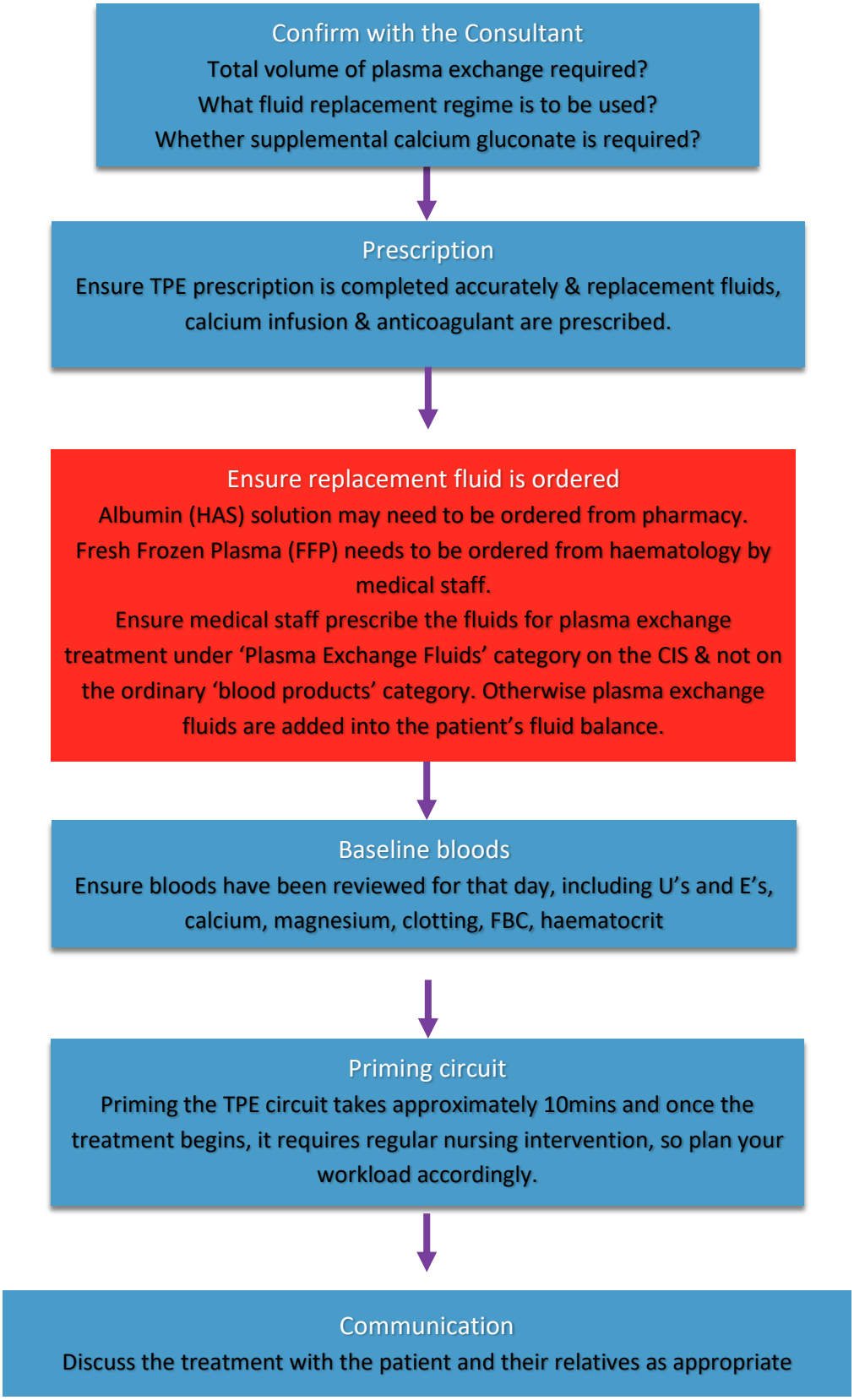
Guidelines for Therapeutic Plasma Exchange in Critical Care



1. INTRODUCTION

Background

TPE removes large-molecular-weight substances such as harmful antibodies from the plasma. It is usually carried out using an automated blood cell separator to ensure fluid balance and maintain a normal plasma volume. This may require the insertion of a femoral or jugular line to allow adequate blood flow. The fluids you use are given to replace the plasma that is being removed from the patient, i.e. a direct exchange & will not add to the patient's blood volume. The volume of fluid usually exchanged in each therapeutic plasma exchange is 100–150% of the patient's plasma volume, this is replaced with isotonic 4.5 or 5.0% human albumin solution, however, some services substitute 25–50% of replacement volume with 0.9% saline.
Exchange with fresh frozen plasma (FFP) is usually reserved for the treatment of thrombotic thrombocytopenic purpura (TTP) or to replace clotting factors. Plasma exchange with albumin or saline causes a transient fall in blood-clotting factors and mild prolongation of prothrombin and activated partial thromboplastin times, recovering in 4 to 24 hours
A one plasma volume exchange removes about 55 – 65% of pathological factors, the second exchange will remove a further 20 – 25%. A list of common indications is available from the JPAC guidelines by clicking on the link and summarised in Table 1 below.

Table 1 Volume of plasma exchange in common conditions

Condition	Volume of Plasma exchange (PV = plasma volume)
TTP or aHUS	150% PV Daily initially, Until condition stabilises
Myaesthenia Gravis	100% PV Daily or Alt. daily, total 5 exchanges
Guillan Barre Syndrome	100% PV Daily initially, total 5 exchanges
Goodpastures	100% PV 10 exchanges over 14 days
Vasculitis	100% PV 7 exchanges over 10 days
Cryoglobulinaemia	100% PV 5 exchanges over 10 days

What Volume of Plasma is Exchanged?

The volume of fluid usually exchanged in each therapeutic plasma exchange is 100–150% of the patient's plasma volume. The patient's plasma volume can be estimated using a nomogram incorporating sex, height, weight and age. Alternatively for adult patients, plasma volume can be approximated to 40 ml/kg. The prescription for plasma exchange therapy is always the responsibility of the critical care medical team, in discussion with the patient's specialist team where appropriate.

Treatment should not be started until a prescription has been completed & all fluids & drugs have been prescribed.
Since the circulating pathological factors become progressively diluted at each exchange treatment, removal of the factors becomes less efficient with time. As an approximate guide:
• one plasma volume exchange removes 55 – 65% of pathological factors
- the second plasma volume exchange will remove a further 20 – 25%
- the third exchange will remove an additional 10%

The pathological factors re-accumulate between treatments due to diffusion from the extra vascular space to the intravascular compartment and endogenous synthesis (the body producing further pathological factors). Therefore patients undergoing TPE to remove pathological Immunoglobulins will also be undergoing immunosuppressive treatment to prevent further endogenous synthesis of these. This might include high dose steroids and/or cyclophosphamide or chemotherapy.
Patients often receive four to five exchanges over a 7 – 10 day period (depending on their underlying pathophysiology). This type of treatment regime will reduce the percentage of pathological factors to less than 10% of their pre-treatment concentration. Serial clinical assessment and measurement of the offending substance (if known) allow decisions to be made regarding the frequency and volume of exchanges.

Substitution (replacement) Fluid

Normally the amount of plasma removed is replaced by an equivalent volume of replacement fluid, donor plasma or a plasma substitute. Typical replacement fluids are:
• Human Albumin 4.5-5%
• Fresh Frozen Plasma (FFP) – specifically indicated in treatment of TTP
• Crystalloid
FFP is the replacement fluid that is most similar to the removed plasma filtrate & contains normal levels of proteins & coagulation factors. For plasma exchange for TTP, Octaplas™ is recommended. This is a solvent/detergent treated FFP, but is handled and used just the same as standard FFP.
Albumin is sometimes combined with 0.9% saline on a 50**:**50 (vol:vol) basis.
The choice of replacement fluid has implications for the efficacy of the procedure, oncotic pressure, coagulation & the range of side effects. The exact combination of replacement fluids is tailored to the needs of the patient, for example, FFP is the fluid of choice for HUS/TTP because the infusion of normal plasma contributes to the replacement of a deficient plasma factor which is causing the disease. Plasma may also be preferable in patients at risk of bleeding, e.g. those with liver disease or disseminated intravascular coagulation.

NOTE: If Fresh Frozen Plasma is prescribed as part of the replacement fluid regime, it is recommended that this is given towards the end of the treatment, in order to minimise its loss through the filter. 'Washing back' with normal saline at the end of treatment will ensure that no FFP remains in the heating coil when treatment is completed.

Anticoagulation

Blood flow through an extracorporeal circuit is associated with activation of the coagulation cascade. The aim of anticoagulation is to prevent the filter and the circuit from clotting, without interfering with the patients' own systemic coagulation. Commonly used anticoagulants for haemofiltration are heparin & citrate, but citrate cannot be used for circuit anticoagulation for TPE.

The extracorporeal circuit is primed with 1 litre of heparinised saline. When the plasmapheresis is started, heparin is delivered continuously via the integral syringe driver into the circuit pre-filter. Larger amounts of heparin are required for TPE than in continuous renal replacement therapy (CRRT). The dose of heparin is approximately twice that needed for haemodialysis or CRRT because of the slower blood flow rate setting & the substantial amount of infused heparin that is removed along with the plasma.
Patients with heparin allergy or HIT, can have a saline-only prime (no heparin) and then infusion of epoprostenol (Flolan) according to our usual CRRT guideline.
Patients with severe bleeding who require plasma exchange, should have the circuit primed with saline only (no heparin). Discuss this with the medical team.

Planning Treatment

• Depending on the blood pump speed and exchange rate selected, one plasma exchange may take between 2 – 4 hours. Plan the treatment when you know you will have time to be at the bedside and monitor the procedure and your patient carefully.

Equipment required for set up of Plasma Exchange

- Aquarius Machine Filter lines set (aqualine) code: 1500000006 and TPE filter (microplas MPS 07)
- spare effluent bag
- Y connector
- Anticoagulant in 50ml **Plastipak syringe**
- Priming solution: 1litre 0.9% sodium chloride + 5000units heparin
- Substitution fluid (replacement solution): to be prescribed by medical staff.
- 1x litre bag of normal saline (to hang instead of substitution fluid for priming purposes)
- 100ml bag of normal saline – labelled as 'COUNTERWEIGHT
- Air inlet for albumin administration

2. PROCESS

Priming the Circuit

	Recommendation (Action)	Justification (Rationale)
1	Wash hands. Put on gloves & apron / PPE protection	To reduce incidence of infection. An aseptic non-touch technique (ANTT) should be used throughout.
2	Connect machine to power supply and turn on. The system test takes 3 to 4 minutes to complete. Lining the machine can start when the green & amber lights at the top of the main screen are static.	
3	Always read the screen carefully and follow step by step instructions.	
4	SELECT THERAPY screen is shown	
5	Choose the TPE therapy mode	Therapeutic Plasma Exchange Mode
6	Choose 'Aqualine for adult treatment' & confirm YES. Choose NEXT STEP.	
7	The Aquarius offers step by step instructions to assist the user. These instructions should be followed systematically using the **ZOOM GRAPHIC** key to find the steps (note: if you press 'previous screen' it will take you back to the very beginning) The machine will not allow you to proceed if part of the lining & priming process has been done incorrectly.	Following the on screen step by step instructions will prevent errors in lining & priming.

	Recommendation (Action)	Justification (Rationale)
8	Take plastic caps off the pressure pod cups before pressing onto pressure sensors on machine. During set up leave all clamps open	To allow correct placement & priming of all lines
9	**Select Step 1** Install the **blood** pump segment by pressing the tubing located near the red marker, into the bottom of the **blood** pump housing and carefully wrapping the tubing around the pump by turning the 'pump head' in the direction of the arrows. Then press the tubing into the holder at the pump outlet. Do the same with the 3 other pump segments	
10	**Follow steps 2-7, at step 5:** Insert degassing chamber into holder, then attach degassing line to the pressure sensor under the degassing chamber.	This does not appear as a prompt on the screen, remember to do this at the same time as you place the degassing chamber in the housing
11	Having completed first seven steps, select NEXT & proceed to next screen, press ZOOM GRAPHIC & start again at step 1.	
12	**Preparation step 4:** Attach Y connector (found in lines bag) to blue return line & spike priming solution. All clamps should be open prior to priming.	To allow air detection & clamp test following priming
13	Hang 1 litre bag of normal saline on substitution (replacement) scale in place of actual substitution fluid when priming	Plasma substitutes such as HAS & FFP are expensive & it is wasteful to use these fluids just to prime the circuit
14	Continue steps 5-7 & select NEXT	
15	Prepare anticoagulant following instruction on screen. Select PREPARE SYRINGE & enter values, then programme other parameters in anticoagulant screen in a similar manner. Press NEXT	
16	Check lines, ensure bags spiked correctly, open any clamps & select 'START PRIMING	To avoid air being drawn into circuit
17	The machine primes the from the post dilution pump (green) first. Initially air will travel into the priming bag, this is normal. If the degassing chamber does not prime fully, simply raise the level of fluid in the chamber to . full by drawing the level up with a 10ml syringe.	

	Recommendation (Action)	Justification (Rationale)
18	The fluid level of the drip chamber needs to be as high as possible after priming. During treatment when aspirating the chamber with a 10ml syringe, the 'blood pump key' under the screen needs to be pressed **twice** to release the return line clamp	
19	It takes 800mls of heparinized saline to prime the circuit	Priming the circuit ensures that there is no air in the system & also rinses out the ethylene oxide which is used to sterilize the circuit & could cause an anaphylactic reaction when the patient's blood comes into contact with it.
20	The machine starts priming the lines at a rate of 80mls/min, the rate automatically increases to 150mls/min.	
21	Ensure the anticoagulation line is primed. Once priming is complete (approx 10mins) the user has the option to reprime individual sections of the circuit if required	To ensure all air in circuit is removed.
22	At the end of priming, the user should visually check the fluid level in the degassing chamber. (see point 17)	
23	If satisfied with priming press 'NEXT'. A red box will appear on the screen to prompt you to do the **clamp & pressure test.** Ensure at this stage that both the access & return lines are connected to the priming saline bag.	To check the air detector clamp is working correctly
24	**Remember:** a static green light should be visible on the air detector button under the main screen. If not, check return line tubing is properly inserted into the clamp & air detector.	Otherwise machine will fail self test
25	The machine takes 4 minutes to self test Ideally, put the machine into RECIRCULATION mode for 1 hour before connecting to the patient, however this is not essential. (Find in OPTIONS menu.) Clamp pre-dilution line.	Recirculating priming fluid around the circuit will soak & separate the filter fibres & may reduce the clotting of the circuit. This prevents blood back-tracking up the line.

	Recommendation (Action)	Justification (Rationale)
26	**Programming & connection of the Aquarius in TPE** **NB: BEFORE PROCEEDING FURTHER, REMOVE 1X LITRE BAG OF SALINE FROM SUBSTITUTION SCALE & HANG PRESCRIBED SUBSTITUTION FLUID** Select **PROGRAMMING** screen. Ignore the time setting window. Set plasma rate to 1500mls/hr Set total plasma exchange to the total exchange documented on the prescription. (note length of treatment time is indicated)	Now priming is complete, it is essential that the prescribed plasma substitute fluid is hung Plasma rates of 1000 – 1500mls/hr are considered acceptable
27	**Set container weight:** If hanging a **glass bottle**, assume weight of bottle is half of its volume eg: 500ml bottle will weigh approx 250g. However, *programme in the weight as 280g,* to avoid entraining air into the line. Use a dedicated air inlet.	
28	If hanging **a bag** of substitute fluid, first put a 100ml bag of normal saline on the substitution scale as a counter-weight. Clearly mark the bag 'COUNTERWEIGHT' then hang the prescribed bag of plasma substitute alongside it. In the container weight screen, programme the weight of the 100ml counterweight as 110gm (to avoid entraining air into the line).	The machine is only looking for the weight remaining after the fluid is removed. Plastic containers are negligible in weight therefore we use the small saline bag as a counterweight. When using Albumin (glass bottles) these normally weigh approx 250grams empty or thereabouts.
29	Set temperature to 37 degrees	This temperature can be altered if necessary, increase if patient's temperature drops
30	Select 'DOUBLE CONNECTION' option.	
31	Set up clean dressing trolley with a sterile dressing pack, sterile gloves, 2% chlorhexidine swabs, two 5ml syringes. Prepare patient access by placing a sterile dressing towel under vascath lines, clean ports with 2% chlorhexidine swabs & let dry.	To comply with aseptic non-touch technique (ANTT) policy & reduce risk of infection
32	Using ANTT aspirate 5mls blood from each port & reclamp. Note blood flow through each lumen, should any clots be seen, aspirate a further 5mls blood & discard syringes.	To remove heparin from vascath lines prior to commencing treatment
33	If blood cannot be drawn back easily, seek advice from senior nurse or medical staff.	Poor vascular access & blood flow may hinder the smooth running of the therapy

	Recommendation (Action)	Justification (Rationale)
34	Attach antibacterial two-way swanlock connector to each vascath port.	To reduce risk of infection when accessing ports
35	Connect access & return lines to the patient using aseptic non-touch technique (ANTT). Remove any clamps & press BLOOD KEY to start blood pump. The blood pump starts at 50mls/min.	
36	Once you have seen blood flow around the system & return to the patient press the TREATMENT KEY to start plasma exchange treatment.	
	Monitor patient's vital signs & seek expert help if the patient becomes unstable	
37	Once the blood flow has commenced without problem & there are no warning screens, increase blood pump speed incrementally to a speed of 100mls/min for a 1 litre exchange, 150mls/min for a 1.5 litre exchange	Read guidance for nursing care on page 14.The faster the blood pump speed the less likelihood of the system clotting, however this must be balanced with the TMP pressure. Monitor the TMP pressure carefully & aim to keep ≤ 50mmHg. Reduce blood pump speed if TMP rising
38	Secure blood lines with atraumatic blue clamps.	
39	Check programming screen and ensure all settings are correct, in particular the plasma rate & total plasma exchange.	
40	Check pressures screen and TMPa pressure in particular.	High TMP pressures could lead to hemolysis
41	Enter data on CIS on TPE tab As treatment progresses, follow instructions on screen to change substitution fluid bags.	
42	Press TREATMENT KEY as fluid level in container reaching empty. Remove empty container & replace with next bag/bottle of substitution fluid, programme in new weight, exit programme screen & press treatment key to restart.	
43	Follow guidance on page 14 for nursing care & observations during TPE treatment.	

	Recommendation (Action)	Justification (Rationale)
44	When the TPE treatment is complete, a message will appear on the screen: THERAPY TARGET ACHIEVED BY PLASMA VOLUME. Washback blood following instructions on screen & end treatment. Unload TPE circuit from machine & clamp all connections, double bag in 2 large yellow clinical waste bags.	See section 9 in CRRT guidelines
45	Heparinise vascath ports according to CRRT guidelines. Monitor patient closely for complications.	See section 10.2 in CRRT guidelines See page 16 for guidance.
	Check U's + E's, FBC, serum calcium & magnesium levels and clotting time one hour after the treatment has ended.	Hypocalcaemia and hypomagnesiaemia are both common following TPE. There may be some abnormalities and you may need to be correct any electrolyte or clotting imbalance as necessary, in liaison with medical staff.
	Continue close observations	Monitor patient's haemodynamic status and temperature closely and observe for signs of complications.
	Check drug infusion rates	If drug infusion rates, for example sedative drugs, have been increased during the plasma exchange, titrate to pre-treatment levels as patient's condition allows.

3. GLOSSARY

APHERESIS: Greek word meaning removal or withdrawal

THERAPEUTIC APHERESIS:
Procedure to separate and so remove a specific blood component in order to benefit the patient. This broad term encompasses the following subdivisions:

THERAPEUTIC PLASMAPHERESIS:
Removes plasma in order to
(i) remove factors in the plasma which are implicated in a disease. The pathological factors removed are proteins e.g.: immune complexes, auto antibodies or albumin bound toxins. Or
(ii) reduce the plasma volume.

THERAPEUTIC PLASMA EXCHANGE (TPE):
This is an extracorpeal blood purification technique, designed for the removal of large molecular weight substances from plasma, removal of plasma. Blood volume is maintained by replacement with donor plasma or a other substitute. It is very similar in concept to the haemofiltration we use for renal replacement therapy, but with much larger filter pore sizes.

The development of filter membranes with pore sizes sufficient to allow the passage of plasma, whilst retaining cellular elements, which can be used with continuous veno-venous haemofiltration units, has made plasmapheresis more readily acceptable to intensive care patients.

The expected benefits and potentially deleterious effects of plasmapheresis are dependent on the timing of the procedure with respect to the onset of the illness, the volume of fluid exchanged, the type of replacement solution and the frequency of plasma removal. By stripping the body of circulating immune factors, plasma exchange is a significantly immunosuppressive treatment.

There are two methods of plasmapheresis:
(i) cell separation ~ involving centrifugation
(ii) membrane filtration ~ the passage of plasma water, molecules and proteins across a semi-permeable membrane. Cellular components are retained and reinfused into the patient with replacement fluid.
The focus of these guidelines is solely on simple membrane plasmapheresis, which is the only form of TPE in use in BSUH critical care units.

PLASMA FILTERS

Standard Haemofilters allow molecules up to 55,000 daltons in size to pass through.
Plasma filters allow molecules up to **980,000** daltons in size to pass through, any substance to be removed using this filter should be greater than 15,000 daltons
For example:
Albumin is 68,000 daltons
IgA is 150,000 daltons
IgG is 180,000 daltons
The plasma filter has 3000 fibres & is sterilized using ethylene oxide. The filter membrane is made of polyethersulfone. The blood compartment holds 70mls, the plasma compartment holds 190mls. The plasma filter looks very similar to the haemofilters we use, but is branded as “MIcroplas MPS07”.

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4 ONLINE RESOURES

JPAC guidelines

http://emedicine.medscape.com/article/1895577-overview

Patient Name:
Unit No:
Date of Birth:

Brighton and Sussex University Hospitals NHS Trust

Therapeutic Plasma Exchange (TPE) Prescription and Session Sheet

Plasma Exchange for (circle one)...
TTP/HUS Vasculitis Paraproteinaemia Anti-GBM Other
(specify).....

Pulmonary Haemorrhage? - Yes / No	Planned No of Sessions: 5 7 10 Other:

What solution to replace with:

For **TTP/HUS** use **FFP alone (60ml/kg; max 4 litres)**

Otherwise

Exchange with **50% volume of Human Albumin Solution (HAS) 4.5% and 50% volume of 0.9% saline** plus 0–30ml of calcium gluconate 10% in 100mls of 0.9% Sodium Chloride infused throughout plasma exchange.
According to serum calcium:

Corrected serum calcium (mmol/l)	<2.2	2.2-2.4	2.4-2.6	>2.6
Give calcium gluconate (10%)	30ml	20ml	10ml	0ml

UNLESS:

a) pulmonary haemorrhage;
b) within 5 days of a renal biopsy;
c) other active haemorrhage; or
d) abnormal coagulation (INR or APTTR >1.4).

In these situations use **HAS 4.5%, then FFP (15ml/kg) at the end of the exchange, plus calcium as above (total exchange volume 60ml/kg, max 4litres)**

Plasma Exchange Prescription	**Date:** ...../...../20.....	**Session No**

Corrected Calcium:.....
INR:.....

Litres to exchange: 3.0 / 3.5 / 4.0 / other .....

Exchange fluid type:

Volume ..... Litres HAS 4.5% (+10% calcium gluconate IV centrally)

Volume ..... ml FFP

Volume ..... Litres other fluid (specify) .....

Calcium Gluconate 10%: 0ml / 10ml / 20ml / 30ml / other

Sign: ..... Print: ..... SpR/Consultant

Administration Record

Affix relevant tags and sign for exchange fluids here	**Calcium Gluconate 10%**	**Heparin**
	Lot no:.....	Bolus Lot no:.....
	Saline lot no.....	Infusion Lot no:.....
	Sign.....	Sign.....
	Sign.....	Sign.....

APPENDIX 2 NURSING CARE and MONITORING AND DOCUMENTATION DURING TPE TREATMENT

NURSING CARE

- Explain the treatment & procedure to the patient & their family, give them the opportunity to ask questions.
- If possible the patient should be made aware of possible complications & be instructed to report any unusual feelings such as numbness, tingling around the mouth, cramping, spasm, dizziness, as these may be signs of hypocalcaemia & would require calcium replacement.
- Monitor patient's vital signs closely, observe for changes in haemodynamic stability, hypotension, changes to QT interval on ECG (related to hypocalcaemia) and core temperature. Adjust temperature on Aquarius if necessary.
- Record hourly sedation score & titrate sedative drugs accordingly. Plasma bound drugs will be lost through the haemofilter, rates of sedative infusions may have to be increased during treatment.
- Position Aquarius machine to allow movement around bed space and easy access for emergency equipment.
- Monitor haematocrit - If a sample of blood is allowed to stand and clotting is prevented, the denser red cells sink to the bottom, the slightly less dense white cells form an intermediate layer and the plasma forms the top layer. If a calibrated tube is used to measure the red cell layer, it shows that 45% of the blood volume is made up of red cells. The figure of 45 (or 0.45) is known as the **haematocrit** or **packed cell volume**. It varies with the number and size of the red cells in the blood and with the plasma volume. The normal range for the haematocrit is 40 – 47 (0.40 – 0.47).
- If large volumes of plasma are exchanged during the therapy, the patient's haematocrit may rise and indicate an increased blood viscosity.

If the haematocrit (HCT) is rising during treatment … reduce the replacement rate (plasma exchange rate) or increase the blood flow rate.

- Monitor the condition of the filter during use. Review working pressures of the Aquarius hourly and note trends in the pressures, adjust programme settings accordingly.Monitor post-treatment HCT value and ultrafiltration fraction as exchange progresses.
- Monitor ABG's, U+E's and **calcium and magnesium** level. (Larger shifts of solutes in TPE therapy can cause cardiac instability)
- Ensure blood lines and vascath are secure.

MONITORING AND DOCUMENTATION

The type of therapy and start and finish times should be documented on the CIS - **CRRT/TPE tab**. Reason for stopping/interrupting therapy should be noted as a comment and documented in the nursing notes. The following functions are monitored continuously and should be checked prior to validating hourly on the CIS.

Ultrafiltration Rate
This is a measurement of how concentrated the blood is at the bottom of the filter, ie: how haemoconcentrated. The higher the ultrafiltration rate the more viscous the blood becomes and the less time the filter will last before it clots. The maximum ultrafiltration rate recommended by Prisma is 20 – 25% of the blood rate.
Is ultrafiltration rate rising to over 20% …

- decrease the replacement rate (rate of plasma exchange) or increase the blood flow rate.

Access pressure
Monitors the pressure in the blood outflow part of the circuit, i.e. from the access catheter to the artificial kidney (Ideal Pressures 0 to -100mmHg)

Return pressure
Monitors the pressure in the part of the circuit where blood flow is returning to the patient i.e. from the exit end of the artificial kidney to the access catheter (Ideal Pressures - 10 to 150mmHg)

Transmembrane pressure (TMP)
Monitors the pressure gradient across the semi-permeable membrane (TMP) of the artificial kidney, that is, between the blood and the effluent (Ideal pressure ≤50mmHg). Increasing transmembrane pressure is a late sign of filter clotting. If TMP pressures rising consider increasing anticoagulant, reducing blood pump speed to 100-120mls/min and/or reduce exchange rate.

Blood Pump speed
Determines the rate of blood flow from the patient. Must be maintained at 100mls/min for 1 litre exchanges & 150mls/min for 1.5 litre exchanges

Filter Pressure Drop
This is the difference in pressures at the top and base end of the filter. Increasing pressures provide an early sign of filter clotting and requires troubleshooting.

Complication	Action
Hypotension	(1) check substitution fluid line connections for leaks (2) check all blood line connections((3) seek medical advice and consider IV fluids / increase rate of vasopressor
Arrhythmias	(1) cardiac monitoring, observe QT interval on ECG for changes (2) check U+E's and ABG's (3) check serum calcium and magnesium and consider supplementation (4) seek medical advice
Non-Cardiogenic Pulmonary Oedema	(1) increase inspired oxygen level/ventilation (2) check ABG's (3) seek medical advice
Bleeding	(1) consider infusing FFP towards end of treatment (2) check anticoagulation rate with prescription (3) send clotting sample (4) check blood line connections and vascath site (5) consider administering additional clotting factors on completion of exchange
Haemolysis	(1) reduce blood flow rate and/or exchange rate to reduce TMP pressures
Hypocalcaemia (check Ca+ level pre and post exchange)	(1) monitor for signs of cardiac arrhythmias, or patient complaint of numbness, tingling of lips or extremities and carpo-pedal spasm (2) check corrected serum calcium level and pH (3) seek medical advice and consider replacement with calcium gluconate
Anaphylaxis	1) stop procedure if severe reaction 2) seek medical advice and begin resuscitative measures as necessary
Infection	(1) consider all sources of infection, take blood cultures (2) seek medical advice and consider removing vascath (3) monitor patient's vital signs
Reduced Levels of Protein Bound Drugs + Effectiveness of Drug Infusions	1) titrate sedative drugs according to sedation scores 2) seek medical advice and consider increasing infusion rates of inotrope infusions until TPE exchange completed 3) seek advice from pharmacist and consider administering other medications after each TPE session is completed
Air Embolism	(1) clamp all lines and stop blood pump (2) lie patient on left side, raise foot of bed and give 100% O2 (3) medical advice urgently
Clotting of Filter	(1) check clotting time and consider increasing anticoagulation (2) increase blood flow rate (3) consider changing vascath if poor blood flow

Complication	Action
Hypothermia	(1) monitor patient's temperature (2) increase temperature on Aquarius (3) consider using bair hugger
Electrolyte Imbalance (larger pore size in plasma exchange filter can mean significant electrolyte losses)	(1) check blood gases during TPE exchange and replace as indicated (2) check biochemistry following completion of treatment

The use of this guideline is subject to professional judgement and accountability. This guideline has been prepared carefully and in good faith for use within the Department of Critical Care at Brighton and Sussex University Hospitals. The decision to implement this guideline is at the discretion of the on-call critical care consultant in conjunction with appropriate critical care medical/ nursing staff.