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March 2011 "Any Breakthroughs in MS Therapy?"

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**THIS MONTH**  
**"Treatment of MS"**

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**Have there been any breakthroughs in treating MS?** In this lesson, we review treatment options for this disease which has no cure. Options are symptomatic therapy. This lesson provides 1.25 hours (0.125 CEUs) of credit, and is intended for pharmacists in all practice settings. **The program ID # for this lesson is 707-000-11-003-H01-P. Pharmacists completing this lesson by March 31, 2014 may receive full credit.**

**To obtain continuing education credit for this lesson,** you must answer the questions on the quiz (70% correct required), and return the quiz. Should you score less than 70%, you will be asked to repeat the quiz. Computerized records are maintained for each participant.

If you have any comments, suggestions or questions, contact us at the above address, or call toll free 1-800-323-4305. (In Alaska and Hawaii phone 1-847-945-8050). **Please write your ID Number (the number that is on the top of the mailing label) in the indicated space on the quiz page** (for continuous participants only).

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**The objectives of this lesson are such that upon completion the participant will be able to:**

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1. List the symptoms of Multiple MS.
2. Name the types of MS
3. Describe pathogenesis of MS
4. State causes that trigger MS
5. Discuss goals of MS treatment
6. List the drugs used in the treatment of MS

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## INTRODUCTION

Multiple Sclerosis (MS), encephalomyelitis disseminata, is an unpredictable inflammatory disease that is believed to be immune-mediated. It affects the Central Nervous System, resulting in damage to the fatty myelin sheath surrounding and protecting the axons of the brain and the spinal cord. The main functions of myelin are to: 1) improve conduction of messages or impulses along the nerves and 2) protect the axons. During the course of time the inflammatory process will gradually cause demyelination (disappearance of myelin), formation of lesions, and scarring of the brain and the spinal cord cells, leading to disruption of the electrical signals, called action potential. The action potential is used to communicate between the cells of the brain and those in other parts of the body. When this occurs, symptoms of MS appear. The severity of symptoms depends on the extent of damage to the myelin and the ability of the nerves in the brain and the spinal cord to communicate with other nerves. The name sclerosis was derived from scleroses meaning plaque or lesion. In the case of MS, scleroses refers to scarring tissue found in the white matter of the brain and spinal cord.

## INCIDENCE

It has been estimated that there are approximately 400,000 persons in the US who are afflicted with MS. However, the prevalence of the disease varies from one region of the world to another and from specific segments of the population of a country. Even though it could occur in children and the elderly, MS usually appears in adults between the ages of 20 to 40, but mostly in the thirties. The primary progressive type of MS is more common in people in their fifties. It is more common among women than men especially when the disease appears early in life. Males are affected more than females if MS occurs at the age of 50 or greater. At one time it was thought that MS is less prevalence in countries near the equator. It has been documented that in countries where incidence of MS is high, certain ethnic groups within the population of that country are at a lower risk of developing the disease. Caucasians are susceptible to MS more than any other group.

## PATHOGENESIS

The pathological hallmarks of MS are:

1. Scar and lesion formation around the axon
2. Inflammation caused by the patient's immune system.

Multiple sclerosis is considered an auto immune and a neurodegenerative disorder that is mediated by a delicate reaction of the patient's genetic make-up and other factors some of which are suspected and others yet to be identified. The exact causes are unknown even though autoimmunity and genetics seem to play an important role in the pathogenicity of the disease. The immune system is a complex one whose main function is to defend the body from any invader. Researchers believe that in the case of MS a foreign invader such as a virus may introduce changes in the immune system whereby the immune cells mistakenly consider the myelin of a particular individual as a foreign invader and attack it, causing partial or complete destruction of the myelin. Thus the damage is caused by the patient's own immune system. Under normal circumstances the CNS is inaccessible to the immune cells due to the presence of the blood-brain-barrier (BBB). The BBB is a capillary network that is not permeable to T cells and tends to protect the CNS by preventing the entrance of the cells and other substances into the CNS. However, viral infection is capable of causing a breakdown of the resistance to the entrance of T cells. After recovery from the viral infection, the BBB regains its integrity and the T cells will have no escape and remain in the CNS. The damage caused by the infection appears as lesions that affect the white matter, brain stem, basal ganglia, spinal cord, and the optic nerve. Once the white matter cells are damaged the signals between the gray matter areas and the body are disrupted. The lesions caused by MS usually affect the CNS, specifically the oligodendrocytes which form and maintain the myelin sheath. When these cells are invaded, the myelin and its sheath gradually disintegrate. Once this happens, the neuron loses its ability to connect the electrical impulses between the brain and the various parts of the body. Ultimately scar-like lesions are formed around the damaged axons. This process seldom involves the peripheral nervous system.

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The second pathological process that is believed to precipitate MS is inflammation caused by lymphocytes, which are T cells that are an important part of the body defenses. The T cells can enter the BBB. The lymphocytes being defenders of the body, mistakenly invade the myelin as if it was attacking a virus or a foreign substance. This invasion triggers an inflammatory process that results in producing other immune cells as well as cytokines and antibodies. Leaks from the BBB cause swelling and stimulation of macrophages and other damaging proteins.

### **TYPES OF MS**

Multiple sclerosis is exhibited in a number of forms some of which have recurring symptoms while others appear first with mild symptoms that increase in intensity over time. Symptoms may disappear between attacks, but often permanent neurological difficulties may occur.

The various types of MS as classified are based on progression of the disease. In 1996 the following types were identified by the US National Multiple Sclerosis Society:

1. Relapsing remitting
2. Secondary progressive
3. Primary progressive
4. Progressive relapsing

#### **Relapsing Remitting**

As the name indicates, this type is characterized by relapses that occur unexpectedly followed by months to years of remission and absence of signs and symptoms of the disease. Impairment in a functional capacity may either resolve or leave deficits. Appearance and disappearance of the symptoms occur in the early stages of MS in the vast majority of patients. Resolution of impairments between attacks may be termed benign MS. However, in the long term some impairment and physical disability may be evident. In this type of MS, the attack may not be severe enough to confirm or meet the criteria for symptoms of MS.

#### **Secondary Progressive**

This type of MS occurs in about 65% of patients who are experiencing relapsing-remitting MS. The neurologic problem becomes more severe and progresses to the extent that no relapse of symptoms takes place between attacks. The time it takes for a person to convert from relapsing-remitting MS is about 20 years.

#### **Primary Progressive**

Primary progressive MS is characterized by complete absence of remission after the initial symptoms and progressive disability. About 10 to 15% of MS patients belong to this type.

#### **Progressive Relapsing**

Progressive relapsing MS is characterized by the presence of neurologic problems from the onset. This type is the least encountered.

### **SYMPTOMS**

Since MS involves disruption of communications between the brain, spinal cord and the rest of the body, a patient may experience any neurological symptoms and signs. The symptoms are unpredictable and may be single or multiple, mild or severe, and short to long in duration. Remission may be partial or complete in about 70% of patients with MS. The initial symptoms that the sufferer may become aware of are visual disturbances such as blurred vision, diplopia (double vision or seeing two images of a single object), red to green color distortion (color desaturation), nystagmus (a rapid involuntary oscillation of the eyeballs), or blindness in one eye. These visual disturbances are due to inflammation of the optic nerve (optic neuritis). Other symptoms include limb and muscle weakness, clonus (a rapid succession of alternating contractions and partial relaxation of a muscle), muscle spasm, difficulty in moving and walking, fatigue, pain, ataxia (inability to coordinate voluntary muscular movement), problems with sensation, tingling, pricking, dizziness, dysarthria (difficulty in speech and in articulating words, dysphagia (difficulty in swallowing), bladder and bowel problems. Cognitive impairment such as lack of judgment, inability to perform sequential tasks, diminished concentration and significant degree of memory loss may occur. Emotional disturbances such as laughing or weeping for

no apparent reason, unstable mood as well as depression and paranoia may often be experienced by MS patients. Occurrence of these symptoms usually takes the form of episodic acute periods of exacerbation of symptoms usually called relapses, bouts, or attacks. Such attacks are due to the gradual and progressive worsening of the neurologic functions. The attacks or relapses may occur without warning and for no obvious reason. A patient may average one or two attacks per year which often occur in spring and summer. Certain attacks may occur as a result of aggravating factors such as pregnancy, viral infections (common cold, and flu), or gastrointestinal disturbances.

### **DIAGNOSIS**

Because of its various forms and intensity of symptoms, MS is rather difficult to diagnose. Furthermore, its signs may resemble other neurologic disorders that affect the CNS. To assist in its diagnosis, medical organizations have established certain diagnostic standards especially in the initial stages of the disease. One method is based on the presence of dissemination of the MS lesions on the axons which should be confirmed by clinical, laboratory and radiological data. These procedures are not totally reliable but definitely helpful. Biopsy can be performed to confirm, through histological methods, the presence or absence of the lesions. Clinical findings may be helpful in the diagnosis of MS in particular if a separate attack with typical MS symptoms has been experienced by the patient. Neuroimaging (magnetic resonance imaging, MRI) analysis of cerebrospinal fluid and evoked potential are the most commonly used tools in the diagnosis of MS. MRI tests may confirm the presence of lesions or plaques which appear as areas of demyelination. To demonstrate the presence of active lesions the contrast agent gadolinium is injected intravenously. Examination of cerebrospinal fluid collected by lumbar puncture is a reliable method for confirmation of the presence of inflammation in the CNS. The presence of oligoclonal bands of IgG on electrophoresis is an inflammation marker found in 75-85% of MS patients. Physical tests such as stimulation of the optic nerve and sensory nerves may reveal the presence of demyelination. Demyelinated nerves usually respond less actively to stimulation. The brain's reaction can be measured by utilizing visual and sensory evoked potentials. An evoked potential is an electro-physiological test that examines how normal the impulses travel through the nerves. Such impulses do not travel normally through demyelinated nerve.

### **ETIOLOGY**

Due to its unpredictability and erratic nature, the cause(s) that triggers the immune system to attack the myelin sheath and result in a wide range of symptoms is unknown. However, epidemiological data helped reach the conclusion that MS is due to a factor or a combination of factors such as genetic, environmental, and infectious.

### **GENETICS**

Multiple sclerosis is not a hereditary disorder, but there are indications that certain genetic variations such as the following may increase the risk of acquiring the disease:

1. The disorder may be encountered in the family of an MS patient (siblings, parents, and children) more than in the population at large.
2. Certain ethnic groups are more susceptible to multiple sclerosis than other groups.
3. Recent studies indicate that a specific gene has been implicated.

### **ENVIRONMENTAL FACTORS**

A number of environmental factors have been suggested as risk factors in the development of MS. It has been observed that people who live in countries farther from the equator are more likely to acquire the disease due to lesser exposure to sunlight. Sunlight plays an important role in the formation of vitamin D by the body. Stress which may weaken the body immune system may contribute to MS. Although the evidence is weak, smoking may be a risk factor. It has been claimed that vaccination should be considered a risk factor, but there is no data to support this claim. Reports indicate that the incidence of MS in persons with gout is lower than the general population. Uric acid which plays a major role in causing gout may act as a protectant against MS.

### **INFECTIONS**

Infections caused by various microorganisms have been proposed as risk factors, though there is no evidence to substantiate this. Some researchers theorized that exposure to infections early in life may protect the body against MS, although later in life infection from such microorganisms may precipitate MS. Others believe that an asymptomatic infection may occur and persist for many years, resulting in demyelination. The association of viral infection with human demyelination encephalomyelitis as well as the ability to demyelinate animals by viral infections suggests that there is a relationship between virus and MS. Human

herpes virus has been implicated with triggering MS. There is evidence to show that persons who have never been infected by Epstein-Barr virus have a low risk for developing MS. Other viral diseases that are linked to MS are measles, mumps, and rubella.

### TREATMENT

Since the exact cause of MS is unknown, treatment of this disease has not been adequately established. Even though there is no cure for MS, various therapies have been attempted and some have been successful, to a certain extent, in providing symptomatic relief, though adverse effects, some of which are serious, are encountered. Many patients continue to have somewhat normal lives without treatment. Some patients with mild symptoms or in the early stages of the disease refrain from taking medications to avoid the adverse effects and lack of safety.

The main objectives of MS treatment are:

1. Providing symptomatic relief
2. Restoring normal body functions (recovering) following an attack
3. Preventing new attacks from recurring
4. Reducing the number of lesions in the axons
5. Slowing or modifying progression of the disease
6. Improving the quality of the patient's life.

Once diagnosis of relapsing remitting multiple sclerosis has been confirmed, treatment should be immediately initiated with anti-inflammatory and Disease Modifying Drugs (DMDs). There should be no delay in the onset of treatment since it has been shown that patients who were treated early have benefited more than those whose treatment was delayed. DMDs exert different effects on MS and usually are targeted to be used for a specific action. Some of those drugs may have an effect on slowing progression of the disability but not for treating the initial attack. Others may be used to slow relapse, but have no effect on slowing progressing disability.

### DISEASE-MODIFYING DRUGS

These medications exert their action by altering the immune system.

#### Interferons

Interferons are naturally-occurring proteins that are produced and released by cells of the immune system (lymphocytes) in response to an invader to the body such as viruses, bacteria, fungi, cancer cells and any other foreign substances. Interferons play an important role in communication between cells to stimulate initiation of the defenses of the immune system in order to eliminate the invading substances. They do not directly kill pathogens or tumor cells. This is achieved indirectly by enhancing the response of the immune systems and checking the multiplication of cancer cells by involving several genes that regulate the release of a number of cellular proteins. The name Interferon was derived because the chemicals interfere with the viral replication within the host cells and with growth of cancer as well. Interferons belong to a glycoprotein class known as cytokinase. In addition to activating immune cells such as white blood cells, natural killer cells, fibroblasts, epithelial cells and macrophages, they boost the ability of healthy host cells to resist infection. Interferons are classified in accordance with the type of their receptor. Three classes of interferons have been recognized: alpha, beta and gamma. Interferon alpha and beta comprise Type I interferon and interferon gamma represents Type II interferon. Members of Type I have similar biological activities. Each class has many functions, but they share many common effects some of which are antiviral, anticancer and are used in the treatment of many diseases such as multiple sclerosis.

**Interferon beta-1a** belongs to the interferon family. It is a human interferon produced by utilizing recombinant DNA technology using genetically engineered Chinese Hamster ovary cells into which human interferon beta has been injected. The final product is identical to the naturally produced interferon beta and has a similar sequence of amino acids. The drug slows down progression of MS due to its anti-inflammatory action, restores the ability of BBB to resist the entrance of T cells and other undesirable substances into the brain. By doing so no harmful substance can reach the brain. The medication is useful in the management of relapsing-remitting MS due to its tendency to alter the immune system. It slows deterioration of physical disability and decreases the frequency of attacks. Its usefulness in chronic progressive MS has not been demonstrated. If used early after the first attack, second attacks were delayed. It is available as a lyophilized powder which needs to be reconstituted, and as a pre-mixed liquid syringe. Usually it is injected intramuscularly once a week. Other products are injected subcutaneously every other day. Interferon beta-1a, like other interferons, can cause irritation at the injection site and eventually will leave dents due to the damage it causes to the fatty tissue of the skin (lipoatrophy). Erythema, pain and hardness at the injection site may be encoun-

tered. Application of ice at the injection site may minimize this adverse effect. Systemic adverse effects such as flu-like symptoms, fever, chills, dizziness, fatigue, depression, suicidal tendencies, muscular aches and headache are encountered by many patients. The use of analgesics is recommended in such cases. In most cases these symptoms are transient and become less severe with time. A more serious side effect is liver impairment. All patients taking interferons must regularly be monitored by performing liver function tests to detect any damage. A significant number of patients may within the first 6 months of use produce anti-IFN neutralizing antibodies whose appearance seem not to interfere with the therapy or its effectiveness. Changes in blood cell count may also occur in some patients. The interferons may have adverse effects on the thyroid gland. Regular thyroid function tests are recommended. Patients should be informed to call their physician in case of development of allergic reactions, hives, difficulty in breathing and swelling in the face or tongue. It is recommended that the administration of the drug should be done under the supervision and guidance of the physician. Self-injection may be performed once the physician determines that it can be done safely.

**Interferon beta-1b** is produced mainly by recombinant DNA technique by bacterial fermentation of strains of E-coli. This interferon is intended for the treatment of relapsing remitting forms of MS to reduce frequency and severity of attacks and symptoms. It is effective especially in patients who have experienced a first clinical attack and have been diagnosed using MRI. It is injected subcutaneously three times a week under the supervision of the physician until the patient is capable of self-injection. The adverse effects of this interferon are similar to interferon beta-1a.

#### **Other Medications**

There is a relatively small number of non-interferon DMDs that are used in reducing the number and exacerbation of attacks in relapsing-remitting MS: glatiramer acetate, mitoxantrone, natalizumab, and fingolimod. These medications vary in efficacy.

**Glatiramer acetate:** This is a synthetic drug which consists of a mixture of polypeptides that are believed to be similar to the protein of myelin. It is a polymer that consists of glutamic acid, lysine, alanine and tyrosine (all are amino acids found in myelin). It has been speculated that the drug exerts its action by blocking or diminishing the activity of the immune system against myelin (immunosuppressant). The drug may be used after one attack in spite of the fact that a patient should experience two or more attacks in order to confirm the presence of MS. Additionally, it is used for treating relapsing-remitting MS. Reduction of progression of disability has not been established. Two years ago the FDA approved the inclusion of the following statement to the indication of the drug "for reduction of the frequency of relapse in patients with relapsing-remitting MS, including patients who have experienced a first clinical episode and have MRI features consistent with multiple sclerosis." Because of its resemblance to myelin protein, it may act as a decoy; thereby avoiding repelling an autoimmune activity against myelin. Unlike interferon, glatiramer acetate has very little or no effect on BBB. Glatiramer acetate is administered parenterally daily.

Adverse effects of this DMD are mild in nature and include aches and fever. Unlike other DMDs, it does not cause flu-like symptoms. However, a reaction involving flushing, shortness of breath, palpitation, anxiety, or hives may occur in 10% of patients immediately after the injection. These reactions usually subside within 30 minutes after terminating treatment. Like other injected DMDs, this drug causes injection site reactions.

**Mitoxantrone:** This medication is used in cancer chemotherapy, but four years ago it was approved to be used in the US for secondary progressive, progressive relapsing, and worsening relapsing remitting MS. It is not indicated for treating primary progressive MS. Mitoxantrone may cause a number of adverse effects that include headache, tiredness, nausea, vomiting, hair loss, anorexia, allergic reactions, constipation, immunosuppression and cardiomyopathy. The most serious side effect is the cardiotoxicity since it is usually severe and irreversible. Regular monitoring of the heart is recommended during therapy. Since mitoxantrone has immunosuppressive activity, it may increase the chances for infections. The drug is administered parenterally usually once every three months for about 2 to 3 years as long term therapy is not advisable due to its toxicity.

**Natalizumab:** Natalizumab is one of the newer FDA approved drugs for the treatment of relapsing MS. It was first approved by the FDA in 2004. However, it was implicated with causing a potentially fatal neurological condition termed progressive multifocal leukoencephalopathy (PML) especially when administered with interferon beta-1a. After a thorough review, the drug was placed on the US market in 2006. In spite of the continuous reports of cases of PML, the FDA kept the drug on the market since its clinical benefits outweigh this adverse effect. The European Medicine Agency's Committee for Medicinal Products for Human Use approved the drug only as a monotherapy for the treatment of MS. It has been shown that it reduces the frequency of clinical relapses by 68% vs. placebo, a result higher than has been found with other treatments. Furthermore, it delayed pro-

gression of physical disability. When administered along with interferon beta-1a, the combination gave better results than administering the interferon alone. Adverse reactions increased. Natalizumab is a humanized monoclonal antibody which acts against alpha-4 ( $\alpha 4$ ) integrin, a substance needed by the immune cells to enter the brain and attach themselves to the affected organs, namely the myelin sheath. The drug is administered by intravenous infusion once a month. One of the major adverse effects of the drug is the risk of causing progressive multifocal leukoencephalopathy (PML), a viral brain infection which could be fatal. The safety and efficacy of natalizumab after two years of use has not been established. Other side effects include allergic reactions, headache, nausea, vomiting, common cold symptoms, fever, fatigue, hepatotoxicity, chest pain, dizziness, wheezing, and flushing of skin. Moreover, it has been implicated with melanoma, though the causes are unknown.

**Fingolimod:** Fingolimod differs from other DMDs in that it is administered orally. It was approved by the US in September, 2010 for the treatment of MS. The exact mechanism of the medication has not been determined, but it is believed that it tends to reduce the number of white blood cells which are essential for immunity and inflammation. It is capable of decreasing the number of attacks and delaying physical disability. Like other DMDs the long term safety of the drug is questionable. The most commonly encountered adverse effects of fingolimod are headache, flu-like symptoms, muscular pain, hepatotoxicity, cough, difficulty in breathing, heart, lung, eye toxicity and susceptibility to infections.

On January 21, 2011 the European Medicine Agency's Committee for Medicinal Products for Human Use recommended that this medication be used in Europe at a 0.5 mg daily dose to treat active relapsing-remitting MS. Fingolimod won US approval last September, news that was welcomed by many MS patients who rely on medication given only by injection.

**Corticosteroids:** Corticosteroids such as prednisone and intravenous methylprednisone are potent anti-inflammatory agents which may be used to reduce inflammation that flares-up during an acute relapse or attack (disability), and may require hospitalization. Patients are given methylprednisone intravenously over a period of three to five days. Corticosteroids are administered in order to provide quick relief from the disabling attack. These medications are proven to be effective in the short term as their effect lasts for about one month after the onset. Long term therapy with corticosteroids is not recommended due to their adverse effects such as adrenal suppression, high blood glucose, insomnia, Cushing's syndrome, weight gain, osteoporosis, glaucoma, cataract and depression.

### MEDICATIONS UNDER REVIEW

On January 21, 2011 two medications intended for the treatment of MS failed to win approval in Europe. These are Cladribine and Fampridine.

**Cladribine** is a purine analog which suppresses the immune system. It is used in the treatment of hairy cell leukemia and is under investigation for use in the treatment of MS. Its use had not been approved in Europe and as of September, 2010, the FDA is investigating the second application. These agencies are still questioning the effectiveness of the drug in improving walking of MS patients. Moreover, the agencies are not convinced that the benefits to be gained outweigh the adverse effects which include dizziness, fatigue, paraesthesia and imbalance. Furthermore, long-term data on safety of the drug has not been determined. The drug is administered by intravenous infusion or subcutaneous injection.

**Fampridine** is a selective neuronal potassium channel blocker which acts on demyelinated axons to keep the charged potassium particles within the damaged nerve cells. This may enable the electrical impulses to use the nerve to stimulate the muscles and improve the MS patient's walking ability. However, in January, 2011 the European Agency recommended against approving fampridine for improving walking ability in adult patients with MS. It was further noted that the small effect on walking did not outweigh its adverse effects which include pain, dizziness, paresthesia and imbalance. The drug is formulated as a prolonged-release tablet.

### COMPLEMENTARY & ALTERNATIVE MEDICINE & OTHERS

A significant percentage of MS patients employ complementary and alternative medicines, perhaps because the effectiveness and safety of conventional treatments are lacking. Furthermore, many patients cannot tolerate the adverse effects of current MS drugs. Even though patients reported improvement after long-term use with complementary and alternative medicines, there are no controlled studies to prove these claims. Conflicting claims were reported when employing herbal medicines. General exercises to relax muscle and improve the quality of life are recommended.

Socially it is important that the patient, especially those who are unable to walk, have the support of the family in coping with physical disabilities. Constant psychiatric and nursing assistant is essential to elevate the patient's mood.

### SUMMARY

Multiple sclerosis is an unpredictable, auto-immune inflammatory disorder of the brain and spinal cord that results in damage to the myelin sheath of the axons. It can affect persons in all ages particularly those in their thirties.

The symptoms of MS are numerous and range from mild to severe. There is no cure for MS but there are drugs that can improve the patient's conditions and prevent attacks or relapses and progression. The main drugs that are used at the present time are DMDs such as the interferons, glatiramer, mixoxantrone, natalizumab, and tingolimed. There are a number of medications that are under review.

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### Other Topics for This Year

**Dry Eye Syndrome; Healthcare Reform & Impact on Pharmacy; Restless Leg Syndrome; Vaccine Update; New Drugs Released in 2010**

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**LESSON EVALUATION**

Please fill out this section as a means of evaluating this lesson. The information will aid us in improving future efforts. Either circle the appropriate evaluation answer, or rate the item from 1 to 7 (1 is the lowest rating; 7 is the highest).

1. Does the program meet the learning objectives?

List the symptoms of MS Yes      No

Name the types of MS Yes      No

Describe pathogenesis of MS Yes      No

State causes that trigger MS Yes      No

Discuss goals of MS treatment Yes      No

List the drugs used in the treatment of MS Yes      No

2. Was the program independent & non-commercial Yes      No

	Poor			Average		Excellent	
3. Relevance of topic	1	2	3	4	5	6	7

4. What did you like most about this lesson? \_\_\_\_\_

5. What did you like least about this lesson? \_\_\_\_\_

**Please Select the Most Correct Answer**

1. Which statement is correct about MS?
  - A. Occurs as result of demyelination
  - B. Myelin sheath is inside the axon
  - C. MS is a viral disease
  - D. Incidence is limited to young adults

2. The blood-brain-barrier is:
  - A. Permeable to drugs
  - B. A membrane surrounding the brain for protection
  - C. A network of blood vessels
  - D. Part of the CNS

3. Which type of MS is characterized by complete absence of remission after the initial symptom?
  - A. Progressive Relapsing
  - B. Primary Progressive
  - C. Secondary Progressive
  - D. Relapsing Remitting

4. Seeing two images of a single object is termed:
  - A. Desaturation
  - B. Diplopia
  - C. Nystagmus
  - D. Dysarthria

5. The incidence of MS in persons with gout is lower than the general population.
  - A. True
  - B. False

6. Glatiramer:
  - A. Is not used for relapsing-remitting MS
  - B. Is given orally
  - C. Resembles myelin protein
  - D. Interferes with BBB function
7. Progressive multifocal leukoencephalopathy is a major adverse effect of:
  - A. Natalizumab
  - B. Mitoxantrone
  - C. Fingolimod
  - D. Corticosteroids
8. Which of these is used orally?
  - A. Cladribine
  - B. Interferon beta-1b
  - C. Natalizumab
  - D. Fingolimod
9. Which of these is not implicated in causing MS?
  - A. Genetics
  - B. Gender
  - C. Infections
  - D. Environmental factors
10. Which statement is correct about interferon?
  - A. It is a synthetic drug
  - B. It directly kills pathogens & tumor cells
  - C. It hinders communication between cells
  - D. It is considered to be a glycoprotein

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