Section of Neuro-Infectious Disease
Strategic Plan

Part I: Introduction

The motivation for formation of the Neuro-Infectious Disease (NID) Section in the American Academy of Neurology (AAN) was to bring together neurologists, neuroscientists and infectious disease experts interested in neurological infections for collaboration and exchange of information about understanding and treating neurological infections, in association with the AAN.

The Section was formed to:

1- Deal with difficult to treat patient illness caused by neurologic infections;
2- Facilitate national collaboration and problem-solving among American neurologists for neurological infections;
3- Facilitate international collaboration and problem-solving for neurological infections in underserved areas of the world where neurological infectious disease is the greatest burden of neurologic disability;
4- Facilitate training in the subspecialty area of neurologic infections;
5- Educate AAN members and residents about the use of laboratory diagnosis and treatment for neurological infections;
6- Promote research in the area of neuro-infectious diseases.

The NID Section aims to annually promote scientific and clinical discussion of neurological infections at the AAN meeting and at the business meeting of the Section of Neuro-Infectious Diseases (SNID). The NID seeks to annually identify a slate of objectives to be solved or investigated in the area of neurologic infections. The section promotes training programs with expertise in neurologic infections for residents and fellows; reviews practice parameters put forth by the AAN pertaining to neurological infections; and serves as a means for organizing data bases in order to study or treat patients with neurologic infections.

The mission of the Neuro-Infectious Disease section is to facilitate scientific research and promote the understanding of neurologic infections, in order to better diagnose and treat patients with those disorders. The mechanism to accomplish this purpose is to promote meetings, seminars and courses, at least on an annual basis in association with the AAN meeting, for scientific exchange of ideas dedicated to this collection of diseases.

Part II: Background/History of Neuro-Infectious Disease Section

The Neuro-Infectious Disease Section and its bylaws were approved by the Committee on Sections (COS) and AAN Board of Directors in 2001 based on a proposal put forth by a group of neurologists in the Academy who felt that infectious diseases clinical practice and research was underserved within the AAN. No organized promotion of the subspecialty was taking place at the AAN meeting. The initial conception was formulated at the Neuro-Infectious Disease course at the AAN meeting in Philadelphia in 2001. The formation of the section was the result of discussion by Academy members who assessed the need, and thus proposed a section that would bring together neurologists, neuroscientists and infectious disease experts for collaboration and exchange of information related to understanding and treating neurological infections.

The first organizational meeting for the NID Section was held on Thursday, April 18, 2002 at the AAN Annual Meeting held in Denver, Colorado. At that meeting elections were held to appoint officers for the section. The section members voted to elect Dr. Allen Aksamit as Chair. The NID section began with 49
Part III: Current State of the Subspecialty or Section

The World Health Organization estimated that in low income countries NIDs were the second leading cause of years of healthy life lost to disability (YLDs) among neurological disorders in 2005, approaching 200 YLDs/100,000 population.  

http://www.who.int/entity/mental_health/neurology/chapter_2_neuro_disorders_public_h_challenges.pdf

By contrast, in high income countries, neurologic infections did not even rank in the top five causes of YLDs attributable to neurologic disorders.  Sanitation, temperate climate, and vaccination programs in developed nations account for much of the difference.  Rabies, some forms of bacterial meningitis, tetanus, leprosy and cerebral malaria are uncommon in most high income nations, including the United States.

The virtual elimination of rabies and polio in the US demonstrated that widespread animal and human immunization can control serious NIDs.  More recent advances include falling rates of Hemophilus influenza meningitis due to vaccines (and the hope that pneumococcal and meningococcal vaccines will yield similar declines) and the recommendation that the zoster vaccine be given to persons 60 and older to prevent shingles (http://www.guidelines.gov/summary/summary.aspx?ss=15&doc_id=12633&nbr=6541).  While vaccination is an effective prevention strategy for infectious disease, including some involving the nervous system, many of the most feared complications are neurologic, including central and peripheral demyelinating disorders.

Many NID challenges remain in the US and other industrialized countries.  HIV/AIDS, cancer chemotherapy, and therapeutic immunomodulation for organ transplantation and autoimmune disorders leave increasing numbers of people vulnerable to NIDs.  Recently, cases of the viral infection progressive multifocal leukoencephalopathy (PML) were associated with therapy using natalizumab, a humanized monoclonal antibody used to treat refractory relapsing forms of multiple sclerosis (Berger JR, Koralnik I. New Engl J Med 353:41406, 2005).  The September 11 attacks and their aftermath renewed interest in bioterrorism agents, including anthrax and botulism, infections with significant neurologic consequences.  Immigration and the increased ease of international travel have brought previously rare infections, such as West Nile neurologic disease and neurocysticercosis to the US.  Timely recognition of emerging infections involving the nervous system will require coordination between NID experts and agencies such as the Centers for Disease Control and Prevention.

Additionally, infectious agents may play roles in the pathogenesis of multiple sclerosis and other CNS demyelinating disorders (transverse myelitis and acute demyelinating encephalomyelitis), as well as in other neuroimmune disorders such as Guillain-Barre syndrome and neurosarcoidosis.  A recent study showed that nearly one-third of patients admitted to the neurology service at a tertiary care center with a suspected NID remained undiagnosed.  The morbidity (28%) and mortality (12%) of these disorders were high (Tan K et al, Neurology, 71:1160, 2008).  NIDs thus remain a significant diagnostic challenge and health care concern in the US and in other high income nations.

Aging with HIV infection or AIDS has become the rule for patients with access to HAART.  This presents further challenges to understand retrovirus-age interactions and improve developmentally-appropriate treatments.

The backgrounds of SNID members are diverse, drawing from related subspecialties including neurovirology, tropical neurology, prion diseases, neuroepidemiology, neuroimmunology, and HIV neurology.  Some academic centers, including Mayo Clinic, University of Kentucky, and Indiana
University, have dedicated NID Clinics; at Johns Hopkins University, subspecialty inpatient NID consultation and fellowship is available.

In its 2004 AAN survey, 16.3% (254 respondents) of international neurologists and 10.3% (649 respondents) of US neurologists reported CNS infectious disease as one of their practice foci.

Medical infectious disease specialists with an interest in NID typically focus on specific diagnoses, such as meningitis or encephalitis, or particular infections, such as TB, coccidiomycosis, etc. These experts and SNID members have collaborated to develop recent practice guidelines from the Infectious Disease Society of America (IDSA) on management of encephalitis (http://www.idsociety.org/content.aspx?id=4430#en) and from the AAN, endorsed by the IDSA, on treatment of nervous system Lyme disease (http://aan.com/practice/guideline/index.cfm?fuseaction=home.view&guideline=242). However, there is no independent organization or other existing mechanism to bring these groups together with other non-neurologist clinicians interested in NID.

At the 2008 AAN Annual Meeting in Chicago, NID research was presented in two platform and two poster sessions. For the first time, an Integrated Neuroscience Session was held on Tropical Neurology, featuring speakers and research from Asia, Africa, and South America, as well as from North America and Europe. In addition to Neurology, NID research is published in other major neurology journals such as Brain, Annals of Neurology, and Archives of Neurology. Recently, the Journal of NeuroVirology expanded its scope to include emerging NIDs. NID research is also published in infectious disease and related journals, including Clinical Infectious Diseases, Journal of Infectious Disease, Journal of Acquired Immune Deficiency Syndromes, and AIDS.

The Chicago meeting included the all-day Infections of the Nervous System course, as well as shorter courses on Approach to Acute CNS Infections, Scientific Basis of Neurologic Infections, and Global Health Challenges: Neurology in Developing Countries. The SNID has developed curricula for teaching NID to medical students (see Appendix). There is thought to be significant variability in NID curricula among neurology residency training programs. Existing fellowships in Neurovirology and HIV neurology have provided a pathway for neurology residents to pursue interests in NID. A NID Fellowship has recently been established at Johns Hopkins University.

The NIH budget situation and potential cuts to Medicare reimbursement have challenged scientists and clinicians, including NID subspecialists. On the research side, this may be offset somewhat by additional funding mechanisms for global health studies. Clinically, the association of some NIDs, such as neurocysticercosis, neurotuberculosis, and HIV/AIDS, with immigrant status or poverty likely increases the risk of affected patients being un- or underinsured. This can create barriers to subspecialty care, particularly for individuals residing in areas without substantial local public health resources.

Legislatively, the NIH budget, stability of Medicare and Medicaid programs, and adequate public health infrastructure and funding for Centers for Neuroinfectious Diseases, and support for vaccine administration and research, are issues of interest to the SNID.

**Part IV: SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis of the Subspecialty**

Strengths are medical, numeric, and epidemic importance of illnesses that are NID, along with membership growth and commitment. A network of individuals, groups, and training programs is already in place to address timely, critical issues in NID.
• Currently there are approximately 120 members of the NID Section of the AAN, a nearly 250% increase in membership in the 5 years since founding of the NID Section. Within the section there is great diversity, depth and breadth of expertise. Clinic-based, epidemiology/surveillance-based, and lab-based programs are well-represented.
• The number of new diseases that qualify as NID is growing. New full day courses at the AAN meeting have been introduced for 2008 and 2009, to compliment the basic full day course in management of neurological infections. AAN members now have opportunities to be informed on relevant neuroscience and challenged on controversies in diagnosis and management. Breakfast and dinner seminars change year to year to address pressing issues such as emerging infections, bioterrorism, and neurologic complications of immunosuppressive treatments.
• The global burden of NID is high. Satisfactory treatment of these conditions is an important and unmet need in Neurology in the US and throughout the world. At least one major Neurological Center of Excellence has developed an NID fellowship program and can provide mentorship and support for development of sub-specialty training in Departments of Neurology nationally and internationally.
• Training of neurological residents in NID has been improved with development by the NID Section by creating minimum uniform standards for residency training.
• A web-based listserv is enabling discussion among experts of difficult cases, forming the basis for a broader effort to assist clinicians nationally and internationally in diagnosing and treating NIDs.
• A web-based listserv also will alert members to emerging or epidemic NID. This capability facilitates rapid responses by multiple institutions, to facilitate the set-up of multicenter treatment or epidemiologic studies.
• Discussion of accreditation for NID as a subspecialty is underway with the Committee on Sections and UCNS.

Weaknesses are in the areas of recognition, representation and sustainability.
• This area of clinical practice and research is underserved within the AAN. No organized subspecialty promotion had taken place within the AAN prior to initiation of the NID Section.
• There is no organized forum available for concentrated information on best practices for treatment of infectious diseases where treatment data is contradictory or non-existent of diseases of significant neurologic morbidity and mortality. This is a potential growth area for the NID Section.
• There is no organized forum for neurologists to identify and discuss controversies in NID.
• Federal (NIH) grants are rare for research in neurologic infectious diseases such as the mosquito-borne encephalitis, PML, viral encephalitides such as Herpes Simplex Encephalitis, as well as for neurosyphilis, neuroborreliosis, and infectious diseases with devastating neurologic complications such as malaria and tuberculosis. Controversies in diagnosis and in treatment exist for each of these diseases with devastating consequences stemming from delay in diagnosis and treatment.
• Neurological infectious disease has been largely ignored as a feature in AAN plenary sessions, limiting members’ awareness of NID evolving knowledge.
• International neurologists with expertise and interest in NIDs are poorly represented in the AAN scientific presentations.
• While it is widely accepted that infections may play an important role in either the pathophysiology or etiology of several neurodegenerative or neuroimmune disorders, there is currently no organized effort to investigate these possibilities.
• NID is an interdisciplinary subspecialty. Interdisciplinary subspecialties are not always recognized or supported at Universities by commitment of resources or promotion. Participation in interdisciplinary activities is may not be popular, because it is time-consuming and outside the scope of regular activities.
Opportunities
The Neuro-Infectious Disease Section hopes to promote an agenda of growth in training, representation, communication, collaboration and funding opportunities. It hopes to:

- Facilitate interest and knowledge base in NID among Neurology trainees
- Establish more training fellowships in NID
- Enlarge network of neurologists both nationally and internationally with expertise in NID
- Provide web-based best practices and assistance in diagnosis and treatment of NIDs, of special benefit to practitioners with limited access to expert consultants and major medical centers
- Recruit representatives from Africa, Latin America and Asia, areas with high burden of NIDs and often limited medical resources
- Globalize NID to benefit the neurologists and their patients in underserved areas as well as enlarge the knowledge base of the specialty as a whole
- Annually promote scientific and clinical discussion of neurological infections at the AAN meeting and at the business meeting of the Section of Neuro-Infectious Diseases (SNID).
- Annually identify a slate of objectives to be solved or investigated in the area of neurologic infections.
- Review practice parameters put forth by the AAN pertaining to neurological infections
- Serve as a means for organizing databases in order to study or treat patients with neurologic infections.
- Disseminate treatment algorithms and information on best practices through greater selection of educational programs at the AAN annual meetings as well as regional meetings, through an AAN-maintained website, and published reviews
- Develop an effective lobby for increased federal funding for research in NIDs afflicting millions across the globe and for neurological diseases in which infectious causes are likely.
- Link training programs nationally and internationally to continually educate about NIDs as epidemiology and treatment options evolve
- Link NID with other infectious disease organizations as well as CDC and, where appropriate WHO, to develop and publish treatment algorithm, evidence-based guidelines and critical updates on changing epidemiology of NIDs
- Develop funding sources for national and international NID training
- Train neurologists to more effectively evaluate and treat NIDs that occur commonly in the developing world.
- Develop a comprehensive and standardized curriculum for training of medical students, residents and fellows in neuroinfectious diseases.

Threats include:
- Insufficient appreciation of importance of NID needs in the AAN, the NIH, and resident training programs.
- Lack of funds and in-kind resources for web-based information dissemination
- Lack of funds for fellowship training programs
- Delay or failure of NID subspecialty certification

Part V: Specific Vision, Goals and Objectives for the Subspecialty or Section

A. Short-term Goals

1. Educational programs at AAN on NID
Currently, the NID section participates in a full day course devoted to the management of neurological infections. In 2008, the section started a new course on the “Scientific Basis of Neurological Infections” at the urging of the membership of the section. In 2009, the section will offer a new course on “Controversies in Neurological Infections”. These courses are a reflection of the increasing awareness of the challenges posed to neurologists by the complexity of knowledge required to manage neurological infections. Through these three courses the NID section will continue to identify challenging and timely topics, provide a discussion on the treatment and practice guidelines of neurological infections and keep the membership of AAN abreast of the latest developments in the field. For example, in 2007, the section offered a half day course on “Therapeutic poisoning: Immune suppressive therapy for non-neoplastic neurological disease”, a dinner seminar on “Neurological complications of emerging infections and bioterrorism” and a breakfast seminar on “Approach to acute CNS infections” All courses and topics are discussed at the section meeting each year.

2. Uniform training guidelines
Minimum standards in NID for medical students, residents and fellowship training are needed. Substantial effort has been made by the NID Section to develop guidelines and minimum training requirements for trainees at each level of training. (See appendix)

3. Review of Practice Parameters in NID
The NID section currently reviews any practice parameter considered by the AAN, involving neurological infection. The NID aims to select topics of general interest and develop guidelines/practice parameters for the AAN. Topics will be chosen at the section meeting and a committee of experts formed to help draft the guidelines. The section will also review previous parameters and update them as needed.

4. NID Press Releases from the AAN Meeting
Public awareness of important developments in the identification and treatment of neurological infections is an important goal of the section. The leadership of the section is willing to work closely with the AAN to help identify and disseminate such information.

5. Speakers for the Plenary Sessions of the AAN Meeting
Important developments in NID or emerging infections should be more widely disseminated to the AAN membership. To date neurological infections have very rarely been represented in the AAN plenary sessions. The NID section would like to work closely with the leadership of the AAN to help identify topics and speakers to increase awareness of important issues and developments in NID.

6. Collaborations and discussion of unusual cases.
A Listserv has recently been established. Such cases have been disseminated among the NID membership. We will attempt to keep the list current and assist in its evolution as an interactive tool amongst the members.

7. Section newsletter
The on-line newsletter administered through the AAN provides updates on NID courses being offered and related platform and poster sessions at the AAN meeting, with other educational opportunities related to NID. It could be used more effectively to raise issues of business within the NID that require input from the membership and keep them abreast of other activities of the section. Members of the executive committee and their terms in office will be displayed in the newsletter so as to encourage others to participate and seek office.

8. Membership
The NID Section encourages junior AAN members and residents to consider NID subspecialty training. More International membership is sought.
B. Long-term Goals
Long term goals are to:

1. Establish accredited fellowship training programs in NID.
The section is already working with the Committee on Sections and UCNS to help develop an accredited NID fellowship.

2. Establish fellowships administered by the AAN for training in NID.
One of the goals of the division is to work with the AAN and potential donors to establish a clinical fellowship for neuro-infectious diseases that would be available on a competitive basis.

3. Establish a network of neurologists with expertise in NID.
Such AAN members exist that can respond to challenges faced by emerging infections or complications of infection. Other examples are establishment of a bank of patient specimens with NID, with special emphasis on rare and undiagnosed cases.

4. Establish guidelines for providing medico-legal expertise in NID.

5. Assist in the development of a website for the diagnosis and treatment of NID.
Amongst other things, the website will list ongoing clinical research studies at various institutions. It would also serve as a venue for consultation for difficult neuro-infectious diseases.

6. Establish a leadership role in issues related to international neuro-infectious diseases.
The international membership of this section seems to be expanding at a rapid pace. As opposed to other neurological diseases, the NID are unique since the types of neurological illness vary in different geographic regions around the world. Organisms are strongly influenced by climate, socio-economic and political pressures. NID are a major burden in developing countries. The section of NID is ideally suited to serve as a liaison between the AAN and the neurologists and other health care professionals in these underserved areas. The section of NID will also work with the AAN to develop educational programs within the AAN for such diseases. Currently, the executive committee of the section of NID has an international councilor. We hope that the international councilor will play an important role in forming a working committee that will address issues related to NID in international settings.

7. Lobby with the AAN to increase funding for research in NID.

8. Identify economic and coding challenges for NID

Part VI: Summary/Concluding Statement

1. Summary of mission/vision/values for specialty
The mission of the Section is to recognize and promote research in NID as a major cause of morbidity and mortality in United States and the world. This subspecialty of neurology remains underserved. The opportunities for growth are significant. There are no formal training programs. There is a severe deficit of funding for research for these diseases and a lack of any concerted effort to develop new treatments for NIDs. Serious funding for discovery of infectious causes of neurological diseases with suspected infectious etiologies is lacking. Neurology as a specialty lacks evidence based practice guidelines for many NIDs.
The major goal of this Section is to promote patient care, education and research for infections of the nervous system. The NID will work closely with the AAN to accomplish these goals. The educational goals will be accomplished by providing standardized training in NID for medical students, residents, fellows and practicing neurologists. The section will establish a certified fellowship training program, and work with the AAN by establishing high quality courses and plenary lectures on NID at the annual meetings, and contribute to AAN publications to educate the membership on NIDs. The Section will also develop practice parameters for NID, and develop a leadership role in issues related to international NID. The NID Section will also work with the AAN in its efforts to lobby for funding for research related to NID.

2. Global conclusion and assessment of sub-specialty’s place within the larger scope of AAN, other specialties, neurology in general and related fields (e.g. neurosurgery).

The NID Section has been established as a separate section and named subspecialty within AAN only seven years ago. The current membership consists of neurologists with either formal interest in NID or those trained in NID related fellowships. However, the establishment of the NID section has revealed to the membership the challenges faced in the diagnosis and treatment of NID and their importance as a major cause of morbidity and mortality. Yet, there have been no plenary lectures in recent years at the AAN on NID or any fellowships funded by the AAN for NID either.

Proper management of NID often requires an interdisciplinary approach. Recent advances in radiological and molecular biological techniques provide improved diagnostic tools for NID. Neurosurgical intervention for diagnosis and treatment by drainage or evacuation of infectious material is one example of the need for an interdisciplinary approach. The wide spread use of immunomodulatory drugs for neurological and systemic disorders has led to the emergence of opportunistic infections that poses unique challenges in management. Close interactions with other subspecialties such as Sections of Multiple Sclerosis, Neuromuscular diseases or Neurooncology should be promoted because of overlapping clinical interests. Even patients successfully treated for the NID have long-term neurological deficits which can be helped by collaboration with behavioral neurology, epileptology, sleep medicine and rehabilitation medicine.

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Appendix:

CNS Infection Information to be Taught to Medical Students

Approved at the AAN Neuro-infections Section Meeting
Final Version April 3, 2006

All versions would require knowledge about the technique of properly performing a lumbar puncture. In addition the student should know the normal and abnormal values for common CSF lab tests.

BASIC VERSION

1. Meningitis
   - Bacterial meningitis-aerobic

2. Brain abscess
   - Bacterial-anaerobic

3. Encephalitis
   - Herpes simplex virus
   - West Nile virus

4. Cerebrospinal fluid
   - Indications
   - CSF infection profiles
   - Available tests for infectious agents (culture, PCR, antigen tests, antibody tests)

INTERMEDIATE VERSION

1. Meningitis
   - Viral meningitis (enterovirus)
   - Bacterial meningitis (*Streptococcus pneumoniae*)
   - Fungal meningitis (*Cryptococcus neoformans*)
   - Tuberculous meningitis (*Mycobacterium tuberculosis*)

2. Brain and epidural abscesses
   - Bacterial-anaerobic
   - Fungal

3. Encephalitis
   - Herpes simplex virus
   - West Nile virus
   - General paresis from *Treponema pallidum*

4. NeuroAIDS
   - AIDS dementia
   - CNS toxoplasmosis
   - AIDS painful distal neuropathy
5. Prion diseases
   - Creutzfeld-Jakob disease

6. Cerebrospinal fluid
   - Indications
   - CSF infection profiles
   - Available tests for infectious agents (culture, PCR, antigen tests, antibody tests)

**COMPREHENSIVE VERSION**

1. Meningitis
   - Viral meningitis (enterovirus)
   - Bacterial meningitis (*Streptococcus pneumoniae*)
     a. neonatal meningitis
     b. childhood and adult meningitis
   - Fungal meningitis (*Cryptococcus neoformans*)
   - Tuberculous meningitis (*Mycobacterium tuberculosis*)

2. Brain and epidural abscesses
   - Bacterial-anaerobic
   - Fungal

3. Encephalitis
   - Herpes simplex virus
   - West Nile virus
   - Poliomyelitis
   - Rabies

4. Retroviral Infections
   - HIV
   - HTLV (II and III)

5. Prion diseases
   - Creutzfeld-Jakob disease

6. Peripheral nerve infections
   - Shingles and post-herpetic neuralgia
   - Leprosy

7. Biologic neurotoxins
   - Botulism (*Clostridium botulinum*)
   - Tetanus (*Clostridium tetani*)

8. Spirochetal, *Rickettsia*, and parasitic CNS infections
   - Neurosyphilis (*Treponema pallidum*)
   - CNS Lyme disease (*Borrelia burgdorferi*)
   - Rocky Mountain spotted fever (*Rickettsia rickettsii*)
   - Neurocysticercosis (*Taenia solium*)

9. Opportunistic infections in immunocompromised patients
- Progressive multifocal leukoencephalopathy
- Opportunistic bacteria and fungi
- CNS Toxoplasmosis

10. Para-infectious illnesses
- Acute disseminated encephalomyelitis
- Guillain-Barre syndrome

11. Cerebrospinal fluid
- Indications
- CSF infection profiles
- Available tests for infectious agents (culture, PCR, antigen tests, antibody tests)

Each medical school should select the amount of material taught to medical students based on their curriculum needs and time available

**CORE CURRICULUM for Fellowship in Neuroinfectious Diseases**

**Clinical evaluation:**
All trainees will have completed a neurology residency and hence would be expected to be able to obtain a complete history and conduct a thorough neurological examination. However, the diseases encountered in the subspecialty of Neuroinfectious diseases and neuroimmunology require special emphasis on certain elements of the neurological assessment.

- History should include a detailed systemic history, travel history, social and family history.
- General physical examination should include examination of the skin, lymph nodes, chest and abdomen.
- Neurological exam should include fundoscopy, extra ocular movements, assessment of gait and spasticity. The trainees should know how to use various neurological assessment scales developed for these diseases, including the EDSS, HIV Dementia scale, the Memorial Sloan Kettering scale (for HIV dementia), and MMSE. They should understand the pros and cons of these scales.

**Pathological manifestations:**
- Gross and microscopic pathology of acute viral meningoencephalitis, brain abscess, HIV encephalitis and CNS opportunistic infections associated with AIDS, chronic bacterial or fungal meningitis, Multiple Sclerosis and its variants, and various forms of CNS vasculitis.
- Develop an understanding of the various pathological and staining techniques including tissue processing for diagnosis of these diseases.
- Learn to make and interpret both cryostat and fixed tissue sections.
- Learn how to handle pathological specimens and autopsy tissue from patients with transmissible diseases.
- Learn techniques for inactivation of infectious agents, such as prions, viruses, and other microbial agents.

**Diagnostic evaluations**

**Radiological:**
- CT scan,
- MRI findings of various CNS infections and immune disorders, to include findings in FLAIR, diffusion weighted and ADC images, and post-contrast scans.
- Use of SPECT and PET scanning.
- Develop an understanding of the basic principles behind each of the imaging techniques.

**Neurophysiology:**
EEG criteria for CJD, SSPE, and its evolution over the disease course.
Use of evoked potentials in the evaluation of neuroimmune conditions.

**Cerebrospinal fluid:** Expertise in performing LPs is usually accomplished during neurology residency. The fellowship training program would reinforce the technique and apply it to special circumstances when there is concern for particularly high risk transmissible diseases (e.g. prions, HIV)
- Should develop expertise in performing LPs in sitting and lateral decubitus positions.
- In accordance with AAN guidelines, should learn to use atraumatic needles and know the indications, contraindications of doing a spinal tap.
- Learn how to do LPs in patients with transmissible diseases.
- Know the potential complications from the procedure and how to manage the complications.
- Know the CSF findings in each of the neuro-infectious and neuroimmune diseases.
- Use of PCR, its sensitivity and specificity for diagnosis of microbial infections.
- Understand the composition, formation and fluid dynamics of the CSF.

**Microbiology:**
Develop a working knowledge of various methods of detecting CNS microbial infections including use of antibody titers,
culture and staining,
molecular biological techniques,
the morphological characteristics of the infectious agents.

**Integration and Presentation of Findings**
1. Integration of collateral history into the clinical assessment.
2. Development of a differential diagnosis pertinent to the neuro-immune or neuroinfectious disorder.
3. Formulation of a diagnosis based on findings from the clinical and laboratory assessment.
4. Development of treatment plan for the neuro-immune or neuroinfectious disorder.
5. Presentation, both verbally and in writing, of clinical impressions and recommendations derived from the comprehensive clinical assessment to:
   a. The patient and his or her family
   b. Other health care professionals
   c. Other private or public agencies providing services to the patient.

**Treatment strategies**
Immumomodulatory drugs: Have a thorough knowledge of current and emerging immunomodulatory drugs used to treat CNS autoimmune diseases. This should include their mechanisms of action, their pharmacology, modes of administration, indications and contraindications and potential side effects and management of the complications. Drugs in this category may include, corticosteroids, beta interferon, glatiramer acetate, natalizumab, plasmapheresis, mitoxantrone, B cell antagonists such as rituximab, T cell antagonists such as celecept, daclizumab, other chemotherapeutic drugs such as cyclophosphamide and other immunomodulatory drugs such as IVIG. It is being increasingly recognized that patients on these therapies may be a risk for developing CNS opportunistic infections. Hence knowledge of the evolving
guidelines for monitoring for such infections and appropriate management of these complications is essential.

**Antimicrobials:** know how to treat with and monitor patients on antiretroviral drugs, particularly those that penetrate the CNS and those that may cause neurologic side effects. Know how to use anti-herpes virus drugs, how to monitor and treat patients for resistance to acyclovir and other antivirals. Know how to treat bacterial and fungal infections of the CNS including syphilis, Lyme disease, tuberculosis, cysticercosis and toxoplasmosis. Trainees should know the pharmacodynamics of agents with respect to the blood-brain barrier, and the potential neurotoxicities and systemic side effects of these anti-infective agents.

**Symptomatic:** This should include treatment of neuropathic pain, such as painful peripheral neuropathies and trigeminal neuralgia; antispastic agents, anticonvulsants, chronic fatigue, spastic bladder and urinary retention and sexual dysfunction.

**Indications for surgical intervention:** baclofen pump, brain biopsy, surgical drainage of brain abscess. Indications and contraindications of surgical procedures. Precautions in patients with transmissible diseases particularly, tuberculosis, CJD, HIV or hepatitis infection.

**Infusion center:** Learn how to manage an infusion clinic and how to administer and monitor patients on immunomodulatory and antimicrobial drugs that require infusions.

  - Patient and family education
  - Use of and referral to other health professionals such as rehabilitation services, urologist, neuro-opthalmologist, neuropsychologist.

**Reporting requirements:**
Know the reporting requirements of neurologic infections, including the urgency of reporting. Should also know how to access state and national public health agencies.

**Didactic course:** Twenty hours of a didactic course that covers all aspects of Neuroinfectious and neuroimmune disorders is an essential requirement. However, this requirement may be fulfilled by any one or a combination of the following: classroom lectures, journal clubs, web based courses, or courses at the AAN in the related subspeciality.

**Neuroinfectious and neuroimmune disorders:**
Fellows in this training program are expected to develop in-depth knowledge regarding the neuropsychiatric and neurobehavioral consequences of many neurological and psychiatric conditions. All fellows are expected to bring to subspecialty training the level of knowledge and clinical competence required by the ACGME-RRC in Neurology.

Due to the limited duration of training in this fellowship, and the fact that some infections and immune disorders are prevalent in different geographical regions around the world, some trainees may not have direct patient interactions with all the diseases that fall under this subspeciality. The elements of the Core Curriculum described above are designed to ensure that Fellows develop the knowledge base and clinical skills required to understand, evaluate, and treat patients with neuroinfectious and neuroimmune disorders. In the service of preparing Fellows to provide care for persons with neuroinfectious and neuroimmune disorders they are expected to both complement and supplement “bedside-learning” through guided self-directed learning activities and/or didactic experiences. Guided self-directed learning activities may include reading relevant textbooks, peer-reviewed articles, or other materials recommended by training program faculty. Didactic experiences may include seminars or other course work provided by the
training program itself or by other programs either within or affiliated with the institution in which the fellowship training occurs. Additionally, Fellows should be encouraged to attend local or national conferences relevant to this aspect of training in neuroinfectious and neuroimmune disorders. Through these means, it is expected that the fellow will develop an advanced level of knowledge regarding the neuroinfectious and neuroimmune disorders including their epidemiology, neurogenetics, putative neurological substrates, and typical neuropathological features of the conditions listed below, where such are known.

**Neuroimmune disorders**

- Multiple sclerosis
  - Relapsing remitting
  - Primary progressive
  - Secondary progressive
  - Progressive relapsing
- Multiple sclerosis variants
  - Marburg’s variant
  - Schilder’s disease
  - Balo’s concentric sclerosis
- Acute disseminated encephalomyelitis
  - Hemorrhagic leukoencephalitis
- Idiopathic Transverse Myelitis
- Optic Neuritis
- Neuromyelitis Optica
- Neurosarcoidosis
- Neurological manifestations of rheumatological diseases
  - Sjogren’s
  - Systemic lupus erythematosus
  - Behcet’s
  - Rheumatoid arthritis
  - Wegener’s granulomatosis
  - Other CNS vasculitis

**Neuro-infectious diseases**

- Meningitis
- Bacterial Meningitis
  - Meningococcal Meningitis
  - Pneumococcal Meningitis
  - Haemophilus Meningitis
  - Staphylococcal Meningitis
  - Listeria Meningitis
  - Tuberculous Meningitis
  - Gram negative bacteria
- Aseptic Meningitis
- Chronic Meningitis
- Fungal Meningitis
- Cerebral Abscess
- Spinal Epidural Abscess
- Subdural Empyema
- Neurological Sequelae of Infectious Endocarditis
- HIV Associated Conditions:
- Aseptic Meningitis
- Acute/Chronic Inflammatory Demyelinating Polyneuropathy
- Distal Painful Sensorimotor Polyneuropathy
- Multiple Mononeuropathies
- Myopathies
- Vacuolar Myelopathy
- HIV associated neurocognitive disorder (HAND)
- CNS-immune reconstitution syndromes

- HIV associated Opportunistic Infections:
  - CNS Cryptococcosis
  - CNS Lymphoma
  - CNS Toxoplasmosis
  - Cytomegalovirus Encephalitis and radiculopathy
  - Varicella zoster virus
  - Progressive multifocal leukoencephalopathy
  - Immune reconstitution inflammatory syndrome

- Human T cell leukemia virus I and II
- Herpes Simplex Encephalitis
- West Nile Encephalitis
- Subacute Sclerosing Panencephalitis
- Other Viral Encephalitides
- Poliomyelitis
- Rabies
- Varicella Zoster
- Dengue
- Leprosy
- Lyme neuroborreliosis
- Neurosyphilis
- Amoebiasis
- Rocky Mountain Spotted Fever
- Prion-Related Diseases
- Neurocysticercosis
- Cerebral malaria

Supplementary Curricular Content
Training programs may elect to facilitate the Fellow’s development of special expertise and/or clinical competence in additional areas in neuroinfectious and neuroimmune disorders. Emphasis on these supplementary areas should not detract from the emphasis needed to master all of the elements of the Core Curriculum. Possible supplementary curricular content may include:

1. dysmyelinating disorders
2. neurogenetics
3. neuro-opthalmology
4. neuro-urology
5. neuro-rehabilitation
6. cognitive rehabilitation
7. neuro-radiology
8. epidemiology, public health
9. virology, microbiology, molecular biology
10. neuropathology
11. peripheral nerve and muscle infections and immunological disorders, such as leprosy, myositis, Guillain Barre, myasthenia gravis

Suggested Reading:
CNS INFECTIONS
5. Practice Guidelines for the Management of Bacterial Meningitis: Clinical Infectious Diseases 2004; 39:1267–84

NEURO-AIDS

MULTIPLE SCLEROSIS
1. Neuroimmunology (Contemporary Neurology Series) by Patricia K.Coyle; 375 pages Publisher: Oxford University Press (December 30, 2006)
2. Clinical Neuroimmunology by Jack Antel, Gary Birnbaum, Hans-Peter Hartung, and Angela Vincent; 468 pages Publisher: Oxford University Press (Nov 24, 2005)

Practice Parameters
Each of the titles below are hyperlinked to their respective webpage. Alternatively they may be accessed through www.aan.com

Date       Title                                                                                               Notes
Nov 2003   The Use of Mitoxantrone (Novantrone) for the Treatment of Multiple Sclerosis                        Current guideline.
Dec 2002   Immunization and Multiple Sclerosis: A Summary of Published Evidence and Recommendations           Current guideline.

TRANSVERSE MYELITIS/ NMO

CEREBROSPINAL FLUID

NEUROPATHOLOGY

4. Select chapters from Greenfield's Neuropathology (2 Volume Set) by David I. Graham and Peter L. Lantos.

Resident CORE CURRICULUM

Introduction
Infections of the nervous system are diagnostic considerations for most neurologic syndromes. HIV/AIDS, cancer chemotherapy, and therapeutic immunosuppression for organ transplantation and autoimmune diseases (including multiple sclerosis and other neurological disorders) have made more people vulnerable to neurologic infections. With globalization and increased international travel, American neurologists have become familiar with previously rare neuroinfectious diseases (NIDs) such as West Nile neuroinvasive disease and neurocysticercosis. Neurology residents must learn to diagnose and manage patients with these often treatable conditions and be able to collaborate effectively with primary care providers, emergency physicians, infectious disease specialists, intensivists, hospitalists, neuroradiologists, neuropathologists, neurosurgeons, and public health authorities in caring for patients with proven or suspected NID.

Goals and Objectives
Goal: To develop a framework to train neurology residents in timely, efficient and where possible, evidence-based, care of patients with NIDs

Objectives: Over three years of neurology training, residents should learn:
1. The clinical approach to the patient with suspected NID: general and neurologic history and examination, prompt and safe utilization of neuroimaging and lumbar puncture (LP), interpretation of CSF results;
2. Management issues in patients with NIDs: blood-brain/CSF-barrier and other issues influencing antibiotic selection, adjunctive medical therapy including corticosteroids, surgical intervention, complications, counseling patients and families, public health reporting requirements, health care worker safety;
3. Assessment and management of patients with major NID syndromes: aseptic meningitis, community-acquired acute bacterial meningitis, chronic meningitis and meningoencephalitis, brain abscess and focal extra-axial cerebral infections, encephalitis and acute demyelinating encephalomyelitis (ADEM), spinal epidural abscess and diskitis/osteomyelitis;
4. Diagnosis and management of patients with infections of particular neurologic relevance: neurocysticercosis, neurotuberculosis, leprosy, neuroborreliosis, neurosyphilis, botulism, tetanus, herpes simplex encephalitis, acute zoster and post-herpetic neuralgia, West Nile neuroinvasive disease, rabies, polio, HTLV-1, subacute sclerosing panencephalitis (SSPE), prion disorders;
5. Assessment and management of patients at increased risk for NIDs: post-neurosurgical or post-head/spine trauma patients, immunosuppressed hosts (including HIV/AIDS), international travelers.
Curriculum

Clinical Approach:

1. Use general and neurologic history and exam findings to:
   a) Assess the host-pathogen relationship: travel, activities, occupation, animal exposure, and other factors influence the risk that a patient has encountered specific pathogens; patients with impaired anatomic barriers to the CNS or immunologic dysfunction based on age, medications, or comorbidities are at particular risk for NIDs;
   b) Define the neurologic syndrome: acute meningitis, encephalitis, rhombencephalitis, chronic meningitis/meningoencephalitis, myelitis, (poly)radiculitis, mononeuritis multiplex, polyneuritis, myositis;
   c) Consider systemic features in constructing a differential diagnosis: fever, tempo of illness, recent antibiotic use, comorbidities, endocarditis, bacteremia, craniofacial or paraspinal infection, pulmonary involvement, rash, other organ involvement.

2. Order and interpret diagnostic studies:
   a) Routine bloodwork, cultures (blood, throat, urine, stool), serologies, skin testing;
   b) CT/MRI for initial diagnosis and to monitor for complications and response to therapy;
   c) Cerebrospinal fluid (CSF) examination: contraindications to LP, strategies when LP cannot be performed safely, interpretation of CSF results, including smears, cultures, antigen/antibody studies, polymerase chain reaction testing;
   d) Special studies: biopsy, including proper handling of specimens, contacting public health authorities.

Management issues:

1. Antibiotics: principles of empiric therapy, including organism-related (likely pathogens based on clinical setting, local resistance patterns) and host-related (allergies, blood-brain/CSF-barrier, comorbidities) factors, route of administration, complications;
2. Adjunctive corticosteroids: timing in community-acquired bacterial meningitis; utility in neuroTB, neurocysticercosis, acute herpes zoster;
3. Other medical management: antitoxins, hyperimmune globulin;
4. Surgical intervention: indications for ventriculostomy and decompressive neurosurgical procedures, addressing craniofacial or paraspinal infection, working effectively with microbiology and neuropathology to optimize yield from operative specimens;
5. Public health concerns: reportable NIDs, safety issues.

Major NID Syndromes: Learn the risk factors, pathogenesis, presenting features, differential diagnosis (including noninfectious etiologies and common age-specific pathogens), clinical approach, management, complications, and prognosis for:

1. Aseptic meningitis,
2. Acute bacterial meningitis,
3. Chronic meningitis and meningencephalitis,
4. Brain abscess and focal extra-axial cerebral infections,
5. Encephalitis

Important Specific NIDs: Learn the epidemiology, pathogenesis, presenting features, differential diagnosis (including noninfectious etiologies), clinical approach, management, complications, and prognosis for:

1. Neurocysticercosis;
2. Mycobacterial infections: neuroTB, leprosy;
3. Spirochete infections: neurosyphilis, neuroborreliosis;
4. Neurotoxigenic clostridia: botulism, tetanus;
5. Viral infections: herpes simplex encephalitis, acute herpes zoster, post-herpetic neuralgia, West Nile neuroinvasive disease, rabies, SSPE, polio, HTLV-1;
6. Prion diseases.

*High-risk patients:* Understand the additional diagnostic challenges and considerations, clinical approach, management, and prognosis for NID in the following groups:

1. Head/spine trauma and post-neurosurgical patients;
2. HIV/AIDS: cryptococcal meningitis, cerebral toxoplasmosis, progressive multifocal leukoencephalopathy, primary CNS lymphoma, HIV-associated dementia, AIDS myelopathy, distal symmetric polyneuropathy;
3. Other immunocompromised states;
4. International travelers.

**Prerequisites for the trainee:** neurology resident in approved training program

**Training methods:** Residents will encounter patients, particularly on consultation and ICU rotations and in clinic, whose care will provide exposure to some elements of the curriculum. It is anticipated that this will vary significantly across programs and that some of the educational process will be self-directed on the part of residents. The chapters and articles listed below fully cover the curriculum outlined and were chosen in part for ease of online access for free or via generally available institutional subscriptions. The textbooks and additional resources at the end of this document address elements of the curriculum in more depth and cover additional topics, providing an additional resource for residents encountering patients with NIDs not in the curriculum or with a particular interest in the field. Neurology faculty with NID expertise will not be available in many departments. Relevant experience may be available from non-neurologists, in particular infectious disease specialists, neurosurgeons, neuroradiologists, and neuropathologists. The residency training director at each program should ensure that residents have ready, free access to the articles listed below and ensure availability of the listed textbooks in the department, hospital, or medical school library. Other available resources for residents and faculty include the references below and NID courses at the AAN Annual Meeting.

**Evaluation:** (Are RITE or board exam scores are granular enough to suggest using those, at least at a programmatic level? I would welcome any ideas here.)

**Teaching Resources and References**

*General*
*Tyler KL: Neurologic infections: advances in therapy, outcome, and prediction. Lancet Neurol 2009;8:19-21

*Clinical Approach and Management*
Aseptic Meningitis
Logan SA, MacMahon E: Viral meningitis. BMJ 2008;336:36-40

Acute Bacterial Meningitis
Steigbigel NH: Computerized tomography of the head before a lumbar puncture in suspected meningitis—is it helpful? New Engl J Med 2001;345:1768-70


Chronic Meningitis/Meningoencephalitis
Ginsburg L Kidd D: Chronic and recurrent meningitis. Pract Neurol 2008;8:348-61

Brain abscess and focal extra-axial cerebral infections

Encephalitis

Spinal Epidural Abscess and Diskitis/Osteomyelitis

Neurocysticercosis

Mycobacteria
Leprosy
Ooi WW, Srinivasan J: Leprosy and the peripheral nervous system: basic and clinical aspects. Muscle Nerve 2004;30:393-409

NeuroTB

Spirochetes
Neuroborreliosis
Neurosyphilis


Neurotoxigenic clostridia


Viral infections
Herpesviruses


West Nile neuroinvasive disease


Rabies


Polio

SSPE

HTLV-1
Cooper SA, van der Loeff MS, Taylor GP: The neurology of HTLV-1 infection. Pract Neurol 2009;9:16-26

Prion disorders

The High-Risk Patient:
Trauma/neurosurgery

NeuroAIDS

Other immunocompromised states
Textbooks
Philadelphia: Lippincott Williams & Wilkins, 2004

Additional Resources

*updated/revised annually
^updated/revised periodically