Apheresis Instrumentation

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Conflict of Interest

- Consulting: Fresenius Kabi
Objectives
- Introduction
- Historical events
- Principles of operation
- Types of separation
- Selective removal
- Common features of apheresis equipment
- Maintenance & cleaning
- Safety
- Extracorporeal photopheresis
- Stem cell collections
- Apheresis vs. Hemodialysis
Reference Book

• Principles of Apheresis Technology 5th, 6th Edition
  Technical Principles of Apheresis Medicine
  Walter Linz, MD.MBA: Senior Editor

• Chapter 2: Apheresis Instrumentation
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  Amber P. Sanchez, MD

Editors: Hans Vrielink, MD,PhD, Sheryl M. Kempin RN,MA

ASFA, 2014,2017
Cross Section of Centrifuge Bowl.

1. Top Seal
2. Whole Blood
3. RBC
4. WBC
5. Plasma
6. Saline
7. Transparent Top
8. Separation Channel
9. Outer Shell
10. Filler Piece
11. Rectangular O Rings
12. Handle
13. Bottom Seal

Dimensions:
- 6.875 inches (174.625mm)
- 5.250 inches (133.35mm)
Principles of Operation
Three Steps

• Draw and separate the blood
• Remove the target component
• Return or replace the remaining components
Types of Separation

- Centrifugation
- Elutriation
- Filtration
- Combination of filtration and centrifugation
### TYPES OF SEPARATION

<table>
<thead>
<tr>
<th>FILTRATION</th>
<th>CENTRIFUGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size (diameter)</strong></td>
<td><strong>Density (specific gravity)</strong></td>
</tr>
<tr>
<td>Plasma</td>
<td>Plasma (1.025-1.029)</td>
</tr>
<tr>
<td>• Platelet (3 ( \mu \text{m} ))</td>
<td>• Platelet (1.040)</td>
</tr>
<tr>
<td>• RBC (7 ( \mu \text{m} ))</td>
<td>• Lymph (1.070)</td>
</tr>
<tr>
<td>• Lymph (10 ( \mu \text{m} ))</td>
<td>• Gran (1.087-1.092)</td>
</tr>
<tr>
<td>• Gran (13 ( \mu \text{m} ))</td>
<td>• RBC (1.093-1.096)</td>
</tr>
</tbody>
</table>
Specific Gravities

The ability of cells to be separated by centrifugation is directly proportional to their specific gravity. Total centrifugal force is a function of g force exerted and time.
CENTRIFUGATION
Centrifuge Apheresis

Permission of Dr. Dobri Kiprov
Centrifugation
Separation by weight (specific gravity)

• Can be used for cells or plasma
• G force defined by RPM and rotor radius
• Dwell time is important
• High viscosity can affect
• RBC size can affect
• Dual stage channels = multiple G forces
• Continuous flow versus intermittent flow
Spectra Dual Stage Channel
Standard and Turbo Modification

TURBO MOD.
Component Separation - TPE

- Platelets/White Cells
- Ramp
- Low-G Wall
- High-G Wall
- Outlet Plasma (low platelets)
- Outlet Packed Red Blood Cells
- Inlet Whole Blood
- G-Force
ELUTRIATION
Basic Principles of MNC Collection

1. Whole blood enters the channel
2. Blood separates in the connector
3. Buffy coat layer is pumped into the chamber
4. Platelets are returned to the patient and MNC cells are pumped into the collection bag
2. Chamber Fills

Separation in the chamber

- Target cells accumulate in the chamber
- Platelets are continuously pumped back to the patient
Separation stage/platelet trajectory

Outlet PRP

Low-G wall

Inlet blood

High-G wall

Outlet PRBC

Separation stage/MNC trajectory

Outlet PRP

Low-G wall

Inlet blood

High-G wall

Outlet PRBC

Separation stage/granulocyte trajectory

Outlet PRP

Low-G wall

Inlet blood

High-G wall

Outlet PRBC
FILTRATION
Membrane Apheresis

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FILTRATION & CENTRIFUGATION
SELECTIVE REMOVAL THERAPY
Membrane Differential Filtration

- Whole Blood
- Plasmapheresis Filter
- Plasma
- Treated Plasma
- Cells
- RheoFilter
- Whole Blood
Blood Cell Adsorption by Adacolumn®

- The Adacolumn is filled cellulose acetate beads that adsorb approx 50% of granulocytes and 40% of monocytes from patient’s blood for each passage.
- The effects on RBC is minimal.
Adacolumn

- Adacolumn
- Adacircuit
- Adamonitor
- Adastand

Venous Pressure Monitor

Air sensor

Blood return

Blood draw

Anticoagulant Port

Venin

Pump

Graphics courtesy of Otsuka America Pharmaceutical, Inc
Immunosorba PA

Anticoagulation

Buffer PA

Eluant PA

Plasma separation via centrifuge

Fraction bag

Waste bag

Graphics courtesy of Fresenius HemoCare
Immunosorba PA

- Immunoglobulins adsorbed with Staph Protein A bound to Sepharose
- Column regenerated with sodium citrate 0.13 M buffer at a pH of 2.2
- Removes:
  - 97% IgG1
  - 98% IgG2
  - 40% IgG3
  - 77% IgG4
  - 56% IgM
  - 55% IgA

Graphics courtesy of Fresenius HemoCare
Liposorber® System

Graphics courtesy of Kaneka Pharma America Corporation
Heparin-induced Extracorporeal LDL Precipitation

Graphics courtesy of B Braun.
COMMON FEATURES of APHERESIS EQUIPMENT
PUMPS
VALVES
SENSORS
SEPARATORS
MICROPROCESSORS
MAINTENACE & CLEANING
Maintenance

• Follow manufacturer recommendations
  • Annual or semiannual PM
  • Routine maintenance
• Watch for worn or damaged parts
• Keep the equipment clean
Cleaning

- Very important
  - Blood, plasma, albumin, ACD-A, HES = sticky
  - Also contaminating agents
  - Saline is corrosive
- Follow manufacturer recommendations
- Use appropriate cleaning agents
- Extreme spills may require service personnel
SAFETY
Safety

- Follow manufacturer operating instructions
- Watch for hemolysis
  - Kinked tubing
  - Wrong fluids
  - Hot centrifuge
  - High TMP during filtration
- Prevent large spills- fluids & electricity=bad day
- Keep safety sensors and latches in place
- Prevent loose items near centrifuges
EXTRACORPOREAL PHOTOPHERESIS
PERIPHERAL BLOOD STEM CELLS (HPC) & MNC COLLECTIONS
Hematopoietic Progenitor Cells

- Autologous
- Allogeneic
- Long procedures
- Mobilized patients/donors
- Difficult to get the specific cells
- Consider extra corporeal volume (ECV)
- Consider citrate toxicity
Mononuclear Cell Collections

- Dendritic cell collections
- Donor lymphocyte infusions (DLI)
- Research collections
# Apheresis versus Hemodialysis

<table>
<thead>
<tr>
<th></th>
<th>Apheresis</th>
<th>Hemodialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Removal</strong></td>
<td>Cell or protein pathogens</td>
<td>Small to midsized diffusible molecules</td>
</tr>
<tr>
<td><strong>Large molecular mass</strong></td>
<td></td>
<td>Spares proteins and cells</td>
</tr>
<tr>
<td><strong>Slow rate of formation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low volume of distribution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanism</strong></td>
<td>Separates by blood fractions, removes or replaces fractions</td>
<td>Uses semi-permeable membranes and concurrent flow, small molecules and electrolytes exchanged</td>
</tr>
<tr>
<td><strong>Technique</strong></td>
<td>Primarily Centrifugation <strong>separates by density</strong></td>
<td>Membrane separation (filter) <strong>separates by size</strong></td>
</tr>
</tbody>
</table>
## Apheresis versus Hemodialysis (cont)

<table>
<thead>
<tr>
<th></th>
<th>Apheresis</th>
<th>Hemodialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Fluid</td>
<td>Very limited</td>
<td>Ultrafiltration to restore fluid balance</td>
</tr>
<tr>
<td>Flow Rates</td>
<td>15-165 mL/min, can use peripheral or IV catheter</td>
<td>100-500 mL/min, requires high flow catheter</td>
</tr>
<tr>
<td>Duration</td>
<td>Usually short term treatment, days-months</td>
<td>Usually long term treatment, up to years</td>
</tr>
<tr>
<td>Anticoagulant</td>
<td>Usually citrate or citrate/heparin combined</td>
<td>Heparin only</td>
</tr>
</tbody>
</table>

Courtesy of Amber Sanchez MD
SUMMARY

• Can’t do apheresis without the instruments

• Need operator and instrument team work to help the patient/donor

• Remember: the instruments are your friends