

Apheresis

Guideline Number: MMG003.L
 Effective Date: February 1, 2021

[➔ Instructions for Use](#)

Table of Contents	Page
Coverage Rationale	1
Documentation Requirements	4
Applicable Codes	4
Description of Services	5
Benefit Considerations	6
Clinical Evidence	6
U.S. Food and Drug Administration	14
References	14
Guideline History/Revision Information	16
Instructions for Use	16

Related Medical Management Guidelines
<ul style="list-style-type: none"> Bone or Soft Tissue Healing and Fusion Enhancement Products Prolotherapy and Platelet Rich Plasma Therapies

Coverage Rationale

[➔ See Benefit Considerations](#)

Therapeutic apheresis is proven and medically necessary for treating or managing the following conditions/diagnoses:

- Acute inflammatory demyelinating polyneuropathy (Guillain-Barré syndrome), primary treatment
- Acute liver failure (requiring [High Volume Plasma Exchange](#))
- ANCA-associated rapidly progressive glomerulonephritis (Granulomatosis with polyangiitis; and Microscopic Polyangiitis)
 - Dialysis dependent
 - Diffuse alveolar hemorrhage (DAH)
- Anti-glomerular basement membrane disease (Goodpasture’s syndrome)
 - Dialysis independent
 - DAH
- Cardiac transplantation, second line therapy
 - Recurrent rejection
 - Desensitization
- Chronic inflammatory demyelinating polyneuropathy
- Cryoglobulinemia, second line therapy
- Cutaneous T-cell lymphoma; mycosis fungoides; Sezary syndrome, erythrodermic
- Familial hypercholesterolemia
 - Homozygous
 - Heterozygous, second line therapy
- Focal segmental glomerulosclerosis, recurrent in transplanted kidney, second line therapy
- Graft-versus-host disease
 - Acute
 - Chronic second line therapy
- Heart transplantation in children less than 40 months of age, ABO incompatible, second line therapy
- Hereditary hemochromatosis
- Hyperlipoproteinemia

- Hypertriglyceridemic pancreatitis, severe
- Hyperviscosity in hypergammaglobulinemia
- Idiopathic dilated cardiomyopathy, NYHA class II-IV, via IA
- Inflammatory bowel disease, via adsorptive cytopheresis
- Liver transplantation, ABO incompatible
 - Desensitized ABOi
 - Living donor
- Lung transplantation, bronchiolitis obliterans syndrome
- Major hematopoietic stem cell transplant, ABO incompatible, second line therapy
 - HPC(M)
 - HPC(A)
- Multiple sclerosis, second line therapy
 - Acute CNS inflammatory, demyelinating
 - Relapsing form with steroid resistant exacerbations
- Myasthenia gravis, acute
- Myeloma cast nephropathy, second line therapy
- Neuromyelitis optica spectrum disorders (Devic's syndrome), acute or relapse, second line therapy
- N-methyl D-aspartate receptor antibody encephalitis
- Paraproteinemic polyneuropathies via Therapeutic Plasma Exchange (TPE)
 - Anti-MAG
 - Multifocal motor
 - IgG/IgA
 - IgM
- Pediatric autoimmune neuropsychiatric disorders associated with streptococcal infections (PANDAS exacerbation)
- Peripheral vascular diseases
- Polycythemia vera; erythrocytosis
- Progressive multifocal leukoencephalopathy associated with natalizumab
- Pruritus due to hepatobiliary diseases
- Renal transplantation, ABO compatible
 - Antibody mediated rejection
 - Desensitization, living donor
- Renal transplantation, ABO incompatible, second line therapy
 - Antibody mediated rejection
- Rheumatoid arthritis, refractory, second line therapy
- Sickle cell disease
 - Acute stroke or multiorgan failure
 - Acute chest syndrome, severe, second line therapy
 - Stroke prevention
 - Prevention of transfusional iron overload – for members requiring chronic transfusion
- Thrombotic microangiopathy, complement mediated
 - MCP mutations
- Thrombotic microangiopathy, Shiga toxin mediated
 - Absence of severe neurological symptoms
- Thrombotic thrombocytopenic purpura
- Vasculitis
 - Behcet's disease (adsorptive cytopheresis)
 - Idiopathic PAN (TPE)
- Voltage gated potassium channel antibodies-related conditions
- Wilson's disease, fulminant

Due to insufficient evidence of efficacy, therapeutic apheresis including plasma exchange, plasmapheresis, or photopheresis is unproven and not medically necessary for treating or managing the following conditions/diagnoses, including but not limited to:

- Acute disseminated encephalomyelitis
- Acute inflammatory demyelinating polyneuropathy (Guillain-Barré syndrome), after IVIG

- Age related macular degeneration
- Amyloidosis, systemic
- Amyotrophic lateral sclerosis
- ANCA-associated rapidly progressive glomerulonephritis, dialysis independent (Granulomatosis with polyangiitis; and Microscopic Polyangiitis)
- Anti-glomerular basement membrane disease, dialysis dependent, without DAH (Goodpasture's syndrome)
- Aplastic anemia; pure red cell aplasia
- Atopic (neuro-) dermatitis (atopic eczema), recalcitrant
- Autoimmune hemolytic anemia; warm autoimmune hemolytic anemia (WAIHA); cold agglutinin disease
- Babesiosis
- Burn shock resuscitation
- Cardiac neonatal lupus
- Cardiac transplantation
 - Antibody mediated rejection
 - Rejection prophylaxis
- Catastrophic antiphospholipid syndrome
- Chronic focal encephalitis (Rasmussen's encephalitis)
- Coagulation factor inhibitors
- Complex regional pain syndrome
- Cutaneous T-cell lymphoma; mycosis fungoides; Sézary syndrome, non-erythrodermic
- Dermatomyositis/polymyositis
- Erythropoietic porphyria, liver disease
- Focal segmental glomerulosclerosis, native kidney, steroid resistant
- Hashimoto's encephalopathy
- HELLP syndrome
- Hematopoietic stem cell transplantation
 - HLA desensitized
 - Major/minor ABO incompatibility with pure RBD aplasia
 - MinorHPC(A)
- Hemolytic uremic syndrome
- Hemophagocytic lymphohistiocytosis
- Henoch-Schonlein purpura
- Heparin induced thrombocytopenia and thrombosis
- Hyperleukocytosis
- Hypertriglyceridemic pancreatitis, prevention
- Immune thrombocytopenia
- IgA nephropathy (Berger's Disease)
- Inflammatory bowel disease, via Extracorporeal Photopheresis
- Lambert-Eaton myasthenic syndrome
- Liver transplantation
 - ABO incompatible
 - Antibody mediated rejection
- Lung transplantation
 - Antibody mediated rejection
 - Desensitization
- Malaria
- Multiple sclerosis, chronic (unless noted above as proven)
- Nephrogenic systemic fibrosis
- Neuromyelitis optica spectrum disorders, maintenance
- Overdose, venoms, and poisoning
- Paraneoplastic neurologic syndromes
- Paraproteinemic polyneuropathy, multiple indications (unless noted above as proven)
- Pediatric autoimmune neuropsychiatric disorders associated with streptococcal infections (Sydenham's chorea, severe)
- Pemphigus vulgaris
- Phytanic acid storage disease (Refsum's disease)

- Post transfusion purpura
- Psoriasis
- Red cell alloimmunization, prevention and treatment
- Renal transplantation, ABO compatible, desensitized, deceased donor
- Scleroderma (systemic sclerosis)
- Sepsis with multiorgan failure
- Sickle cell disease (unless noted above as proven)
- Stiff-person syndrome
- Sudden sensorineural hearing loss
- Systemic lupus erythematosus, severe
- Thrombocytosis
- Thrombotic microangiopathy (unless noted above as proven)
- Thyroid storm
- Toxic epidermal necrolysis
- Vasculitis (unless noted above as proven)

Note: Please see [Description of Services](#) section for information regarding all apheresis-based procedures.

Documentation Requirements

Benefit coverage for health services is determined by the member specific benefit plan document and applicable laws that may require coverage for a specific service. The documentation requirements outlined below are used to assess whether the member meets the clinical criteria for coverage but do not guarantee coverage of the service requested.

Required Clinical Information
Apheresis
Medical notes documenting the following, when applicable: <ul style="list-style-type: none"> • Medical history, including transfusion history • Diagnosis • Treatment plan

Applicable Codes

The following list(s) of procedure and/or diagnosis codes is provided for reference purposes only and may not be all inclusive. Listing of a code in this guideline does not imply that the service described by the code is a covered or non-covered health service. Benefit coverage for health services is determined by the member specific benefit plan document and applicable laws that may require coverage for a specific service. The inclusion of a code does not imply any right to reimbursement or guarantee claim payment. Other Policies and Guidelines may apply.

CPT Code	Description
0342T	Therapeutic apheresis with selective HDL delipidation and plasma reinfusion
36511	Therapeutic apheresis; for white blood cells
36512	Therapeutic apheresis; for red blood cells
36513	Therapeutic apheresis; for platelets
36514	Therapeutic apheresis; for plasma pheresis
36516	Therapeutic apheresis; with extracorporeal immunoadsorption, selective adsorption or selective filtration and plasma reinfusion
36522	Photopheresis, extracorporeal

CPT® is a registered trademark of the American Medical Association

HCPCS Code	Description
S2120	Low density lipoprotein (LDL) apheresis using heparin-induced extracorporeal LDL precipitation

Description of Services

Therapeutic apheresis is a procedure in which the blood of a member is passed through an extracorporeal medical device which separates components of blood to treat a disease. It is a general term which includes all apheresis based procedures (Schwartz, et al., 2016; Padmanabhan et al.,2019):

Adsorptive Cytapheresis: A therapeutic procedure in which blood of the member is passed through a medical device, which contains a column or a filter that selectively adsorbs activated monocytes and granulocytes, allowing the remaining leukocytes and other blood components to be returned to the member.

Apheresis: A procedure in which blood of the member or donor is passed through a medical device which separates one or more components of blood and returns the remainder with or without extracorporeal treatment or replacement of the separated component.

B2 Microglobulin Column: The B2 microglobulin apheresis column contains porous cellulose beads specifically designed to bind to B2 microglobulin as the member's blood passes over the beads.

Erythrocytapheresis: A procedure in which blood of the member or donor is passed through a medical device which separates red blood cells from other components of blood. The red blood cells are removed and replaced with crystalloid or colloid solution, when necessary.

Extracorporeal photopheresis (ECP): A therapeutic procedure in which the buffy coat is separated from the member's blood, treated extracorporeally with a photoactive compound (e.g., psoralens) and exposed to ultraviolet A light then subsequently reinfused to the member during the same procedure.

Filtration Selective Removal: A procedure which uses a filter to remove components from the blood based on size. Depending on the pore size of the filters used, different components can be removed. Filtration-based instruments can be used to perform plasma exchange or LDL apheresis. They can also be used to perform donor plasmapheresis where plasma is collected for transfusion or further manufacture.

High-Volume Plasma Exchange (HVP): HVP is defined as an exchange of 15% of ideal body weight (representing 8–12 L); member plasma was removed at a rate of 1–2 L per hour with replacement with plasma in equivalent volume.

Immunoabsorption (IA): A therapeutic procedure in which plasma of the member, after separation from the blood, is passed through a medical device which has a capacity to remove immunoglobulins by specifically binding them to the active component (e.g., Staphylococcal protein A) of the device.

LDL Apheresis: The selective removal of low-density lipoproteins from the blood with the return of the remaining components. A variety of instruments are available which remove LDL cholesterol based on charge (dextran sulfate and polyacrylate), size (double-membrane filtration), precipitation at low pH (HELP), or immunoabsorption with anti-Apo B-100 antibodies.

Leukocytapheresis (LCP): A procedure in which blood of the member or the donor is passed through a medical device which separates white blood cells (e.g., leukemic blasts or granulocytes), collects the selected cells, and returns the remainder of the member's or the donor's blood with or without the addition of replacement fluid such as colloid and/or crystalloid solution. This procedure can be used therapeutically or in the preparation of blood components.

Plasmapheresis: A procedure in which blood of the member or the donor is passed through a medical device which separates plasma from other components of blood and the plasma is removed (i.e., less than 15% of total plasma volume) without the use of colloid replacement solution. This procedure is used to collect plasma for blood components or plasma derivatives.

Platelet Apheresis: A procedure in which blood of the donor is passed through a medical device which separates platelets, collects the platelets, and returns the remainder of the donor's blood. This procedure is used in the preparation of blood components (e.g., apheresis platelets).

RBC Exchange: A therapeutic procedure in which blood of the member is passed through a medical device which separates red blood cells from other components of blood. The member's red blood cells are removed and replaced with donor red blood cells and colloid solution.

Rheopheresis: A therapeutic procedure in which blood of the member is passed through a medical device which separates high-molecular-weight plasma components such as fibrinogen, a₂-macroglobulin, low-density lipoprotein cholesterol, and IgM to reduce plasma viscosity and red cell aggregation. This is done to improve blood flow and tissue oxygenation. LDL apheresis devices and selective filtration devices using two filters, one to separate plasma from cells and a second to separate the high-molecular-weight components, are used for these procedures.

Therapeutic Plasma Exchange (TPE): A therapeutic procedure in which blood of the member is passed through a medical device which separates plasma from other components of blood. The plasma is removed and replaced with a replacement solution such as colloid solution (e.g., albumin and/or plasma) or a combination of crystalloid/colloid solution.

Thrombocytapheresis: A therapeutic procedure in which blood of the member is passed through a medical device which separates platelets, removes the platelets, and returns the remainder of the member's blood with or without the addition of replacement fluid such as colloid and/or crystalloid solution.

Therapeutic apheresis does not include stem cell collection or harvesting for use in bone marrow/stem cell transplantation. It is usually performed in an outpatient facility and usually requires several hours to complete. In some clinical situations, plasma exchange may be performed daily for at least 1 week.

Benefit Considerations

Some of the disorders for which apheresis is unproven are serious, rare diseases. Coverage exists for some otherwise unproven services that treat serious, rare diseases when certain conditions are met. Consult the Policy & Procedure on review of benefit coverage for treatment of serious, rare diseases.

Clinical Evidence

The American Society for Apheresis (ASFA) (Padmanabhan et al., 2019) has reviewed therapeutic apheresis outcomes and published practice guidelines. The guidelines included analysis based on the quality of the evidence as well as the strength of recommendation derived from the evidence. ASFA categorizes disorders as noted below :

- Category I: Disorders for which apheresis is accepted as first-line therapy, either as a primary standalone treatment or in conjunction with other modes of treatment.
- Category II: Disorders for which apheresis is accepted as second-line therapy, either as a standalone treatment or in conjunction with other modes of treatment.
- Category III: Optimum role of apheresis therapy is not established. Decision making should be individualized.
- Category IV: Disorders in which published evidence demonstrates or suggests apheresis to be ineffective or harmful. IRB approval is desirable if apheresis treatment is undertaken in these circumstances.

ASFA recognized that categories alone are difficult to translate into clinical practice. Thus, they adopted a system to assign recommendation grades for therapeutic apheresis to enhance the clinical value of ASFA categories. The grading recommendations are adopted from Guyatt et al., 2008; Szczepiorkowski et al., 2010, Schwartz et al., 2016, and Padmanabhan et al., 2019:

- Grade 1A: Strong recommendation, high-quality evidence
- Grade 1B: Strong recommendation, moderate quality evidence
- Grade 1C: Strong recommendation, low-quality or very low-quality evidence
- Grade 2A: Weak recommendation, high quality evidence
- Grade 2B: Weak recommendation, moderate quality evidence

- Grade 2C: Weak recommendation, low-quality or very low-quality evidence

Sickle Cell Disease

Red blood cell exchange or erythrocytapheresis is being increasingly used for transfusion therapy in sickle cell disease (SCD). Many of the studies performed to evaluate this therapy are retrospective studies with small patient population.

The National Heart, Lung, and Blood Institute (NHLBI) published a clinical guideline for the management of SCD that includes the following recommendations relative to therapeutic apheresis (2014):

- In children with SCA, screen annually with TCD according to methods employed in the STOP studies, beginning at age 2 and continuing until at least age 16.
- In children with conditional (170–199 cm/sec) or elevated (>200 cm/sec) TCD results, refer to a specialist with expertise in chronic transfusion therapy aimed at preventing stroke.
- In all persons with SCD, perform urgent exchange transfusion—with consultation from hematology, critical care, and/or apheresis specialists—when there is rapid progression of ACS as manifested by oxygen saturation below 90 percent despite supplemental oxygen, increasing respiratory distress, progressive pulmonary infiltrates, and/or decline in hemoglobin concentration despite simple transfusion.
- In consultation with a sickle cell expert, perform exchange transfusion in people with SCD who develop acute stroke confirmed by neuroimaging.
- Initiate prompt evaluation, including neurologic consultation and neuroimaging studies, in people with SCD who have mild, subtle, or recent history of signs or symptoms consistent with transient ischemic attack.
- In children and adults who have had a stroke, initiate a program of monthly simple or exchange transfusions.
- In adults and children with SCA, transfuse RBCs to bring the hemoglobin level to 10 g/dL prior to undergoing a surgical procedure involving general anesthesia.
- In adults and children with HbSC or HbSB⁺-thalassemia, consult a sickle cell expert to determine if full or partial exchange transfusion is indicated before a surgical procedure involving general anesthesia.
- Administer iron chelation therapy, in consultation with a hematologist, to patients with SCD and with documented transfusion-acquired iron overload.

Wahl et al. (2012) compared alloimmunization rates between patients receiving simple or exchange chronic transfusions with erythrocytapheresis (ECP). Data were retrospectively collected for 45 SCD patients (N=23 simple, N=22 ECP) on a chronic transfusion program to determine the rate of antibody formation (antibodies formed per 100 units transfused). The 45 patients received 10,949 units and formed 6 new alloantibodies during the study period; therefore, the overall alloimmunization rate was 0.055 alloantibodies per 100U. The ECP group received significantly more blood. The rate of antibody formation (auto plus allo) was 0.040 antibodies per 100U in the ECP group and 0.171 antibodies per 100U in the simple transfusion group. The alloantibodies formed per 100 units was 0.013 in the ECP group and 0.143 in the simple transfusion group. The authors concluded that chronic ECP should be considered in patients requiring optimal management of HbS levels and iron burden. The authors stated that concerns about increased alloimmunization with ECP may be unjustified.

Velasquez et al. (2009) retrospectively reviewed red cell exchange (RCE) for the management of acute chest syndrome (ACS) in 44 patients with SCD. Clinical Respiratory Score (CRS) was assigned retrospectively to assess respiratory distress (0 = no distress, > 6 = severe). Median admission CRS of 2, progressed to 4 before RCE and declined to 2 within 24 hr afterwards. Median day of RCE was day 2 (IQR 1-3) and the main indication was worsening respiratory distress. No patient developed venous thrombosis, alloantibodies or other complications from RCE. According to the authors, RCE appears to be a safe and effective treatment for patients with SCD and ACS. The small study population limits the validity of the conclusion of this study.

Turner et al. (2009) evaluated the efficacy of exchange transfusion (XC) versus simple transfusion (ST) for treatment of SCA ACS. Twenty patients who received XC for ACS were compared with 20 patients who received ST. Cohorts were similar with regard to age; sex; prior ACS episodes; echocardiogram results; and antibiotic, bronchodilator, and hydroxyurea use. Maximum temperature recorded was higher in the XC group, but lactate dehydrogenase (LDH), WBCs, and indirect bilirubin were comparable. Admission Hb levels were higher for XC (XC 8.6 g/dL vs. ST 7.4 g/dL, p = 0.02) and XC had higher peak Hb levels during hospitalization. No differences were demonstrable in postprocedure length of stay (XC 5.6 days vs. ST 5.9 days) or total length of stay (XC 8.4 days vs. ST 8.0 days). A total of 10.3 +/- 3.0 units were transfused for XC compared to 2.4 +/- 1.2 units for ST. Based on postprocedure length of stay or total length of stay, the authors could not detect a difference in the efficacy of XC compared to ST in populations despite red blood cell product usage fourfold higher in the XC group. According to the authors, there is a need for an adequately powered, randomized trial to examine the true risk-benefit ratio of XC in ACS.

Hulbert et al. (2006) conducted a retrospective cohort study of 137 children with sickle cell anemia (SCA) and strokes to test the hypothesis that exchange transfusion at the time of stroke presentation more effectively prevents second strokes than simple transfusion. Children receiving simple transfusion had a 5-fold greater relative risk of second stroke than those receiving exchange transfusions. Interpretation of these findings is limited due to the retrospective design of the study.

Professional Societies

American Society for Apheresis (ASFA)

Regarding sickle cell disease, ASFA states:

- Red blood cell (RBC) exchange is an option for patients with acute stroke, severe acute chest syndrome (ACS), or other complication including but not limited to multiorgan failure.
- RBC exchange is also recommended as a prophylaxis for primary or secondary stroke.
- Studies have shown automated RBC exchange results in a more efficient removal/replacement of HbS RBCs than manual exchange or simple transfusions.
- Long-term RBC exchange has the advantage of preventing or markedly reducing transfusional iron accumulation (Padmanabhan et al., 2019).

Desensitization for Renal Transplants

Plasmapheresis has been used prior to renal transplants in highly sensitized patients to remove human leukocyte antigen (HLA) antibodies. Desensitization protocols use high dose intravenous immunoglobulin (IVIg) or low dose IVIg with plasmapheresis to convert a positive crossmatch to a negative crossmatch and allow for transplantation. Plasmapheresis may continue after the transplant or be reserved for posttransplant treatment of acute antibody mediated rejection (AMR). Clinical trials have demonstrated that living or deceased donor kidney recipients treated with plasmapheresis and IVIg have beneficial outcomes.

Montgomery et al. (2011b) used mathematical simulations verified by actual data from several national kidney-paired donation (KPD) programs to evaluate which donor/recipient phenotypes are likely to benefit from each transplant modality. They found that pairs that are easy to match are likely to receive compatible kidneys in a KPD. Those who are hard to match may be better served by desensitization with high-dose IVIg or plasmapheresis and low-dose IVIg. The phenotype which is both hard to match and hard to desensitize due to board and strong HLA reactivity are most likely to be transplanted by a hybrid modality utilizing desensitization after identifying a more immunologically favorable donor in a KPD. The authors state that recent outcomes from desensitization in which starting donor-specific antibody strength is low have been very good. For broadly sensitized patients with a high-strength cross-match, searching for a better donor in a KPD pool can facilitate a safer and more successful desensitization treatment course.

Montgomery et al. (2011a) used a protocol that included plasmapheresis and the administration of low-dose IVIg to desensitize 211 human leukocyte antigen (HLA)-sensitized patients who underwent live-donor renal transplantation (treatment group). The rates of death were compared between the group undergoing desensitization treatment and 2 carefully matched control groups of patients on a waiting list for kidney transplantation who continued to undergo dialysis (dialysis-only group) or who underwent either dialysis or HLA-compatible transplantation (dialysis-or-transplantation group). In the treatment group, Kaplan-Meier estimates of patient survival were 90.6% at 1 year, 85.7% at 3 years, 80.6% at 5 years, and 80.6% at 8 years, as compared with rates of 91.1%, 67.2%, 51.5%, and 30.5%, respectively, for patients in the dialysis-only group and rates of 93.1%, 77.0%, 65.6%, and 49.1%, respectively, for patients in the dialysis-or-transplantation group. The authors concluded that live-donor transplantation after desensitization provided a significant survival benefit for patients with HLA sensitization, as compared with waiting for a compatible organ. By 8 years, this survival advantage more than doubled. According to the authors, plasmapheresis does not result in a durable reduction in HLA antibody unless the patient undergoes transplantation within several days after the last treatment. This factor accounts for the paucity of reports of protocols that use plasmapheresis to desensitize patients who are on the waiting list for a transplant from a deceased donor.

Yuan et al. (2010) evaluated the efficacy of plasmapheresis plus low-dose IVIg in highly sensitized patients waiting for a deceased-donor renal transplant. Thirty-five highly sensitized patients (HLA class I panel reactive antibody greater than 50%) received plasmapheresis, plus low-dose IVIg treatment. In 25 patients (group 1), a positive T- and/or B-cell cytotoxicity crossmatch became negative by plasmapheresis plus low-dose IVIg treatment. Two patients did not receive renal transplants due to persistent positive crossmatch. Eight patients already had a negative crossmatch before desensitization. During the same time, 32 highly sensitized patients (group 2), without desensitization, had a negative crossmatch and received deceased-

donor renal transplants. Group 1 showed a numerically higher rate of acute rejection (32.0% vs 21.9%) and AMR (20.0% vs 9.4%), but the difference was not statistically significant. Comparable mean serum creatinine levels at 24 months were observed. No difference in Kaplan-Meier graft survival was found between group 1 and group 2 after follow-up of 52 +/- 26 months. The authors concluded that desensitization with plasmapheresis plus low-dose IVIG enables successful deceased-donor renal transplant in highly sensitized patients with a positive crossmatch. AMR occurred predominantly in recipients with donor-specific antibodies of high titers.

Meng et al. (2009) determined the percentage of panel reactivity and specificity of anti-HLA immunoglobulin (IgG) antibodies in 73 presensitized renal allograft recipients who underwent cadaveric renal transplantation compared with 81 unsensitized recipients who received cadaveric renal transplantation (control group). Sensitized patients had higher rates of graft rejection and graft loss. A total of 20 out of the 73 patients received pre-transplantation plasmapheresis (PP) and/or immunoadsorption (IA) and of these, 10 achieved negative panel reactive antibodies (PRAs). Graft rejection rate was 18% in unsensitized group, 41% in non-PP and/or IA sensitized group, and 20% in PP and/or IA sensitized group. Graft loss rate was 5% in unsensitized group, 21% in non-PP and/or IA sensitized group, and 15% in PP and/or IA sensitized group (20% positive PRA at transplant and 10% negative PRA at transplant). The authors concluded that pre-transplant PRA preparations might improve the access of presensitized patients to renal donors.

Pediatric ABO-Incompatible Heart Transplantation

Issitt et al. (2012) performed a retrospective analysis of all elective ABO-incompatible heart transplants performed at a single center from January 2001 - January 2011. Data included underlying conditions and demographics of the patients, the isohemagglutinin titer before and after plasma exchange, and survival figures to date. Twenty-one patients (ages 3-44 months) underwent ABO-incompatible heart transplantation. All patients underwent a "3 times" plasma exchange before transplantation, requiring exchange volumes of up to 3209 mL. Isohemagglutinin titers that were as high as 1:32 preoperatively were reduced to a range of 0-1:16 posttransplantation. One patient expired from causes unrelated to organ rejection. The authors concluded that through the use of a combination of adult reservoir/pediatric oxygenator and extracorporeal circuit, ABO-incompatible plasma exchange transfusions can be undertaken safely using a simplified "3 times" method, reducing the circulating levels of isohemagglutinins while providing minimal circuit size. This allows ABO-incompatible heart transplantation in a broader patient population than reported previously.

Dipschand et al. (2010) conducted a non-randomized prospective observational single institution study comparing clinical outcomes over 10 years of the largest cohort of ABO-incompatible recipients. ABO-incompatible (N=35) and ABO-compatible (N=45) infant heart transplantation recipients (\leq 14 months old, 1996-2006) showed no important differences in pretransplantation characteristics. In 7 patients, donor-specific isohemagglutinin titers were elevated at the time of transplantation, but were significantly reduced using intraoperative plasma exchange. Only 2 of the 7 required treatment for AMR (which occurred early post-transplantation, was easily managed and did not recur in follow-up). Occurrence of graft vasculopathy (11%), malignancy (11%) and freedom from severe renal dysfunction were identical in both groups. Survival was identical (74% at 7 years posttransplantation). The researchers concluded that ABO-blood group incompatible heart transplantation has excellent outcomes that are indistinguishable from those of the ABO-compatible population and there is no clinical justification for withholding this lifesaving strategy from all infants listed for heart transplantation. Further studies into observed differing responses in the development of donor-specific isohemagglutinins and the implications for graft accommodation are warranted.

Pediatric Autoimmune Neuropsychiatric Disorders Associated with Streptococcal Infections (PANDAS) and Sydenham's Chorea

Sigra et al. (2018) conducted a systematic review of published peer reviewed literature which addressed treatment for PANDAS and related disorders. Twelve studies (N=529) as well as 240 case reports were identified. Treatments evaluated in these studies included IVIG, TPE, antibiotics, cognitive behavior therapy, and tonsillectomy. The authors determined that the studies generally had a high risk of bias and the results were inconclusive. Further rigorous research is needed.

Pediatric autoimmune neuropsychiatric disorders associated with streptococcal infections (PANDAS) and Sydenham's Chorea (SC) are pediatric post-infectious autoimmune neuropsychiatric disorders. Both share an array of neuropsychiatric symptoms and both may have a shared etiopathogenesis. Because of the possible role of antineuronal antibodies in the pathogenesis, antibody removal by therapeutic plasma exchange (TPE) may be effective. However, the mechanism for the benefit of TPE is

not clear, as there is a lack of relationship between therapeutic response and the rate of antibody removal (Szczepiorkowski et al., 2010).

Eighteen patients were entered into a randomized controlled trial (RCT) designed to determine if IVIG or plasma exchange would be superior to prednisone in decreasing the severity of chorea. Mean chorea severity for the entire group was significantly lower at the 1-month follow-up evaluation (overall 48% improvement). Although the between-group differences were not statistically significant, clinical improvements appeared to be more rapid and robust in the IVIG and plasma exchange groups than in the prednisone group (mean chorea severity scores decreased by 72% in the intravenous immunoglobulin group, 50% in the plasma exchange group, and 29% in the prednisone group). According to the authors, larger studies are required to confirm these clinical observations and to determine if these treatments are cost-effective for this disorder (Garvey, 2005).

Rheumatoid Arthritis

In a single institution observational study, Kitagaichi et al. evaluated the efficacy of treatment on 85 individuals with rheumatoid arthritis (RA) using leukocytapheresis (LCAP) and drug therapy initiated between 2006 and 2015. Participants received LCAP once a week for up to 5 weeks. The clinical response was evaluated at the completion of the series and again 4 weeks later using the American College of Rheumatology (ACR) criteria and the 28-joint disease activity score (DAS28) of the European League Against Rheumatism (EULAR). Marked decreases were seen in tender joint count, swollen joint count, and CRP level, and the DAS28-CRP was significantly improved from before to after LCAP. The authors concluded that LCAP is a safe and worthy therapy for individuals with intractable RA where there is drug allergy or other complications. ACR20 response was 61%, and efficacy persisted to 4 weeks after LCAP completion (2016).

Roth (2004) conducted a noninterventional prospective study on 91 patients with RA who qualified for ProSORBA column apheresis therapy (PCT) per the package insert and completed the 12 prescribed treatments. An initial baseline assessment was performed prior to first treatment and then up to 4 additional assessments were performed at weeks 9, 16, 20, and 24. Criteria from the ACR (ACR20) were noted in order to assess response rate, and commercial adverse event (AE) reporting was used to record serious/unanticipated AEs. There was a ACR20 (or greater) response rate of 53.8% in these patients with previously refractory RA. The individual criteria showed a much greater improvement than reflected by ACR20; for example, this response included a 52% improvement in joint tenderness, 40% improvement in swelling, 42% improvement in patient's pain, 38% improvement in patient's global response, and 48% improvement in physician's global scores (76% of responders had measured ACR20 by Week 16 and 100% by Week 24). Some patients stated that they felt improvement began closer to the 6th week. Most responders were concurrently taking biologics or DMARD, e.g., methotrexate and etanercept, despite previously inadequate RA response to those medications. The author concluded that this postmarketing study of PCT used commercially in 59 rheumatology practice settings supports the safety and efficacy of this treatment regime in selected patients with refractory RA and compares favorably with the initial sham controlled clinical trial. PCT is a relatively underutilized choice for the management of active, aggressive RA.

Furst et al. (2000) conducted a double-blind, placebo RCT to determine the efficacy of the ProSORBA Immunoabsorption Column in patients with refractory RA. Ninety nine patients received 12 weekly procedures after being randomized to the active treatment arm or to the sham treatment arm (apheresis only). Evaluations were double-blinded and occurred at baseline and periodically for 24 weeks thereafter. Primary efficacy was assessed at 7 and 8 weeks after the completion of 12 treatments (at trial weeks 19 and 20) using the ACR definition of improvement, and results from the assessments at weeks 19 and 20 were averaged. Analysis of patients who completed all treatments and follow-up indicated that 15 of 36 (41.7%) ProSORBA-treated patients responded compared to 5 of 32 (15.6%) sham-treated patients. Common AEs included joint pain, fatigue, joint swelling, and hypotension. There was no significant increase in AEs in ProSORBA-treated patients compared to sham-treated patients. The authors concluded that immunoabsorption therapy was proven to be a new alternative in patients with severe, refractory disease.

Cardiovascular Disease

Khan et al. (2017) conducted a single-blinded RCT to determine the clinical impact of lipoprotein apheresis in 20 patients with refractory angina and raised lipoprotein(a) > 500 mg/L. Participants received 3 months of blinded weekly lipoprotein apheresis or sham, followed by crossover. The primary endpoint was change in quantitative myocardial perfusion reserve (MPR). Secondary endpoints included measures of atheroma burden, exercise capacity, symptoms and quality of life. MPR increased following apheresis compared with sham, yielding a net treatment increase of 0.63. All secondary endpoints showed

improvements as well. The researchers concluded that lipoprotein apheresis may represent an effective novel treatment for patients with refractory angina and raised lipoprotein(a). They state that a larger study in these patients incorporating the impact of apheresis on major cardiovascular AEs would help to validate the findings.

Low levels of high density lipoprotein (HDL) are associated with increased risk of cardiovascular disease. Researchers theorize that plasma selective delipidation converts alpha-HDL to pre-beta-like HDL, the most effective form of HDL for lipid removal from arterial plaques. However, there is a paucity of clinical evidence regarding HDL delipidation for various cardiac disease indications, including acute coronary syndrome (ACS). A search of the peer-reviewed medical literature identified one placebo-controlled RCT (N=28) (Waksman et al., 2010). This study sought to determine whether serial autologous infusions of selective HDL delipidated plasma are feasible and well tolerated in patients with ACS. Patients undergoing cardiac catheterization were randomized to either 7 weekly HDL selective delipidated or control plasma apheresis/reinfusions. Patients underwent intravascular ultrasound (IVUS) evaluation of the target vessel. All reinfusion sessions were tolerated well by all patients. The levels of prebeta-like HDL and alphaHDL in the delipidated plasma converted from 5.6% to 79.1% and 92.8% to 20.9%, respectively. The IVUS data demonstrated a numeric and non-significant trend toward regression in the total atheroma volume in the delipidated group compared with an increase of total atheroma volume in the control group. Study results demonstrated that serial autologous infusions of selective HDL delipidated plasma is clinically feasible and well tolerated. Study limitations included small study population and lack of appropriate blinding methods. The study may not have been sufficiently powered to detect differences between treatment and controls. Additional well-designed studies are necessary to determine the ability of HDL delipidation and plasma reinfusion to improve patient-relevant clinical outcomes, such as the reduction of cardiovascular events and increased overall survival.

A prospective, multi-center, international, two-arm matched-pair cohort study known as MultiSELEct is in progress, evaluating the clinical benefit of lipoprotein apheresis on cardiovascular outcomes. For more information, go to www.clinicaltrials.gov. (Accessed July 18, 2019)

Light Chain Nephropathy

Premuzic et al. examined whether plasmapheresis in combination with chemotherapy could significantly remove free light chains (FLCs) in multiple myeloma (MM) patients with acute kidney injury (AKI), ultimately improving renal recovery and patient survival in a single center study. During the study period, 29 patients with MM and AKI were treated with two different therapy modalities (plasmapheresis with chemotherapy or bortezomib). At the end of treatment, a significant decrease of FLCs was present in the group treated with plasmapheresis compared to the bortezomib group. While overall survival was similar between groups, there was a significantly higher decrease of FLCs and longer survival in patients treated with ≥ 3 plasmapheresis sessions than in patients treated with two sessions. The authors concluded that plasmapheresis therapy still remains a useful and effective method in the treatment of AKI in MM patients. Plasmapheresis significantly reduces FLCs compared to bortezomib, especially with higher number of plasma exchange sessions, but it must be combined with other chemotherapy agents in order to prolong renal recovery and therefore patient survival (2018).

As an adjunct to chemotherapy, several new extracorporeal techniques have raised interest as a further means to reduce serum FLC (sFLC) concentrations in the treatment of myeloma cast nephropathy. Whether addition of extracorporeal therapies to renoprotective therapy can result in better renal recovery is still a matter of debate and there are currently no guidelines in this field (Fabbrini et al., 2016).

Yu et al. (2015) conducted a meta-analysis to quantitatively evaluate the clinical efficacy of chemotherapy with or without plasmapheresis in the treatment of MM patients with renal failure. Three RCTs were selected and analyzed. A total of 63 patients received chemotherapy only and 84 patients were given both chemotherapy and plasmapheresis. No difference was observed in 6-month survival rate between plasmapheresis and control group (75% vs. 66.7%). The 6-month dialysis-dependent ratio was significantly lower in patients treated with both chemotherapy and plasmapheresis than chemotherapy alone (15.6% vs. 37.2%). The authors concluded that plasmapheresis used as an adjunct to chemotherapy had a benefit in the management of dialysis-dependent MM patients with renal failure.

In a review on current approaches to diagnosing and managing acute renal failure in individuals with multiple myeloma (MM), Leung and Behrens state that rapid reduction of sFLC, the cause of cast nephropathy, is required to reverse renal injury. If extracorporeal removal is used, it should be directed by sFLC levels, although its efficacy remains to be determined (2012).

A systematic review covering 56 articles regarding survival benefits, recovery, and improvement in renal function after extracorporeal removal of sFLCs did not suggest a benefit of plasmapheresis independent of chemotherapy for MM patients with acute renal injury (Gupta et al., 2010).

A 2020 ECRI health technology assessment focuses on the effectiveness of LDL apheresis for treating steroid-resistant nephrotic syndrome associated with focal segmental glomerulosclerosis (FSGS.) The conclusion of four small studies reported that LDL apheresis treatment may delay progression to end-stage renal disease and complications associated with chronic kidney disease. Additional studies and long-term follow up would be useful to confirm findings. All studies identified were conducted in Japan and results may not be generalizable to other countries and healthcare systems.

National Comprehensive Cancer Network (NCCN)

NCCN MM Panel members consider the use of plasmapheresis for improvement of renal function as category 2B (2019).

Severe Cryoglobulinemia

In a 2018 review on the use of emergency apheresis in the management of plasma cell disorders, Kalayoglu-Besisik stated that in hepatitis C virus-related mixed cryoglobulinemias, plasmapheresis is indicated if rapidly evolving life-threatening disease with immunosuppressive agent exists. In non-infectious mixed cryoglobulinemia plasmapheresis is indicated when the disease manifestations are severe, as a second line option.

Rockx and Clark conducted a review of the medical literature over a 20-year span for evidence supporting or refuting the reported use of plasmapheresis for cryoglobulinemia. The 11 articles reviewed included a total of 156 patients. While plasma exchange is an accepted treatment for cryoglobulinemia, there were no large multicenter RCTs of plasma exchange versus placebo or versus immunosuppressive therapy. None had a clear report of the apheresis procedures or clearly defined quantitative outcomes. The quality and variability of the evidence precluded a meta-analysis or systematic analysis however, the authors found that these studies weakly supported the use of plasma exchange largely on a mechanistic basis. Further studies of greater rigor will provide better evidence to support or refute the use of plasma exchange in treating this condition (2010).

Inflammatory Bowel Disease

Domènech and colleagues conducted a multi-center, open randomized trial to evaluate the efficacy and safety of adding granulocyte/monocyte apheresis (GMA) to oral prednisone in patients with steroid-dependent UC. The study compared GMA plus oral prednisone (40 mg/day) with prednisone alone administered in 7 weekly sessions to 123 patients with active, steroid-dependent UC. The GMA group consisted of 63 participants, and 62 received prednisone alone. A 9-week tapering schedule of prednisone was pre-established in both study groups. The primary endpoint was steroid-free remission at week 24, with no re-introduction of corticosteroids. Remission at week 24 was achieved in 13% in the GMA group and 7% in the control group. Time to relapse was significantly longer and steroid-related AEs were significantly lower in the GMA group. The authors concluded that while the addition of GMA to a conventional course of oral prednisone delayed clinical relapse, it did not increase the proportion of steroid-free remissions in patients with active steroid-dependent UC (2018).

Eberhardson et al. conducted a double-blind, placebo-RCT to evaluate safety, tolerability, and immunological response when selectively removing circulating CCR9-expressing monocytes via leukapheresis in individuals with moderate to severe UC. Fourteen individuals made up the active treatment group, and 8 were in the placebo group. Participants were treated every second day with leukapheresis during 5 sessions. No major safety concerns were raised and the procedure was well tolerated. Eight of 14 patients (57.1%) in the active treatment group responded compared with 3 of 8 (37.5%) in the placebo group. The authors concluded that this trial demonstrated that activated monocytes could be removed from UC patients safely and efficaciously via leukapheresis. With this being the first trial of its kind in humans, further studies with larger participant groups are needed.

A large-scale, prospective, observational study was performed by Yokoyama et al. (2014) which enrolled patients from 116 medical facilities in Japan with active ulcerative colitis (UC) treated with LCAP. Out of 847 patients, 623 were available for efficacy analysis. 80.3% of the patients had moderate to severe disease activity, and 67.6% were steroid refractory. Concomitant medications, 5-aminosalicylic acids, corticosteroids, and thiopurines were administered to 94.8%, 63.8%, and 32.8% of the patients, respectively. In addition, infliximab and tacrolimus were concomitantly used in 5.8% and 12.3%, respectively. Intensive LCAP (≥ 4 sessions within the first 2 weeks) was used in $>70\%$ of the patients. AEs were seen in 10.3% , which were severe in only 5 patients. Any concomitant medications did not increase the incidence of AEs. The authors

concluded that that LCAP, including intensive procedure, is a safe and effective therapeutic option for active UC. However, this study did not translate research data into clinical guidelines that can be used to improve physician decision-making and patient care.

Professional Societies

American Academy of Neurology (AAN)/MS Council for Clinical Practice

The Therapeutics and Technology Assessment Subcommittee of the AAN and the MS Council for Clinical Practice Guidelines issued a report on disease-modifying therapies in MS. The subcommittee concluded that "on the basis of consistent class I, II, and III studies, plasma exchange is of little or no value in the treatment of progressive MS." The AAN guideline also states that on the basis of a single small Class I study, it is considered possible that plasma exchange may be helpful in the treatment of severe acute episodes of demyelination in previously non-disabled individuals (Goodin et al., 2002).

American Academy of Neurology (AAN)

The AAN evidence based guidelines on the clinical evaluation and treatment of transverse myelitis state that plasma exchange may be considered in patients who fail to improve after corticosteroid treatment (Scott, et al., 2011. Reaffirmed 2016).

An evidence-based guideline on plasmapheresis in neurologic disorders from AAN identifies the following (Cortese, 2011):

- Plasmapheresis is established as effective and should be offered in severe acute inflammatory demyelinating polyneuropathy (AIDP)/Guillain-Barre ´ syndrome (GBS) and in the short-term management of chronic inflammatory demyelinating polyneuropathy (Class I studies, Level A).
- Plasmapheresis is probably effective and should be considered for mild AIDP/GBS, as second-line treatment of steroid-resistant exacerbations in relapsing forms of MS, and for neuropathy associated with immunoglobulin A or immunoglobulin G gammopathy, based on at least one Class I or 2 Class II studies (Level B).
- Plasmapheresis is possibly effective and may be considered for acute fulminant demyelinating CNS disease (Level C).
- Plasmapheresis is probably not effective and should not be considered for neuropathy associated with immunoglobulin M gammopathy, based on one Class I study (Level B).
- Plasmapheresis is established as ineffective and should not be offered for chronic or secondary progressive multiple sclerosis (MS) (Class I studies, Level A).
- There is insufficient evidence to support or refute the use of plasmapheresis for myasthenia gravis, pediatric autoimmune neuropsychiatric disorders associated with streptococcus infection, and Sydenham chorea (Class III evidence, Level U).

National Comprehensive Cancer Network (NCCN)

Guidelines on acute myeloid leukemia indicate that leukapheresis is not recommended in the routine management of patients with a high WBC in acute promyelocytic leukemia (APL). However, in life threatening cases with leukostasis that is not responsive to other modalities, leukapheresis can be considered with caution (2019).

National Institute of Neurological Disorders and Stroke (NINDS)

The Neuromyelitis Optica (NMO) information page states that relapses and attacks of NMO (also known as Devic Syndrome) are often treated with corticosteroids and plasma exchange (National Institutes of Health, May 2017).

National Institute for Health and Clinical Excellence (NICE)

NICE clinical guidelines on the management of MS in adults do not address any type of therapeutic apheresis (2014; reviewed 2018).

NICE also recommended that Extracorporeal Photopheresis should not be used outside the context of research for Crohn's disease for both adults and children (2009).

Multiple clinical trials studying therapeutic apheresis and inflammatory bowel disease have been completed but results have not yet been published. For more information, go to www.clinicaltrials.gov. (Accessed October 21, 2020)

Additional Search Terms

Photoimmune Therapy, Photoimmunotherapy

U.S. Food and Drug Administration (FDA)

This section is to be used for informational purposes only. FDA approval alone is not a basis for coverage.

Devices for therapeutic apheresis are regulated by the FDA as Class II or III devices depending on whether they rely on centrifugation or filtration of blood. Devices that separate blood cells from plasma by filtration are Class III devices that are subject to the most extensive regulations enforced by the FDA.

For additional information, search product code LKN (separator, automated, blood cell and plasma, therapeutic) at the following website: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmnm.cfm>. (Accessed October 21, 2020)

The FDA has granted premarket approval (PMA) to one extracorporeal photopheresis (ECP) device, the UVAR Photopheresis System (Therakos, Inc., Exton, PA, USA). This system is currently only approved for the palliative treatment of skin manifestations resulting from cutaneous T-cell lymphoma (CTCL), which are unresponsive to other treatments. Therakos now markets a second generation of the system under the name UVAR XTS. The UVAR XTS system utilizes the photoactive drug, UVADEX (8-methoxsalen), also manufactured by Therakos and approved by FDA for the same indication. Additional information is available at the following website:

https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpma/pma.cfm?start_search=1&applicant=&tradename=&productcode=&pmanumber=P860003&supplementnumber=&advisorycommittee=&docketnumber=&supplementtype=&expeditedreview=&ivdproducts=off&combinationproducts=off&decisiondatefrom=&decisiondateto=¬icedatefrom=¬icedateto=&PAGENUM=50. (Accessed October 21, 2020)

UVADEX was granted Orphan Drug Status "for use in conjunction with the UVAR photopheresis [system] to treat diffuse systemic sclerosis" in June 1993 and "for use in conjunction with the UVAR photopheresis system to treat graft versus host disease (GVHD)" in October 1998. In addition, UVADEX was granted Orphan Drug Status "for the prevention of acute rejection of cardiac allografts" in May 1994. Additional information is available at the following website:

https://www.accessdata.fda.gov/drugsatfda_docs/label/2013/020969s006lbl.pdf.

(Accessed October 21, 2020)

Additional Products

Haemonetics Therapeutic Plasma Exchange Set, Fresenius P1r Plasma Treatment Set, Cobe Spectra™ Blood Component Separator, Plasma Separation System, Heparin-Induced Extracorporeal Lipoprotein Precipitation (H.E.L.P.) System, Liposorber LA-15 System, LDL-Therasorb, Prosorba

References

- Cortese I, Chaudhry V, So YT, et al. Evidence-based guideline update: Plasmapheresis in neurologic disorders: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology*. 2011 Jan 18;76(3):294-300.
- Dipchand AI, Pollock BarZiv SM, Manlhiot C, et al. Equivalent outcomes for pediatric heart transplantation recipients: ABO-blood group incompatible versus ABO-compatible. *Am J Transplant*. 2010 Feb;10(2):389-97.
- Domènech E, Panés J, Hinojosa J, et al. Addition of Granulocyte/Monocyte Apheresis to Oral Prednisone for Steroid-dependent Ulcerative Colitis: A Randomized Multicentre Clinical Trial. *J Crohns Colitis*. 2018 May 25;12(6):687-694.
- Eberhardson M, Karlén P, Linton L, et al. Randomised, Double-blind, Placebo-controlled Trial of CCR9-targeted Leukapheresis Treatment of Ulcerative Colitis Patients. *J Crohns Colitis*. 2017 May 1;11(5):534-542.
- Fabbrini P, Finkel K, Gallieni M, et al. Light chains removal by extracorporeal techniques in acute kidney injury due to multiple myeloma: a position statement of the Onconeurology Work Group of the Italian Society of Nephrology. *J Nephrol*. 2016 Dec;29(6):735-746.
- Furst D, Felson D, Thoren G, et al. Immunoabsorption for the treatment of rheumatoid arthritis: final results of a randomized trial. Prosorba Trial Investigators. *Ther Apher*. 2000 Oct;4(5):363-73. Erratum in: *Ther Apher* 2002 Feb;6(1):99.

Garvey MA, Snider LA, Leitman SF, et al. Treatment of Sydenham's chorea with intravenous immunoglobulin, plasma exchange, or prednisone. *J Child Neurol*. 2005 May;20(5):424-9.

Goodin DS, Frohman EM, Garmany GP Jr, et al. Disease modifying therapies in multiple sclerosis: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology and the MS Council for Clinical Practice Guidelines. *Neurology*. 2002;58(2):169-178.

Gupta D., Bachegowda L., Phadke G., et al. Role of plasmapheresis in the management of myeloma kidney: a systematic review. *Hemodial Int* 2010; 14: pp. 355-363.

Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ Clin Res Ed* 2008;336:924–926.

Hayes, Inc. Health Information Assessment. Low-density Lipoprotein Apheresis for Treating Hyperlipidemia in Patients with Nephrotic Syndrome. Lansdale, PA: Hayes. March 2020.

Hulbert ML, Scothorn DJ, Panepinto JA, et al. Exchange blood transfusion compared with simple transfusion for first overt stroke is associated with a lower risk of subsequent stroke: a retrospective cohort study of 137 children with sickle cell anemia. *J Pediatr*. 2006 Nov;149(5):710-2.

Issitt RW, Crook RM, Cross NT, et al. Incompatible ABO-plasma exchange and its impact on patient selection in paediatric cardiac transplantation. *Perfusion*. 2012 Nov;27(6):480-5.

Kalayoglu-Besisik S. The use of emergency apheresis in the management of plasma cell disorders. *Transfus Apher Sci*. 2018 Feb;57(1):35-39.

Khan TZ, Hsu LY, Arai AE, et al. Apheresis as novel treatment for refractory angina with raised lipoprotein(a): a randomized controlled cross-over trial. *Eur Heart J*. 2017 May 21;38(20):1561-1569.

Kitagaichi M, Kusaoi M, Tsukahara T, et al. Safety and efficacy of the leukocytapheresis procedure in eighty-five patients with rheumatoid arthritis. *Transfus Apher Sci*. 2016 Oct;55(2):225-232.

Leung N, Behrens J. Current approach to diagnosis and management of acute renal failure in myeloma patients. *Adv Chronic Kidney Dis*. 2012 Sep;19(5):297-302.

Meng HL, Jin XB, Li XT, et al. Impact of human leukocyte antigen matching and recipients' panel reactive antibodies on two-year outcome in presensitized renal allograft recipients. *Chin Med J (Engl)*. 2009 Feb 20;122(4):420-6.

Montgomery RA, Lonze BE, Jackson AM. Using donor exchange paradigms with desensitization to enhance transplant rates among highly sensitized patients. *Curr Opin Organ Transplant*. 2011b Aug;16(4):439-43.

Montgomery RA, Lonze BE, King KE, et al. Desensitization in HLA-incompatible kidney recipients and survival. *N Engl J Med*. 2011a Jul 28;365(4):318-26.

National Comprehensive Cancer Network (NCCN). Clinical Practice Guidelines in Oncology. Acute Myeloid Leukemia. v3.2019. May 7, 2019.

National Comprehensive Cancer Network (NCCN). Clinical Practice Guidelines in Oncology. Multiple Myeloma. v3.2019. June 19, 2019.

National Heart, Lung, and Blood Institute (NHLBI). Evidence-Based Management of Sickle Cell Disease. Expert Panel Report 2014. U.S. Department of Health and Human Services; National Institutes of Health.

National Institute for Health and Clinical Excellence (NICE). Extracorporeal Photopheresis for Crohn's Disease. Interventional procedures guidance [IPG288]. February 2009. Accessed October 22, 2020.

National Institute for Health and Clinical Excellence (NICE). Multiple sclerosis in adults: management. Clinical guideline [CG186]. October 2014; reviewed October 2018. Accessed October 22, 2020.

National Institutes of Health (NIH), National Institute for Neurological Disorders and Stroke (NINDS). Neuromyelitis Optica Information Page. Bethesda, MD: NIH; updated March 2019. Accessed October 23, 2020.

Padmanabhan A, Connelly-Smith L, Aquilino N, et al. Guidelines on the Use of Therapeutic Apheresis in Clinical Practice - Evidence-Based Approach from the Writing Committee of the American Society for Apheresis: The Eighth Special Issue. *J Clin Apher*. 2019 Jun;34(3):171-354.

Premuzic V, Batinic J, Roncevic P, et al. Role of Plasmapheresis in the Management of Acute Kidney Injury in Patients With Multiple Myeloma: Should We Abandon It? *Ther Apher Dial*. 2018 Feb;22(1):79-86.

Rockx MA, Clark WF. Plasma exchange for treating cryoglobulinemia: a descriptive analysis. *Transfus Apher Sci*. 2010 Jun;42(3):247-51.

Roth S. Effects of ProSORBA column apheresis in patients with chronic refractory rheumatoid arthritis. *J Rheumatol*. 2004 Nov;31(11):2131-5.

Schwartz J, Padmanabhan A, Aqui N, et al. Guidelines on the Use of Therapeutic Apheresis in Clinical Practice—Evidence-Based Approach from the Writing Committee of the American Society for Apheresis: The Seventh Special Issue. *J Clin Apher*. 2016 Jun;31(3):149-62.

Scott TF, Frohman EM, De Seze J, et al. Therapeutics and Technology Assessment Subcommittee of American Academy of Neurology. Evidence-based guideline: clinical evaluation and treatment of transverse myelitis: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology*. 2011 Dec 13;77(24):2128-34. Reaffirmed 2016 Nov 22.

Sigra S, Hesselmark E, Bejerot S. Treatment of PANDAS and PANS: a systematic review. *Neurosci Biobehav Rev*. 2018 Mar;86:51-65.

Szczepiorkowski ZM, Winters JL, Bandarenko N, et al; Apheresis Applications Committee of the American Society for Apheresis. Guidelines on the use of therapeutic apheresis in clinical practice—evidence-based approach from the Apheresis Applications Committee of the American Society for Apheresis. *J Clin Apher*. 2010;25(3):83-177.

Turner JM, Kaplan JB, Cohen HW, et al. Exchange versus simple transfusion for acute chest syndrome in sickle cell anemia adults. *Transfusion* 2009;49:863–868.

Velasquez MP, Mariscalco MM, Goldstein SL, et al. Erythrocytapheresis in children with sickle cell disease and acute chest syndrome. *Pediatric Blood Cancer* 2009;53:1060–1063.

Wahl SK, Garcia A, Hagar W, et al. Lower alloimmunization rates in pediatric sickle cell patients on chronic erythrocytapheresis compared to chronic simple transfusions. *Transfusion*. 2012 Dec;52(12):2671-6.

Waksman R, Torguson R, Kent KM et al. A first-in-man, randomized, placebo-controlled study to evaluate the safety and feasibility of autologous delipidated high-density lipoprotein plasma infusions in patients with acute coronary syndrome. *J Am Coll Cardiol*. 2010 Jun 15;55(24):2727-2735.

Yokoyama Y, Matsuoka K, Kobayashi T, et al. A large-scale, prospective, observational study of leukocytapheresis for ulcerative colitis: treatment outcomes of 847 patients in clinical practice. *J Crohns Colitis*. 2014 Sep;8(9):981-91.

Yu X, Gan L, Wang Z, et al. Chemotherapy with or without plasmapheresis in acute renal failure due to multiple myeloma: a meta-analysis. *Int J Clin Pharmacol Ther*. 2015 May;53(5):391-7.

Yuan XP, Wang CX, Gao W, et al. Kidney transplant in highly sensitized patients after desensitization with plasmapheresis and low-dose intravenous immunoglobulin. *Exp Clin Transplant*. 2010 Jun;8(2):130-5.

Guideline History/Revision Information

Date	Summary of Changes
02/01/2021	<p>Coverage Rationale</p> <ul style="list-style-type: none"> Revised list of conditions/diagnoses for which therapeutic apheresis is proven and medically necessary; replaced “sickle cell disease, prevention of transfusional iron overload” with “sickle cell disease, prevention of transfusional iron overload – <i>for members requiring chronic transfusion</i>” <p>Documentation Requirements</p> <ul style="list-style-type: none"> Updated list of applicable documentation requirements to include “transfusion history” <p>Supporting Information</p> <ul style="list-style-type: none"> Updated <i>Clinical Evidence</i> and <i>References</i> sections to reflect the most current information Archived previous policy version MMG003.K

Instructions for Use

This Medical Management Guideline provides assistance in interpreting UnitedHealthcare standard benefit plans. When deciding coverage, the member specific benefit plan document must be referenced as the terms of the member specific

benefit plan may differ from the standard plan. In the event of a conflict, the member specific benefit plan document governs. Before using this guideline, please check the member specific benefit plan document and any applicable federal or state mandates. UnitedHealthcare reserves the right to modify its Policies and Guidelines as necessary. This Medical Management Guideline is provided for informational purposes. It does not constitute medical advice.

UnitedHealthcare may also use tools developed by third parties, such as the MCG™ Care Guidelines, to assist us in administering health benefits. UnitedHealthcare West Medical Management Guidelines are intended to be used in connection with the independent professional medical judgment of a qualified health care provider and do not constitute the practice of medicine or medical advice.

Member benefit coverage and limitations may vary based on the member's benefit plan Health Plan coverage provided by or through UnitedHealthcare of California, UnitedHealthcare Benefits Plan of California, UnitedHealthcare of Oklahoma, Inc., UnitedHealthcare of Oregon, Inc., UnitedHealthcare Benefits of Texas, Inc., or UnitedHealthcare of Washington, Inc.