Therapeutic Plasma Exchange
Part II: Treatment Considerations

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Overview

- TPE selection criteria, treatment goals, and plan
- Factors influencing TPE treatment dose and schedule
- Vascular access and blood flow rate
- TPE replacement fluids
- Anticoagulation
- Complications
- TPE and medications
- Influence of TMPa, blood flow rate, and patient hematocrit
TPE: Standard Medical Treatment

Treatment Goals
• Early treatment to halt inflammatory response
• Modulation of the abnormal immune response
• Remove the causative factor

Treatment Plan
• Immunosuppressant medications (i.e., steroids) to inhibit inflammatory response
• Chemotherapy/immunomodulators (i.e., Rituxan) to modulate immune function
• TPE to remove diseased components

The TPE treatment schedule is prescribed by the physician based upon the patient-specific disease state.

TPE treatment schedule and patient outcomes are influenced by the plasma protein kinetics of the targeted substance:

- Volume of distribution
- Rebound / resynthesis
- Half-life

**Volume of Distribution**

**Intravascular vs. extravascular**

- Is the substance targeted to be removed primarily in the intravascular or extravascular space?

The extent of removal of a substance during TPE depends on:²

- The volume of the patient’s plasma removed in relation to total plasma volume
- The distribution of the substance between the intravascular and extravascular compartments
- How rapidly the substance re-equilibrates between compartments

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Plasma Rebound

**TPE is an intermittent therapy**

- Intervals between treatments will be determined by the time it takes for plasma levels to rebound
- Plasma rebound is defined by the length of time it takes for the targeted substance to return to near pre-treatment value
- Plasma rebound is governed by two processes:
  - **Resynthesis:** as the substance is removed by TPE, the body continues to synthesize more
  - **Re-distribution:** the process by which a substance equalizes and moves from the intracellular to the extracellular then to the intravascular space.

Plasma Half-Life

**Half-life (t_{1/2}):** the amount of time it takes for a substance to be reduced to half of its initial value

The half-life of a substance plays a role in TPE prescription because it predicts how long it takes for plasma rebound to occur.

**IgM as an example:**

- **IgM t\textsubscript{1/2} = 5 days**
  - It takes 5 days to↓ IgM levels by ½

- **IgM is accumulating** – although IgM is being exhausted by half over 5 days, it is also being resynthesized by the body

- **TPE treatment is planned to stay ahead of this production curve** and decrease total body burden
TPE Prescription and Dose

After the patient- and disease-specific treatment schedule has been determined, the physician must make a few more prescription and TPE dose decisions:

- Vascular access and blood flow rate
- Estimated total blood volume (TBV) and plasma volume (PV)
- Plasma exchange volume (replacement fluid rate)
- Replacement fluid
- Anticoagulation
- Machine settings
Vascular Access & Blood Flow Rate

**Vascular Access**\(^1,2\)

- Central Venous Catheter:
  - Internal Jugular
  - Femoral
  - Subclavian
- Arteriovenous fistula/graft

**Blood Flow Rate**

- Range: 100 – 250 ml/min\(^3\)
- Minimum: 100 ml/min\(^3\)
- *Lower rates can be delivered for low weight patients, if necessary; lower BFR may contribute to clotting and/or access issues*\(^2\)

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Volume Calculations: Total Blood, Plasma & Total Exchange

Several steps are involved in determining the volume of plasma to be exchanged per treatment

<table>
<thead>
<tr>
<th>Necessary values and common formulas to determine TPE volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient’s weight</td>
</tr>
<tr>
<td>Patient lab results</td>
</tr>
<tr>
<td>Estimated TBV</td>
</tr>
<tr>
<td>Estimated PV</td>
</tr>
<tr>
<td>TPE prescription</td>
</tr>
<tr>
<td>Total exchange volume</td>
</tr>
</tbody>
</table>

Step 1:
Estimating Total Blood Volume (TBV)

Formulas:

Weight (kg) x 70 ml/kg for normal male adults = TBV
Weight (kg) x 65 ml/kg for normal female adults = TBV
Weight (kg) x 80/70 ml/kg for normal infant/child = TBV

Example: (normal adult male)
100 kg x 70 ml/kg = 7000 ml TBV

(Note: Some facilities may use alternative formulas to calculate TBV and Plasma Volume. Example: Nadler's Formula)

Step 2:
Estimating Plasma Volume (PV)

**Formula:**

\[ \text{TBV} \times (1.0 - \text{Hct} \%) = \text{PV} \]

**Example:**

7000 ml \( \times (1.0 - 0.42) \)
7000 ml \( \times 0.58 = 4060 \text{ ml PV} \)

(Note: Hct of 42% = 0.42)

Step 3: Calculating Plasma Exchange Volume

**Formula:**

\[ PV \times \text{Number of exchanges prescribed} = \text{Total Exchange Volume} \]

**Example:**

- \(4060 \text{ ml} \times 1.5 \text{ (or 150\%)} = 6090 \text{ ml}\)
- Total plasma volume to exchange: \(6090 \text{ ml}\)

(Note: The total replacement volume ordered will reflect the total plasma volume to exchange.)


The number of PV exchanges is prescribed by the physician based on treatment goals.

- The relationship between plasma volume exchanged and concentration of substances is illustrated below:

<table>
<thead>
<tr>
<th>Plasma Volume Exchanged</th>
<th>Volume Exchanged</th>
<th>Amount of Substances Removed (macromolecule reduction ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 or 50%</td>
<td>1,400</td>
<td>39%</td>
</tr>
<tr>
<td>1.0 or 100%</td>
<td>2,800</td>
<td>63% (24% increase)</td>
</tr>
<tr>
<td>1.5 or 150%</td>
<td>4,200</td>
<td>78% (15% increase)</td>
</tr>
<tr>
<td>2.0 or 200%</td>
<td>5,600</td>
<td>86% (8% increase)</td>
</tr>
<tr>
<td>2.5 or 250%</td>
<td>7,000</td>
<td>92% (6% increase)</td>
</tr>
</tbody>
</table>

# TPE Calculation Practice

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<tr>
<th>Patient characteristics</th>
<th>Results</th>
</tr>
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<tbody>
<tr>
<td>Patient’s weight</td>
<td>100 kg</td>
</tr>
<tr>
<td>Patient’s lab result: Pre-treatment HCT %</td>
<td>34% or 0.34</td>
</tr>
<tr>
<td><strong>TPE prescription:</strong></td>
<td></td>
</tr>
<tr>
<td>Number of exchanges</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>TBV:</strong> Weight (kg) x 70 mL/kg for adults = TBV</td>
<td></td>
</tr>
<tr>
<td><strong>PV:</strong> TBV x (1.0 – HCT %) = PV</td>
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</tr>
<tr>
<td><strong>Total exchange volume:</strong> PV x number of exchanges = total exchange volume</td>
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# TPE Calculation Practice - Answers

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<td>Weight (kg) x 70 mL/kg for adults = TBV</td>
<td>7000 mL</td>
</tr>
<tr>
<td>PV:</td>
<td></td>
</tr>
<tr>
<td>TBV x (1.0 – HCT %) = PV</td>
<td>4620 mL</td>
</tr>
<tr>
<td>Total exchange volume:</td>
<td></td>
</tr>
<tr>
<td>PV x number of exchanges = total exchange volume</td>
<td>6930 mL</td>
</tr>
</tbody>
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TPE Replacement Fluids

**Purpose**
- Restore vascular volume
- Restore oncotic pressure
- Supply coagulation factors

**Most Common Types**
- Colloid solution (albumin and/or fresh frozen plasma)
- Combination of crystalloid/colloid solution

## Albumin (5%)

### Limitations
- Occasional hypotension
- Pulmonary edema following rapid increase in albumin
- Clotting factor depletion or Coagulopathy
- Immunoglobulin depletion

### Benefits
- Most commonly used
- No viral transmission
- Less expensive than FFP
- Maintains stable blood volume
- Allergic reactions are rare

### Clinical Note
A less commonly used mixture is 70:30 5% Albumin and 0.9% normal saline (with or without added electrolytes)

Fresh Frozen Plasma (FFP)

**Benefits**
- Replaces plasma clotting factors
- No post-pheresis coagulopathy
- No immunoglobulin deficiencies

**Limitations**
- Anaphylactic reactions
- ABO matching
- Viral transmission (rare)
- Citrate load: Hypocalcemia
- Expensive

**Selection Criteria**
- Fibrinogen level <125mg/dl
- Coagulation factors below normal value
- Reduced platelet count

Anticoagulation

- Recommended for use in TPE if no contraindication exists
- Heparin (systemic): preferred method for membrane filtration
- Citrate (regional): preferred method for centrifugal devices (but can be used for membrane devices)
- Follow hospital standard protocol

Potential Complications

Adverse effects of TPE may include:

- Anaphylactoid reactions (with FFP)
- Fluid imbalance: hypovolemia or overload
- Hypothermia
- Convective electrolyte loss
- Hemolysis*
- Clotting*

* Risk of clotting and hemolysis can be minimized by closely monitoring TMPs and filtration fraction levels during therapy

**Medications and TPE**

**ACE inhibitors**

**Risk**
- Anaphylactic reactions if albumin is used for replacement solution during TPE
- Bradykinin release resulting in vasodilation and hypotension

**Prevention**
- Withhold ACE inhibitors for at least 24-48 hours prior to TPE procedure

**Antibiotics, other medications**

**Risk**
- May be removed during TPE based on the volume of distribution of the drug in the body
- Drugs that are highly protein bound have a small volume of distribution and will easily be eliminated by TPE because the drug remains in the plasma component of the blood

**Prevention**
- Whenever possible, medications should be administered after the TPE procedure under physician guidance

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Factors Influencing Plasmafiltration

**TMPa**
- Access Transmembrane Pressure
- Machine calculated
- Alarm limit varies with BFR

**Blood flow rate (BFR)**
- Minimum of 100 ml/min
- Maximum of 250 ml/min

**Patient’s hematocrit (Hct)**

To decrease the TMPa and filtration fraction:
- Decrease the replacement rate or patient plasma loss flow rate
- And/or increase the blood flow rate

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Knowledge Check

- Can you identify the common TPE therapeutic goals?
- Can you identify the basic TPE prescription components?
- Can you cite nursing considerations when administering TPE?

Please refer to your facility's protocols before performing this treatment.
References
References