Title/Description:	**NURSING MANAGEMENT OF PATIENT UNDERGOING CONTINUOUS RENAL REPLACEMENT THERAPY (CRRT)**		
Department:	Division of Nursing	**Effective Date:**	01-09-2006
Procedure No:	61220-3004	**Revision No.:**	6
Revision Date:	01-09-2020	**Approved by:**	Chief Nurse
Applies To:	All ICU Registered Nurses		

Amendments:
☐ New document ⊗ Content change ☐ Reviewed with no changes on DD/MM/YY

1.0 PURPOSE

To provide guidelines on continuous renal replacement therapy in the critically ill children / adult.

2.0 POLICY

2.1 Continuous renal replacement therapy is carried out in the Intensive Care Unit (ICU) only.

2.2 Doctor in charge in ICU prescribes the CRRT order.

2.3 Staff Nurse in ICU will prepare, prime, initiate and terminate the CRRT treatment.

2.4 ICU Staff Nurse will perform nursing management and monitor patient on CRRT.

2.5 The purpose of renal replacement therapy is for fluid removal, solute removal or both.
The indications include:

1 Diuretic unresponsive volume overload
2 Hyperkalaemia
3 Intractable acidosis
4 Progressive oliguria/ renal failure
5 Inborn errors of metabolism
6 Intoxication of dialyzable substance

Each patient is assessed, on an individual basis, to the need for starting renal replacement therapy by the intensive care physician.

3.0 DEFINITION

Continuous renal replacement therapy (CRRT)

3.1 CRRT is the filtration of blood through a hollow fiber, semi permeable membrane outside of the body (extracorporeal circuit). CRRT is a slow, continuous (24 hours/day) therapy. The different modes of CRRT used are: slow continuous ultrafiltration, continuous venovenous haemodialysis, continuous venovenous haemofiltration and continuous venovenous haemodiafiltration

3.1.1 Continuous venovenous haemodialysis (CVVHD)
In continuous venovenous dialysis, blood is removed from the patient via one lumen of the dual-lumen catheter and pumped through the tubing circuit and haemofilter. Solute is removed by diffusion from the blood (higher concentration) to the dialysis solution (lower concentration) that runs countercurrent to the blood flow.

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3.1.2 Continuous venovenous haemofiltration (CVVH)
In continuous venovenous haemofiltration, blood is removed from the patient via one lumen of the dual-lumen catheter and pumped through the extracorporeal circuit and haemofilter. Solute is removed via a convective process. In this mode of therapy, fluid replacement is required.

3.1.3 Continuous venovenous haemodiafiltration (CVVHDF)
In this process, solute removal is by both diffusive and convective process. Both dialysis solution and replacement solution are required.

3.1.4 Slow continuous ultrafiltration (SCUF)
In this process, fluid is removed by ultrafiltration. There is minimal solute removal by this method.

4.0 PROCEDURE

4.1 Equipment

4.1.1 PRISMAFLEX machines
This machine allows the following modes of continuous renal replacement therapy: SCUF, CVVH, CVVHD and CVVHDF

4.1.2 Haemofilter
The haemofilter is a semi permeable membrane that allows the passage of water and dissolved solutes. The PRISMA machine uses the biocompatible AN69 membrane.

Characteristics	**M60**	**M100**	**HF20**
Patient weight (Kg)	11-30	>30	8-10
Membrane	AN69	AN69	PAES
Surface area (m2)	0.6	0.9	0.2
Priming volume	42	66	3
Minimum blood flow rate (Qb ml/min)	50	75	20

4.1.3 Vascular access
Vascular access is achieved by the insertion of a double lumen dialysis catheter into the femoral, internal jugular or subclavian veins. The size of the catheter used is based on the size of the patient.

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Weight of patient (Kg)	**Cannula size**
Neonate	Single lumen 5F
	Double lumen 6.5F
3-6	Double lumen 6.5F, 7F
6-15	Double lumen 8F, 9F
15-30	Double lumen 10F
>30	Double lumen 11.5F
	Triple lumen 13F

4.1.4 Dialysis and replacement solutions

Prismasol BO and Biphozyl are isotonic solutions used for both replacement and dialysis solutions. Prismasol BO is used in heparin-free dialysis with systemic heparin coagulation. Biphoayl is used in dialysis with regional citrate anticoagulation as it does not contain calcium.

Compositions of Prismsol BO and Biphozyl:

	Biphozyl	**Prismasol BO**
Na (mmol/l)	140	140
K (mmol/l)	4	0
Cl (mmol/l)	122	109.5
Ca (mmol/l)	0	1.75
Mg (mmol/l)	0.75	0.5
Lactate (mmol/l)	0	3
Osmol (mOsml/l)	290	287
Glucose (mmol/l)	0	0
HCO3 (mmol/l)	22	32
PO4 (mmol/l)	1	0

4.2 Anticoagulation

4.2.1 Anticoagulation is usually needed to prevent clotting of the extracorporeal circuit. In patients who are in disseminated intravascular coagulation and has a high activated clotting time, dialysis without anticoagulation may be considered in patients with high blood flow rate and a large access.

4.2.2 Regional citrate anticoagulation

This form of anticoagulation is performed by introducing citrate into the blood as it leaves the patient into the circuit. Citrate binds calcium causing a lowering of the ionized Ca^{2+} in the blood. This prevents the blood in the circuit from clotting. A calcium infusion is given to the patient to normalize the serum

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ionized Ca^{2+}.
This results in an anticoagulation of the circuit without anticoagulation of the patient. (see Annex 1 "Citrate Protocol for Continuous Renal Replacement Therapy" for Paeds)

4.2.3 Systemic heparin anticoagulation
Heparin is given as a form of systemic anticoagulation. In this form of anticoagulation, patient is at risk of bleeding. A heparin bolus followed by an infusion is given to achieve a target activated clotting time (ACT) of 180-220 seconds. (see Annex 2 "Heparin Protocol for Continuous Renal Replacement Therapy" for Paeds)

4.3 Procedure

4.3.1 General Steps

- Informed consent
  Informed consent must be obtained before the implementation of CRRT. In situations where CRRT is considered to be urgent and life-saving, verbal consent may be obtained first before the informed consent form is signed. An information leaflet will be given to patients/parent/guardian. (See Annex 3)
- Vascular access
  Vascular access is obtained by the intensive care registrar, associate consultant or consultant by aseptic technique.
- CRRT Order Sheet
  The intensive care physician orders the blood flow rate, dialysate flow rate, replacement flow rate, fluid removal rate and anticoagulation on a CRRT order sheet in CLMM system for paediatric patient (See Annex 4)/ CRRT form for adult patients (See Annex 5) and CLMM system.

4.3.2 Priming of Continuous Renal Replacement Therapy Circuits using PrimaFlex machine

- Perform medical hand washing.
- Counter-check doctor's order in SCM CRRT ordersheet.
- Prepare the followings:
  Prepare heparinsed saline in a 50 ml syringe, dosage as per doctor's order (For Heparin protocol) To be infused via systemic route.
  Add 10,000 unit of heparin into the 1 litre normal saline bag (10 units of heparin per ml of normal saline) for priming
- Prime set when ready to start treatment.
- Perform medical hand washing.
- Open PrismaFlex set.

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- On the PrismaFlex machine:
  - Select new or same patient.
  - When choosing therapy, select CVVHDF mode – as this mode allow access to other modes therapies.
  - Load the PrismaFlex set onto the machine and follow the step-by-step instructions on the screen.
  - Prepare dialysate/ replacement solutions and connect lines to solutions as instructed on the screen.
  - Select "Prime" after the connection of the lines to the solutions is complete
  - First prime with heparinised normal saline (10 units per ml) as prepared earlier to coat the surface of the tubing and filter with heparin.
  - Re-prime the PrismaFlex circuit with 1 litre of normal saline.
  - Inspect the set for air and observe closely for leakage at joints and connections within the system during priming.
  - Once the priming process is completed and the "self-test" is passed, the machine is ready for use.
  - If the circuit is not used on patient for more than an hour, re-prime the circuit manually with 300 ml of normal saline.
  - Do not use the PrismaFlex set if the circuit is left unused for more than 8 hours.
  - Important Note: Press "CONTINUE" key ONLY when patient is ready to start CRRT.

4.3.3 Initiation of continuous renal replacement therapy via central venous catheter.

- Doctor to be present before initiating treatment.
- Before the procedure, the nurse should:
  - Counter-check and key-in CRRT order on the PrismaFlex machine with another RN.
  - Assess and record patient's haemodynamic status
  - Assess catheter site for redness and swelling
- Put on mask and apron.
- Perform surgical hand washing.
- Prepare the following in a sterile dressing set:-
  - Don on sterile gloves
  - Pour normal saline 0.9% into the compartment
  - Pour in cleansing solution chlorhexidine 2% / alcohol 70% (Paeds)/ Prepare Chlorhexidine 2% with isopropyl alcohol 70% swabs (Adults)
  - Add in the syringes and gauze
- Drape catheter site with sterile towel.
- Scrub the arterial and venous lumen of the catheter access ports one at a

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time with chlorhexidine 2% / alcohol 70% for one minute.
- Remove catheter caps and discard.
- Connect a 3ml syringe filled with 1ml 0.9%NaCl to arterial port (red).
- Aspirate 1.5 ml (Paeds)/ 10mls (Adult) of blood and spread the blood onto a piece of gauze to check for blood clots.
- Flush with 3ml (Paeds)/ 10 mls (Adult) of 0.9%NaCl into the catheter and clamp with positive pressure.
- Repeat steps for the venous port (blue).
- Connect arterial and venous lines and ensure that there is no air bubble within the line.
- Release all clamps on access lines.
- Initiate CRRT treatments as per Doctor's order.
- Secure lines with micro-pore tape.

4.3.4 Patient monitoring

All patients on CRRT will have continuous cardiac rhythm and arterial blood pressure.

For paediatric patients, serum electrolytes and blood gases are monitored 4 hourly initially. Serum urea, creatinine, calcium, magnesium and phosphate are monitored twice daily on the first day of CRRT and may be reduced to daily thereafter.

For adult patients, the blood tests to be done according to Intensivist's orders.

4.3.5 Troubleshooting PRISMA alarms in continuous renal replacement therapy (Refer to P&P 61220-3005)

4.3.6 Termination of continuous renal replacement therapy from PRISMA machine
- Ensure that termination of CRRT is ordered in the patient's case-notes.
- Put on mask and apron.
- Prepare the followings in a sterile dressing set:-
  - Pour cleansing solution into compartment
  - Open and put in all stopcocks, syringes, needles and transparent dressing
- Perform handwashing before putting on sterile glove.
- Prepare heparinised saline to heparin lock lumens of dialysis catheter.
  - < 5kg –660 units in 20mls normal saline (33u/ml)
  - > 5kg – 2000units in 20mls normal saline (100u/ml)
  - Adult 1000u/ml without dilution
- Prepare 2 x 2ml syringes with the prepared heparinsed saline/ heparin.

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- Filled the 2 x 5ml (Paeds)/ 2 x 10mls (Adults) syringes with 0.9% NaCl
- Termination is operated through the interactive display screen.
- Standby mode is automatically entered when pressing the stop button on the Status screen.
- Select "END TREATMENT" from the screen.

- To return blood to the patient, select "RETURN BLOOD" from the next screen. Follow the instruction on the "RETURN BLOOD" screen.
- Select "DISCONNECT" if end treatment without returning blood. Follow instruction on the "DISCONNECT PATIENT" screen
- Hang the bag of 0.9% NaCl at lower left corner of PrismaFlex machine.
- Clamp the access port (red) of patient's catheter.
- Clean connecting section with chlorhexidine gauze (Paeds) / Chlorhexidine 2% with isopropyl alcohol 70% swabs (Adult) as per manufacturer guide for one minute
- Disconnect access line from patient.
- Attach 2ml(Paeds)/10mls(Adult) syringe to access port.
- Unclamp the access port.
- Aspirate 2 – 3 mls(Paeds)/10mls(Adult) of blood from the lumen.
- Squelch aspirate on gauge to check for any blood clot.
- Flush access port with 0.9% NaCl.
- Check patient's catheter to determine the amount of heparin to be injected. The volume should not exceed the amount indicated on the lumen.
- Heparin lock lumen and clamp port.
- Cap lumen with stopcock.
- Connect access line (from PrismaFlex machine) to the bag of saline using spike
- Hold down "START RETURN" key on the screen to return desired amount of blood. WARNING: Do not return blood if clotting is present in blood lines or filter.
- Repeat steps with the venous port (blue).
- Change dressing at exit site if soiled or wet.
- Secure the catheter down with micropore tape to keep it from dangling and to prevent dislodgement.
- Press "CONTINUE" key on screen.
- Press "UNLOAD" to unload pump segments from pump raceways from the next screen
- Clamp all lines attach to bags.
- Disconnect lines from all bags.
- Remove and discard the set, solution bags and effluent bag.
- Press "TREATMENT HISTORY" to view treatment history data from the last 24 hours.

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- Record post dialysis parameter.
- Turn off machine and power point.
- Wipe the machine with medic wipe before storage.

4.4 Guidelines

- The Vendor will do the scales calibration six monthly.
- Set up therapy in CVVHDF mode ONLY to allow user to change the mode during therapy if desired. This allows access to the other modes of therapy at any time.
- When prime - add 10,000 IU heparin/L of 0.9% NaCl to the priming solution.
- Do not inject medications into the circuit, it is a low compliance system and will not accept fluids pushed into the ports
- Never use the STOP button to trouble shoot alarms. This will cause the circuit to clot off prematurely
- Use the HELP menu to assist in troubleshooting
- Do not hang any bag on the other scale when the machine is not in used.
- In the event of a cardiac arrest. Turn the PrismaFlex machine off and disconnect the circuit from the patient.
- The machine indicates that the circuit needs to be changed at 72 hours. The yellow caution light remains on when 72 hours passes. Change circuit after 120 hours if circuit remains patent.
- For patients who are in disseminated intravascular coagulation–consult medical team whether to use heparinised prime. If not re-prime with normal saline. The circuit needs an initial prime with Heparin to coat the surface of the tubing and the filters. To empty the prime collection bag before re-priming
- Caution: To release all clamps on fluid lines before initiation to avoid system from withdrawing fluid off the patient. The machine will stop the blood pump when it detect an incorrect weight change. There is a "Incorrect Weight Change" management feature on the Prismaflex which will limit how much extra fluid can be removed from the patient in excess of the prescribed set rate. Once this limit is reached, the machine will alert user to end treatment and shut the machine down.
- To start ACDA and IV CaCl2 15-20mins after initiation of CRRT.
- During initiation, to start BFR at slower rate and gradually increase as tolerated.
- To add KCL /KH2PO4 in dialysate solution for CVVHD mode, to replacement solution in CVVH mode and both dialysate and replacement solutions in CVVHDF mode, as per CRRT ordersheet.
- For CVVHDF mode, the combined replacement and dialysate flow rate is set at

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2L/1.73m2/hr unless otherwise indicated by ICU consultant.

5.0 REFERENCE

- Prisma Education Programme Student Handbook
- P&P 61220-3005 - Troubleshooting PRISMA alarms in continuous renal replacement therapy
- Mowbray, K. (2009). Continuous renal replacement therapy: An education package for critical care nurses. https://www.aci.health.nsw.gov.au/_data/assets/pdf_file/0006/220677/nepean_CRRT_2009.pdf

6.0 ANNEXES

Annex 1	Citrate Protocol for Continuous Renal Replacement Therapy
Annex 2	Heparin Protocol for Continuous Renal Replacement Therapy
Annex 3	Patient Information on CRRT
Annex 4	CRRT Ordersheet (Paeds)
Annex 5	CRRT order form (Adult)

7.0 SPECIAL INSTRUCTION

Nil

8.0 DISTRIBUTION LIST

As per "Applies To"

Annex 1

CITRATE PROTOCCOL FOR CONTINUOUS RENAL REPLACEMENT THERAPY

1. Prime in CVVHDF Mode using ordered dialysate and replacement solutions.
   Dialysate: HCO3-based without Ca (Biphozyl)
   Replacement: normal saline or HCO3-based (Biphozyl)

2. When ready to start the citrate rate in mls/hr will be 1.5 x the blood flow rate of the Primaflex machine at mls/min. (eg Start Citrate at 150 mls/hr if the BFR is 100 mls/min)

3. Set up the Ca++ infusion (ie. 8gms Calcium Chloride in 1L NS or 23.5 g of Calcium Gluconate in 1L of NS) as ordered via central line other than the dialysis access (unless using a triple lumen vascath 3rd lumen) . This will run at 40% of the citrate flow rate. (eg citrate rate = 150 mls/hr then CaCl rate = 60 mls/hr)

4. Set the flow rates in Primaflex machine as ordered.

5. Patient Fluid Removal Rate is calculated by:
   Net Ultrafiltration rate + Citrate rate + Calcium infusion rate = Pt. Fluid Removal Rate.

6. Connect the Primaflex machine circuit to the dialysis catheter as per procedure and press start.

7. 2 hour after initiation of therapy and every 6 hours thereafter, send the following blood work
   - Post-filter ionized Ca++ (drawn from the return line, blue sample port)
   - Systemic ionized Ca++ (drawn from patient (true) arterial line or peripheral draw)
   - Renal Panel, Ca++/ Mg++/ Phosphate) (see # 14 for citrate and calcium adjustment)

8. Metabolic alkalosis occurs due to citrate metabolism to bicarbonate and due to bicarbonate in the Dialysate. Call ICU consultant if the Serum Bicarb is > 35 mmol/l. ICU consult may add in NS as a replacement solution by 20% and decrease the dialysate rate by the same amount if patient is on CVVHD, or add NS as a dialysate solution by 20% and decrease the replacement rate by the same amount if the patient is on CVVH. This will give an acid load from the NS and diminish the HCO3 from the bath at the same time.

9. Notify ICU consultant for the following:
   a. Systemic Ionized Ca++ < 0.75 mmol/L. (Consider holding citrate for 1 hour and resuming infusion at 30% of the citrate flow rate and bolus with 10 mg/kg of CaCl and increase Ca infusion by 10%)
   b. Na+ > 150 mmol/L. Consider changing replacement solution to 0.45% NaCl.

10. If the filter clots, stop the Citrate and Ca++ infusions and discontinue the filter.

11. **In children less than 10 kg who require a blood transfusion when going on, avoid the use of citrate for the first 15 minutes for it may exacerbate the bradykinin release syndrome seen in some children.**

12. Citrate Lock occurs when the total calcium rises with a dropping ionized calcium. This is due to the fact of the citrate infusion exceeds the clearance on dialysis and from hepatic metabolism. When this is seen, stop the citrate for 1-2 hours then restart at 70% of the previous dose. Stop the CaCl infusion at the same time and resume at 40% of the citrate flow rate when it is restarted. Watch the ionized calcium during this time to avoid inadequate anticoagulation of the circuit (i.e. the ionized calcium of the system rising causing system clotting). Inform ICU consultant is citrate lock is persistent.

13. Titrate the Citrate infusion according to the citrate sliding scale below:

Prisma ionized Ca++ (mmol/L)	**Citrate Infusion Adjustment**	
	> 20 kg	< 20 kg
< 0.35	↓ rate by 10 ml/hr	↓ rate by 5 ml/hr
0.35 – 0.5 (Optimum Range)	No adjustment	
0.5 – 0.6	↑ rate by 10 ml/hr	↑ rate by 5 ml/hr
> 0.6	↑ rate by 20 ml/hr	↑ rate by 10 ml/hr
NOTIFY DOCTOR IF CITRATE INFUSION RATE > 200 ml/hr		

Titrate the Calcium infusion according to the calcium sliding scale below:

Patient ionized Ca++ (mmol/L)	**Calcium Infusion Adjustment**	
	> 20 kg	< 20 kg
> 1.3	↓ rate by 10 ml/hr	↓ rate by 5 ml/hr
1.1-1.3 (Optimum Range)	No adjustment	
0.9-1.1	↑ rate by 10 ml/hr	↑ rate by 5 ml/hr
< 0.9	↑ rate by 20 ml/hr	↑ rate by 10 ml/hr
NOTIFY DOCTOR IF Calcium INFUSION RATE > 200 ml/hr		

Note:
Monitor for "Citrate lock" using the following formula:

Ratio of Ca_{tot} / Ca_{ion} > 2.5

Ca_{tot} - Total calcium
Ca_{ion} – Ionised calcium

References:

1. Brophy PD, Bunchman TE. References and Overview for Hemofiltration in Pediatrics and Adolescents. www.PCRRT.com

REGIONAL CITRATE ANTICOAGULATION

Principles of Citrate Anticoagulation

Citrate ($C_6H_5O_7$) is an organic acid. It is used as an anticoagulant in our protocol as acid citrate dextrose (ACD) solution (3.22% citrate, 112.9 mmol/L citrate, 123.6 mmol/L glucose, 224.4 mmol/L sodium and 114.2 mmol/L hydrogen ions). Citrate binds calcium in the blood with the formation of citrate–calcium complexes (CCC), thereby reducing the level of ionized free calcium (Ca^{++}). Ca^{++} is a mandatory co-factor of most enzymes of the coagulation cascade. The reduction of Ca^{++} results in anticoagulation of the blood. Post-filter Ca^{++} is monitored to ensure adequate anticoagulation and permit citrate dose adjustment. Calcium replacement is required for the patient to prevent hypocalcaemia and this is done with an infusion calcium chloride solution through a separate central line. Regular monitoring of systemic, post filter and total calcium is required to maintain adequate anticoagulation, ensure normocalcaemia and monitor for citrate accumulation (total Ca/Ca^{++}).

Citrate Clearance and Metabolism

CCC has a low molecular weight and its clearance via the CRRT is high, with a sieving coefficient 1.0. This clearance can be increased by increasing the dialysate flow rate in the diffusive method or the filtration flow rate (in PrismaFlex it is the “replacement flow rate”) in the convective method. CCC which are not cleared is returned to the patient and metabolized via the Krebs (citric acid) cycle in liver, muscle and kidney, generating HCO_3^- and releasing Na^+ and Ca^{++}in the process.

Citrate and Acid-Base Balance

Citrate is a weak acid. In the blood, it mainly exists as CCC with 2 of its 3 carboxylates bound with calcium, further weakening its plasma acidification effect. If citrate catabolism is normal, the regional citrate anticoagulation leads to plasma alkalinization due to HCO_3^- generation.

Citrate Accumulation (“citrate lock”)

The body’s capacity to metabolize citrate is saturable. When this capacity is exceeded, citrate accumulates as CCC. This is reflected as an increase in Ca/Ca^{++} ratio (>2.5). This happens especially in shock states and liver failure when the ability to metabolize citrate is reduced. This can result in life-threatening hypocalcaemia. An increase in the calcium infusion need (binding of calcium to citrate) and lactic acidosis (reflects underlying pathology that impairs tricarboxylic cycle) may be warning signs.

Net citrate overload

Net citrate overload occurs when there is excessive citrate administration or low clearance of citrate in the haemofilter. The body’s capacity to metabolize citrate is not reached and the CCC is all metabolized. The Ca/Ca^{++} is not raised and serum Ca^{++} remains normal. Metabolic alkalosis is commonly observed. Troubleshooting includes ensuring that the circuit setup is correct (e.g. citrate infusion is not given post filter), citrate delivery is not continued when the pump is stopped, the clearance (dialysis or haemofiltration rates) is adequate and filter function is intact (e.g. filter clotting).

Management of citrate accumulation/ overload

For both citrate accumulation and citrate overload, the strategy is to reduce the net citrate load by:

- Reducing the citrate infusion rate
- Increasing clearance (increase dialysis or haemofiltration rate)
- Decreasing target concentration in Ca^{++} in the circuit (risk of clotting)

In citrate overload, this problem is usually fixed with reduction with citrate delivery. In citrate accumulation, if no improvement is observed quickly with the interventions, an alternative anticoagulation should be considered as the risk of hypocalcaemia can be life-threatening.

Annex 2

Heparin Protocol for Continuous Venovenous Haemodialysis and/or Haemofiltration

1. **Before Initiation**
   - Obtain baseline Full Blood Count, PT/PTT, Fibrinogen and Activated Clotting Time (ACT)
   - Correct haemoglobin, platelets, PT and fibrinogen if deranged, as indicated. Discuss with ICU consultant.
   - If patient's ACT < 140s, consider giving a bolus of heparin at 20 units/kg to patient and recheck ACT.
   - Repeat heparin bolus and ACT check until ACT 180-220s. (maximum 2 boluses of heparin)

2. **During Haemodialysis or Haemofiltration**

   - When ACT > 160s, start heparin infusion (10 units/ml) at 10 units/kg/hr. Check system ACT 30 minutes after initiation.
   - Titrate heparin infusion to keep post-filter ACT between 180-220 s.

   - If the ACT is <180s:
     - if ACT is 160-180s: increase heparin infusion by 10%
     - if ACT is 140-160s: increase heparin infusion by 20%
     - if ACT < 140s: consider heparin bolus 10-25units/kg & increase heparin infusion by 20%. Inform ICU consultant.

   - If the ACT is >220s:
     - if ACT is 220-240s: decrease heparin infusion by 10%
     - if ACT is 240-260s: decrease heparin infusion by 20%
     - if ACT >260s: Inform ICU consultant.

3. **ACT monitoring**
   - With each circuit change and when platelets or blood are administered to the patient**,** obtain postfilter (blue port) ACT every 30 minutes until ACT is stable between 180-220s.
   - Monitor ACTs 30 min after any heparin change.
   - Monitor ACTs every four hours once stable

Reference:

1. Brophy PD, Bunchman TE. References and Overview for Hemofiltration in Pediatrics and Adolescents. www.PCRRT.com

Annex 3

KK Women's and Children's Hospital
SingHealth

Children's Intensive Care Unit

CONTINUOUS VENOVENOUS HAEMODIALYSIS/FILTRATION (CVVHD/F)

This leaflet serves to provide patient/parents with some general information on continuous dialysis/filtration for children who are critically ill at our Intensive Care Unit.

Patient/Parents are encouraged to discuss any concerns or doubts regarding their child's condition with the doctor-in-charge.

What is CVVHD/F?

Haemodialysis is a process by which blood is drawn from a patient and passed through an external circuit where toxins and/or fluid are removed. This is usually done for patients with renal failure, fluid overload or intoxication with a substance that can be removed by dialysis.

How does CVVHD/F work?

This involves the insertion of a dialysis catheter into a big vein – the femoral vein in the groin or the subclavian/ internal jugular veins in the neck.

In the intensive care unit where the patients are critically ill, dialysis is done by a continuous process where blood is drawn from one lumen of the catheter, "cleansed" in the dialysis circuit and returned to the patient in the second lumen of the catheter, throughout the day.

What are some of the risks associated with CVVHD/F?

1. To prevent blood in the dialysis circuit from clotting, the medications are given to the patients. This is usually done by giving a medication (anticoagulant) to bind calcium (which is needed for normal clotting) when the blood is in the dialysis circuit. Calcium is then replaced to the patient via a separate catheter into the patient. Sometimes, when heparin is used instead. Heparin also prevents blood from clotting in the patient that can cause to patient to bleed more easily. The choice of the anticoagulant is based on the medical condition of the patient. Blood tests are done on a regular basis to ensure adequate anticoagulation and safety of the dialysis.

2. Whenever a tube is inserted into a blood vessel there is an increased risk of infection. Signs of infection are watched for carefully and antibiotics given if needed.

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3. During initiation, instability of the blood pressure is sometimes encountered. This will be monitored closely and the necessary action taken.

4. As the catheter is relatively large, it can sometimes impair the blood flow in the limb (if inserted in the leg) or clots can form in the vein.

How long will patient be on CVVHD/F?

The duration of use of CVVHD/F is dependent on return of kidney function for the case of kidney failure. For the case of toxin removal, it is stopped once the toxin in the body is reduced to a safe level.

Care for patients under CVVHD/F

During the course of CVVHD/F treatment, the patient will be reviewed daily and his condition monitored closely by the team. Blood tests to monitor the kidney and electrolyte status will be done regularly.

The Family's Role

Parents and other family members like siblings play an important role in the child's care and recovery. Visitation is strongly encouraged.

KK Women's and Children's Hospital
SingHealth

Annex 4

Patient Sticky Label

CONTINUOUS RENAL REPLACEMENT THERAPY PRISMA ORDER SHEET

Weight (kg)		**Height (cm)**	_____	**BSA (m^2)**	_____
Allergy		**Date**	_____		
Catheter	_____	_____Fr	_____cm	**Site**	_____
Filter	HF20	M60	M100		
Mode	SCUF	CVVH	CVVHD	CVVHDF	

Blood flow (ml/min) (4-5ml/kg/min)	Start at	_____	Target	_____
Replacement rate (ml/hr) (2L/1.73m^2/hr)	Start at	_____	Target	_____ _____
Dialysate rate (ml/hr) (2L/1.73m^2/hr)	Start at	_____	Target	_____
With citrate anticoagulation **Citrate infusion rate (ml/hr)** 1.5 x blood flow rate **CaCl2 rate (ml/hr)** 40% of Citrate rate	Start at Start at	_____ _____	Titrate citrate and CaCl2 infusion rates as per citrate protocol	

With heparin anticoagulation **Heparin infusion dilution (Systemic)** **Heparin loading** **Heparin maintenance infusion** **ACT Monitoring** **(baseline, 1hr and 4-6hrly)**	Dilute _____U heparin in 50ml N/S (Amt= Wt(kg)x10Ux20) 1ml/hr=10U/kg/hr Bolus 20U/kg; 2ml of 50ml syringe Continuous infusion at _____ml/hr Baseline ACT _____ (normal 80-120) Keep ACT between _____ and _____ Increase or decrease by 10%

Fluid removal rate (ml/hr) _____ **(A+C-B)**

A: Intake (IV fluids, drug volume, fluid replacement, TPN, blood products, calcium infusion, citrate infusion)
B: Output (urine losses, drains losses)
C: Desired negative balance

Inform the MO if MAP drops below _____mmHg

Solutions used	**Replacement Fluid**	**Dialysate Fluid**
Biphozyl (used in citrate anticoagulation only)		
PrismaSol BO		

If **PrismaSol BO** is used as a replacement or dialysate solution, add 2mmmol/l of KCL and 2mmol/l of KH2PO4 to the solution **unless** serum K is >5mmol/l or the patient has a risk of rapid rise in serum K or phosphate, such as in severe burns, massive trauma or severe tumor lysis.

Biphozyl contains physiological concentrations of potassium and phosphate.

Priming solution (**Avoid blood prime with M60 or M100**)	First prime: 1000ml Heparin Saline (10,000U/L)	2nd prime: 1000 ml normal saline
Connecting to patient	Heparinized prime can be given to patient within 1hr prime* If machine is stagnant >1hr after priming, perform manual prime with 300ml N/S and load heparin 20U/kg	
Recirculation	Use N/S for re-circulation. Dilute 100U heparin per 100 N/S Maximum re-circulation time is 2hrs Heparin locked lumen; <5kg (33U heparin/ml) >5kg (100U heparin/ml)	