The Newcastle upon Tyne Hospitals NHS Foundation Trust

Guideline for Renal Replacement Therapy using Citrate in Critical Care

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Ratified By:	Critical Care Guidelines Committee

1 Introduction

In order to provide continuous renal replacement therapy on the adult critical care unit, an anticoagulant is usually required. Citrate anticoagulation is now the first line technique. This guideline explains the process of achieving this. It does not replace formal training from clinical staff but is to be used as a reference tool.

2 Guideline Scope

This document applies to adult critical care units in Newcastle Hospitals.

3 Main Body of the Guideline

3.1 Before starting treatment

- Check the daily blood results before the start of treatment to include:
  - Total Calcium (not the corrected value), magnesium and potassium levels
  - Ensure a recent arterial blood gas includes a Calcium (ionised calcium)

- APTT levels will NOT be required to operate the treatment

3.2 Equipment needed

- 1 Kit Prismaflex ST150
- 1 CA250 Calcium line
- 1 50ml Luer lock syringe
- 1 bag of 5L **PRISMOCITRATE 18/0** (citrate used as pre-dilution)
- 1 bag of 5L **PRISM0CAL B22** (dialysate)
- 1 bag or 5L **PHOXILIUM** for replacement (post dilution)
- 0.9% Sodium Chloride (priming solution) – 2000mls ST150
- Calcium Chloride 30mmol to 50mls 0.9% Sodium Chloride
- Non filtered blunt needle

3.3 Setting up and priming circuit

- Choose the option CVVHDF

- Choose Citrate –Calcium via Prismaflex Syringe Pump

- Follow the installation steps on the screen.

- Install **PRISMOCITRATE 18/0** on the white scale (PBP= Pre Blood Pump)
- Install **PRISM0CAL B22** on the green scale. (Dialysate).
- Install **PHOXILIUM** on the purple scale (Replacement).
- Prime the circuit with 2L (ST150) of 0.9% Sodium Chloride (NO Heparin required)
- Install the CALCIUM Chloride syringe in the Prismaflex syringe pump

3.4 Starting Parameters

MODE: CVVHDF
STARTING CITRATE DOSE IS 3.0 MMOLS/L/BLOOD
STARTING CALCIUM COMPENSATION 100%

Weight Kg	Blood Flow ml/min	Dialysate Ml/hr	Replacement Post-filter ml/hr	Actual Treatment dose obtained
50	100	1000	200	37mls/kg/hr
60	110	1100	400	37mls/kg/hr
70	120	1200	500	35mls/kg/hr
80	130	1300	500	33mls/kg/hr
90	140	1400	500	31mls/kg/hr
100	150	1500	600	31mls/kg/hr
110	160	1600	700	30mls/kg/hr
120	170	1700	800	30mls/kg/hr
130	180	1800	1000	30mls/kg/hr

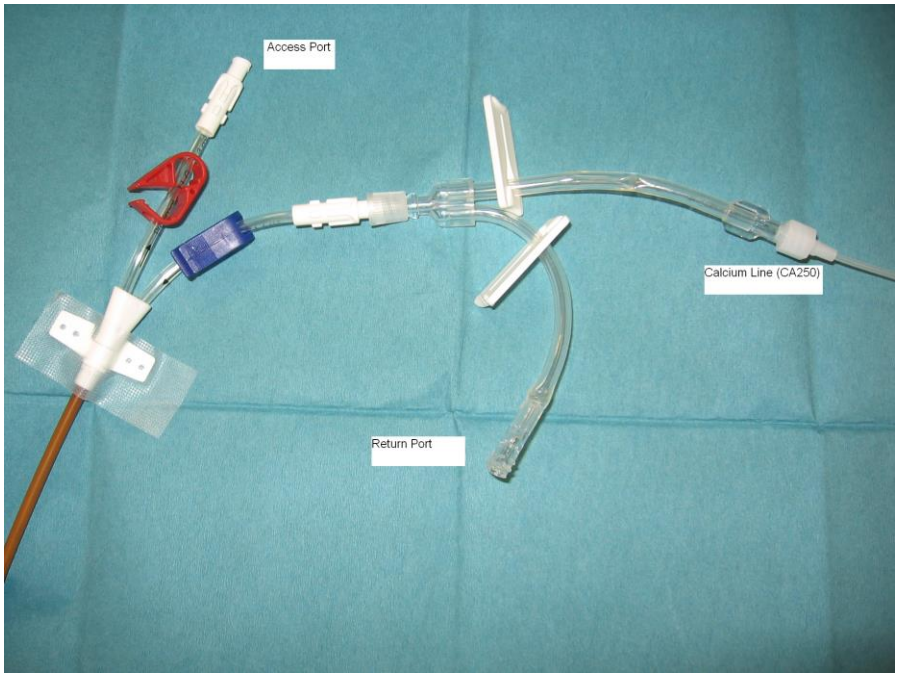
1. For the higher blood flow rates consider a lower flow and build up if patient is haemodynamically unstable
2. Actual treatment dose is effluent minus 15% downtime
3. If bicarbonate is too low it can be corrected by IV Sodium Bicarbonate

CONNECTION: - (see photo for additional guidance)

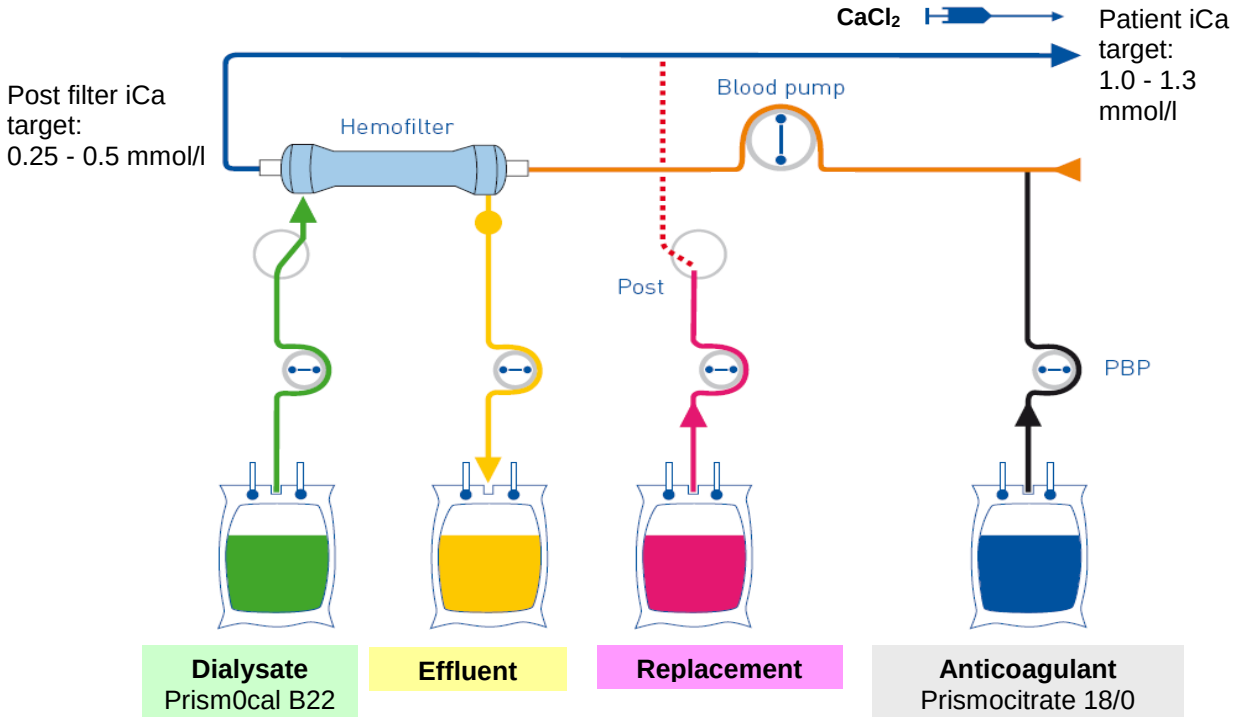
1. Connect access line to patient (red)
2. Connect Blue return line to the vacated port on the Y connector
3. Connect yellow line to effluent bag
4. Connect calcium line to available port on the Y connector and tape calcium line to return line to ensure that calcium line and return line always stay together if access and return lines need to be swapped.
5. Disconnect Y connector from priming bag spike and attach to patient
6. Unclamp all lines

START treatment
Once patient stable - increase blood pump speed to required level as above
Patient fluid removal as required

PLEASE RECORD PATIENTS TEMPERATURE AND CIRCUIT TEMPERATURE ON AN HOURLY BASIS ALONG WITH OTHER PARAMETERS REQUIRED.



Please note that Gambro advise connecting the Calcium line directly to the patients central line, and the connection to a Y connector attached to the catheter is an unofficial procedure that has been found to have advantages.



3.5 Treatment Monitoring

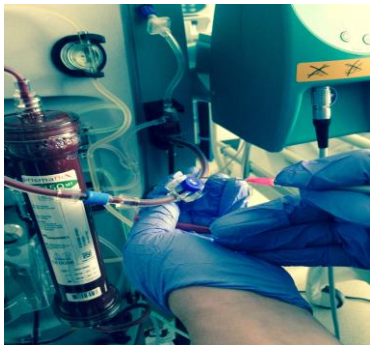
Treatment Monitoring has four components

1. Ionised Calcium – post filter and patient
2. Total Calcium/ ionised calcium patient ratio
3. pH – acid/ base balance
4. U+E + daily checks

3.5.1 Ionised Calcium – post filter and patient

Once treatment is initiated and blood flow established at one hour make two ionised Calcium checks (one from the blue port on the set and another from the patient's arterial line) and alter according to the following table.
Measure at 1 hour: either after starting CRRT, when the Citrate or Calcium infusion has changed or after recirculation.

Continue to measure hourly until stable for 2 consecutive hours then check 6 hourly



	Filter Ca^{2+} >0.50	Filter Ca^{2+} 0.25 – 0.5	Filter Ca^{2+} <0.25
Patient Ca^{2+} < 1.0	Increase Citrate dose by 0.5mmols/l blood Increase Calcium compensation by 10%	Increase Calcium compensation by 10%	Decrease Citrate dose by 0.5mmols/l blood
Patient Ca^{2+} 1.0 – 1.3	Increase Citrate dose by 0.5mmols/l blood	Normal Ideal Values	Decrease Citrate dose by 0.5mmols/l blood
Patient Ca^{2+} > 1.3	Increase Citrate dose by 0.5mmols/l blood Decrease Calcium compensation by 10%	Decrease Calcium compensation by 10%	Decrease Calcium compensation by 10% Decrease Citrate dose by 0.5mmols/l blood

Increasing requirements for calcium compensation could indicate citrate accumulation the calcium ratio should be checked.

Should the protocol stipulate that the citrate dose be reduced, pre-blood pump flow and hence total effluent dose will also fall. If the total effluent dose falls below 30mls/kg/hr as a result, increase the replacement flow until a dose of 30mls/kg/hr is achieved.

If there are any changes in citrate dose or blood flow rate, hourly checks need to be carried out again.

3.5.2 Citrate Accumulation

Approximately half of the citrate calcium complexes are removed by dialysis from the blood. The remaining citrate is metabolised to bicarbonate in the liver and in the muscles. In severe liver dysfunction metabolism of citrate may be compromised and accumulation of citrate can occur. Most of these patients present with high lactate concentrations as well due to liver failure or poor perfusion. The impaired citrate metabolism can result in low systemic ionised calcium and increased total calcium with an increase in the total to ionised ratio. Citrate accumulation should be considered in patients with persistent hypocalcaemia despite increase in calcium compensation. Signs that are indicative of accumulation are:

1. Calcium compensation is >150%
2. A high lab Total Calcium, >3mmol/L and low ABG ionised calcium
3. Unexplained metabolic acidosis in conjunction with a high lactate

Diagnosis of Citrate Accumulation:

A calcium ratio greater than 2.5 is likely to indicate citrate accumulation

Measure this value

1. Initially 4 hours after starting CRRT
2. Subsequently once every 24 hours or every 12 hours in liver failure
3. One hour after making any changes to resolve an outstanding citrate accumulation.

To measure:

a) Send a Total Calcium from patient's arterial line to biochemistry (usually with 6am morning bloods unless 4 hour check).
b) At SAME time take ABG from patient's arterial line and enter the ionised
calcium into the following formula.
c) Once Total Uncorrected Calcium result obtained, divide patients total (uncorrected) calcium by the patients ionised calcium.

$$\frac{\text{Total Uncorrected Calcium (lab)}}{\text{Patients Ionised Calcium (ABG value)}} = \textbf{Calcium Ratio}$$

Value	Action
<2.5	Indicates achieving target range therefore check daily calcium ratio. Liver failure patients require twice daily calcium ratio.
>2.5	Not achieving target range therefore could indicate citrate accumulation. Seek Medical Support Aim for a post filter calcium of 0.4 to 0.5 mmol/l by reducing citrate dose in 0.2mmol/l increments until this range is achieved. If ratio remains above 2.5 despite post filter calcium of 0.4 – 0.5mmol/l then consider • Doubling base line dialysate flow (to increase citrate clearance) and reduce blood pump speed (to reduce total administered citrate dose). If ratio remains above 2.5 consider stopping citrate and using an alternative anticoagulant or no anticoagulant If changes are made to resolve accumulation please check ratio again after one hour.

Alternative treatment should be considered if

1. Citrate accumulation cannot be resolved
2. Patient develops a metabolic acidosis as a result of changes made to manage a citrate accumulation and acidosis cannot be resolved (see part 3)

Calcium Monitoring – Timing Summary	Initially	And then
POST FILTER IONISED CALCIUM (Blood Gas from circuit) Target 0.25 to 0.50 mmol/L	Hourly until stable for 2 consecutive hours	6 Hourly
PATIENT SYSTEMIC IONISED BLOOD CALCIUM (Blood Gas from patient) Target 1.00 to 1.30 mmol/L	Hourly until stable for 2 consecutive hours	6 Hourly
PATIENT TOTAL CALCIUM (not corrected calcium) Target 2.20 to 2.50 mmol/L	After 4 hours	Daily/ twice in liver failure. Within an hour if changes made
CALCIUM RATIO (Total Ca / Patient systemic ionised Ca) Target ratio <2.5	After 4 hours	Daily/twice in liver failure Within an hour if changes made

3.5.3 Blood Gas/ Acid Base Status

Aim for a pH between 7.35 and 7.45.

i) Metabolic Acidosis; pH less than 7.35 (BXS worse than - 4mmol/l, HCO_3 less than 22mmol/l)

Most patients in renal failure will have a degree of metabolic acidosis on commencing CVVHDF. This should improve with treatment over hours.

Failure to improve the Base excess / HCO_3 towards normal. Consider

a) Reduce dialysate flow by 50% from baseline (more citrate will reach patient).
b) Increase blood pump speed (delivers more citrate to patient).
c) Giving systemic $NaHCO_3$ to the patient (eg 100mls of 8.4% $NaHCO_3$ i.v.)

These will have differing effects on clearance, potential for citrate toxicity and CVS status and should be discussed with an experienced user.

ii) Metabolic Alkalosis; pH greater than 7.45 (BXS higher than +4 mmol/l, HCO_3 greater than 25mmol/l)

Consider

a) Increasing dialysate flow by double baseline rate
b) Reducing blood pump flow

These changes may affect clearance and filter life and should be discussed with an experienced user.

3.5.4 U+E and other daily checks

Test	REASON	Frequency
U+E	To assess clearance of urea and creatinine and check Na^+ and K^+	6 hourly initially. 12 hourly when stable.
Potassium	Monitoring for hypo or hyperkalaemia – adjust according to K^+ protocol	According to K^+ protocol
Glucose	Be aware there is no glucose in Prismocitrate 18/0	According to glucose protocol
FBC	Assess Hb/ Haematocrit	Daily
Mg, PO4	Ensure stable plasma levels	Daily

4 Training, Implementation & Resource Implications

Training will be provided predominantly by senior nursing staff and nurse educators on the respective critical care units. Regular training events will occur to maintain skill set.

5 Monitoring Section

A nominated nurse on each critical care unit will audit compliance with this guideline and where necessary make improvements.

6 Evidence Review and Evaluation

This document was compiled in consultation with recommendations from Gambro.

7 References

No references listed.