Use of Prismaflex® Continuous Renal Replacement Therapy using Citrate as an Anticoagulant Procedure

Contents

1. Purpose

The purpose of this document is to outline the process of implementing Continuous Renal Replacement Therapy (CRRT) using Citrate as an anticoagulant and the Prismaflex® machine at Bunbury Hospital Intensive Care Unit (ICU).

Acute kidney injury (AKI) is a syndrome characterised by an abrupt deterioration of renal function, resulting in accumulation of metabolic wastes, fluids, and electrolytes, usually accompanied by a marked decline in urinary output. AKI is caused by decreased renal perfusion (pre renal), parenchymal damage (intrarenal) or obstruction (post renal). Key assessments used in monitoring renal function are urine output, serum creatinine and urea levels. Dialysis can help damaged kidneys by performing the task of filtering.

CRRT is a continuous (24 hour a day) treatment, providing a gentler blood filtering technique, attempting to avoid the complications associated with Haemodialysis and Peritoneal Dialysis, in critically ill/unstable patients requiring renal dialysis. Bunbury Hospital ICU uses the Prismaflex® system to deliver CRRT.

2. Procedure

This document outlines the care of CRRT patients using Citrate as an anticoagulant. For specific management for CRRT using Heparin/no anticoagulant – see Use of Prismaflex® Continuous Renal Replacement Therapy using Heparin or no Anticoagulant as an Anticoagulant Procedure (under development)

Citrate anticoagulation is a form of regional anticoagulation. Citrate binds to calcium in the blood flowing through the access line of the circuit, forming calcium-citrate complexes, and reducing the available calcium required for coagulation in the circuit. Patient calcium levels are restored with a continuous infusion of concentrated calcium.

Monitoring and management of Calcium levels, both in the filter and systemically, is important to the success of regional citrate anticoagulation. Ionised Calcium (iCa2+) levels refer to calcium that is not bound to a protein (available calcium); total calcium refers to both bound and free calcium. Ionised calcium is measured on an arterial or venous blood gas.

Fluid containing Citrate is delivered pre-filter via the Pre-Blood Pump (PBP) line. The citrate dose is the amount of citrate per litre of blood flow, this anticoagulates the filter by chelating (binding) ionised calcium to citrate molecules.

A significant portion of these calcium-citrate complexes are lost across the filter in the effluent. A small amount of citrate enters the systemic circulation but has no effect on the systemic anticoagulation due to dilution and rapid metabolism in the liver and skeletal muscle. Citrate also provides buffer when metabolised to bicarbonate by the liver (18mmol/L citrate forms 54mmol/L bicarbonate).

Systemic calcium is infused via a dedicated Central Venous Line lumen. Vas caths with a third central access lumen can be used to infuse calcium chloride. The calcium infusion acts to replace the calcium lost via effluent fluid. The result of using both citrate and calcium administration is that only the circuit is anticoagulated resulting in a minimal risk of bleeding for the patient.

The calcium infusion is titrated to the systemic ionised calcium level and controlled by the Prismaflex®. The calcium infusion will automatically stop when the filter stops. Magnesium may need to be replaced systemically by intermittent bolus as this is also chelated by citrate.

If the citrate infusion rate is too high, or the liver is unable to metabolise citrate such as patients in acute liver failure or severe septic shock, citrate will accumulate and bind with (chelate) calcium in the systemic circulation leading to citrate toxicity. The presence of low levels of ionised calcium in the body will predispose to coagulopathy, muscle twitching, tetany, possible seizures, and arrhythmias.

2.1 Contraindications

The potential contraindications to using citrate as an anticoagulant:

- Acute or chronic liver failure (liver failure may prevent citrate being metabolised into bicarbonate, leading to citrate accumulation in the blood).
- High CRRT blood flow rates of greater than 200 mL/min. Blood Flow rates greater than 200 mL/min flow rate- will lead to an increase in citrate load and lead to metabolic alkalosis in a healthy liver. A patient with liver dysfunction may find it more difficult to metabolise citrate and may subsequently put them at more risk for citrate accumulation in the blood.

In these situations, citrate can accumulate and lead to metabolic acidosis, hypocalcaemia, and systemic coagulopathy (citrate toxicity).

2.2 Potential Complications of Citrate Anticoagulation

Derangement	Cause	Signs	Management
Metabolic Acidosis	Inadequate acidaemia clearance	Normal or increased anion gap (4-16)	pH Management Flow Chart
	Citrate accumulation	Increased anion gap, deranged LFT's, Systemic iCa2+ <0.8 Calcium ratio >2.5:1	Citrate Toxicity Flow Chart
Metabolic Alkalosis	Too much Buffer		pH Management Flow Chart
	Decreased loss of Buffer due to Decreased filter flow		Replace filter or increase rate of Dialysate
Hypercalcaemia	Too much Calcium	Increased systemic iCa2+	Patient Systemic Ionised Calcium Flow Chart
Hypocalcaemia	Excessive removal on Dialysis, Inadequate replacement	Decreased systemic iCa2+ Calcium ratio >2.5:1	Patient Systemic Ionised Calcium Flow Chart

	Citrate accumulation	Increased anion gap, deranged LFTs, Systemic iCa2+ <0.8 Calcium ratio >2.5:1	Patient Systemic Ionised Calcium Flow Chart

Table 1: Potential Complications of Citrate Anticoagulation

Systemic Signs of Hypocalcaemia:

- **Cardiac:** prolonged QT interval, Hypotension, Heart Failure and Arrhythmia
- **Neuromuscular:** paraesthesia, Muscle twitching, Seizures and Laryngospasm/Bronchospasm
- **Bleeding.**

2.3 Procedure requirements

Equipment

The Prismaflex® machine and ST 100 set or Oxiris set are used. The priming procedure is outlined in Appendix A.

A CRRT Set up box should be on a trolley at the bedside to be used during Trouble Shooting, Connection and Disconnection of CRRT. This box contains all required equipment for emergency return and troubleshooting.

Documentation

A suite of specific forms is used:

- MR174 WACHS SW Standard CRRT Orders and Calculations
- MR174A WACHS SW CRRT Standard Dialysate Fluid
- MR174B WACHS SW CRRT Standard Replacement Fluid
- MR174C WACHS SW CRRT Standard Pre Blood-Pump (PBP) Fluid
- MR174D WACHS SW Intravenous Infusion Chart for CRRT Heparin Infusion
- MR174E WACHS SW Citrate Regional Anticoagulation CRRT Orders and Patient Systemic Ionised Calcium Results
- MR174F WACHS SW Citrate Regional Anticoagulant Nursing Calculations
- MR174G WACHS SW CRRT PBP Citrate Fluid Orders
- MR174H WACHS SW Intravenous Infusion Chart for CRRT Calcium Chloride 10% Infusion
- MR174I WACHS SW Citrate CRRT Replacement Fluid WACHS SW Citrate CRRT Replacement Fluid
- MR174J WACHS SW Citrate CRRT Dialysate Fluid Orders

Pathology

Print Pathology Blood forms as required:

- Twice daily Urea and electrolytes.
- Daily Full Blood Count, Coagulation profile, Magnesium and Phosphate levels.
- Total calcium level as indicated by Citrate Toxicity flowchart (Appendix H).

Ensure:

- Patient ABG and Pre Filter venous blood gas (VBG) one hour post commencement of treatment and 1 hour after any adjustment to flow rates.
- Patient ABG forms as indicated by Patient Systemic Ionised Calcium Flowchart (Appendix E).

Calculate:

- Calcium Ratio as indicated by Citrate Toxicity flowchart (Appendix H). (Total Calcium ÷ Patient iCa2+ expressed as a ratio (result of calculation: 1).

General Requirements:

- Patient connection requires two registered nursing staff. The steps are outlined in Appendix B.
- Ceasing treatment also requires two registered nursing staff. The steps are outlined in Appendix C
- A Vas Cath is a large bore central venous catheter normally inserted for short term dialysis. Patients receiving CRRT can be intermittently discontinued from CRRT, requiring the Vas cath to be locked with an appropriate solution. The procedure for locking the Vas Cath is outlined in Appendix D.

Prior to the commencement of CRRT - Medical officer requirements:

- **Order** the Dialysis mode (CVVHDF), net loss, blood flow rate (150 mL/min), pre blood pump (PBP), replacement and dialysate volumes on MR174E WACHS SW Citrate Regional Anticoagulation CRRT orders and Patient Systemic Ionised Calcium Results
- **Blood flow rates safe range:** 100-200 mL/min. Rates > 200 mL/min may be required under rare circumstances (i.e., patient weight > 100 kg, need for higher PBP rate). These should be discussed with the ICU Consultant and reasons why documented in BOSSnet.
- **Prescribe**
  - PBP Fluid (Prismocitrate 18/0, **White** scale). Rate is determined by Prismaflex® based on Blood Flow Rate and Citrate dose and thus rate is not independently prescribed. Add 20 mmol potassium per 5000 mL bag. If patient requires dialysis for hyperkalaemia discuss with ICU consultant, the role of adding potassium to PBP fluid (and/or replacement fluid).
  - Dialysate (PrismOcal B22, **Green** scale) at 1000 mL/hr. **Do not** add potassium.
  - Replacement (**post filter**, **Purple** scale) fluid Hemosol BO at 200 mL/hr. Add 20 mmol potassium per 5000 mL bag.
  - Citrate anticoagulant dose (3 mmol/L). The therapeutic range is 2.4 –5.4 mmol/L blood flow through the filter.
  - Calcium infusion (CaCl2 10% 50 mL neat solution).
  - The % compensation of the calcium infusion (100% at commencement)
  - Fluid removal rate as clinically indicated.
- **Prescribe** Hemofiltration catheter (Vas Cath) lock to both catheter lumens if access not used for more than 2 hours. **TauroLock™ lock or Heparin Lock requires a written medical order on the HMC**.
- **Ensure** patient's iCa2+ is 1.1 – 1.3 mmol/L prior to commencing therapy. Correct using IV CaCl2 if necessary. Recheck until in range (level can be checked 5 minutes after administration of calcium).

Nursing Requirements:

- All patients receiving CRRT will be allocated an with a 1:1 Ratio.
- Patients receiving CRRT will not be left unattended at any time.
- CRRT set up box to be kept on a trolley at the bedside. This box contains all required equipment for emergency return and troubleshooting.
- The Haemofiltration catheter (Vas Cath) Site will be always visible. Check insertion site hourly for bleeding.
- Fluid removal calculation will be performed a minimum of 6 hourly and documented on MR 174F WACHS-SW Citrate Regional Anticoagulation CRRT Nursing Fluid and Calculations chart.
  - When there is a **significant** change in the patient's hourly input and/or output amounts **or**
  - If a change to net loss prescribed or significant haemodynamic changes.
- **Colloid or boluses of fluid** given for haemodynamic management (hypotension) is excluded from calculations but is included if given for other reasons e.g., packed cells for low haemoglobin (check with medical officer).
- Total fluid balance will be performed **2 hourly** (to detect inadvertent fluid imbalance).
- Patients are to be weighed daily.
- If minimal/ no urine output, remove IDC and perform daily bladder scans, if greater than 300 mL perform review re: an in/out or a re-catheterisation.
- Ensure Prismocitrate 18/0 has a medical order and is charted on 174G WACHS SW CRRT PBP Citrate Fluid Orders
- Document on MR146A ICU – 24 Hour Flow Chart start and stop times of treatment, and if blood returned or not.
- Document **hourly** on MR 146A:
  - Blood flow rate
  - Access and Return pressure to monitor catheter function and patient fluid volume status.
  - Trans Membrane Pressure (TMP) and Pressure Drop to monitor filter clotting and performance.
  - Blood pump speed and fluid removal volume (IN DIALYSIS OUTPUT SECTION).
  - Filter pressure
  - Deareation chamber level check
  - Citrate dose in mmol/L**,** Calcium compensation % (Calcium volume delivered ***does not*** need to be documented on the ICU flow chart as input, the Prismaflex automatically considers this in its fluid balance calculations).
- Electrolytes should be added prior to hanging bags. If required urgently, give intravenously, or make a new bag and change (maximum 20 mmol per 5000 mL bag).
- Ensure catheter is locked with TauroLock™ solution or Heparin if not used for 2 hours. Install the volume of each lumen as marked on the catheter (plus an extra 0.2 mL) and label with time and date of lock. **TauroLock™ lock and Heparin Lock requires a written medical order on the** Hospital Medication Chart (**HMC)**. Lock must be changed every 72 hours.
- Aseptic Technique principles apply to setup, management and ceasing of treatments.
- Check all circuit connections are secure and lines are positioned to prevent kinking and are secured to prevent drag.
- Check Prismaflex® brake is on.

Management of blood tests

Pre-filter VBG:
- taken from the red port closest to the filter in the CRRT circuit
- **routinely sampled 1 hour post commencement of treatment to check iCa2+ level**
- used to monitor effectiveness of citrate chelating (binding) to calcium molecules in the filter (which provides filter anticoagulation)
- alter Citrate Dose according to Pre-filter Ionised Calcium Flowchart (Appendix F).

Patient ABG:
- taken from arterial line
- sampled prior to commencing treatment to ensure systemic iCa2+ level within normal limits
- used during treatment to monitor effectiveness of calcium infusion, and acid base balance of patient
- routinely sampled 1 hour post commencing treatment to check patient systemic iCa2+ level then as indicated by
- pH, base excess and HCO3, and anion Gap should be assessed for presence of metabolic derangement. If either Metabolic Acidosis or Metabolic Alkalosis is present, request medical officer to review patient and manage as per Appendix G.

Calcium monitoring:
- sampled from arterial line in normal manner into a green blood tube.
- total calcium level and calcium ratio (Total Ca2+: Ionised Ca2+) may be required if citrate toxicity is suspected – refer to Appendix H: Citrate Toxicity Flowchart
- **calcium ratio calculation:** Total Calcium ÷ Patient iCa2+ expressed as a ratio (result of calculation :1).

Magnesium monitoring:
- check daily to ensure level is >1.0 mmol/L.
- citrate also chelates Magnesium, hence the need for monitoring and replacement as indicated.

Phosphate monitoring:
- check daily to ensure level is >0.8 mmol/L

Coagulation Profile:
- checked daily to ensure within acceptable limits

2.4 Labelling Requirements

Labelling must adhere to the Australian Commission on Safety and Quality in Health Care (ACSQHC) National Standard for User-applied Labelling of Injectable Medicines Fluids and Lines

3. Roles and Responsibilities

Medical and nursing staff are responsible for ensuring the following:
- complying with this procedure
- work within scope of practice and job role

- appropriate documentation
- maintaining a personal record of professional development achievements.

All staff are required to work within policies and guidelines to make sure that WACHS is a safe, equitable and positive place to be.

4. Monitoring and Evaluation

4.1 Monitoring

The monitoring of effectiveness of this document is to be carried out by the Clinical Nurse Manager and Clinical Nurse Specialist Intensive Care Unit at Bunbury Hospital, using the following means:

- review of clinical practice and patient outcomes associated with this procedure.
- seeking Health professionals' feedback on their role and practical application.

4.2 Evaluation

This procedure will be reviewed as required to determine effectiveness, relevance and currency. At a minimum it will be reviewed every three years by Clinical Nurse Specialist and ICU consultant.

Evaluation areas for consideration:

- implementation has been undertaken
- procedure compliance is good across all staff roles
- procedure is effective and efficient
- procedure aligns with current best practice
- accessed capacity in staff training is adequate.

5. Compliance

This procedure is a mandatory requirement under the Work Health and Safety Framework.

Failure to comply with this procedure may constitute a breach of the WA Health Code of Conduct (Code). The Code is part of the Integrity Policy Framework issued pursuant to Section 26 of the *Health Services Act 2016* and is binding on all WACHS staff which for this purpose includes trainees, students, volunteers, researchers, contractors for service (including all visiting health professionals and agency staff) and persons delivering training or education within WACHS.

WACHS staff are reminded that compliance with all policies and procedures is mandatory.

6. References

Royal Perth Hospital Renal Replacement Therapy (CRRT) for Acute Kidney Injury in the Intensive Care Unit NPS.
https://healthpoint.hdwa.health.wa.gov.au/policies/Policies/EMHS/RPH/R%20-%20Renal%20Replacement%20Therapy%20Continuous%20(CRRT)%20for%20Kidney%20Injury%20in%20ICU%20S_NPS.pdf.

Sir Charles Gairdner Hospital Intensive Care Unit (2016) Departmental Guideline for Citrate as Anticoagulant in Continuous Renal Replacement Therapy (CRRT) Using Prismaflex. Accessed June 2023.

Prismaflex® Operators Manual. [No author]. Gambro Lundia AB, Sweden. HCEN12719. Revision 05.2017.

7. Definitions

Term	Definition
Continuous Renal replacement Therapy	Continuous Renal replacement Therapy (CRRT) is a continuous (24 hour a day) treatment, providing a gentler blood filtering technique, attempting to avoid the complications associated with Haemodialysis and Peritoneal Dialysis, in critically ill/unstable patients requiring renal dialysis.
Continuous Veno-Venous Hemodiafiltration	Continuous veno-venous hemodiafiltration is where solute removal is achieved by a combination of convection and diffusion. During this therapy, a patient's blood passes through a special filter that removes fluid and uremic toxins, returning clean blood to the body.

8. Document Summary

Coverage	Bunbury Hospital
Audience	Nursing and Medical Staff
Records Management	Non Clinical: Records Management Policy Clinical: Health Record Management Policy
Related Legislation	*Health Practitioner Regulation National Law (WA) Act 2010* *Medicines and Poisons Act 2014* (WA) Medicines and Poisons Regulations 2016 (WA) *Work Health and Safety Act 2020 (WA)*
Related Mandatory Policies / Frameworks	• MP 0095/18 - Clinical Handover Policy • Work Health and Safety Framework
Related WACHS Policy Documents	• Aseptic Technique Policy • Central Venous Access Device (CVAD) and Long Peripheral Venous Catheter (Long PVC) Management Clinical Practice Standard • Documentation Clinical Practice Standard • Use of Prismaflex® Continuous Renal Replacement Therapy using Heparin or no Anticoagulant as an Anticoagulant Procedure (under development)
Other Related Documents	• ACSQHC National Standard for User-applied Labelling of Injectable Medicines Fluids and Lines
Related Forms	• MR174 WACHS SW Standard CRRT Orders and Calculations • MR174A WACHS SW CRRT Standard Dialysate Fluid • MR174B WACHS SW CRRT Standard Replacement Fluid • MR174C WACHS SW CRRT Standard Pre Blood-Pump (PBP) Fluid • MR174D WACHS SW Intravenous Infusion Chart for CRRT Heparin Infusion • MR174E WACHS SW Citrate Regional Anticoagulation CRRT Orders and Patient Systemic Ionised Calcium Results • MR174F WACHS SW Citrate Regional Anticoagulant Nursing Calculations • MR174G WACHS SW CRRT PBP Citrate Fluid Orders • MR174H WACHS SW Intravenous Infusion Chart for CRRT Calcium Chloride 10% Infusion • MR174I WACHS SW Citrate CRRT Replacement Fluid WACHS SW Citrate CRRT Replacement Fluid • MR174J WACHS SW Citrate CRRT Dialysate Fluid Orders
Related Training Packages	Nil

Aboriginal Health Impact Statement Declaration (ISD)	ISD Record ID: 2567
National Safety and Quality Health Service (NSQHS) Standards	1.1, 3.2, 3.8, 3.11, 6.9, 7.4, 8.4.
Aged Care Quality Standards	1, 2, 3, 8.
Chief Psychiatrist's Standards for Clinical Care	Nil

9. Document Control

Version	Published date	Current from	Summary of changes
1.00	29 April 2024	29 April 2024	New procedure

10. Approval

Policy Owner	Executive Director South West
Co-approver	Executive Director Clinical Excellence Executive Director Nursing and Midwifery
Contact	Clinical Nurse Specialist
Business Unit	South West Intensive Care Unit
EDRMS #	ED-CO-17-54129

This document can be made available in alternative formats on request.

Appendix A: Priming

Supplies required:

- Prismaflex® machine and ST 100 set or Oxiris set
- effluent bags x 2
- calcium infusion line
- 50 mL leur lock syringe (***Terumo syringe only***)
- priming fluid: 0.9% Normal Saline 1000 mL
- 50 mL Calcium Chloride 10% solution
- Prismocitrate 18/0 five litre bag for PBP scale.
- Prism0cal B22 five litre bag for dialysate scale.
- Hemosol B0 five litre bag for replacement scale (post filter)

Procedure for priming the circuit**:**

- Plug in Prismaflex® to mains (UPPS-blue switch) and turn power on button on right side.
- **Start-up** - follow initialisation press 'continue' to choose patient.
- **Choose patient** - choose **NEW PATIENT** every time.
- **Enter patient information** - enter patient details ID, weight and Haematocrit (latest bloods).
- **Choose therapy** - **'CVVHDF'** from CRRT menu. This is the standard choice.
- **Choose anticoagulation method** - choose anticoagulant method (**Do not select no anticoagulant option**).

  Note: If NOT prescribed anti-coagulant therapy insertion of sodium chloride 0.9% filled 50 mL Terumo syringe to retain option for adding anti-coagulation without priming a new set.

- **Confirm** anticoagulant method.
- **Load set** - follow instructions and prompts step by step to load set.
- If **Set up error** alarm is activated, unload set, check and reload.
- **Prepare and connect solutions**- follow on screen prompts.
- **DO NOT Prime Calcium Line** - after the syringe is loaded an auto prime is done by the Prismaflex®.
- **Install syringe** - follow on screen prompts.
- **Confirm syringe installation**.
- **Verify set up** - ensure all lines are unclamped before priming
- Press **PRIME + Test**
- **Inspect and adjust level in deareation chamber** - to ensure level is at top of replacement line inlet.
- A primed set can be used up to 6 hours post prime. However, if primed set is not used within 30 minutes reprime with 1000 mL sodium chloride 0.9%.
- **Prime test passed** - PRESS **Continue** ONLY when you are ready to connect to patient and Haemofiltration catheter (Vas Cath) patency has been checked (refer Appendix B: To Connect to Patient - point 7).

Appendix B: Connection

Patient connection requires two registered nursing staff

Supplies Required:
- Dressing Pack
- Sterile gloves
- Chlorhexidine 2% with 70% alcohol
- 2 x 10 mL syringes
- 4 x 10 mL sodium chloride 0.9%
- 2 x 20 mL syringes.

Procedure for connecting therapy to the patient:
- If more than 30 minutes has elapsed since '**Prime test passed'**, a second prime of 1000 mL sodium chloride 0.9% will be required to flush out ethylene oxide (used in the sterilising process) which may have diffused out of the tubing. Flushing also reduces the likelihood of a decreased blood pressure secondary to vasodilation caused by ethylene oxide.
- Ensure patient is not hypotensive prior to connection. Hypotension may occur during initiation of treatment.
- Choose **NEW PATIENT** every time.
- **Enter treatment settings** - Patient fluid loss/gain LIMIT protects the patient from an unintentional fluid loss or gain that could harm. The default is 400 mL within 3 hours - press **CONFIRM**.
- **Enter flow settings** - enter and confirm flow rates as per medical orders:
  - standard set up flow rates for Citrate:
  - blood flow rate (BFR) set at 150 mL/hr **ONLY** (start at 100 mL/hr then increase to target rate as tolerated)
  - dialysate rate (**Green** scale) 1000 mL/hr
  - replacement 200 mL/hr- (**Purple** scale) **POST**, do not have as Pre unless medical order (to maintain deareation chamber fluid level to reduce formation of clots).
  - patient fluid removal
- **Enter Anticoagulation Settings** - set citrate dose at 3.0 mmol/L (default)
- Calcium compensation set at 100% (default)
- **Estimated citrate load** - will be shown on the screen which is the total amount of citrate being delivered to the patient in mmol/hr. This value will change according to flow and anticoagulation settings. This value does not need to be recorded.
- **Review Prescription** - screen summarises all the selected settings.
- Adjustments can be made by pressing the buttons down the left side of screen.
- **To Connect Patient:**
  1. prepare connection equipment and have a second registered nurse (RN) available to assist
  2. don PPE
  3. wash hands and put on sterile gloves
  4. drape access site
  5. swab vascular access ports with gauze soaked in chlorhexidine 2% in 70% alcohol and allow drying
  6. using a 10 mL syringe aspirate 10 mL from each lumen and discard. If not able to aspirate, **do not flush** and inform medical officer


ATTENTION

7. flush each lumen with 20 mL sodium chloride 0.9% by a 'quick aspiration and flush' to assess resistance and patency. If increased resistance is noted or blood does not aspirate freely from either lumen seek advice.

8. check blood lines for presence of air and connect access and return as per screen prompts.

- Once connected, press **'Start'** to commence treatment.
- Commence with blood pump speed at 100 mL/minute and increase to target rate 150 mL/minute as tolerated. Changes to BFR should only occur as recommended by the **pH Management Algorithm (**Appendix G).
- Changes in BFR will result in automatic changes to the PBP fluid rate (Prismocitrate 18/0), effluent volume and calcium requirements. This increase in citrate administration which may be too high for the liver to metabolise, leading to citrate accumulation causing metabolic acidosis and hypocalcaemia.
- Consult with medical officer if rate change is recommended and ensure rate change is prescribed on MR174E WACHS-SW Citrate Regional Anticoagulation CRRT Orders and Patient Systemic Ionised Calcium Results Form
- Turn on blood warmer and ensure wrap blood warmer sleeve around the return line.

Fluids

Pre-Blood-Pump (PBP) Fluid (Citrate):

- Use Prismocitrate 18/0 Fluid. Add potassium 20 mmol per 5000 L bag. If patient requires dialysis for hyperkalaemia, please discuss with ICU consultant, the role of adding potassium to PBP fluid (and/or replacement fluid).
- Administered pre-filter (**White** PBP fluid line) at a rate determined by the Prismaflex® based on Blood Flow Rate and citrate dose.
- Medical order for Prismocitrate 18/0 to be charted on MR174G WACHS SW CRRT PBP Citrate Fluid Orders **.**
- Commence therapy with a citrate dose of 3 mmol/L blood.
- Ideal pre-filter iCa2+ is 0.25 – 0.50 mmol/L. It does not require routine checking.
- Citrate dose does not require adjustment unless:
  - Circuit clotting: adjust as per Appendix F: Pre Filter Ionised Calcium Flow Chart
  - Citrate toxicity evident: manage as per Appendix H: Citrate Toxicity Flow Chart
- If the citrate dose (rate of PBP fluid) is increased, this will result in increase to effluent loss and calcium-citrate complex loss and may result in increased systemic calcium requirements. It may also affect pH.

Dialysate Fluid:

- Use Prism0cal B22 Fluid. This fluid contains 4 mmol/L Potassium, **DO NOT add** any further potassium to this bag.
- Administer on **Green** Dialysate line, run at 1000 mL/hr.
- Prism0cal B22 fluid contains no calcium and less bicarbonate than Hemosol BO (The absence of calcium reduces clotting within the filter, and the reduced bicarbonate level is appropriate as bicarbonate is produced during citrate metabolism in the liver.)

Replacement Fluid:

- Use Hemosol BO fluid. Potassium replacement not effective due to low flow rate, however up to 20 mmol of potassium per 5000 mL bag can be added.
- Administered post-filter (**Purple** Replacement line) at 200 mL/hr.
- Used to optimise deareation chamber function.

Calcium Infusion:

- The calcium infusion solution will be 50 mL of CaCl2 10% solution (neat) in a 50 ml Terumo syringe, infused using the Prismaflex® Syringe Driver. Medical prescription on the MR174E WACHS SW Citrate Regional Anticoagulation CRRT Orders and Patient Systemic Ionised Calcium Results Chart.
- Do not alter the solution or concentration.
- Only use the extension line provided for the calcium infusion. This is specifically manufactured to deliver a precise infusion rate.
- **Do not manually prime the calcium line** - the Prismaflex® will auto prime after the syringe is loaded. Follow screen prompts during priming.
- Rate of calcium infusion will be determined by Prismaflex® based on the % of calcium compensation.
- Calcium compensation should be set at 100% at commencement of treatment.
- Calcium infusion must **NOT** be delivered via peripheral IV access as this may cause tissue necrosis. It can be run on a dedicated CVC lumen or if the Vas Cath has a third central access lumen, this can be used to infuse the calcium infusion.
- Ensure patients iCa2+ on a recent arterial blood gas (ABG) is in the 1.1 – 1.3 mmol/L range prior to commencing therapy (if not refer to medical officer as must be corrected).
  The patient's systemic iCa2+ on ABG will be used to manipulate the % of calcium compensation as per Appendix E: Patient Systemic Ionised Calcium Flowchart).

Appendix C: Ceasing Treatment

Ceasing treatment requires two registered nursing staff.

This section explains in detail the procedure for returning blood due to a clotting filter or cessation of treatment. Prismaflex® circuits contain approximately 152 mL of blood. In a critically ill patient this volume is significant and therefore attempts should be made to return the blood prior to disconnection. If the Prismaflex® circuits are running smoothly, but a patient needs to break from treatment for medical reasons, recirculating the blood is an option. Recirculating is not appropriate for all situations and can only be considered if a patient is going to be disconnected from the filter for **no longer than 2 hours** (see Appendix K for recirculation procedure).

The CRRT Set up box should be on a trolley at the bedside to be used during Trouble Shooting, Connection and Disconnection of CRRT.

Supplies required:

- dressing pack
- 2 x 10 mL leur lock syringes
- 2 x 20 mL leur lock syringes
- Chlorhexidine 2% in Alcohol 70%
- 4 x 10 mL sodium chloride 0.9% ampules
- pair Sterile Gloves and other PPE
- 2 x Non teeth Arterial Clamps
- 500 mL bag sodium chloride 0.9%
- 2 x red leur lock caps
- 1 x connector spike
- 2 x packets of sterile gauze squares

How to cease treatment procedure:

- Ensure appropriate hand hygiene is performed and dressing pack is set-up prior to pressing '***Stop'*** key on screen. Dressing pack should be set-up with sterile gloves, gauze, chlorhexidine, syringes, red bungs and sodium chloride 0.9%. This set-up may need to be done promptly if the machine is already alarming '**Filter is clotting**'.
- When ready, ask your assistant (second RN) to press: '**Stop**' to advance to the End Mode Screen. In this screen you either select '**End Treatment**' or '**Recirculate**'.
- Select '**End treatment**' and follow screen prompts.
- **Return blood**. First screen requires you to '**Prepare to Return Blood**', follow prompts then ask assistant to press continue.
- If unable to return blood, clamp all lines, progress to step '**Disconnect Patient**' and follow instructions on screen. If returning blood, use your assistant to clamp the circuit access line.
- Using aseptic technique, a chlorhexidine-soaked gauze is used to clean and clamp access port of the vas cath. Then using a second soaked gauze, disconnect the access line from the Vas Cath and attach to connector spike. Hand the access line to your assistant, to spike the bag of 500 mL sodium chloride 0.9% and hang the bag on the hook provided on the right side of the Prismaflex® machine.
- **DO NOT return blood if:**
  - filter has already clotted
  - filter membrane has ruptured

  - there are visible clots in the circuit.
- Second screen '**Return Blood**' using '**Auto return**' button. Return rate is set at default of 70 mL/min. This rate can be increased by setting option. Remember to cease any dialysis related infusions running on external syringes to the patient when treatment stopped.
- Press '**Continue' Note**: pressing '**Continue**' will take you straight to '**Disconnect Patient**' without letting you return the blood.
- **Disconnect Patient** follow prompts. Aspirate 10 mL of blood from access and return lines on vas cath discard blood then flush each lumen of vas cath with 10 mL of sodium chloride 0.9% following any disconnection. Lock Vas Cath with TauroLock™ Lock solution if therapy not recommencing within a definite period or greater than 2 hours has elapsed since therapy ceased.
- Select '**History**' to obtain final values.
- If '**End Treatment**' was selected, once all lines are disconnected from patient and clamped, your assistant can unload the set by pressing the '**Unload**' and follow the prompts. Dispose of used circuits in clinical waste bins. Use red leur lock caps to seal ends to avoid contamination from lines that may leak.

Appendix D: Haemofiltration Catheter (Vas Cath) Locking

A Vas Cath is a large bore central venous catheter normally inserted for short term dialysis. Patients receiving CRRT can be intermittently discontinued from CRRT, requiring the Vas Cath to be locked with an appropriate solution.

The purpose of locking the Vas Cath is to prevent blood clot formation thereby preserving the catheter patency. Another purpose is to reduce the incidence of catheter related infections.

TauroLock™ has been shown to maintain line patency as well as the additional benefit of reduced incidence of catheter related infection, while avoiding potential inadvertent anticoagulation when using Heparin as a lock.

All Vas Caths that are not going to be used within two (2) hours must have a TauroLock™ or Heparin lock.

Anticoagulant Lock Choice

Anticoagulation Lock	Concentrations
Heparin	1000 units per 1 mL ampoule
TauroLock™	5 mL ampoule

Table 2: Anticoagulation Lock Choice

Supplies required:
- Dressing pack
- Sterile gloves
- Chlorhexidine 2% in 70% Alcohol
- 2 x 10 mL, 2 x 20 mL, and 2 x 3 mL leur lock syringes
- 4 x 10 mL sodium chloride 0.9% ampoules
- 1 x TauroLock™ 5 mL ampoule
- 1 x drawing up needle
- 2 x red leur lock caps

How to lock Vas Caths procedure:
- obtain medication order from ICU consultant/registrar. Prescription to be written on HMC.
- ensure clamps on
- sash hands and don PPE
- prepare sterile field around catheter and clean catheter with gauze swabs soaked in Chlorhexidine 2% in 70% Alcohol
- fill 10 mL syringes with sodium chloride 0.9%.

For Each Lumen:
1. Attach 10 mL syringe to lumen and aspirate 10 mL blood (including any previous lock). Clamp line.
2. Attach 10 mL sodium chloride 0.9% filled syringe, unclamp line and flush each lumen. Clamp line.

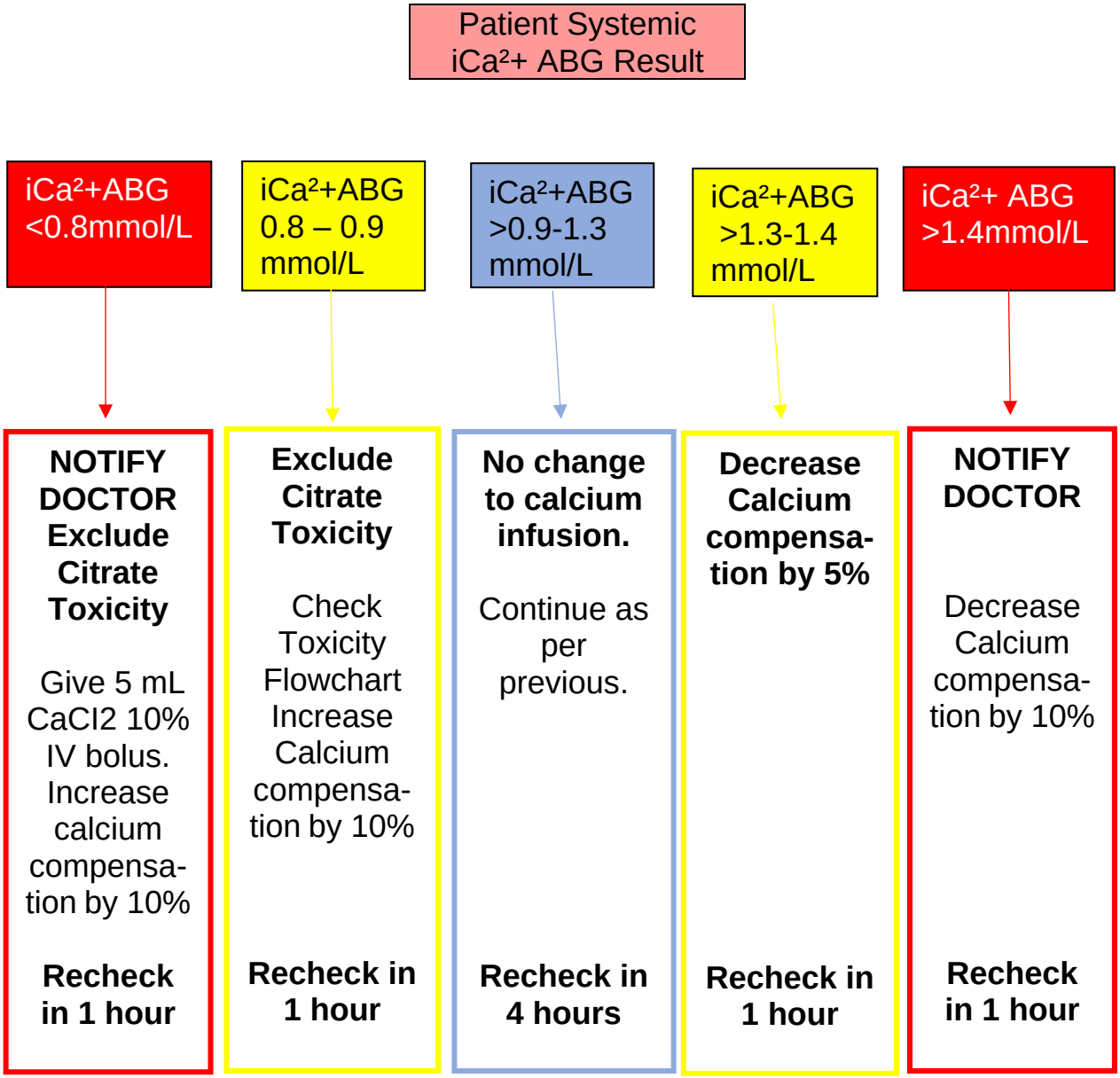
3. A locking agent, either TauroLock or Heparin is administered into each lumen. Use 2 syringes with up to 2.5 mL of locking agent in each syringe to administer into each lumen (**total volume of each individual lumen + 0.2 mL**). Clamp line.
4. Attach red leur lock cap.
5. Attach 'Vas Cath Lock' label to each lumen with locking details (date, time and agent used).

Summary of Circuit / Fluid Use	
Clean unprimed circuit loaded on machine / packet opened	24 hours
Clean primed circuit loaded on machine - ensure labelled and date time	6 hours
A 1000 mL sodium chloride 0.9% reprime is required if primed circuit is left standing more than	30 minutes
Used circuit, temporarily disconnected, in saline recirculation mode	2 hours
Hemosol fluid- if bag mixed but **NO** electrolytes added- use within	24 hours
***** Once KCl and/or Mg added to dialysate/ pre blood pump – use within	2 hours

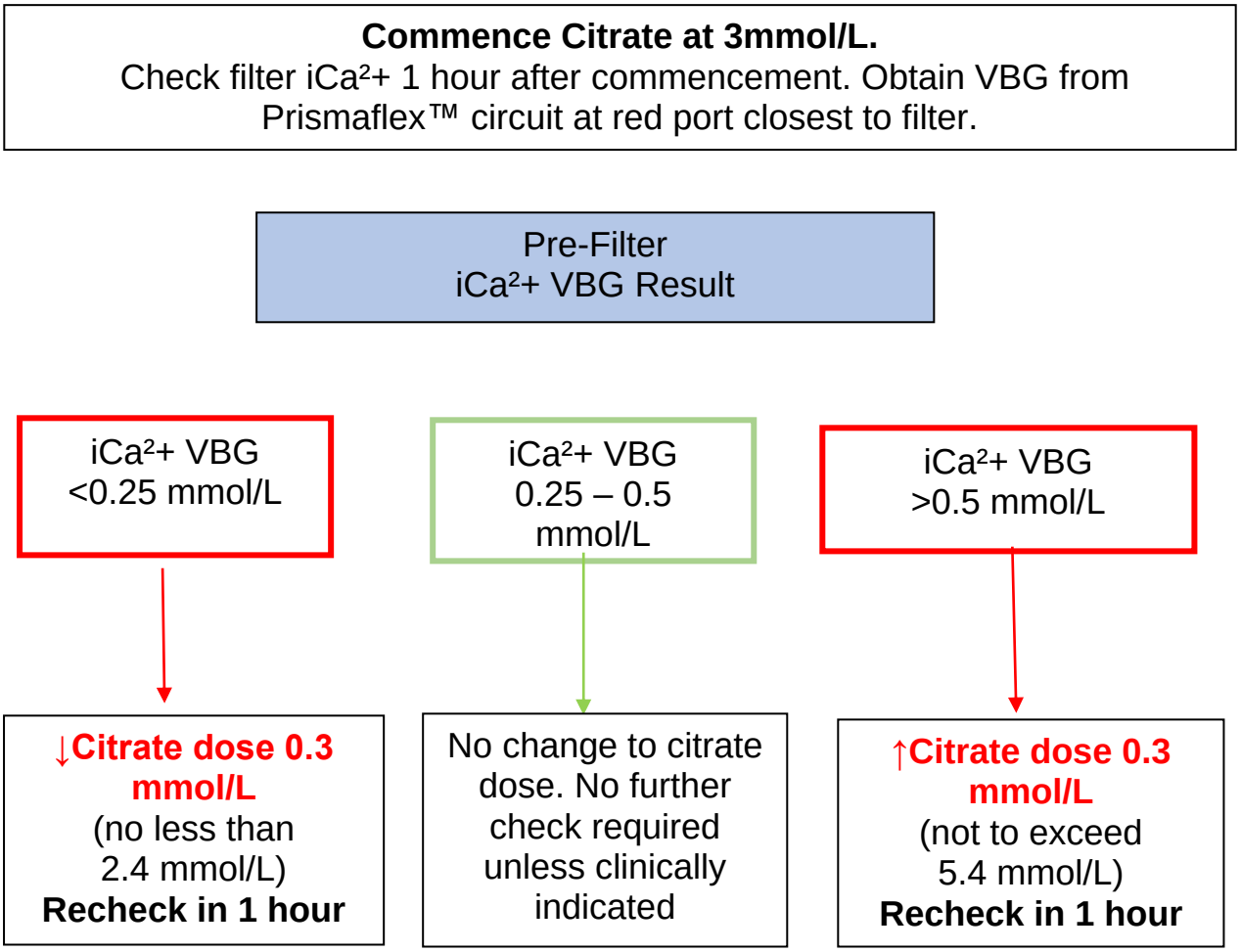
Table 3: Summary of Circuit / Fluid Use

Appendix E: Patient Systemic Ionised Calcium Flowchart

Prior to commencing dialysis check patient systemic iCa^{2+} on ABG.
Check systemic iCa^{2+} 1 hour after commencement. Ensure level is 1.1-1.3 mmol/L. Replace via IV CaCI2 bolus if required.
Commence calcium infusion at 100% compensation.



Appendix F: Pre Filter-Ionised Calcium Flowchart



Appendix G: pH Management Algorithm

Metabolic Acidosis
pH< 7.3 and decrease in base excess on ABG

↓

Exclude Citrate Toxicity
(see Toxicity Flowchart)

↓

- **If blood flow is <180 mL/min:** ↑blood flow to 180 mL/min.
- **If blood flow = 180 mL/min:** ↑citrate dose by 0.5 mmol/L (this ↑ systemic citrate load and thus ↑HCO3)

Check patient ionised calcium, filter ionised calcium, sodium and, patient ABG acid-base balance in 2 hours

Metabolic Alkalosis
pH> 7.5 increasing base excess on ABG

↓

If blood flow **is > 150 mL/min**: ↓ blood flow to 150 mL/min.

- **If blood flow = 150 mL/min:** ↓ citrate dose by 0.5 mmol/L (this ↓ systemic citrate load and thus ↓ HCO3)

Check pre-filter Ionised calcium and patient ABG acid-base balance in 2 hours

The reduced citrate dose may increase iCa^{2+} pre-filter. If so, return citrate dose to previous rate and increase dialysate flow by 500 mL/hr.

Recheck in 2 hours

Appendix H: Citrate Toxicity Flowchart

Signs of Citrate Toxicity:

- Falling pH and Base Excess with ↑ anion gap
- ↑Total Calcium and persistently low patient Ionised Ca^{2+}
- ↑Calcium Ratio (total Ca^{2+}: Ionised Ca^{2+} > 2.1:)

High suspicion for Citrate Toxicity when Calcium Ratio exceeds 2.5:1

↓

If confirmed, consider ceasing citrate and starting alternative anticoagulation.

(Example of higher risk groups include those with liver failure, cardiogenic shock, acute kidney injury, and many toxic agents – check with on call Clin.Tox)

↓

If persisting with citrate or awaiting Calcium Ratio results:

- ↓ citrate dose by 0.5 mmol/L And
- ↑ dialysate (PrismOcal™) rate by 500 mL/hr

Re-check: blood including Patient Ionised Calcium, Filter Ionised Calcium, Total Calcium, Calcium Ratio, Patient Sodium and Patient ABG acid-base balance – in 2 hours

Appendix I: Trouble Shooting CRRT

Pressure Drop (PD):

- is the pressure reduction that occurs as blood flows through the filter.
- Micro-clotting can occur in the hollow fibres. This creates resistance as blood flows through, thus pressure drop increases over time.
- Micro-clotting eventually leads to a build-up of gross clotting and the need to change to a new Prismaflex® set.

ATTENTION

A gradual increase in PD and TMP are indicators of impending circuit failure due to the accumulation of blood clots inside the filter.

Transmembrane pressure (TMP):

- TMP is the pressure exerted on the filter membrane during operation. It reflects the pressure difference between the fluid and blood compartments of the filter.
- As duration of filter use increases, permeability of the filter decreases due to protein coating on the blood side. This causes TMP to increase

Access (outflow) pressure alarms:

- Check all connections are secured and trace the 'access (red)' tubing looking for kinks Excessive negative pressure usually indicates an occlusion somewhere in the access tubing of the circuit. If no problems are apparent externally there may be a kink or occlusion internally

To relieve the excess access pressure:

- Prepare a 10 mL syringe
- Prepare sterile field around catheter and the positive pressure valve (PPV) attached to the Y-connector on the access line. Clean with gauze swabs soaked in Chlorhexidine 2% in 70% Alcohol for 15 seconds, allow to air dry
- Attach sodium chloride 0.9% filled 10 mL syringe to the PPV
- Release clamp on Y-connector and pressure within the access pod will be equalised by drawing down plunger on the syringe
- Reposition the patient to optimise access flows and support the access and return tubing with clamps to the bed sheets
- Blood flow can be titrated between 150-200 mL/min to achieve lower access pressures

Report continued access problems to the ICU Consultant/registrar for possible manipulation of the catheter

Return (inflow) pressure alarms:

- Low return pressures may indicate disconnection – check 'return' (blue) tubing for tight connections
- Low return pressures are frequently encountered when patients are laterally rotated during pressure area care. Position the patient to minimise flexion near the insertion site and consider aspirating and manually flushing the 'inflow' lumen of the catheter.

- Sudden high return pressures are seen with occlusions – check 'return' (blue) tubing for kinks or a clamp that has been inadvertently applied
- Localised clotting inside the 'inflow' lumen of the vascular access may also elevate venous pressure

NOTE - if filter clots abruptly, it may not be possible to return filter blood to the patient.

- If return pressure >200 mmHg consider electively returning blood by 500 mL sodium chloride 0.9% infusion into circuit and ceasing treatment. Liaise with ICU Consultant/registrar and consider recommencing CRRT with new lines.

Filter Clotting Alarm:

- If alarm activates it is usually due to a high TMP or a high pressure drop (PD) Slowing your blood flow to 100 mL/min may allow you time to prepare to return the patient's blood

Blood Leak Detector

This is an infrared device that monitors the effluent line for blood that may have passed through the filter. If this line is removed/reinserted from the detector during treatment it must be normalised by:

- Select '**Tools**' then '**Norm Bld**'.
- Draw a sample of effluent and test for blood with urinalysis strip.
- If blood present cease treatment and change set.
- If no blood is present, verify signal on top left of screen is equal/ greater than 42 000. You may be able to increase this number by moving the effluent line up or down slightly.
- If the number is still below 42 000, change set. If above 38 000 press '**Start Norm**'.
- When process is completed status screen will return automatically.
- If normalisation fails, treatment will be terminated.

Air Removal Procedure

- Air is normally removed through the initial prime, however small bubble/foam may accumulate in the deareation chamber. Remove by:
  - Pressing **'adjust chamber'** select up or down arrows to bring the fluid level to the correct height and return pressure is negative (air will be expelled through the return pressure port).
  - If the '**Air in blood**' alarm is triggered follow on screen instructions.

Pressure Pod Alarms

- If one of the pods is accidently removed after priming or an alarm screen identifies a problem with one or more pods:
  - Select '**system tools'** and press '**Self-test**' usually this will resolve alarm.

Appendix J: Using the Prismatherm™ II Dialysis Infusion Warmer

- follow priming procedure
- after **Confirm syringe installation** press **connect warmer**
- disconnect blue connection on return line between filter and deareation chamber, add extension tubing for warmer and install in the Prismatherm II, ensuring no kinks/twists in the line are present
- ensure all lines are unclamped then continue to prime
- set Prismatherm II according to patient temperature and titrate every 4 hours while on CRRT
- **use the following guidelines to titrate:**

Patient Temperature	Prismatherm II setting
Less than 37	43.5
37 - 38.5	41
38.5 - 39.5	38
Greater than 39.5	Off

Appendix K: Recirculation Procedure

The Bunbury ICU **only** utilises the Saline Recirculation option on the Prismaflex™.
The Saline Recirculation mode can only be utilised for a maximum of **120 minutes** before a repriming is required. If the expected disconnection time will be longer **do not** attempt the recirculation process.

Supplies required:

- 2 x dialysis spikes
- 500 mL IV bag sodium chloride 0.9%
- 2 x 1000 mL IV bag sodium chloride 0.9%

Procedure:

- press the **"recirc."** Soft key on the Prismaflex™ machine
- complete procedure on Returning Blood to the patient prior to continuing with the setup for recirculation. See section Appendix C: Ceasing Treatment Procedure.

ATTENTION

If the set is observed to have significant clotting, the operator can choose to automatically unload it change the set. This can be done by pressing the **"DISCONNECT"** softkey.

- once blood is returned
- wash hands and don PPE
- prepare sterile field around catheter and clean catheter with gauze swabs soaked in Chlorhexidine 2% in 70% Alcohol
- use non-touch technique to disconnect and clamp both the access line from the empty 500mL IV bag sodium chloride 0.9% and the return line from the patient's access and connect both to a primed y- connector attached to a clean spike. Insert spike to a 1000mL IV bag sodium chloride 0.9% and unclamp.
- press the '**start recirc'** soft key to commence the recirculation process
- doff gloves and perform hand hygiene
- enter desired Recirculation Rate 20-100mL/min (default 50mL/min) and begin recirculation
- **note:** the recirculation flow rate can be changed at any time while recirculation is in process
- you can stop the recirc any time within the maximum of 120 min, simply press "stop recirc". You must now prepare to prime the set as the blood pump is no longer running. Press Soft key **'Prepare to prime'**
- wash hands and don PPE
- hang 1000 mL IV bag Sodium Chloride 0.9% to priming hook on left side of machine. Clamp access line and disconnect from recirc bag and connect to the priming solution
- hang empty 1000 mL bag of sodium chloride 0.9% on priming hook on right side of machine, for collection bag. Clamp return line and attach to this collection bag
- unclamp access and return lines and press soft key **'prime and test'**
- doff gloves and perform hand hygiene

ATTENTION

Note: when '**PRIME'** softkey is pressed the control unit leaves 'End Mode' and enters 'Setup' Mode

- as the prime test is completed the reconnect patient screen reappears to prompt you with the final step to reconnect and recommence your CRRT. See Appendix B: Connection.