DIVISION OF MEDICINE
DEPARTMENT OF NEPHROLOGY

# Education Program and Self-Directed Learning Package

# Therapeutic Plasma Exchange

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HUNTER NEW ENGLAND
NSW HEALTH

HUNTER NEW ENGLAND AREA HEALTH SERVICE

John Hunter Hospital – Division of Medicine

Department of Nephrology

## Education Program and
## Self Directed Learning Package

# Therapeutic Plasma Exchange

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The following package has been written using the references cited in the reference list. Much of the information presented in this module outline is considered generic information and is widely reflected in the nephrology literature, as such it is not feasible to reference all sources of information. Only citations that are directly attributed to a single source/s are referenced in the text presented herein

## OVERVIEW OF THE EDUCATION PROGRAM

This self directed education program for therapeutic plasma exchange contains not only the self directed learning package but also contains additional clinical components to develop clinical skills and knowledge in the delivery of therapeutic plasma exchange which is one form of apheresis treatment.

The education program is aimed primarily at the Registered Nurse with demonstrated competence and experience in the delivery of haemodialysis nursing care who wishes to expand their scope of practice to include therapeutic plasma exchange within the haemodialysis unit at the John Hunter Centre Dialysis Unit.

It is highly desirable that the registered nursing staff completing this package also have undertaken the cannulation program conducted at the John Hunter Hospital. This program involves a one hour theoretical session and a related clinical experience in peripheral cannulation.

This education program is divided into three sections:

SECTION 1 – Therapeutic Plasma Exchange Education Program Outline

SECTION 2 – Therapeutic Plasma Exchange Self Directed Learning Package

SECTION 3 – Therapeutic Plasma Exchange Clinical Competency Assessment

Section one involves assisting the participant in the acquisition of both clinical and theoretical knowledge using a clinical mentor. Staff participating are required to have supernumerary time in which they can undertake directed learning from a colleague who has demonstrated clinical competency in the delivery of therapeutic plasma exchange care.

Section two utilises the standard format for self-directed learning packages within the department of nephrology. Nursing staff other than those who are competent haemodialysis nurses within the centre dialysis unit at John Hunter Hospital may also wish to also expand their knowledge on therapeutic plasma exchange. These staff members can undertake section 2 and are not required to undertake the clinical components in sections one and three.

Section three is the clinical competency proforma which has been adapted from The Guidelines for Education, Training and Competency Working Party of the Australian and New Zealand Apheresis Association.

There are a number of appendices located at the end of this document including

APPENDIX A – Haemonetics MCS+ Quiz

APPENDIX B - Glossary

If assistance is required during your completion of this program please either discuss directly with the Nephrology Clinical Nurse Educator or your line manager.

# SECTION 1

## THERAEUTIC PLASMA EXCHANGE EDUCATION PROGRAM OUTLINE

The education program consists of both theoretical and clinical components. The aim is to provide registered nursing staff with demonstrated haemodialysis competency the skills and knowledge to provide safe and competent nursing care to an individual undergoing Therapeutic Plasma Exchange (TPE) treatment within the auspices of the Centre Dialysis Unit at the John Hunter Hospital, Hunter New England Area Health Service. Apheresis treatment in this unit is currently limited to Therapeutic Plasma Exchange.

At the completion of this program the staff member should be able to:

1) Apply theoretical concepts of therapeutic plasma exchange to clinical practice
2) Analyse the individual's clinical assessment data and implement appropriate therapeutic plasma exchange nursing care and interventions.
3) Demonstrate specific clinical skills related to the care of the individual receiving therapeutic plasma exchange.

## CLINICAL EDUCATION

The therapeutic plasma exchange clinical education program is designed to guide staff through the acquisition of both the clinical skills and knowledge required by the individual registered nurse and includes the following domains:

**Clinical skills to be observed during clinical experience**

1. Appropriately plans a Therapeutic Plasma Exchange treatment regime considering:
    - Implications of disease
    - Anticoagulation requirements
    - Type of access
    - Replacement of solution required
    - Prescription treatment
    - Legal requirements

2. Correctly sets up the machine including:
    - Maintains aseptic technique
    - Ability to source all necessary equipment/supplies
    - Ensures appropriate bowl set/ lines for treatment

3. Correctly commences a treatment session for Therapeutic Plasma Exchange including:
    - Connection to patient
    - Running on to the machine
    - Sets appropriate machine parameters
    - Observes for complications

4. Accurately monitors patient during treatment including:
    - Fluid replacement

- Intra-treatment observations
- Signs' and symptoms of hypocalcaemia

5. Correctly discontinues the treatment session for Therapeutic Plasma Exchange including:
    - Returns blood
    - Monitors haemodynamic stability
    - Disconnects patient appropriately
    - Attends to post observations
    - Cleans machine

6. Documents treatment appropriately

**Clinical Issues to be discussed during clinical experiences**

1. Discuss the reasons for commencement of therapeutic plasma exchange therapy.
2. Explain the principles of therapeutic plasma exchange
3. Outline the pre and post assessment for therapeutic plasma exchange
4. Outline the causes, signs and symptoms, prevention and treatment for the major complications of therapeutic plasma exchange.
5. Describe the methods of achieving anticoagulation during therapeutic plasma exchange.
6. List the functions and operation of the therapeutic plasma exchange machines used in the Centre Dialysis Unit at The John Hunter Hospital.
7. Discuss the therapeutic plasma exchange commencement procedures related to various access types.
8. Recognise the signs and symptoms related to access complications.

All clinical experience must be supervised by experienced staff who have demonstrated their competence in Therapeutic Plasma Exchange within the John Hunter Hospital Centre Dialysis Unit. The clinical component requires that there are eight fully supervised practice Therapeutic Plasma Exchange sessions. Five of these sessions must be on the Haemonetics MCS+ and three sessions on the Fresenius 4008S. Four independent sessions, two on each machine must also be completed. Independent sessions requires no direct supervision, however there must be back-up clinical support from another registered nurse who has demonstrated clinical competence with therapeutic plasma exchange within the facility.

The following page provides tables for recording of clinical experience.

Staff Members Name: _____

| **Haemonetics - Direct Supervised TPE** (Supernumerary experience) | | | |
|---|---|---|---|
| **Number** | **Date** | **Assessed by** | **Signature** |
| 1 Haemonetics | | | |
| 2 Haemonetics | | | |
| 3 Haemonetics | | | |
| 4 Haemonetics | | | |
| 5 Haemonetics | | | |

| **Fresenius - Direct Supervised TPE** (Supernumerary experience) | | | |
|---|---|---|---|
| 1 Fresenius | | | |
| 2 Fresenius | | | |
| 3 Fresenius | | | |

| **Haemonetics - Independent TPE** (With support person available) | | | |
|---|---|---|---|
| **Number** | **Date** | **Support Person** | **Signature** |
| 1 Haemonetics | | | |
| 2 Haemonetics | | | |

| **Fresenius - Independent TPE** (With support person available) | | | |
|---|---|---|---|
| **Number** | **Date** | **Support Person** | **Signature** |
| 1 Fresenius | | | |
| 2 Fresenius | | | |

Date Competency Completed: _____

## THEORETICAL EDUCATION

The theoretical component primarily consists of the content of this self directed learning package (Section 2) and is to be supplemented with structured discussions with a clinical mentor to explore specific areas learning (detailed in the following table). A minimum of five structured sessions with a mentor at intervals of not more than one week apart.

Mentees should avail themselves of the opportunity to ask questions and to explore ideas with their mentors to facilitate a greater understanding of the therapeutic plasma exchange process and associated delivery of nursing care. Emphasis needs to be placed on managing the acute patient.

MENTORS NAME:_____

MENTORS SIGNATURE AND INITIALS: _____

***Structured Mentor Discussions***

| SESSION | SUGGESTED TOPICS OF DISCUSSION | Mentor and Mentee to Initial once session completed |
|---|---|---|
| 1 | • Diseases treated with therapeutic plasma exchange.<br>• Benefits in relation to specific disease process.<br>• Variations in therapy for different disease. | |
| 2 | • Apheresis Definition, and exploration of the concept of therapeutic plasma exchange<br>• History, uses, benefits of therapeutic plasma exchange<br>• The process of therapeutic plasma exchange<br>• Different treatment methods: centrifugal and plasma filter systems<br>• Physiological effects of therapeutic plasma exchange | |
| 3 | • The machine mechanics including: machine set-up; the treatment; documentation; procedure options; discontinuing treatment; cleaning; patient observations | |
| 4 | • Prescription therapeutic plasma exchange including; patient assessment; replacement fluid; treatment time; anticoagulation; access; treatment frequency; special considerations | |
| 5 | • Potential complications of therapeutic plasma exchange and their management<br>• Common machine problems.<br>• Problem solving strategies | |

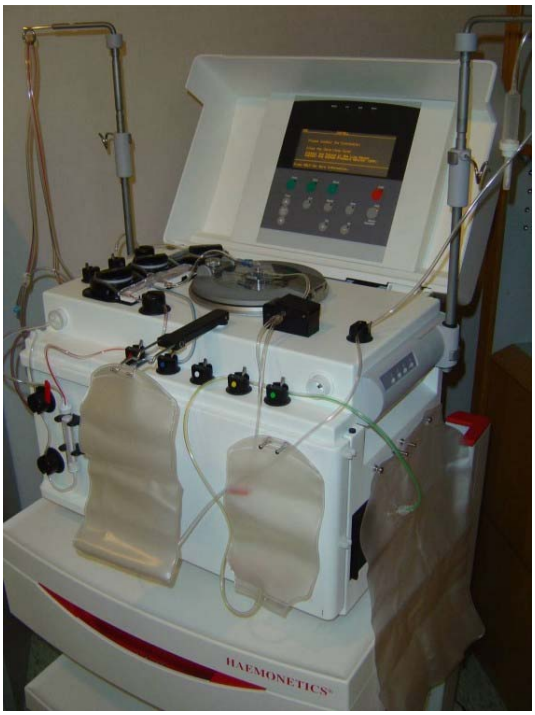
It is envisioned that additional theoretical sessions in the form of in-services will be offered during the year. Where possible therapeutic plasma exchange staff should endeavour to attend or lead these sessions.

## MACHINE BASICS

The Centre Dialysis Unit at the John Hunter Hospital currently has two machines available for the delivery of therapeutic plasma exchange. These machines are the Haemonetics MCS+ and the Fresenius 4008S. These machines work using different principles. The Haemonetics uses centrifuge and the Fresenius requires the use of a plasma filter. These differences will be explained in greater detail in Section Two. The following pages contain pictures of the two different machines

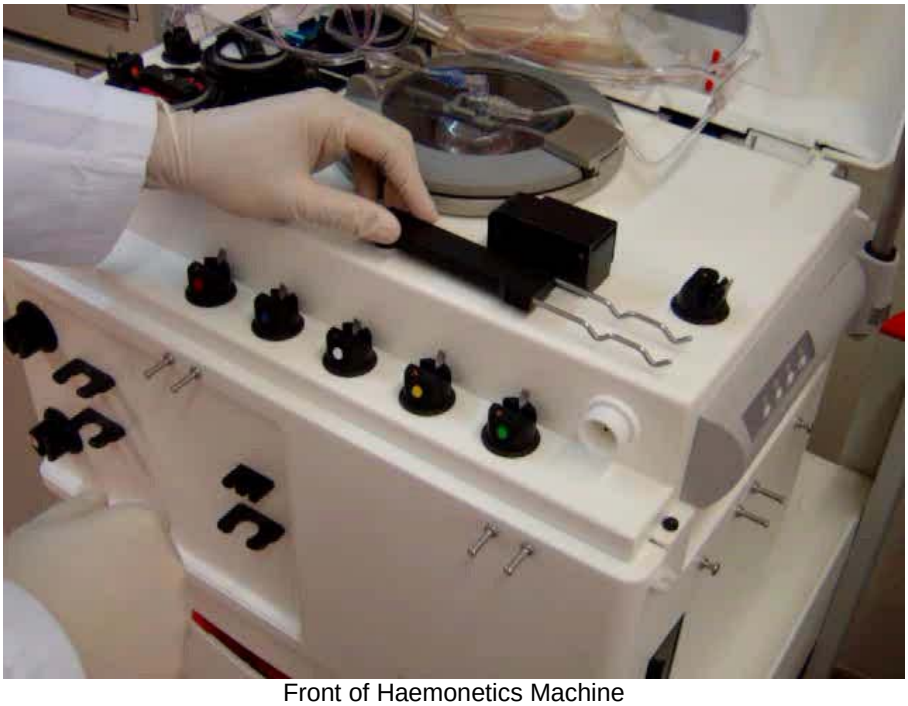
## HAEMONETICS MCS+

The quiz in Appendix A will help familiarise you with the various components and functions of the machine including its set-up. Please complete the quiz and ask your mentor to review your responses. You will need to have access to a Haemonetics MCS+ Machine Manual.

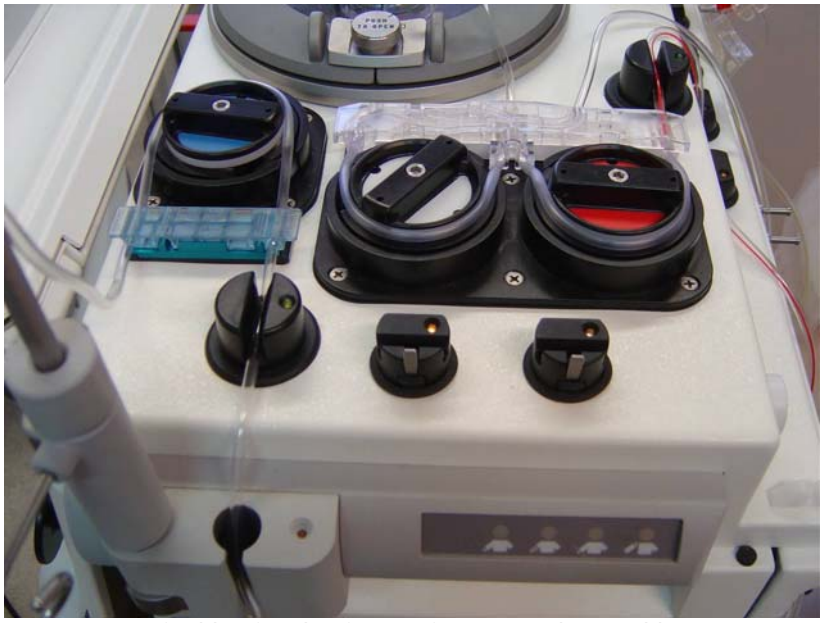



Haemonetics Machine set up ready for use

Top of Haemonetics Machine with Centrifuge Bowl

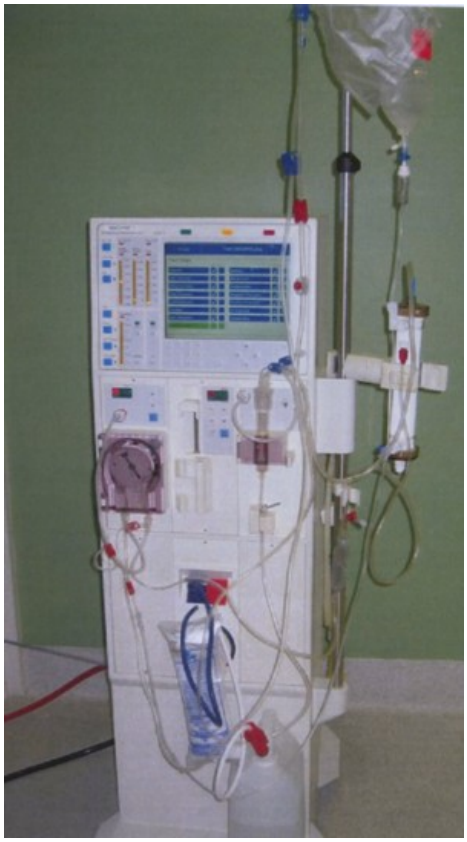


Front of Haemonetics Machine

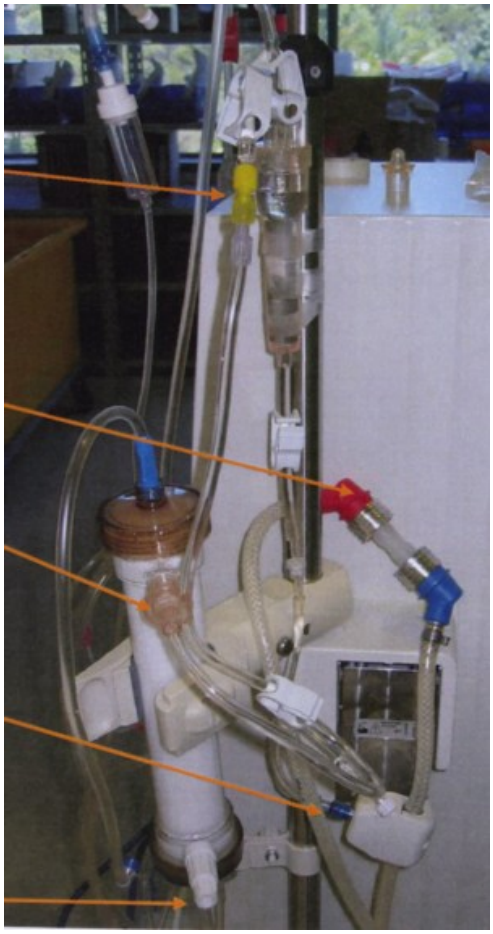


Left Side of and Left Top of Haemonetics Machine

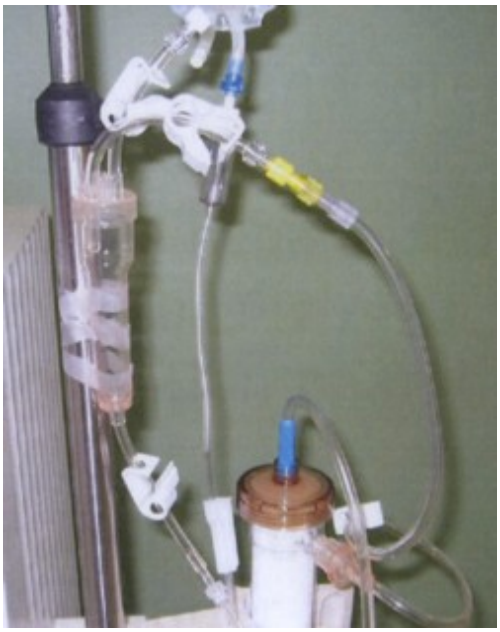
## FRESENIUS 4008S



Fresenius machine set up ready for haemodialysis use

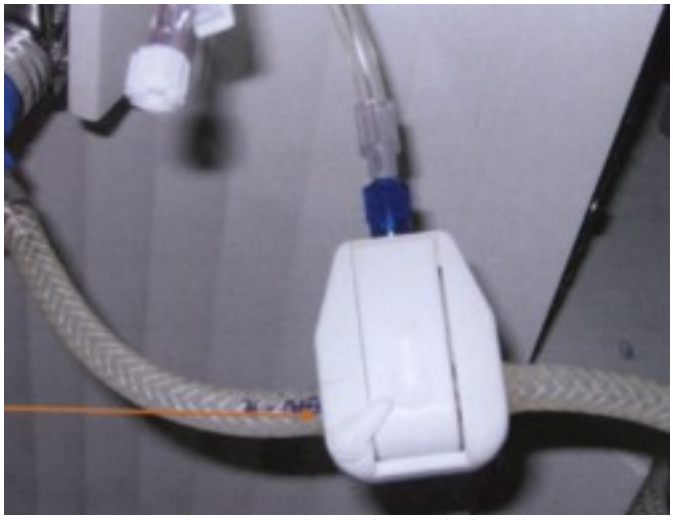


Fresenius Machine Final set up



Anti-contamination chamber on Fresenius Machine

Schlauchset



Sample port on the dialysate inflow line
NOTE :in open position

# SECTION 2

# THERAPEUTIC PLASMA EXCHANGE SELF-DIRECTED LEARNING PROGRAM

## INTRODUCTION

The Department of Nephrology is committed to providing resources for nursing staff to expand their nephrology knowledge and skills. This self directed learning package, education program and competency assessment is one of a suite of packages aimed at offering guided learning for nephrology nurses to further enhance their clinical skills and knowledge.

The self directed learning package section provides theoretical knowledge while the education program guides staff in their clinical acquisition of skills and knowledge while the competency program is designed to assess staff competence in the delivery of therapeutic plasma exchange care using both the Haemonetics MCS+ and the Fresenius 4008S Machines.

It is expected that it will take you up to 10 hours to complete this self directed learning package in addition to the clinical experience.

### USING THE SELF DIRECTED LEARNING PACKAGE

Throughout this self directed learning package there are readings and activities that you need to complete. Readings are divided into two categories, those included in the appendices, and those that are identified as online readings. The online readings are not provided due to copyright law restrictions. You will be provided with the source of the article, articles will be available to you from a variety of sources.

- For example to access an article from CIAP you would need to go to the intranet, select the CIAP option from the quick links menu on the home page. Scroll down to databases, select journals@OVID. Log into CIAP using the hospital username and password that is circulated by the library staff.

If you have any difficulty locating the readings please seek assistance from either the Clinical Nurse Educator or the Clinical Nurse Consultant for Nephrology.

This SDLP uses the following icons


### READING

**This icon alerts you to undertake reading related to the topic this may include Safe Work Practices, Journal Articles or Books**


### LEARNING ACTIVITY

**This icon denotes a learning activity or competency assessment that you will need to complete**

## CARI GUIDLINES

**This icon alerts you to the presence of a CARI guideline, related to the subject available at www.cari.org.au**

### MARKING THE SELF DIRECTED LEARNING PACKAGE

Once you have completed this package you need to submit the completed learning activities to the Clinical Nurse Educator. The Clinical Nurse Educator will then forward the package to the allocated marker.

Please note it may take up to four weeks to have the package marked and returned to you. Staff will be issued with a certificate of completion and can also have this notarised in their record of professional development booklet.

### OBJECTIVES

Following the completion of this self directed learning package, the participant will be able to:

i. demonstrate safe practice in the area of therapeutic plasma exchange to ensure patient safety and quality care;
ii. demonstrate a competent level of practice with the technical aspects of therapeutic plasma exchange;
iii. apply a problem solving approach to therapeutic plasma exchange within a given situation;
iv. practice within the legal and ethical standards of nursing based on professional codes of practice and nephrology department safe work practices;
v. perform nursing actions competently, based on sound scientific, technological, biological and behavioural principles;

NOTE: This Section may be completed by any staff wishing to expand their knowledge on a-therapeutic plasma exchange.

## OVERVIEW

The terms therapeutic apheresis, plasmapheresis, and plasma exchange are often used interchangeably, but when properly used denote different procedures. Apheresis is a general term describing removal of blood from a patient; a portion of the blood is separated, manipulated and/or retained while the rest is returned to the patient. This package will focus solely on therapeutic plasma exchange (TPE) as this is the modality of treatment offered in the Centre Dialysis Unit at John Hunter Hospital.

Therapeutic plasma exchange can be performed using a centrifugal or filtration system. The filtration system is a continuous process where blood components are simultaneously removed and re-infused and works on the same concepts as haemodialysis where the membrane is porous to the blood components for removal. Centrifugal systems can be either continuous or discontinuous and work on the principle of separating the blood components based on density. Continual centrifugal systems are able to remove and reinfuse blood components simultaneously while discontinuous centrifugal systems remove the blood components where they are separated then the blood components to be retained are returned to the patient.

Regardless of the mechanism the goal of therapeutic plasma exchange is the removal of harmful plasma components. Theoretically, decreasing the concentration of the harmful plasma component, will improve the course of the disease. Abnormal components potentially removed with therapeutic plasma exchange include toxins, metabolic substances, and plasma components, such as complement or antibodies. Therefore, diseases thought to be caused by these abnormal constituents might best be treated with this form of therapy. Diseases benefiting from these procedures are largely autoimmune or neurological disorders. Therapeutic plasma exchange is not intended to be a curative treatment for most indications. Rather, it is used to address disease related symptoms. Depending on the indication, adjunct treatments, such as pharmacological therapy, may be incorporated into the treatment regime.

Therapeutic plasma exchange procedures can be performed as an inpatient or in outpatient setting. Reinfusion with human plasma may cause anaphylaxis and bleeding complications, and although rare, may require replacement clotting factors. Therefore, therapeutic plasma exchange procedures should be performed by specialty-trained clinicians in a setting that can respond to medical emergencies at all times.

In order to develop an understanding of the therapeutic plasma exchange process the nurse needs to be familiar with a number of concepts that will be explored throughout this self directed learning package.

- Blood and blood components
- Blood Groups
- Coagulation Pathway
- Therapeutic Plasma Exchange and disease processes
- Anticoagulation during therapeutic plasma exchange
- Complications of therapeutic plasma exchange
- Patient assessment
- Replacement fluids

It is essential that nurses are able to gain an understanding of the different apheresis treatment methods even though they may be offered as a form of treatment in the unit in which they are employed.

Plasmapheresis (PP), is where plasma is separated and manipulated in a variety of ways, and is probably the most common type of apheresis procedure. However, leukapheresis or lymphocytapheresis also describes apheresis procedures in which the white blood cells are isolated and retained. As another example, peripheral stem cell collection, done in preparation for autologous bone marrow transplant, involves an apheresis procedure in which the critical stem cells are isolated and retained.

Extracorporeal immunoadsorption using Protein A columns involves a procedure which specifically removes circulating immune complexes. Low density lipoprotein (LDL) apheresis is another selective procedure in which LDL particles are removed from the plasma while preserving the rest of the plasma and re-infusing it into the patient. The following policy refers only to plasma exchange.

Plasma exchange (PE) also known as therapeutic plasma exchange (TPE) is where the plasma is isolated, then discarded and replaced with a substitution fluid such as albumin, fresh frozen plasma (FFP), or in rare occasions cryoprecipitate and is frequently done in conjunction with plasmapheresis. Plasma exchange is a nonspecific therapy, since the entire plasma is discarded.

The rationale for therapeutic plasma exchange is based on the fact that circulating substances, such as toxins or autoantibodies, can accumulate in the plasma. Also, it is hypothesised that removal of these factors can be therapeutic in certain situations. Plasma exchange is essentially a symptomatic therapy, since it does not remove the source of the pathogenic factors. Therefore the success of plasma exchange will depend on whether the pathogenic substances are accessible through the circulation, and whether their rate of production and transfer to the plasma component can be adequately addressed by plasma exchange. For example, plasma exchange can rapidly reduce levels of serum autoantibodies; however, through a feedback mechanism this rapid reduction may lead to a rebound overproduction of the same antibodies. This rebound production of antibodies is thought to render the replicating pathogenic clone of lymphocytes more vulnerable to cytotoxic drugs; therefore, plasma exchange is sometimes used in conjunction with cyclophosphamide.

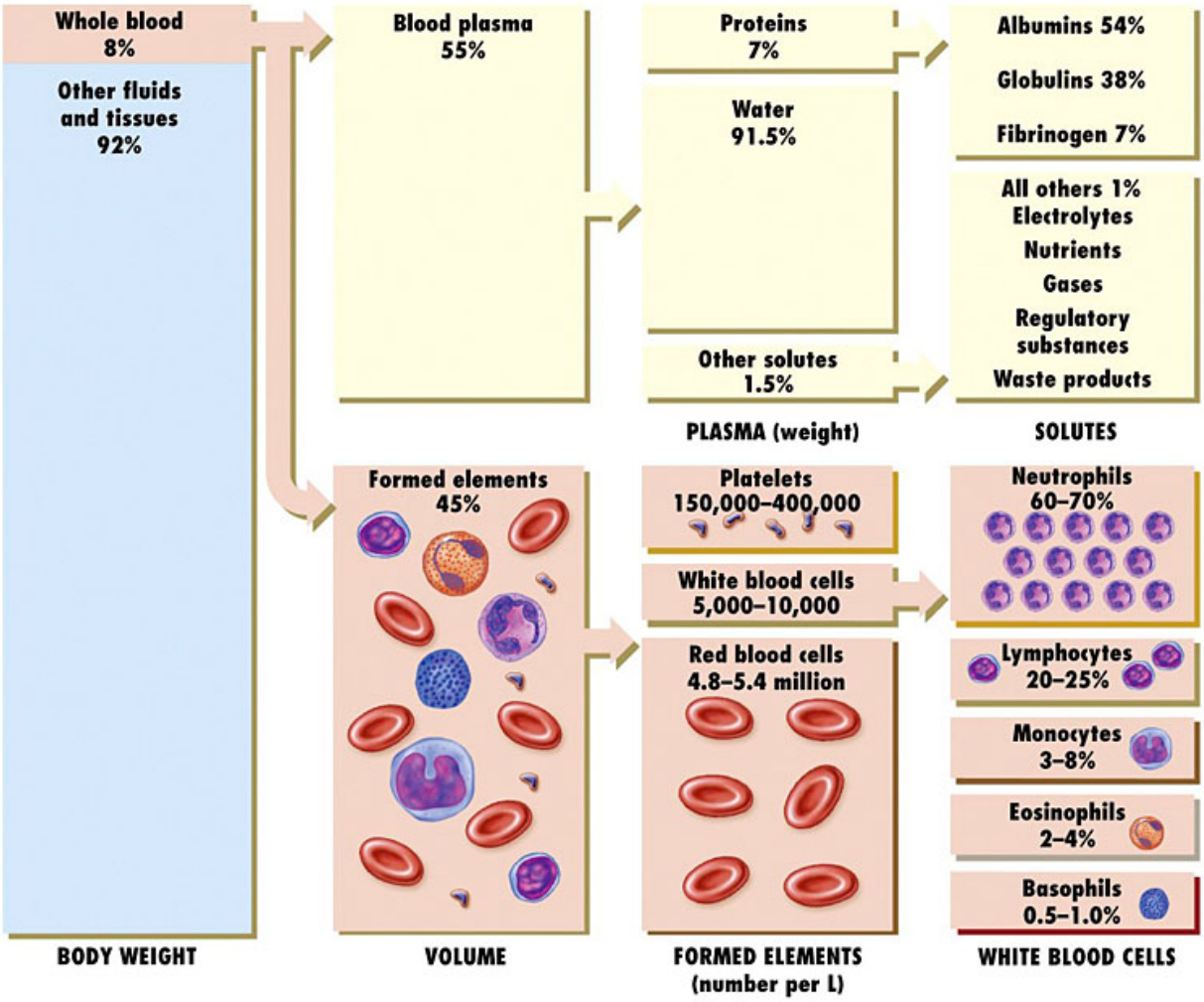
At the Centre Dialysis Unit in the John Hunter Hospital therapeutic plasma exchange (TPE) is the only form of apheresis offered. Other forms of apheresis are offered at the Calvary Mater Hospital, and the blood bank uses apheresis techniques when collecting donations of specific blood components. As such the focus of this self directed learning package will be on therapeutic plasma exchange.

Upon completion of this package and for those wishing to explore the concept of apheresis in general in more detail please consider undertaking further professional development such as enrolling in a post graduate program/course. For further information or guidance you can discuss this with your line manager, clinical nurse educator or clinical nurse consultant.

## BLOOD AND BLOOD COMPONENTS

The average adult has a blood volume of approximately 5.5L that circulates through the cardiovascular system. Human Blood consists of 45 – 50% of a variety of formed elements (cells and proteins) suspended in plasma which is 90% water and the remaining 10% is dissolved substances known as solutes . Solutes consist of organic and in-organic elements. The constant movement of the blood through the cardiovascular system ensures the formed elements and solutes are fairly evenly dispersed.

The following diagram provides a pictorial representation of the various components of the blood.




**Components of blood**



### READING

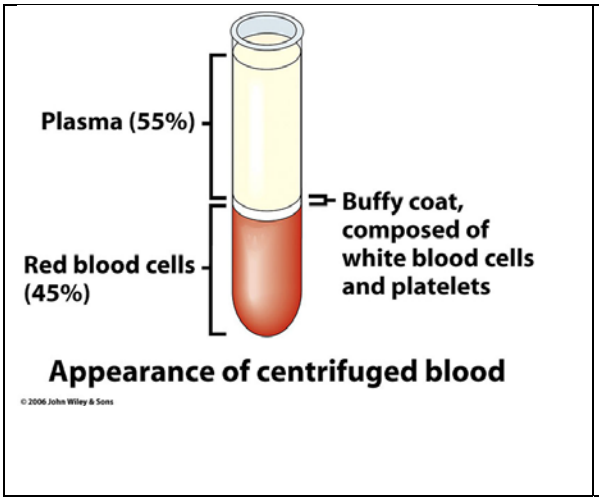
It is recommended that you locate a current nursing pathophysiology book and read the chapter on the structure and function of the hematologic system.

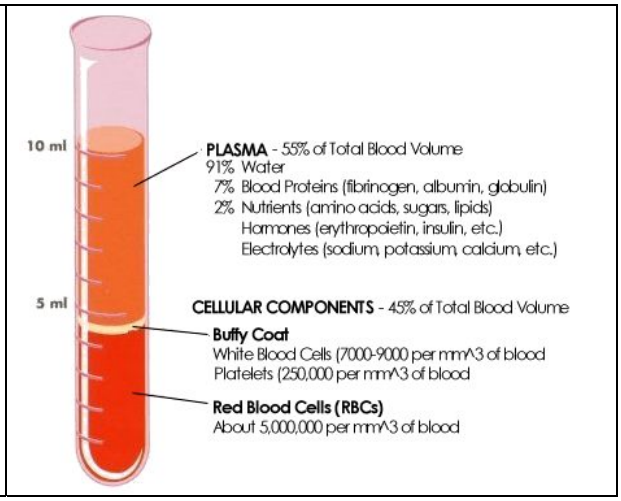
While the entire chapter on the structure and function of the hematologic system is essential for the nurse delivering therapeutic plasma exchange only a few items will be highlighted in the following discussion.

**NORMAL HAEMATOLOGICAL BLOOD VALUES**

| Formed Element | Male | Female |
|---|---|---|
| Haemoglobin | 130 - 180g/L | 120 - 160g/L |
| HCT | 0.40-0.54% | 0.36-0.47% |
| RBC | 4.5 - 6.5 x 10^9/L | 4.2 - 5.4 x 10^12/L |
| Platelet Count | 150 - 400 x 10^9/L | 150-400 x10^9/L |
| WCC | 4.0 - 11.0 X 10^9/L | 4.0- 11.0 x 10^9/L |

When fluid is spun very rapidly in a centrifuge, the heavier components will quickly settle to the bottom of the tube with the lighter fluids settling on top. When this is applied to the blood the erythrocytes (red blood cells) are forced to the bottom of the tube because they are the heaviest element in the blood. The white blood cells and the platelets are lighter and come to rest on top of the heavier red blood cells in a layer called the buffy coat. Above the buffy coat rests the plasma which is the lightest of all components in the blood. The following two diagrams are different representations of the appearance of blood once it has been centrifuged.




**DENSITY AND SIZE OF BLOOD COMPONENTS**

Understanding the specific gravity and the size of the various blood components will assist in understanding how blood can be separated by both centrifugal and filter methods. Heavy substances will sink during centrifuge and those substances that are too large for the membrane pore will be retained in filtration methods. The average size of a plasma filter is 6 microns.

| COMPONENT | SPECIFIC GRAVITY (g/ml) | DIAMETER (Microns) |
|---|---|---|
| Plasma | 1.025 - 1.029 | |
| Platelets | 1.040 | 3 microns |
| White Blood Cells | | |
| B-Lymphocytes | 1.050 – 1.060 | 10 microns |
| T-Lymphocytes | 1.050 – 1.061 | 10 microns |
| Blasts/Promyelocytes | 1.058 – 1.066 | |
| Monocytes | 1.065 – 1.066 | |
| Myelocytes/Basophils | 1.070 | |
| Reticulocytes | 1.078 | |
| Metamyelocytes | 1.080 | |
| Bands & Segmented Neutrophils | 1.087 – 1.092 | |
| Erythocytes | 1.078 – 1.114 | 7 microns |
| Granulocytes | | 13 microns |

Adapted from Zielinski 2002, pages 35-36.

Common laboratory examining haematocrit can tell a great deal about the volume of red cells in a blood sample. The volume of red blood cells refers to the amount of space that the red blood cells occupy within the blood, and is expressed as a percentage of the total volume. This percentage then can be used in conjunction with height and weight values to calculate the volume of the plasma and subsequently determine the volume of plasma to be exchanged during the therapeutic plasma exchange treatment process.

While the estimated plasma volume can be calculated using mathematical calculations, the following table assists in the calculation of estimated plasma volume using the patients weight and haematocrit levels. This then can be used to inform the volume of the plasma exchange required for the treatment session.

**Table 2-1. Estimated Plasma Volume by Weight and Hematocrit: EPV = [0.065 × wt (kg)] × [1 − Hct]**

| | | Hct% | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wt (kg) | BV (L) | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| 30 | 1.95 | 1.66 | 1.56 | 1.46 | 1.37 | 1.27 | 1.17 | 1.07 | 0.98 | 0.88 |
| 35 | 2.28 | 1.94 | 1.82 | 1.71 | 1.6 | 1.48 | 1.37 | 1.25 | 1.14 | 1.03 |
| 40 | 2.6 | 2.21 | 2.08 | 1.95 | 1.82 | 1.69 | 1.56 | 1.43 | 1.3 | 1.17 |
| 45 | 2.9 | 2.47 | 2.32 | 2.18 | 2.03 | 1.89 | 1.74 | 1.6 | 1.45 | 1.31 |
| 50 | 3.25 | 2.76 | 2.6 | 2.44 | 2.28 | 2.11 | 1.95 | 1.79 | 1.63 | 1.46 |
| 55 | 3.58 | 3.04 | 2.86 | 2.69 | 2.51 | 2.33 | 2.15 | 1.97 | 1.79 | 1.61 |
| 60 | 3.9 | 3.32 | 3.12 | 2.93 | 2.73 | 2.54 | 2.34 | 2.15 | 1.95 | 1.76 |
| 65 | 4.23 | 3.6 | 3.38 | 3.17 | 2.96 | 2.75 | 2.54 | 2.33 | 2.12 | 1.90 |
| 70 | 4.55 | 3.87 | 3.64 | 3.41 | 3.19 | 2.96 | 2.73 | 2.50 | 2.28 | 2.05 |
| 75 | 4.88 | 4.15 | 3.9 | 3.66 | 3.42 | 3.17 | 2.93 | 2.68 | 2.44 | 2.20 |
| 80 | 5.2 | 4.42 | 4.16 | 3.9 | 3.64 | 3.38 | 3.12 | 2.86 | 2.6 | 2.34 |
| 85 | 5.53 | 4.7 | 4.42 | 4.15 | 3.87 | 3.59 | 3.32 | 3.04 | 2.77 | 2.49 |
| 90 | 5.85 | 4.97 | 4.68 | 4.39 | 4.10 | 3.8 | 3.51 | 3.22 | 2.93 | 2.63 |
| 95 | 6.18 | 5.25 | 4.94 | 4.64 | 4.33 | 4.02 | 3.71 | 3.40 | 3.09 | 2.78 |
| 100 | 6.5 | 5.53 | 5.2 | 4.88 | 4.55 | 4.23 | 3.9 | 3.58 | 3.25 | 2.93 |
| 105 | 6.83 | 5.81 | 5.46 | 5.12 | 4.78 | 4.44 | 4.10 | 3.76 | 3.42 | 3.07 |
| 110 | 7.15 | 6.08 | 5.72 | 5.36 | 5.01 | 4.65 | 4.29 | 3.93 | 3.58 | 3.22 |
| 115 | 7.48 | 6.36 | 5.98 | 5.61 | 5.24 | 4.86 | 4.49 | 4.11 | 3.74 | 3.37 |
| 120 | 7.8 | 6.63 | 6.24 | 5.85 | 5.46 | 5.07 | 4.68 | 4.29 | 3.9 | 3.51 |
| 125 | 8.13 | 6.91 | 6.5 | 6.10 | 5.69 | 5.28 | 4.88 | 4.47 | 4.07 | 3.66 |
| 130 | 8.45 | 7.18 | 6.76 | 6.34 | 5.92 | 5.49 | 5.07 | 4.65 | 4.23 | 3.80 |
| 135 | 8.78 | 7.46 | 7.02 | 6.59 | 6.15 | 5.71 | 5.27 | 4.83 | 4.39 | 3.95 |
| 140 | 9.1 | 7.74 | 7.28 | 6.83 | 6.37 | 5.92 | 5.46 | 5.01 | 4.55 | 4.10 |

These values will not be valid for patients with severe hyperviscosity, such as in those with Waldenström's macroglobulinemia, in which plasma volumes will be greater than predicted (Bloch KJ, Maki DG. Hyperviscosity syndromes associated with immunoglobulin abnormalities. Semin Hematol 1973;20:113–124).

EPV values in liters. Wt, dry weight in kilograms; BV, blood volume in liters; Hct, hematocrit.

Adapted from: Kaplan , A.A. (1999). *A practical guide to therapeutic plasma exchange.* Massachusetts, USA: Blackwell Science Inc.

## BLOOD GROUPING

The surface of erythrocytes (red blood cells) contain genetically determined antigens called aggglutinogens or isoantigens. There are many blood group systems that can be detected on the surface, however the two major blood group classifications are ABO and Rh-.

ABO blood group is based on two agglutinogens symbolised by A and B. There are individuals who have only A or only B, those with both A and B and those who have neither A or B and are considered type O. Hence giving us the four commonly known blood groups: A; B; AB; and O.

The blood plasma of many people contains genetically determined antibodies call agglutinins or isoantibodies that attacks the agglutinogen. Your agglutinins do not attack your own erythrocytes but do attack donated erythrocytes with incompatible agglutinogens. This incompatibility manifests by the clumping of blood cells (agglutinated) which then lodge in the capillaries causing haemolysis.

| Blood Type | Agglutinogen (Antigen) | Agglutinin (Antibody) | Compatible Donor Blood Types | Incompatible Donor Blood Types |
|---|---|---|---|---|
| A | Anti-A | Anti-B | A, O | B, AB |
| B | Anti-B | Anti-A | B, O | A, AB |
| AB | Anti-AB | Neither Anti-A or Anti-B | A, B, AB, O | Nil |
| O | Neither Anti-A or Anti-B | Anti-A and Anti-B | O | A, B, AB |

One will note from the above table that blood group O is the universal donor and blood group AB is the universal recipient as they have no agglutinins (antibodies). As such those with Blood Group AB are ideal donors for plasma

The Rh System of the blood is also known as Rhesus, so named because of the work on the rhesis monkey. The Rh system is also based on whether Rh agglutinogens are present on the surface of erythrocytes. Individuals with the Rh agglutinogen are deemed Rh+ (positive) and those without the Rh agglutinogen are deemed Rh- (negative). It is thought that about 85% of the population are Rh+. It is important to note that plasma does not contain ant-Rh agglutinins. Rh incompatibility is particularly important in relation to pregnancy. The Rh Agglutinogen is also referred to as a D antigen.

If a patient who is Rh- receives Rh+ blood they may form an antibody to the Rh+ agglutinogen causing sensitisation. If this occurs the patient cannot receive further Rh+ blood as they will have a reaction resulting in haemolysis. To avoid this sensitisation and possible transfusion reaction Rh- patients are given Rh- blood transfusions.

It is imperative that cross matching of blood between the donor and recipient occurs to minimise the risk of a transfusion reactions as a result of incompatibility between blood group classifications.

## LEARNING ACTIVITY

For those unfamiliar with this concept of blood group and matching, or those who feel they need to refresh their knowledge it is recommended that you further explore this area by reading and self directed study. It may also be worthwhile to discuss with your clinical nurse educator.

## CLOTTING PATHWAY

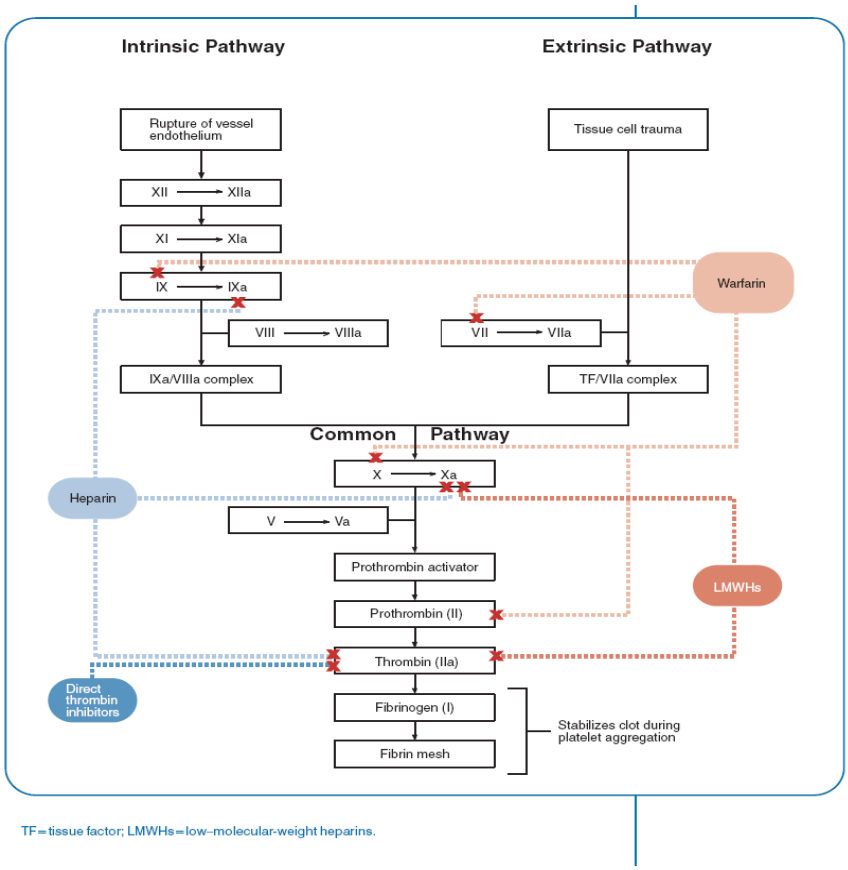
Blood is approximately four and a half times thicker than water and maintains its liquid state if it remains in the intravascular system. If blood is removed from the intravascular space it thickens and forms a gel (clot) This process of clotting is called coagulation and involves various chemicals known as coagulation (clotting) factors. Clotting is a complex process where one reaction occurs and triggers of the next reaction, this process is commonly referred to as the clotting cascade.

The clotting mechanism occurs in three stages

Stage 1 – Formation of prothrombin activator
Stage 2 – Conversion of prothrombin into thrombin
Stage 3 – Conversion of fibrinogen into insoluble fibrin by thrombin

Stage one can occur using either an extrinsic or intrinsic pathway. The extrinsic pathway occurs rapidly (seconds) as a result of trauma (damage to blood vessels or surrounding tissues). The intrinsic pathway is more complex and occurs over several minutes and is triggered when blood comes into contact with the underlying collagenous fibers of damaged blood vessels or is removed from the body. Stage two and three are known as the common pathway.

The following diagram outlines the clotting cascade and identifies the location where a number of anticoagulants act on the cascade.




TF = tissue factor; LMWHs = low-molecular-weight heparins.

## READING

It is recommended that you refresh your knowledge on the mechanism of coagulation and the clotting cascade. An anatomy and physiology book or a nursing pathophysiology book will provide a general overview.

## LEARNING ACTIVITY

1. Identify where the action of the calcium/citrate compound blocks the clotting cascade. You may need to come back to this activity once you have read the section on anticoagulation.

Coagulation studies can be performed to measure a patient's capacity to clot within expected norms and to determine if there are complications with the clotting cascade, in particular coagulopathies.

| Clotting Study | Abbreviation | Site of Measurement | Range |
|---|---|---|---|
| Activated Partial Thromboplastin Time | APTT | Measures the intrinsic pathway of coagulation | 27 - 42 sec |
| Prothrombin Time & | PT | Measures the extrinsic pathway of coagulation | 10 -12 sec |
| International Normalised Ratio (Warfarin) | INR | Measures the extrinsic pathway of coagulation under the influence of Warfarin | 0.9-1.2 sec |
| Thrombin Time (TT) | TT | Measures final common pathway | 17 -25 sec |
| Fibrinogen Determination | | Measures the fibrinogen concentration of whole blood | 2.0 - 4.Og/L (150 -350mg%) |
| Fibrin Degradation Products | | | <10mg/L |
| Bleeding Time | | Measures the amount of time it takes to start and stop bleeding | 9 - 12min |
| Coagulation factors | | | 500- 1500U/L |

Anticoagulation used in therapeutic plasma exchange will be discussed latter in this self-directed learning package.

## THERAPEUTIC PLASMA EXCHANGE AND DISEASE PROCESSES

Applications of therapeutic plasma exchange can be broadly subdivided into two general categories:

1. Acute self-limited diseases where therapeutic plasma exchange is used to actively lower the circulating pathogenic substance; and
2. Chronic diseases where there is ongoing production of pathogenic auto-antibodies.

Because therapeutic plasma exchange does not address the underlying disease pathology, and as a result of the phenomenon where there is rebound antibody production, therapeutic plasma exchanges use in chronic diseases has been more controversial than in acute self-limited diseases. The applications of plasma exchange in acute self-limited conditions and chronic conditions are discussed in the following paragraphs:

- **Conditions associated with hyperviscosity**: Serum hyperviscosity is most commonly related to overproduction of immunoglobulins and thus is seen in association with B-cell lymphocyte neoplasms such as multiple myeloma and Waldenström's macroglobulinemia. Symptoms of hyperviscosity include bleeding disorders, retinopathy, and neurologic disorders, including stroke. Treatment is principally directed at the underlying disorder, but TPE may be used to acutely lower the serum viscosity.

- **Acute exacerbations of myasthenia gravis**: Myasthenia gravis is an autoimmune disease with autoantibodies directed against the postsynaptic membrane of the muscle end-plate (anti acetylcholine receptor). Clinically, the disease is characterised by fatigable weakness of voluntary muscles. Initial treatment focuses on the use of cholinesterase inhibitors to overcome the postsynaptic blockade. Immunosuppressant drugs including corticosteroids and azathioprine are also effective. TPE has been used as a short-term therapy in patients with acute exacerbations associated with severe weakness.

- **Guillain-Barré syndrome**: GBS is an acute monophasic demyelinating neuropathy that is characterised by loss of motor strength, loss of reflexes, and variable sensory loss whose severity is graded on a scale of 1-5. TPE has been recommended for the treatment of nonambulant patients within four weeks of disease onset and for ambulant patients within two weeks of disease onset. Improved outcomes are seen when therapeutic plasma exchange is initiated early in the disease process. A combination of therapeutic plasma exchange and intravenous immunoglobulin (IVIg) have been determined to be effective.

- **Rapidly progressive glomerulonephritis (RPGN) including Goodpasture's syndrome**: RPGN is a general term describing the rapid loss of renal function in conjunction with the finding of glomerular crescents on renal biopsy specimens. There are multiple etiologies of RPGN, including vasculitis, the deposition of anti-glomerular basement membrane (GBM) antibodies as seen in Goodpasture's syndrome, or the deposition of immune complexes as seen in various infectious diseases or connective tissue diseases. RPGN may also be idiopathic. Because

many cases of RPGN represent an immune-mediated disease of acute onset, RPGN was an early focus of TPE research.

- **Transplant rejection /pre-sensitisation/ABO Incompatibility**
  Therapeutic plasma exchange can be used for a number of reasons in renal transplantation. In the pre-transplantation phase plasma exchange can be used to decrease the number of preformed cytotoxic antibodies for those patients who are highly sensitised and allow for transplantation to occur. This decreases the risk of hyper-acute and acute allograft rejection. Therapeutic Plasma exchange can also be used to treat those individuals who have immune related renal disease process such as IgA to prevent the primary disease reoccurring in the transplanted organ. In those with a transplant plasma exchange can be used to treat acute allograft rejection episodes. More recently there has been increasing trend to undertake therapeutic plasma exchange in conjunction with the use of an ABO column to allow transplantation across ABO groups.

- **Thrombotic thrombocytopenic purpura (TTP) - Hemolytic uremic syndrome (HUS)**: Once considered distinct syndromes, TTP and HUS are now considered different manifestations of the same disease process, i.e., thrombotic microangiopathy. The classic signs and symptoms include fever, thrombocytopenia, microangiopathic hemolytic anemia, neurologic abnormalities, and/or renal involvement. TTP-HUS may be seen in association with other conditions, such as pregnancy or HIV infection. TPE has become the primary treatment for TTP-HUS, although a rationale for its effectiveness is unknown. TPE is performed daily until a response is noted; the length of treatment averages about one month with increasing intervals between TPE treatments.

- **Idiopathic thrombocytopenic purpura (ITP)**: ITP is an acquired disease of either adults or children characterized by the development of auto-antibodies to platelets. Management of acute bleeding due to thrombocytopenia typically involves immediate platelet transfusion, occasionally in conjunction with a single infusion of IVIG. TPE has been occasionally used in emergency situations. TPE does not appear to have a role in chronic ITP.

- **HELLP syndrome of pregnancy**: HELLP is a severe form of preeclampsia characterized by hemolysis (H), elevated liver enzymes (EL), and low platelet (LP) counts. The principal form of treatment is delivery of the fetus. However, for patients with severe thrombocytopenia, TPE may be indicated if the foetus cannot safely be delivered or if the maternal thrombocytopenia persists into the postnatal period.

- **Post-transfusion purpura** : Post transfusion purpura is a rare disorder characterized by an acute severe thrombocytopenia, occurring about 1 week after a blood transfusion in association with a high titre of anti-platelet alloantibodies. Due to its rapid effect, TPE is considered the initial treatment of choice.

- **Acute fulminant CNS demyelination**: Multiple sclerosis and other idiopathic inflammatory demyelinating diseases may present with an acute fulminant onset, which may proceed to severe cognitive dysfunction, hemiplegia, paraplegia or quadriplegia.

The applications of therapeutic plasma exchange seen in chronic conditions are as follows:

- **Chronic inflammatory demyelinating polyneuropathy (CIDP)**: CIDP is a symmetric polyneuropathy associated with both motor and sensory deficits. The disease course may present as either a relapsing/fluctuating or slowly progressive disease. Therapeutic plasma exchange is reserved for those patients who do not respond to treatment with prednisone or IVIG. Therapeutic plasma exchange may be required on a chronic basis if the patient demonstrates a benefit from the treatment in the transient reduction of symptomology. Frequency of treatment is titrated according to the durability of the patient's response. Some of the symptoms of CIDP may overlap with those of chronic fatigue syndrome. However, the American Academy of Neurology has established diagnostic guidelines for CIDP.

- **Paraproteinemic polyneuropathy**: A monoclonal immunoglobulin (paraprotein) is found in the serum or urine of approximately 10% of patients with idiopathic polyneuropathy, typically occurring in the context of a monoclonal gammopathy of undetermined significance (MGUS). Additionally, approximately 25% of patients with CIDP may have a monoclonal gammopathy. The gammopathy is typically an IgM (where it is often directed against myelin-associated proteins or the ganglioside GM-1) or less commonly IgG or IgA.

- **Multiple sclerosis (MS)**: MS is an inflammatory demyelinating disease, the etiology of which has remained frustratingly elusive with both environmental and genetic factors thought to play a role. Laboratory abnormalities suggest that MS is an immune-medicated disease. TPE has been used primarily as a technique to either shorten the duration of an acute attack or to reduce the number of acute attacks.

- **Devic's disease:** also called neuromyelitis optica is a rare inflammatory disease of the central nervous system which resembles MS. There are episodes of inflammation and damage to the myelin (fatty, protective covering of nerves) that almost exclusively affect the optic nerves and spinal cord. It usually causes temporary blindness, occasionally permanent, in one or both eyes. It can also lead to varying degrees of weakness or paralysis in the legs or arms, painful spasms, loss of sensation, and bladder or bowel dysfunction from spinal cord damage

- **Paraneoplastic neuromuscular syndromes**: Paraneoplastic neuromuscular syndromes are characterized by the production of tumour antibodies that cross-react with the patient's nervous system tissues. In many cases, the paraneoplastic syndrome may be the initial manifestation of the tumour and in other instances, the symptoms of the syndrome are more disabling than the tumour itself. The Lambert Eaton myasthenic syndrome (LEMS), characterized by proximal muscle weakness of the lower extremities and associated most frequently with small cell lung cancer, is the most common paraneoplastic syndrome. Although presence of LEMS should prompt a search for a lung primary tumour, the syndrome may also occur idiopathically. Other syndromes

include paraneoplastic sensory neuropathy, encephalomyelitis, cerebella degeneration or opsoclonus/myoclonus (related to the presence of anti-Hu antibody, or in the case of cerebella degeneration, anti-Purkinje cell antibodies). Paraproteinemic immunoglobulin M can also be associated with a demyelinating polyneuropathy. Although treatment of the underlying primary tumour is the cornerstone of treatment, TPE has also been investigated due to the presence of circulating autoantibodies.

- **Stiff Man Syndrome**: Stiff man syndrome is an autoimmune disorder characterized by involuntary stiffness of axial muscles and intermittent painful muscle spasm. Symptoms are related to autoantibodies directed against glutamic acid decarboxylase in the nervous system. Stiff man syndrome may be idiopathic in nature, or seen in association with thymoma, Hodgkin's disease, small cell lung, colon or breast cancer.

- **Pemphigus**: Pemphigus is an autoimmune blistering skin disease that is characterized by serum antibodies that bind to squamous epithelia. Clinically it is characterized by flaccid bullae that rupture and leave areas of denuded skin, creating serious problems with secondary infection and fluid balance. Steroids or other immunosuppressants are the most common forms of treatment, but the high doses of steroids can produce significant side effects. TPE has been investigated in patients refractory or intolerant to steroids or other immunosuppressant therapies.

- **Autoimmune connective tissue diseases**: This family of diseases includes systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), systemic sclerosis (also referred to as scleroderma), polymyositis, and dermatomyositis. Inclusion body myositis is the most common acquired inflammatory myopathy over the age of 50 years, characterized by weakness of the quadriceps, biceps and triceps. When TPE first became available during the 1970s and early 1980s, there was considerable interest and enthusiasm for the use of PP/TPE for these autoimmune diseases. However, since that time, successive randomized controlled trials have not validated the role of TPE as a treatment of the chronic phase of these conditions.

- **Eaton-Lambert Syndrome (ELS)**: Eaton-Lambert Syndrome seems to be an immune-mediated disease of the myoneural junction. It is characterized by weakness that may decrease with exercise and by specific electromyographic abnormalities. The evidence that it is an immune-mediated process comes from its association with other autoimmune diseases, presence of organ-specific autoantibodies, and the fact that the electrophysiologic features of the disease can be passively transferred to animals by immunoglobulin. Sixty-five percent of patients have an associated small cell carcinoma of the lung. The rationale for the use of TPE in ELS is based on the presence of a serum antibody that blocks the release of neurotransmitter from the presynaptic membrane. Only a limited number of patients with ELS have had TPE.

- **Enzyme disorders such as Refsums disease**
  Phytanic acid storage disease (known also as Refsum's Disease) is caused by inherited defects in the metabolic pathway for phytanic acid, a dietary branched-

chain fatty acid. Poorly metabolized phytanic acid accumulates in fatty tissues, including myelin sheaths, and in organs including the liver and kidneys. Over time, affected individuals may develop classical diagnostic features of retinitis pigmentosa, cerebella ataxia, peripheral polyneuropathy and an elevated protein content in the cerebrospinal fluid. Liver, kidney, and heart disease may also develop. Dietary restriction of phytanic acid is useful in preventing acute attacks and arresting the progression of organ impairment, especially in the peripheral nervous system. Therapeutic plasma exchange has been shown to be particularly useful for rapidly lowering plasma phytanic acid levels during acute attacks and may play a significant role as maintenance therapy as well (Weinstein, 1999).

Additionally, due to the mechanisms of therapeutic plasma exchange other agents with smaller molecular weights can also be removed during the treatment process. Substances include: immunoglobulins; clotting factors; albumin; urea; creatinine; glucose; and other electrolytes. It is also possible to remove high plasma concentrations of toxins and poisons and wastes accumulating in the presence of hepatic failure

## READING

Bosch, T. (2005). Therapeutic apheresis: State of the art in the year 2005. *Therapeutic apheresis and dialysis, 9*(6), 459-468.

Madore, F., Lazarus, M. & Brady, H.R. (1996). Therapeutic plasma exchange in renal disease,*Journal American Society Nephrology, 7*(3), 367-386.

## MECHANISMS OF THERAPEUTIC PLASMA EXCHANGE DELIVERY

As discussed in section one the Centre Dialysis Unit at the John Hunter Hospital currently has two machines available for the delivery of therapeutic plasma exchange. These machines are the Haemonetics MCS+ and the Fresenius 4008S. These machines work using different principles. The Haemonetics uses centrifuge to remove the plasma and the Fresenius requires the use of a plasma filter.

The filtration system is a continuous process where blood components are simultaneously removed and re-infused and works on the same concepts as haemodialysis where the membrane is porous to the blood components for removal. The membrane is a generally a hollow fibre membrane like the membranes used for haemodialysis. The primary difference is the size of the membrane pore. Platelets are the smallest of the formed cells at 2-3 microns. The membrane for therapeutic plasma exchange needs to be large enough to allow plasma to cross but retain the formed elements; generally permeability is approximately 0.6 microns.

Centrifugal systems can be either continuous or discontinuous (intermittent) and work on the principle of separating the blood components based on density. Continual centrifugal systems are able to remove and reinfuse blood components simultaneously while discontinuous centrifugal systems remove the blood components where they are separated then the blood components to be retained are returned to the patient. Discontinuous centrifugal systems are considered older technology and generally take longer treatment times however they are ideally suited for those with a single lumen/needle vascular access.

## READING

McLeod, B.C.; Price, T.H. & Weinstein, R. (2003). Apheresis: principles and practice (2nd ed). Bethesda, Maryland USA: AABB Press.

- Chapter 5 by Edwina A. Burgstaler on Current Instrumentation for Apheresis.
- Chapter 15 by Robert Weinstein on the Basic Principles of Therapeutic Blood Exchange

Please pay particular attention to the information about the types of instrumentation that is reflective of the equipment utilized in the Centre Dialysis Unit.

## LEARNING ACTIVITY

This learning activity is designed to help you gain an understanding the equipment available for use in the Centre Dialysis Unit. You will need to ensure you are able to discuss the following with your mentor

Fresenius 4008S

- What are the disposable supplies/equipment used with this machine?
- Familiarise yourself with the technical data of the plasma filter utilised in the unit.
- What role does the concentrate solution have in the apheresis process?

Haemonetics MCS+

- What disposables are available for this machine?
- Outline the selection criteria when choosing different disposables (bowl sizes). Consider the following in your responses:
    - pregnancy,
    - severe anaemia
    - patients with severe IIHD
    - those with aortic valve disease

Additionally consider the following:

- Where are the machines and disposables kept?
- What is the process of obtaining more supplies if there are insufficient supplies in the unit?

## ANTICOAGULATION IN THERAPEUTIC PLASMA EXCHANGE

Anticoagulation of whole blood for the collection of blood components is an essential element in any procedure using therapeutic plasma exchange machines to prevent thrombosis. Extracorporeal anticoagulation means that the blood in the therapeutic plasma exchange machine and tubing is anti-coagulated while it is being processed during the therapeutic plasma exchange procedure.

Citrate anticoagulants remain the most commonly used solution for the extracorporeal anticoagulation of blood during centrifugal therapeutic plasma exchange treatments. Conversely, heparin is the drug of choice for haemodialysis and haemodialysis associated treatments and aphereis using haemodialysis technology such as the Fresenius 4008S. Both heparin and low molecular weight heparins are used routinely in haemodialysis and will not be explored further in this package. However for many nurses the use of sodium citrate will be a new experience.

Sodium citrate is rapidly metabolised by the kidney, liver and muscles and has a half life of only 20-60 minutes when the liver function is normal. Citrate anticoagulants prevent

coagulation by forming citrate-calcium complexes with ionized calcium in the plasma. This complex formation lowers the ionized calcium inhibiting the calcium dependent coagulation pathway preventing the formation of fibrin clots. Citrate also lowers the pH of the blood.

Sodium citrate is supplied as a premixed solution ready for immediate use. The citrate load returned to the patient is dependent on a number of variables including:

- The blood fraction returned
- The return speed
- The return interval
- The separation efficiency
- The anticoagulation concentration
- The anticoagulant ratio used
- The donors haematocrit
- Donor susceptibility
- The length of the procedure

## READING

Hayes, D.D. (2004). Calcium in the balance. *Nursing made incredibly easy*. 46-53.

## LEARNING ACTIVITY

What is the exact mechanism by which sodium citrate acts on the clotting cascade? You will need to consider what clotting factors are involved.

Sodium citrate use decreases the amount of available ionized calcium which can result in hypocalcaemia during the treatment process. This hypocalcaemia is referred to as citrate toxicity. Nursing staff delivering therapeutic plasma exchange care need to be alert and monitor patients for signs and symptoms of hypocalcaemia. This requires prompt intervention by

- Reducing the return speed and draw speed to lengthen time between each cycle to allow for citrate metabolism
- Shortening the return interval (smaller volume per pass)
- Reducing the AC concentration or AC ratio, the Haemonetics is set in the default position (1:16) to deliver the smallest possible ratio. If the operator has altered this ratio consideration needs to be given to decrease the ratio.
- Administer calcium drinks (glass of milk) or tablets pre-treatment and/or during treatment
- Halting the draw cycle to allow for the subsidence of symptoms, or until calcium replacement has had an effect.

It is important to note that fresh frozen plasma contains sodium citrate. So for those patients using that fresh frozen plasma as their substitution fluid they will be receiving additional sodium citrate to that administered via the extracorporeal circuit. This therefore needs to be considered when administering calcium supplements. Oral calcium supplements are the preferred mode treatment either in either milk containing drinks or oral tablets prior to or

during the treatment. Calcium supplementation should be based on an assessment of ionized calcium levels pre treatment and pretreatment correction. Generally it is safer to correct hypocalcaemia by the above methods than to infuse concentrated calcium solutions once the patient becomes symptomatic.

Serum ionized calcium levels will generally decrease within the first thirty minutes when the citrate molecules bind with the ionized calcium. Hypocalcaemia is defined as a serum ionized calcium below normal reference values. The literature suggests that citrate infusions of 1mg/kg per minute or less is “innocuous” to many individuals, a citrate infusion of 1.7mg/kg or greater is associated with a moderate to severe Hypocalcaemic reactions (Sink, 2002). An infusion of citrate at 1.0 to 1.8mg/kg per minute is thought to lower ionized calcium levels between 25-35% after only one to two hours. An upper limit citrate administration of 4mg/kg per minute is thought to be suitable for humans (Sink 2002).

## READING

Weinstein, R. (2001) Hypocalcaemic toxicity and atypical reactions in therapeutic plasma exchange. *Journal of clinical apheresis, 16*, 210-211.

John Hunter Hospital Division of Medicine Safe Work Practice on Management of Sodium Citrate Toxicity

## LEARNING ACTIVITY

What are the signs and symptoms you need to observe for when using sodium citrate?

## COMPLICATIONS OF THERAPEUTIC PLASMA EXCHANGE

While therapeutic plasma exchange is a relatively safe procedure as with many other medical interventions it is not without potential complications. The rate of adverse events during therapeutic plasma exchange is generally greater in therapeutic procedures compared to donor procedures. The operator needs to be ever vigilant in identifying the emerging signs of an adverse reaction. Vague and non-specific complaints need to be acted upon as patients may exhibit non-specific symptoms including: inappropriate laughter; excessive talking; irregular breathing patterns; hyperventilation; tachycardia; cold and clammy hands; flushed or pale face; restlessness; yawning; sneezing and non specific abdominal pain.

The complications associated with the use of an extracorporeal circuit are similar to those associated with haemodialysis and include but are not limited to: hypotension; fluid volume shifts/depletion; air embolism; haemolysis; machine malfunction. The performance of therapeutic plasma exchange also introduces the risk of other treatment associated complications including:

- Endocrine and metabolic abnormalities including hypocalcaemia, hypokalaemia, metabolic alkalosis and altered hormonal concentrations. Hypocalcaemia manifests as: peri-oral tingling; shivers; cramping; nausea and vomiting; hypotension; cardiac arrhythmia; and cardiac arrest.

- Altered concentrations of clotting factors in particular Factor VII and IX are reduced but generally normalise within 24 hours.

- Fibrinogen levels may be deficient for 48-72 hours as Antithrombin III levels may be depressed by multiple large volume exchanges and contribute to a hypercoagulable state.

- Fibronectin (whose role is in the regulation of coagulation and probably important in defense against infection), decreases to 50% after 3 days, with a 2.0-3.0 litre exchange.

- Infections associated with the use of blood and blood products as replacement solutions (CMV, hepatitis and HIV).

- Immunodeficiency from immunoglobulin depletion after repeated large volume exchanges. IgM is 75% intravascular and is more readily removed than IgG, which has a much larger volume of distribution. Though 6-8 litre exchanges may result in significant reductions of IgG. Some regimes include the administration of intravenous gammaglobulin after each treatment.

- Hypersensitivity reactions include, rashes, urticaria, wheezing, shortness of breath, facial swelling, laryngeal oedema and gastrointestinal disturbances. Circulatory disturbances may result in cardiac arrest. It is thought 70% of these reactions are linked to an allergy to ethylene oxide used for sterilising the circuit components.

- Altered medication response may result from, enhanced removal of water-soluble and protein bound drugs, RBC depletion, hypocalcaemia and hypotension. The greater the affinity of the drug to bind with protein the greater the removal of the drug will be. Some of the drugs commonly used in ICU that have strong protein binding properties include: mexiletine, theophylline, amiodarone, phenytoin, diazepam, and many antibiotics that are at least 30% bound to albumin.

- Hypokalaemia is also a potential in patients undergoing therapeutic plasma exchange. It is estimated that potassium levels can fall by up to 11%, so those individuals with low or in the lower limits of normal serum potassium are at risk of hypokalaemia and may require potassium supplements. Oral potassium supplements are the preferred method of treatment.

- Vascular Access complications. While there is a higher risk associated with peripheral cannulations there are risks associated with specifically created vascular accesses. Peripheral complications include haematomas, venous sclerosis, thrombosis; infection; and nerve, muscle, tendon injury.

- Transfusion reactions related to the use of blood products such as Albumin 4% and/or fresh frozen plasma (FFP).

- Histamine reaction associated with the use of ACE inhibitors which may manifest as flushing, nausea, vomiting and hypotension. It is recommended that ACE inhibitors be with held for twenty-four to forty-eight hours prior to a treatment.

ACE inhibitors are thought to potentiate allergic reactions due to increased levels of bradykinin

Nurses can do much to avoid treatment related complications including the following:

- Patients are more likely to have a reaction to therapeutic plasma exchange during their first treatment, or if fresh frozen plasma is the replacement solution. Close medical supervision is warranted for those individuals at risk.

- Ensure there is a valid medical order. Prescriptions are discussed in detail later in this self directed learning module.

- Do not commence treatment until replacement solution is available in the unit. Replacement solutions need to be transported from the blood bank to the unit. Fresh frozen plasma must be thawed prior to use. The nurse must coordinate the availability of the replacement solution.

- Minimum treatment time should not be less than one and a half hours to minimise the risk associated with the administration of both the replacement solution and the anticoagulation.

- The patient needs to be assessed pre-treatment, intra treatment and post treatment. Patient assessment is discussed later in the self directed learning package.

- The patient should remain isovolaemic, with no net fluid loss or gain. Fluid balance must be closely monitored to prevent hypo or hypervolaemia.

- When using the Fresenius 4008S the maximum filtrate/replacement flow rate should not exceed 20% of the effective blood flow rate. For example if the blood flow rate is 200mls/minute, a 20% filtrate flow rate is 40mls per minute. If one then calculates this over one hour it equates to 2400mls. This 2400mls is therefore the maximum filtrate/replacement flow rate per hour. The treatment time needs to be calculated by ensuring that the filtration rate is set to no more than 2400mls/hour with a trans-membrane pressure (TMP) of between 80-100mmHg. If the trans-membrane pressure (TMP) exceeds 100mmHg haemolysis is likely to occur. Trans-membrane pressure can be reduced by decreasing the blood flow rate, lowering the filtration rate and increasing the treatment duration.

- During the use of the Haemonetics MCS+ the draw rate should not exceed 100mls/minute and the return rate should not exceed 100mls/minute to minimise the risk of sodium citrate complications. The flow rate is dependent on the capability of the vascular access, for example when peripheral vein cannulations are used they may not tolerate these maximum speeds.

Any complication or adverse event must be documented in the patient's medical records, the treating physician and the Nursing Unit Manager (or if after hours the After Hours Nurse Manager ) must be informed and an IIMS notification made.

## LEARNING ACTIVITY

A patient asks you to explain the potential complications of the therapeutic plasma exchange treatment. How would you explain these to the patient? What signs and symptoms should the patient be observed for? You might like to answer this question verbally with your mentor.

## PATIENT ASSESMENT FOR THERAPEUTIC PLASMA EXCHANGE

Good patient assessment is the cornerstone of quality therapeutic plasma exchange care. Patient assessment begins with a thorough evaluation of the patient upon their arrival for treatment and only concludes once the patient has departed the unit. Patient assessment is about evaluating the patient's individual response to the treatment process and with the aim of avoiding treatment related complications or intervening early if a complication does arise.

The pre- treatment patient assessment needs to also include haematological parameters including: a full blood count (haematocrit needed to calculate estimated plasma volume); blood biochemistry (potassium, albumin, calcium, ionised calcium are of particular interest) coagulation studies as per medical orders. The frequency of this testing will be determined by the frequency and the rationale for the delivery of therapeutic plasma exchange. An acutely unwell patient is likely to have these parameters assessed prior to each treatment whereas a patient on chronic maintenance treatment may only require such assessment at predetermined intervals.

Consideration needs to a number of other patient assessment parameters especially in the acute or acutely unwell patients. Some areas for consideration include:

- A medical assessment including medical history and review of biochemical and haemoatological parameters.
- A nursing assessment of patients current status.
- The nurse who is to conduct the therapeutic plasma exchange treatment should also be aware of all medications the patient is or has been talking. If the patient has been taking cytotoxic medications cytotoxic precautions need to be used when disposing of wastes.
  **NOTE: The Fresenius 4008S must be used for patients requiring cytotoxic precautions** as the removed plasma is disposed of immediately rather than being allowed to collect in a drainage bag. A cytotoxic spill kit can only effectively clean up one litre of cytotoxic spill and the volume of plasma being replaced generally exceeds this capacity. Such large cytotoxic spill would require additional assistance (possibly hazmat) to manage the cytotoxic spill clean up.
- A full fluid assessment. While the fluid assessment follows the same process as a haemodialysis assessment. The fluid assessment for therapeutic plasma exchange is about determining if the patient requires isolated ultrafiltration to treat fluid volume overload (using haemodialysis technology) pre therapeutic plasma exchange. Of if the patient is volume depleted consideration needs to be given to the concurrent use of intravenous fluid administration to prevent hypotension (especially during the draw cycle when using the Haemonetics Machine).

Upon arrival to the unit the patient needs to have a full set of baseline observations including: weight; blood pressure (lying and standing); heart rate; respiratory rate;

oxygen saturation; and temperature. The patient should also be interviewed about any recent health changes and their general well being.

It is essential these observations parameters are monitored throughout the treatment.

- When using the Haemonetics MCS+ the patients observations need to be recorded at the end of each draw cycle as this is when the patient's intravascular volume is the lowest.
- When a treatment with the Fresenius 4008S is delivered the patients observations need to be monitored every 15 minutes

Post treatment should include a repeat of the pre-treatment assessment and the reinforcement of the need to report any treatment related complications/side-effects.

The use of sodium citrate and the potential for hypocalcaemia requires closer monitoring of the patient. The patient should where possible remain awake for the treatment process so that early signs of hypocalcaemia can be detected and treated immediately. It may not be possible to keep all patients awake depending on their medical condition for example those patients who have been sedated or those who are unconscious.

## READING

Price, C. & McCarley, P. (1994). Physical assessment for patients receiving therapeutic plasma exchange. ANNA Journal, 2(4), 149-154, 201.

## LEARNING ACTIVITY

What are the guidelines for patient assessment during the therapeutic plasma exchange treatment? Are there differences between the assessment processes when using different machine? Please explain your response.

## VASCULAR ACCESS FOR THERAPEUTIC PLASMA EXCHANGE

Vascular access for therapeutic plasma exchange is dependent on a number of factors including the type of machine utilised, the length and frequency of the treatment/s and individual patient characteristics. The Haemonetics MCS+ requires a single venous access site/needle whereas the Fresenius 4008S requires two venous access sites/needles.

Patients can have peripheral access or use the same type of vascular access associated with haemodialysis. Peripheral veins are used primarily for plasma donations rather than the therapeutic plasma exchange process, though some patients do have adequate peripheral veins for therapeutic plasma exchange. Peripheral cannulation requires a good cubital-fossa vein that is able to be cannulated with a steel 15-17 gauge back-eye butterfly needle. To ensure blood flow is constant via peripheral veins a pressure cuff is generally applied to the patients arm above the cannulation site. The pressure needs to be kept at a level that is titrated in conjunction with assessment of the patients' systolic blood pressure and draw pressure (usually around 50mmHg is sufficient).

Most patients requiring ongoing therapeutic plasma exchange will generally have a vascular access created that allows for ongoing access to the venous system. Vascular

access creation is in-line with that required for haemodialysis treatment. As such the ongoing care and management of this vascular access is as per departmental safe work practices already in existence. Staff undertaking this education program should already be familiar with these.

**READING**

Stegmayr, B. & Wikdahl, A.M. (2003). Access in therapeutic apheresis. *Therapeutic apheresis, 7(*2), 209-214.

## PRESCRIPTIONS FOR THERAPUTIC PLASMA EXCHANGE

Therapeutic plasma exchange is not without potential risks, as such for therapeutic plasma exchange to occur under the auspices of the Centre Dialysis Unit at John Hunter Hospital it must be prescribed by one of the following:

- A Nephrologist
- A Haematologist or
- A Nephrology Medical Registrar in consultation with the treating Nephrologist

Nursing staff should not initiate therapeutic plasma exchange if ordered by any other Medical Officer. In addition to the appropriate medical orders the patient needs to provide written consent for the procedure.

Medical orders for the therapeutic plasma exchange treatment session should include a number of factors as outlined below. It is important to note that this list is neither exhaustive nor prescriptive, but aimed rather at providing insight for the novice practitioner.

- The volume of plasma to be exchanged must be determined and written as a medical order.

- Replacement Solution: While Albumin 4% is often used consideration needs to be given to the use of fresh frozen plasma (FFP) for those patients with fibrinogen levels of less than 2.0g/L or for those who disease process requires this as a form of replacement fluid. Replacement solutions must be charted by a medical officer. If fresh frozen plasma is utilised a Pal Leukocyte Plasma Filter must be used and changed after the administration of 1600mls. The procedure for checking blood and blood products must be adhered to.

- Anticoagulation: is dependent on the machine being utilised for the treatment process. If the Haemonetics MCS+ is utilised consideration needs to be given to the prescribing of calcium supplementation. It is essential to consider the individual patient circumstances and the type of anticoagulation used including factors such as recent or impending surgery, type of substitution fluid and invasive procedures and the presence of active bleeding or bleeding abnormalities. The medical order therefore should consider the use of short acting or long acting anticoagulation.

- All medication including replacement solutions must be charted on appropriate prescribing forms. It may also be prudent to consider the charting of

medications to manage hypersensitivity reactions especially in patients receiving fresh frozen plasma.

- The need for assessing haematological and coagulation parameters pre treatment must be considered.

The nurse is responsible for ensuring they have valid medical orders prior to the commencement of the therapeutic plasma exchange.

Nurses who are delivering therapeutic plasma exchange need to familiarise themselves with the disease process that the patient is being treated for to identify if there are any other additional precautions or treatment requirements needed in order to deliver safe therapeutic plasma care. The nurse needs to initiate discussion with the ordering medical officer if further information is required.

## READING

John Hunter Hospital Division of Medicine Safe Work Practices on:

- Therapeutic Plasma Exchange Treatment – Haemonetics MCS+
- Therapeutic Plasma Exchange Treatment – Fresenius 4008S

Congratulations you have completed the self-directed learning package

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# SECTION 3

## THERAPEUTIC PLASMA EXCHANGE COMPETENCY ASSESSMENT

It is your responsibility to organise competency assessment. If you do not attain competency on the first attempt the procedure can be re-attempted twice, but 24 hours must lapse between each attempt. The procedure will be terminated if the patient or staff member is put at risk during the assessment.

| **Competency** | | **Y** | **N** | **N/A** |
|---|---|---|---|---|
| **1.0** | **EDUCATION** | | | |
| **1.1** | The Therapeutic plasma exchange professional will have a sound knowledge of basic anatomy and physiology particularly of blood and circulation and basic immunology and pathophysiology of diseases treated by therapeutic plasma exchange | | | |
| 1.1.1 | **The therapeutic plasma exchange professional should be able to:-** | | | |
| | · List the components of blood and know their normal ranges, life span and site of genesis | | | |
| | · Explain the function of blood in relation to transport of oxygen, carbon dioxide, waste products, hormones and enzymes | | | |
| | · Explain the role of blood in regulation of body temperature, pH and water content of cells | | | |
| | · Understand the clinical process of the immune system and the application of this process in Therapeutic plasma exchange | | | |
| 1.1.2 | The therapeutic plasma exchange professional should have sound knowledge of the principles of centrifugal separation and be aware of the specific gravity of blood and its components. | | | |
| 1.1.3 | The therapeutic plasma exchange professional should have sound knowledge of the principles of therapeutic plasma exchange. The principles of therapeutic plasma exchange shall include, but not be limited to, knowledge of available technology eg: continuous flow centrifugal devices, discontinuous flow, centrifugal devices and membrane technology.<br>The therapeutic plasma exchange professional should be able to:- | | | |
| | · Describe the concepts behind said devices | | | |
| | · Describe diseases treated by therapeutic plasma exchange and the clinical indications for therapeutic plasma exchange in those diseases. | | | |
| | · List other modalities that may be included in an therapeutic plasma exchange program eg: selective plasma component removal, photopheresis and column absorption. | | | |

| CONT | | Y | N | N/A |
|---|---|---|---|---|
| 1.1.4 | The therapeutic plasma exchange professional should have a sound knowledge of medications employed during therapeutic plasma exchange procedures. | | | |
| | · Assess and describe patient's current prescribed medications and their potential interactions and loss of effectiveness during therapeutic plasma exchange procedures. Eg: TPE – cardiac drug interactions, antibiotics, oral contraceptive blood levels and cytotoxic agents | | | |
| | · Have sound knowledge and awareness of the clinical implications of medications employed during therapeutic plasma exchange procedures eg: sodium citrate, heparin and calcium gluconate, steroids etc. | | | |

| **1.2** | **Education is a broad concept and includes all aspects of knowledge, skills and attitudes relevant to the therapeutic plasma exchange professional.** |
|---|---|

| 1.2.1 | The content should be a means of enhancing the intellectual development of the therapeutic plasma exchange professional not an end in itself eg: the therapeutic plasma exchange professional should be able to use critical thinking to utilise the information acquired such as solve problems, create new information or gain self knowledge. | | | |
|---|---|---|---|---|

| | | Y | N | N/A |
|---|---|---|---|---|
| 1.2.2 | The content should also promote discussion regarding moral and ethical considerations and outline attitudes and behaviour appropriate to the professional role. | | | |

| 1.2.3 | The content should provide the opportunity to advance clinical skills as well as broaden and deepen knowledge in clinical assessment. | | | |
|---|---|---|---|---|

| **1.3** | **ANZAA acknowledges that education is never static, but rather learning is an on-going process. Therefore continuing education opportunities should be made available and accessible.** |
|---|---|

| 1.3.1 | It is recommended that therapeutic plasma exchange professionals should:- | | | |
|---|---|---|---|---|
| | · Hold membership of the ANZAA organisation as a pre-requisite to credentialing | | | |
| | · Attend an international meeting eg: WAA or ASFA no less often than every three years | | | |
| | · A national meeting annually | | | |
| | · Local branch meetings twice a year. | | | |

| 1.3.2 | Continuing Education Units (CEU's) will be awarded yearly at the national meeting and it is recommended all staff currently undertaking therapeutic plasma exchange procedures achieve 30 points over a 3 year period. | | | |
|---|---|---|---|---|

| Competency | | Y | N | N/A |
|---|---|---|---|---|
| **2.0** | **CLINICAL** | | | |

| | | | | |
|---|---|---|---|---|
| **2.1** | **The therapeutic plasma exchange professional should be able to successfully screen donors for suitability to donate.** | | | |

| | | | | |
|---|---|---|---|---|
| 2.1.1 | The clinical component should ensure exposure to, and experience and identification of, screening requirements which include but are not limited to:- | | | √ |
| | · Knowledge of current legal blood donation medical questionnaire and HIV declaration forms | | | √ |
| | · Being able to answer questions regarding HIV associated risk behaviour and the donation process | | | √ |
| | · Being familiar with the correct procedure for identifying donors | | | √ |
| | · Being familiar with correct component labelling as per Therapeutic plasma exchange Guideline 9.1.3 | | | √ |
| | · Identifying that the donor has read and accurately completed the blood donation medical questionnaire and HIV declaration | | | √ |
| | · Identifying that the donor has had sufficient, appropriate fluid and food intake prior to donating | | | √ |
| | · Knowing the correct procedures for correcting an incomplete or inaccurate donor written response | | | √ |
| | · Scanning donor history to ensure all areas are completed, initialised and that signatures are present | | | √ |
| | · Identifying how the donor feels during and post donation, being knowledgeable of potential side effects and taking correct action | | | √ |
| | · Examining the donor for suitable venous access | | | √ |
| | · Knowing the pulse, temperature and blood pressure parameters for safe donation practice | | | √ |
| | · Knowing the recommended product volume for safe donation practice according to donor weight | | | √ |

| | | | | |
|---|---|---|---|---|
| 2.1.2 | The therapeutic plasma exchange professional should be competent at venipuncture and cannulation demonstrating correct technique and cleansing of site according to the facility's SWP's and infection control guidelines | | | √ |

| | | | | |
|---|---|---|---|---|
| **2.2** | **The therapeutic plasma exchange professional is expected to be able to identify the range of patients and disease entities treated by therapeutic plasma exchange (TA) and be able to manage same.** | | | |

| | | | | |
|---|---|---|---|---|
| 2.2.1 | The clinical component should provide experience that enables the development to competence in, but not be limited to:- | | | |
| | · Recognition of the different haematological variations from the normal | | | |
| | · Ability to review patient's medical history and chart for appropriate TA request form, laboratory values, allergies, medications and haemodynamic stability including fluid assessment | | | |
| | · Management of potential side effects from the procedure and the patient's underlying condition | | | |
| | · Recognition of conditions requiring medical officer attention and the appropriate line of reporting | | | |
| | · Management of the patient's education of the procedure being undertaken, their physical comfort and post procedure instruction | | | |

| Cont | | Y | N | N/A |
|---|---|---|---|---|
| | · Managing and accessing the variety of devices required for TA such as subclavian and jugular central venous catheters, arterio-venous fistulae and implanted vascular prosthetics | | | |
| | · Venipuncture techniques for patients with less than optimal venous access | | | |

| **2.3** | **The therapeutic plasma exchange professional will have training in the practices, policies and procedures of the institution** |
|---|---|

| 2.3.1 | The clinical component will have training in:- | | | |
|---|---|---|---|---|
| | · CPR proficiency skills – competency to be assessed and training updated annually | | | |
| | · Emergency drugs, their dosages and routes of administration | | | |
| | · Fire and evacuation procedures | | | |
| | · Actions to be taken in the event of possible or actual harm occurring to the patient/donor | | | |
| | · Actions to be taken in the event of electrical shutdown or other emergency | | | |

| 2.3.2 | The clinical component will require the annual review of manuals containing standards of practice, clinical protocols for therapeutic plasma exchange and the institution's policies and procedures | | | |
|---|---|---|---|---|

| 2.3.3 | The therapeutic plasma exchange professional will demonstrate effective communication skills | | | |
|---|---|---|---|---|

| 2.3.4 | The therapeutic plasma exchange professional will provide and maintain a safe environment according to OH&S guidelines | | | |
|---|---|---|---|---|

| **2.4** | **It is recommended the therapeutic plasma exchange professional undergo a competency evaluation that demonstrated relevant current safe practice, evolving national standards and standards expected of the experienced nurse at an advanced level of professional practice at 3 yearly intervals.** |
|---|---|

| 2.4.1 | Competency tools are developed by the therapeutic plasma exchange instrument companies and are available following training programs, computer and software updates or following purchase of a new machine. | | | |
|---|---|---|---|---|

| 2.4.2 | Local competency tools are often available within a facility's SWP's, or training program and can be evaluated by peers, therapeutic plasma exchange consultants during annual appraisal, or company representatives in line with machine company validation including consideration of the following:<br>• Use of PPE,s, and other infection control principles<br>• Checking of blood and blood products ,<br>• Cytotoxic precautions/discarding of effluent following cytotoxic administration and appropriate timeframes | | | |
|---|---|---|---|---|

| Competency | | Y | N | N/A |
|---|---|---|---|---|
| **3.0** | **TRAINING** | | | |

| | |
|---|---|
| **3.1** | **The therapeutic plasma exchange professional should obtain the knowledge and ability to safely and competently operate the therapeutic plasma exchange device by successfully completing a training program and competency assessment tool. Such specific training programs and assessment tools are available for each procedure on each device by the instrument company eg: COBE BCT, Baxter Healthcare Pty Ltd and Haemonetics.** |

| | | | | |
|---|---|---|---|---|
| 3.1.1 | The familiarisation program will result in the ability to:- | | | |
| | · Identify and name the machine and kit components | | | |
| | · Identify the safety features of the instrument | | | |
| | · Describe and understand the mechanism of the instrument's separation device | | | |
| | · Describe and understand the vein monitoring system and flow rate control | | | |
| | · Identify the tubing links and pathways and their significance | | | |
| | · Know the structure of the Unit and the line of reporting | | | |
| | · Describe and understand the procedure of record keeping | | | |
| | · Describe universal precautions as safeguard to patients, staff and donors | | | |
| | · Successfully screen donors | | | |
| | · Demonstrate correct cleaning methods and routine maintenance required for specific instrumentation and management of blood spills | | | |

| | | | | |
|---|---|---|---|---|
| 3.1.2 | The clinical skills program will result in obtaining the knowledge for and the ability to:- | | | |
| | · Skilfully perform venipuncture and cannulation | | | |
| | · Install and prime a variety of procedure kits | | | |
| | · Perform programming for different procedures | | | |
| | · Discuss with and describe to patient/donors when their cooperation is required to aid the procedure such as during venipuncture | | | |
| | · Understand the Control Panel and access and modify procedural information | | | |
| | · Discuss and understand the use of drugs during a run | | | |
| | · Discuss and understand the choice of appropriate replacement fluid | | | |
| | · Calculate blood and plasma volumes exchanged | | | |
| | · Troubleshoot successfully potential problems arising from the instrument | | | |
| | · Manage appropriately patient reactions and complications | | | |
| | · Perform successfully and independently procedures of Therapeutic Plasma Exchange using different equipment | | | |

| | | | | |
|---|---|---|---|---|
| **3.2** | **Training shall also incorporate the knowledge:-** | | | |
| | · To debate and critically analyse ethical issues and considerations surrounding therapeutic plasma exchange such as informed consent and patient autonomy in treatment decisions, evidenced based treatments | | | |
| | · Of the procedure for contacting technicians and servicemen in the event of machine breakdown or for routine maintenance | | | |

| CONT | | Y | N | N/A |
|---|---|---|---|---|
| | · To understand cost effectiveness in relation to component production, maintenance contracts, maintenance and expiry of stores and supplies | | | |
| | · To build into the budget software updates and machine replacement according to current market best practice | | | |
| | · To discuss and present research or study projects related to therapeutic plasma exchange | | | |

| **Comments** | |
|---|---|
| | |
| | |
| | |
| | |
| | |
| **Registered Nurse** | |
| **Mentor** | |
| **Date of Competence** | |
| **Review Date** | |

Adapted from

The Guidelines for Education, Training and Competency Working Party

Of

Australian and New Zealand Apheresis Association Inc.

Once deemed competent staff must undertake an annual peer review using the above competency proforma to ensure their clinical skills and knowledge remain current and are reflective of best practice.

# APPENDIX A

# MCS+ SYSTEM QUIZ

This quiz has been taken directly from the Haemonetics Training Manual and can be used as a method of orientating on self to both the manual and the MCS+

## Complete the following statements from the MCS+ General Operators Manual.

1. The MCS is a lightweight, compact, _____ _____instrument.

2. All disposables include the following:
   a. _____ _____ through which blood flows.
   b. _____ _____in which blood is separated into its components.
   c. _____ _____ into which component(s) are collected.

3. The MCS+ User Panel consists of three main sections:
   1. The _____ _____ _____.
   2. The _____ _____.
   3. The _____ _____ .

4. The Flow Lights indicate the status of_____to and from the_____.

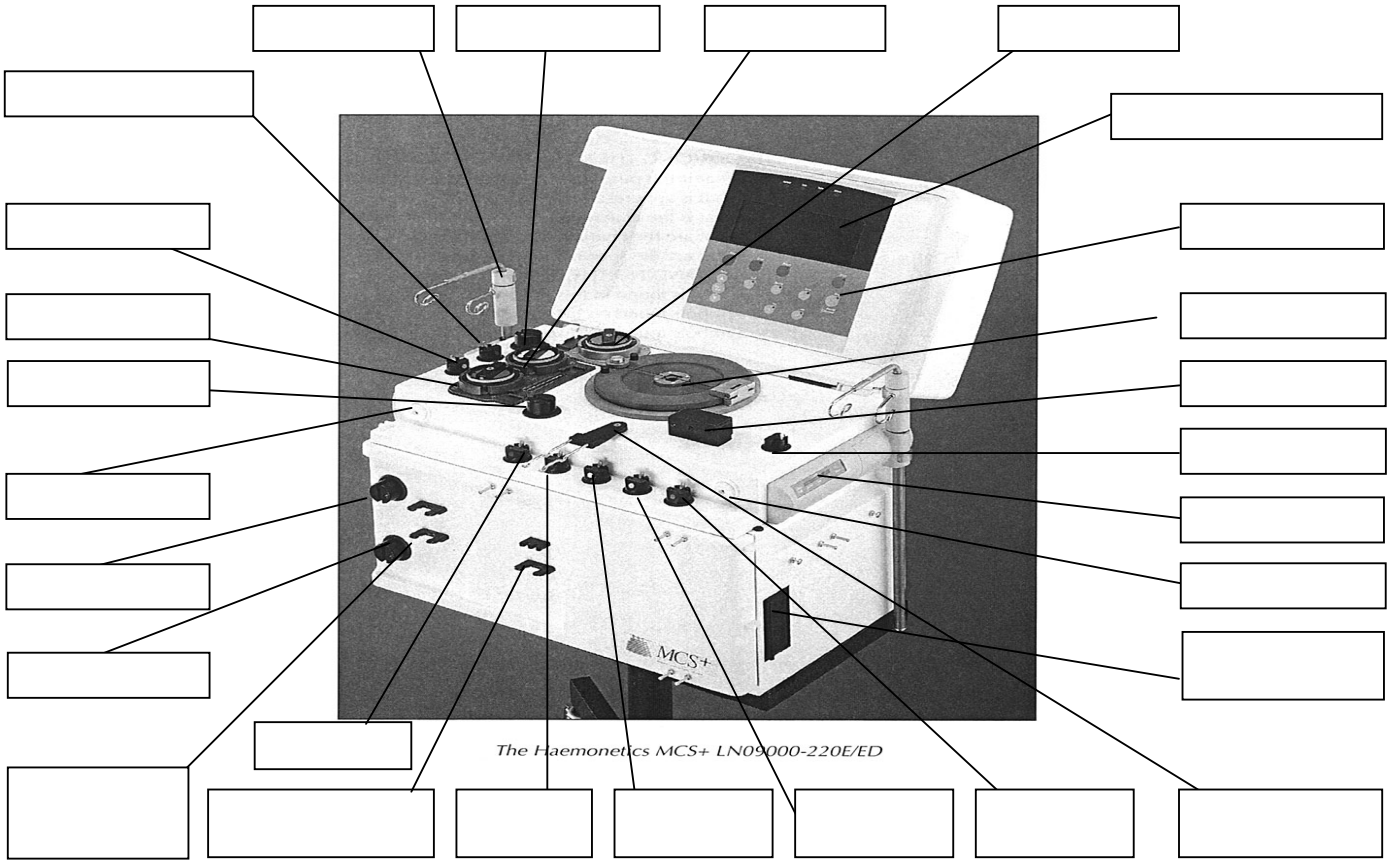
5. The _____ panel provides _____ updates on the status of the _____.

6. Pressing _____ once, displays the Haemo Update screen.

7. Pressing the _____ key displays the _____ Parameters screen.

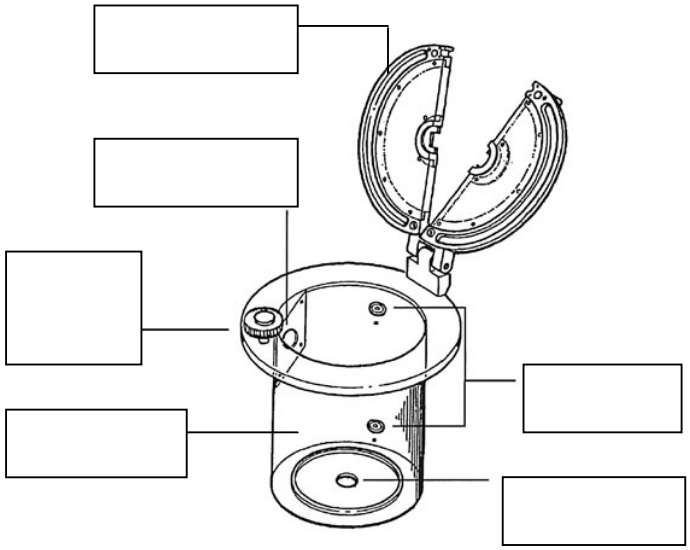
8. To permanently save the modified value, press _____ .

9. Label the following top view of the deck of the MCS+ machine using the list of items below:




| | | | | |
|---|---|---|---|---|
| - ACAD | - Weigher | - Blood pump | - BLAD | - Red valve |
| - Line Sensor | - Centrifuge | - Blood filter holder | - Clear Valve | - Purple valve |
| - Green valve | - SPM | - DLAD2 | - Control Panel | - AC solution pole |
| - AC pump | - White valve | - Transfer pump | - Flow indicator lights | - DPM |
| - DLAD1 | - Orange valve | - Blue valve | - Recirculation chamber | |
| - Protocol card port | - Display Screen | - Yellow valve | brackets | |

10. Label the following diagram of the MCS Centrifuge well using the list of names below



- Centrifuge Well
- Cover Switch
- Centrifuge Cover
- Fluid Detectors
- Vacuum Chuck
- Bowl Optics

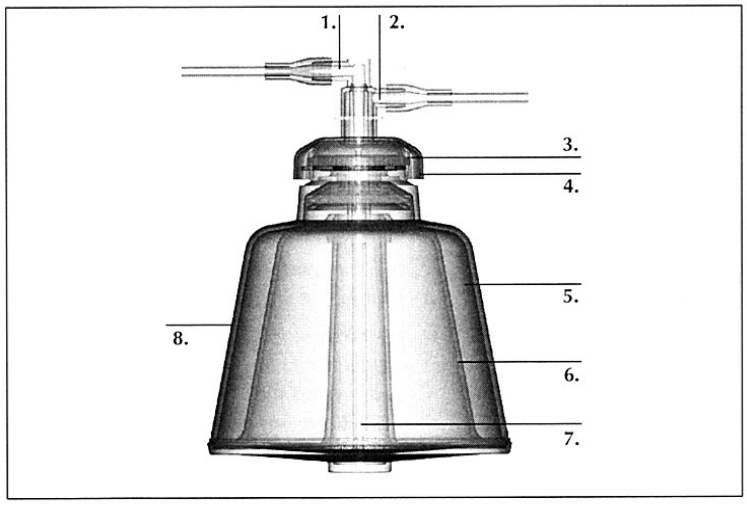



*Figure 4-6, Latham centrifuge bowl*

11. Identify item 1 to 8 on the above bowl diagram

*1* _____ *2* _____

*3* _____ *4* _____

*5* _____ *6* _____

*7* _____ *8* _____

12. If the MCS+ encounters an error, the machine stops its _____, sounds an _____ and displays the _____ _____ . Each notice _____ has its own message.

13. The operator communicates with the MCS+ computer through the _____.

14. When _____ is pressed, the disposable set is primed with_____

15. When _____ is pressed, the _____ is initiated.

16. In the RETURN mode, the machine _____ the remaining _____ to the patient.

17. The PUMP _____ key stops the _____ and _____pumps.

18. The UP/DOWN arrows _____ and _____ the pump speed during a procedure.

19. Pressing MODIFY displays the _____ _____ screen.

20. The _____ Card contains the operating program for an MCS+.

21. The _____ Pressure _____ regulates the speed of the pumps and provides feedback about the _____ from the patient.

22. The _____ Pressure _____ ensures that the functionally closed barrier of the _____ seal of the bowl has not been compromised.

23. The _____ measures, in grams, the weight of the _____ in the bag.

24. The _____ monitors the anticoagulant line, and the_____ _____ monitors the donor line for air.

25. The _____ is monitoring for _____ only during _____ and at the beginning of ._____

26. The _____ monitors for air and serves as a backup to the _____

27. In DRAW the _____ Pump _____ anticoagulated whole blood through the set and into the bowl.

28. The Anticoagulant Pump turns only in _____ and _____.

29. The Anticoagulant _____ _____ detects flow of anticoagulant during the and _____ mode.

30. The Centrifuge operates in a range of _____ to _____revolutions per minute.

31. The bowl is held in the Centrifuge by a _____.

32. The Bowl Optics Sensor is located in the _____ _____.

33. The _____ Sensor monitors the density of the blood components in the _____tubing, after they exit the _____.

34. The Pressure Cuff maintains pressure during _____ and automatically deflates when the machine enters the _____ mode.

35. The 1000 ml temporary substitution fluid bag is hung in the following manner:
    A. Hang with ports down on the top front pins at the front panel
    B. Hang with ports down on the four pins located on the right side panel
    C. Hang with ports down on the weigher arm
    D. Hang with ports up on the weigher arm

36. If the operator hears a loud bowl noise after installation of the disposable, they should:
    A. Press STOP key
    B. Reseat the bowl
    C. Discard the disposable
    D. A, B
    E. A, C

37. The outlet port of the bowl faces to the left
    A. TRUE
    B. FALSE

38. Which of the following must be confirmed to be correct prior to installing the disposable?
    A. List Number
    B. Disposable Type
    C. Expiry Date
    D. A and D
    E. All of the above

39. When the Latham Bowl is installed in the centrifuge, the Outlet Port should face to the right.
    A. True
    B. False

40. When connecting the System Pressure Monitor (SPM) to the SPM port, the connection needs to be secured with a quarter turn.
    A. True
    B. False

41. How many mls does the air bag hold?
    A. 1000 mls
    B. 500 mls
    C. 250 mls
    D. 5000 mls

42. Which of the following tubing is installed into the BLAD and Donor Valve?
    A. Red Coded Tubing
    B. Green Coded Tubing
    C. Colorless Tubing
    D. Yellow Coded Tubing
    E. None of the above

43. Which of the following tubing is installed into the ACAD and DLAD
    A. Red Coded Tubing
    B. Green Coded Tubing
    C. Colourless Tubing
    D. Yellow Coded Tubing
    E. None of the above

44. What is the final step in the disposable set up?
    A. Connect the DPM
    B. Close the White ratchet clamp on the “pig tail” line near the Blue needle connector.
    C. Spike all solutions
    D. Clamp Platelet Storage Bags
    E. None of the above

# APPENDIX B

## Glossary and Definition of Terms

**Allogeneic:** A graft or tissue from someone other than the patient, usually a matched sibling (a brother or sister), but may be a matched unrelated volunteer donor.

**Antibodies:** immunoglobulins (a specialized immune protein) produced as a result of the introduction of an antigen into the body

**ARCBS:** Australian Red Cross Blood Service

**Autoimmune disease:** an illness occurring when the body tissues are attacked by its own immune system; as a result, patients with these diseases frequently have unusual antibodies circulating in their blood that target their own body tissues

**Autologous:** A transplant or transfusion in which, the patients own blood/bone marrow/stem cells are used.

**Bullous pemphigoid:** a disease characterized by tense blistering eruptions of the skin, generally caused by antibodies abnormally accumulating in a layer of the skin

**CD34+:** Is a cell surface antigen representative of a stem cell as well as some other cell types. Currently there are no methods to directly identify or quantitate stem cells therefore CD34 is used as a surrogate marker for stem cells.

**Cerebritis:** inflammation of the brain

**CFU:** Colony Forming Units.

**Cryoglobulinemia:** the presence of abnormal proteins called cryoglobulins that, by definition, have the unusual properties of precipitating from the blood serum when it is chilled and redissolving upon rewarming

**Cryoprecipitate:** Cryoprecipitate is rich in factor VIII, von Willebrand's factor, fibrinogen, fibronectin and factor XIII. It contains about 70% of factor VIII and is the most concentrated form other than the factor VIII concentrates. In addition, it is useful for treatment of von Willebrand's disease, factor XIII deficiency, fibrinogen deficiencies and DIC.

**Cryosupernate:** FFP from which cryoprecipitate has been removed and plasma has been re-frozen. Also called **cryo-poor plasma** as it is poor in factor VIII, fibrinogen, von Willebrand's factor XIII but contains other coagulation factors. It may therefore, be used for the management of factor IX deficiency and for haemostatic disorders complicating liver disease.

**Dendritic Cells:** Dendritic cells (DC) are the most effective or 'professional' of the antigenpresenting cells (APC) that initiate primary immune responses. They are located at surveillance sites where they capture and process antigens. Dendritic cells not only activate lymphocytes to induce the immune response, but they also minimize autoimmune reactions by tolerizing T cells to self-antigens. There is evidence for two developmental lineages for DC: a myeloid line shared with phagocytes, and a lymphoid line shared with T cells.

**Erythrocytes:** Are red blood cells (RBC). Their primary function is to transport haemoglobin that carries oxygen from the lungs to the tissues.

**FBC:** Full Blood Count, a pathology test

**Fresh Frozen Plasma:** FFP contains the coagulation factors present in the original unit of blood. On average, one ml of plasma, contains one unit of each of the coagulation factors other than fibrinogen. FFP is the treatment of choice for replacement of coagulation factor deficiencies where the specific factor concentrate is not available, immediate reversal of warfarin effect, DIC and TTP (thrombotic thrombocytopenic purpura). FFP is also indicated in patients with bleeding tendencies due to multiple coagutation factors deficiencies such as liver disease, DIC, massive blood transfusion and cardiovascular bypass surgery.

**G-CSF:** Granulocyte Colony Stimulating Factor.

**Guillain-Barre:** this condition usually occurs after an infection; the signs and symptoms include loss of sensation in the arms and legs and increasing weakness

**Haematopoiesis:** Is the process by which circulating blood cells are produced in sufficient numbers, under normal conditions and in times of increased need. Times of increased need may include response to infection, bleeding, and increased oxygen demand after chemotherapy. In infants haematopoiesis occurs in almost every bone. By adulthood it occurs mainly in large bones such as the sternum, ribs, pelvis, skull and the proximal end of the long bones.

**Heterozygotes:** a person possessing two different forms of a particular gene, one inherited from each parent

**H.E.L.L.P. syndrome of pregnancy:** a severe disease affecting pregnant women; the liver, blood cells, and other organs are involved

**Hct:** Haematocrit, the volume percentage of erythrocytes in whole blood and indicates the ratio of cell volume to plasma volume.

**Homozygotes:** a person who has two identical forms of a particular gene, one inherited from each parent

**HPC:** Haematopoietic Progenitor Cells

**Human Leukocyte Antigens:** Human leukocyte antigen (leukocyte is the name for a white blood cell, while antigen refers to a genetic marker) is a substance that is located on the surface of white blood cells. This substance plays an important role in the body's immune response. Because the HLA antigens are essential to immunity, identification aids in determination of the degree of tissue compatibility between transplant recipients and donors. Testing is done to diminish the likelihood of rejection after transplant, and to minimise graft-versus-host disease (GVHD) following major organ or bone marrow transplantation.

**Immune complex:** a combination of an antibody (immunoglobulin), and an antigen (the target that the antibody is attacking)

**Immune thromobocytopenic purpura:** a condition in which antibodies destroy the cells in the body that are responsible for blood clotting (platelets)

**Immunoglobulin:** a protein produced by plasma cells and lymphocytes; immunoglobulins are an essential part of the body's immune system which attach to foreign substances, such as bacteria, and assist in destroying them

**Leukocytes:** Are white blood cells (WBC) and there are three (3) different lineages:

- Granulocytes (neutrophils, basophils, eosinophils)
- Monocytes
- Lymphocytes

**Megakaryocytes:** Are the precursor to platelets. Their primary function is to participate in the clotting mechanism by adhering to injured tissue & each other to form a clot.

**MNC:** Mononuclear cell.

**Myeloma kidney:** kidney damage from antibodies made by a tumour of the white blood cells

**Myocarditis:** inflammation of the heart muscle

**Nephritis:** inflammation of the kidney

**Pemphigus vulgaris:** an autoimmune disease of the skin, with blistering

**PBPC:** Peripheral Blood Progenitor Cell.

**PBSC:** Peripheral Blood Stem Cell.

**Plt:** Platelet

**PMN**: Polymorphonuclear Leukocytes (neutrophils/ granulocytes)

**Polymyositis:** a chronic inflammatory disease of muscle that begins when white blood cells spontaneously invade muscles, which may result in severe muscle pain, tenderness and weakness

**PP:** Plasmapheresis

**PRA:** panel reactive antibodies

**Pure red cell aplasia:** inability to produce red blood cells

**Regional enteritis:** (Crohn's disease) a chronic inflammatory disease of the intestine primarily in the small and large intestines but which can occur anywhere in the digestive system between the mouth and the anus

**Scleroderma:** a disease of connective tissue resulting in formation of scar tissue in the skin and at times other organs of the body

**Segmental glomerulosclerosis:** an illness that occurs when scar tissue forms in some of the glomeruli (structures involved in the filtration of blood) of the kidney

**Stem Cells:** Are produced in the bone marrow from which all blood cells originate. The stem cell is the most primitive cell having the ability to replicate repeatedly and differentiate into both the myeloid or lymphoid cell lines.

**TPE:** Therapeutic plasma exchange

**Vasculitis:** a general term for a group of uncommon diseases characterized by inflammation of the blood vessels

**Waldenstrom's macroglobulinemia:** a disease where abnormal white blood cells produce excessive amounts of antibodies; bleeding and enlarged liver and spleen may be seen

**WCC:** White cell count

**WBC:** White blood cell