemiology of paediatric AKI have been made in recent years, in part due to a consensus AKI definition from KDIGO. AKI is a common and serious complication in critically ill children, particularly in PICU. The incidence of AKI in PICUs is alarmingly high, with recent studies suggesting that up to 50% of critically ill children develop some degree of AKI during their hospital stay. AKI in this setting is often multifactorial, with causes ranging from sepsis and dehydration to nephrotoxic medications and underlying chronic illnesses. Moreover, children who survive an episode of AKI are at increased risk of developing CKD later in life, underscoring the importance of early detection and intervention.

Prevalence and incidence of chronic kidney disease

Chronic kidney disease (CKD) in children is a significant global health issue with 844 patients aged less than 16 years receiving RRT at UK paediatric kidney centres on 31/12/2022, similar to the number in 2021.[2] The causes of CKD in children differ from those in adults, with congenital anomalies of the kidney and urinary tract (CAKUT) and hereditary nephropathies being the most common aetiologies.[3]

In the UK a retrospective observational study demonstrated 2.9% of children admitted to PICU received RRT. Volume of RRT did not alter outcome and overall survival to PICU discharge was 73.8%. Indications for renal replacement therapy are outlined in Table 1.

Particles can pass through a semi-permeable membrane through different ways; diffusion, convection, ultrafiltration and some can adhere to the membrane through adsorption.

Modes of renal replacement therapy available in children are as outlined in Table 2.

In this article, we will explore the two most frequently used modalities in the UK, with some discussion on their uses in specific settings.

Indications for renal replacement therapy

Renal indications (AKI/CKD)	
Uraemia and related complications	Uraemic encephalopathy Uraemic pericarditis
Electrolyte abnormalities (Refractory to medical therapy	Hyperkalaemia Hyperchloraemia Hyperphosphataemia Hypernatraemia
Acidosis (refractory to medical therapy)	Metabolic acidosis secondary to kidney injury Primary metabolic disorders
Non-renal indications	
Fluid overload	
Sepsis (cytokine removal)	
Poisoning (toxin removal)	

Table 1

CRRT in children

Introduction

Continuous renal replacement therapy is an extracorporeal therapy designed to be slow and gentle, mimicking the kidney's own method of fluid and solute clearance. CRRT has been shown to be superior to intermittent haemodialysis (IHD) in critically ill adults. CRRT is used in critically ill children for gradual fluid removal and electrolyte correction. CRRT also allows for replacement of fluid. This makes it the renal replacement therapy of choice in children with septic shock and low cardiac output, as the chances of haemodynamic instability compared to methods like haemodialysis are lower. In addition, CRRT allows administration of fluids during the resuscitation phase and targeted fluid removal throughout, especially during the de-resuscitation phase of critical illness.[2,4]

Modes

Multiple modes of CRRT are available, as outlined in Table 2. Most modes provide both solute and fluid clearance, while SCUF (slow continuous ultrafiltration) allows only for fluid removal.

The mode of choice is dependent on different PICUs and their experience. A survey conducted across 123 PICUs in Europe revealed that CVVHDF was the most preferred modality (51%). Our unit predominately uses CVVH or CVVHDF.

Theory and principle of CRRT

CRRT operates along two primary principles: diffusion and/or convection (see Figure 1).

Diffusion, is the process by which solute molecules equilibrate across a pressure gradient created by a semi-permeable membrane. This is the main principle of conventional haemodialysis (HD), sustained low efficiency dialysis (SLED) and peritoneal dialysis. It is also the main theory operating in CVVHD. The dialysate is given counter-current to blood flow, thereby permitting sustained solute gradient, increasing the efficiency of clearance.

Convection or solvent drag is the method by which fluid moves across a semi-permeable membrane due to a pressure gradient. When fluid (solvent) moves in this manner, it drags across molecules with it, resulting in both fluid and solute clearance. This is known as solvent drag. This is the main principle in action in CVVH.

CVVDHF combines both, diffusion and convection.

Molecular clearance: the clearance of molecules across the semi-permeable membrane depends on both, pore size of the membrane and the size of molecules. Molecules less than 500 daltons are classified as small, greater than 500 daltons to less than the size of albumin are medium molecules and albumin and similar sized solutes (66–70 kilodaltons) are large molecules (see Table 3). In addition to the size, the sieving coefficient (SC) is an important determinant of clearance-i.e., how readily a molecule crosses the membrane.

$$SC = C_d / C_b$$

(C_d, concentration in dialysate; C_b, concentration in blood)

If a molecule has SC=1, it will completely be cleared from blood. Some examples are potassium and urea. While if its SC=0, e.g. albumin, it will not be filtered out at all.

© 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

Modes of renal replacement therapy in children

Types	CVVHF	CVVHD	CVVHDF	SCUF	IHD
	Continuous removal of waste products using a substitution solution	Continuous removal of waste products using a dialysis solution	Continuous removal of waste products using both dialysate and substitution solution	Removal of ultrafiltrate at low rates without administration of a substitution solution.	Intermittent removal of waste products using a dialysis solution. For haemodynamically stable patient only
Ultrafiltration	Yes	No	Yes	Yes	Yes
Convection	Yes	No	Yes	Yes	No
Diffusion	No	Yes	Yes	No	Yes
Blood Flow Rate (mL/minutes)	30—120	30—120	30—120		
Dialysate (mL/minutes)	NA			NA	
Ultrafiltration (mL/minutes)	= effluent rate		= effluent rate		
Indications	Small and large molecules clearance (cytokines) Uraemia, severe acid/base or electrolyte imbalance	Small molecules Uraemia	Small and large molecules clearance. Uraemia and fluid overload	Fluid overload without significant electrolyte imbalance. Used when waste product removal or pH correction isn't necessary.	Fluid overload, hyperkalaemia, uraemia
Duration	Continuous	Continuous	Continuous	Continuous	3—4 h
Replacement fluid	Yes	No	Yes	No	Yes

CVVH, continuous venovenous haemofiltration; CVVHD, continuous venovenous haemodialysis; CVVHDF, continuous venovenous haemodiafiltration; SCUF, slow continuous ultrafiltration; IHD, intermittent hameodialysis.

Table 2

Indications for CRRT

The indications for most renal replacement therapy is common to those for CRRT, as mentioned in Table 1. However, there are some specific indications:

- Fluid overload greater than 10%
- Hyperammonaemia and other inborn errors of metabolism causing severe metabolic acidosis
- Intoxications (e.g., drugs and toxins)
- Septic shock with need of toxin clearance (e.g., endotoxins, cytokines)
- Need to make room for more fluids for drug therapy and/or nutrition

Preparation

Vascular access: age and weight appropriate vascular access catheters (or Vascaths) should be inserted in the internal jugular vein or femoral veins under ultrasound guidance. The brachiocephalic vein may also be used in centres with expertise. The larger the size of the catheter, better is the flow through the circuit. However, larger catheters in relation to vessel size are associated with higher risk of venous thrombosis and vessel wall related complications. Therefore, a vessel to catheter ratio of 1:0.45 or 0.5 is usually recommended.

Circuit prime: the circuit volume in paediatrics ranges from 60 to 250 mL and while these are much smaller volumes than adult circuits, these may still be large blood volumes for a baby to have outside of the body. If the extracorporeal circuit volume is more than 10% of the child's circulating blood volume, a blood prime is done (usually a mixture of blood and crystalloid/colloid). If not, then the circuit is primed with crystalloid.

CRRT prescription:

a. Blood flow rate: Blood flow rates are set at 5—10 mL/kg/minutes, with a minimum of 30 mL/minutes in most paediatric machines. This can be as low as 3—5 mL/kg/minutes. However, circuit life will be longer with higher blood flow rates. Initially, starting slow and then increasing the rate is a better method of avoiding significant haemodynamic compromise.
b. Dose (ultrafiltration rate/effluent rate/pre-dilution): This is the determinant of fluid and solute removal. In standard dose CRRT, it is prescribed at 30—35 mL/kg/hours. Conditions like hyperammonaemia and sepsis might require much higher flow rates for effective molecule removal, going up to 80—120 mL/kg/hours. Therefore, in our centre, the prescription reads 30—120 mL/kg/hours, with a minimum flow rate of 120 mL/hours.

© 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

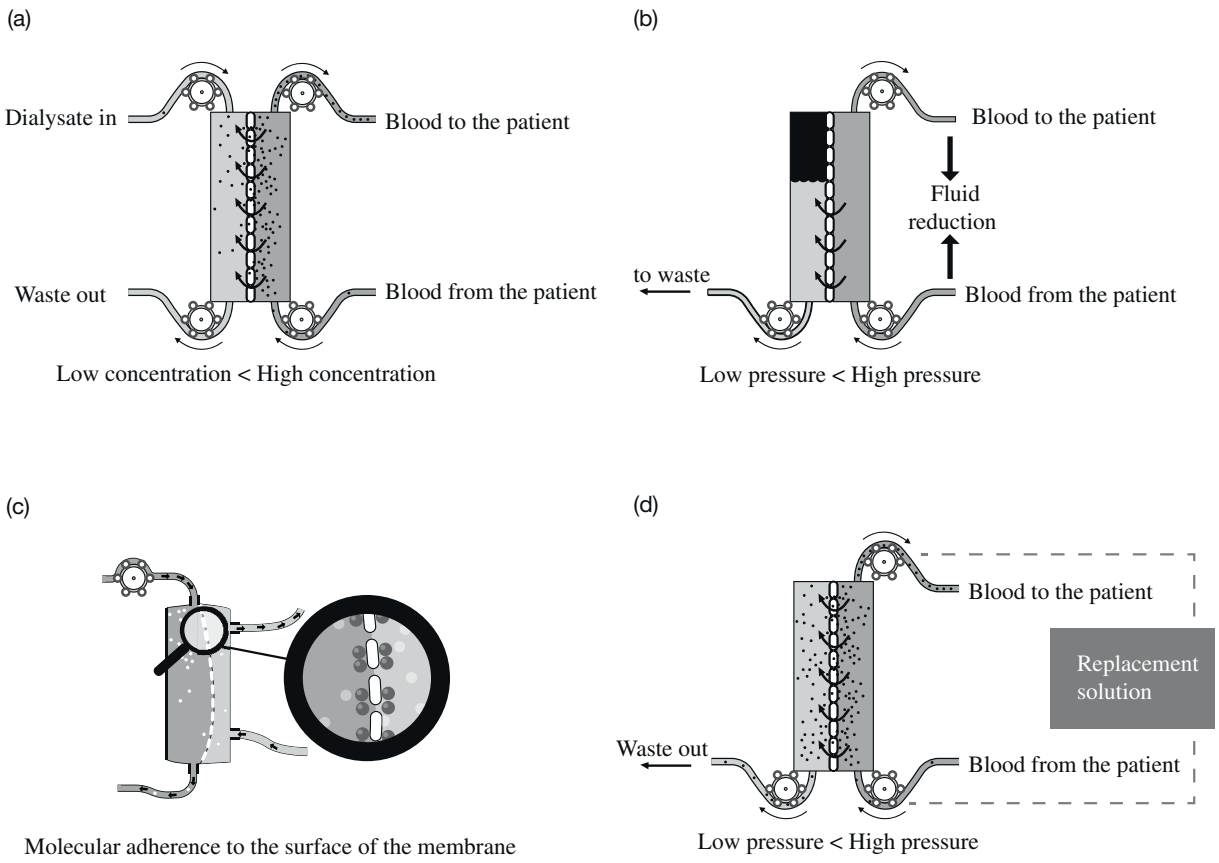

Figure 1 Principles of CRRT. (**a**) Haemodialysis: diffusion; (**b**) ultrafiltration; (**c**) adsorption; (**d**) haemofiltration: convection.

Size of solutes over a broad molecular range

Molecule	Molecular weight (Da)	Relative size
Albumin	55,000—60,000	Large
Inflammatory mediators	1200—40,000	
Myoglobin	17,800	
β2-Macroglobulin	11,800	
Inulin	5200	
Vitamin B_{12}	1355	Middle
Aluminium—desferoxamine complex	700	
Glucose	180	
Uric acid	168	
Creatinine	113	Small
Phosphate	80	
Urea	60	
Potassium	35	
Phosphorus	31	
Sodium	23	

Table 3

c. Post-dilution: Post-dilution is set at a volume which will determine net fluid removal. During the resuscitation phase, it can be equal or slightly less than the pre-dilution, but can be much lower as the child enters the de-resuscitation phase of the illness, and fluid and solute removal become the priority.
d. Dialysate dose: If the child is undergoing CVVHD or CVVHDF, the dialysate flow rate is set. This is usually equal to the dose or in CVVHDF, the dose is a sum of the dialysate rate and pre-dilution.
e. Anticoagulation: CRRT being an extracorporeal therapy with large volumes of blood in contact with plastic surfaces, is an extremely pro-coagulant state. Therefore, to prolong circuit and vascular access life, anti-coagulation may be necessary. Many adult centres are able to run circuits without anti-coagulation as the circuit flow rate is very high, preventing haemostasis. However, in paediatrics, with low volumes and flow rates, this is usually difficult to achieve. The most commonly used anticoagulants are enumerated in Table 4. Heparin is the cheapest and easiest to use, but is labour intensive, with frequent monitoring of ACT, and higher risks of bleeding in the patient. Regional citrate anticoagulation is gaining more favour as it anti-coagulates the circuit and reduces the risks of bleeding significantly. Other drugs used are serine protease inhibitors like nafamostat and direct thrombin inhibitors like bivalirudin.

Timing of CRRT

The initiation of CRRT may sometimes be a straightforward decision in children with anuria, with or without fluid overload unresponsive to medical therapy. In this case, CRRT is initiated as rescue therapy. However, in some situations, initiation of

© 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

Anticoagulants used in CRRT

Anticoagulant	Dose	Monitoring	Advantages	Disadvantages
Heparin	10—60 U/kg/hours	Activated clotting time (150—180 s)	Low cost Easily reversible with protamine	Higher risk of haemorrhage Heparin induced thrombocytopaenia
Regional citrate anticoagulation	Start at 3 mmol/L	Anti-Xa - 0.3—0.7 IU/mL	No patient anticoagulation Lower bleeding risks Longer circuit life	More training and expertise required for staff Electrolyte abnormalities like hypocalcaemia Use with caution in liver failure
Prostacyclin	2—8 ng/kg/minutes	Circuit aPTT - 45—60 s or ACT 180—200 s	No need for patient anticoagulation monitoring Easy to use	May have systemic adverse effects like vasodilatation, hypotension

Table 4

CRRT may need to be pre-emptive. For example, a child in septic shock requiring large amounts of fluid resuscitation and concurrent AKI may be started on CRRT, as clinical reasoning would suggest that CRRT would enable fluid administration while preventing fluid overload in the first place.

There are no randomised controlled trials in children which have compared early versus late initiation strategies but some studies have shown higher mortality in children in whom CRRT was delayed, with one showing a 1% increase in mortality for every hour's delay in initiation. The ELAIN trial in adults, which compared early vs late initiation of RRT, also showed similar results, with the early initiation (within 8 hours of diagnosis of AKI) group having lower mortality and earlier recovery of renal function. In adults, the AKIKI trial, however, failed to show a difference between the 2 groups, and showed that delayed initiation (if indications for RRT persisted for 72 hours after diagnosis of AKI) was safe and reduced the need to invasive therapy like RRT. The AKIKI-2 trial explored this further-it compared delayed RRT vs initiation of RRT when a definitive indication like hyperkalaemia arose. This trial showed that mortality was higher in the latter group.

Therefore, there is need for research in children to determine the optimal timing of CRRT initiation. However, at present, it is used as rescue therapy if fluid overload greater than 10% is present or for renal indications, as mentioned earlier.

CRRT in neonates and small infants

Neonates, especially preterm babies, pose a challenge with respect to vascular access with vessel size being too small to insert an appropriately sized Vascath. Neonatal RRT especially in children with inborn errors of metabolism can be lifesaving and inability to establish adequate vascular access may be a life-limiting step.

One of the first machines introduced to perform CRRT in neonates was the NIDUS (Newcastle Infant Dialysis Ultrafiltration System) which was designed for use in infants weighing 0.8 −8 kg. This is shown to accurately fluid remove in a premature infant population. It has the benefit of requiring only a 20/22 gauge cannula for access but requires systemic anticoagulation. The other machine available for this purpose is the Cardio-Renal Pediatric Dialysis Emergency Machine (CARPEDIEM). This is used in Europe and the USA for under 10 kg infants and has a priming volume of under 30 mL. It can be used to treat acidosis, for solute removal as well as for fluid removal.

CRRT in extracorporeal life support (ECLS)

Children who are on extracorporeal life support are another cohort who can have a systemic inflammatory response and may develop AKI, anuria and fluid overload. In these children, CRRT may be initiated using separate vascular access, but, more often than not, the CRRT machine can be connected to the ECLS circuit. Children on this dual extra-corporeal therapy, however, may require larger amounts of blood and blood products as replacement as their blood is in contact with a large surface area of the non-biologic ECLS and RRT circuits.

Peritoneal dialysis

Introduction

Peritoneal dialysis (PD) is a type of RRT that provides gradual continuous solute clearance through diffusion and ultrafiltration. In Europe, there is particular interest in the use of PD for AKI/fluid overload post cardiac surgery in neonates especially those with low birth weights.[3]

Physiology of PD

Dialysate solution is introduced to the peritoneal cavity via a catheter. Waste and water move into the peritoneal cavity across the peritoneal membrane either via ultrafiltration or diffusion, this solution now called effluent is then removed from the peritoneal cavity. The peritoneal membrane serves as a natural semi-permeable membrane due to its extensive capillary surface area providing an area for diffusion and ultrafiltration between the blood and the dialysate.

The peritoneum consists of three layers, the mesothelial cell layer, the interstium and the capillary wall. The mesothelial cell layer allows water and solute to transport easily while the two other layers are size-selective. Substances with low molecular weight, free substances that are not easily bound to protein and water soluble are dialysed easily.

Ultrafiltration (UF) in PD is determined by the osmotic gradient provided by the high glucose concentration in the

© 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

dialysate compared to the blood glucose. The concentration of glucose in the dialysate fluid can be increased to improve ultrafiltration.

$$\text{UF} = \text{Effluent (mL)} - \text{Fill volume (mL)}$$

Peritoneal dialysis may be considered over other forms of RRT because

1. Access to PD can be quickly and safely obtained even in haemodynamically unstable children. It also does not require vascular access, so vessels are spared for future treatment.
2. PD is less expensive compared to other modalities of renal replacement therapy, so it is ideal in low resource settings.
3. It is easier to perform in low birthweight/preterm babies where there might be difficulty in inserting large enough vascular catheters, especially post cardiac surgery.

Contraindications for PD

Absolute	Open abdomen (gastroschisis, omphalocele, bladder exstrophy)
	Abdominal compartment syndrome
	Fungal peritonitis
Relative	Recent abdominal surgery
	Paralytic ileus
	Difficult-to-ventilate patients
	Pleuroperitoneal connection allowing dialysate in the chest such as diaphragmatic hernia
	Inguinal hernia
	Abdominal wall cellulitis or abdominal wall burn

Table 5

Contraindications for PD are shown in Table 5.

PD may not be the ideal modality of RRT in situations like hyperammonaemia or if precise fluid removal is required.

Terminology in PD prescriptions

Fill volume: it is the total volume of dialysate infused into the peritoneal cavity per cycle. It is recommended to start at 5 mL/kg to 10 mL/kg, increasing up to 20 mL/kg, rarely more. The larger the volume the higher the solute clearance and fluid removal.

Fill time: refers to the 5–10-minute period during which the dialysate flows into the peritoneal cavity.

Dwell time: it is amount of time the dialysate remains in the peritoneal cavity. The duration varies depending on the goal of the dialysis.

Drain time: ideally no more than 10 minutes for the dialysate to drain out of the peritoneal cavity.

Cycles: refers to the number of exchanges in a 24-hour period. The most effective clearance and ultrafiltration are achieved by doing more frequent exchanges.

Catheter placement

Placement of the PD catheter may be done in the operation theatre as is usually the case post-cardiac surgery. It may also be places in PICU percutaneously, either using ultrasound guidance or blindly, by a direct or Seldinger technique, as may be available. Long term PD catheters may also be placed in Interventional Radiology.

In low resource settings, alternate options to PD catheters include central venous, dialysis lines, chest drains, Foley's catheter and nasogastric tubes.

Complications of PD

Peritonitis	Cloudy effluent, abdominal pain, peritoneal signs, nausea and vomiting, fever, leucocytosis (WBC of effluent > 100 WBC/cc), polymorphs > 50%. Treatment consists of antibiotics, heparin and changing the catheter if symptoms persist.
Catheter obstruction	Presents as poor ultrafiltration, pain during drain time or impaired outflow drain time. Steps to management include checking for kinks, flushing the catheter and abdominal X-ray to look for catheter position. If it persists, consider administration of fibrinolytics.
Electrolyte imbalance	Hyponatremia, hypokalaemia, hypoglycaemia and hyperglycaemia. Treatment involves replacing loss/deficit either enterally, intravenously or adding or removing the electrolyte from the dialysate
Peritoneal catheter leak	Check the glucose concentration of the leaking fluids to confirm it is dialysate. Recommendation for management includes delay in using the catheter for few days allowing the surgical site to heal, application of surgical glue, reduction of fill volume and surgical management.
Poor ultrafiltration	Non-improvement in fluid overload despite being on PD. Management includes strict fluid balance, increased glucose concentration of the dialysate, increasing fill volume, increase in frequency of cycles and use of diuretics. However, this may sometimes represent failure of PD to achieve the primary goal of initiation of RRT.
Protein loss	Patients on PD also require increased protein intake due to amino acid losses with PD, and they may also lose immunoglobulins in the dialysate, making them more susceptible to infection. This is more relevant to those children on continuous ambulatory peritoneal dialysis (CAPD), as opposed to those needing PD in PICU.
Hydrothorax	Due to dialysate leakage into the pleural space.
Hernia	Due to fluid in the peritoneal space and increased abdominal pressure

Table 6

© 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.

Recommended insertion sites for bedside percutaneous placement of a PD catheter are in the midline in the mid-rectus abdominis sheath below the umbilicus, or midpoint between the umbilicus and the anterior superior iliac spine of the hip.

Types of PD

a. Manual delivery system: It is a gravity-based method in which the fill bag is connected to the PD catheter via its inlet channel and outlet channel is linked to an effluent/drain bag either through a closed system using a buretrol which permits precise measurement of inflow and outflow. This system requires an operator to monitor inflow and outflow. This method is inexpensive to execute and therefore, is used extensively in low- and middle-income countries.
b. Automated system: It involves using cycler which when programmed performs the treatment. This is the method used in home PD systems.

Dialysate composition

Dialysate is hyperosmolar fluid relative to plasma, to create an osmotic gradient that promote ultrafiltration. The osmotic agent used is glucose. Glucose concentration used varies from 1.5% to 4.25%; The greater the glucose concentration, the greater the ultrafiltration. Sodium, potassium and heparin could all be added to the diasylate prescription to reduce electrolyte imbalance.

Continuous/cross-flow dialysis

This modality is used when an increase in solute clearance and ultrafiltration is desired but cannot be achieved by standard acute PD or when the use of very small fill volume is preferred in children, A second catheter is inserted into the peritoneal cavity to allow continuous flow.

Complications of PD are listed in Table 6.

Use of CRRT for adsorption

Independent of diffusion and convection, adsorption occurs as larger molecules i.e., biological material can adhere to the semi-permeable membrane (examples of these can be proinflammatory cytokines and endotoxins). This has been taken further with haemadsorption via different adsorbers has been used for immunomodulation in children with acute inflammatory conditions such as sepsis or post cardiopulmonary bypass. These are attached to the RRT machines and examples of this include the Oxiris and the Cytosorb. There are a few case studies demonstrating feasibility with efficacy and safety studies conducted.

Summary

RRT involves placement of a large bore vascular access or a peritoneal dialysis catheter, a well-trained team and local expertise. The majority of children who require it acutely due to anuria or AKI have this on PICU for volume overload, acidosis or electrolyte abnormalities. The optimal timing of RRT initiation and cessation is based on local experience.

Initiation of RRT needs to be considered in the setting of the use of a life sustaining treatment and the overall management of the child. ◆

REFERENCES

1 Kellum JA, Lameire N, Aspelin P, et al. Kidney disease: improving global outcomes (KDIGO) acute kidney injury work group. KDIGO clinical practice guideline for acute kidney injury. *Kidney Int Suppl* 2012; **2:** 1–138.
2 John JC, Taha S, Bunchman TE. Basics of continuous renal replacement therapy in pediatrics. *Kidney Res Clin Pract* 2019; **38:** 455–61.
3 Nourse P, Cullis B, Finkelstein F, et al. ISPD guidelines for peritoneal dialysis in acute kidney injury: 2020 Update (paediatrics). *Perit Dial Int J Int Soc Perit Dial* 2021; **41:** 139–57.
4 Cortina G, Daverio M, Demirkol D, Chanchlani R, et al. Continuous renal replacement therapy in neonates and children: what does the pediatrician need to know? An overview from the Critical Care Nephrology Section of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). *Eur J Pediatr* 2024; **183:** 529–41.

FURTHER READING

Hsu CN, Chen HL, Tain YL. Epidemiology and outcomes of community-acquired and hospital-acquired acute kidney injury in children and adolescents. *Pediatr Res* 2018; **83:** 622–9.
Plumb L, Casula A, Sinha MD, et al. Epidemiology of childhood acute kidney injury in England using e-alerts. *Clin Kidney J* 2023; **16:** 1288–97.
Ricci Z, Goldstein SL. Pediatric continuous renal replacement therapy. *Contrib Nephrol* 2016; **187:** 121–30.
Ronco C, Brendolan A, Bragantini L, et al. Treatment of acute renal failure in newborns by continuous arterio-venous hemofiltration. *Kidney Int* 1986; **29:** 908–15.
UK Kidney Association. 26th Annual Report - data to 31/12/2022. Available from: https://ukkidney.org/audit-research/annual-report/26th-annual-report-data-31122022.

Practice points

- Acute kidney injury (AKI) is common in PICU, affecting up to 50% of critically ill children. This can lead to increased mortality, prolonged period in hospital and a greater risk of developing chronic kidney disease (CKD)
- Delayed initiation of RRT in critically ill children has been associated with increased mortality. RRT should be considered for patients with severe electrolyte or metabolic disturbances, persistent AKI, significant fluid overload (>10%), or for toxin removal
- Continuous renal replacement therapy (CRRT) is often favoured over intermittent haemodialysis (IHD) in PICU due to its ability to provide gradual fluid removal, better hemodynamic stability, and continuous solute clearance. It requires wide bore vascular access, careful management of anticoagulation, clinical expertise and equipment
- Peritoneal dialysis (PD) is a cost effective alternative and does not require vascular access. It is used in smaller children and those with an intact peritoneum
- There are newer neonatal CRRT machines, like CARPEDIEM and NIDUS that may improve treatment options for infants

© 2025 Published by Elsevier Ltd.

Descargado para Lucia Angulo (lu.maru26@gmail.com) en National Library of Health and Social Security de ClinicalKey.es por Elsevier en junio 19, 2025. Para uso personal exclusivamente. No se permiten otros usos sin autorización. Copyright ©2025. Elsevier Inc. Todos los derechos reservados.