

Table 11.2 Medications Used to Treat Multiple Sclerosis

Medication	Indications and mechanisms	Dosing	Side effects affecting rehab	Other side effects or considerations
<b>Immunomodulators</b>				
Interferon beta-1a (Avonex)	RRMS Antagonizes effects of proinflammatory cytokines, downregulates T-cell activity.	30 µg intramuscularly once weekly	Cog: 0 S: 0 A: 0 Motor: 0 D: 0/+ Com: 0 F: 0	Flu-like symptoms with injection, depression, mild anemia, allergic reaction, elevated liver enzymes.
Interferon beta-1a (Rebif)	RRMS Enhances suppressor T-cell activity; reduces cytokines.	250 µg subcutaneously every other day	Cog: 0 S: 0 A: 0 Motor: 0 D: 0/+ Com: 0 F: 0	Flu-like symptoms with injection, depression, low white and red cell counts, allergic reaction.
Interferon beta-1b (Betaseron)	RRMS Antagonizes effects of proinflammatory cytokines; downregulates T-cell activity.	22 or 44 µg subcutaneously every 3 wk	Cog: 0 S: 0 A: 0 Motor: 0 D: 0/+ Com: 0 F: 0	Flu-like symptoms with injection, depression, low white cell count, allergic reaction, elevated liver enzymes.
Glatiramer acetate (Copaxone)	RRMS Interferes with activation of myelin-based, protein-reactive T-cells; affects T-cell differentiation.	20 mg subcutaneously/day	Cog: 0 S: 0 A: + Motor: 0 D: 0/+ Com: 0 F: +	Reactions at injection site, vasodilation, chest pain, anxiety, shortness of breath, flushing for 15-30 min after injection.
Mitoxantrone (Novantrone)	RRMS Inhibits cells that destroy myelin in the CNS.	12 mg/m <sup>2</sup> IV infusion 4 times/yr. Lifetime cumulative dose is 140 mg/m <sup>2</sup> (~8-12 doses over 2-3 yr).	Cog: 0 S: 0 A: 0 Motor: 0 D: +++ Com: 0 F: 0	Blue-green urine for 24 h, bone marrow suppression, hair loss, nausea, bladder infections, mouth ulcers. Monitor for liver and heart toxicity.
<b>New oral agents</b>				
Cladribine (Leustatin)*	PPMS Damages CD4 cells.	0.07 mg/kg/day for 5 consecutive days every 4 wk	Cog: 0 S: 0 A: 0 Motor: 0/+ D: 0 Com: 0 F: 0	Decreased white blood cell and lymphocyte counts, peripheral neuropathy (rare).
Fingolimod (Gilenya)	RRMS, SPMS Reduces lymphocyte migration into the CNS.	0.5 mg by mouth/day	Cog: 0 S: 0 A: 0 Motor: ++ D: 0 Com: 0	Reduction of lymphocytes by 20%-30%, increased risk of infection, maculopapular rash, macular edema resulting in loss of vision, decreased pulmonary function, increased liver

From L. Carl, J. Gallo, and P. Johnson, 2014, *Practical Pharmacology in Rehabilitation: Effect of Medication on Therapy* (Champaign, IL: Human Kinetics).

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			F: ++	enzymes. Restricted by FDA REMS due to risk of bradycardia. Baseline electrocardiography is needed; ophthalmologic exams required at baseline and after 3-4 mo. Teratogenic.
Laquinimod**	RRMS, SPMS Reduces action of T-helper cells.	0.3 mg by mouth/day	Cog: 0 S: 0 A: 0 Motor: 0 D: 0 Com: 0 F: 0	Increased erythrocyte sedimentation rate, increased liver enzymes.
Teriflunomide (Aubagio)	RRMS, SPMS Blocks pyrimidine and cell synthesis; reduces T-cell activation and cyclooxygenase activity.	7 or 14 mg by mouth/day	Cog: 0 S: 0 A: 0 Motor: +++ D: +++ Com: 0 F: +++	Hepatic enzyme elevation and hepatic dysfunction, neutropenia, rhabdomyolysis, trigeminal neuralgia, paresthesias, limb pain, arthralgias, nausea, diarrhea, alopecia, urinary tract infection.
<b>Monoclonal antibodies***</b>				
Natalizumab (Tysabri)	RRMS Blocks access of lymphocytes into CNS.	300 mg IV infusion over 1 h every 4 wk	Cog: 0 S: 0 A: 0 Motor: ++ D: 0 Com: 0 F: 0	Headache, fatigue, urinary tract infection, respiratory infection, depression, joint pain, chest discomfort. Restricted by FDA manufacturer REMS. Allergic reactions occur within 2 h of infusion; monitor for progressive multifocal leukoencephalopathy.
Alemtuzumab (Campath)*	RRMS Targets CD52 on lymphocytes and monocytes, reducing number of circulating T-cells.	20 mg by IV infusion/day for 5 days	Cog: 0 S: 0 A: 0 Motor: + D: ++ Com: 0 F: 0	Infusion reactions (rigors, fever, nausea, vomiting, rash, and hypotension) occur in 90%; pretreat with 1 g of methylprednisolone before infusion. Other side effects include increased infections, reduced T- and B-cell counts, and Graves' disease (27% of patients).
Daclizumab (Zenapax)*	RRMS, SPMS Targets interleukin-2 on activated lymphocytes, reducing IL CD24 complexation; reduces T-cell activation.	1 or 2 mg/kg IV infusion every 2 wk for 2 doses, then monthly for 5 doses in combination with interferon	Cog: 0 S: 0 A: 0 Motor: 0 D: ++ Com: 0 F: 0	Mouth ulcers, photosensitivity with rash, formation of antibodies causing discontinuance, reduced lymphocyte count, lymphadenopathy, transient increase in bilirubin.
Rituximab (Rituxan)*	RRMS, PPMS Depletes CD20+ pre-B- and B-cells.	1 g IV infusion on days 1 and 15	Cog: ++ S: ++ A: 0	Infusion reactions (chills, headache, nausea, pruritus, pyrexia, and fatigue) occur in

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			Motor: 0 D: ++ Com: ++ F: ++	75%; pretreat with diphenhydramine and acetaminophen 30-60 min before infusion. Other side effects include increased urinary tract infections, sinusitis, throat irritation, and nasopharyngitis.

**Steroids used for short-term treatment of acute exacerbations**

Methylprednisolone (Solu-Medrol)	RRMS, PPMS Decreases inflammatory cytokines, decreases activation of T-lymphocytes, decreases migration of lymphocytes into the CNS.	1 g IV infusion/day as single or divided doses for 3-5 days	Cog: ++ S: 0 A: ++ Motor: ++ D: 0 Com: + F: ++	Increased appetite, psychosis, bloating, acne, insomnia, headache, muscle weakness, hyperglycemia, altered mental status.
Prednisone	RRMS, PPMS Decreases inflammatory cytokines, decreases activation of T-lymphocytes, decreases migration of lymphocytes into the CNS.	1250 mg by mouth every other day for 5 days	Cog: ++ S: 0 A: ++ Motor: ++ D: 0 Com: + F: ++	Increased appetite, psychosis, bloating, acne, insomnia, headache, muscle weakness, hyperglycemia, altered mental status.

\*Available but not approved for multiple sclerosis. \*\*Not available. \*\*\*Immunize prior to initiation. Avoid in patients with congestive heart failure. Monitor for reactivation of latent infections such as hepatitis, tuberculosis, or fungal infections (e.g., histoplasmosis).

Cog = cognition; S = sedation; A = agitation or mania; Motor = discoordination; D = dysphagia; Com = communication; F = falls; CNS = central nervous system; IV = intravenous; PPMS = primary progressive multiple sclerosis; RRMS = relapsing–remitting multiple sclerosis; SPMS = secondary progressive multiple sclerosis; REMS = Risk Evaluation and Mitigation Strategies; IL = interleukin; FDA = U.S. Food and Drug Administration.

The likelihood rating scale for encountering the side effects is as follows: 0 = Almost no probability of encountering side effects. 0/+ = Slight probability of encountering side effects with higher doses. + = Little likelihood of encountering side effects. +/++ = Low probability of encountering side effects; however, probability increases with increased dosage. ++ = Medium likelihood of encountering side effects. +++ = High likelihood of encountering side effects, particularly with high doses. ++++ = Highest likelihood of encountering side effects; best to avoid in at-risk patients.