Overview of Neurosurgery

Neurosurgery is the branch of medicine that provides surgical treatment and management for diseases of the nervous system including the brain, spinal cord, and peripheral nerves. Neurosurgery is a broad field but can be divided into several sub-specialties: functional neurosurgery, neurovascular, oncology, pediatrics, spine, and trauma. Several of the sub-disciplines are highlighted in greater depth with an emphasis on clinical research that has been particularly important for advancing the field. Neurovascular, oncology, and functional neurosurgery are highlighted in this document. Across the spectrum of neurosurgery the neurological exam, neuroimaging, anatomy, and physiology are the fundamentals in each discipline. In addition to the brief synopsis of research that is highlighted there are also several suggested resources as well as general advice provided by current residents and faculty.

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Comprehensive neurosurgical texts appropriate for medical students

Essential Neurosurgery by Andrew H. Kaye
Handbook of Neurosurgery by Mark S. Greenberg
Toronto Notes Neurosurgery Chapter

Comprehensive neurosurgical texts

Youmans Neurological Surgery by H. Richard Winn
Schmidek and Sweet: Operative Neurosurgical Techniques by Alfredo Quinones-Hinijosa

Neuroanatomy resources

An excellent website with anatomy and imaging of the brain
www.neuroanatomy.ca

Lasts’s Anatomy by Chummy S. Sinnatamby
Neuroanatomy through Clinical Cases by Hal Blumenfeld

General advice from residents and faculty

Focus on basic understanding of anatomy, physiology, and pathology of the nervous system
A general understanding of common brain tumours
**Additional Resources**

* A video data-base for neurosurgical procedures

* AANS Grand Rounds mobile application:
  Available for free in the App store. This application provides quick access to procedural videos, background information, and case discussions.

**Neurovascular**

Neurovascular neurosurgery is the branch of neurosurgery that deals with the treatment and management of disorders of the vasculature in the brain and spinal cord. Vascular disorders of the central nervous system can be classified as ischemic or hemorrhagic. Ischemic strokes can be caused by the blockage of a blood vessel (carotid artery stenosis) or hypoperfusion (after a myocardial infarction). Hemorrhagic strokes can be broken down into structural or non-structural etiologies. Structural abnormalities include aneurysms and arteriovenous malformations (an abnormal connection between arteries and veins), while non-structural conditions include medications (eg. anticoagulants), coagulopathies (eg. cancer), and infections. Given that strokes are common and often have poor outcomes, much attention has been given to them, especially in neurovascular neurosurgery. In particular, this branch of neurosurgery often deals with conditions causing ischemic strokes, such as carotid artery disease, as well as conditions causing hemorrhagic strokes, such as cerebral aneurysms.

Cerebral aneurysms and carotid artery stenosis can be treated either by ‘open’ surgical procedures (where part of the skull is opened to access the brain) or by a ‘minimally invasive’ endovascular approach (where thin catheters are inserted into the peripheral vasculature to access the brain). Several large clinical trials have examined the difference between these approaches and medical management:

*Treatment of carotid artery stenosis:*

Two important trials have been conducted to examine the efficacy of treatments for carotid artery stenosis. The first is the NASCET trial, a randomized control trial examining the outcomes between carotid endarterectomy to surgically remove the atherosclerotic plaque (open surgery) and medical management (ie. antiplatelet therapy). This trial demonstrated significant benefits for patients undergoing carotid endarterectomy compared to medical management alone. Patients undergoing carotid endarterectomy are less likely to experience a stroke after the surgery. The significant benefit was for patients who had 70-99% carotid artery stenosis and had also had symptoms due to carotid artery stenosis (TIA, stroke) in the previous 120 days before surgery, this is known as symptomatic carotid artery stenosis. (North American Symptomatic Carotid Endarterectomy Trial

The second trial is the CREST trial. This trial compared the ‘open’ carotid endarterectomy to the ‘minimally invasive’ endovascular stenting approach for the treatment of symptomatic carotid artery stenosis. Two important findings came out of the CREST trial. First, there was no difference between the surgical and endovascular approach for the rates of stroke, myocardial infarction, or death at four years follow up. Second, the periprocedural (not long-term) rates of minor stroke were higher in the endovascular stenting group while the rates of myocardial infarction were higher in the carotid endarterectomy group, periprocedurally. (CREST Investigators N Engl J Med 2010; 363:11-23)

Treatment of ruptured intracranial aneurysms:

Ruptured intracranial aneurysms lead to a hemorrhagic stroke known as a subarachnoid hemorrhage. The prognosis for this disease is poor and many patients go on to be permanently disabled, if they survive the initial event. In order to achieve the best possible outcome the ruptured aneurysm needs to be repaired as early as possible. Ruptured intracranial aneurysms can be treated by ‘open’ surgery where aneurysm is ‘clipped’ with a small metal clip to stop the bleeding. It is also possible to treat the ruptured aneurysm with a ‘minimally invasive’ endovascular approach, where the aneurysm is filled from the inside with a fine wire to stop the bleeding, this is known as ‘coiling’. Although coiling is the preferred method of treatment for ruptured intracranial aneurysms, surgical clipping is still employed when the aneurysm size, shape, and location preclude coiling.

The ISAT trial is a randomized control trial that examined the difference between surgical clipping and endovascular coiling for the treatment of ruptured intracranial aneurysms. Using a rating scale to examine the disability level of patients after each procedure, the ISAT trial demonstrated that one year after the repair of the ruptured aneurysm, the patients who had undergone endovascular coiling had lower levels of disability and lower rates of mortality, as compared to the surgical clipping group. Although coiling of aneurysms has demonstrated to be favourable both clipping and coiling are still used depending on the aneurysm location, size, and shape. (Molyneaux et al., Lancet. 2005 Sep 3-9;366(9488):809-17).

Functional Neurosurgery

Functional neurosurgery deals with conditions of the nervous system where a patient suffers from a functional deficit that may be due to abnormal neural circuitry. Functional neurosurgery treats and manages conditions such as chronic pain, spasticity, movement disorders (such as Parkinson’s disease and dystonia), epilepsy, and even psychiatric conditions. In order to manage diseases that lead to impaired brain circuits it is the goal of functional neurosurgeons to modulate or change these circuits. Modulation
Surgery for Temporal-Lobe Epilepsy

Epilepsy is a serious health condition that greatly impacts patients' lives, with a prevalence of 5-10 per 1000 population in North America alone. Mesial temporal sclerosis is a common anatomical abnormality in the brain associated with temporal lobe epilepsy, and recent neuroimaging and neurosurgical advances have improved the utility of surgical treatment of epilepsy. A one year randomized controlled trial where 80 patients with temporal-lobe epilepsy were randomly assigned to either surgery to remove a portion of the temporal lobe or traditional medical treatment with antiepileptic drugs. The study demonstrated the superiority of surgery in treating temporal-lobe epilepsy compared to standard therapy. After the surgery, patients were more likely to be seizure free, have fewer seizures, and have a better quality of life compared to those on medical management alone. (Wiebe et al., N Engl J Med, Vol. 345, No. 5 · August 2, 2001)

Deep-brain stimulation for Parkinson’s Disease

Research in animal models of Parkinson’s disease had implicated that the basal ganglia as a potential target to improve motor symptoms associated with the disease. A prospective, double blind, crossover study in patients with advanced Parkinson’s disease was conducted to determine if the same was true in humans. The purpose of this study was to understand if modulation of the brain circuits that control movement, which are abnormal in Parkinson’s disease, could improve motor symptoms. Patients underwent surgery where electrodes were implanted below the cortex of the brain into an area known as the basal ganglia, which plays an important role in the control of voluntary movements. The basal ganglia are deep in the brain, giving this treatment method the name, deep brain stimulation (aka DBS). Specifically, the subthalamic nucleus or pars inerna of the globus pallidus were targeted with the electrodes. Bilateral electrodes delivered high-frequency deep brain stimulation and the scores of the motor portion of the Unified Parkinson’s Disease Rating Scale were compared when the stimulation was on or off. The study showed significant improvement in motor function with deep-brain stimulation in patients with Parkinson’s disease whose condition could not be improved with medical therapy. (The Deep Brain Stimulation for Parkinson’s Disease Study Group. N Engl J Med, Vol. 345, No. 13. September 27, 2001)

Neurosurgical-oncology

Neurosurgical-oncology is a multidimensional field involving specialists from various disciplines and employing state of the art technology in tackling benign and
cancerous brain and spinal tumors. Highly trained specialists in areas such as neurosurgery, neurology, radiation oncology, neuroradiology, neuropathology, neuroendocrinology, physiatry, and psychiatry combine their efforts in both the research lab, as well as the clinical setting, to overcome the challenges of cancer treatment. In the early days, the neurosurgeon’s role was limited to tumor resection or biopsy, while minimizing the damage associated with normal brain tissue disruption. However, in today’s complex management of nervous system tumors, neurosurgeons are also involved in the medical treatment of CNS tumors, as well as investigation of novel, minimally invasive therapies.

There are over 100 different types of brain tumors; however an understanding of the clinical presentation of brain tumors is very useful (which can be divided into raised ICP, focal neurological signs, and epilepsy. See the brain tumor chapter in the Andrew Kaye textbook listed above). In addition, having a simple classification system of brain tumors can be useful. Brain tumors can be divided into primary, which originate in the brain, and secondary, which originate outside of the brain. Amongst the primary brain tumours the most common are the gliomas and glioblastoma multiform (GBM), which is the most malignant form. This link provides a very brief organization of brain tumors:


A very good, and up to date, review of the most common and lethal primary brain tumour, glioblastoma. Provides a brief overview of gliomas and how they fit in the general breakdown of all kind of brain tumours in terms of epidemiology, histopathology, and therapeutics.


A Norwegian study where patients from two different hospitals, each adopting a different approaches to treat low grade gliomas. One hospital favored a tumour biopsy, followed by watchful waiting, while patients in the second hospital underwent early tumour resection. Median follow-up was 7 years, and the primary end point was overall survival. The study results clearly favor early surgical resection, where the estimated 5 year survival was 60% for biopsy and watchful waiting compared to 74% in the early resection group.
This is a review of the main reference for classifying tumours of the central nervous system that was published in 2007. This review goes over the history of this classification, the new additions in the 2007 edition, and provides a list of all the tumours described in the original document, as well as their WHO grading’s. This is the complete list of brain tumours and is meant to provide an appreciation for the scope of neurosurgical oncology.

This major review highlights the six hallmarks of cancer: sustaining proliferative signaling, evading growth suppressors, resisting cell death, enabling replicative immortality, inducing angiogenesis, and activating invasion and metastasis. These hallmarks are underlined by genetic and epigenetic aberrations that potentiate tumour growth and resistance to treatment. This review also highlights recent developments in therapeutic approaches, and the challenges faced by clinicians and researchers in pre-clinical as well as clinical testing of these therapies.