

Continuous Veno-Venous Haemodialysis (CVVHD) using either citrate-calcium (Ci-Ca) or conventional (heparin, epoprostenol) anticoagulation with Fresenius multiFiltratePRO® Continuous Renal Replacement Therapy (CRRT)

Guidelines and User Protocol Intensive Care Unit

Frimley Park and Wexham Park Hospital

Key Points

- CRRT with Fresenius multiFiltratePRO must only be provided on Intensive Care Unit (ICU). This policy applies to both ICUs across Frimley Health (Frimley and Wexham Park Hospitals).
- Fresenius MultiFiltratePRO machines must only be used by a member of staff who has had relevant training. CRRT must be prescribed by ICU medical team before commencement.
- Continuous Veno-Venous Haemodialysis (CVVHD) is the only modality available for CRRT on both ICUs across Frimley Health.
- This protocol applies to all types of anticoagulation used to prevent clotting of the dialysis filter and circuit (citrate, heparin, epoprostenol).
- Citrate-Calcium (Ci-Ca) anticoagulation is the first line treatment in patients requiring CRRT.

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Abbreviations

Ci-Ca	Citrate-Calcium
CRRT	Continuous Renal Replacement Therapy
CVVHD	Continuous Veno-Venous HaemoDialysis
PfCa²⁺	Post-Filter Ionised Calcium
RRT	Renal Replacement Therapy
SiCa²⁺	Systemic Ionised Calcium
T:I	Total calcium and Ionised calcium ratio

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This guideline has been registered with the trust. However, clinical guidelines are guidelines only. The interpretation and application of clinical guidelines will remain the responsibility of the individual clinician. If in doubt contact a senior colleague or expert. Caution is advised when using guidelines after the review date. This guideline is for use in Frimley Health Trust hospitals only. Any use outside this location will not be supported by the Trust and will be at the risk of the individual using it.	

Version Control Sheet

Version	Date	Policy Lead(s)	Status	Comment
0.1	12/10/15	Istvan Kajtor	Draft	First draft
1.0	22/11/15	Istvan Kajtor Patricia McCready	Final	First final version
2.0	16/05/16	Istvan Kajtor Patricia McCready	Final	Management of citrate accumulation and metabolic derangement
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4.0	09/03/20	IK, LJ and KL	Final	2 nd cross-site final v.
5.0	10/06/24	IK, LJ and KL	Final	General review, 3 rd cross-site

Document Location

Document Type	Location
Electronic	FPH/WPH: Guideline app. and EPIC
Paper	FPH/WPH: Folders attached to each multiFiltratePRO machines, ICU Guideline Folder

Related Documents

Document Type	Document Name
Drug chart	Ci-Ca Prescription, Administration and Documentation Chart V5.0
Drug chart	Conventional CRRT Prescription, Administration and Documentation Chart V5.0
Flow chart	CRRT: Treatment and Prescription Guidance V5.0
Guideline	Management of heparin and epoprostenol anticoagulation for Renal Replacement Therapy (attached to Ci-Ca/Conventional CRRT Prescription, Administration and Documentation Charts V4.0 and it can also be found at the end of this guideline)
Troubleshooting guide	Citrate Accumulation Troubleshooting Card (TC) Clearance TC Hyperkalaemia TC

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PRINCIPLES OF USING FRESENIUS multiFiltratePRO® (CVVHD)

1. Commencement of **Continuous Renal Replacement Therapy (CRRT)** must be a Consultant Intensivist decision and delivered **only on ICU either at Wexham Park Hospital (WPH) or Frimley Park Hospital (FPH)**.
2. This protocol applies to **all types of anticoagulation** used to prevent clotting of the dialysis filter and circuit (citrate, heparin, epoprostenol).
3. **Strict adherence to the protocol is mandatory when citrate anticoagulation is being used. If there is a deviation to this protocol required, it should be discussed with the duty consultant and clearly documented.**
4. **Continuous Veno-Venous Haemodialysis (CVVHD)** is the only modality available for CRRT on both ICUs across Frimley Health.
5. A **Standard High Flux Filter** should be used for CRRT. A High Cut Off Filter **Emic 2** could be used for clearance of middle molecules (e.g. Rhabdomyolysis, Severe sepsis) up to 40 kDa but this must be a Consultant decision and the reason should be clearly documented.
6. **Citrate-Calcium (Ci-Ca)** anticoagulation is the **first line treatment** in patients requiring CRRT. However, some patient may not tolerate citrate (Ci-Ca) including those with liver failure or fluid responsive lactic acidosis. These conditions are not contraindication of citrate anticoagulation, however closer monitoring is required. Discuss with a Consultant whether a trial of citrate with close monitoring is appropriate.
7. Patients with a **high (e.g. > 6mmol/L) or rapidly rising lactate despite fluid resuscitation** probably will not tolerate citrate and conventional anticoagulation should be chosen.
8. **Citrate accumulation** is a rare complication of Ci-Ca (**T:I ratio > 2.3**) anticoagulation. **If it is suspected, then follow the 'Management of citrate accumulation' on [page 17-19](#).**
9. Citrate accumulation may persist despite preventive measures, in this case **Ci-Ca anticoagulation should be stopped** and other non-citrate anticoagulation should be used.
10. **Conventional anticoagulation** means either unfractionated heparin, epoprostenol or no anticoagulation with a high blood flow rate.
11. Note that **different dialysis fluids** should be used for Ci-Ca (**Ci-Ca K2 or Ci-Ca K4**) and conventional (non-citrate) anticoagulation (**Multibic K2 or Multibic K4**). When switching from Ci-Ca to non-citrate anticoagulation, Multibic dialysate fluid should be prescribed.
12. **Citrate can be deselected without changing the circuit.** Dialysate fluid must be changed to Multibic though.
13. **Citrate does not provide systemic anticoagulation, so appropriate VTE prophylaxis maybe required.**
14. **Heparin/LMWH anticoagulation can be used alongside citrate if the patient requires treatment dose of systemic heparin for another indication (e.g. PE or AF)**

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

1. Commencement of Citrate CRRT

Criteria

1. **Citrate-Calcium (Ci-Ca) anticoagulation is the first line treatment** in patients requiring continuous renal replacement therapy (CRRT). However, some patient **may not tolerate** citrate (Ci-Ca) including those with:
 - **Acute liver failure** (elevated AST/ALT, lactate and INR)
 - **Elevated (e.g. >5mmol/l) but fluid responsive lactic acidosis** (e.g. generalised poor tissue oxygenation or impaired intracellular oxidative state due to drugs such as metformin)
2. In these patients discuss with a Consultant Intensivist whether a trial of citrate with close monitoring is appropriate (see '**Management of citrate accumulation**' on [Page 17-19](#)).
3. **Contraindication:** Patients with a **high (e.g. > 8mmol/L) or rapidly rising lactate despite fluid resuscitation** probably will not tolerate citrate and **conventional anticoagulation should be chosen**
4. **Situations when non-citrate anticoagulation may be preferred:**
 - **Severe coagulopathy** Citrate is not contraindicated however you may want to try CRRT without anticoagulation. Use citrate if circuits clot prematurely.
 - **Required RRT dose >4L/hr**
 - **Severe hypo- or hypernatraemia** To avoid over-rapid correction of serum sodium level it is probably worth using conventional anticoagulation with a low renal dose (e.g. 20 ml/kg/hr) and altering the sodium concentration of Multibic (normally 140 mmol/L) by the addition of sterile water or concentrated sodium chloride. Please note, **there is no Unit protocol for this yet** hence it should be a Consultant decision.
 - **Recent citrate use resulted in accumulation or poor circuit life** with associated metabolic derangement.
 - **Patient is receiving systemic anticoagulation** (systemic heparin, fondaparinux, argatroban) that may enable satisfactory circuit patency and life.

PLEASE NOTE:

Citrate can be used in conjunction with systemic anticoagulation to achieve satisfactory circuit life.

Citrate can be deselected without changing circuit (see Page 21).

If citrate circuits clog or clot too quickly, follow suggestions on page 20.

In severe hypo/hypernatraemia, where circuit life with non-citrate anticoagulation is poor, Citrate CVVHD can be tried cautiously. Use slow dialysis rates (20ml/kg/hr or less) and monitor sodium levels at least 6 hourly.

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

Preparation for commencement of treatment

- Machine used for Citrate (Ci-Ca) anticoagulation is **Fresenius multiFiltratePRO®**
- The prescription must be written under the supervision of the Consultant
- Select '**Citrate-Calcium (CiCa) Prescription and Administration Chart**' for CVVHD
- Prescribe the following on the drug chart
 - AV1000S multiFiltratePRO Kit Ci-Ca HD Filter** (default) – **yellow** label on the box
 - Sodium Chloride 1000mL 0.9 %** for priming the circuit
 - 1500mL Calcium Chloride 100mmol/L** concentration
 - Sodium Citrate 4% 1500mL**
 - Calcium pre-treatment (see [Page 9](#)) if required
 - Dialysate fluid:
 - **CiCa K4** (contains K⁺ of 4mmol/L) as default
 - **CiCa K2** (K⁺ of 2mmol/L) if hyperkalemia present (K⁺ ≥ 6.5mmol/L)
 - The **start-up dialysate and blood flow rates** according to the patient's needs (see on [Page 8](#))
- The Fresenius multiFiltratePRO® machine should only be set up by a member of the team who has had relevant training. The lined and primed machine should always be checked by a second nurse who has undergone relevant training before commencing treatment

Setting up

Fluids
1500mL Calcium Chloride (100mmol/L)
1500mL Sodium Citrate 4%
2 X 5L Ci-Ca K2 or K4 Dialysate Solution Bags
1 X 1000mL Sodium Chloride 0.9% for priming and wash back
Equipment
AV1000S multiFiltratePRO Kit Ci-Ca HD Filter Circuit (yellow label)
Wash back equipment
dressing pack, priming spike adapter, yellow bag and pressure transducer line
Red and Blue Y connectors

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

To start

1. Switch on the machine
2. Wait for functional test to be completed
3. Select Ci-Ca CVVHD treatment mode
4. Check all the starting conditions have been fulfilled:
• Citrate solution concentration – 136 mmol/L (4%) • Citrate volume 1500mL • Calcium solution concentration – 100 mmol/L • Calcium volume 1500mL • Calcium free dialysis solution used (CiCa K4 or CiCaK2)
5. Confirm conditions are fulfilled
6. Follow the step by step guide to line the machine
7. Measure post-filter iCa^{2+} 5 minutes after starting to confirm there is adequate anticoagulation

PLEASE NOTE:

The citrate and calcium line clamps should be closed.

Always read the instructions and do not skip a section.

The citrate and calcium lines are primed first

Ensure the filter is turned upside down during the ultrafiltration (UF) rinse phase to ensure the outer compartment of the filter has had all of the air removed

Dialysis Flow Rate (equals RRT dose, clearance)

- The default dialysis flow rate is 25mL/kg/hour**
- Only consider increasing dialysis flow rate up to 35mL/kg/hour in the following circumstances:
 - Severe metabolic acidosis (pH < 7.2 and BE < -10mmol/L)
 - Hyperkalemia (Potassium > 6.5mmol/L)
 - Inadequate response to default dialysis flow rate
 - Poisoning (e.g. ethylene glycol)
- The maximum RRT dose can be used with citrate CVVHD is 4000 mL/h. In this case the start-up blood flow should be 200 mL/min.
- See 'Adequacy of clearance' part of this guideline

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

Standard start-up flow rates

(based on dialysate flow rate 25mL/kg/hour)

The **Ratio of Dialysis Flow Rate : Blood Flow Rate** should be **20:1** at the start of citrate CVVHD, and can then be adjusted according to the acid base balance of the patient. **Table 1** shows the recommended standard start-up rates. You may start with a different or higher (up to 4000mL) Dialysate Flow but Blood Flow should be adjusted accordingly (e.g. 4000mL/h : 200 mL/min or 3600mL/h : 180mL/min) to maintain the 20:1 ratio between the two (see **Table 6** on [Page 13](#)). Remember your patients systemic ionised calcium may need to be pre-treated prior to commencement (**Table 3, Page 9**).

TABLE 1

Ideal Body Weight	<60kg	60 – 80kg	>80kg
Dialysis Flow Rate	1600 mL/h	2000 mL/h	2400 mL/h
Blood Flow Rate	80 mL/min	100 mL/min	120 mL/min
Citrate Dose	4.0 mmol/L	4.0 mmol/L	4.0 mmol/L
Calcium Dose	1.7 mmol/L	1.7 mmol/L	1.7 mmol/L

Standard start-up flow rates

(based on dialysate flow rate 35mL/kg/hour, Table 2)

TABLE 2

Ideal Body Weight	<60kg	60 – 80kg	>80kg
Dialysis Flow Rate	2000 mL/h	2600 mL/h	3200 mL/h
Blood Flow Rate	100 mL/min	130 mL/min	160 mL/min
Citrate Dose	4.0mmol/L	4.0mmol/L	4.0mmol/L
Calcium Dose	1.7mmol/L	1.7mmol/L	1.7mmol/L

Ci-Ca CVVHD mode uses blood flow rates at least half of those used with conventional anticoagulation. As a result, there may be less wear and tear on the blood pump segment of the circuit and therefore a reduced risk that this part of the device may split. Because of this Ci-Ca CVVHD circuits could be running for longer than 72 hours. The Trust Pharmacy approved to run the circuit for maximum 72 hours in line with the recommendation of the Manufacturer. After the blood pump has been running for 72hr a pop up message will alert you the recommended time has been reached. Elective wash back must be done and you should restart Ci-Ca CVVHD with a new circuit if CRRT is clinically still indicated.

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

Start-up Citrate and Calcium Dose

1. **Citrate dose is always 4mmol/L at the start** except if RRT is restarted with a new circuit or following wash back (see below)
2. **Calcium dose is 1.7mmol/L at commencement of citrate RRT** unless the patient is hypo- or hypercalcaemic (see Calcium pre-treatment, **Table 3**)
3. If you restart Ci-Ca CVVHD following wash back (see on **Page 22**), or connect a new circuit **within 4 hours of interruption**, you can *set the dialysate/blood flow rates, citrate and calcium doses as they were before*, except when the patient's clinical condition has changed. If concerned about a change in condition discuss with a Consultant Intensivist
4. If it is **greater than 4 hours** after disconnection restart CVVHD according to the start-up Dialysis, Blood Flow Rates and Citrate, Calcium Dose.

Management of patients systemic ionised calcium pre-treatment

To enable the safe management of the patient's systemic ionised calcium (SiCa^{2+}) you must ensure that the patient's systemic iCa^{2+} is within safe levels. To do this check the patient's SiCa^{2+} via a blood gas at least **one hour prior to starting the treatment** (blood gas taken on ward/ED/theatre can be used). You must then use the guide below (**Table 3**) how to maintain the patient's SiCa^{2+} .

TABLE 3

Systemic iCa^{2+} (mmol/L)	< 1.01	1.01 – 1.11	1.12 – 1.20	1.21 – 1.45	> 1.45
Pre-Treatment with Calcium Chloride [#]	Yes	Yes	No	No	No
Starting Calcium Chloride Dose (mmol/L)	2.0	1.9	1.7	1.5	1.4
Check first systemic iCa^{2+} and review calcium dose after	2 hours	6 hours	6 hours	6 hours	6 hours

[#] Infuse 10mmol Calcium Chloride in 50mL Sodium Chloride 0.9% over 30 minutes

First Post-filter ionised Calcium (PFiCa^{2+}) check

Measure the post-filter iCa^{2+} **five minutes after starting** and adjust the citrate dosage according to **Table 4**. This check ensures the circuit is adequately anticoagulated. The **optimum range is between 0.25 – 0.34**. Subsequent PFiCa^{2+} should be confirmed and the citrate dose reviewed **once every six hours**.

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESenius multifiltratePRO® (CVVHD)

2. Monitoring and adjustment of treatment

General points

- Try to correct just one problem at a time, i.e. SiCa^{2+} , PFiCa^{2+} , acid-base derangement, inappropriate clearance
- All adjustments should be clearly documented on the patient's observation chart
- Adjustments to citrate and calcium settings are usually only needed in the first day or two, then things should stabilise
- Any change in Dialysis or Blood Flow Rate should be prescribed by ITU doctor before adjustment
- If both SiCa^{2+} and PFiCa^{2+} are above their target range, only reduce the calcium dose initially. The PFiCa^{2+} should come down as the SiCa^{2+} reduces. (However, check the post-filter value again 1h after the change and increase the citrate dose if it is still too high.) If both are below their target range, only increase the calcium dose.

Monitoring Post-Filter Ionised Calcium (PFiCa^{2+}) levels (Table 4)

- If there is suspected citrate accumulation refer to [Page 17-19](#).
- The standard target for PFiCa^{2+} in this protocol is **0.25–0.34mmol/L blood**. The more consistently the PFiCa^{2+} is kept below 0.35mmol/L during treatment, the lower the risk of circuit clotting.
- The first check of PFiCa^{2+} is after 5 minutes of commencement of citrate RRT then 6 hourly unless you are concerned or suspect early filter clotting/clogging.

TABLE 4

FILTER CHECK		
Post-Filter ionised calcium (mmol/L)	Change of the citrate dose (Citrate/blood)	Check Post-Filter ionized calcium and review citrate dose after
>0.45	Increase by 0.3 mmol/L (Inform Doctor)	6 hours
0.41 – 0.45	Increase by 0.2 mmol/L	6 hours
0.35 – 0.40	Increase by 0.1 mmol/L	6 hours
0.25 – 0.34	No Change	6 hours
0.20 – 0.24	Reduction by 0.1 mmol/L	6 hours
<0.19	Reduction by 0.1 mmol/L	6 hours

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESenius multiFiltratePRO® (CVVHD)

- **PfCa²⁺ should respond quickly to any adjustments of the citrate dose** so it can be checked again 5 to 10 min after any change to check that the required level has been achieved and a further adjustment made if necessary.
- If the following problems occur:
 - systemic bicarbonate (HCO³⁻) increasing
 - systemic iCa²⁺ increasing
 - PfCa²⁺ high, e.g. 0.65mmol/L (+citrate requirements increasing to try to reduce it)
 - increasing systemic Na⁺

Check whether Multibic fluid has been used instead of Ci-Ca Dialysate in error!

Monitoring Systemic Ionised Calcium (SiCa²⁺, Table 5)

1. The target for the **SiCa²⁺** in the Fresenius protocol is 1.12 to 1.20mmol/L. Please use this target range even though it differs a little from the standard 'normal range'.
2. The first check of **SiCa²⁺** is after 6 hour of commencement of citrate RRT.

TABLE 5

Systemic ionised calcium (mmol/L)	Change of the calcium dose (Calcium/filtrate)	Check systemic ionised calcium and review calcium dose after
>1.45	Reduction by 0.6 mmol/L (Inform Doctor)	6 hours
1.31 – 1.45	Reduction by 0.4 mmol/L	6 hours
1.21 – 1.30	Reduction by 0.2 mmol/L	6 hours
1.12 – 1.20	No Change	6 hours
1.05 – 1.11	Increase by 0.2 mmol/L	6 hours
0.95 – 1.04	Increase by 0.4 mmol/L	6 hours
<0.95	Increase by 0.6 mmol/L (Inform Doctor)	6 hours

IMPORTANT NOTE: If the systemic ionised calcium rises to the point where the protocol indicates you to turn off the Calcium, you must change to conventional anticoagulation with Multibic solution or assess whether or not CVVHD is required. UNDER NO CIRCUMSTANCES SHOULD YOU RUN THE CITRATE WITHOUT THE CALCIUM RUNNING TOO.

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

3. **You may see a drop in the patient's systemic iCa^{2+} on commencement of treatment if a blood gas was taken for other reason.** A fall in $SiCa^{2+}$ in the first few hours of citrate treatment is quite common hence there is no need to adjust the calcium dose within 6 hours of commencement of RRT (. The $SiCa^{2+}$ usually corrects without intervention. Moreover, this is not an indication of Citrate accumulation but an isolated figure instead. See the algorithm for Citrate accumulation ([Page 17-19](#)) and management.
4. **If anytime the $SiCa^{2+}$ is <0.95 or >1.45 :**
 - Inform medical team
 - Recheck ABG or VBG (sample error, peripheral stab if CV-line is co-located with vas cath) $SiCa^{2+}$
 - adjust Calcium according to the chart then re-check when it is normally due
 - If $SiCa^{2+} <0.95$ Consider citrate accumulation ([Page 17-19](#))
 - If $SiCa^{2+} >1.45$ Check whether Multibic has been used in error and consider filter clogging ([Page 20](#))
5. $SiCa^{2+}$ levels tend to vary over time (even when the calcium rate has not been adjusted). Do not be too quick to adjust the calcium dose if the $SiCa^{2+}$ is not very far from the target range as the patient is unlikely to be at risk. Changes in the $SiCa^{2+}$ occur slowly unless the membrane is clogging (see below). Give the systemic calcium mechanisms sufficient time to stabilise after any change in $CaCl_2$ dose before changing the rate further.
6. If the calcium dose has to be increased in the first 6-12h to keep the $SiCa^{2+}$ in the target range, it could be because citrate is not being metabolised. However, if the patient's $SiCa^{2+}$ baseline was low then it could just mean further correction is necessary. Alternatively it could be due to both! Check Total Calcium (uncorrected) and **T:I ratio** to find out (see [Page 17-19](#)).
7. If the $SiCa^{2+}$ rises unexpectedly accompanied by an increasing base excess (metabolic alkalosis), the dialyser membrane may be clogging and impairing clearance of calcium citrate complexes. The extra calcium citrate received by the patient is being metabolised into bicarbonate and free calcium ions. If this happens wash back and start a new circuit (see [Page 20](#)).
8. Note that the maximum calcium infusion rate on the Ci-Ca multiFiltratePRO is 100mL/h = 10mmol/h. At high dialysate rates, the machine may not be able to deliver the desired dose of calcium (e.g. 2.6mmol/L when the dialysate rate is set at 4L/h, which would need an infusion rate of >10 mmol/h). The machine will alarm 'Filtrate rate too high for the Calcium dose! Calcium rate above the maximum rate of 100mL/h'. In this case, the dialysate and blood flow rates have to be reduced (in the same proportion) until the calcium infusion rate is ≤ 100 mL/h.

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESenius multiFiltratePRO® (CVVHD)

Acid-Base Balance Management

Fifty per cent of the calcium citrate complexes are dialysed out into the waste and 50% is re-infused into the patient along with some unbound citrate. **The 50-50 % split** maintained by the **default 20:1 ratio** between the Dialysis Flow Rate and Blood Flow Rate (see **start-up flow rates Table 1 and 2, and also Table 6**). Citrate is typically **metabolised to bicarbonate**, and the bound calcium is released as free ionised calcium.

The standard Dialysis and Blood Flow rate settings in the Fresenius protocol are as follows (Note: The blood flow rate (in mL/min) is one-twentieth of the dialysate flow (in mL/hour).

Table 6

Dialysis Rate (mL/hr)	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000
Blood Flow Rate (mL/min)	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200

Normally treatment is programmed to run at one of these standard settings which should keep patients in a normal metabolic acid-base balance once treatment starts and any renal-related acidosis has been corrected

Changing the ratio between the Dialysis Flow Rate and Blood Flow Rate will have an impact on the patient's acid-base balance.

- Increased dialysate flow at constant blood flow will decrease the citrate load delivered to the patient (hence less bicarbonate produced by the citric-acid cycle)
- Increased blood flow at constant dialysate flow will increase the citrate load delivered to the patient (hence more bicarbonate produced by the citric-acid cycle)

Management of the acid-base balance is therefore an important factor of citrate anticoagulation. A patient's metabolic acid-base status can be manipulated if more or less citrate is delivered by altering the blood flow independently of the dialysate rate or vice versa (as long as the patient's ability to metabolise citrate efficiently is unimpaired).

PLEASE NOTE:

- If the dialysate rate is increased or reduced during treatment in order to increase or decrease clearance, the blood flow rate should be increased or reduced by the same proportion. E.g. If dialysate rate increased from 2000mL/h to 2400mL/h, the blood flow rate should be increased from 100mL/min to 120mL/min.
- If the acid-base balance is within normal ranges and you are changing the blood flow rate due to vascular access issues (alarms) then dialysate flow rate also needs to be changed to maintain the 20:1 ratio (to maintain normal pH).

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

When treating an acid-base derangement please consider the following potential causes and the actions (**Table 7 and 8**) which should be taken:

TABLE 7

Metabolic Acidosis	
Potential causes	Potential actions
Patient's underlying condition	If citrate accumulation is <u>not suspected</u>: 1. Improve clearance – increase dialysate and blood flow rates in the same proportion (to 35mL/kg/h, see Table 2 for recommended settings) 2. <u>Either</u> increase blood flow rate by 20-40 mL/min and keep dialysis rate constant (if clearance is not adequate, i.e. urea > 10 mmol/L) 3. <u>Or</u> decrease dialysate rate by 400-800 mL/h and keep blood flow rate constant (if clearance is adequate, i.e. urea < 10 mmol/L) Note: <i>N 2. and 3. will not be effective if citrate accumulation is the cause</i> If citrate accumulation is <u>suspected</u>: 1. Check T:I ratio <u>and</u> 2. See 'Management of citrate accumulation'
Dialysate flow rate too high in relation to the blood flow rate (insufficient citrate is being supplied to the patient)	Correct the dialysis and blood flow rates to standard settings (to maintain 20:1 ratio, see Table 6)
The full effect of these adjustments <u>above</u> will take some hours to develop. Keep under review: if alkalosis develops, return to standard settings.	
CRRT has not been running long enough to correct the renal failure-induced acidosis	1. Just wait for RRT to correct the acidosis <u>or</u> 2. Increase clearance rate by increasing both the blood flow and the dialysate rate by the same proportion (to 35mL/kg/h, see Table 2)
Inadequate dialysis dose	Increase clearance rate by increasing both the blood flow and the dialysate rate by the same proportion (Table 2)
Citrate accumulation due to impaired metabolism (e.g. acute severe liver failure, severe lactic acidosis). This is indicated by a T:I ratio >2.3	See 'Management of citrate accumulation'
Wrong sampling of blood (possible with switched connections)	See 'Blood sampling'

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If an acid-base derangement occurs it is important to distinguish if this is due to a primary metabolic process in the patient or the accumulation of citrate (reduced capacity of the liver, kidneys and muscle to metabolise citrate). If a primary metabolic process is considered likely this should be treated first (sodium bicarbonate can be added as required).

TABLE 8

Metabolic Alkalosis	
Potential causes	Potential actions
Patient's underlying condition	1. <u>Either</u> reduce blood flow rate by 20-40 mL/min and keep dialysis rate constant (if clearance is adequate, i.e. urea < 10 mmol/L) 2. <u>Or</u> increase dialysate rate by 400-800 mL/h and keep blood flow rate constant (if clearance is not adequate, i.e. urea > 10 mmol/L)
Dialysate flow rate too low in relation to the blood flow rate (giving an excess supply of citrate)	Correct the dialysis and blood flow rates to standard settings (to maintain 20:1 ratio, see Table 6)
Filter clogging – Impaired clearance of calcium-citrate complexes (associated with a rise in systemic Ca ²⁺ and Na ⁺)	Consider washing back the circuit and starting new one (see 'Premature circuit clotting/clogging')
The full effect of these adjustments will take some hours to develop. Keep under review: if acidosis develops, return to standard settings.	

Nurses may only change the flow rates if there was an issue (e.g. vascular access) to troubleshoot. Both Dialysis and Blood Flow Rate should be changed (usually reduced) by the same proportion and clearly documented. Notify medical staff as soon as possible. **Changing the flow rates for other reason (modify clearance or treat metabolic derangement) should be a senior doctor decision.**

**ALTERATION OF BLOOD OR DIALYSATE RATE IS A CHANGE TO THE PRESCRIPTION
THIS MUST BE DOCUMENTED ON THE CHART BY THE PRESCRIBER**

Lactic acidosis – Remember that although patients who develop a lactic acidosis might have a reduced capacity to metabolise citrate, there is no evidence that using citrate can cause lactic acidosis. **Lactic acidosis may develop or worsen coincidentally when citrate is started.** Other causes linked to the patient's underlying condition should be considered and addressed. Citrate should only be discontinued if it appears to be accumulating significantly.

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Adequacy of clearance

If more clearance is necessary, both the blood flow and the dialysate flow rate should be increased by the same proportion, e.g. increase both by 20%. (See **Table 6** for standard settings)

If a reduction in clearance is required, decrease the blood flow and dialysate flow by the same proportion.

Management of Potassium

Ci-Ca K4 Dialysate contains 4.0mmol/L of Potassium.

Ci-Ca K2 Dialysate contains 2.0mmol/L of Potassium.

The default solution is Ci-Ca K4.

Serum Potassium levels should be checked (via blood gas) at least every 3 to 4 hours unless indicated. If hyper/hypokalemia occurs checking should be increased to 1 to 2 hourly.

Severe hyperkalemia ($K^+ \geq 6.5\text{mmol/L}$):

1. Increase clearance (e.g. 35mL/kg/h, see Table 2 for recommended settings)
2. Ci-Ca K2 should be used
3. Consider giving other treatment (e.g. dextrose/insulin)
4. If severe hyperkalemia persists, refer to Consultant

Hypokalemia can be corrected by giving Potassium Chloride supplementation according to ICU guidelines.

Always use Ci-Ca K4 as a default solution if hyperkalemia is not present.

Management of Phosphate and Magnesium

Both hypophosphatemia and hypomagnesemia may occur during Ci-Ca CRRT. **Magnesium** forms complexes with citrate which can be dialysed out. Ci-Ca K2/K4 dialysate contains 0.75mmol/L of magnesium which should help maintain good levels of systemic magnesium. Daily checks of phosphate and magnesium levels should take place and should be substituted as clinically required in line with relevant ICU guidelines.

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3. Citrate Accumulation

Detection of citrate accumulation

Problems may occur if the patient is unable to adequately metabolise citrate in the presence of acute severe liver failure and/or severe lactic acidosis (sign of poor tissue perfusion and hypoxia). Problems associated with **impairment of citrate metabolism** and the **signs of citrate accumulation include:**

1. **Hypocalcaemia** – marked drop in systemic ionised calcium (SiCa^{2+}) resulting in **increased Calcium dose requirements**. The hypocalcaemia (**low SiCa^{2+}**) is due to unmetabolised citrate remaining chelated to calcium ions. Citrate is not toxic, but the hypocalcaemia has to be corrected by increasing the calcium chloride dose.
2. **Elevated Total Calcium (uncorrected) > 3mmol/L and Raised Total: Ionised Calcium Ratio (T:I)** – As the calcium-citrate complexes accumulate in the blood and extra CaCl_2 is given to correct the low SiCa^{2+} , the total calcium rises and the total calcium/free ionised calcium ratio rises correspondingly. *This T: I Calcium Ratio is a reliable indirect measure of and correlates best with raised citrate levels in the blood.*
3. **Metabolic acidosis** – due to failure to metabolise citrate to bicarbonate and the accumulation of citrate ions producing an **elevated anion gap acidosis**.

Note - exclude other causes of metabolic acidosis as this may not necessarily be secondary to citrate accumulation.

Patient at risk of citrate accumulation:

- **Acute liver failure** (elevated AST/ALT, lactate and INR)
- **Elevated (e.g. > 5mmol/L) but fluid responsive lactic acidosis** (e.g. generalised poor tissue oxygenation or impaired intracellular oxidative state due to drugs such as metformin)

Citrate accumulation should be suspected if:

1. Increasing Calcium Dose requirements
2. Calcium chloride (CaCl_2) dose > 2.1 mmol/L
3. Total (uncorrected) : Ionised Calcium (T:I) Ratio > 2.3
4. Increase in Total Calcium (uncorrected), possibly >3.0 mmol/L
5. Metabolic acidosis is present

If Calcium Chloride (CaCl_2) infusion dose is >2.1 mmol/L the machine will prompt you to consider citrate accumulation.

The **T:I ratio** is calculated using the morning bloods ('ICU profile') for **Total (uncorrected) calcium** (**NOTE: Total Calcium is called 'Calcium' in laboratory results**) level and an arterial blood gas sample taken **within 1 hour** of this time for your **Systemic ionized calcium (iCa^{2+})**.

$$\text{Equation for T: I ratio} = \frac{\text{Total Calcium [laboratory]}}{\text{Systemic (iCa}^{2+}) \text{ [ABG]}}$$

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Monitoring T:I Ratio

Total Calcium level should be checked **daily** as part of the morning 'ICU profile'. Calculate and document T:I ratio using the formula provided on the previous page. If patient is at risk of developing citrate accumulation or citrate accumulation is suspected, T:I ratio should be checked **more often**. As a rule of thumb send bloods for measuring Total Calcium level and calculate T:I ratio **any time you are suspicious or concerned**. Remember to take a blood gas to check SiCa^{2+} .

Management of Citrate Accumulation

Please refer to **Table 9** on [Page 19](#).

4. Blood sampling

1. Blood sample for PFiCa^{2+} should only be collected from the **blue port** of the circuit.
2. Ideally arterial line (ABG) should be used to take bloods for checking SiCa^{2+} .
3. Alternatively the **red port** of the circuit can be used for SiCa^{2+} check if arterial line is not available
4. **Connections to the dialysis catheter should never be interchanged as it may cause recirculation of blood from the return limb of the circuit, which contains some free citrate ions, into the access limb.**

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TABLE 9. Management of Citrate accumulation

Clinical setting	T:I and SiCa ²⁺ check	Management
1. Patient at risk (before commencement of RRT) <i>Acute liver failure</i> (high AST/ALT, lactate and INR) <i>Elevated (e.g. > 5mmol/l) but fluid responsive lactic acidosis</i> (circulatory shock, metformin etc.)	6 hourly	A trial of close monitoring may be appropriate. Decision should be made by Consultant. Do not forget Calcium pre-treatment if necessary. Look closely for signs of citrate accumulation then follow Section 2-5.
2. Citrate accumulation is suspected <i>Increasing Calcium Chloride dose</i> <i>Hypocalcaemia (SiCa²⁺ < 1mmol/L)</i> <i>Metabolic acidosis is present (either developing, steady, unresponsive to dialysis or worsening)</i>	Immediately then 4 hourly	Inform medical staff Adjust Calcium dose immediately then 4 hourly Consider giving Sodium Bicarbonate 8.4 % systemically to correct acidosis Refer to Section 5 if T:I > 2.3
3. Calcium chloride (CaCl₂) dose > 2.1mmol/L <i>Machine will prompt you to consider citrate accumulation</i>	Immediately	Inform medical staff. Look for other signs of citrate accumulation (Section 2) then follow management detailed in Section 2
4. Total Calcium > 2.5mmol/L but T:I < 2.3, hypocalcaemia is not present instead SiCa²⁺ > 1.2mmol/L <i>Citrate accumulation is unlikely</i>	No change	Decrease Calcium dose according to protocol If metabolic alkalosis also present: - check whether you are using the correct dialysis fluid - filter may be clogged (you may need to start a new circuit, inform Consultant)
5. Clinically relevant citrate accumulation is present <i>Increasing Calcium Chloride dose requirements</i> <i>Hypocalcaemia (SiCa²⁺ < 1mmol/L)</i> <i>Metabolic acidosis is present (often unresponsive to dialysis and/or worsening)</i> <i>T:I Ratio > 2.3</i> <i>Increase in Total Calcium, possibly > 3mmol/L</i>	4 hourly	Inform medical staff Adjust Calcium dose immediately then 4 hourly Consider giving Sodium Bicarbonate 8.4 % systemically to correct acidosis Let PFiCa ²⁺ rise to the 0.35 to 0.4mmol/L range by reducing the citrate dose in steps of 0.1mmol/L, checking the PFiCa ²⁺ 5 to 10mins afterwards and then reducing the citrate again if necessary. (The circuit may not last as long.) Also consider reducing blood flow by 20 ml/min. If clinically relevant citrate accumulation persists refer to Section 6.
6. Severe citrate accumulation <i>Signs of citrate accumulation accompany a rapidly increasing lactic acidosis <u>or</u></i> <i>T:I > 2.5 <u>or</u></i> <i>No improvement in the signs of citrate accumulation despite measures described in Section 5 <u>or</u></i> <i>Measures described in Section 5 cause the circuit to clot early</i>	Nil	Switch to another form of anticoagulation (citrate will just make acidosis worse!) Inform Consultant

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

5. Invasive procedures during citrate RRT

There is no need to discontinue citrate anticoagulation or stop RRT treatment. Citrate does not cause systemic anticoagulation instead it provides the so called **Regional Citrate Anticoagulation (RCA) within the circuit**. All common ICU related invasive procedures (CV-line, Arterial line insertion, chest drain, percutaneous tracheostomy, ascetic drainage or removal of lines, epidural catheters etc.) can be carried out without stopping dialysis – unless patient is on other anticoagulation.

6. Premature circuit clotting or membrane clogging

Most patients on Ci-Ca CVVHD achieve good circuit life with satisfactory solute clearance, acid-base balance and systemic SiCa^{2+} levels.

In a minority of patients, clearance of solutes (including calcium citrate complexes) becomes less efficient over the course of the circuit life, probably due to deterioration in membrane permeability (these circuits has often been running for 2 days). In these cases, the circuit often clots prematurely.

If you are concerned that the filter is clotting or clogging:

1. Check whether Multibic fluid has been used instead of Ci-Ca Dialysate in error!
2. Send ICU profile (at least U&Es) + fibrinogen level
3. Inform medical staff/Consultant

If the following changes are observed, it is better to end treatment and start again with a new circuit:

- Unusually rapid rise in base excess (and in HCO_3^-)
- Unusually rapid rise in SiCa^{2+}
- Rise in systemic Na^+
- Visible clotting in the AV filter
- Gradual rise in renal chemistry (urea, creatinin)

7. What happens if you use the wrong dialysis solution during Ci-Ca?

Ci-Ca K2/K4 is a specific solution made for Ci-Ca anticoagulation. If you use Multibic fluid instead you may encounter:

- systemic bicarbonate increasing
- systemic iCa^{2+} increasing
- post-filter iCa^{2+} high, e.g. 0.65mmol/L (+citrate requirements increasing to try to reduce it)
- increasing systemic Na^+

IF YOU NOTICE ANY OF THE ABOVE, CHECK YOU ARE USING THE CORRECT DIALYSIS FLUID

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

8. Frequently asked questions

How to convert from Citrate to Heparin / Epoprostenol / No Anticoagulation without changing the circuit?

1. **Use this option if citrate is accumulating, circuit keeps clotting.** Changing to heparin from citrate must be a Consultant Intensivist decision.
2. **Select anticoagulant to be used** (Refer to non-citrate protocol for details):
 - Use 50mL BD Plastic syringes for both heparin or epoprostenol
 - Use a Braun® syringe driver (the built in syringe driver of the Fresenius machine could only be used for heparin)
 - After priming the line, it can be attached to the additional lumen of the Fresenius circuit
3. **A different dialysis fluid (Multibic) is required:**
 - **Multibic K4** (contains K⁺ of 4mmol/L) as default
 - **Multibic K2** (contains K⁺ of 2mmol/L) if severe hyperkalemia present (K⁺ ≥ 6.5mmol/L)
4. **Then follow the step by step guide below**

Step by Step Guide on how to change the circuit from citrate to non-citrate CVVHD (should be done by 2 nurses)

1. Refer to non-citrate protocol for details
2. Attach BD Plastic 50 mL syringe to an extension line and prime manually. **Heparin:** use the **'built-in' syringe driver of Fresenius multiFiltratePRO** and commence after doing the following steps (alternatively a separate syringe driver can also be used if necessary). **Epoprostenol:** Braun® syringe driver must be used for **epoprostenol** administration.
3. **Heparin:** attach the primed line to the additional lumen of the arterial (**red**) line of the Fresenius circuit. **Epoprostenol:** must be given via central or PiCC line
4. On the **'Menu tab'** select **'Deselect Ci-Ca anticoagulation'**.
5. Confirm decision by selecting **'Yes'** on the next screen.
6. Confirm all conditions for change are fulfilled.
7. All pumps will stop except the blood pump. You will be asked to change the bags, which you will change to **Multibic**.
8. Start syringe driver. Once change made and accepted, the pumps will recommence treatment.

The blood flow rate needs to be changed when you are not using Citrate due to the size of the filter. Increase to a minimum of 250mL/min. If extra clearance is necessary you can then increase the dialysis flow rate to maximum rate of 4.8 Litres/hour. The circuit must be used for a maximum of 72 hours (including the time the circuit has been running with citrate for).

CITRATE-CALCIUM (Ci-Ca) ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

How to save a circuit when a patient needs to be temporarily disconnected?

1. This is an aseptic procedure and should be done by two nurses.
2. Providing there has been no changes in their clinical state, and it is **not more than 4 hours since the circuit was disconnected**, patients can be **re-connected using the previous rates for dialysate and blood flows, and citrate and calcium doses**. If you are concerned about a change in condition discuss this with a Consultant Intensivist.
3. **Circuits disconnected greater than 4 hours must be replaced**. The new circuit must be set up using the protocol settings for dialysate and blood flows, and citrate and calcium doses.

There are two methods of temporary disconnection

METHOD 1 – Wash back and re-circulate - e.g. Transfer to CT scan.

The maximum disconnection time with this method is **4 hours**

METHOD 2 - Re-circulate with whole blood - e.g. when transferring bed space

This method can be used for disconnections lasting not more than **30 minutes**

- 1000mL 0.9% Sodium Chloride bag and/or recirculation adaptor is required
- Select **Treatment Interruption** in Menu tab
- Choose **Recirculation with blood** or **Without blood**
- Follow the **step by step guidance of the multiFiltratePRO**
- **It should only be done by trained staff**

CONVENTIONAL ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

1. **Conventional anticoagulation** means either unfractionated **heparin**, **epoprostenol** or **no anticoagulation** with a high blood flow rate.

2. Non-citrate anticoagulation is a **second line treatment** for patients requiring CRRT.

Indications:

- High (e.g. > 6mmol/L) or rapidly rising lactate despite fluid resuscitation
- Citrate is accumulating
- If a Consultant Intensivist decides not to use citrate anticoagulation due to high risk of citrate accumulation (e.g. severe liver failure, elevated >6mmol/L but fluid responsive lactate). Reason for this decision should be documented.

3. **Situations when non-citrate anticoagulation may be preferred:**

- **Severe coagulopathy** Citrate is not contraindicated however you may want to try CRRT without anticoagulation. Use citrate if circuits clot prematurely.
- **Required RRT dose >4L/hr** (4L/hr is the maximum possible rate in citrate mode)
- **Severe hypo- or hypernatraemia** To avoid over-rapid correction of serum sodium level it is probably worth using non-citrate RRT with a low renal dose (e.g. 20ml/kg/hr) and altering the sodium concentration of Multibic (normally 140mmol/L) by the addition of sterile water or concentrated sodium chloride. Please note, **there is no Unit protocol for this yet** hence it should be a Consultant decision.
- **Recent citrate use resulted in accumulation or poor circuit life** with associated metabolic derangement.
- **Patient is receiving systemic anticoagulation** (systemic heparin, fondaparinux argatroban) that may enable satisfactory circuit patency and life.

4. **Continuous Veno-Venous Haemodialysis (CVVHD)** is the only modality available for CRRT using non-citrate anticoagulation on ICUs at Frimley Park and Wexham Park Hospital.

5. 1000mL Sodium Chloride 0.9% should be prescribed to prime and recirculate the system.

6. A Standard High Flux non-citrate filter (**multiFiltratePRO HDF AV1000S**) should be used for CRRT. A High Cut Off filter **Emic 2 is also available and** could be used for clearance of middle molecules (e.g. Rhabdomyolysis, Severe sepsis) up to 40 kDa but this must be a Consultant decision and the reason should be clearly documented

CONVENTIONAL ANTICOAGULATION USING THE FRESENIUS multiFiltratePRO® (CVVHD)

7. **Multibic** dialysate fluid must be prescribed and used:
 - **Multibic K4** (contains K⁺ of 4mmol/L) as default
 - **Multibic K2** (contains K⁺ of 2mmol/L) if severe hyperkalemia present (K⁺ ≥ 6.5mmol/L)
8. **Heparin** or **epoprostenol** must be prescribed and titrated according to the Anticoagulation with heparin / epoprostenol for CRRT guideline ([page 25](#)). Both ICU (WPH and FPH) should follow their own preparation and administration guidance.
 - For **heparin** either the built-in Fresenius multiFiltratePRO® syringe driver or a separate Braun® syringe driver can be used with BD plastic 50mL syringes
 - Only the Braun® syringe driver must be used for **epoprostenol** administration. Epoprostenol must be administered via central venous access (central venous line or PiCC-line)
 - **A high initial Blood Flow Rate (250 mL/min)** should be prescribed for non-citrate CVVHD regardless the Dialysis Flow Rate. It may need to be decreased if vascular access is poor. **1600 – 4800 mL/h Dialysis Flow Rate (equals Clearance)** can be prescribed depending on the clearance necessary (patients with severe metabolic acidosis, hyperkalaemia or poisoning e.g. ethylene glycol will require higher clearance)
 - When the CRRT system is in steady state condition and the patient is recovering from the acute phase of his/her critical illness, the target blood flow should range within 180 and 220 mL/min unless there is an issue with vascular access.
 - Critically ill patients often require high dialysate flow rate however, once they get stabilised, one should aim a 25mL/kg/hour dialysis dose (IBW).
 - Alternatively, CRRT can be run **without any anticoagulation using a high blood flow rate (250 mL/min)** if heparin/epoprostenol is contraindicated (active or high risk of bleeding, HIT, severe coagulopathy). Always consider Ci-Ca CVVHD as soon as appropriate.

PLEASE NOTE:

Ensure that **Multibic dialysate fluid is used with all kind of conventional anticoagulation. If Ci-Ca fluid is used for CRRT without citrate anticoagulation, then you can potentially cause a fatal drop in the patients systemic ionised Calcium.**

ANTICOAGULATION WITH HEPARIN / EPOPROSTENOL FOR CRRT

CRRT Conventional Anticoagulation Selection (TABLE 10)

TABLE 10

Clotting	Platelets	Heparin	Epoprostenol
Confirmed or suspected HIT		NO	YES
Normal	>60	YES	NO
Normal	<60	If platelets rise above 60	YES
Deranged	>60	If clotting normalises	YES
Deranged	<60	NO	YES

Blood samples should be taken from an **arterial line** or the **blue port of the filter**

Management and monitoring of Heparin anticoagulation

- Give **5000 Unit bolus of IV heparin** into circuit
- Commence **infusion at hourly rate of 10 units per kg ideal body weight (IBW)**
- Check **APTT in 4 hours** then monitor according to **TABLE 11**

TABLE 11

APTT (SEC)	BOLUS DOSE (UNITS)	INFUSION HOLD (min)	INFUSION DOSE	REPEAT APTT
<40	1000	0	Increase by 1.0ml/hr (200 units/hr)	In 6 hours
40.1 – 45	0	0	Increase by 0.5 ml/hr (100 units/hr)	In 4 hours
45.1 – 55	0	0	No change	In 6 hours
55.1 – 65.0	0	30	Decrease by 0.5ml/hr (100 units/hr)	In 4 hours
>65	0	60	Decrease by 1.0ml/hr (200 units/hr)	In 4 hours

Heparin Anticoagulation for CRRT (Amanzadeh J. et al, 2006)

- Always eliminate mechanical reasons for filter clotting before increasing doses of anticoagulant
- Document any bolus doses given as part of the protocol. Boluses given outside of protocol should be prescribed on the 'once only section' of the drug chart

ANTICOAGULATION WITH HEPARIN / EPOPROSTENOL FOR CRRT GUIDELINE

Management and monitoring of Epoprostenol anticoagulation

Epoprostenol doses should be calculated on Ideal Body Weight (please see the calculator at the back of this document). All doses should be calculated, the **TABLE 12** below is for guidance only using an Epoprostenol dose of 2000 nanograms per ml.

- The **normal starting dose for Epoprostenol is 2.5 nanograms/kg/minute** but dose should be adjusted to platelets and patient response as it can cause dose dependent hypotension
- **Epoprostenol has a pH of approximately 12 when reconstituted and should not be given peripherally. It must be administered via central line (or PiCC)**
- **If epoprostenol is given neat, then it must only be diluted with the glycine buffer provided**
- **Epoprostenol must not be flushed.** Lines should be aspirated and then flushed with 0.9% Sodium Chloride
- **Diluted solution should be used within 8 hours**

TABLE 12

	Weight in Kg (doses should be calculated on the Ideal Body Weight) 2000nanograms/ml This table is for guidance only								
Dose	30 Kg	40 Kg	50 Kg	60 Kg	70 Kg	80 Kg	90 Kg	100Kg	110 Kg
2.5 ng/kg/min	2.25mls/hr	3.0mls/hr	3.75mls/hr	4.5mls/hr	5.25mls/hr	6.0mls/hr	6.75mls/hr	7.5mls/hr	8.25mls/hr
3.0 ng/kg/min	2.70mls/hr	3.6mls/hr	4.5mls/hr	5.4mls/hr	6.3mls/hr	7.2mls/hr	8.1mls/hr	9.0mls/hr	9.9mls/hr
3.5 ng/kg/min	3.15mls/hr	4.2mls/hr	5.25mls/hr	6.3mls/hr	7.35mls/hr	8.4mls/hr	9.45mls/hr	10.5mls/hr	11.55mls/hr
4.0 ng/kg/min	3.60mls/hr	4.8mls/hr	6.0mls/hr	7.2mls/hr	8.4mls/hr	9.6mls/hr	10.8mls/hr	12.0mls/hr	13.2mls/hr
4.5 ng/kg/min	4.05mls/hr	5.4mls/hr	6.75mls/hr	8.1mls/hr	9.45mls/hr	10.8mls/hr	12.15mls/hr	13.5mls/hr	14.85mls/hr
5.0 ng/kg/min	4.50mls/hr	6.0mls/hr	7.5mls/hr	9.0mls/hr	10.5mls/hr	12.0mls/hr	13.5mls/hr	15mls/hr	16.5mls/hr

How to Calculate Epoprostenol Dosing

Dose in nanograms/kg/min X Ideal Body Weight X 60

Epoprostenol concentration in nanograms per ml

If ideal body weight of the individual is 63 kg and the dose of Epoprostenol required is 2.5 nanograms/kg/min. The dose required in mls is 4.72.

$$\frac{2.5 \times 63 \times 60 \text{ (9450 nanograms)}}{2000 \text{ (concentration in nanograms per ml)}} = 4.725\text{mls/hr}$$

The pump will only dose to two decimal points and you may need to round up or round down your dose

This protocol has been written with the guidance and help of Fresenius Medical Care using their basic principles and from the protocol devised by Sister Charlotte Trumper and Dr Andrew Lewington Consultant Renal Physician in Leeds Teaching Hospitals.

These guidelines are for reference only and for interpretation by Clinical Healthcare Professionals.