CONTINUOUS VENO-VENOUS HAEMO(DIA)FILTRATION (CVVHDF) IN PICU – CHW - PRISMAX

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- All CVVH prescriptions must be made on Haemofiltration - Medical and Haemofiltration - Nursing on eMR. All prescriptions must be made by a senior medical officer **(Intensivist or PICU Fellow)** and signed on eMR before set-up.
- A new prescription must be written and signed on eMR every day. All changes to prescriptions must be made and signed on eMR and then implemented.
- Every new circuit must be entered by the nurse on eMR.
- Be careful to choose the correct size double lumen GamCath® and the correct size filter/ circuit for the size of the patient.
- Pre-Blood-Pump (PBP) Replacement Fluid goes on the hook with the white triangle Δ. This is usually Prismocitrate 18/0, occasionally Hemosol B0. Run at 30 mL/kg/hr (minimum 200ml/hr) for both citrate and Hemosol. See Table 1 on Page 8 for exact rates.
- If extra clearance wanted, add dialysis first at 30-50 mL/kg/hr. If further additional clearance is required then increase post filter replacement to 30 ml/kg/hr as the third step. See Table 1 on Page 8 for exact rates.
- Dialysis Fluid goes on the hook with the green square ■. This is usually Prism0cal B22 if citrate used, occasionally Hemosol B0, run at 0 mL/hr, but sometimes run at 30-50 mL/kg/hr. This is the first option to increase clearance.
- Post-Filter Replacement Fluid goes on the hook with the purple octagon. The fluid used is always Hemosol B0. This is run at 10 mL/**kg**/hr default when using both citrate and Hemosol (see Table 1 on Page 8). If further additional clearance is required then increase rate to 30 mL/kg/hr. See Table 1 on Page 8 for exact rates.
- See Table 5 on Page 15 for the correct additives.

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	29th December 2021	**Review Period**: 3 years
Team Leader:	Staff Specialist	**Area/Dept**: PICU CHW

- Default set-up mode is CVVHDF, but with dialysis set at zero, so actual treatment mode is CVVH. Dialysis and/or post-filter replacement fluid can be added later.
- When using citrate replacement fluid, an additional calcium chloride infusion is needed, and a separate prescription for magnesium, after normalising both before starting CVVH.
- Plasma ionised calcium must be **normalised prior to starting** citrate anticoagulation (>1.0 mmol/L). Give a bolus if necessary: 0.07-0.14 mmol/kg (= 0.1-0.2 mL/kg of 10% calcium chloride) over 30 min.
- The PrisMax machine will administer the Calcium Chloride infusion from the syringe driver located on the machine. This is to be connected to a separate infusion line directly to the patient via central venous catheter (or, if no access available, into a Y-connector inserted into the circuit of the blood return lumen of the GamCath).There will be three different concentrations of the Calcium Chloride infusion based on the filter size. See page 18.
- Calcium Chloride will be administered via the PrisMax syringe driver as a percentage of compensation, replacing a percentage of the calcium lost in the effluent. Starting compensation will be 100% and titrated as required based on the patient's ionized calcium.
- Recalculate "Patient Fluid Removal" regularly, at least every three to four hours.
- Citrate (Prismocitrate 18/0) is the default substitution fluid and anticoagulation method.
- **Prism0cal B22 is the dialysate fluid when using Prismocitrate 18/0. Note this contains 4 mmol/L Potassium as default. Do not add additional Potassium to this fluid type.**
- The same one person must stay with the machine for the entire set-up process, with or without an assistant.
- The set-up must be performed in a well-lit central place.
- The prescription settings in the machine must be checked and signed on the Haemofiltration Medical/ Haemofiltration Nursing on eMR by 2 CVVH trained nurses.
- A medical officer should be present whenever a patient goes on to the extra-corporeal circuit (blood pump started) and when CVVH is ceased and when there is any significant interruption.
- The emergency CVVH trolley must be assembled for every patient prior to starting CVVH.

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CHANGE SUMMARY

Key changes to the document are as follows:

- Removal of ST150 set
- Change of Prismocitrate 10/2 to Prismocitrate 18/0.
- Change of Prism0cal to Prism0cal B22
- Change from Prismaflex to PrisMax machine
- Change from high flow three way tap to Y connector for calcium infusion connection to return line
- Changes in Calcium Chloride administration, no longer require a separate infusion pump. The PrisMax will administer the Calcium Chloride through the syringe pump on the machine. This will require a separate infusion line connecting the syringe directly to the patient. Administration of Calcium Chloride will be run on a compensation basis on the calcium lost in the effluent.
- Addition of autoeffluent accessory for PrisMax, available in specific PICU rooms only.
- **26/04/22:** CHW Drug Committee approved with changes. Added instructions for Hemosol BO – to break frangible seal prior to use and use epoprostenol consistently thought out the guideline.

READ ACKNOWLEDGEMENT

- Training/Assessment Required – All PICU nursing staff undertaking training to manage patients on CRRT using the Baxter PrisMax® machine
- Read Acknowledge Only – All PICU nursing staff already trained to manage patients on CRRT Baxter PrisMax® machine. PICU Intensivists and all other PICU medical staff required to write orders for CRRT using the Baxter PrisMax® machine.

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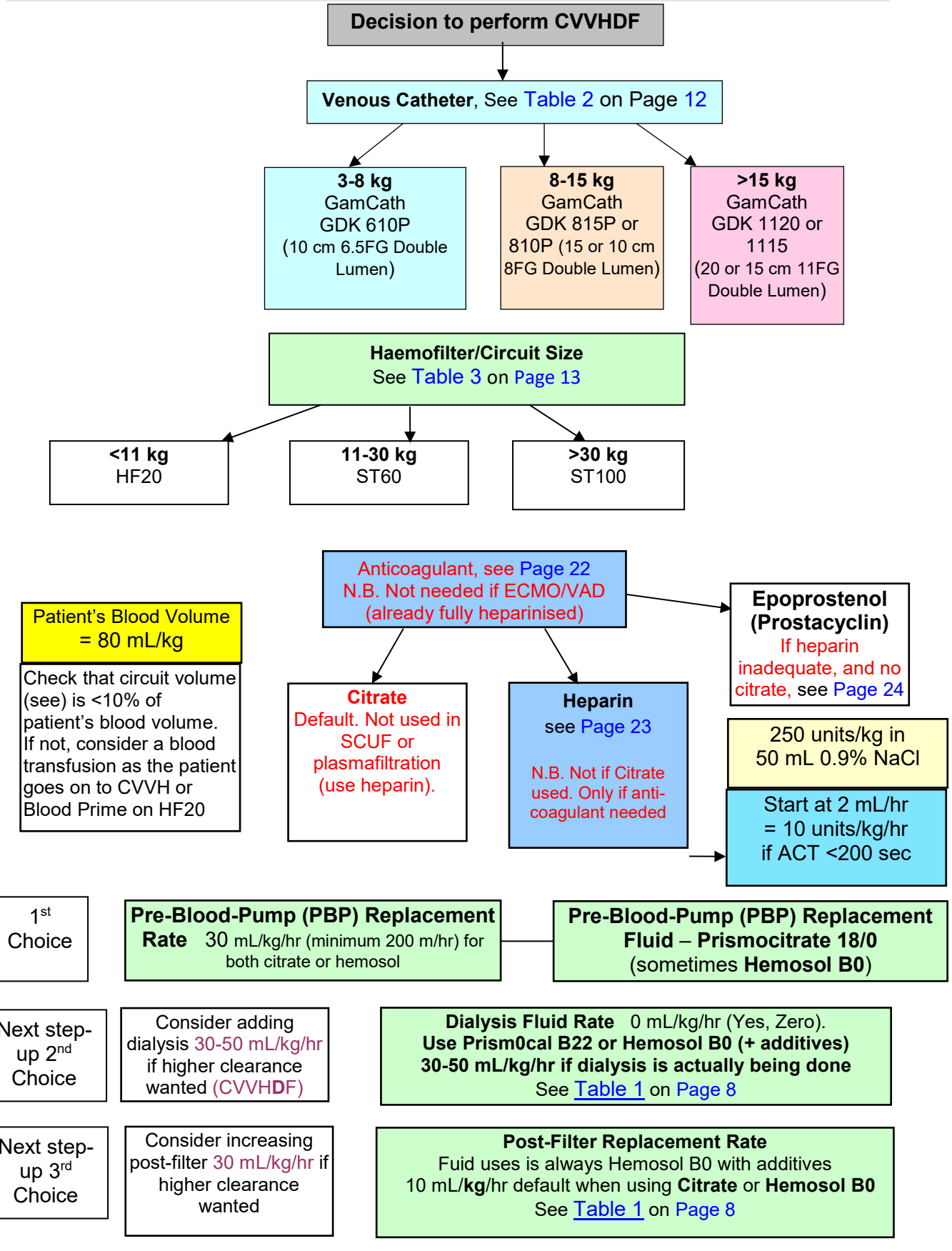
Prescriptions Flow Diagram



Blood Flow
Minimum 20 mL/min

Pre-Blood-Pump (PBP) Replacement Rate	200 mL/hr (minimum)	30 mL/kg/hr for Citrate or Hemosol Maximum rate 2100 mL/hr	Add Dialysis if higher clearances needed – Filtration rate automatically increases	And increase Post-Filter replacement fluid if further additional clearance needed
Blood Flow	20 mL/min (minimum)	3 mL/kg/min (only option) Normal max 210 ml/hr		
Round the blood flow up to the next number or to 20 minimum (and have Replacement rate = 240).				
Dialysis flow (if CVVHDF) is 30 or 50 mL/kg/hr (normally max 3300 mL/hr)				
Post-filter flow is 10 mL/kg/hr **default** when using both **Citrate** or **Hemosol B0** (this can go up to 30 mL/kg/hr, but normally max 2100 mL/hr)				

Replacement Fluid
See Page 15

Slow Continuous Ultrafiltration (SCUF) only
- No replacement fluid
- Blood flow 3 mL/kg/min (min 20 mL/min)

N.B. needs heparin if any anticoagulation needed

Citrate-based (Prismocitrate 18/0) if needs anticoagulant

Bicarbonate-based (Hemosol B0) if anticoagulant not needed

Check serum K, PO_4

If Citrate, prescribe calcium and magnesium separately. See Page 18, 20

See text for additives (See Page **15**)
Additives are final concentration *per Litre*

Renal Failure	Tumour Lysis	Inborn Error of Metabolism -	Systemic Inflammatory Response Syndrome
KCl up to 4.5 mmol/L if K <4 mmol/L No Phosphate	KCl up to 4.5 mmol/L if K <4 mmol/L No Phosphate	KCl 3.0 mmol/L KH_2PO_4 1.5 mmol/L	KCl up to 3.0 mmol/L KH_2PO_4 1.5 mmol/L

Dialysis fluid (If CVVHDF is being done) – With Citrate use Prism0cal B22, otherwise use Hemosol. Add K &/or Phos to make same concentration as the replacement fluid.
Dose is 30-50 mL/kg/hr (max 3300 mL/hr).
The machine calculates diafiltration rate automatically.
Note: Prism0cal B22 contains 4 mmol/L Potassium as default. Do not add additional Potassium to this fluid type.

Insensible water loss

2 kg - 1.3 mL/kg/hr
4 kg - 1.0 mL/kg/hr
10 kg - 0.8 mL/kg/hr
20 kg - 0.6 mL/kg/hr
40 kg - 0.5 mL/kg/hr
60 kg - 0.4 mL/kg/hr

"Patient Fluid Removal" See worksheet, Page 10

= Expected IV fluids including drugs mL/hr (don't include any boluses)
+ Expected feeds mL/hr
– Expected urine mL/hr
– Expected other losses mL/hr
– Insensible loss (see adjacent table)
+ Desired hourly **fluid off** (this refers to the *whole patient's body*, i.e. what you want off the patient overall per hour. E.g. if you want 50 mL/hr off, then this line reads **+ 50**) N.B in burns, you usually want the patient neutral but don't include the extra fluid given for increased insensible loss (see worksheet, Page 10).

"Patient Fluid Removal" will be Positive when you want the patient to LOSE fluid
Round up/down to nearest 10 (Care in small babies as this means patient balance is up to 240 mL/day more or less than desired)

→ **Replacement rate = (Dia-) Filtration rate (– Dialysis rate) + "Patient Fluid Removal"**

Flow Rates

N.B. This table does not apply to SCUF – Choose 3 mL/kg/min blood flow (minimum 20), zero replacement and no calcium

Table 1. Pre-Blood-Pump (PBP) Replacement flow and Blood flow.

Use the following version for Prismocitrate 18/0

(**see next page for Hemosol B0**)

N.B. The PBP Prismocitrate 18/0 column is a default aimed to achieve blood Citrate concentration of 3.0 mmol/L. If more or less citrate is needed then change the 3.0 figure and the PBP flow changes automatically.

Weight Kg	Blood	Pre-Blood-Pump (PBP)	Dialysate	Dialysate	Post-filter	Post-filter	Calcium
		Prismo-citrate	Prism0cal B22	Prism0cal B22	Hemosol	Hemosol	As per the machine
	Default	Default	Default	Optional	Default	Optional	Starting dilution
	mL/min	mL/hr	mL/hr	mL/hr	mL/hr	mL/hr	mmol/L
2 — 6	20	200	0	200 — 300	60	200	**136**
6 — 7	22	220	0	200 — 350	70	220	136
7 — 8	26	260	0	250 — 400	80	260	136
8 — 9	28	280	0	250 — 400	90	280	136
9 — 10	30	300	0	300 — 450	100	300	136
10 — 11	34	340	0	300 — 500	110	340	136
11 — 12	36	#360	0	350 — 550	120	360	**408**
12 — 13	40	#400	0	400 — 600	130	400	408
13 — 14	44	#440	0	400 — 700	140	440	408
14 — 15	46	#460	0	450 — 700	150	460	408
	#50 and 600 for PBP if ST60 is used						
15 — 16	50	500	0	500 — 800	160	500	408
16 — 18	55	550	0	550 — 850	180	550	408
18 — 20	60	600	0	600 — 950	200	600	408
20 — 21	65	650	0	650 — 1000	210	650	408
21 — 23	70	700	0	700 — 1100	230	700	408
23 — 25	75	750	0	750 — 1200	250	750	408
25 — 26	80	800	0	800 — 1250	260	800	408
26 — 28	85	850	0	850 — 1350	280	850	408
28 — 30	90	900	0	900 — 1400	300	900	408
30 — 36	110	1100	0	1100 — 1700	360	1100	**680**
36 — 40	120	1200	0	1200 — 1900	400	1200	680
40 — 43	130	1300	0	1300 — 2000	430	1300	680
43 — 46	140	1400	0	1400 — 2200	460	1400	680
46 — 50	150	1500	0	1500 — 2400	500	1500	680
50 — 53	160	1600	0	1600 — 2500	530	1600	680
53 — 56	170	1700	0	1700 — 2700	560	1700	680
56 — 60	180	1800	0	1800 — 2800	600	1800	680
60 — 63	190	1900	0	1900 — 3000	630	1900	680
63 — 66	200	2000	0	2000 — 3200	660	2000	680
>66	210	2100	0	2100 — 3300	700	2100	680

Use the following version for Hemosol B0 (with/without Heparin)

Weight Kg	Blood	Pre-Blood-Pump (PBP)	Dialysate	Dialysate	Post-filter	Post-filter
		Hemosol	Hemosol	Hemosol	Hemosol	Hemosol
	Default	Default	Default	Optional	Default	Optional
	mL/min	mL/hr	mL/hr	mL/hr	mL/hr	mL/hr
2 — 6	20	200	0	200 — 300	60	200
6 — 7	22	220	0	200 — 350	70	220
7 — 8	26	260	0	250 — 400	80	260
8 — 9	28	280	0	250 — 400	90	280
9 — 10	30	300	0	300 — 450	100	300
10 — 11	34	340	0	300 — 500	110	340
11 — 12	#36	360	0	350 — 550	120	360
12 — 13	#40	400	0	400 — 600	130	400
13 — 14	#44	440	0	400 — 700	140	440
14 — 15	#46	460	0	450 — 700	150	460
	#50 and 600 for PBP if ST60 is used					
15 — 16	50	500	0	500 — 800	160	500
16 — 18	55	550	0	550 — 850	180	550
18 — 20	60	600	0	600 — 950	200	600
20 — 21	65	650	0	650 — 1000	210	650
21 — 23	70	700	0	700 — 1100	230	700
23 — 25	75	750	0	750 — 1200	250	750
25 — 26	80	800	0	800 — 1250	260	800
26 — 28	85	850	0	850 — 1350	280	850
28 — 30	90	900	0	900 — 1400	300	900
30 — 36	110	1100	0	1100 — 1700	360	1100
36 — 40	120	1200	0	1200 — 1900	400	1200
40 — 43	130	1300	0	1300 — 2000	430	1300
43 — 46	140	1400	0	1400 — 2200	460	1400
46 — 50	150	1500	0	1500 — 2400	500	1500
50 — 53	160	1600	0	1600 — 2500	530	1600
53 — 56	170	1700	0	1700 — 2700	560	1700
56 — 60	180	1800	0	1800 — 2800	600	1800
60 — 63	190	1900	0	1900 — 3000	630	1900
63 — 66	200	2000	0	2000 — 3200	660	2000
>66	210	2100	0	2100 — 3300	700	2100

Transcribe on to the prescription sheet

Worksheet (manual) for "Patient Fluid Removal"

Name:

Calculations (Enter HOURLY amounts.

If variable, estimate daily amount and divide by 24)

In Burn patients, don't include the extra fluid given for increased insensible loss.

This is a Positive number for a negative patient balance

Date	Time	Feeds +	Drugs + (including infusions)	Blood products & colloid (not urgent volume) +	IV's +	TPN –	Urine –	Other losses –	Insens. Loss +	Desired fluid off =	"Patient Fluid Removal" (usually positive)
2/11/11	11.30	5	5	20	17	23	25	10	15	30	+ 50
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	
		+	+	+	+	–	–	–	+	=	

Example only

Example only

Enter the starting Replacement Flow here

_____

Filtration flow rate is given by:

Diafiltrate (Effluent)
=
Pre-Blood-Pump (PBP) Replacement fluid flow
+ Post-Filter Replacement fluid flow
+ Dialysis fluid flow
+ "Patient Fluid Removal"

e.g.
Filtrate = 720 + 600 + 20 + 50
= 1390

"Patient Fluid Removal" used to be known as "Machine Balance"

Machine balance used to be entered as a negative number, "Patient Fluid Removal" is entered as a positive number.

Prescriptions

All CVVH prescriptions must be made and signed on eMR by Intensivist or PICU fellow.

A new prescription must be written every day by Intensivist or PICU fellow.

Every change in the prescription must be entered and signed on the eMR by Intensivist or PICU fellow before set-up.

Every new circuit must be entered by the nurse on the eMR.

The decision to start CVVH

- CVVH may only be commenced after discussion with the Intensivist.
- CVVH is indicated in unstable patients with any of the indications below.

Indications

- Correction of water overload when the kidney is unable to excrete sufficient water.
- To remove larger quantities of water from the body than the kidney is able to achieve in order to enable the administration of therapeutic fluids such as parenteral nutrition.
- To remove excess electrolytes from the body in cases of retention of, e.g., potassium, magnesium, phosphate.
- Correction of disorders of acid/base homeostasis, including inborn errors of metabolism, particularly metabolic acidosis, when non-volatile acid is being produced in quantities greater than the kidney can excrete.
- Ammonium removal in liver failure (but it does not substitute liver function!).
- Removal of urea and other waste products of metabolism in cases of renal failure or hypercatabolic state where excess urea is produced.
- Occasionally, removal of ingested poisons or toxins in sepsis.
- For patients who are haemodynamically stable and not ventilated, and who are developing renal failure and/or water overload, intermittent haemodialysis may be a better option, because it is less labour-intensive and less anticoagulation is needed.
- Some rooms are plumbed for intermittent haemodialysis, and the dialysis unit should be consulted for this service.
- Patients on CVVH may be changed to intermittent haemodialysis once the primary disease is resolving and the patient is haemodynamically stable.
- For more information see Background on Page 46.

Choosing a Venous Catheter (Venous Access)

- Venous access is achieved using a double-lumen GamCath. Often the femoral vein is used, though subclavian or internal or external jugular veins can be used.
- If the femoral vein is used its tip must be confirmed on X-ray to be in the IVC.
- As a general guide, use (See Table 2 below):
  - 6.5 FG double lumen GamCath in children <8 kg (10 cm)
  - 8 FG double lumen GamCath in children 8-15 kg (15 cm)
  - 11 FG double lumen GamCath in children >15 kg (20 cm)
- The proximal lumen is usually for blood withdrawal (it is colour coded red), the distal for blood return (blue).

Table 2. Central Venous Catheters for CVVH

Patient size	Manufacturer/ Brand Name	Description	Catheter Size	Lumen Volumes (mL) NB normally inject 0.1 mL more than these figures, rapidly Prox	Dist	Maximum recommended Blood Flow
<8 kg	GamCath	GDK 607-5P double lumen	6.5 FG × 7.5 cm	0.75	0.78	75 mL/min
<8 kg	GamCath	GDK 610P double lumen	6.5 FG × 10 cm	0.75	0.78	75 mL/min
<10 kg	Arrow	double	7FG × 20 cm			75 mL/min
8-15 kg	GamCath	GDK 815P double lumen	8 FG × 15 cm	0.88	0.90	150 mL/min
>15 kg	GamCath	GDK 1120P double lumen	11 FG × 20 cm	1.2	1.26	300 mL/min

Choosing the Haemofilter/Circuit

See Table 3 on Page 13.

- HF20 for children <11 kg. This filter provides 200-600 mL/hr of filtrate at a blood flow of 20-120 mL/min and trans-membrane pressure (TMP) 100 mmHg. Higher filtrate flow can be achieved, but a higher TMP is developed by the filtrate pump.
- ST60 for children 11-30 kg. Filtrate 900-1400 mL/hr is provided at blood flow 50-180 mL/min at TMP 100 mm Hg.
- ST100 for children >30 kg. Filtrate up to 6000 mL/hr is provided at blood flow 80-400 mL/min at TMP 100 mm Hg.

For plasmafiltration:

- TPE1000 for children 11-60 kg. Not routinely kept.
- TPE2000 for children >60 kg. Not routinely kept.

Table 3. Haemofilters/Circuits for Paediatric CVVH(DF) and Plasma Filtration

Patient size	Manufacturer	Sterilisation	Circuit volume mL	Membrane	Blood flow
Haemofiltration					
<11 kg	Gambro HF20	Ethylene oxide	60	Polyethersulfone	20-120 mL/min
11-30 kg	Gambro ST60	Ethylene oxide	93	AN69	50-180 mL/min
>30 kg	Gambro ST100	Ethylene oxide	152	AN69	80-400 mL/min
>60 kg	Gambro ST150	Ethylene oxide	189	AN69	100-450 mL/min
Plasma filtration					
<60 kg	Gambro TPE1000	Ethylene oxide	94		
>60 kg	Gambro TPE2000	Ethylene oxide	166		

Choosing the Flushing fluid; Priming the Circuit

- Initial priming of the circuit is with Heparinised saline (2500units Heparin/ Litre);
  - 1 litre 0.9% Sodium Chloride for HF20, ST60 & ST100
- Final prime is with 4% NSA
  (N.B. Albumin is OK for metabolic disease – the albumin is not metabolised).
  - 100 mL for HF20
  - 150 mL for ST60
  - 200 mL for ST100
- For babies weighing <10 kg, only use HF20 circuit.

  Blood prime option is ONLY available for HF20 circuit & ST60 (see blood prime method).

  If extracorporeal blood volume is >10% of patient's blood volume, discussion must occur with Intensivist/ PICU fellow whether the patient requires a blood prime or a packed red blood cell transfusion separately.

Choosing anticoagulant

- Citrate anticoagulation is the default. Always discuss with the intensivist which anticoagulant to use. If there are contraindications to citrate (rare) then choose heparin or none. If there is a coagulopathy then anticoagulation may not be needed, but you may still use citrate if there is not a contraindication. If there is a contraindication to heparin as well as to citrate, then choose Epoprostenol (see below).
- Citrate is rarely contraindicated in liver impairment – discuss with intensivist.
- Note that if anticoagulation method is changed from heparin to citrate or vice versa, during the course of treatment, then a new circuit will need to be set up. "New Patient" will have to be selected on the PrisMax to allow the user to set up a new prescription on the machine.

Is Replacement fluid needed?

Choosing Between CVVH or SCUF (Slow Continuous Ultrafiltration)

- Continuous veno-venous haemofiltration (CVVH) is the standard mode used within this hospital, however the machine is always set up in CVVHDF mode without any dialysate being run. If fluid overload needs to be corrected, or the patient requires room for TPN or other non-standard fluids, then SCUF without replacement fluid can be utilised. See Background Page 46.
- If CVVH/SCUF is being performed to make room for TPN, then note that, in effect, TPN (low Na concentration) is replacing filtered extracellular fluid (high Na) so there will be a sodium drain. Watch for a fall in plasma Na. Na supplementation will not be achieved by increasing the Na content of the replacement fluid. A *separate 3% NaCl infusion* may be needed.
- See Table 4 below for replacement fluid guidelines in various disease processes.
- In SCUF, "Patient Fluid Removal" = Filtration rate (displayed as a positive value), and Replacement rate = 0. Blood flow should be 3 mL/kg/min (minimum 20 mL/min).

Table 4. Mode to choose for various disease processes.

Disease Process	Mode to Use	Technique
▪ Fluid overload only	Slow continuous ultrafiltration - SCUF	Remove as much fluid per hour as is required. Na supplementation may be needed.
▪ Systemic inflammatory response syndrome ▪ Drug overdose ▪ Inborn error of metabolism ▪ Renal failure	CVVH	36-60 mL/kg/hr filtrate, replaced IV with Bicarbonate- or Citrate-containing, haemofiltration replacement fluid, depending on choice of anticoagulant + choice of KCl /K acetate /KH_2PO_4 (see **Table 5**- exact quantities added depend on plasma chemistry)
▪ Tumour lysis syndrome	CVVH	36-60 mL/kg/hr filtrate, replaced IV with Bicarbonate - or Citrate-containing haemofiltration replacement fluid, depending on choice of anticoagulant, + choice of KCl /K acetate (NOT Phosphate) (see Table 5- exact quantities added depend on plasma chemistry)

Choosing Replacement Fluid

Citrate-based solution (5 litre bags)

To be used when citrate anticoagulation is preferred (see Choosing anticoagulant below and Citrate theory, Appendix 3). Although citrate-based replacement fluid is satisfactory for the majority of patients, some may not be able to efficiently metabolise citrate into bicarbonate. This leads to a loss of the patients' normal acid-base state. Patients who may be contraindicated include:

- Those already with high lactate production (septicaemia, hypoxia/ischaemia, mitochondriopathies)

  Mild hyperlactataemia up to 5 mmol/L is not generally a problem.

- Babies (minimum replacement flow is 240 mL/min)
- Patients with severe hepatic dysfunction (see page 21)

For patients receiving citrate-based solution a Calcium Chloride infusion will need to be administered via the PrisMax machine. This is charted in the CVVH order form on eMR (See Prescribing Calcium on Page 18)

A separate prescription for magnesium supplementation is needed. (See

Prescribing **Magnesium** on Page 20)

- **Additives**: Potassium dihydrogen phosphate, potassium acetate, or potassium chloride will need to be added according to desired potassium and phosphate levels, and acid-base state, immediately before use (see
- **Table 5** below).

Never add potassium to >4.5 mmol/L total

Never add phosphate to >2.0 mmol/L total (normal max is 1.5 mmol/L)

- Hypophosphataemia should be corrected with a separate Potassium Phosphate or Sodium Phosphate infusion (see Water and Electrolyte Management in PICU Policy).

NB: Do not add extra K and PO_4 to the bags in renal failure (with elevated serum K and PO_4).

Bicarbonate-based solution Hemosol B0 (5 litre bags)

To be used when Heparin is chosen for anticoagulation. It contains both calcium and magnesium.

Table 5. Haemofiltration replacement fluid composition.

	Hemosol B0		PrismoCitrate 18/0	Prism0cal B22
Electrolyte (all figures in mmol/L)	Gambro Hemosol B0	Gambro Hemosol B0 + KH_2PO_4 1.5 mmol/L + KCl 3.0 mmol/L	Gambro PrismoCitrate 18/0	Gambro Prism0cal B22 (calcium-free)
Sodium	140	**140**	140	140
Potassium	0	**4.5**	0	4
Calcium	1.75	**1.75**	0	0
Magnesium	0.5	**0.5**	0	0.75
Chloride	109.5	**113**	86	120.5
Lactate	3	**3**	0	3
Bicarbonate	32	**32**	0	22
Citrate			18	
Phosphate		**1.5**	0	
Glucose	0	**0**	0	6.1
			Add prescriptions of Calcium infusion and Magnesium as per page 18	

Pre-filter replacement fluid

- The standard site for adding Pre-filter replacement fluid is Pre-Blood-Pump (PBP) on the white triangle hanger. This fluid is Prismocitrate 18/0 when on Citrate anticoagulant, and Hemosol B0 when on heparin anticoagulant.

Dialysis fluid

- We always set the machine up for CVVHDF but usually do not run the dialysis fluid. Prism0cal (if Citrate) or Hemosol B0, with same additives as the pre-filter replacement fluid, is hung on the green dialysis hanger with the rate set to 0mls/hr.
- **Note: Prism0cal B22 contains 4 mmol/ L Potassium as default.** Do not add additional Potassium to this fluid type.

- Occasionally dialysis is used in order to increase clearance, for example in cases of severe metabolic derangement in inborn errors of metabolism. In this case run the dialysis at approx. 30-50 mL/kg/hr (see Table 1 on Page 8 above for exact flow rate).

Post-Filter replacement fluid

- In all cases this is run at a constant rate of 10mL/**kg**/hour (see Table 1 on Page 8 above for exact rate). Hemosol B0 is used in all circumstances with the same additives as the Pre-Blood Pump replacement fluid.
- If a decision is made to increase clearance by increasing filtration rate (on top of adding dialysis), then this is achieved by increasing post-filter Hemosol to approx. 30 mL/kg/hr (see Table 1 on Page 8 for exact flow rate).

Choosing Replacement, Dialysis and Blood Flow Rates

- Pre-Blood-Pump (PBP) Replacement is approx. 30 mL/kg/hr for citrate or Hemosol (minimum rate of 200ml/hr). Actual numbers to choose are in Table 1 on Page 8 above.
- If you want a higher clearance, such as in sepsis, hyperkalaemia or inborn errors of metabolism, then add dialysis and/or increase post-filter replacement (see Table 1 on Page 8 for flow rates). **Do not change blood flow!**
- The figures for Pre-Blood-Pump (PBP) replacement flow, Post-Filter replacement flow and Dialysis flow and "Patient Fluid Removal" are what you programme into the machine. The machine automatically calculates the Effluent rate.
- Note that Blood flow is actually 6 × the Pre-Blood-Pump (PBP) Replacement flow rate, 100 mL/min of blood flow for every 1000 mL/hr of replacement flow. This is for both citrate and hemosol.
- Filtrate flow is approximately equal to the total replacement + dialysis flow. It is slightly higher due to the "Patient Fluid Removal". Remember that the effluent rate is not programmed into the PrisMax machine, but rather the "Patient Fluid Removal", replacement and dialysis flows are programmed in.
- Because of the pre-dilution, urea clearance is approximately 7/8th (citrate) or 5/6th (Hemosol) of the filtrate.
- Do not have less than 20 mL/min blood flow and 200 mL/hr Pre-Blood-Pump (PBP) replacement flow (for both citrate and hemosol).
- Blood flow is 20-50 mL/min (2 mL/min increments) with the infant HF20 circuit, 50-100 mL/min (5 mL/min increments) with the ST60 circuit and 100-400 mL/min (10 mL/min increments) with the ST100. Accuracy is ±10%. When returning blood to the patient at the end of treatment, blood flow is 10-100 mL/min. When recirculating a closed circuit, blood pump flow is 50-150 mL/min.
- Minimum Pre-Blood-Pump (PBP) flow (other than zero) is 10 mL/hr for the HF20 circuit and 10 mL/hr for the larger ones. Increments are 10 and 10 respectively. Accuracy is ±30 mL/hr.

- Minimum Dialysis flow (other than zero) is 50 mL/hr for the HF20 circuit and 50 mL/hr for the larger ones. Increments are 50 and 50 respectively. Accuracy is ±30 mL/hr.
- Minimum Post-Filter flow (other than zero) is 20 mL/hr for the HF20 circuit and 50 mL/hr for the larger ones. Increments are 20 and 50 respectively. Accuracy is ±30 mL/hr.
- Patient fluid removal is 0-500 mL/hr in increments of 10 mL/hr. Accuracy is ±30 mL/hr and ±300 mL/24 hr
- If clearance is inadequate (continuing uraemia or acidosis), dialysis may be added &/or post-filter replacement may be increased (CVVHDF – see Background on Page 46). Discuss with intensivist.

What to do if you want to make changes to the "Calculated Patient Fluid Removal".

- Remember that this is actually done by changing the "Calculated Patient Fluid Removal" which itself changes the filtrate rate. The replacement rate must not be changed. If you use the worksheet to recalculate the "Patient Fluid Removal", stop at "Patient Fluid Removal" and do not recalculate filtrate rate.
- The filtrate rate changes automatically as you programme the new "Patient Fluid Removal". This is correct. The small change in filtrate rate does not matter.
- To adjust "Patient Fluid Removal", press on yellow box on running screen labelled "PFR" and adjust to calculated Patient Fluid Removal.
- To view the current period and cumulative period of fluid removal, press "History" then "PFR"

Prescribing Calcium chloride infusion for Citrate based Treatment

- Plasma ionised calcium must be **normalised prior to starting** treatment (>1.0 mmol/L). Give a bolus if necessary: 0.07-0.14 mmol/kg (= 0.1-0.2 mL/kg of 10% calcium chloride) over 30 min.
- The Calcium Chloride infusion is attached to the PrisMax syringe driver and the rate is programmed by the machine
- The concentration of the Calcium infusion will depend on the filter size used for the patient as below:

Filter Size	Concentration mmol/L	mmols per 50mL syringe
HF20	136mmol/Litre	6.8mmols in 50mL of 0.9% Sodium Chloride (1 vial in 50mls)
ST60	408mmol/Litre	20.4mmols in 50mL of 0.9% Sodium Chloride (3vials in 50mls)
ST100	680mmol/Litre	34mmols in 50mL NEAT (5 vials in 50mls)

- Commence the calcium chloride infusion at 100% compensation. This is set when inserting the prescription in the therapy set up.

- Calcium infusion will need to be connected to a specific infusion line called "Calcium Line for Prismaxflex – CA 250". This infusion line has a one way valve built in so does not require a NAD to be attached.
- This infusion line will connect onto the existing, primed Y connector attached to the return line. Remember: The Calcium infusion MUST run with return line (Blue).

Monitoring and Adjusting the Systemic (Patient) Ionised Calcium

- Arterial or venous blood gases from a separate arterial or venous line should be performed hourly initially, to measure systemic ionised calcium. Ionised calcium must be kept in the range 1.0-1.2 mmol/L. Adjust the calcium chloride compensation according to table 6 below. Sequential adjustments may be needed.
- Record both the patient's ionised calcium and the circuit ionised calcium in the respective rows on eMR Haemofiltration Nursing screen.

Table 6. Adjustment of Calcium Chloride Infusion based on percentage of compensation)

Systemic ionised calcium (Ca_i)	
>1.2	Decrease Calcium compensation by 10%
0.9-1.2 mmol/L (optimum)	No adjustment
0.8-0.9	Increase Calcium compensation by 10%
<0.8	Give 0.1 mmol/kg over 30 min and Increase Calcium compensation by 10%

PLEASE NOTE: If Calcium Chloride Compensation is >140% then consider Citrate Accumulation and discuss with PICU Intensivist.

Monitoring and Adjusting the Circuit (Post-Filter) Ionised Calcium (when on Citrate only)

- Plasma ionised calcium in the circuit must be <0.5 mmol/L to ensure effective anticoagulation (aim for 0.25-0.35 mmol/L). The sample should be taken from the venous return line blue port immediately post filter.
- With the above adjustments the ionised calcium is almost always <0.5 mmol/L. It should be measured hourly for three hours or until stable, then 12 hourly ongoingly.
- If the circuit ionised calcium is high or low then titrate the citrate concentration in 0.1mmol/L increments as shown in the table below. This automatically changes the citrate flow rate relative to blood flow.

Circuit calcium	
<0.25	Decrease Citrate by 0.1mmol/L and repeat level within 1hr
0.25-0.35	No adjustment
0.35- 0.5	Monitor every hour until within normal ranges
>0.5	Increase Citrate by 0.1mmol/L and repeat level within 1hr

Prescribing Magnesium for Citrate based Treatment

- **Plasma magnesium must be normalised prior to starting this treatment (>0.7 mmol/L)**.
  Give a bolus if necessary (0.4 mmol/kg $MgSO_4$ IV over 30-60 min).
- 50% magnesium sulphate (undiluted) 0.4 mmol/kg (0.2 mL/kg) should be given every 6-12 hours while citrate is running, into a separate central venous catheter (if a spare lumen is available). Do not mix it with calcium.
- The plasma magnesium should be measured 12 hourly. If it falls to 0.7 mmol/L give an extra 0.4 mmol/kg of Magnesium Sulphate and decrease the interval between regular doses to 6-8 hours whilst citrate continues.

Acid-Base balance for Citrate based Treatment

- Citrate is completely metabolised in most patients with normal liver function. However some patients may accumulate citrate exhibited by a rising anion gap and rising total patient calcium, with a falling ionised calcium despite increasing the calcium chloride infusion. This is also known as citrate lock. Acidaemia is likely to develop in conjunction with a falling bicarbonate. This can only be managed by decreasing the citrate/replacement amount. You do this by decreasing the blood flow prescribed which will automatically decrease the citrate flow rate. Citrate anticoagulation may have to be abandoned and replaced by heparin, especially if already on minimum blood flow (20 ml/min).
- The citrate in the circuit blood will cause an anion gap in the circuit which is 5-7 meq/L greater than the patient's anion gap. Care should be taken to avoid the result of the circuit blood gas appearing on the patient's eMR results to avoid any confusion over electrolyte and bicarbonate levels. Please use the generic MRN 9999997 for circuit blood gas samples.

Fluid Balance – Prescribing "Calculated Patient Fluid Removal"

- During CVVH the fluid balance for the patient for each hour is calculated as follows: -
  - **Patient balance = + IV fluids (TPN including lipid + crystalloid + drugs + colloid)**
    + Enteral feeds
    – Urine

– Insensible losses/other losses
– "Patient Fluid Removal"

- This last term "Patient Fluid Removal" is the amount of fluid taken off the patient by the machine. It is equal to the difference between Filtrate out and Replacement fluid in.
    - **"Patient Fluid Removal" = Filtrate out – Replacement fluid in**
- If dialysis is being added then it is the difference between the diafiltration rate and the replacement + dialysis fluid rate.
    - **"Patient Fluid Removal" = Diafiltrate (Effluent) out – Replacement fluid in – Dialysis fluid in**
- First use the printed worksheet to calculate the "Patient Fluid Removal" to programme on the PRISMAX machine. The worksheet calculates it as follows

"Calculated Patient Fluid Removal" =
+ Feeds
+ Other regular IV infusions and drugs
+ Colloid & Blood products
+ Maintenance IV fluids
+ TPN
– Urine
– Other measured losses
– Insensible loss
+ Desired (total body) fluid off the patient

Occasionally there is a confounder such as bladder irrigation fluid. Ignore this, but always pay attention continuously to overall fluid balance

See worksheet on Page 10. All numbers entered must be POSITIVE

You programme the Replacement rate (and sometimes Dialysis rate) and the "**Calculated** Patient Fluid Removal" into the machine. The machine calculates the Diafiltrate rate. Therefore:

Filtrate rate = Replacement rate + "Calculated Patient Fluid Removal"

Diafiltrate rate = Replacement rate + Dialysis rate + "Calculated Patient Fluid Removal"

N.B. Replacement rate = PBP replacement rate + Post-filter replacement rate

- These formulas will not guarantee euvolaemia for several reasons:
    - Insensible water loss cannot be known precisely. 10-30 mL/kg/day is a reasonable estimate. See the box on Page 7.
    - Boluses of volume may have to be given for hypotension. These will not have been included in the IV fluids in the above formula because it may not be appropriate to take off in one hour all the filling given in the previous hour.
    - Urine flow, other losses, IV fluids and feeds may change from hour to hour.
    - Frequent circuit changes may result in volume loading if the blood in the circuit is returned to the patient each time.

These inaccuracies can make a significant cumulative inaccuracy in the patient's water balance daily. The only way to judge water balance is by examining the patient frequently and examining the cumulative fluid balance for the day which is displayed on the eMR Fluid balance screen.

You then need to adjust the desired negative (or positive) hourly patient balance and recalculate "Patient Fluid Removal" on the worksheet.

- Discuss 'Ordered hourly patient balance' with intensivist. Pay particular attention to all filling which has been given, as to how slowly to take this off, if at all. Once the patient is at the right hydration state, this hourly balance should be set to zero and "Patient Fluid Removal" recalculated on the worksheet.

Prescribing Heparin for Anticoagulation

Bolus dose (if Heparin is chosen as the anticoagulant)

- If packed cells or albumin is used as the priming solution, the circuit is first primed with heparinised saline as above, then primed with albumin or occasionally packed cells (HF20 & ST60 only).
- Then if ACT is normal (<160 seconds) and there are no signs of active bleeding, give 25 units/kg load of heparin into circuit as the child goes on to the extracorporeal circuit. This should be prescribed as a STAT dose on eMR.

Continuous heparin infusion pre-filter (if Heparin is chosen as the anticoagulant)

This should be prescribed on the IV infusions chart and recorded as a continuous infusion on eMR.

- Continuous infusion of Heparin is routinely used to anticoagulate the CVVH circuit.
- Because heparinisation must be maintained continuously, the need to anticoagulate these circuits can present substantial risks to some patients.
- In all patients, anticoagulation must be accomplished with caution, the heparin dose controlled by close monitoring of the ACT. Patients with coagulopathies may not need any heparin beyond that required for rinsing or "priming" the circuit. If a patient's ACT is >200 seconds before CVVH treatment, do not use heparin (or citrate) until the coagulopathy spontaneously improves. Choose Hemosol B0 for replacement.
- Do activated clotting time (ACT) before commencing heparin for baseline level (normal is
  80-120 sec, but in many patients the baseline will be higher than this). If the baseline level is >160 sec discuss with the intensivist whether heparin is needed or bolus needed.
- Prescribe on eMR continuous infusions screen.
- Heparin is given as a continuous infusion into the prefilter limb via the PrisMax syringe pump at an initial rate of 10 units/kg/hr (generally 0-25 units/kg/hr)

- Usual dilution:
  250 units/kg of heparin sodium in 50 mL 0.9% Sodium Chloride (2 mL/hr = 10 units/kg/hr).
- N.B. the smallest volume allowed by the syringe pump is 0.5 mL bolus (2.5 units/kg) and lowest infusion rate (other than zero) is 0.5 mL/hr (2.5 units/kg/hr). The infusion rate is able to increase by increments 0.1ml/hr if required.
- Prescribe on eMR continuous infusions screen.
- Adjust Heparin infusion to maintain ACT around 200 seconds.

  Notify Doctor if ACT rises above 210 seconds. Omit one hour of heparin, then restart at 5 u/kg/hr less than previously.
- Monitoring heparinisation – ACT Use Low range Junior Haemochron device.
- Measure ACT hourly initially, then 4 hourly once stabilised (target 180-200 secs) and document the value on the eMR CVVH nursing observation screen.
- ACT samples should be collected from the first red access port before the Pre-blood pump mixes with the blood or alternatively from the patient's intra-arterial lines (IAL).

Prescribing Citrate for Anticoagulation

- The circuit should be primed with 0.9% Sodium Chloride with 2500 units Heparin per litre as per the standard CVVH policy.
- Patients on CVVHDF (haemodiafiltration) can have citrate for the Pre-Blood-Pump (PBP) replacement fluid for the filtration component but calcium-free bicarbonate-based Prism0cal is used for the dialysis fluid, and Hemosol B0 for the post-filter replacement fluid. See Table 5 on Page 16.
- Patients with coagulopathy (ACT >200 sec, or APTT > twice normal) should not have heparin, and bicarbonate-based Hemosol B0 is used, or citrate-based Prismocitrate 18/0 may be used if there is no severe liver impairment. See Prescribing Calcium on Page 18 above and
-
- Prescribing **Magnesium** on Page 20 above.

All cases, including mild-moderate liver dysfunction, are eligible for citrate except the following:

Contraindications

Citrate anticoagulation is NOT an option for:

- Patients on slow continuous ultrafiltration (SCUF).
- Patients with severe hepatic dysfunction.
- Patients with "Citrate lock", where citrate has accumulated during citrate anticoagulation. See Acid/Base in Other monitoring below.

They will need heparinisation as per the heparin policy.

Anticoagulation for Patients on ECMO

- ECMO patients will be typically anticoagulated with heparin and therefore have adequate anticoagulation for the CVVHDF circuit. Patients on ECMO can run citrate anticoagulation for the circuit even with heparin running through the ECMO circuit if the patient is able to metabolize the citrate adequately. See Page 54 ECMO in PICU Policy Hyperlink

Prescribing Epoprostenol (Prostacyclin)

Indications

- Citrate is contraindicated as anticoagulant.
- And one of the following:
    - **i.** History of heparin allergy or Heparin-Induced Thrombocytopenia Syndrome (HITS).
    - **ii.** Antithrombin III deficiency.
    - **iii.** More than 2 filters clotting in 24 hours on heparin alone.

Discuss with Consultant Intensivist.

Dose: 5 nanograms/kg/min infusion immediate pre-filter. Reconstituted and diluted Epoprostenol is only stable for 24 hours at room temperature. Must filter the solution before infusion using a 0.22 micron filter or preferably use an in-line filter during the infusion

- For indications (i) and (ii) above, Epoprostenol (Prostacyclin) alone should be initially tried. For indication (iii) above, the addition of heparin at 5 units/kg/hr should be used.

CVVH on eMR

1. **Medical Prescription on eMR**
    - Log into correct patient on eMR
    - Open AdHoc icon located on top bar of eMR
    - Choose ICU Service → ICU CHW
    - Choose Haemofiltration Medical Instructions
    - Prescribe Prismocitrate or Hemosol for PBP replacement fluid, Dialysate and Post filter replacement
    - Prescribe Additives (refer to page 15)

    ➔ All 3 bags (PBP/dialysate/Post filter replacement bags) must have the same additives ordered. Note the default Potassium of 4 mmol/L in Prism0cal.

    ➔ **Never add potassium to >4.5 mmol/L total**

    ➔ **Never add phosphate to >2.0 mmol/L total** (normal max is 1.5 mmol/L)

- Prescribe other settings
  - ➔ Circuit size (refer page 12)
  - ➔ Ordered blood flow, ordered PBP replacement flow, ordered post filter replacement flow, ordered diaysate flow and citrate dose (refer to page 8-9).
- Prescribe Ordered Fluid removal (ml/hr)
- If on Heparin anticoagulation, prescribe separate Heparin infusion on continuous infusion on MAR on eMR (refer to page 22).
- If on Citrate anticoagulation
  - ➔ Prescribe Calcium Chloride infusion based on filter size (see page 18) in the CVVH orders on eMR. This will not be a separate infusion in eMR as the fluid should not be accounted for in the patients I&O.
  - ➔ Prescribe regular Magnesium dose on MAR on eMR (refer to page 20)

  **** If the patient is coming off the circuit for a period of time, suspend regular Magnesium dosage on MAR on eMR ****
- **Any changes to therapy such as change in ordered fluid removal, change in additives, change in flows or change in Citrate dose requires a new medical prescription on eMR.**
- The medical prescription will be visible in eMR under:
  - ➔ Interactive view and I&O
  - ➔ Haemofiltration – Medical

2. Nursing Documentation on eMR

- Login to correct patient on eMR
- Open Interactive view & I&O
- Open Haemofiltration Nursing
- Document all values every hour
- Calculations of “calculated patient fluid removal” every 3-4 hours (refer to page 10)

3. PICU Safety with patients on CVVH

- CVVH Safety Pause – to be done daily in the PICU morning rounds (see Appendix 4)
- CVVH Bedside Checklist – to be done on handover by all CVVH accredited staff

Set-Up Procedure

Equipment to set up PrisMax Machine

One person must stay with the machine for the entire set-up process, with or without an assistant. The set-up must be performed in a well-lit central place by an accredited Nurse.

- Circuit of appropriate size (Table 3)
- **Circuit Priming Solution** (1000 mL 0.9% Sodium Chloride + 2500 units Heparin)
- 19 G needle + 5 mL syringe for drawing up Heparin
  - 1000 mL of priming solution required to prime HF20, ST60 and ST100
- Additional Priming Fluid as ordered. 500mL NSA 4% or 1 unit Red Blood Cells X-matched to patient on HF20.
- Anticoagulant Preparation (if not citrate)
  - Anticoagulant as ordered (usually Heparin Sodium 250 units/kg/50 mL 0.9% NaCl (see Page 22 for standard dilution or alternative dilution)
  - Syringe and needle for drawing up anticoagulant
  - Diluent as ordered (usually 0.9% Sodium Chloride)
  - 50 mL syringe
  - Red Cap
  - Additive Label
- Pre-Blood-Pump (PBP) Replacement fluid as ordered
- Dialysis fluid as ordered
- Post-filter Replacement fluid as ordered
- Additives as ordered for each bag. Needles + Syringes for drawing up Additives
- Additive labels
- Trolley + sterile plastic drape.
- $CaCl_2$ infusion if citrate used.
-

For set up of CRRT into the ECMO circuit

Please see: **Hyperlink to ECMO PICU Policy: Connecting CRRT to ECMO circuit 'Continuous Renal Replacement Therapy on ECMO'**

Preparing circuit and flushing solution

A clean technique is used for performing a Circuit Set Up

- Gather equipment
- Clean trolley
- 1-minute hand wash
- Drape trolley, open equipment on to trolley
- Use clean technique to assemble equipment.
- With the 5 mL syringe and 19G needle draw up Heparin Sodium
- Mix priming solution bag(s) 1000 mL 0.9% Sodium Chloride + 2,500 units Heparin (1000 units/mL solution)
- Check all additives in accordance with hospital policy

Prepare Pre-Blood-Pump (PBP) replacement fluid

All CRRT fluid bags are valid for 24hours once plastic casing has been removed

- Prismocitrate 18/0 is standard but occasionally Hemosol B0 will be prescribed.
- When using Hemosol, compartments are separated before use and must be mixed between small and large sections twice. **Break frangible seal prior to use.**
- Load Additives (if ordered) into Pre-Blood-Pump (PBP) using syringe and needle to insert into rubber bung. Additives must be doubled checked by two accredited staff members.

Preparing dialysis fluid (if ordered)

- Prism0cal B22 is usually used (with citrate), occasionally Hemosol B0 (with heparin).
- Mix the small and large compartments together twice for Hemosol.
- Load additives (if ordered) into dialysis fluid using syringe and needle to insert into rubber bung. Additives must be doubled checked by two accredited staff members.
- **Note that Prism0cal B22 contains 4 mmol/L Potassium as default. Do not add additional Potassium to this fluid type.**

Preparing post-filter replacement fluid

- Hemosol is always used: Mix the small and large compartments together twice. **Break frangible seal prior to use.**
- Load additives (if ordered) into replacement fluid using syringe and needle to insert into rubber bung. Additives must be doubled checked by two accredited staff members.

Set Up PrisMax Machine

- ALL SETUP INFORMATION IS DIAGRAMATICALLY REPRESENTED ON THE PRISMAX SCREEN.
- Refer to **PrisMax Operators Manual**: Baxter PrisMax Operator's Manual Hyperlink

- Plug PrisMax machine and heater into RED power point.
- Turn on machine (Press and hold green button on left hand side when facing the machine).
- Choose New Patient or Same Patient - machine will automatically perform an initialization test.
- Use barcode scanner located behind the screen to scan patient's MRN details, enter patient's date of birth, weight.
- Default hematocrit 30%. If the patient has a recent blood gas, enter the patients hematocrit
- Confirm details and accept
- The next steps (follow the onscreen prompts) –
    - **i.** Select therapy as CRRT
    - **ii.** Select CVVHDF modality
    - **iii.** Select Set Size
    - **iv.** Select anticoagulation
    - **v.** Select Prismocomfort
    - **vi.** Auto-Effluent – select Yes or None. Auto-Effluent is an option for ST60 and ST100. Check with Team Leader and Intensivist about room availabilities prior to selecting as this modality can only work in certain rooms with appropriate drainage option.
    - **vii. If using citrate:** Select Citrate solution (Ensure correct citrate solution selected of 18mmol/L)
    - **viii.** Enter Prescription order**: IMPORTANT If using citrate**:
        a. Confirm correct Calcium Chloride concentration on bottom right
        b. To adjust select, "Other settings" to select "Change Solutions" -> Accept
        c. Choose appropriate Calcium Chloride Concentration for the set size via the drop-down menu
    - **ix.** Scan circuit barcode: If barcode error manually "select set" and identify appropriate set
    - **x.** Check expiration date
- Attach set onto machine and follow-on screen prompts
    - The on-screen prompts will direct you to attach pressure pods and feed lines into the correct positioning. Blue ticks will appear automatically when each section has been inserted. If something has not been installed correctly there will be flashing blue circles in the relevant sections. Once all blue ticks are present select "LOAD SET"

- If using Auto-effluent, scan Auto-effluent barcode located on the front of the sent and follow-on screen prompts for installation.

Auto-Effluent

- The Auto Effluent points effluent flow into one of two effluent bags. This allows effluent to flow into one bag while the other bag drains fluid automatically into purposefully designed drains located in specific rooms within PICU. This means you do not need to manually change effluent bags during treatment.
- Maximum time for each auto effluent set to run is 6 days or 560,000 pump revolutions (whichever comes first)
- Changing the auto effluent set is only available when changing the entire circuit.
- Use Auto-Effluent for ST60 or ST100 circuits
- Check with Team Leader and Intensivist about room availabilities prior to selecting as this modality can only work in certain rooms with appropriate drainage option.

Prepare and Connect Solutions

- FOLLOW ON SCREEN PROMPTS AS TO WHICH BAGS TO HANG.
- Ensure bags are loaded with appropriate additives as per prescription. When inserting additives ensure to use drawing up needle to pierce the capped rubber port (right port on bottom of bag).
- When connecting fluid bags to fluid lines on the circuit, disconnect and discard Gambro spikes and connect line directly to Blue luer lock NAD (left port on bottom of bag)
- Connect access/effluent to a Y-Line to priming solution bag (2500units Heparin in 1000ml 0.9% Sodium Chloride Bag); hang bag on priming hook on the left.

- Connect return line (BLUE) to collection/effluent bag hanging on effluent scale. Follow on screen prompts if using Auto-Effluent set.

- Connect Pre-Blood-Pump (PBP) line to PBP fluid bag. Hang bag on its scale. This is the WHITE line and WHITE scale

- Connect Dialysate line to Dialysate fluid bag. Hang bag on its scale. This is the GREEN line and GREEN scale

- Connect Post-filter replacement line to replacement fluid bag. Hang bag on its scale. This is the PURPLE line and PURPLE scale
- The PrisMax machine will illuminate colour coded LED lights for each scale. If not installed correctly, the LED light will continue to flash.

Install Calcium Chloride Syringe When Using Citrate

- The PrisMax will automatically prime the extension line leading from the calcium syringe.

- **Calcium chloride infusion must be attached to the "Calcium Line for Prismaflex – CA 250" which is a separate extension line. This leads DIRECTLY to the Y connector that is attached to the patient return line. Calcium chloride is NOT to be connected to the Heparin syringe line that leads into the filter. This line that leads into the filter is ONLY to be used with Heparin.**
- To install Calcium syringe into the syringe pump on the machine, the on screen prompts will ask you to clamp the line press "check" to continue. You will need to install the fluid bags next. Once the fluid bags are connected to the appropriate lines, you can install the calcium syringe.
- Prepare the syringe as per appropriate concentration (See Page 18)
- To install syringe follow onscreen prompts that will ask you to select "Arm down"
- Ensure to select "Choose Brand" the correct 50ml syringe brand
- Insert syringe as per picture then select "Arm Up" -> "Close Plunger" -> "Accept"

Install Syringe When Using Heparin

- Once the fluid bags are connected to the appropriate lines, you can install the heparin syringe.
- To install syringe follow onscreen prompts that will ask you to select "Arm down"
- Ensure to select "Choose Brand" the correct 50ml syringe brand
- Insert syringe as per picture then select "Arm Up" -> "Close Plunger" -> "Accept"

Priming

- "Prepare to Prime Set" select "Prime" (This will take approx. 10 minutes for the circuit and syringe to perform a pre prime test)
- Machine will automatically prime. Stay with machine. Check for leakage from any connections during priming
- Follow instructions on screen if any alarms are activated
- When completed, message will read "Prime Completed"

Prime Set Completed

- **No further priming can be done beyond this screen**. This is the last chance to prime air out of the lines
- Inspect fluid level in de-aeration chamber. To adjust see below
- Inspect set for air, if more priming required see below for options:
    - Manual Prime: Used for Albumin Prime. See below for more details

- Reprime: Suitable if air present or an extended period of time has elapsed since completing the prime. This requires a new 1000ml bag of priming solution
- Reprime Ca-Line: Repeats the prime through the calcium infusion line only (ensure this is not connected to the patient).
- Flush: Flushing the set replaces the fluid in the filter with fresh solution from the priming bag. This requires a new 1000ml bag of priming solution.
- Change Bag: to change the solution bag/container or syringe

- HF20 sets will give you the option to complete a blood prime as the next step

Saline Prime

- Once Prime and Test is completed, the saline solution used to prime the circuit is valid for 24 Hours. Once this has been breached, it is recommended to discard set and prime a new filter.
- PrisMax will ask for a reprime of the circuit once 1 hour has passed. This does not required a new set to be primed, simply prime through the same solution.

Adjust De-aeration Chamber

- Ensure to adjust de-aration chamber prior to priming select “TOOLS” at the top of the screen, select “Adjust De-aeration Chamber”
- Visually inspect fluid level hourly in the de-aeration chamber – Fluid level should be as shown on the on-screen illustration.
- PrisMax will automatically adjust the chamber level every 2 hours
- If the level is higher than the sensor or has foam in the chamber, it will not be able to detect the level therefore will need to adjust manually

Albumin 4% Prime

- Albumin 4% prime is required when Blood prime is NOT indicated. Do not prime with albumin if you are going to do a blood prime.
- Once albumin has been primed through the set, the patient must be commenced on therapy within **30 minutes**. If the patient has not been connected within this time frame, an additional manual prime is required to flush all stagnant fluid out of the circuit (ethylene oxide build up). The machine will alarm if there has been a delay of 60 minutes between priming and connecting the patient
- Volume of albumin needs to be at least the circuit volume. 100 mL for HF20, 150 mL for ST60, 200 mL for ST100. Prime until albumin is visible in effluent bag.

- Spike Albumin 4% and press and hold MANUAL PRIME to prime entire circuit with Albumin
- When patient ready, press CONTINUE leaving priming and collection bags attached.

Blood Prime

- If you are using a HF20 & ST60 circuit you will be offered a BLOOD PRIME option.
- A blood prime needs to be ordered by a doctor and cross matched to the patient. Packed Red cells are used
- Check blood as per hospital policy
- Remove bag of hepsaline priming fluid.
- Spike blood with the access/effluent Y line.
- Press and hold BLOOD PRIME to prime the blood through the circuit. Stop flow just prior to blood entering the effluent bag i.e., end of blue return line
- Alarm will say Blood detected in circuit
- Press FINISHED and follow on-screen instructions as per routine patient connection.

Commencing CVVH

- A medical officer should be notified whenever a patient goes on to the extra-corporeal circuit (blood pump started) and when CVVH is ceased or when there is any significant interruption**. If the patient is unstable**, the medical officer should be present to manage any haemodynamic instability which may occur, especially in babies who will have a circuit volume >10% of blood volume.
- Consider increasing inotropes by 50-100% when the blood circulation is started, especially in haemodynamically unstable patients. This may be required for the first few minutes when circulating inotropes become diluted and filtered.
- Closely assess patient's haemodynamic state to assess patient's tolerance to fluid shift.

Be prepared to adjust inotrope dose. Some patients end up on less inotropes than before starting because CVVH often stabilises circulation, possibly by filtering cytokines.

Procedure for connecting patient to circuit

- Gather Equipment:
- Basic Dressing Pack
- 4 x 3M Soluprep Antiseptic wipe LargeSterile gloves
- 10 mL syringe × 4
- Drawing up needle x 3

- 0.9% NaCl ampoules 10 mL x 2
- Y-Connector (if using Citrate/Calcium)
- Gauze squares x 2 packets
- 1-minute hand-wash.
- Open dressing pack. Open sterile equipment on to sterile surface.
- 3-minute hand wash. Don gloves.
- Draw up 2 × 5 mL NaCl in 10 mL syringes. An assistant is required.
- Place sterile towel under ends of venous catheter lumens.
- Check that both lumens and blood lines are clamped to prevent blood loss when caps removed.
- Clean ends with large antiseptic wipe. Scrub the hub vigorously for 20 seconds and allow to dry.
- Using ANTT principles, clean entire line and cap and allow to dry for 20 seconds. Hold the lumen in a downward position and remove cap using a new antiseptic wipe. Attach a 10 ml syringe to aspirate heplock (minimum 3mls).
- If taking blood cultures, use discard volume as the sample
- If previously Heplocked, withdraw and discard the Heplock volume (see Heplock section). Flush lumen with pulsating action using 0.9% NaCl. Clamp lumen under positive pressure, leave empty syringe in place until ready to connect. Repeat procedure on other lumen.
- If blood cannot be aspirated from either lumen, or lines are resistant to flushing, notify registrar and do not connect to circuit until line patency is restored.

Confirming Parameters and Starting Treatment

- Use the Medical prescription as per Policy along with Medical prescription in eMR.
- Independent double check prescription details with another experienced accredited CVVH RN
- Ensure that the correct calcium chloride concentration has been selected based on the filter size. See page 19.
- Ensure patient is hemodynamically stable prior to commencing treatment.

CONNECT TO PATIENT

- FOLLOW ON SCREEN INSTRUCTIONS
- Clamp all Y lines, access, effluent and return lines

- Disconnect access line from Y Line; connect to access lumen on GamCath (usually the RED lumen)
- Disconnect the return line from the collection/effluent bag; Connect to return lumen on GamCath (Usually the BLUE lumen)
- Disconnect the effluent line from the Y Line; connect to free port on effluent bag.
- UNCLAMP effluent, access, return and GamCath lines. Secure all lines into clip closest to patient
- Clamp all UNUSED lines (should not be any in CVVHDF mode); ensure calcium line is UNCLAMPED if in use, verify correct set up; press START to begin treatment.
- If using Citrate, the Calcium infusion will automatically commence once treatment has commence.
- If using Citrate/Calcium, connect calcium infusion line to a Y-connector connected to the return (blue) lumen on vascath.
- If using heparin, note: Heparin syringe starts when treatment commences. If Heparin bolus dose required, give immediately after starting blood flow.
- Once blood is completely through the circuit and returning to patient, place heater sleeve over return line. Start from machine end. Secure into holder. Minimise weight on return line with positioning.
- Start heater at 37°C and adjust to maintain normothermia. Keep heater sleeve clear of external heating.
- Patient may need Bair Hugger as well
- Monitor haemodynamics closely and be prepared to increase inotropes.
- If the PrisMax alarms "Effluent bag volume incorrect", press "keep bag" and press CONTINUE.

Terminating Haemofiltration (Elective or Emergency)

Emergency Change of Filter will only be necessary if there is a sudden rupture of the filter causing blood to be lost into the filtrate. The whole circuit has to be changed.

Emergency termination may be necessary for any patient emergency, air in the lines, catheter problems, or circuit problems. This may be temporary (preserving the circuit) or permanent. For temporary disconnection with recirculation of blood see Blood Recirculation on Page 37. **Circuit can be temporarily disconnected for 1 hour using a blood recirculation or 2 hours with 0.9% sodium chloride recirculation**.

Discuss with medical officer, just before stopping CVVH, whether blood should be **returned, and if so, how much.**

- NB: It is the responsibility of the medical staff to prescribe whether blood within the extra corporeal circuit is returned to the patient.

- The exact volume should be prescribed. This is calculated as you return the blood to the patient. Return the circuit volume unless this is >8 mL/kg. In this case only return 8 mL/kg.
- Circuit volume is 60 mL for HF20, 93 mL for ST60 and 152 mL for ST100
- Do not return circuit blood if there is any danger of volume overload or if circuit has visibly clotted.
- Normally no more than 10% of patient's blood volume should be returned (i.e., not more than 8 mL/kg, max 60 mL in <15 kg, max 93 mL in <30 kg, max 152 mL in >30 kg).
- Discussions should be made with the medical officer regarding the return of circuit blood to the patient.
- This is entered as an input on the fluid balance. Select Blood product / Autotransfusion / CVVH blood return volume.

Equipment for termination

- Y line × 1 (only open if planning to recirculate)
- Gambro spike × 1
- 1 litre bag of 0.9% Sodium Chloride (required if you need to perform a **saline recirculation** (see Page 386) or a blood return to patient
- 100 mL bag of 0.9 % Sodium Chloride (required if you need to perform a **blood recirculation**)
- 4 x 3M Soluprep Antiseptic wipe LargeDressing pack
- Sterile gauze squares × 2
- Ampoules of 0.9% NaCl 10 mL × 2
- Ampoule of Heparin Sodium 10 units/mL to Hep flush or Heparin (5000 units /5 mL) to Hep Lock
- Sterile gloves
- Syringes 2 mL × 2 (These are for injecting accurate amounts of heparin to flush lumens. NOT to be used for attempts at unblocking)
- Syringes 10 mL × 4
- Drawing up needles x 4
- Red Caps x 2

Procedure for termination

Rationale: To achieve a circuit change or the cessation of therapy in a safe & controlled manner.

- Gather equipment.
- Clean trolley.

- 1-minute hand wash.
- Drape trolley, open equipment on to trolley.
- 3-minute hand wash, don gloves.
- With the help of an assistant:
    - Draw up 0.9% Sodium Chloride and heparin sodium or Heparin to either Hepflush or HepLock GamCath, Page 45.
    - Press the STOP button
    - Options are;
    - END TREATMENT/DISCARD SET:
        - Same Patient (Replace set and restart treatment on same patient)
            - New Patient (Replace set, start treatment on a new patient)
            - Discard All (Discard set without starting a new treatment)
        - Return Blood: Yes or No
        - Reuse Fluids: Yes or No
            - Re-use Fluids may be appropriate if bags are within 24 hour time limit
        - Reuse Auto Effluent: Yes or No (NA if not in use)
            - Re-use Auto Effluent if within 6 day expiry
    - RECIRCULATE BLOOD –See page 37
    - RECIRCULATE SALINE– See page 38

End Treatment (Patient ending Haemofiltration)

- If not returning blood, select DISCARD ALL and follow instructions.
- If Returning blood to patient, press the BLOOD RETURN softkey, select the desired blood return rate and follow the instructions on the Return Blood Screen.
- If CRRT connected to ECMO circuit do not return blood to ECMO circuit
- When complete, disconnect the patient from the set, clamp all lines and unload the set and Heparin/Calcium Chloride syringe by pressing the UNLOAD softkey.
- Aspirate and Flush both lumens of the Vascath. Hepflush or Heplock (Page 43) Cap Lumens.
- Enter into the I/O flowsheet on the eMR the volume of blood returned to patient as a bolus of “blood”.

Change Set (Patient continuing Haemofiltration)

- Press END for END TREATMENT OPTIONS
- Select SAME PATIENT
- If Returning blood to patient, press the RETURN BLOOD (yes), select the desired blood return rate and **follow the instructions on the Return Blood Screen**.
- If CRRT connected to ECMO circuit do not return blood to ECMO circuit.
- If not returning blood, select NO and follow instructions.
- Disconnect the patient from the set, **clamp all lines** and unload the set by pressing the UNLOAD softkey. Discard set with Heparin/Calcium Chloride Syringe.
- Aspirate and Flush both lumens of the Vascath with 0.9% Sodium Chloride if reconnecting to new set within 1hour or HepFlush Vascath if expecting delay > 1hour.
- PrisMax will return to standby mode. Options for "New Patient" or "Same Patient" will be present.
- Select "Same Patient" to utilize the same prescription.
- Select "New Patient" to start patient on a different prescription including changing anticoagulation methods.
- Enter into the I/O flowsheet on the eMR the volume of blood returned to patient as a bolus of "blood".

BLOOD RECIRCULATION

Useful for catheter or circuit issues, moving patients or other patient emergency:

N.B. Circuit is preserved for imminent re-use. **Max time 1 hour**.

- If blood flow through the venous catheter is inadequate for any reason then the blood access pressure alarm will activate, or blood return pressure will alarm and the pump will stop. Reasons may include:
  - Clots or poor blood flow in the vein or through Vascath
  - Kinking of the catheter
  - The catheter being up against the wall of the vein
  - Poor cardiac output
  - Poor blood flow in the vein where the cannula is sited.
- It is most important that the blood pump does not stop for more than a minute or two, otherwise clotting may occur rapidly in the circuit.
- If the problem cannot be fixed immediately then STOP and choose the BLOOD RECIRCULATION option. PrisMax will automatically stop delivering the calcium infusion.
- The PrisMax will prompt you to disconnect the Calcium Chloride line from the patient

Maximum time allowed for blood to circulate before reconnection to patient is 60 minutes

- Emergency kit contains all equipment required for blood recirculation

Procedure

- Select on screen "STOP" button
- Select Recirculate Blood
- Follow all prompts on Prismax screen.

On Completion of Blood Recirculation

- Select Stop
- Select either "Reconnect Patient" or "Discard Set"
- Follow on screen prompts on Prismax Screen, reconfirm prescription and therapy details.
- Select Start Treatment

SALINE RECIRCULATION

Useful for time off for scans or other procedures up to 2 hours.

- **Maximum time for saline recirculation is 120 minutes**

Procedure

- Select on screen "STOP" button
- Select Recirculate Saline
- Follow all prompts on Prismax screen.
- A 1000ml bag of 0.9% Sodium Chloride is required for Saline Recirculation
- There is an option to return blood back to the patient. If the filter has clots, do not return blood to the patient and discard the set.
- If returning blood select "Prepare for Blood Return" and follow on screen prompts
- Manual Return button allows a maximum 150% of the circuit volume to be returned
- Return Blood button automatically returns 100% of the circuit volume to the patient

Monitoring During CVVH

- The patient should be WEIGHED daily if stable.
- The prescriptions for filtrate and replacement fluid are based on estimates of inputs and losses which may vary during the course of treatment. The patient should be evaluated

at least every 6 hours by a clinical examination of the state of hydration, and by monitoring filling pressures.

- At least every 6 hours examine the patient's fluid balance on eMR.

  Remember that these do not include insensible loss. Insensible losses are accounted for in the patient fluid calculation and should not be documented into the I&O.

Monitoring electrolytes

- It is essential to monitor the serum electrolytes via ABG (Glucose, Na, K, Cl, Bicarbonate, and Ca) every 4 hours. Do them hourly for 1st 4 hours if they were abnormal.
- Mg and Phosphate should be measured at least twice daily and plasma lactate at least daily.
- Anti Xa level and coagulation profile should also be measured 4-8 hourly when heparin is being used as anticoagulant.
- See the section on Citrate anticoagulation for additional tests performed in this mode.

Clinical monitoring

Patients receiving CVVH/ Plasmapheresis require constant nursing attendance to ensure cardiovascular stability, system maintenance and troubleshooting of problems arising.

- The circuit needs hourly observations to ensure integrity of the circuit and that disconnection will not occur: -
  - Check all connections.
  - Check careful positioning and anchoring of circuit to prevent drag (if patient is moving).
  - Check patency of catheter (clots and air).
  - Check for clots in the circuit (a pen torch may aid this).
- Hourly documentation in eMR Haemofiltration Nursing -
  - Blood pump flow setting
  - Ordered Replacement and Dialysis pump flows
  - Ordered hourly patient balance
  - Calculated Patient Fluid Removal
  - Actual Replacement and Dialysis pump flows
  - Actual Patient Fluid Removal
  - Blood return ("venous") pressure (= Return Pressure).
  - Blood withdrawal ("arterial") pressure (= Access Pressure).
  - Filter pressure (Pressure at blood inlet to filter).

- Effluent Pressure
  - (TMP) = $\frac{\text{Filter pressure + Return pressure}}{2}$ — Effluent pressure
  - Pressure drop = Filter pressure – Return pressure
    - De-aeration chamber check and adjust fluid level if required
    - Heater temperature
    - Unintended Fluid gain/loss

- Maintenance of all other input and output totals are documented in input and output to ensure required hourly balance as ordered by medical officer.
- Continuous monitoring and hourly documentation initials at ECG, blood pressure, heart rate and CVP recordings (if available) for early detection of low cardiac output and hypovolaemia or hypervolaemia.
- Monitor and record temperature to detect for any signs of infection. Also indicates circuit related hypothermia.
- When on heparin, Activated Clotting Times (ACTs) as per page 23. Record heparin dose hourly.

Machine Troubleshooting

Machine Alarms

IF ALARMS FOR BLOOD PUMP CEASED FOR MORE THAN 2 MINUTES, ATTEND TO A BLOOD RECIRCULATION AS PER Page 35.

- 4 types of alarm based on Priority
  - WARNING – Patient hazard TREATMENT, SYRINGE AND BLOOD PUMP STOPS
  - MALFUNCTION – System Hazard TREATMENT, SYRINGE AND BLOOD PUMP STOPS
  - CAUTION – Condition requires stopping of fluid pumps. BLOOD PUMP CONTINUES
  - ADVISORY – Informs of a condition or needed action. ALL PUMPS CONTINUE
- DOCK:
  - Dock button will minimize the alarm window and return to the previous screen. If an active alarm window is minimized, an alarm icon appears in the toolbar and the alarm is silenced for up to 2 minutes
  - This does not rectify the issue that has caused the alarm, it simply allows the alarm to minimize in order to utilize the previous screen
- SILENCE:
  - Silence button will silence the alarm for up to 2 minutes

- All alarms have on screen information. Follow the suggested remedies.
- Fix problem prior to continuing treatment.
- Prismax has the function to screen shot

Refer to PrisMax Operators Manual from Page 96: Baxter PrisMax Operators Manual Hyperlink

Clinical Troubleshooting

Access/Return pressure alarms – related to Vascath or patient.

- Reposition the patient
- Temporarily reduce the blood flow to relieve pressure on the vessel wall
- Aspirate and flush the lumens- expel blood aspirated onto gauze to visualise any clots
- Rotate vascath hub by 180 degrees to overcome negative withdrawal pressures.
- This technique can be done by an accredited CRRT nurse in consultation with PICU fellow/Intensivist.
- Last option after first attempting the above, is switching the lumens if blood withdrawal is poor, but this may cause some risk of recirculation of filtered blood (~25%) through the circuit and consequent decreased clearances by ~10% (Discuss with Intensivist prior to switching lumens).

If Access/Return pressure alarms when CRRT circuit attached to ECMO circuit:

- A restrictive gate clamp may be placed on the CVVH withdrawal line in order to make the pressure in the CVVH withdrawal line <300mmHg
- There may be some back flow down the return line but this will resolve
- If the return pressure of CRRT circuit into the ECMO circuit is >300mmHg the blood will not return (i.e. if patient blood flow is high) – if this occurs:
- Troubleshoot with the PICU and perfusion team
- May require turning down the CVVH blood flow rate or reducing the ECMO flow - only to be done in discussion with senior medical team
- If unable to troubleshoot and unable to return CRRT blood flow then consider need for a vascath

Filter Alarms and filter pressure rising

- Maximum filter pressure is +450mmHg. This will alarm Filter clotting once it reaches 300mmHg to indicate considerable clotting has taken place.
- Review pressure graphs under History to view TMP and Filter pressures.

- If Filter pressure is static and TMP increases, this is due to adsorption (e.g. sepsis or a build-up of fatty particles from propofol or lipid infusions.
- If both filter and TMP pressures increases suddenly, prepare for termination of treatment (refer to page 33).
-

Emergency Change of Filter

This will only be necessary if there is a **sudden rupture of the filter** causing blood to be lost into the filtrate. The whole circuit has to be changed.

This is uncommon but if it occurs, ensure to keep the ruptured filter in a clinical waste bag to return to the company for revision. Ensure you communicate this to the education team and complete a IMS+.

See Terminating on Page 34

Anaphylactic Reaction

- On rare occasions the patient may have an anaphylactic reaction to the filter membrane or to Ethylene Oxide which is used to sterilise the filters. Priming with albumin or blood immediately prior to connecting to patient may minimise this risk. That is, don't leave the machine set up and primed for >30minutes prior to patient connection. If it is left greater than 30 minutes, reprime with priming solution to remove ethylene oxide build up.
- This presents with the usual symptoms of anaphylaxis including tachycardia, hypotension, urticarial or maculo-papular skin rash, and bronchospasm.
- It may resemble a transfusion reaction and may not be distinguishable from this if the circuit has been primed with blood.
- The treatment in very mild cases is to give antihistamines.
- In the majority of cases the haemofiltration will have to be ceased.
- If severe, cease treatment immediately and treat for ABCs.
- **The blood contained in the extracorporeal circuit should not be returned to the patient.**
- Send a blood sample for Ig's, IgE, Mast cell tryptase.

ECMO Emergency

- If patient required to come off ECMO in an emergency- turn taps off to and clamp access/return lines and stop CRRT circuit

Emergency CRRT Trolley Checklist

This **must** be prepared before commencing CVVH, ready for any emergency or disconnection. It should be kept in at the bedside at all times. It consists of:

- Y line × 1
- Gambro spike × 1
- 1 litre bag of 0.9% Sodium Chloride (required if you need to perform a normal saline recirculation or a blood return to patient)
- 100mL bag of 0.9 % saline (required if you need to perform a blood recirculation)
- Alcoholic chlorhexidine 2% in 70% alcohol
- Dressing pack
- Sterile gauze squares × 4
- Ampoules of 0.9% NaCl 10 mL × 4
- Ampoule of Heparin Sodium 10 units/mL x 2 (HepSaline)
- Sterile gloves
- Syringes 2 mL × 2 (These are for injecting accurate amounts of heparin to flush lumens. NOT to be used for attempts at unblocking)
- Syringes 10 mL × 4
- Drawing up needles x 4
- Plastic clamps x 2
- Y connector Spare pressure transducer
- Printed copy of MANUAL TERMINATION OF TREATMENT from policy.
- YOU MUST HAVE THE EMERGENCY TROLLEY CHECKED AND AT THE BEDSIDE PRIOR TO CONNECTING PATIENT TO THE PRISMAX

Appendix 1 HEPLOCK and HEPFLUSH

- **Heplock** means to prime the lumen(s) of a CVAD with high concentration heparin (1000 units/mL) with the aim of maintaining patency for a period of non-use >1 day and up to 1 week.
- The quantity of heparin for Heplock is such that, if it goes into the patient, it may result in complete heparinisation of the patient. The quantity should be **0.1 mL greater than the lumen volume**. See Table 2 on Page 12 for volumes of lumens of catheters in use at CHW. In neonates this will always be less than one mL.
- Heplocking of lumens must be ordered and documented in eMR.
- **Hepflush** means to prime the lumen(s) of a CVAD with low concentration heparin (10 units/mL) with the aim of maintaining patency for a period of non-use up to 1 day.
- Use 1.5 mL per lumen. This quantity of heparin will not heparinise the patient if flushed into the patient.

EQUIPMENT:

- 2 x 2 mL syringe
- 2 x10ml syringe
- Needle
- Luer Locking cap(s)
- Handtowel
- 4 x 3M Soluprep Antiseptic wipe LargeSterile gloves
- Sodium Heparin (1000 u/mL for Heplocking, 10 u/mL for Hepflushing)

PROCEDURE:

- Wash hands and prepare equipment employing an aseptic technique.
- Position patient comfortable with access to GamCath.
- Clamp the catheter with special guarded clamps or use the clamp attached to catheter. Rotate clamping to prevent damage to the line.
- Remove cap with sterile gauze maintaining asepsis, discard both
- Swab hub vigorously with 3M Soluprep Antiseptic wipe Large .

If previously Heplocked, attach empty 10 ml syringe and withdraw minimum 3ml and discard.

- Ensure all air is removed from heparin syringe to avoid air embolus which may be fatal.
- Insert 2ml syringe containing appropriate heparin solution.

- Clamp the tubing until instillation of heparin sodium is commenced to prevent any backflow or exsanguination occurring.
- Inject using pulsating action with the prescribed quantity.
- Reclamp catheter on completion of heparin sodium injection.
- Remove syringe and replace with appropriate luer locking cap.
- Observe for leaking.
- Ensure catheter is securely taped at entry site.
- Document hep lock or hepflushed in eMR

APPENDIX 2 – Background and Indication

Introduction

- Haemofiltration is a form of continuous renal replacement therapy. It is a technique which takes over some functions of the kidney when the kidney is unable to meet demands placed upon it, either because the kidney is failing to excrete water, urea, creatinine or electrolytes or because there is an excessive amount of toxic metabolites being produced.
- Instead of blood being filtered in the glomerulus of the kidney and then water and salts being reclaimed from the filtrate by tubular reabsorption, in haemofiltration blood is circulated outside the body through an artificial filter to produce a filtrate very similar to glomerular filtrate and the excessive water and salts removed are substituted using a separate replacement fluid.
- Haemofiltration is not dialysis. It is better than haemodialysis in critically ill children because haemodynamics are more stable (less hypotension) and larger 'middle' molecules are filtered, eg toxins, cytokines.
- It is better than peritoneal dialysis because it removes water better and does not compromise ventilation.
- The disadvantage is that anticoagulation is needed, and it is much more labour intensive and expensive.
- The technique used in Paediatric Intensive Care is continuous veno-venous haemofiltration (CVVH). Blood is drawn from the body from a large central vein and pumped using a roller pump through an extracorporeal circuit incorporating a haemofilter (which takes over some of the functions of the kidney) and then back again into the patient, usually into the same vein, via a bubble trap to trap air bubbles and clots.
- The pumping of blood under pressure through the filter causes passage of water and dissolved solids from the plasma through the filter membrane and out into the filtrate collection line. This process is called ultrafiltration because it is filtration under pressure

and produces a filtrate which is very similar in composition to plasma but without the plasma proteins and other large molecules.

- There are 4 or 5 pumps involved: -
    - One roller pump on the PrisMax pumps blood through the extracorporeal circuit. This pump works by occluding the lumen of the blood tubing with a roller which moves along the tubing drawing blood along behind it with a suction effect. Actual blood flow is not measured and may be less than is dialled up if there is any obstruction or resistance to flow.
    - A second roller pump pumps (dia)filtrate OUT of the filter.
    - A third roller pump pumps replacement fluid INto the circuit Pre-Blood-Pump (PBP), i.e. pre-filter.
    - A fourth pumps replacement fluid INto the circuit Post-Filter
    - A fifth roller pump may be used for pumping dialysis fluid through the filtrate chamber of the filter when CVVHDF is performed.
    - The sixth pump is a 50 mL syringe driver for the heparin line (if heparin used).
- The filters which we use are cylindrical filters containing 1000-5000 hollow fibres. These fibres have small pores allowing the passage of water and small solute molecules up to a molecular weight of approximately 15000.
- The filtrate collects in the space inside the filter around these hollow fibres and passes out through a filtrate port into a waste container.
- The concentration of solutes in the filtrate is approximately the same as in plasma except that there are no proteins.
- The amount of filtrate which can be produced depends on the following:
    - The flow rate of blood through the filter. This itself is determined by the pressure gradient from one end of the hollow fibre to the other, the cross-sectional surface area and the length of the fibres. The blood flow that can be achieved depends also on the size of the venous cannulas. Generally, filtrate is produced better when blood flow is as high as possible without turbulence in the system. There should be no problem in achieving blood flow of 3-5 mL/kg/min (patient weight) if appropriate sized filters and cannulas have been selected.
    - The trans-membrane pressure (TMP). Average TMP = PIn/2 + PV/2 – PF where PIn is the pressure of blood at the ‘blood in’ end of the filter, PV = pressure of the blood at the ‘blood out’ end where blood exits the filter to return to the patient, and PF is the pressure at the filtrate outlet (effluent), often negative (sub-atmospheric) because the (dia)filtrate pump ‘sucks’ filtrate out of the filter.
    - The change in oncotic pressure as blood passes along the filter, caused by increasing concentration of plasma proteins as plasma water and other solutes are filtered along the filter, impedes filtration at the ‘blood out’ end of the filter in addition to the lower TMP.

- Whether or not the blood is diluted with the replacement fluid before it passes through the haemofilter. Pre-dilution enhanced clearance of urea and creatinine and overall filtrate production when CAVH was performed, in which both blood flow and filtrate production were dependent on the patient's own blood pressure; in this case blood flow and filtrate flow were lower than we achieve with pump-controlled blood flow and filtration. In pump-controlled CVVH, predilution actually diminishes filtration and urea/creatinine clearance.

Definitions and Terminology

- CRRT - Continuous renal replacement therapy. Sometimes called renal replacement therapy. A broad term covering peritoneal dialysis and the forms of continuous haemo(dia)filtration described below.
- SCUF - Slow continuous ultrafiltration. This is haemofiltration performed with very low filtrate volumes and without any haemofiltration replacement fluid being needed. It is to correct water overload only.
- CVVH (sometimes called CVVHF) - continuous veno-venous haemofiltration. This is haemofiltration performed with large volumes of filtrate when the purpose is to remove urea or metabolic acid, for example. This inevitably results in far too much water and electrolytes being removed from the body, so these are then replaced with a replacement fluid which is very similar in composition to plasma and its dissolved solutes except that it contains no proteins, urea or creatinine. The haemofiltration replacement fluid is pumped directly into the patient, either into a separate vein or into the line returning blood from the haemofilter to the patient.
- CVVHDF - continuous veno-venous haemodiafiltration. This is continuous haemofiltration with dialysis added to improve clearance of urea, creatinine and other small molecules.
- CVVHD - continuous veno-venous haemodialysis. There is no filtration under pressure in this technique and no pressure gradient across the membrane. This technique is not used in PICU. Intermittent haemodialysis may sometimes be performed on PICU, by renal dialysis staff, or patients may go to the renal treatment centre for this technique.
- Extra-corporeal circuit. This is the circuit which takes blood out of the patient, through the haemofilter and back into the patient again ('extracorporeal' equals 'out of the body').
- Ultrafiltration. This is the process of filtration of plasma where plasma and all its dissolved solutes except proteins, is forced across a porous membrane under pressure.
- Sieving coefficient. The ratio between filtrate concentration and plasma concentration for a given molecule. Molecules filtered freely (eg electrolytes, urea, glucose) have a sieving coefficient of 1.0. Larger molecules,(eg some drugs) may have a lower sieving coefficient because the small pores retard passage of larger molecules. Sieving coefficient is zero for very large molecules (>20,000 Daltons), eg albumin.
- Convection. The movement of water/solute across the membrane by hydrostatic pressure is called movement by convection.

- Filtrate. This is the fluid which is usually colourless (straw coloured in plasma filtration) which is filtered from the blood which passes through the haemofilter.
- Diffusion. The movement of solute across a membrane down a concentration gradient is called diffusion. This occurs in dialysis.
- Trans-membrane pressure (TMP). This is the pressure gradient which drives the plasma water across the haemofilter membrane. It is generated by the blood pump which pushes blood into the filter under pressure, and by the pump which pumps the filtrate (effluent) out of the filter where it generates a negative pressure on the filtrate side of the membrane. TMP is higher at the 'blood in' end of the filter (where blood enters the filter) than at the 'blood return ("venous")' end (where blood leaves the filter) because there is a pressure gradient along the filter. This means that filtration is more efficient at the 'blood in' end than the 'blood return ("venous")' end. There may even be backfiltration in some circumstances.
- Blood withdrawal (Access pressure or Venous take-off or Blood access or "Arterial" pressure). This refers to the section of the extra-corporeal circuit between the lumen of the central venous catheter from which blood is withdrawn from the patient up to the blood pump itself. This is sometimes called the 'arterial' side of the circuit and this dates from an earlier procedure called continuous arterio-venous haemofiltration (CAVH) where blood was taken out of an artery rather than a vein. The 'blood withdrawal ("arterial")' blood line has red connectors for this reason. CAVH is no longer performed because it causes more haemodynamic instability and blood flow may be inadequate as it relies on the patient's own heart to pump blood through the extracorporeal circuit.
- Blood return (Return Pressure or Venous return or simply "Venous" pressure). This refers to the portion of the extra-corporeal circuit between the filter and the lumen of the central venous catheter through which blood is returned to the patient. This is sometimes just called the 'venous' side of the circuit. The 'blood return' line has blue connectors for this reason.
- Pre-filter Line. This is the segment of the extracorporeal circuit between the blood pump and the haemofilter.
- Replacement fluid. This is fluid pumped into the patient to replace most of the water and electrolytes lost from the body in the large volume of filtrate.
- Pre-filter dilution/post-filter dilution. The haemofiltration replacement fluid 'dilutes' the blood at the point in the circuit where it is added. This is usually 'pre-filter'. 'Pre-filter' dilution was originally used in CAVH, to improve filtrate flow and solute clearance. In CVVH, when filtrate flow is controlled, pre-filter dilution decreases clearance of solute which is compensated by increasing filtrate flow. Post-filter dilution results in a higher blood viscosity at the venous return end of the filter. This may decrease filter life or cause excessive TMP. Pre-filter dilution is done Pre-Blood Pumpb (PBP) on the PrisMax
- ACT- Activated Clotting Time. This is a crude measure of the ability of the blood to clot and is prolonged in patients with a coagulation disorder or who are heparinised. The normal is <100 seconds and, when running haemofiltration with heparin anticoagulation,

is normally controlled at 180-200 sec, and coincides with the APTT running at about twice normal.

Modes of Continuous Renal Replacement Therapy

Table 7 Abbreviations

QB	Blood flow through the filter
QUF	Flow of filtrate across the membrane (sometimes called QF)
QD	Flow of dialysis fluid counter-current through the filtrate/dialysate side of the membrane
QRF	Flow of replacement fluid intravenously
QDO	Total flow out of filter = volume drained = filtrate + dialysate

Table 8. Features of the various modes of continuous renal replacement therapy

Mode		Technique	Clinical Use
SCUF	Slow continuous ultrafiltration	Filtrate is collected, but not replaced. This represents convective clearance.	Fluid overload. Small molecules will be lost proportional to plasma concentration.
CVVH	Continuous veno-venous haemofiltration	Filtrate is collected and replaced totally or partially by intravenous infusion of a balanced glucose/electrolyte solution (PBP 'replacement fluid').	Fluid overload or for clearance of small molecules; better than dialysis for middle molecule clearance (MW 500+), eg cytokines. Clearance dependent on trans-membrane pressure, blood flow and sieving coefficient of molecule.
CVVHD CVVHD with SCUF	Continuous veno-venous haemodialysis	Dialysis fluid is run counter-current through the membrane. Clearance approximates to QD if QD<<QB (QD less than approx. 1/5 of QB) so that the dialysis fluid saturates with small molecules at blood concentrations, so QD = diffusive clearance rate. There may also be some convective clearance if outflow QDO is not limited to QD. The extra flow (QUF) is not replaced. Even with QDO = QD there is some filtration at the blood-in end of the filter and back filtration at the other end. Some dialysis fluid does therefore enter the patient's circulation.	Clearance of small molecules. Clearance of middle molecules is still very good, eg tobramycin (MW 468) has clearance of 93% of QD. Clearance dependent on concentration gradient across membrane: higher with high blood flow and high dialysate flow.
CVVHDF	Continuous veno-venous haemodiafiltration	Dialysis fluid is run counter-current through the membrane, but outflow from the filter QDO is pumped out at a higher rate than the dialysis flow QD. The extra volume represents Filtrate (QUF) and is replaced with replacement fluid intravenously.	To improve small and middle molecule clearance when CVVH or CVVHD alone are inadequate.

Table 9. Flows and clearances with the various modes of renal replacement therapy

Technique	Dialysis Fluid Flow (QD) = Diffusive Clearance	Filtrate Flow (QUF) = Convective Clearance	Replacement Fluid Flow (QRF)	Total Clearance (approx. = filter outflow‡)
SCUF	0	Filtrate flow = QUF	0	QUF
CVVH	0	Filtrate flow = QUF	Replacement flow = QRF	QUF
CVVHD (any QDO >QD is not replaced)	Dialysate flow = QD	Filtrate+Dialysate flow = QDO = QD + QUF (where QUF is small)	0	QD (+ optional small QUF)
CVVHDF (= CVVHD + replaced ultrafiltration)	Dialysate flow = QD	Filtrate+Dialysate flow = QDO = QD + QUF	Replacement flow = QRF	QD + QUF

‡ Actual clearance is reduced by around 20% if prefilter addition of replacement fluid is performed.
See Notes to Figure 1 below.

- The 2 techniques, dialysis and high-volume filtration, can be combined as CVVHDF. Dialysis fluid is pumped into the filtrate side of the membrane counter-current to blood flow. Outflow from the filter is pumped out at a flow exceeding that of dialysis fluid flow. Then, the amount by which flow exceeds dialysis fluid flow is filtrate. This excess amount is replaced by replacement fluid. The ideal place for this particular combination of techniques is in a situation where CVVH alone is already running at 36 mL/kg/hr filtrate flow and clearance of urea etc is still inadequate.

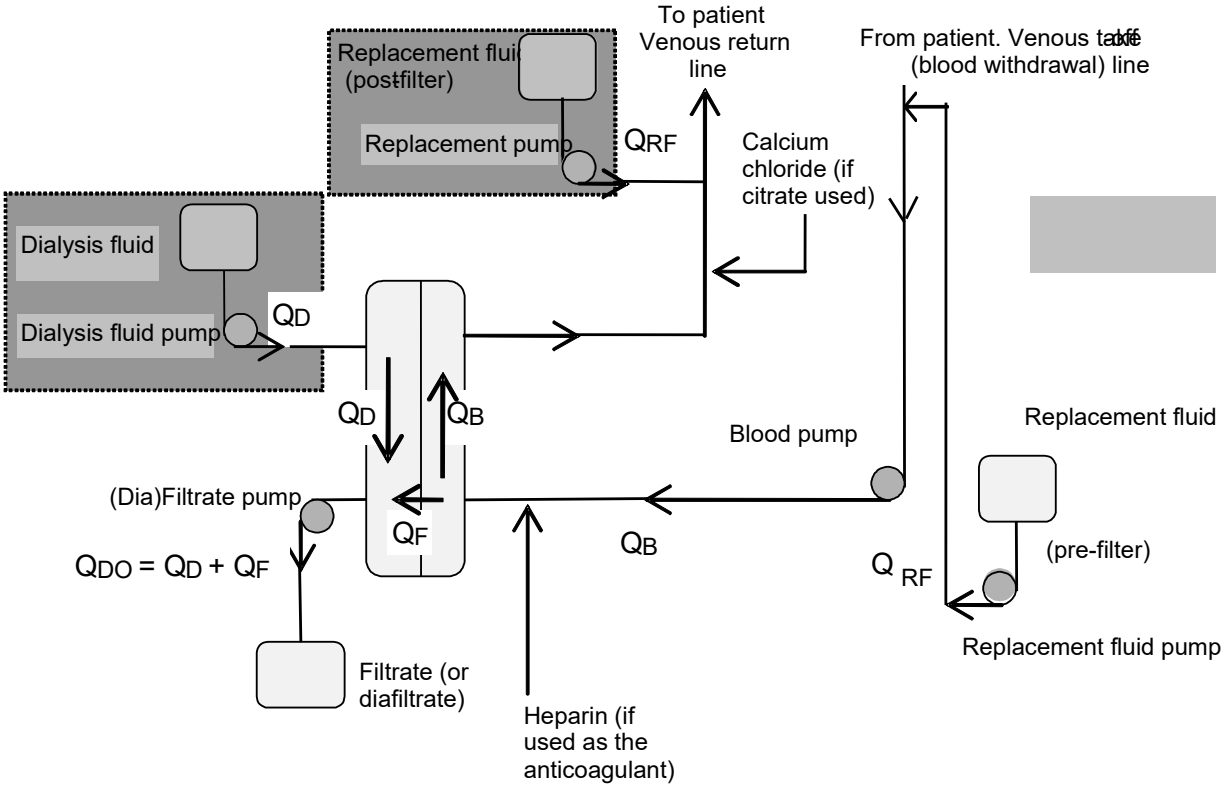


Figure 1. Arrangement for CVVH/CVVHD/CVVHDF

Notes to Figure 1:

- The dotted rectangle on the left side of the diagram represents the haemodialysis option. If CVVHD (Haemodialysis without filtration) is performed (Rare), then the Dialysis fluid and its pump are included, but the Replacement fluid and its pump are omitted. QDO is then the QD plus the small amount of filtrate (QF), which is not replaced.
- The dotted rectangle on the top of the diagram represents the post-filter replacement fluid option. The prefilter replacement fluid and pump are then omitted. If pre-filter replacement fluid is chosen then the blood flowing into the filter is diluted by the replacement fluid, which leads to reduced clearance of solutes. To compensate, increase QRF to 1/5th of QB instead of 1/6th of QB. "Patient Fluid Removal" remains the same so that QF increases by the same amount. Blood pump flow should not be changed.
- Clearance of solute can be increased even further in the predilution option (but not if citrate is being used), without increasing blood flow, by increasing bicarbonate-based replacement fluid and filtrate even further. To increase clearance by 1.5× the filtrate flow must be increased by 1.67×, and to increase clearance by 2× the filtrate flow must be increased by 2.5×. This gets rather expensive in terms of replacement fluid, but is an option if blood flow cannot be increased. To increase clearances in the post-filter dilution option, blood flow must be increased along with filtrate flow.
- If citrate is used as anticoagulant, then the pre-filter option is mandatory.

APPENDIX 3 Citrate Anticoagulation

Figure 2: Relationship of prefilter citrate to prefilter ionised calcium

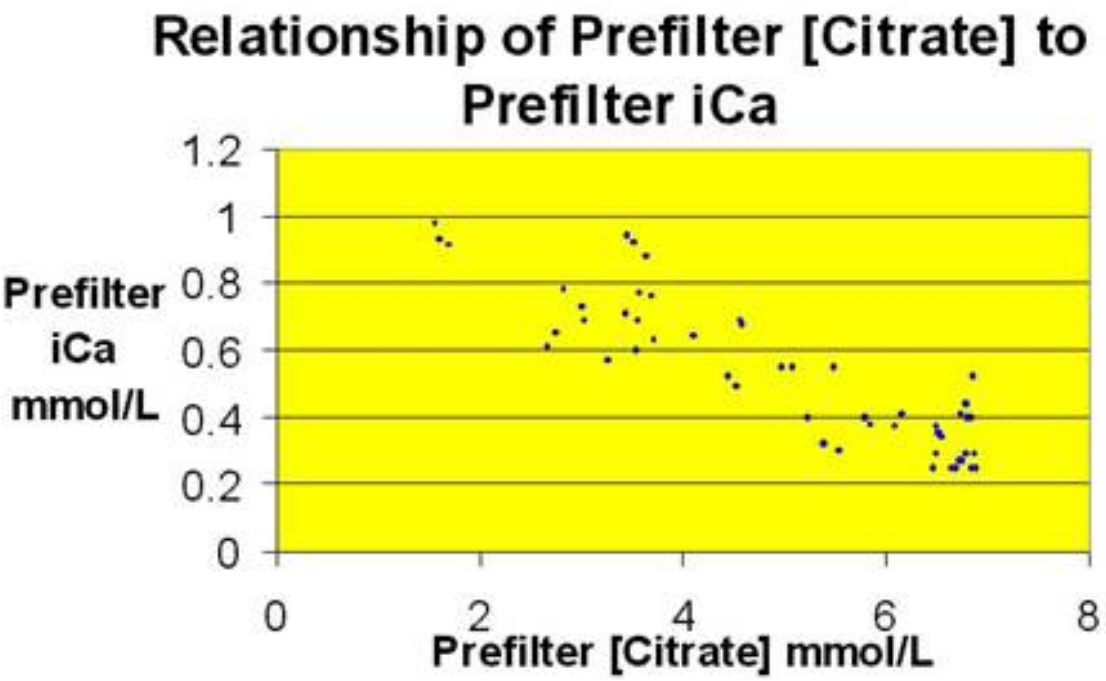
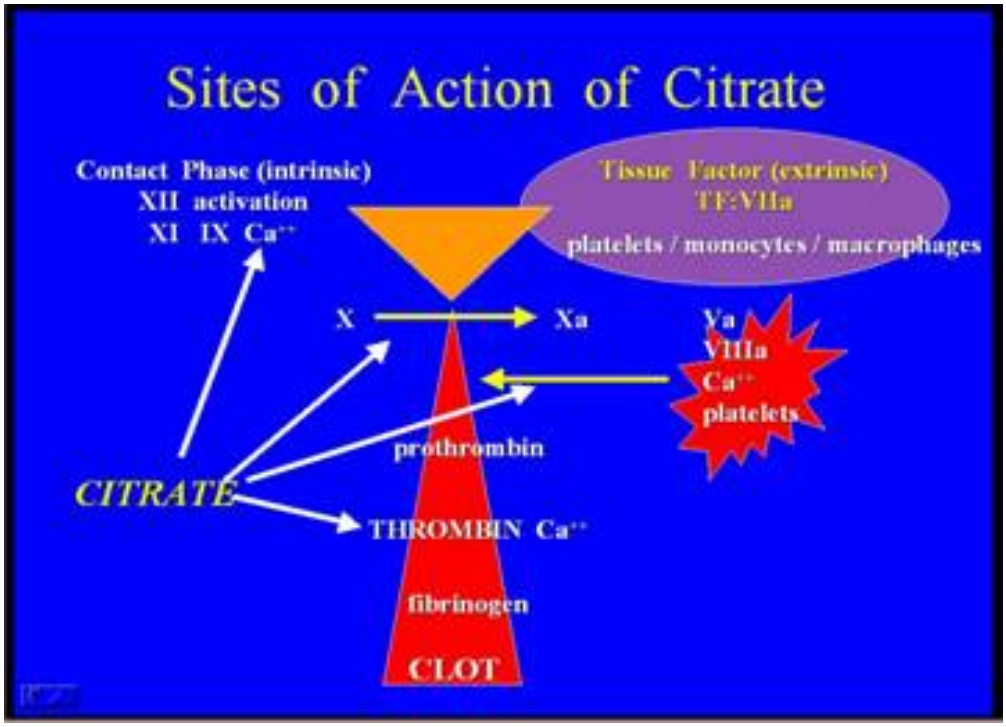


Figure 3: Sites of action of Citrate



Citrate acts by chelating calcium ions that are essential in the clotting cascade. It also chelates other divalent cations including magnesium and aluminium. Normal plasma citrate concentration is <1 mmol/L (it is a normal metabolite of carbohydrate metabolism). A plasma citrate concentration of about 5-6 mmol/L is required in order to reduce ionised calcium concentration to less than 0.6 mmol/L, which is required for anticoagulation. Most published protocols add approximately 2-3 mmol of citrate per litre of blood flowing through the filter, and this rate is adjusted periodically according to ionised calcium level in the plasma of blood exiting the filter.

If plasma citrate level is measured (not routinely available), it agrees closely with the level predicted from the relative blood and replacement flow rates. Some of the citrate/calcium chelate is filtered. The rest returns to the patient and is metabolised rapidly by the liver, though there is a continuously slightly elevated systemic plasma citrate level. This chelates some calcium in the systemic circulation, which can lead to a low systemic ionised calcium level even with normal total calcium. Some chelated calcium is filtered, and the replacement fluid contains no calcium. Approx. 2-3 mmol/kg/day is lost in the filtrate. This is greater than with non-citrate use where about 1 mmol/kg/day is filtered at a filtrate flow of 50 mL/kg/hr. In order to avoid systemic ionised hypocalcaemia, a separate infusion of calcium is required at a rate of approx. 1.2 mmol/kg/day for a blood flow of 3 mL/kg/min, and this is adjusted to maintain systemic plasma ionised calcium level of approx. 0.9-1.2 mmol/L. A separate magnesium replacement is also necessary because the citrate-based replacement fluid contains no magnesium.

Citrate is metabolised to bicarbonate (3 molecules per molecule of citrate), mostly in the liver. A metabolic alkalosis therefore develops in protocols which add citrate separately (even when some of the citrate is as citric acid, e.g., acid-citrate dextrose), and hypernatraemia if the citrate is added as trisodium citrate. This is avoided if sodium citrate is an integral component of the replacement fluid, the citrate acting as the base instead of bicarbonate or lactate. NB The citrate could be separated from the replacement fluid, allowing the flow rates of the citrate and replacement fluid to be varied independently, but citrate is only available as a pharmaceutical preparation as 4% trisodium citrate dihydrate which would have to be given at approx. 4 mL/kg/hr by a separate infusion into a high pressure segment of the circuit.

Table 10. Comparison of Heparin and Citrate Anticoagulation

	Heparin	Citrate
Systemic or Regional Anticoagulation	Systemic	Regional – only the circuit between the blood pump and the venous return catheter is anticoagulated
Likelihood of filter clotting	High	Low
Risk of internal haemorrhage	Some risk	Minimal risk
Ease of adjustment of anticoagulation	Poor - ACT imprecise Heparin long half-life	Rapid - Ca_i rapid and precise Citrate adjustment rapid
Risk of metabolic alkalosis	Low	Moderate
Risk of metabolic acidosis	Low	Low
Risk of hypocalcaemia	Low	Moderate, but easily correctable
Risk of hypomagnesaemia	Low	Moderate, but easily correctable
Can be used with SCUF	Yes	No, unless separate protocol with 4% Trisodium citrate infusion

APPENDIX 4A - PICU CRRT Checklist

PATIENT STICKER

PICU CRRT Checklist

Select Anticoagulation ☐ Citrate ☐ Heparin ☐ None

	Yes	No
Correct Flow Rate & therapy prescription as per policy & medical prescription	☐	☐
Correct bags and additives as per medical prescription	☐	☐

Never add potassium to >4.5 mmol/L total
Never add phosphate to >2.0 mmol/L total (normal max is 1.5 mmol/L)

Anticoagulation monitoring					
Citrate	Yes	No	Heparin	Yes	No
Is circuit calcium level <0.5mmol/L (sample taken from blue port immediately post filter - aim 0.25-0.35mmo/L)	☐	☐	Correct Heparin dose ordered? Collect sample from first red access port before the PBP mixes with the blood or IAL).	☐	☐
Is there rising anion gap?	☐	☐	Does Heparin infusion need readjustments?	☐	☐
Is there rising total calcium but a falling ionised calcium (despite increasing the calcium chloride compensation? (If compensation >140% review for potential citrate lock)	☐	☐	Anticoagulation complications: Bleeding or Hypocalcaemia or Incidence of HIT	☐	☐
Is there Acidaemia with falling bicarbonate?	☐	☐		☐	☐
IF YES to all the above Discuss the risk of citrate accumulation ("citrate lock") with PICU Consultant	☐	☐		☐	☐
Correct Calcium Concentration selected based on filter size? (via a Y-connecter attached to return lumen, aiming for ionised calcium 0.9mmol/L – 1.2mmol/L)	☐	☐		☐	☐

Correct regular Magnesium Sulphate dose charted every 6-12 hourly (suspend order if and when CRRT ceased)	☐	☐		☐	☐

Catheter related issues	Yes	No
Site appears reddened/ infection?	☐	☐
Site oozing/ blooding	☐	☐
Thrombosis/ aspirating clots from access or withdrawal lumens	☐	☐
Extremely negative pressure alarms?	☐	☐
Extremely positive pressure alarms?	☐	☐
Are both lumens aspirating freely without resistance?	☐	☐
Circuit related issues		
Filter clotting, Filter or TMP pressure alarming?	☐	☐
Filter and TMP graph trend rising?	☐	☐
Does the filter need changing?	☐	☐
Does the patient have a valid crossmatch?	☐	☐

Is the ordered hourly fluid off reflecting on patient overall fluid status?	☐	☐
Daily plan documented on Patient notes	☐	☐
New daily medical prescription done by PICU fellow/Consultant	☐	☐

Any concerns to discuss with PICU team?

_____
__
_____
__
_____
__
_____
__

APPENDIX 4B - PICU CVVH Safety Pause

PATIENT STICKER

CRRT Safety Pause (PICU)

- Is the medical CRRT prescription correct as per policy?
  - ☐ YES
  - ☐ NO, specify reason:_____
- Are CRRT orders complete and up to date?
  - ☐ YES
  - ☐ NO (Please specify):_____
- Is the patient's fluid balance over the last 24 hours reflecting what has been ordered?
  - ☐ YES
  - ☐ NO, (Please specify):_____
- Is anticoagulation appropriate?
  - ☐ YES
  - ☐ NO, specify reason:_____
    - ACT range -
    - Calcium Compensation -
    - Circuit calcium levels –
- CRRT circuit status (clots, pressures): ☐ Satisfactory ☐ Unsatisfactory
- Is there a documented CVVH plan for the next 12 to 24 hours?

Signatures

- Date: _____ / _____ / 20_____ Time: _____ / _____
- Nurse handing over sign:_____
- Nurse accepting responsibility sign:_____

☐ YES

☐ NO, specify reason:_____

Date:

PICU consultant/ fellow sign ……

CVVH Specialist Nurse sign ……

INSTRUCTIONS:

WHO: *PICU consultant/fellow, PICU registrar, CVVH Nurse, Nursing team leader*

WHEN: *During AM PICU round*

WHERE: *Patient bedside*

APPENDIX 5 Anticoagulation References

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