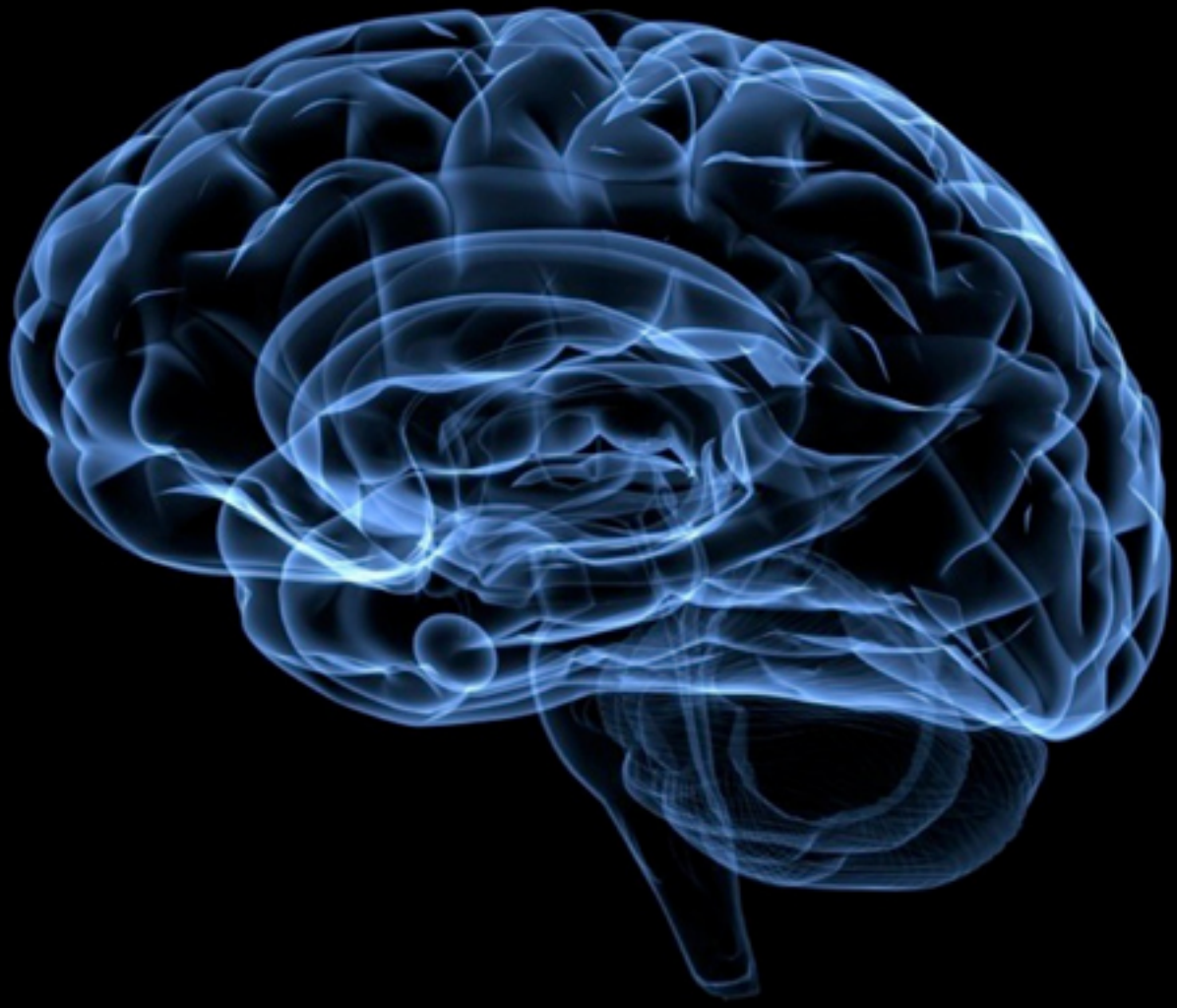
Neurology and Nervous System Procedures



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Chapter 1

Neurology

Neurologist	
Occupation	
Names	Doctor, Medical Practitioner
Type	Profession
Activity sectors	Medicine
Description	
Education required	M.D. or D.O. (US) MBBS (UK)
Fields of employment	Hospitals, Clinics

Neurology (from Greek νεῦρον, *neuron*, "nerve"; and -λογία, '-logia', '"study of") is a medical specialty dealing with disorders of the nervous system. Specifically, it deals with the diagnosis and treatment of all categories of disease involving the central, peripheral, and autonomic nervous systems, including their coverings, blood vessels, and all effector tissue, such as muscle. The corresponding surgical specialty is neurosurgery. A neurologist is a physician who specializes in neurology, and is trained to investigate, or diagnose and treat neurological disorders. Pediatric neurologists treat neurological disease in children. Neurologists may also be involved in clinical research, clinical trials, as well as basic research and translational research.

Neurology is the medical application of neuroscience which is the scientific study of the nervous system.

Field of work

A large number of Neurological disorders have been described. These can affect the central nervous system (brain and spinal cord), the peripheral nervous system, or the autonomic nervous system.

Qualifications

In the United States and Canada, neurologists are physicians who have completed postgraduate training in neurology after graduation from medical school. Neurologists complete, on average, at least 10-12 years of college education and clinical training. This training includes obtaining a four-year undergraduate degree, a medical degree, which is an additional four years, and then completing a three or four-year residency in neurology. The four-year residency consists of one year of internal medicine training followed by three years of training in neurology. One and two year fellowships are available following completion of the neurology residency if desired.

Many neurologists also have additional subspecialty training (fellowships) after completing their residency in one area of neurology such as stroke or vascular neurology, interventional neurology, epilepsy, neuromuscular, neurorehabilitation, behavioral neurology, sleep medicine, pain management, neuroimmunology, clinical neurophysiology, or movement disorders.

In Germany, a compulsory year of psychiatry must be done to complete a residency of neurology.

In the United Kingdom and Ireland, neurology is a subspecialty of general (internal) medicine. After five to nine years of medical school and a year as a pre-registration house officer (or two years on the Foundation Programme) a neurologist must pass the examination for Membership of the Royal College of Physicians (or the Irish equivalent) before entering specialist training in neurology. A generation ago some neurologists would also spend a couple of years working in psychiatric units and obtain a Diploma in Psychological Medicine, but that became uncommon and now that a basic psychiatric qualification takes three years to obtain it is no longer practical. A period of research is essential, and obtaining a higher degree aids career progression: many found it was eased after an attachment to the Institute of Neurology at Queen Square in London. Some neurologists enter the field of rehabilitation medicine (known as physiatry in the US) to specialise in neurological rehabilitation, which may include stroke medicine as well as brain injuries.

Testing examinations

During a neurological examination, the neurologist reviews the patient's health history with special attention to the current condition. The patient then takes a neurological exam. Typically, the exam tests mental status, function of the cranial nerves (including vision), strength, coordination, reflexes and sensation. This information helps the neurologist determine if the problem exists in the nervous system and the clinical localization. Localization of the pathology is the key process by which neurologists develop their differential diagnosis. Further tests may be needed to confirm a diagnosis and ultimately guide therapy and appropriate management.

Clinical tasks

General caseload

Neurologists are responsible for the diagnosis, treatment, and management of all the above conditions. When surgical intervention is required, the neurologist may refer the patient to a neurosurgeon. In some countries, additional legal responsibilities of a neurologist may include making a finding of brain death when it is suspected that a patient is deceased. Neurologists frequently care for people with hereditary (genetic) diseases when the major manifestations are neurological, as is frequently the case. Lumbar punctures are frequently performed by neurologists. Some neurologists may develop an interest in particular subfields, such as dementia, movement disorders, headaches, epilepsy, sleep disorders, chronic pain management, multiple sclerosis or neuromuscular diseases.

Overlapping areas

There is some overlap with other specialties, varying from country to country and even within a local geographic area. Acute head trauma is most often treated by neurosurgeons, whereas sequelae of head trauma may be treated by neurologists or specialists in rehabilitation medicine. Although stroke cases have been traditionally managed by internal medicine or hospitalists, the emergence of vascular neurology and interventional neurologists has created a demand for stroke specialists. The establishment of JCAHO certified stroke centers has increased the role of neurologists in stroke care in many primary as well as tertiary hospitals. Some cases of nervous system infectious diseases are treated by infectious disease specialists. Most cases of headache are diagnosed and treated primarily by general practitioners, at least the less severe cases. Similarly, most cases of sciatica and other mechanical radiculopathies are treated by general practitioners, though they may be referred to neurologists or a surgeon (neurosurgeons or orthopedic surgeons). Sleep disorders are also treated by pulmonologists and psychiatrists. Cerebral palsy is initially treated by pediatricians, but care may be transferred to an adult neurologist after the patient reaches a certain age. In the United Kingdom and other countries, many of the conditions encountered by older patients such as movement disorders including Parkinson's Disease, stroke, dementia or gait disorders are managed predominantly by specialists in geriatric medicine.

Clinical neuropsychologists are often called upon to evaluate brain-behavior relationships for the purpose of assisting with differential diagnosis, planning rehabilitation strategies, documenting cognitive strengths and weaknesses, and measuring change over time (e.g., for identifying abnormal aging or tracking the progression of a dementia).

Relationship to clinical neurophysiology

In some countries, e.g. USA and Germany, neurologists may specialize in clinical neurophysiology, the field responsible for EEG, nerve conduction studies, EMG and

evoked potentials. In other countries, this is an autonomous specialty (e.g. United Kingdom, Sweden).

Overlap with psychiatry

Although many mental illnesses are believed to be neurological disorders affecting the central nervous system, traditionally they are classified separately, and treated by psychiatrists. In a 2002 review article in the American Journal of Psychiatry, Professor Joseph B. Martin, Dean of Harvard Medical School and a neurologist by training, wrote that *the separation of the two categories is arbitrary, often influenced by beliefs rather than proven scientific observations. And the fact that the brain and mind are one makes the separation artificial anyway.*

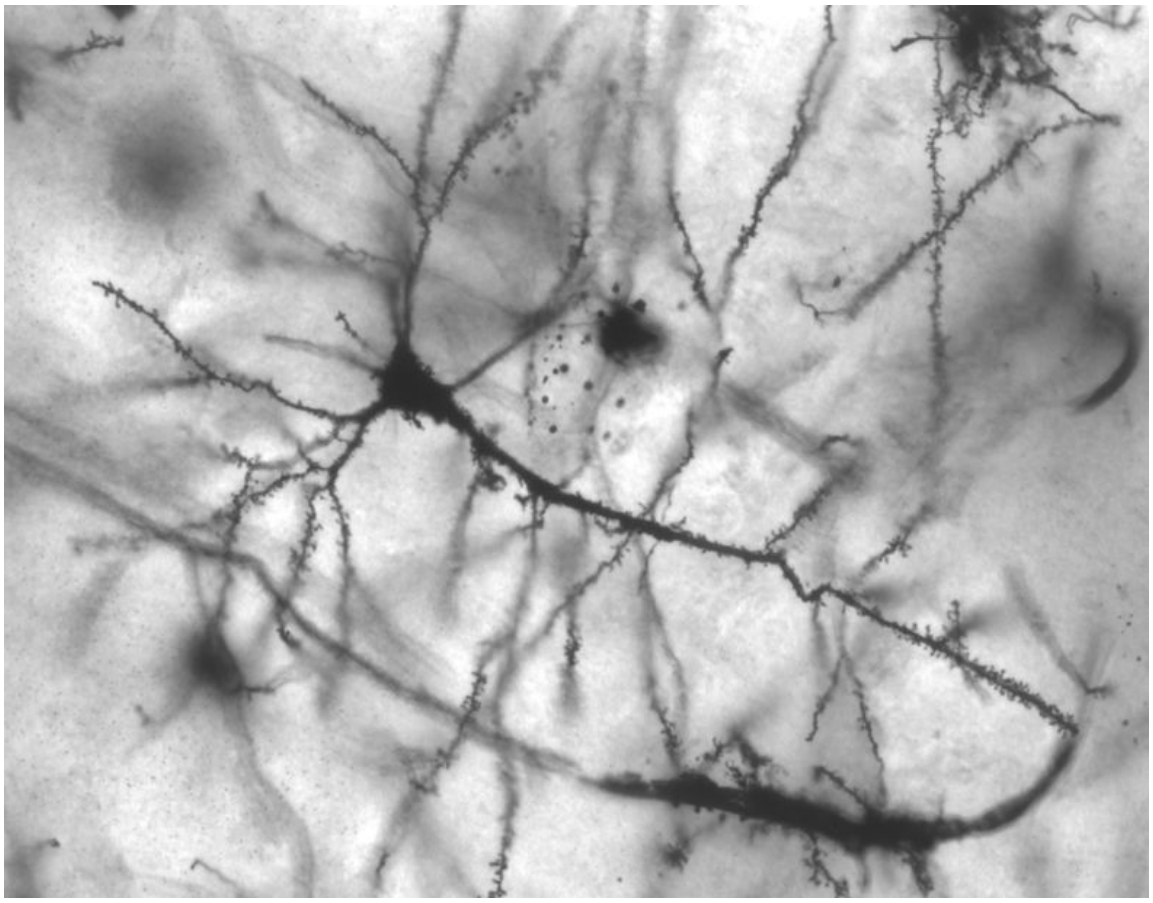
There are strong indications that neurochemical mechanisms play an important role in the development of, for instance, bipolar disorder and schizophrenia. Also, "neurological" diseases often have "psychiatric" manifestations, such as post-stroke depression, depression and dementia associated with Parkinson's disease, mood and cognitive dysfunctions in Alzheimer's disease and Huntington disease, to name a few. Hence, there is no sharp distinction between neurology and psychiatry on a biological basis – this distinction has mainly practical reasoning and strong historical roots (such as the dominance of Freud's psychoanalytic theory in the first three quarters of the 20th century – which has since then been largely replaced by the focus on neurosciences – aided by the tremendous advances in genetics and neuroimaging.)

Cosmetic Neurology

The emerging field of cosmetic neurology highlights the potential of therapies to improve such things as workplace efficacy, attention in school, and overall happiness in personal lives. However, this field has also given rise to questions about neuroethics and the psychopharmacology of "lifestyle drugs".

Chapter 2

Neurological Disorder

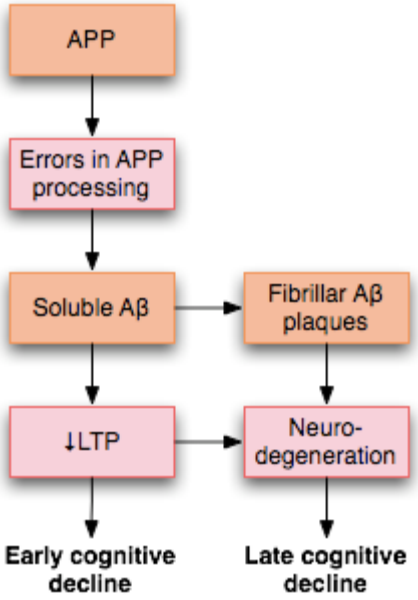


Neurons in patient with epilepsy

A **neurological disorder** is a disorder of the body's nervous system. Structural, biochemical or electrical abnormalities in the brain or spinal cord, or in the nerves leading to or from them, can result in symptoms such as paralysis, muscle weakness, poor coordination, loss of sensation, seizures, confusion, pain and altered levels of consciousness. There are many recognized neurological disorders, some relatively common, but many rare. They may be revealed by neurological examination and studied and treated within the specialities of neurology and clinical neuropsychology. Interventions include preventative measures, lifestyle changes, physiotherapy or other

therapy, neurorehabilitation, pain management, medication, or operations performed by neurosurgeons. The World Health Organization estimated in 2006 that neurological disorders and their sequelae affect as many as one billion people worldwide, and identified health inequalities and social stigma/discrimination as major factors contributing to the associated disability and suffering.

Causes



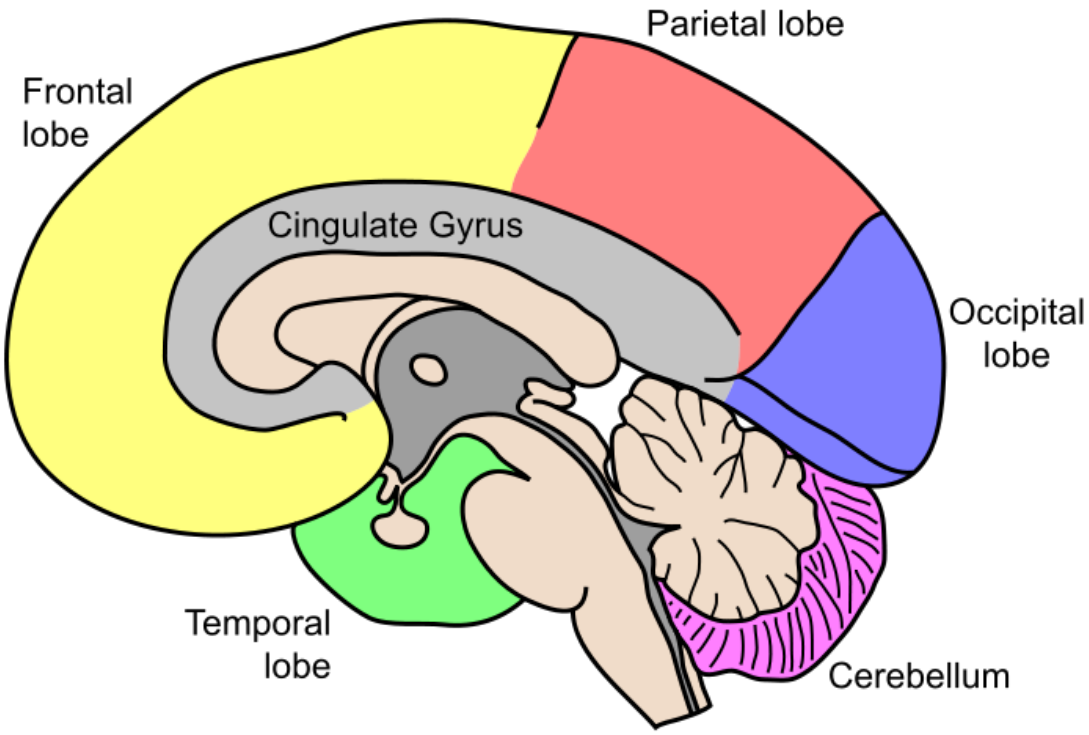
Part of the causal chain leading to Alzheimer's disease

Although the brain and spinal cord are surrounded by tough membranes, enclosed in the bones of the skull and spinal vertebrae, and chemically isolated by the so-called blood-brain barrier, they are very susceptible if compromised. Peripheral nerves tend to lie deep under the skin but are also still relatively exposed to damage. And individual neurons, the building blocks of the nervous system, and the neural networks into which they form, are susceptible to electrochemical and structural disruption. While neuroregeneration may occur in the peripheral nervous system, it is thought to be rare in the brain and spinal cord.

The specific causes vary by disorder and sometimes by individual case, but can include genetic disorders; congenital abnormalities or disorders; infections; lifestyle or environmental health problems including malnutrition; and brain injury, spinal cord injury or nerve injury. The problem may start in another body system that interacts with the nervous system; for example cerebrovascular disorders involve brain injury due to problems with the blood vessels (cardiovascular system) supplying the brain, and autoimmune disorders involve damage caused by the body's own immune system.

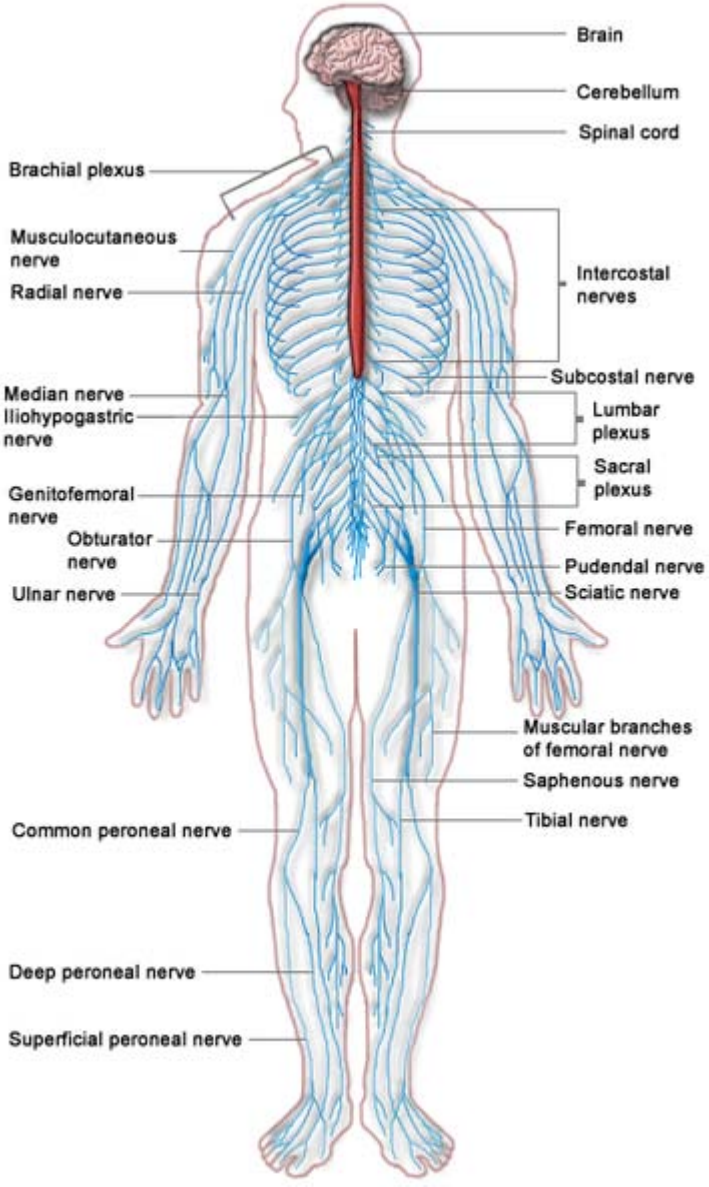
In a substantial minority of cases of neurological symptoms, no neural cause can be identified using current testing procedures, and such "idiopathic" conditions can invite different theories about what is occurring.

Classification



Anatomy of the human brain

Nervous system



The Human Nervous System.

Neurological disorders can be categorized according to the primary location affected, the primary type of dysfunction involved, or the primary type of cause. The broadest division is between central nervous system (CNS) disorders and peripheral nervous system (PNS) disorders. The Merck Manual lists brain, spinal cord and nerve disorders in the following overlapping categories:

- Brain:
  - Brain damage according to cerebral lobe:
    - Frontal lobe damage

        - Parietal lobe damage
        - Temporal lobe damage
        - Occipital lobe damage
    - Brain dysfunction according to type:
        - Aphasia (language)
        - Dysarthria (speech)
        - Apraxia (patterns or sequences of movements)
        - Agnosia (identifying things/people)
        - Amnesia (memory)
- Spinal cord disorders
- Peripheral nervous system disorders
- Cranial nerve disorders
- Autonomic nervous system disorders
- Seizure disorders such as epilepsy
- Movement disorders such as Parkinson's disease
- Sleep disorders
- Headaches (including migraine)
- Lower back and neck pain
- Other pain
- Delirium and dementia such as Alzheimer's disease
- Dizziness and vertigo
- Stupor and coma
- Head injury
- Stroke (CVA, cerebrovascular attack)
- Tumors of the nervous system (e.g. cancer)
- Multiple sclerosis (MS) and other demyelinating diseases
- Infections of the brain or spinal cord (including meningitis)
- Prion diseases (a type of infectious agent)
- Complex regional pain syndrome (CRPS) (a chronic pain condition.)

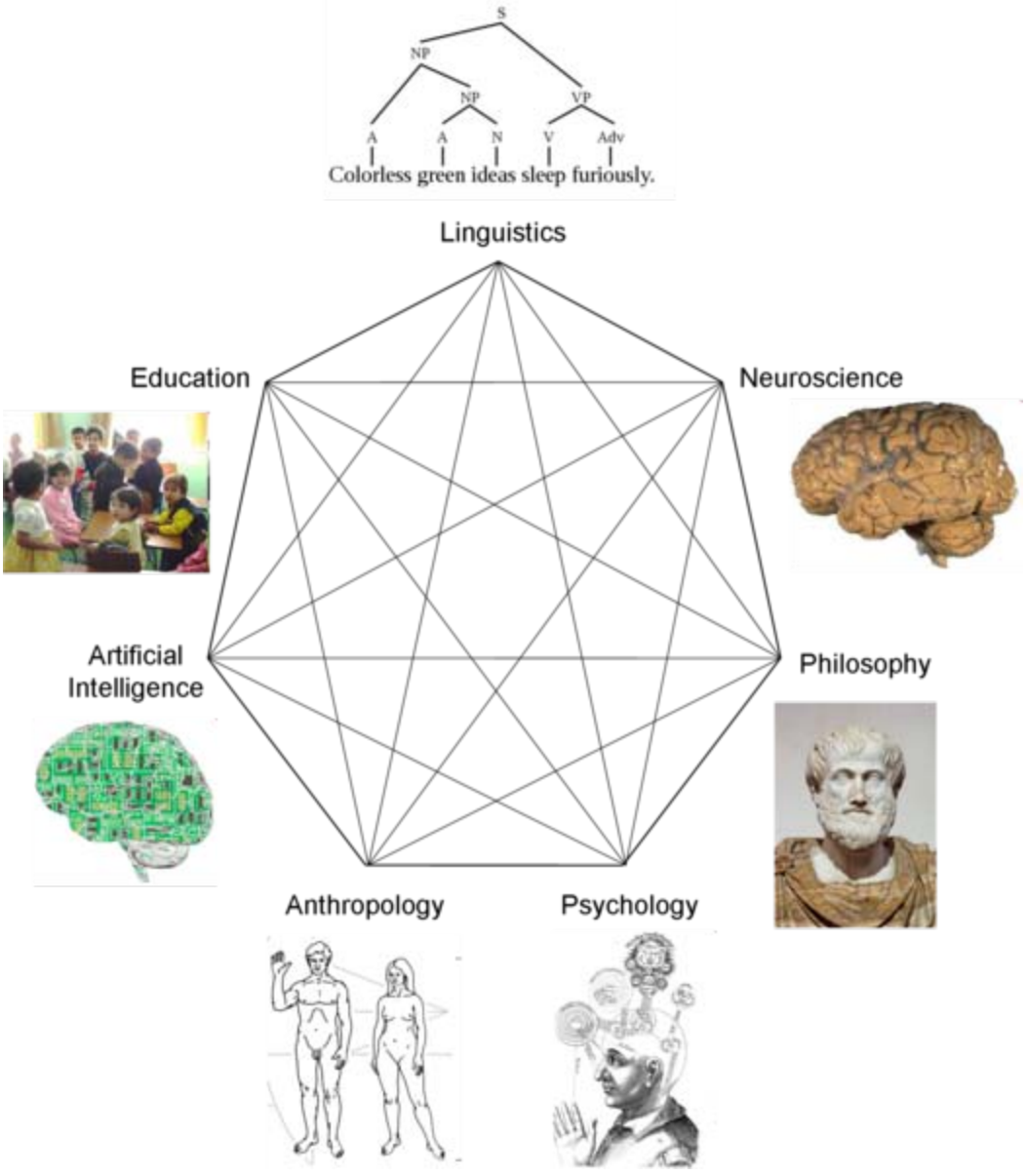
Neurological disorders in non-human animals are treated by veterinarians.

Neural and mental dysfunction

Mental disorders, learning disabilities and mental retardation are not usually classed as primarily neurological. However the distinction can be a matter of some debate, either in regard to specific facts about the cause of a condition or in regard to the general understanding of brain and mind. Furthermore the definition of disorder can be contested in regard to what is considered abnormal, dysfunctional, harmful or unnatural in neurological, evolutionary, psychometric or social terms.

While certain types of mental condition are not usually classified primarily as neurological disorders, and certain types of brain disorder are not usually classified primarily as mental conditions, there are now an array of basic sciences that deal with the continuum between the neural and the mental, including subspecialities of psychology and neuroscience such as neuropsychology, cognitive neuropsychology or cognitive

(thought) neuroscience, affective (emotion) neuroscience, behavior neuroscience (also known as biopsychology), social neuroscience, and neurophenomenology (subjective experience and consciousness).



Different levels of analysis in the understanding of cognition in the brain

These basic fields inform the applied medical and clinical disciplines of neurology, psychiatry and clinical psychology, whose theories and treatments now routinely encompass a biopsychosocial model. These disciplines in turn comprise subspecialities such as behavioral neurology, neuropsychiatry and clinical neuropsychology that deal with cases where a connection between mental/behavioral problems and brain dysfunction is particularly called for. Biopsychiatry is the general term for the approach

in psychiatry that seeks to explain all mental disorders primarily in terms of the biological functioning of the nervous system.

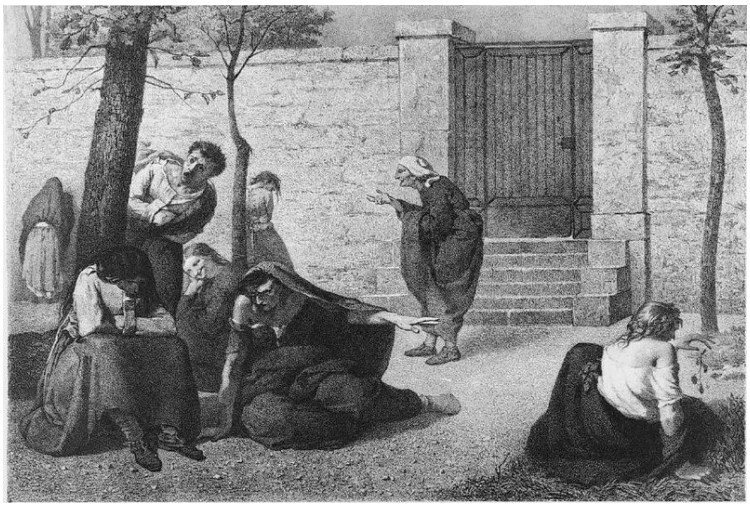
The conventional distinctions drawn between mind, brain and nervous system are to some extent mirrored by the various overlapping categories of clinical examination, namely mental state examination, neuropsychological assessment and neurological examination. At the present time a brain scan alone cannot accurately diagnose a mental disorder or tell the risk of developing one, but can be used to rule out other medical conditions such as a brain tumor.

Such distinctions can affect the explanation given for idiopathic (of unknown origin) neurological symptoms if it is thought (perhaps by exclusion of any other diagnosis) that higher brain/mental activity is causing symptoms that usually originate in other areas of the nervous system. Classic examples are "functional" seizures, sensory numbness, "functional" limb weakness and functional neurological deficit ("functional" in this context is usually contrasted with the old term "organic disease"). Such cases may be contentiously interpreted as being "psychological" rather than "neurological". In psychiatry some cases may then be classified as mental disorders, for example conversion disorder if the symptoms appear to be causally linked to emotional states or responses to social stress. However there are also accepted neurological conditions of dissociation where the brain/mind appears to register neurological stimuli that cannot possibly be coming from the part of the nervous system to which they would normally be attributed, such as phantom pain or synesthesia, or where limbs act without conscious direction as in alien hand syndrome.

Chapter 3

Mental Disorder

Mental disorder



Eight women representing prominent mental diagnoses in the 19th century. (Armand Gautier)

ICD-10	F.
MeSH	D001523

A **mental disorder** or **mental illness** is a psychological or behavioral pattern generally associated with subjective distress or disability that occurs in an individual, and which are not a part of normal development or culture. The recognition and understanding of mental health conditions has changed over time and across cultures, and there are still variations in the definition, assessment, and classification of mental disorders, although standard guideline criteria are widely accepted. A few mental disorders are diagnosed based on the harm to others, regardless of the subject's perception of distress. Over a third of people in most countries report meeting criteria for the major categories at some point in their lives.

The causes are often explained in terms of a diathesis-stress model or biopsychosocial model. In biological psychiatry, mental disorders are conceptualized as disorders of brain

circuits likely caused by developmental processes shaped by a complex interplay of genetics and experience.

Services are based in psychiatric hospitals or in the community. Diagnoses are made by psychiatrists or clinical psychologists using various methods, often relying on observation and questioning in interviews. Treatments are provided by various mental health professionals. Psychotherapy and psychiatric medication are two major treatment options as are social interventions, peer support and self-help. In some cases there may be involuntary detention and involuntary treatment where legislation allows.

Stigma and discrimination add to the suffering associated with the disorders, and have led to various social movements attempting to increase acceptance.

Classifications

The definition and classification of mental disorders is a key issue for mental health and for users and providers of mental health services. Most international clinical documents use the term "mental disorder". There are currently two widely established systems that classify mental disorders—*ICD-10 Chapter V: Mental and behavioural disorders*, part of the International Classification of Diseases produced by the World Health Organization (WHO), and the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) produced by the American Psychiatric Association (APA).

Both list categories of disorder and provide standardized criteria for diagnosis. They have deliberately converged their codes in recent revisions so that the manuals are often broadly comparable, although significant differences remain. Other classification schemes may be used in non-western cultures (see, for example, the *Chinese Classification of Mental Disorders*), and other manuals may be used by those of alternative theoretical persuasions, for example the *Psychodynamic Diagnostic Manual*. In general, mental disorders are classified separately to neurological disorders, learning disabilities or mental retardation.

Unlike most of the above systems, some approaches to classification do not employ distinct categories of disorder or dichotomous cut-offs intended to separate the abnormal from the normal. There is significant scientific debate about the different kinds of categorization and the relative merits of categorical versus non-categorical (or hybrid) schemes, with the latter including spectrum, continuum or dimensional systems.

Disorders

There are many different categories of mental disorder, and many different facets of human behavior and personality that can become disordered.

Anxiety or fear that interferes with normal functioning may be classified as an anxiety disorder. Commonly recognized categories include specific phobias, generalized anxiety

disorder, social anxiety disorder, panic disorder, agoraphobia, obsessive-compulsive disorder and post-traumatic stress disorder.

Other affective (emotion/mood) processes can also become disordered. Mood disorder involving unusually intense and sustained sadness, melancholia or despair is known as Major depression or Clinical depression (milder but still prolonged depression can be diagnosed as dysthymia). Bipolar disorder (also known as manic depression) involves abnormally "high" or pressured mood states, known as mania or hypomania, alternating with normal or depressed mood. Whether unipolar and bipolar mood phenomena represent distinct categories of disorder, or whether they usually mix and merge together along a dimension or spectrum of mood, is under debate in the scientific literature.

Patterns of belief, language use and perception can become disordered (e.g. delusions, thought disorder, hallucinations). Psychotic disorders in this domain include schizophrenia, and delusional disorder. Schizoaffective disorder is a category used for individuals showing aspects of both schizophrenia and affective disorders. Schizotypy is a category used for individuals showing some of the characteristics associated with schizophrenia but without meeting cut-off criteria.

Personality—the fundamental characteristics of a person that influence his or her thoughts and behaviors across situations and time—may be considered disordered if judged to be abnormally rigid and maladaptive. Categorical schemes list a number of different such personality disorders, including those sometimes classed as eccentric (e.g. paranoid, schizoid and schizotypal personality disorders), to those sometimes classed as dramatic or emotional (antisocial, borderline, histrionic or narcissistic personality disorders) or those seen as fear-related (avoidant, dependent, or obsessive-compulsive personality disorders). If an inability to sufficiently adjust to life circumstances begins within three months of a particular event or situation, and ends within six months after the stressor stops or is eliminated, it may instead be classed as an adjustment disorder. There is an emerging consensus that so-called "personality disorders", like personality traits in general, actually incorporate a mixture of acute dysfunctional behaviors that resolve in short periods, and maladaptive temperamental traits that are more stable. Furthermore, there are also non-categorical schemes that rate all individuals via a profile of different dimensions of personality rather than using a cut-off from normal personality variation, for example through schemes based on the Big Five personality traits.

Eating disorders involve disproportionate concern in matters of food and weight. Categories of disorder in this area include anorexia nervosa, bulimia nervosa, exercise bulimia or binge eating disorder.

Sleep disorders such as insomnia involve disruption to normal sleep patterns, or a feeling of tiredness despite sleep appearing normal.

Sexual and gender identity disorders may be diagnosed, including dyspareunia, gender identity disorder and ego-dystonic homosexuality. Various kinds of paraphilia are

considered mental disorders (sexual arousal to objects, situations, or individuals that are considered abnormal or harmful to the person or others).

People who are abnormally unable to resist certain urges or impulses that could be harmful to themselves or others, may be classed as having an impulse control disorder, including various kinds of tic disorders such as Tourette's syndrome, and disorders such as kleptomania (stealing) or pyromania (fire-setting). Various behavioral addictions, such as gambling addiction, may be classed as a disorder. Obsessive-compulsive disorder can sometimes involve an inability to resist certain acts but is classed separately as being primarily an anxiety disorder.

The use of drugs (legal or illegal), when it persists despite significant problems related to the use, may be defined as a mental disorder termed substance dependence or substance abuse (a broader category than drug abuse). The DSM does not currently use the common term drug addiction and the ICD simply talks about "harmful use". Disordered substance use may be due to a pattern of compulsive and repetitive use of the drug that results in tolerance to its effects and withdrawal symptoms when use is reduced or stopped.

People who suffer severe disturbances of their self-identity, memory and general awareness of themselves and their surroundings may be classed as having a dissociative identity disorder, such as depersonalization disorder or Dissociative Identity Disorder itself (which has also been called multiple personality disorder, or "split personality"). Other memory or cognitive disorders include amnesia or various kinds of old age dementia.

A range of developmental disorders that initially occur in childhood may be diagnosed, for example autism spectrum disorders, oppositional defiant disorder and conduct disorder, and attention deficit hyperactivity disorder (ADHD), which may continue into adulthood.

Conduct disorder, if continuing into adulthood, may be diagnosed as antisocial personality disorder (dissocial personality disorder in the ICD). Popularist labels such as psychopath (or sociopath) do not appear in the DSM or ICD but are linked by some to these diagnoses.

Disorders appearing to originate in the body, but thought to be mental, are known as somatoform disorders, including somatization disorder and conversion disorder. There are also disorders of the perception of the body, including body dysmorphic disorder. Neurasthenia is an old diagnosis involving somatic complaints as well as fatigue and low spirits/depression, which is officially recognized by the ICD-10 but no longer by the DSM-IV.

Factitious disorders, such as Munchausen syndrome, are diagnosed where symptoms are thought to be experienced (deliberately produced) and/or reported (feigned) for personal gain.

There are attempts to introduce a category of relational disorder, where the diagnosis is of a relationship rather than on any one individual in that relationship. The relationship may be between children and their parents, between couples, or others. There already exists, under the category of psychosis, a diagnosis of shared psychotic disorder where two or more individuals share a particular delusion because of their close relationship with each other.

Various new types of mental disorder diagnosis are occasionally proposed. Among those controversially considered by the official committees of the diagnostic manuals include self-defeating personality disorder, sadistic personality disorder, passive-aggressive personality disorder and premenstrual dysphoric disorder.

Two recent unique isolated proposals are solastalgia by Glenn Albrecht and hubris syndrome by David Owen. The application of the concept of mental illness to the phenomena described by these authors has in turn been critiqued by Seamus Mac Suibhne.

Causes

Mental disorders can arise from a combination of sources. In many cases there is no single accepted or consistent cause currently established. A common belief even to this day is that disorders result from genetic vulnerabilities exposed by environmental stressors. However, it is clear enough from a simple statistical analysis across the whole spectrum of mental health disorders at least in western cultures that there is a strong relationship between the various forms of severe and complex mental disorder in adulthood and the abuse (physical, sexual or emotional) or neglect of children during the developmental years. Child sexual abuse alone plays a significant role in the causation of a significant percentage of all mental disorders in adult females, most notable examples being eating disorders and borderline personality disorder.

An eclectic or pluralistic mix of models may be used to explain particular disorders, and the primary paradigm of contemporary mainstream Western psychiatry is said to be the biopsychosocial (BPS) model, incorporating biological, psychological and social factors, although this may not always be applied in practice. Biopsychiatry has tended to follow a biomedical model, focusing on "organic" or "hardware" pathology of the brain. Psychoanalytic theories have continued to evolve alongside congitive-behavioural and systemic-family approaches been popular but are now less so. Evolutionary psychology may be used as an overall explanatory theory, and attachment theory is another kind of evolutionary-psychological approach sometimes applied in the context of mental disorders. A distinction is sometimes made between a "medical model" or a "social model" of disorder and disability.

Studies have indicated that genes often play an important role in the development of mental disorders, although the reliable identification of connections between specific genes and specific categories of disorder has proven more difficult. Environmental events surrounding pregnancy and birth have also been implicated. Traumatic brain injury may

increase the risk of developing certain mental disorders. There have been some tentative inconsistent links found to certain viral infections, to substance misuse, and to general physical health.

Abnormal functioning of neurotransmitter systems has been implicated, including serotonin, norepinephrine, dopamine and glutamate systems. Differences have also been found in the size or activity of certain brain regions in some cases. Psychological mechanisms have also been implicated, such as cognitive (e.g. reason), emotional processes, personality, temperament and coping style.

Social influences have been found to be important, including abuse, bullying and other negative or stressful life experiences. The specific risks and pathways to particular disorders are less clear, however. Aspects of the wider community have also been implicated, including employment problems, socioeconomic inequality, lack of social cohesion, problems linked to migration, and features of particular societies and cultures.

Gender-specific influences

Female-specific indicators of mental illness incorporate physical or sexual abuse, stress, loss of social network, rape and domestic violence, high progesterone oral contraceptives, and mood disorders during early reproductive years. It is important to note that the intersection of biological, social, and behavioral health problems may result in exacerbated mental health issues. An investigation carried out by the US National Camorbidity Survey (NCS) showed that 5% of woman that had been exposed to a traumatic event went onto develop posttramautic stress disorder (PTSD). It is also reported that women are the most vulnerable during the aftermath of a disaster. These circumstances increase the risk of poor physical health, anxiety, and depression which are all factors of mental health disorders. (Chandra P.S., et al. 2009).

Diagnosis

Many mental health professionals, particularly psychiatrists, seek to diagnose individuals by ascertaining their particular mental disorder. Some professionals, for example some clinical psychologists, may avoid diagnosis in favor of other assessment methods such as formulation of a client's difficulties and circumstances. The majority of mental health problems are actually assessed and treated by family physicians during consultations, who may refer on for more specialist diagnosis in acute or chronic cases. Routine diagnostic practice in mental health services typically involves an interview (which may be referred to as a mental status examination), where judgments are made of the interviewee's appearance and behavior, self-reported symptoms, mental health history, and current life circumstances. The views of relatives or other third parties may be taken into account. A physical examination to check for ill health or the effects of medications or other drugs may be conducted. Psychological testing is sometimes used via paper-and-pen or computerized questionnaires, which may include algorithms based on ticking off standardized diagnostic criteria, and in rare specialist cases neuroimaging tests may be

requested, but these methods are more commonly found in research studies than routine clinical practice.

Time and budgetary constraints often limit practicing psychiatrists from conducting more thorough diagnostic evaluations. It has been found that most clinicians evaluate patients using an unstructured, open-ended approach, with limited training in evidence-based assessment methods, and that inaccurate diagnosis may be common in routine practice. Mental illness involving hallucinations or delusions (especially schizophrenia) are prone to misdiagnosis in developing countries due to the presence of psychotic symptoms instigated by nutritional deficiencies. Comorbidity is very common in psychiatric diagnoses, i.e. the same person given a diagnosis in more than one category of disorder.

Management

Treatment and support for mental disorders is provided in psychiatric hospitals, clinics or any of a diverse range of community mental health services. In many countries services are increasingly based on a recovery model that is meant to support each individual's independence, choice and personal journey to regain a meaningful life, although individuals may be treated against their will in a minority of cases. There are a range of different types of treatment and what is most suitable depends on the disorder and on the individual. Many things have been found to help at least some people, and a placebo effect may play a role in any intervention or medication.

Psychotherapy

A major option for many mental disorders is psychotherapy. There are several main types. Cognitive behavioral therapy (CBT) is widely used and is based on modifying the patterns of thought and behavior associated with a particular disorder. Psychoanalysis, addressing underlying psychic conflicts and defenses, has been a dominant school of psychotherapy and is still in use. Systemic therapy or family therapy is sometimes used, addressing a network of significant others as well as an individual.

Some psychotherapies are based on a humanistic approach. There are a number of specific therapies used for particular disorders, which may be offshoots or hybrids of the above types. Mental health professionals often employ an eclectic or integrative approach. Much may depend on the therapeutic relationship, and there may be problems with trust, confidentiality and engagement.

Medication

A major option for many mental disorders is psychiatric medication and there are several main groups. Antidepressants are used for the treatment of clinical depression as well as often for anxiety and other disorders. Anxiolytics are used for anxiety disorders and related problems such as insomnia. Mood stabilizers are used primarily in bipolar disorder. Antipsychotics are mainly used for psychotic disorders, notably for positive symptoms in schizophrenia. Stimulants are commonly used, notably for ADHD.

Despite the different conventional names of the drug groups, there may be considerable overlap in the disorders for which they are actually indicated, and there may also be off-label use of medications. There can be problems with adverse effects of medication and adherence to them, and there is also criticism of pharmaceutical marketing and professional conflicts of interest.

Other

Electroconvulsive therapy (ECT) is sometimes used in severe cases when other interventions for severe intractable depression have failed. Psychosurgery is considered experimental but is advocated by certain neurologists in certain rare cases.

Counseling (professional) and co-counseling (between peers) may be used. Psychoeducation programs may provide people with the information to understand and manage their problems. Creative therapies are sometimes used, including music therapy, art therapy or drama therapy. Lifestyle adjustments and supportive measures are often used, including peer support, self-help groups for mental health and supported housing or supported employment (including social firms). Some advocate dietary supplements.

Prognosis

Prognosis depends on the disorder, the individual and numerous related factors. Some disorders are transient, while others may last a lifetime. Some disorders may be very limited in their functional effects, while others may involve substantial disability and support needs. The degree of ability or disability may vary across different life domains. Continued disability has been linked to institutionalization, discrimination and social exclusion as well as to the inherent properties of disorders.

Even those disorders often considered the most serious and intractable have varied courses. Long-term international studies of schizophrenia have found that over a half of individuals recover in terms of symptoms, and around a fifth to a third in terms of symptoms and functioning, with some requiring no medication. At the same time, many have serious difficulties and support needs for many years, although "late" recovery is still possible. The World Health Organization concluded that the long-term studies' findings converged with others in "relieving patients, carers and clinicians of the chronicity paradigm which dominated thinking throughout much of the 20th century."

Around half of people initially diagnosed with bipolar disorder achieve syndromal recovery (no longer meeting criteria for the diagnosis) within six weeks, and nearly all achieve it within two years, with nearly half regaining their prior occupational and residential status in that period. However, nearly half go on to experience a new episode of mania or major depression within the next two years. Functioning has been found to vary, being poor during periods of major depression or mania but otherwise fair to good, and possibly superior during periods of hypomania in Bipolar II.

Some mental disorders are linked, on average, to increased rates of attempted and/or completed suicide or self-harm.

Despite often being characterized in purely negative terms, some mental states labeled as disorders can also involve above-average creativity, non-conformity, goal-striving, meticulousness, or empathy. In addition, the public perception of the level of disability associated with mental disorders can change.

Epidemiology

Mental disorders are common. World wide more than one in three people in most countries report sufficient criteria for at least one at some point in their life. In the United States 46% qualifies for a mental illness at some point. An ongoing survey indicates that anxiety disorders are the most common in all but one country, followed by mood disorders in all but two countries, while substance disorders and impulse-control disorders were consistently less prevalent. Rates varied by region. Such statistics are widely believed to be underestimates, due to poor diagnosis (especially in countries without affordable access to mental health services) and low reporting rates, in part because of the predominant use of self-report data rather than semi-structured instruments. Actual lifetime prevalence rates for mental disorders are estimated to be between 65% and 85%.

A review of anxiety disorder surveys in different countries found average lifetime prevalence estimates of 16.6%, with women having higher rates on average. A review of mood disorder surveys in different countries found lifetime rates of 6.7% for major depressive disorder (higher in some studies, and in women) and 0.8% for Bipolar I disorder.

In the United States the frequency of disorder is: anxiety disorder (28.8%), mood disorder (20.8%), impulse-control disorder (24.8%) or substance use disorder (14.6%).

A 2004 cross-Europe study found that approximately one in four people reported meeting criteria at some point in their life for at least one of the DSM-IV disorders assessed, which included mood disorders (13.9%), anxiety disorders (13.6%) or alcohol disorder (5.2%). Approximately one in ten met criteria within a 12-month period. Women and younger people of either gender showed more cases of disorder. A 2005 review of surveys in 16 European countries found that 27% of adult Europeans are affected by at least one mental disorder in a 12 month period.

An international review of studies on the prevalence of schizophrenia found an average (median) figure of 0.4% for lifetime prevalence; it was consistently lower in poorer countries.

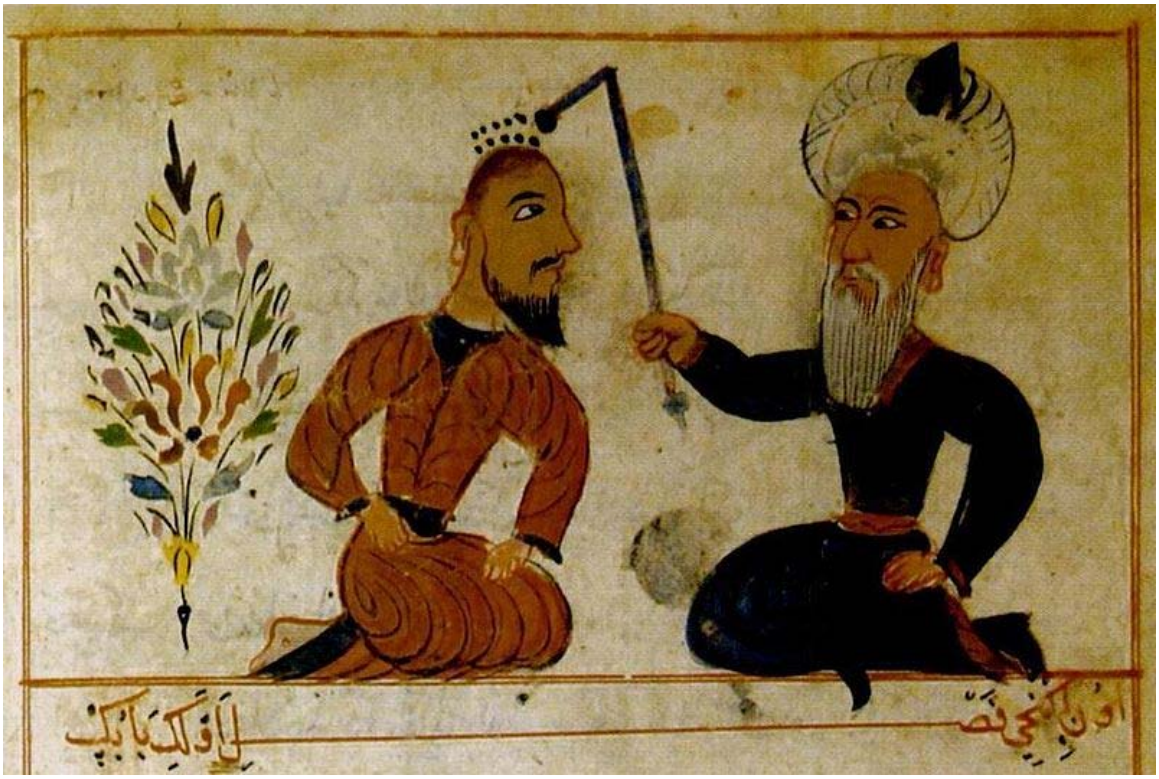
Studies of the prevalence of personality disorders (PDs) have been fewer and smaller-scale, but one broad Norwegian survey found a five-year prevalence of almost 1 in 7 (13.4%). Rates for specific disorders ranged from 0.8% to 2.8%, differing across

countries, and by gender, educational level and other factors. A US survey that incidentally screened for personality disorder found a rate of 14.79%.

Approximately 7% of a preschool pediatric sample were given a psychiatric diagnosis in one clinical study, and approximately 10% of 1- and 2-year-olds receiving developmental screening have been assessed as having significant emotional/behavioral problems based on parent and pediatrician reports.

While rates of psychological disorders are the same for men and women, women have twice the rate of depression than men. Each year 73 million women are afflicted with major depression, and suicide is ranked 7th as the cause of death for women between the ages of 20-59. Depressive disorders account for close to 41.9% of the disability from neuropsychiatric disorders among women compared to 29.3% among men.

History



Early color illustration of psychiatric treatment methods

Ancient civilizations

Ancient civilizations described and treated a number of mental disorders. The Greeks coined terms for melancholy, hysteria and phobia and developed the humorism theory. Psychiatric theories and treatments developed in Persia, Arabia and the Muslim Empire, particularly in the medieval Islamic world from the 8th century, where the first psychiatric hospitals were built.

Europe

Middle Ages

Conceptions of madness in the Middle Ages in Christian Europe were a mixture of the divine, diabolical, magical and humoral, as well as more down to earth considerations. In the early modern period, some people with mental disorders may have been victims of the witch-hunts but were increasingly admitted to local workhouses and jails or sometimes to private madhouses. Many terms for mental disorder that found their way into everyday use first became popular in the 16th and 17th centuries.

Eighteenth century

By the end of the 17th century and into the Enlightenment, madness was increasingly seen as an organic physical phenomenon with no connection to the soul or moral responsibility. Asylum care was often harsh and treated people like wild animals, but towards the end of the 18th century a moral treatment movement gradually developed. Clear descriptions of some syndromes may be rare prior to the 19th century.

Nineteenth century

Industrialization and population growth led to a massive expansion of the number and size of insane asylums in every Western country in the 19th century. Numerous different classification schemes and diagnostic terms were developed by different authorities, and the term psychiatry was coined, though medical superintendents were still known as alienists.

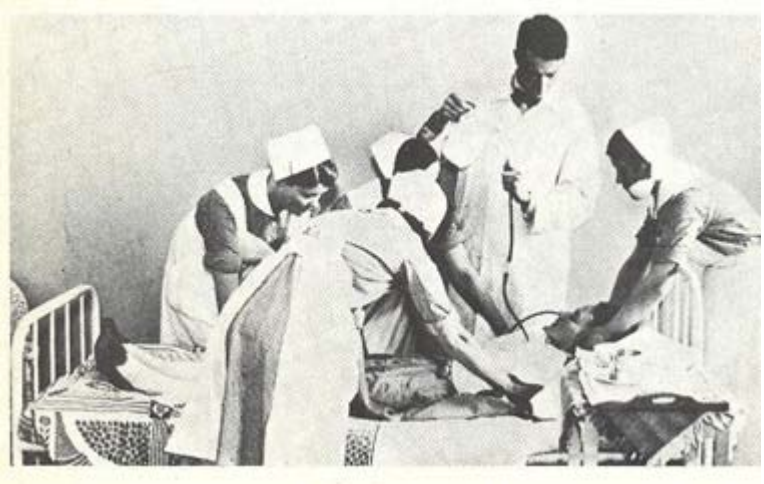
Twentieth century

The turn of the 20th century saw the development of psychoanalysis, which would later come to the fore, along with Kraepelin's classification scheme. Asylum "inmates" were increasingly referred to as "patients", and asylums renamed as hospitals.

Europe and the U.S.

In the 20th century in the United States, a mental hygiene movement developed, aiming to prevent mental disorders. Clinical psychology and social work developed as professions. World War I saw a massive increase of conditions that came to be termed "shell shock".

World War II saw the development in the U.S. of a new psychiatric manual for categorizing mental disorders, which along with existing systems for collecting census and hospital statistics led to the first Diagnostic and Statistical Manual of Mental Disorders (DSM). The International Classification of Diseases (ICD) followed suit with a section on mental disorders. The term stress, having emerged out of endocrinology work in the 1930s, was increasingly applied to mental disorders.

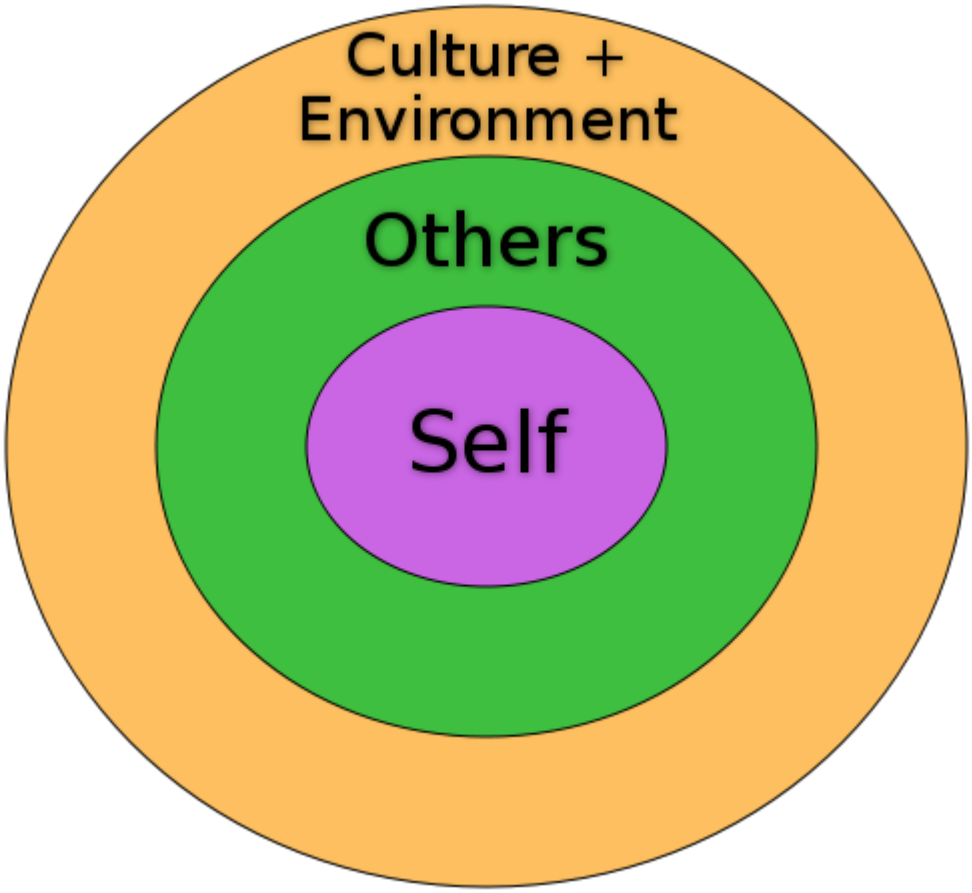


Insulin Shock Therapy

Electroconvulsive therapy, insulin shock therapy, lobotomies and the "neuroleptic" chlorpromazine came to be used by mid-century. An antipsychiatry movement came to the fore in the 1960s. Deinstitutionalization gradually occurred in the West, with isolated psychiatric hospitals being closed down in favor of community mental health services. A consumer/survivor movement gained momentum. Other kinds of psychiatric medication gradually came into use, such as "psychic energizers" and lithium. Benzodiazepines gained widespread use in the 1970s for anxiety and depression, until dependency problems curtailed their popularity.

Advances in neuroscience and genetics led to new research agendas. Cognitive behavioral therapy was developed. The DSM and then ICD adopted new criteria-based classifications, and the number of "official" diagnoses saw a large expansion. Through the 1990s, new SSRI antidepressants became some of the most widely prescribed drugs in the world. Also during the 1990s, a recovery model developed.

Society and culture



Different societies or cultures and even different individuals in a culture can disagree as to what constitutes optimal versus pathological biological and psychological functioning. Research has demonstrated that cultures vary in the relative importance placed on, for example, happiness, autonomy, or social relationships for pleasure. Likewise, the fact that a behavior pattern is valued, accepted, encouraged, or even statistically normative in a culture does not necessarily mean that it is conducive to optimal psychological functioning.

People in all cultures find some behaviors bizarre or even incomprehensible. But just what they feel is bizarre or incomprehensible is ambiguous and subjective. These differences in determination can become highly contentious.

The process by which conditions and difficulties come to be defined and treated as medical conditions and problems, and thus come under the authority of doctors and other health professionals, is known as medicalization or pathologization.

In the scientific and academic literature on the definition or classification of mental disorder, one extreme argues that it is entirely a matter of value judgements (including of what is normal) while another proposes that it is or could be entirely objective and scientific (including by reference to statistical norms). Common hybrid views argue that

the concept of mental disorder is objective but a "fuzzy prototype" that can never be precisely defined, or alternatively that it inevitably involves a mix of scientific facts and subjective value judgments.

Professions and fields

A number of professions have developed that specialize in the treatment of mental disorders, including the medical speciality of psychiatry (including psychiatric nursing), a subset of psychology known as clinical psychology, social work, as well as mental health counselors, marriage and family therapists, psychotherapists, counselors and public health professionals. Those with personal experience of using mental health services are also increasingly involved in researching and delivering mental health services and working as mental health professionals. The different clinical and scientific perspectives draw on diverse fields of research and theory, and different disciplines may favor differing models, explanations and goals.

Movements

The consumer/survivor movement (also known as user/survivor movement) is made up of individuals (and organizations representing them) who are clients of mental health services or who consider themselves "survivors" of mental health services. The movement campaigns for improved mental health services and for more involvement and empowerment within mental health services, policies and wider society. Patient advocacy organizations have expanded with increasing deinstitutionalization in developed countries, working to challenge the stereotypes, stigma and exclusion associated with psychiatric conditions. An antipsychiatry movement fundamentally challenges mainstream psychiatric theory and practice, including asserting that psychiatric diagnoses of mental illnesses are neither real nor useful.

Intangible experiences

Religious, spiritual, or transpersonal experiences and beliefs are typically not defined as disordered, especially if widely shared, despite meeting many criteria of delusional or psychotic disorders. Even when a belief or experience can be shown to produce distress or disability—the ordinary standard for judging mental disorders—the presence of a strong cultural basis for that belief, experience, or interpretation of experience, generally disqualifies it from counting as evidence of mental disorder.

Western bias

Current diagnostic guidelines have been criticized as having a fundamentally Euro-American outlook. They have been widely implemented, but opponents argue that even when diagnostic criteria are accepted across different cultures, it does not mean that the underlying constructs have any validity within those cultures; even reliable application can prove only consistency, not legitimacy.

Advocating a more culturally sensitive approach, critics such as Carl Bell and Marcello Maviglia contend that the cultural and ethnic diversity of individuals is often discounted by researchers and service providers.

Cross-cultural psychiatrist Arthur Kleinman contends that the Western bias is ironically illustrated in the introduction of cultural factors to the DSM-IV: that disorders or concepts from non-Western or non-mainstream cultures are described as "culture-bound", whereas standard psychiatric diagnoses are given no cultural qualification whatsoever, reveals to Kleinman an underlying assumption that Western cultural phenomena are universal. Kleinman's negative view towards the culture-bound syndrome is largely shared by other cross-cultural critics, common responses included both disappointment over the large number of documented non-Western mental disorders still left out and frustration that even those included were often misinterpreted or misrepresented.

Many mainstream psychiatrists are dissatisfied with the new culture-bound diagnoses, although for different reasons. Robert Spitzer, a lead architect of the DSM-III, has hypothesized that adding cultural formulations was an attempt to appease cultural critics and stated that the formulations lack any scientific motivation or support. Spitzer also posits that the new culture-bound diagnoses are rarely used, maintaining that the standard diagnoses apply regardless of the culture involved. In general, mainstream psychiatric opinion remains that if a diagnostic category is valid, cross-cultural factors are either irrelevant or are significant only to specific symptom presentations.

Relationships and morality

Clinical conceptions of mental illness also overlap with personal and cultural values in the domain of morality, so much so that it is sometimes argued that separating the two is impossible without fundamentally redefining the essence of being a particular person in a society. In clinical psychiatry, persistent distress and disability indicate an internal disorder requiring treatment; but in another context, that same distress and disability can be seen as an indicator of emotional struggle and the need to address social and structural problems. This dichotomy has lead some academics and clinicians to advocate a postmodernist conceptualization of mental distress and well-being.

Such approaches, along with cross-cultural and "heretical" psychologies centered on alternative cultural and ethnic and race-based identities and experiences, stand in contrast to the mainstream psychiatric community's active avoidance of any involvement with either morality or culture. In many countries there are attempts to challenge perceived prejudice against minority groups, including alleged institutional racism within psychiatric services.

Laws and policies

Three quarters of countries around the world have mental health legislation. Compulsory admission to mental health facilities (also known as involuntary commitment or sectioning), is a controversial topic. From some points of view it can impinge on personal

liberty and the right to choose, and carry the risk of abuse for political, social and other reasons; from other points of view, it can potentially prevent harm to self and others, and assist some people in attaining their right to healthcare when unable to decide in their own interests.

All human-rights oriented mental health laws require proof of the presence of a mental disorder as defined by internationally accepted standards, but the type and severity of disorder that counts can vary in different jurisdictions. The two most often utilized grounds for involuntary admission are said to be serious likelihood of immediate or imminent danger to self or others, and the need for treatment. Applications for someone to be involuntarily admitted may usually come from a mental health practitioner, a family member, a close relative, or a guardian. Human-rights-oriented laws usually stipulate that independent medical practitioners or other accredited mental health practitioners must examine the patient separately and that there should be regular, time-bound review by an independent review body. An individual must be shown to lack the capacity to give or withhold informed consent (i.e. to understand treatment information and its implications). Legal challenges in some areas have resulted in supreme court decisions that a person does *not* have to agree with a psychiatrist's characterization of their issues as an "illness", nor with a psychiatrist's conviction in medication, but only recognize the issues and the information about treatment options.

Proxy consent (also known as substituted decision-making) may be given to a personal representative, a family member or a legally appointed guardian, or patients may have been able to enact an advance directive as to how they wish to be treated. The right to supported decision-making may also be included in legislation. Involuntary treatment laws are increasingly extended to those living in the community, for example outpatient commitment laws (known by different names) are used in New Zealand, Australia, the United Kingdom and most of the United States.

The World Health Organization reports that in many instances national mental health legislation takes away the rights of persons with mental disorders rather than protecting rights, and is often outdated. In 1991, the United Nations adopted the Principles for the Protection of Persons with Mental Illness and the Improvement of Mental Health Care, which established minimum human rights standards of practice in the mental health field. In 2006, the UN formally agreed the Convention on the Rights of Persons with Disabilities to protect and enhance the rights and opportunities of disabled people, including those with psychosocial disabilities.

The term insanity, sometimes used colloquially as a synonym for mental illness, is often used technically as a legal term. The insanity defense may be used in a legal trial (known as the mental disorder defence in some countries).

Perception and discrimination

Stigma

The social stigma associated with mental disorders is a widespread problem. Some people believe those with serious mental illnesses cannot recover, or are to blame for problems. The US Surgeon General stated in 1999 that: "Powerful and pervasive, stigma prevents people from acknowledging their own mental health problems, much less disclosing them to others." Employment discrimination is reported to play a significant part in the high rate of unemployment among those with a diagnosis of mental illness.

Efforts are being undertaken worldwide to eliminate the stigma of mental illness, although their methods and outcomes have sometimes been criticized.

A 2008 study by Baylor University researchers found that clergy in the US often deny or dismiss the existence of a mental illness. Of 293 Christian church members, more than 32 percent were told by their church pastor that they or their loved one did not really have a mental illness, and that the cause of their problem was solely spiritual in nature, such as a personal sin, lack of faith or demonic involvement. The researchers also found that women were more likely than men to get this response. All participants in both studies were previously diagnosed by a licensed mental health provider as having a serious mental illness. However, there is also research suggesting that people are often helped by extended families and supportive religious leaders who listen with kindness and respect, which can often contrast with usual practice in psychiatric diagnosis and medication.

Media and general public

Media coverage of mental illness comprises predominantly negative depictions, for example, of incompetence, violence or criminality, with far less coverage of positive issues such as accomplishments or human rights issues. Such negative depictions, including in children's cartoons, are thought to contribute to stigma and negative attitudes in the public and in those with mental health problems themselves, although more sensitive or serious cinematic portrayals have increased in prevalence.

In the United States, the Carter Center has created fellowships for journalists in South Africa, the U.S., and Romania, to enable reporters to research and write stories on mental health topics. Former US First Lady Rosalynn Carter began the fellowships not only to train reporters in how to sensitively and accurately discuss mental health and mental illness, but also to increase the number of stories on these topics in the news media. There is a World Mental Health Day, which the US and Canada subsume under a Mental Illness Awareness Week.

The general public have been found to hold a strong stereotype of dangerousness and desire for social distance from individuals described as mentally ill. A US national survey found that a higher percentage of people rate individuals described as displaying the characteristics of a mental disorder as "likely to do something violent to others",

compared to the percentage of people who are rating individuals described as being "troubled".

Violence

Despite public or media opinion, national studies have indicated that severe mental illness does not independently predict future violent behavior, on average, and is not a leading cause of violence in society. There is a statistical association with various factors that do relate to violence (in anyone), such as substance abuse and various personal, social and economic factors.

In fact, findings consistently indicate that it is many times more likely that people diagnosed with a serious mental illness living in the community will be the victims rather than the perpetrators of violence. In a study of individuals diagnosed with "severe mental illness" living in a US inner-city area, a quarter were found to have been victims of at least one violent crime over the course of a year, a proportion eleven times higher than the inner-city average, and higher in every category of crime including violent assaults and theft. People with a diagnosis may find it more difficult to secure prosecutions, however, due in part to prejudice and being seen as less credible.

However, there are some specific diagnoses, such as childhood conduct disorder or adult antisocial personality disorder or psychopathy, which are defined by or inherently associated with conduct problems and violence. There are conflicting findings about the extent to which certain specific symptoms, notably some kinds of psychosis (hallucinations or delusions) that can occur in disorders such as schizophrenia, delusional disorder or mood disorder, are linked to an increased risk of serious violence on average. The mediating factors of violent acts, however, are most consistently found to be mainly socio-demographic and socio-economic factors such as being young, male, of lower socioeconomic status and, in particular, substance abuse (including alcoholism) to which some people may be particularly vulnerable.

High-profile cases have led to fears that serious crimes, such as homicide, have increased due to deinstitutionalization, but the evidence does not support this conclusion. Violence that does occur in relation to mental disorder (against the mentally ill or by the mentally ill) typically occurs in the context of complex social interactions, often in a family setting rather than between strangers. It is also an issue in health care settings and the wider community.

In animals

Psychopathology in non-human primates has been studied since the mid-20th century. Over 20 behavioral patterns in captive chimpanzees have been documented as (statistically) abnormal for their frequency, severity or oddness—some of which have also been observed in the wild. Captive great apes show gross behavioral abnormalities such as stereotypy of movements, self-mutilation, disturbed emotional reactions (mainly fear or aggression) towards companions, lack of species-typical communications, and

generalized learned helplessness. In some cases such behaviors are hypothesized to be equivalent to symptoms associated with psychiatric disorders in humans such as depression, anxiety disorders, eating disorders and post-traumatic stress disorder. Concepts of antisocial, borderline and schizoid personality disorders have also been applied to non-human great apes.

The risk of anthropomorphism is often raised with regard to such comparisons, and assessment of non-human animals cannot incorporate evidence from linguistic communication. However, available evidence may range from nonverbal behaviors—including physiological responses and homologous facial displays and acoustic utterances—to neurochemical studies. It is pointed out that human psychiatric classification is often based on statistical description and judgement of behaviors (especially when speech or language is impaired) and that the use of verbal self-report is itself problematic and unreliable.

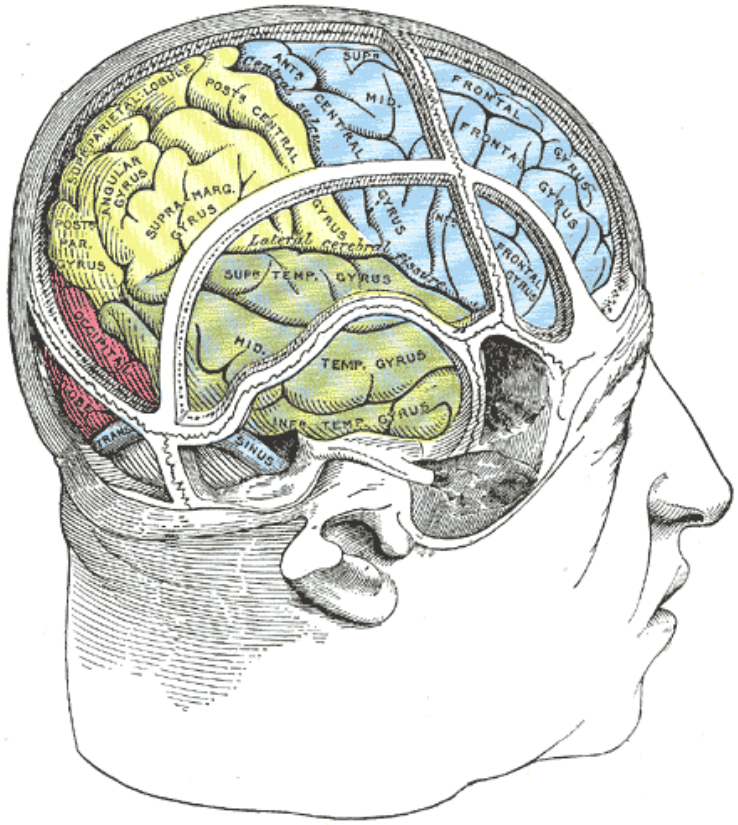
Psychopathology has generally been traced, at least in captivity, to adverse rearing conditions such as early separation of infants from mothers; early sensory deprivation; and extended periods of social isolation. Studies have also indicated individual variation in temperament, such as sociability or impulsiveness. Particular causes of problems in captivity have included integration of strangers into existing groups and a lack of individual space, in which context some pathological behaviors have also been seen as coping mechanisms. Remedial interventions have included careful individually tailored re-socialization programs, behavior therapy, environment enrichment, and on rare occasions psychiatric drugs. Socialization has been found to work 90% of the time in disturbed chimpanzees, although restoration of functional sexuality and care-giving is often not achieved.

Laboratory researchers sometimes try to develop animal models of human mental disorders, including by inducing or treating symptoms in animals through genetic, neurological, chemical or behavioral manipulation, but this has been criticized on empirical grounds and opposed on animal rights grounds.

Chapter 4

Allochiria

Allochiria

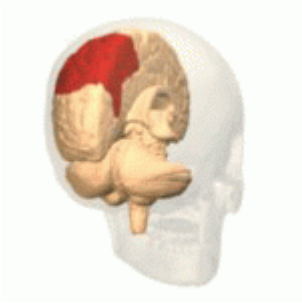


Allochiria is most frequently associated with a lesion of the right parietal lobe (in yellow, at top)

Allochiria (from the Greek meaning "other hand") is associated to spatial transpositions, usually symmetrical, of stimuli from one side of the body (or of the space) to the opposite one. It is a neurological disorder in which the patient responds to stimuli presented to one side of their body as if the stimuli had been presented at the opposite side. Thus a touch to the left arm will be reported as a touch to the right arm, which is also known as somatosensory allochiria. If the auditory or visual senses are affected, sounds (a person's voice for instance) will be reported as being heard on the opposite side to that on which

they occur and objects presented visually will be reported as having been presented on the opposite side. Often patients may express allochiria in their drawing while copying an image. Allochiria often co-occurs with unilateral neglect and, like neglect, the disorder arises commonly from damage to the right parietal lobe.

Definitional criteria



Parietal lobe (red)

Allochiria has been observed mainly in the context of neglect which is usually due to a lesion that affects the right parietal lobe. In patients with allochiria, their sensibility is retained completely but the patient is not clear as to which side of the body has been touched. Their power of localization is retained but error exists to the side touched and they often refer the irritation to the corresponding part of the limb. In the patients' mind there is doubt or error as to which side of the body is touched. There are multiple definitions of allochiria. According to Musser, it is a term employed to describe the reference of a sensory stimulus to the corresponding location on the opposite location on the opposite side of the body. Judson Bury says that a patient may refer to an impression on one side to a corresponding place on the opposite side of the body. Thus, if a patient is pricked on one limb, he may say that he feels it on the other. Overall, even though different author's definition differs on points such as the type of stimulus, and the symmetry between the site of the stimulus and the seat of its localization, they all agree that an essential feature of allochiria is the deflection of a sensation to the wrong side of the body, which is true allochiria. In none of these definitions is any stress laid on the state of the patient's knowledge of a right or left side and the symptoms are seen as an error in localization. Obersteiner laid stress that there is in allochiria no defect in vertical localization but merely confusion in the patient's mind between the opposite sides of the body and come to look upon the symptom as simply any form of bad mistake in localization. There is in the patient's mind doubt or error as to the side touched while sensibility including the power of localization is otherwise retained. Allochiria has been described as occurring in peripheral nerve lesions, Hemiplegia, disseminated sclerosis Multiple sclerosis, tabes dorsalis, unilateral injury to the spinal cord, Ménière's disease, hysteria, symmetrical gangrene, and in connection with touch, pain, the "muscle sense," the temperature sense, sight, smell, taste, hearing, and the electrical reactions. Allochiria can occur in relation to any or every segment of the body. In some cases allochiria may be bilateral, and in others it may be restricted to certain regions of the body, or even only to one part of the body. Allochiria is marked to have connections with a variety of senses

and sometimes only certain kinds of stimuli can arouse the appropriate feeling of one sidedness.

Types of Allochiria

Electromotor Allochiria

This is seen when there is a cross of electrical reflexes as a muscle is stimulated. Electromotor allochiria has been observed in the face, lower limbs, and upper limbs. In these cases, a stimulus presented on the affected side caused contraction of the opposite facial muscles with a current so weak that the healthy facial did not react. Another example is that pressure on one forearm caused movement of the opposite forearm. The central fact is that an electrical stimulus may manifest its effect at a distant part of the nervous system. This distant part may be on the same side of the body or on the opposite side, naturally it is more often on the opposite side because the representation of corresponding contralateral limbs in the spinal cord are nearer to each other than homolateral limbs. This has nothing to do with the confusion of the two sides that occurs in the patients mind when allochiria is present.

Motor Allochiria

If patient asked to carry out a movement on effect side he does so with the corresponding part of the opposite side fully under the impression that he has correctly performed the required movement.

Reflex Allochiria

Patients with reflex allochiria respond to a stimulation of the sole of the foot or in the inner part of the thigh as being evoked as the corresponding reflex on the opposite side only.

Auditory Allochiria

In cases of auditory allochiria, observations recorded that when a tuning fork was held constantly to one ear, the patient responded with a series of symptoms, including pain and deafness, in the opposite ear.

Visual Allochiria

In visual allochiria, objects situated on one side of the visual field are perceived in the contralateral visual field. In the two cases that have been recorded, in one case the visual impression received by the right open eye was regularly referred to the left eye, and the patient maintain that she perceived the impression with the left eye that in fact was shut. In another case a colored object held in front of the left eye was recognized and the patient maintained that she saw the color with the right eye.

Gustatory Allochiria

In a case of gustatory allochiria, a substance placed on one side of the tongue was said to have been tasted on the opposite side. Also, touches on that side of the tongue were also referred to the opposite side. In this type of allochiria, it is difficult to see how one can in this case dissociate the reference of taste from that of touch.

True or False Allochiria

Allochiria divides itself into two groups. There is true allochiria which is also a symptom of dyschiria and unilateral neglect. Dyschiria is a disorder in the localization of sensation due to various degrees of dissociation and cause impairment in one side causing the inability to tell which side of the body was touched. Allochiria is often mixed up with alloesthesia, also known as false allochiria. These two different kinds have in the past and currently are confused under the name of allochiria. However, allochiria has a precise diagnostic value and the occurrence of allochiria should be regarded as an indication that there is a presence of hysteria.

Alloesthesia

Alloesthesia (ie, allesthesia) (Greek allache = elsewhere + alsthesis = perception) is also known as false allochiria and many dictionaries list the same definition as allochiria and even give same greek roots. The term allesthesia was introduced by T. Grainger Stewart in an article published in the British Medical Journal in 1894. The cases that Stewart found were mainly related to sensation and he observed consistent horizontal movement. Alloesthesia is a mistake due to incomplete perception of the stimulus and is accompanied by many other failures in perception such as defective localization. In a case study, which was incorrectly described as allochiria, a stimulus applied to the inside of the cheek was referred to the outside. In another case, a touch to the index finger was referred to the thumb. False allochiria may occur in bilateral affections of peripheral nerves such as multiple neuritis, and although no such case has yet been recorded it is still clear that the condition above is not related to allochiria.

Dyschiria

In dyschiria the failure to determine the correct side is a specific failure and is quite independent of any other failure as regards to perception of stimulus. In other words the patient may recognize every single feature concerning a single stimulus—its precise nature, position, etc—except the one point of its side. Evidence goes to show that there is present a mental defect of the specific feeling. Dyschiria has many forms which include achiria, allochiria, and synchiria.

Achiria

Achiria is referred to as simple allochiria and is the term proposed to show the failure to regard feelings of sidedness or handedness. Achiria has sensory, motor, and introspective

components. For the sensory achiria, a stimulus applied to the affected part arouses no feeling of sidedness. The stimulus is presented to the side of the body that the person with the disorder has no notion. For the motor component, if a patient is asked to carry out any movement with the limb in question he is unable to do so unless is indicated in some other way than by the use of the words right and left. Reason for this is that he has lost the knowledge of the meaning of these words either altogether or at all events when they are applied to limbs concerned. For the introspective component a patient loses memory for feeling of part of the body that the stimulus is presented and declares that though he knows he has a part he cannot feel it.

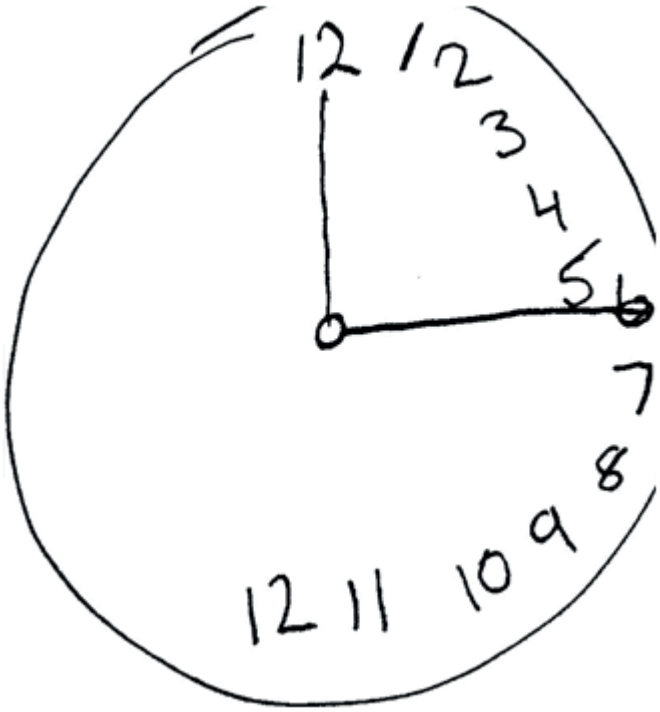
Allochiria

Allochiria is when a stimuli presented on one side is constantly referred to the corresponding point of the opposite side. Allochiria has sensory, motor, and introspective manifestations. In sensory cases, a point to which they are referred on the opposite side corresponds exactly with the symmetrical point touched at fact which in itself disposes of the view that allochiria is in any way merely a disturbance of localization. For cases of motor allochiria, if a patient is asked to carry out a movement on effect side, he does so with the corresponding part of the opposite side fully under the impression that he has correctly performed the required movement. For the introspective cases the patient can appreciate a given feeling of sidedness only when the opposite limb is moved or stimulated.

Synchiria

Synchiria is a form of dyschiria in which a stimulus applied to one side of the body is felt on both sides. Synchiria has sensory, motor, and introspective signs. The sensory component refers to a stimulus applied to the affected part evokes two simultaneous sensations which are referred to the corresponding points on both sides of the body. The motor symptom is when a patient is asked to carry out movement on affected side he does so on both sides though in doing so he gets only the feeling of sidedness of the affected part. The introspective component shows that a patient is unable to appreciate the affected feeling of sidedness alone apart from the simultaneously appreciated feeling of the corresponding opposite side though he can appreciate it when he moves both limbs together under the impression that he is moving only the affected one.

Experiences



Drawing of a clock by an neglect patient with allochiria

There are many cases that patients have shown symptoms of allochiria. Allochiria in constructional tasks is commonly seen when neglect patients transpose the elements on the left side to the right side but fail to see or fix their mistakes. Some cases in which patients have shown allochiria is in copying and drawing clocks from memory. A defect of mental representations may lead the patients to transpose all the elements to the ipsilesional side in drawing tasks. In these drawing and memory tasks, patients with allochiria have a tendency to place all of the hours to the right half of the clock. There are different kinds of spatial transpositions that exist in these drawing tasks in patients with allochiria.

The figure shows an example of Allochiria in the clock drawing of a patient with hemispatial neglect. The patient omitted the left side of objects when drawing a clock. Even though the patient could verbally express that the clock face has a left side, he or she would fail to notice that the drawing was incomplete. This implies that drawing tasks can play an important role in differentiating the specific impairment of the brain lesion, and not just saying that a patient has dementia.

Diagnosis

When diagnosing allochiria, it is important to consider the sensory and the motor aspects of the problem. In absence of knowledge there are a number of ways in which the various symptoms may be overlooked or misinterpreted and as the condition goes frequently unrecognized. One rare example in medicine that causes a wrong diagnosis of allochiria is due to the unawareness of a few simple facts than to any failure in judgment. It is evident that the details of the sensory symptoms get overlooked when testing a patient's localizing capacity. The observer neglects to inquire expressly as to the side to which the sensation is referred. This is evident when patients with allochiria show no fault in sensorial perception and localization. However, even if the patient mentions the wrong side, it is sometimes being just regarded as a slip of the tongue and matter may not be pursued any further. Looking at the motor aspect of allochiria, the symptoms again are described in a misleading way due to the fact that the symptoms are less obvious. Unless motor manifestations are carefully analyzed, they may be interpreted as clumsiness or weakness. Moreover, when patients complained of weakness and awkwardness of right side—examinations apparently confirmed that the truth of this statement and defect was marked as acts consciously performed and was present only in relation to such acts. If a patient says that he cannot tell on which side the certain stimulus is applied—existence of allochiria is confirmed, provided that sensibility is intact.

Diagnostic value of allochiria

Allochiria represents a psychical affection and the occurrence of any form of allochiria should be regarded as a positive indication of the presence of hysteria. Recognition of the allochiria may throw light upon a number of symptoms that would otherwise be misinterpreted as paresis, aboulia, and defective sensibility. This enables a correct analysis to be made of the precise defects present and serve as a guide toward the original focus of the whole affection and proving an important step in the exact psychological diagnosis that is an essential preliminary to the scientific treatment of hysteria.

Theory of Allochiria

There are multiple theories that explain the outcome of allochiria. The current and most widely accepted explanation of allochiria is Hammond's Theory. This theory assumes that there is an almost complete decussation of sensory fibers within the grey matter. He concludes that with a lesion on one posterior side, this would reach center in the corresponding hemisphere, and thus, the sensation is then referred by this hemisphere to the opposite side of the body. Hammond goes on to say that if another unilateral lesion supervened at a different level from the first, the sensation that was previously deflected to the wrong hemisphere was now redirected by meeting with another obstacle and so arrived at its proper hemisphere. Allochiria occurs equally with unilateral and bilateral lesions as long as they are asymmetrical. Another theory is Huber's theory which assumes that an appearance of a new lesion on the opposite side from that of the block redirecting the impulse towards its original destination. Disappearance of symptoms due to retrogression of the lesion and track are cleared.

Chapter 5

Frontal Lobe Epilepsy

Frontal lobe epilepsy, or FLE, is a neurological disorder that is characterized by brief, recurring seizures that arise in the frontal lobes of the brain, often while the patient is sleeping. It is the second most common type of epilepsy after temporal lobe epilepsy (TLE), and is related to the temporal form by the fact that both forms are characterized by the occurrence of partial (focal) seizures. Partial seizures occurring in the frontal lobes can occur in one of two different forms: either simple partial seizures (that do not affect awareness or memory) or complex partial seizures (that affect awareness or memory either before, during or after a seizure). The symptoms and clinical manifestations of frontal lobe epilepsy can differ depending on which specific area of the frontal lobe is affected.

The onset of a seizure may be hard to detect since the frontal lobes contain and regulate many structures and functions about which relatively little is known. Due to the lack of knowledge surrounding the functions associated with the frontal lobes, seizures occurring in these regions of the brain may produce unusual symptoms which can often be misdiagnosed as a psychiatric disorder, non-epileptic seizure or a sleep disorder.

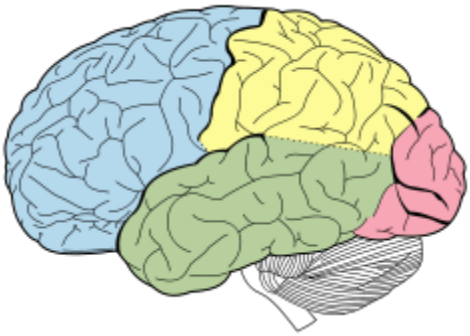
During the onset of a seizure, the patient may exhibit abnormal body posturing, sensorimotor tics, or other abnormalities in motor skills. In rare cases, uncontrollable laughing or crying may occur during a seizure. Afflicted persons may or may not be aware that they are behaving in an abnormal manner, depending on the patient and type of seizure. A brief period of confusion known as a postictal state may sometimes follow a seizure occurring in the frontal lobes. However, these postictal states are oftentimes undetectable and generally do not last as long as the periods of confusion following seizures that occur in the temporal lobes.

There are a variety of different causes of frontal lobe epilepsy ranging from genetics to head trauma that result in lesions in the frontal lobes. Although frontal lobe epilepsy is often misdiagnosed, tests such as prolonged EEG monitoring and/or a MRI scan of the frontal lobes can be administered in order to reveal the presence of a tumor or vascular malformation. Unlike most epileptic EEGs, the abnormalities in FLE EEGs precede the physical onset of the seizure and aid in localization of the seizure's origin. Medications such as anticonvulsants can typically control the onset of seizures, however, if medications are ineffective the patient may undergo surgery to have focal areas of the frontal lobe removed.

Anatomy of Frontal Lobe Cortex

Due to the difference in brain processing and function as well as various surface anatomy landmarks, the frontal lobes have traditionally been divided into two major areas known as the precentral cortex and prefrontal cortex.

Brain: Frontal lobe



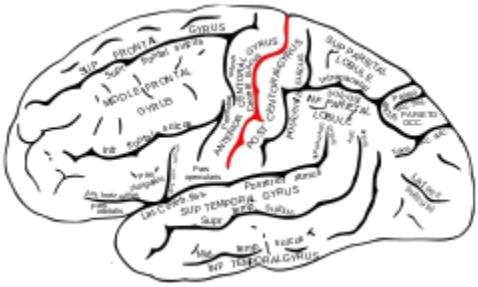
Frontal lobe

Temporal lobe

Parietal lobe

Occipital lobe

Principal fissures and lobes of the cerebrum viewed laterally. (Frontal lobe is blue.)



Lateral surface of left cerebral hemisphere, viewed from the side. Red line indicates the central sulcus.

Latin	*lobus frontalis*
NeuroNames	*hier-29*
NeuroLex ID	*birnlex_4035*

Precentral Cortex

The precentral cortex is an area of the frontal cortex that is located directly anterior to the central sulcus and includes both the primary motor cortex and the supplementary motor area. Inputs that project to both of these areas arise from a variety of locations in the brain that integrate sensory stimuli including the primary motor cortex, the thalamus and corticospinal projections. These two areas along with several other main functional areas control both the preparation of motor movement as well as the execution of movements. These main functional areas are crucial to the development of the motor related symptoms associated with frontal lobe epilepsy focally when seizures are located within these defined areas. The major functional areas include:

- **Primary Motor Cortex**
  - Contains large neurons that project axons down to the spinal cord where they synapse onto alpha motor neurons. These neurons are involved in the planning of motor movements and the refining of motor movements based on sensory inputs that are received from the cerebellum.

- **Supplementary motor area**
  - Area anterior to the primary motor cortex that is involved in planning complex motor movements and coordinating movements along both hands. The main inputs for this area are received from the thalamus.

- **Frontal eye field**
  - The frontal eye field is a posterior part of the middle frontal gyrus and is involved in the control of saccadic, contralateral and conjugate eye movement. This area receives its main inputs from both the occipital cortex and dorsal thalamus.

- **Broca's Area**
  - Controls the motor movements of both the tongue and larynx that enables speech formation. This area receives direct inputs from the primary motor area as well as Wernicke's area located in the temporal lobe.

Prefrontal Cortex

The prefrontal cortex, the most anterior region of the brain, comprises several key areas that are particularly important for higher mental functions that control various aspects of human personality including anticipation and planning, initiative/judgement, memory and the control of decision making. Damage or lesions to this region of the brain can result in major changes in personality. A classic example is Phineas Gage, who exhibited a change in behavior after one or both frontal lobes were destroyed by a large iron bar accidentally driven through his head (though Gage did not exhibit the aggression, antiosocial behavior, or loss of impulse control sometimes reported in patients with similar injuries).

There are two main regions of the prefrontal cortex that each control various aspects of behavior and personality:

- **Dorsolateral Prefrontal Cortex**
  - This area is associated with the impairment of the cognitive abilities that control and regulate behavior and long term memory formation (especially relating to procedural sequence memory) when either brain damage or a lesion is present.

- **Orbitofrontal Cortex**
  - The orbitofrontal cortex has similar functions as the dorsolateral prefrontal cortex but is thought to be mainly responsible for the ability to make choices and determine right from wrong.

Symptoms

Epileptic symptoms are frequently the product of the spread of overactivation occurring within one central foci that travels to lateral brain regions thereby causing an array of symptoms. Due to the massive amount of diversity in both the cognitive and motor functions that occur within the frontal lobes, there is an immense variety in the types of symptoms that can arise from epileptic seizures based on the side and topography of the focal origin. In general these symptoms can range anywhere from asymmetric and abnormal body positionsing to repetitive vocal outburts and repetitive jerking movements. The symptoms typically come in short bursts that last less than a minute and often occur while a patient is sleeping. In most cases, a patient will experience a physical or emotional Aura of tingling, numbness or tension prior to a seizure occurring. Fear is associated with temporal and frontal lobe epilepsies, but in FLE the fear is predominantly expressed on the person's face whereas in TLE the fear is subjective and internal, not perceptible to the observer.

Tonic posture and clonic movements are common symptoms among most of the areas of the frontal lobe, therefore the type of seizures associated with frontal lobe epilepsy are commonly called tonic-clonic seizures. Dystonic motor movements are common to both TLE and FLE, but are usually the first symptom in FLE episodes where they are quite brief and do not affect consciousness. The seizures are complex partial, simple partial, secondarily generalized or a combination of the three. These partial seizures are often misdiagnosed as psychogenic seizures. A wide range of more specific symptoms arise when different parts of the frontal cortex are affected.

- **Supplementary motor area (SMA)**
  - The onset and relief of the seizure are quite abrupt.
  - The tonic posturing in this area is unilateral or asymmetric between the left and right hemispheres. A somatosensory aura frequently precedes many large motor and vocal symptoms and most often the afflicted person is responsive.

- *Motor symptoms*: Facial grimacing and complex automatisms like kicking and pelvic thrusting
- *Vocal symptoms*: Laughing, yelling, or speech arrest.

- **Primary motor cortex**
  - The primary motor cortex has jacksonian seizures that spread to adjacent areas of the lobe which often trigger a second round of seizures originating in another cortical area. The seizures are much simpler than those that originate in the SMA and are usually clonic or myoclonic movements with speech arrest. Some dystonic or contralateral adversive posturing may also be present.

- **Medial frontal, cingulate gyrus, orbitofrontal, or frontopolar regions**
  - Motor symptoms of seizures in this area are accompanied by emotional feelings and viscerosensory symptoms. Motor and vocal agitation are similar to that of the SMA with short repetitive thrashing, pedaling, thrusting, laughing, screaming and/or crying.
  - This is some of what can cause the misdiagnosis of a psychological disorder.

- **Dorsolateral cortex**
  - This area does not seem to have many motor symptoms beyond tonic posturing or clonic movements. Contralateral or less commonly ipsilateral head turn and eye deviation are commonly associated with this area as well.

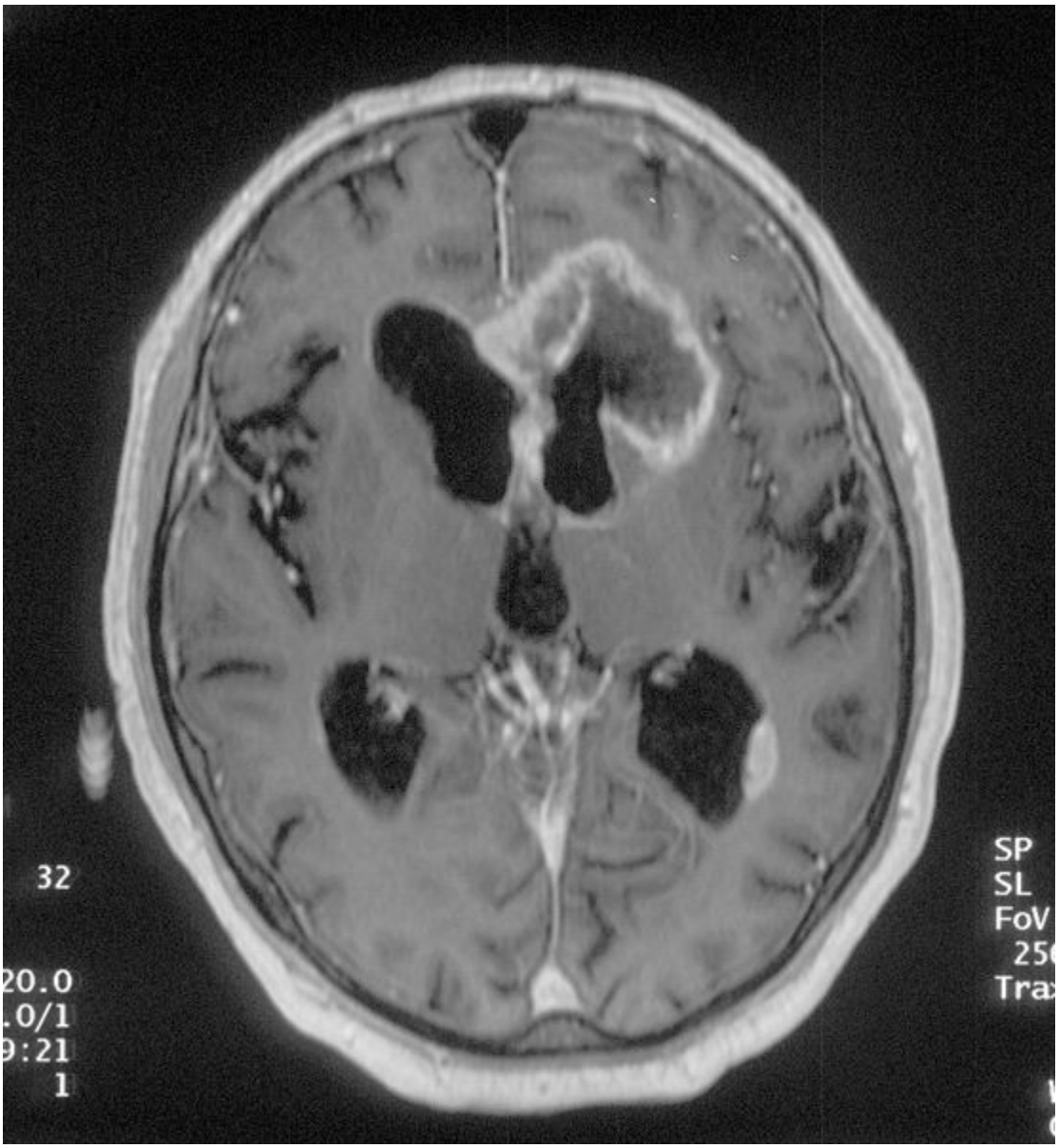
- **Operculum**
  - Many of the symptoms associated with this area involve the head and digestive tract: swallowing, salivation, mastication and possibly gustatory hallucinations. Preceding the seizure the person is fearful and often has an epigastric aura. There is not much physical movement except clonic facial movements. Speech is often arrested.

Common Misdiagnoses

Episodes that include complex hyperactivity of the proximal portions of the limbs that lead to increased overall motor activity are called hypermotor seizures. When associated with bizarre movements and vocalizations these seizures are often misdiagnosed as pseudoseizures or other episodic movement disorders such as psychogenic movement disorders, familial paroxysmal dystonic choreoathetosis, paroxysmal kinesogenic choreoathetosis, or episodic ataxia type 1. Hypermotor seizure in children are often confused with pavor nocturnus (night terrors). Paroxysmal nocturnal dystonia or hypnogenic paroxysmal dystonia are other names given to describe FLE symptoms but are simply just FLE.

Autosomal Dominant Nocturnal Frontal Lobe Epilepsy (ADNFLE) is the best understood form of frontal lobe epilepsy but is often misdiagnosed as sleep apnea. Both disorders are characterized by awakening during the night which leads to daytime sleepiness. Some symptoms of sleep apnea overlap with those of ADNFLE, such as sudden awakening accompanied by a feeling of choking and on occasion motor activity which makes diagnosis difficult based on symptoms alone. Video surveillance as well as EEG is occasionally needed to differentiate between the two disorders. It has been reported that sleep apnea might be associated with epilepsy which would account for some of the misdiagnoses.

Causes



An MRI image of a brain with an invasive, multilocular tumor in the left Frontal lobe of the brain

The origins of frontal lobe seizures range from tumors to head trauma to genetics. Tumors account for about one third of all frontal lobe epilepsy cases. Low-grade tumors such as gangliogliomas, low-grade gliomas, and epidermoid tumors are most common, but many high-grade tumors were most likely once involved with seizures. Other lesions on the frontal lobe such as hamartomas and nodular heterotopias can cause frontal lobe symptoms as well. Birth defects such as vascular malformation are known to cause seizures, especially arteriovenous malformations and cavernous angiomas. Head trauma frequently causes damage to the frontal lobe and can cause seizures directly or indirectly through gliosis. Seizures originating directly from head trauma usually occur within a few months, but occasionally they can take years to manifest. On occasion encephalitis can cause frontal lobe seizures but it is most often associated with temporal lobe affliction. The main genetic cause of frontal lobe epilepsy is an autosomal dominant disease called Autosomal Dominant Nocturnal Frontal Lobe Epilepsy, which involves mutations in 2 nicotinic acetylcholine receptor genes. A genetic mutation on chromosome 22 has also been associated with another genetic form of the disorder.

Frequency

Epilepsy is a relatively common disorder, affecting between 0.5-1% of the population, and frontal lobe epilepsy accounts for about 1-2% of all epilepsies. The most common subdivision of epilepsy is symptomatic partial epilepsy, which causes simple partial seizures, and can be further divided into temporal and frontal lobe epilepsy. Although the exact number of cases of frontal lobe epilepsy is not currently known, it is known that FLE is the less common type of partial epilepsy, accounting for 20-30% of operative procedures involving intractable epilepsy. The disorder also has no gender or age bias, affecting males and females of all ages. In a recent study, the mean subject age with frontal lobe epilepsy was 28.5 years old, and the average age of epilepsy onset for left frontal epilepsy was 9.3 years old whereas for right frontal epilepsy it was 11.1 years old.

Social Impacts and Quality of Life

Epilepsy has a substantial impact on the quality of life of the individuals that are afflicted with it. Physicians and researchers are coming to understand that the impact on the quality of life of the patient is as important as the effects of the seizures. Quality of life questionnaires and other assessment tools have been created to help quantify quality of life for individual patients. They consider such factors as physical health (including numbers and severity of seizures, medication side effects etc.), mental health, social relationships, lifestyle, role activities and life fulfillment. A Center for Disease Control study reported that seizure sufferers were more likely to have lower education levels, higher unemployment, higher levels of pain, hypersomnia/insomnia, increased psychological distress and social isolation/connection issues. Some of the issues which impact quality of life for epileptics are: ability to drive and travel, the ability to date, marry and have children, the ability to have a job and independence, the ability to have an education and learn, and the ability to have good health and mental functioning. Future research is needed to find ways to not only control frontal lobe seizures, but to also address the specific quality of life issues that plague those with frontal lobe epilepsy.

- **Driving and Transportation Restrictions**
  - Driving and travel restrictions are one of the greatest limitations that epileptic patients experience. Laws restricting driving privileges vary greatly in the United States as well as across the world. In the United States, 28 states require a patient to be seizure free for fixed periods of time ranging from 3–12 months. However, research done by Johns Hopkins University showed that there was no difference in seizure related fatal crash rates in states with 3 month restrictions versus states with 6-12 month seizure free restrictions. In 23 states, the restrictions and seizure free periods vary depending on the type of epilepsy and the individual case and in 13 states physicians were responsible for determining whether their patients should be allowed to drive. In 6 of those 13 states physicians could be held legally liable for their decisions regarding their epileptic patients' driving capabilities. In many states, patients can also be legally liable for accidents, injury, damage and death caused by seizure related accidents.
  - One of the major arguments in favor of restricting the licensing of epileptic drivers is the concern for public safety. However, the Johns Hopkins study showed that in a particular 2 year timeframe only .2% of fatal crashes occurred as a result of seizures. Alcohol related crash fatalities caused 156 times more driver deaths than seizure related crashes and young drivers between the ages of 16 and 24 were 123 times more likely to die in a fatal crash caused by their inexperience than an epileptic driver was to die in a crash that resulted from a seizure.
  - Frontal lobe epileptic seizures unlike other epileptic seizures create symptoms that are as dangerous as loss of consciousness and much more difficult to discern from other problems such as drug and alcohol abuse, psychiatric disorders and disobedience. Jerking movements/lack of motor control, pedaling, pelvic thrusting, lapses in cognitive functioning and other hallmark symptoms of frontal lobe epileptic seizures all create dangerous behavior behind the wheel. Studies have not been done to date to determine the differential risk posed by drivers with frontal lobe epilepsy relative to the general epileptic population.

- **Hormones & Pregnancy Issues**
  - Hormonal changes and pregnancy can shift seizure activity and the use of antiepileptic drugs can alter the efficacy of hormones as well as cause congenital malformations in fetuses. Seizure control in pregnant women is very important to the welfare of both the developing fetus and the mother. Hormonal shifts at puberty, with birth control and at menopause can also cause changes in the frequency and severity of seizures and must be closely monitored. Increased seizure activity is reported by 50% of women during the course of the pregnancy due to changing levels of hormones, fluids, salts and absorption and elimination of medications.

- **Employment**
  - A report by the Epilepsy Foundation noted that the unemployment rate amongst epileptics is 25% and in patients whose seizures are poorly controlled the rate jumps to 50%. Even though epileptics are protected under The Americans with Disabilities Act, employment discrimination and high rates of unemployment due to employer attitudes still exist. A study in the UK showed that 16% of employers surveyed felt there were no jobs in their company suitable for epileptics and that 21% felt that employing an epileptic would be a "major issue". Fifty percent of the employers said they had a high concern regarding employing epileptics with most citing safety concerns/workplace accidents as their major issue. Patients with frontal lobe epilepsy may be particularly prone to being discriminated against in employment and subject to higher rates of termination due to the unusual motor symptoms, speech, vocal outbursts and cognitive/judgment symptoms displayed during frontal lobe seizures. Frontal lobe seizures also tend to come on suddenly and progress rapidly making it difficult for an employer to control the exposure of the seizure to others.

- **Education/Learning & Cognitive Function**
  - Patients with frontal lobe epilepsy will likely also experience issues with learning and education. Many factors contribute to these issues including the impact of anticonvulsant medications. Anticonvulsant medications cause patients to feel "foggy" and sluggish. Drugs such as Topiramate cause problems such as mental blunting, word retrieval difficulties and irritability. Phenobarbital, Primidone and Vigabatrin can cause depression and suicidal tendencies. Stress and lack of sleep during exam periods can trigger seizures and many school sports teams restrict or ban epileptics from sports for safety and liability reasons. Frontal lobe epilepsy sufferers also exhibit dysfunctional cognitive skills and memory issues which can make learning challenging. Research has shown that frontal lobe epilepsy has a greater negative impact than other forms of epilepsy on cognitive functioning. Frontal lobe epileptics show decreased cognitive capabilities in the following areas: humor appreciation, recognition of emotional expressions, response selection/initiation and inhibition, hyperactivity, conscientiousness, obsession, addictive behavior, motor coordination and planning, attention span, performance speed, continuous performance without intrusion and interference errors, copying and recall, concept formation, anticipatory behavior, memory span, working memory, executive planning, visuo-spatial organization, mental flexibility, conceptual shift, problem solving, programming of complex motor sequences, impulse control, judgment and forecasting of consequences.

- **Physical Health & Risk Of Other Conditions**
  - Patients with epilepsy face a greater risk of accidents, injury and other medical conditions than the general population. A European study showed

that epileptics were at greater risk for accidental injuries related to seizures such as concussions, abrasions and wounds and reported more hospitalizations and medical action than the general population. Other studies have shown that epileptics are at a greater risk of seizure related drowning, suffocation, broken bones and burns and more likely to die in a fatal automobile crash.
    - Epilepsy Ontario reports that epileptics are also more likely to have other conditions than the general population such as: 30% of autistic children have epilepsy, 33% of cerebral palsy patients have epilepsy, 15-20% of fragile X syndrome patients have epilepsy, 50% of children with learning disabilities will have some form of epilepsy, 3-10% of patients with Lennox-Gastaut syndrome will have epilepsy, 80% of children with Rett syndrome will have epilepsy and 80% of patients with Tuberous Sclerosis will have epilepsy.

- **Mental/Emotional Health**
    - Epileptic patients are more prone to suffer psychological and social dysfunction than individuals that do not have epilepsy. They report higher levels of anxiety and stress due to social isolation, discrimination, the unpredictability of their seizures and people's reactions to them as well as fear of injury, death and brain damage from their seizures. Anticonvulsants can also result in lower functioning, depression, sluggishness and suicidal thoughts. Approximately 20% of epileptics are depressed and the rate of suicide amongst epileptics is 5 times the rate in the general population.
    - Frontal lobe epileptics experience more significant social effects because the manifested symptoms are more unusual. Symptoms such as screaming, bicycling limbs, pelvic thrusting, inhibition control and other outbursts can be particularly embarrassing and isolating for the patient.

Treatments

There are several different ways to treat frontal lobe epileptic seizures, however, the most common form of treatment is through the use of anticonvulsant medications that help to prevent seizures from occurring. In some cases, however, when medications are ineffective, a neurologist may choose to operate on the patient in order to remove the focal area of the brain in which the seizures are occurring. Other treatments that can be administered to aid in reducing the occurrence of seizures include the implementation of a specific, regimented diet and/or the implantation of a **vagus nerve stimulator**.

Medications

Anticonvulsants are the most successful medication in reducing and preventing seizures from reoccurring. The goal of these medications in being able to reduce the reoccurrence of seizures is to be able to limit the amount of rapid and extensive firing of neurons so that a focal region of neurons cannot become over-activated thereby initiating a seizure.

Although anticonvulsants are able to reduce the amount of seizures that occur in the brain, no medication has been discovered to date that is able to prevent the development of epilepsy following a head injury. There are a wide range of anticonvulsants that have both different modes of action and different abilities in preventing certain types of seizures. Some of the anticonvulsants that are prescribed to patients today include: Carbamazepine (Tegretol), Phenytoin (Dilantin Kapseals), Gabapentin (Neurontin), Levetiracetam (Keppra), Lamotrigine (Lamictal), Topiramate (Topamax), Tiagabine (Gabitril), Zonisamide (Zonegran) and Pregabalin (Lyrica).

Chemical Pathways for Anticonvulsants

Anticonvulsant medications can affect one or more ion channel pathways depending on the type of seizure. They typically affect GABA, sodium channels, calcium channels, glutamate, or a combination of these. One mechanism involves the increased release of GABA or the inhibition of its metabolism so that it is present in the synapse for longer periods of time. This is effective for generalized or focal seizures, and is the mechanism of medications such as valproate and gabapentin. Sodium channels are typically targeted for the prevention of focal seizures. This is accomplished by lengthening the refractory period, during which the channels are inactive, and as such eliminating the ability of the neuron to fire rapidly in succession. Medications that affect this pathway include Carbamazepine and Lamotrigine. Calcium channels can be blocked according to their subunits, specifically targeting T-calcium channels. Ethosuximide works in this manner, and it is effective against absence seizures. The final pathway involves blocking excitatory glutamate receptor, namely AMPA and NMDA. This effectively decreases the probability that a presynaptic action potential will produce an action potential in the postsynaptic neuron. Drugs utilizing this mechanism are effective, but no drug currently in use acts solely on this pathway. Some examples include diazepam and valproate.

Surgical Treatment

When both the amount and severity of seizures becomes uncontrollable and seizures remain resistant to the various anticonvulsants, a patient most likely will be considered for a **frontal lobectomy**. This procedure involves the removal of focal regions of the frontal lobes that have been identified as being problematic for the patient. It has been found that around 30% to 50% of patients that undergo a frontal lobectomy will forever be free from seizures that cause a loss of consciousness or cause abnormal movements.

If on the other hand, the seizures occur in an area that is too vital to remove (such as areas that control motor, sensory or language functions), then the surgeon will perform a procedure known as a **multiple subpial transection**. This procedure involves making a series of cuts that surround the focal region where the seizures have originated. By making cuts surrounding the focal region, the surgeon is able to isolate that specific section of the brain and prevent electrical impulses from being able to travel horizontally to other areas of the brain.

The last surgical procedure that can be done to help prevent the reoccurrence of seizures in the frontal lobes is to implant a stimulator on the vagus nerve. This device is a self-activating device that is inserted directly under the skin and can be controlled directly by the patient. When a patient is feeling the onset of an aura, he/she can activate the stimulator which in turn will provide stimulation to the left vagus nerve (the left vagus nerve is used because the right nerve plays a role in cardiac function). Although little is understood about the exact mechanism for vagal nerve stimulation, it has been proven to be a successful treatment that can often terminate seizures before they begin.

Diet

The use of a regimented diet is an approach that has been found to help control seizures in children with severe, medically-intractable frontal lobe epilepsy. Although the use of dieting to prevent seizures from occurring is a lost treatment that has been replaced by the use of new types of anticonvulsants, it is still recommended to patients to this day. A ketogenic diet is a high-fat, low-carbohydrate based diet that patients are typically asked to follow in conjunction with their anticonvulsant medications. This diet was designed in order to mimic many of the effects that starvation has on the metabolic functioning of the body. By limiting the amount of carbohydrates and increasing the amount of exogenous fats available to the metabolism, the body will create an excess of water-soluble compounds known as ketone bodies. Although the mechanism of action is still unknown, it is believed that these excessive amounts of ketone bodies become the brain's main source of energy and in turn are able to suppress the frequencty of seizure occurrence.

Importance of Neuroimaging

Once anticonvulsant medications prove to be no longer effective and a patient is selected to undergo resective epilepsy surgery, the doctors must begin the surgical process by first identifying the epileptogenic zone. The removal of the epileptogenic zone, the area of brain tissue that is responsible for the generation of seizures, can lead to a reduction or freedom in the amount of seizures. One of the major concerns for surgeons before they operate on patients that have intractable epilepsis is to not only be able to pinpoint the epileptogenic zone that is to be removed but to also map out the localized regions surrounding the focal area that are associated with somatosensory, cognitive and motor functions. Through the use of neuroimaging devices such as fMRIs, PET scans and SPECT scans doctors are now able to identify the exact positions of the lesions causing the seizures and can map out the sensorimotor, language, visual and memory functional locations in the frontal lobes of the brain prior to the resective surgery. Therefore structural and functional neuroimaging techniques help to fulfill two major goals: localiztion of the epileptogenic zone and the determination of the etiology producing the seizure. Prior to the invention of neuroimaging techniques, surgeries to eliminate frontal lobe seizures from occurring were very rare and not very successful. However the ability to localize the epiletogenic zone and the specific etiology for the seizures has made frontal lobe resective surgery just as successful as that for temporal lobe resective surgery.

Resective Surgery using Gamma-Knife Radiosurgery

Over the past decade or so, researchers have been attempting to discover less invasive, safer and more efficient technologies that enable surgeons to remove epileptogenic focal zones without causing any damage to neighboring cortical areas. One such technology that has emerged and has great promise, is the use of gamma knife radiosurgery to either excise a brain tumor or repair a vascular malformation.

In Gamma Knife radiosurgery, intersecting gamma radiation beams are applied directly to the tumor site or vascular malformation site that had been established using neuroimaging. Although each beam itself is not strong enough to damage brain tissue, when the beams interesect they are strong enough to destroy the specific brain tissue that is to be excised. This process is extremely efficient and entirely non-invasive and is therefore much safer than actual neurosurgery itself.

Recently researchers and surgeons alike have begun to use Gamma Knife radiosurgery to treat cases of epilepsy by removing tumors responsible for causing the seizures. The early success rates in being able to alleviate seizures seem to be similar to those of temporal resective surgery however Gamma Knife radiosurgery has less associated risk factors. Current research on this topic is aimed at improving the technique in order to increase success rates as well as developing non-invasive forms of physiologic monitoring in order to determine the epileptogenic focus conclusively.

Chapter 6

Auditory Processing Disorder

Auditory processing disorder	
ICD-9	315.32, 388.45
MeSH	D001308

Auditory Processing Disorder (APD), also known as **(Central) Auditory Processing Disorder** ((C)APD) is an umbrella term for a variety of disorders that affect the way the brain processes auditory information. It is not a sensory (inner ear) hearing impairment; individuals with APD usually have normal peripheral hearing ability. However, they cannot process the information they hear in the same way as others do, which leads to difficulties in recognizing and interpreting sounds, especially the sounds composing speech.

APD can affect both children and adults. Approximately 2-3% of children and 17-20% of adults have this disorder. Males are two times more likely to be affected by the disorder than females.

Definitions

The American Speech-Language-Hearing Association (ASHA) published "(Central) Auditory Processing Disorders" in January 2005 as an update to the "Central Auditory Processing: Current Status of Research and Implications for Clinical Practice (ASHA, 1996)", complementing the UK's Medical Research Council's.

Auditory processing disorder can be genetic or acquired. It may result from ear infections, head injuries or developmental delays that cause central nervous system difficulties that affect processing of auditory information. This can include problems with: "...sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal integration, temporal discrimination (e.g., temporal gap detection), temporal ordering, and temporal masking; auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals."

The Committee of UK Medical Professionals Steering the UK Auditory Processing Disorder Research Program have developed the following working definition of Auditory Processing Disorder:

"APD results from impaired neural function and is characterized by poor recognition, discrimination, separation, grouping, localization, or ordering of non-speech sounds. It does not solely result from a deficit in general attention, language or other cognitive processes."

Diagnosis

As APD is one of the more difficult information processing disorders to detect and diagnose, it may sometimes be misdiagnosed as ADD/ADHD, Asperger syndrome and other forms of autism, but it may also be a comorbid aspect of those conditions if it is considered a significant part of the overall diagnostic picture. APD shares common symptoms in areas of overlap, such that professionals unfamiliar with APD might misdiagnose it as a condition they are aware of.

People with APD intermittently experience an inability to process verbal information. When people with APD have a processing failure, they do not process what is being said to them.

There are also many other hidden implications, which are not always apparent even to the person with the disability. For example, because people with APD are used to guessing to fill in the processing gaps, they may not even be aware that they have misunderstood something.

APD has been defined anatomically in terms of the integrity of the auditory nervous system, as "what we do with what we hear", and in terms of performances on a selected group of behavioral auditory tests (Task Force for the American Speech, Language, and Hearing Association; ASHA, 1994). The ASHA Task Force definition considered APD to be any observed deficits in one or more of these so-called "behaviors". Problems inherent in test validation by consensus are highlighted by the succession of task force reports that have appeared in recent years. The first of these occurred in 1996. This was followed by a conference organized by the American Academy of Audiology that explicitly embraced modality specificity as a defining characteristic of auditory processing disorders. Subsequently, an ASHA committee rejected modality specificity as a defining characteristic of auditory processing disorders.

There have been several commentaries questioning various aspects of these proposals. Additionally, Moore suggests that APD is primarily a difficulty in processing non-speech sounds and that a population-based approach should be taken to identify outlying performers. However, inclusive conceptualizations of APD have been criticized based on their lack of diagnostic specificity. Auditory processing disorder has been defined as a modality specific perceptual dysfunction that is not due to peripheral hearing loss. This viewpoint emphasizes the perceptual nature of auditory processing and asserts that the

disorder should be conceptualized as being limited to problems in processing auditory material. Modality specificity has been advocated as a way to improve APD diagnosis. There are several limitations to the approach suggested by proponents of modality specificity testing, including: major differences between primary auditory and visual cortices in the way information is coded and processed, how such approaches would separate children with both visual and auditory processing deficits from children with supramodal deficits, cross modal test equivalence, clinical infeasibility of visual processing test administration, lack of appropriate visual analogs to be used by audiologists, redundancy of modality specificity testing with neuropsychological assessment, and non-modularity of the central nervous system, among others.

Causes

The causes of APD are unknown. There is anecdotal evidence to suggest links to autistic spectrum disorder, dyslexia, middle ear infections and lack of oxygen at birth, as well as occurring in association with aniridia, (due to a PAX6 mutation) among other conditions.

Characteristics

The National Institute on Deafness and Other Communication Disorders is the author of "Auditory Processing Disorder in Children". Facilities, such as The Lewis School of Princeton, have specialists that can assist in determining the presence of this disorder. They state that children with Auditory Processing Disorder often:

- have trouble paying attention to and remembering information presented orally, and may cope better with visually acquired information
- have problems carrying out multi-step directions given orally; need to hear only one direction at a time
- have poor listening skills
- need more time to process information
- have low academic performance
- have behavior problems
- have language difficulties (e.g., they confuse syllable sequences and have problems developing vocabulary and understanding language)
- have difficulty with reading, comprehension, spelling, and vocabulary

Other characteristics may include:

- needing people to speak slowly
- disliking locations with background noise such as bar, clubs or other social locations
- a preference for written communication (e.g. text chat)
- having trouble paying attention and remembering information when information is simultaneously presented in multiple modalities

APD can manifest as problems determining the direction of sounds, difficulty perceiving differences between speech sounds and the sequencing of these sounds into meaningful words, confusing similar sounds such as "hat" with "bat", "there" with "where", etc. Fewer words may be perceived than were actually said, as there can be problems detecting the gaps between words, creating the sense that someone is speaking unfamiliar or nonsense words. Those suffering from APD may have problems relating what has been said with its meaning, despite obvious recognition that a word has been said, as well as repetition of the word. Background noise, such as the sound of a radio, television or a noisy bar can make it difficult to impossible to understand speech, depending on the severity of the auditory processing disorder. Using a telephone can be problematic for someone with auditory processing disorder, in comparison with someone with normal auditory processing, due to low quality audio, poor signal, intermittent sounds and the chopping of words. Many who have auditory processing disorder subconsciously develop visual coping strategies, such as lip reading, reading body language, and eye contact, to compensate for their auditory deficit, and these coping strategies are not available when using a telephone.

Secondary characteristics

Those who have APD tend to be quiet or shy, even withdrawn from mainstream society due to their communication problems, and the lack of understanding of these problems by their peers.

One who fails to process any part of the communication of others may be unable to comprehend what is being communicated. This has some obvious social and educational implication, which can cause a lack of understanding from others. In adults this can lead to persistent interpersonal relationship problems.

APD shares some of these signs with related disorders, which may have other overlap areas, such as acquired brain injury, attention deficits, dyslexia, learning difficulties, hearing loss, and psychologically-based behavioral problems.

APD may be related to cluttering, a fluency disorder marked by word and phrase repetitions.

Remediations and training

Recent research has shown that practice with basic auditory processing tasks (i.e. auditory training) may improve performance on auditory processing measures and phonemic awareness measures (Moore et al., 2005). These auditory training benefits have also been recorded at the physiological level (Russo et al., 2005; Alonso & Schochat, 2009). Many of these tasks are incorporated into computer based auditory training programs such as Earobics and Fast Foreword.

There is no research supporting the following APD treatments:

- Auditory Integration Training typically involves a child attending two 30-minute sessions per day for ten days.
- Lindamood-Bell Learning Processes (particularly, the Visualizing and Verbalizing program)
- Physical activities that require frequent crossing of the midline (e.g., occupational therapy)
- Sound Field Amplification

Relation to Specific language impairment

APD can also be confused with Specific language impairment (SLI).

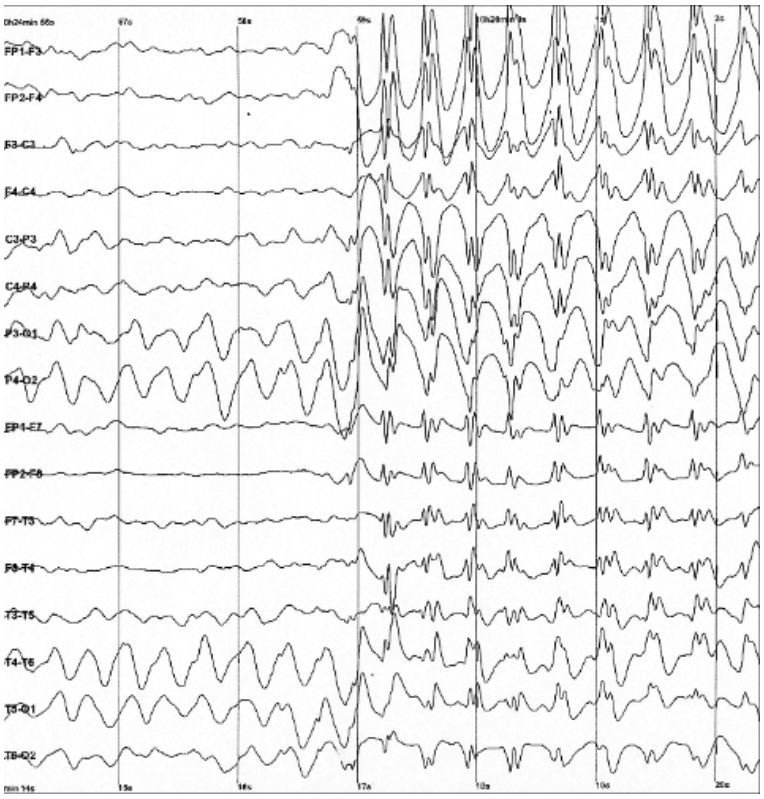
SLI is more specifically a problem associated with the linking of words, both written and spoken, to semantics (meaning) and someone can have both APD and SLI. Unlike those with SLI, those with APD can usually get the meaning of language from written words where those with SLI show problems with both heard and read words, demonstrating that the basic issue is not an auditory one.

Those with APD have auditory difficulty distinguishing sounds including speech from extraneous sounds, e.g. fans or other chatter. APD is purely about processing what you hear both verbal and non-verbal. For those who have SLI, difficulty processing verbal language is only one of many symptoms.

Chapter 7

Epilepsy

Epilepsy



Generalized 3 Hz spike and wave discharges in EEG

ICD-10	G40.-G41.
ICD-9	345
DiseasesDB	4366
MedlinePlus	000694
eMedicine	neuro/415
MeSH	D004827

Epilepsy (from the Ancient Greek ἐπιληψία (*epilēpsía*) — "to seize") is a common chronic neurological disorder characterized by seizures. These seizures are transient signs and/or symptoms of abnormal, excessive or synchronous neuronal activity in the brain. About 50 million people worldwide have epilepsy, with almost 90% of these people being in developing countries. Epilepsy is more likely to occur in young children, or people over the age of 65 years; however, it can occur at any time. As a consequence of brain surgery, epileptic seizures may occur in recovering patients.

Epilepsy is usually controlled, but cannot be cured with medication, although surgery may be considered in difficult cases. However, over 30% of people with epilepsy do not have seizure control even with the best available medications. Not all epilepsy syndromes are lifelong – some forms are confined to particular stages of childhood. Epilepsy should not be understood as a single disorder, but rather as syndromic with vastly divergent symptoms but all involving episodic abnormal electrical activity in the brain.

Classification

Epilepsies are classified in five ways:

1. By their first cause (or etiology).
2. By the observable manifestations of the seizures, known as semiology.
3. By the location in the brain where the seizures originate.
4. As a part of discrete, identifiable medical syndromes.
5. By the event that triggers the seizures, as in primary reading epilepsy or musicogenic epilepsy.

In 1981, the International League Against Epilepsy (ILAE) proposed a classification scheme for individual seizures that remains in common use. This classification is based on observation (clinical and EEG) rather than the underlying pathophysiology or anatomy and is outlined later on in this article. In 1989, the ILAE proposed a classification scheme for epilepsies and epileptic syndromes. This can be broadly described as a two-axis scheme having the cause on one axis and the extent of localization within the brain on the other. Since 1997, the ILAE have been working on a new scheme that has five axes:

1. ictal phenomenon, (pertaining to an epileptic seizure)

2. seizure type,

3. syndrome,

4. etiology,

5. impairment.

Seizure types

Seizure types are organized firstly according to whether the source of the seizure within the brain is localized (*partial* or *focal* onset seizures) or distributed (*generalized* seizures). Partial seizures are further divided on the extent to which consciousness is affected. If it is unaffected, then it is a *simple partial* seizure; otherwise it is a *complex partial* (psychomotor) seizure. A partial seizure may spread within the brain - a process known as *secondary generalization*. Generalized seizures are divided according to the effect on the body but all involve loss of consciousness. These include absence (petit mal), myoclonic, clonic, tonic, tonic-clonic (grand mal), and atonic seizures.

Children may exhibit behaviors that are easily mistaken for epileptic seizures but are not caused by epilepsy. These include:

- Inattentive staring
- Benign shudders (among children younger than age 2, usually when they are tired or excited)
- Self-gratification behaviors (nodding, rocking, head banging)
- Conversion disorder (flailing and jerking of the head, often in response to severe personal stress such as physical abuse)

Conversion disorder can be distinguished from epilepsy because the episodes never occur during sleep and do not involve incontinence or self-injury.

Epilepsy syndromes

There are over 40 different types of epilepsy, including: Absence seizures, atonic seizures, benign Rolandic epilepsy, childhood absence, clonic seizures, complex partial seizures, frontal lobe epilepsy, febrile seizures, infantile spasms, juvenile myoclonic epilepsy, juvenile absence epilepsy, hot water epilepsy, Lennox-Gastaut syndrome, Landau-Kleffner syndrome, myoclonic seizures, mitochondrial disorders, progressive myoclonic epilepsy, psychogenic seizures, reflex epilepsy, Rasmussen's syndrome, simple partial seizures, secondarily generalized seizures, temporal lobe epilepsy, tonic-clonic seizures, tonic seizures, psychomotor seizures, limbic epilepsy, partial-onset seizures, Rett syndrome, generalized-onset seizures, status epilepticus, abdominal epilepsy, akinetic seizures, autonomic seizures, massive bilateral myoclonus, catamenial epilepsy, drop seizures, emotional seizures, focal seizures, gelastic seizures, Jacksonian seizure disorder, Lafora disease, motor seizures, multifocal seizures, neonatal seizures, nocturnal seizures, photosensitive epilepsy, pseudoseizures, sensory seizures, subtle seizures, Sylvan seizures, withdrawal seizures and visual reflex seizures, among others.

Each type of epilepsy presents with its own unique combination of seizure type, typical age of onset, EEG findings, treatment, and prognosis. The most widespread classification of the epilepsies divides epilepsy syndromes by location or distribution of seizures (as revealed by the appearance of the seizures and by EEG) and by cause. Syndromes are

divided into localization-related epilepsies, generalized epilepsies, or epilepsies of unknown localization.

Localization-related epilepsies, sometimes termed partial or focal epilepsies, arise from an epileptic focus, a small portion of the brain that serves as the irritant driving the epileptic response. Generalized epilepsies, in contrast, arise from many independent foci (multifocal epilepsies) or from epileptic circuits that involve the whole brain. Epilepsies of unknown localization remain unclear as to whether they arise from a portion of the brain or from more widespread circuits.

Epilepsy syndromes are further divided by presumptive cause: idiopathic, symptomatic, and cryptogenic. In general, idiopathic epilepsies are thought to arise from genetic abnormalities that lead to alteration of basic neuronal regulation. Symptomatic epilepsies arise from the effects of an epileptic lesion, whether that lesion is focal, such as a tumor, or a defect in metabolism causing widespread injury to the brain. Cryptogenic epilepsies involve a presumptive lesion that is otherwise difficult or impossible to uncover during evaluation.

The genetic component to epilepsy is receiving particular interest from the scientific community. Conditions such as ring chromosome 20 syndrome (r(20)) are gaining acknowledgment, and although only 60 cases have been reported in the literature since 1976, "more widespread cytogenetic chromosomal karyotyping in nonetiological cases of epilepsy" is likely.

Some epileptic syndromes are difficult to fit within this classification scheme and fall in the unknown localization/etiology category. People having had only a single seizure, or those with seizures that occur only after specific precipitants ("provoked seizures"), have "epilepsies" that fall into this category. Febrile convulsions are an example of seizures bound to a particular precipitant. Landau-Kleffner syndrome is another epilepsy that, because of its variety of EEG distributions, falls uneasily in clear categories. What can be even more confusing is that certain syndromes, such as West syndrome, featuring seizures such as infantile spasms, can be classified as idiopathic, syndromic, or cryptogenic depending on cause and can arise from both focal or generalized epileptic lesions.

Below are some common seizure syndromes:

- **Autosomal dominant nocturnal frontal lobe epilepsy** (ADNFLE) is an idiopathic localization-related epilepsy that is an inherited epileptic disorder that causes seizures during sleep. Onset is usually in childhood. These seizures arise from the frontal lobes and consist of complex motor movements, such as hand clenching, arm raising/lowering, and knee bending. Vocalizations such as shouting, moaning, or crying are also common. ADNFLE is often misdiagnosed as nightmares. ADNFLE has a genetic basis. These genes encode various nicotinic acetylcholine receptors.

- **Benign centrotemporal lobe epilepsy of childhood** or benign Rolandic epilepsy is an idiopathic localization-related epilepsy that occurs in children between the ages of 3 and 13 years, with peak onset in prepubertal late childhood. Apart from their seizure disorder, these patients are otherwise normal. This syndrome features simple partial seizures that involve facial muscles and frequently cause drooling. Although most episodes are brief, seizures sometimes spread and generalize. Seizures are typically nocturnal and confined to sleep. The EEG may demonstrate spike discharges that occur over the centrotemporal scalp over the central sulcus of the brain (the Rolandic sulcus) that are predisposed to occur during drowsiness or light sleep. Seizures cease near puberty. Seizures may require anticonvulsant treatment, but sometimes are infrequent enough to allow physicians to defer treatment.

- **Benign occipital epilepsy of childhood** (BOEC) is an idiopathic localization-related epilepsy and consists of an evolving group of syndromes. Most authorities include two subtypes, an early subtype with onset between three and five years, and a late onset between seven and 10 years. Seizures in BOEC usually feature visual symptoms such as scotoma or fortifications (brightly colored spots or lines) or amaurosis (blindness or impairment of vision). Convulsions involving one half the body, hemiconvulsions, or forced eye deviation or head turning are common. Younger patients typically experience symptoms similar to migraine with nausea and headache, and older patients typically complain of more visual symptoms. The EEG in BOEC shows spikes recorded from the occipital (back of head) regions. The EEG and genetic pattern suggest an autosomal dominant transmission as described by Ruben Kuzniecky, et al. Lately, a group of epilepsies termed Panayiotopoulos syndrome that share some clinical features of BOEC but have a wider variety of EEG findings are classified by some as BOEC.

- **Catamenial epilepsy** (CE) is when seizures cluster around certain phases of a woman's menstrual cycle.

- **Childhood absence epilepsy** (CAE) is an idiopathic generalized epilepsy that affects children between the ages of four and 12 years of age, although peak onset is around five to six years old. These patients have recurrent absence seizures, brief episodes of unresponsive staring, sometimes with minor motor features such as eye blinking or subtle chewing. The EEG finding in CAE is generalized 3 Hz spike and wave discharges. Some go on to develop generalized tonic-clonic seizures. This condition carries a good prognosis because children do not usually show cognitive decline or neurological deficits, and the seizures in the majority cease spontaneously with onging maturation.

- **Dravet's syndrome**, previously known as severe myoclonic epilepsy of infancy (SMEI), is a neurodevelopmental disorder beginning in infancy and characterized by severe epilepsy that does not respond well to treatment. This syndrome was described by Charlotte Dravet, French psychiatrist and epileptologist (born July 14, 1936). Dravet described this syndrome while working at the Centre Saint Paul

at the University of Marseille. At Centre Saint Paul, one of her supervisors was Henri Gastaut, who described the Lennox-Gastaut syndrome. She described this condition in 1978 Estimates of the prevalence of this rare disorder have ranged from 1:20,000 to 1:40,000 births, though the incidence may be found to be greater as the syndrome becomes better recognized and new genetic evidence is discovered. It is thought to occur with similar frequency in both genders, and knows no geographic or ethnic boundaries.

The course of Dravet syndrome is highly variable from person to person. Seizures begin during the first year of life and development is normal prior to their onset. In most cases, the first seizures occur with fever and are generalized tonic-clonic (grand mal) or unilateral (one-sided) convulsions. These seizures are often prolonged, and may lead to status epilepticus, a medical emergency. In time, seizures increase in frequency and begin to occur without fever. Additional seizure types appear, most often these are myoclonic, atypical absence, and complex-partial seizures.
Additional features that are seen in significant numbers of patients with Dravet syndrome may include sensory integration disorders and other autism spectrum characteristics, orthopedic or movement disorders, frequent or chronic upper respiratory and ear infections, sleep disturbance, dysautonomia, and problems with growth and nutrition.

- **Frontal lobe epilepsy**, usually a symptomatic or cryptogenic localization-related epilepsy, arises from lesions causing seizures that occur in the frontal lobes of the brain. These epilepsies can be difficult to diagnose because the symptoms of seizures can easily be confused with nonepileptic spells and, because of limitations of the EEG, be difficult to "see" with standard scalp EEG.

- **Juvenile absence epilepsy** is an idiopathic generalized epilepsy with later onset than CAE, typically in prepubertal adolescence, with the most frequent seizure type being absence seizures. Generalized tonic-clonic seizures can occur. Often, 3 Hz spike-wave or multiple spike discharges can be seen on EEG. The prognosis is mixed, with some patients going on to a syndrome that is poorly distinguishable from JME.

- **Juvenile myoclonic epilepsy** (JME) is an idiopathic generalized epilepsy that occurs in patients aged 8 to 20 years. Patients have normal cognition and are otherwise neurologically intact. The most common seizures are myoclonic jerks, although generalized tonic-clonic seizures and absence seizures may occur as well. Myoclonic jerks usually cluster in the early morning after awakening. The EEG reveals generalized 4–6 Hz spike wave discharges or multiple spike discharges. Interestingly, these patients are often first diagnosed when they have their first generalized tonic-clonic seizure later in life, when they experience sleep deprivation (e.g., freshman year in college after staying up late to study for exams). Alcohol withdrawal can also be a major contributing factor in breakthrough seizures, as well. The risk of the tendency to have seizures is

lifelong; however, the majority have well-controlled seizures with anticonvulsant medication and avoidance of seizure precipitants.

- **Lennox-Gastaut syndrome** (LGS) is a generalized epilepsy that consists of a triad of developmental delay or childhood dementia, mixed generalized seizures, and EEG demonstrating a pattern of approximately 2 Hz "slow" spike-waves. Onset occurs between two and 18 years. As in West syndrome, LGS result from idiopathic, symptomatic, or cryptogenic causes, and many patients first have West syndrome. Authorities emphasize different seizure types as important in LGS, but most have astatic seizures (drop attacks), tonic seizures, tonic-clonic seizures, atypical absence seizures, and sometimes, complex partial seizures. Anticonvulsants are usually only partially successful in treatment.

- **Ohtahara syndrome** is a rare, but severe epilepsy syndrome usually starting in the first few days or weeks of life. The seizures are often in the form of stiffening spasms but other seizures including unilateral ones may be seen. The electroencephalogram (EEG) is characteristic. The prognosis is poor with about half of the infants dying in the first year of life; most if not all surviving infants are severely intellectually disabled and many have cerebral palsy. There is no effective treatment. A number of children have underlying structural brain abnormalities.
- **Primary reading epilepsy** is a reflex epilepsy classified as an idiopathic localization-related epilepsy. Reading in susceptible individuals triggers characteristic seizures.

- **Progressive myoclonic epilepsies** define a group of symptomatic generalized epilepsies characterized by progressive dementia and myoclonic seizures. Tonic-clonic seizures may occur as well. Diseases usually classified in this group are Unverricht-Lundborg disease, myoclonus epilepsy with ragged red fibers (MERRF syndrome), Lafora disease, neuronal ceroid lipofucinosis, and sialdosis.

- **Rasmussen's encephalitis** is a symptomatic localization-related epilepsy that is a progressive, inflammatory lesion affecting children with onset before the age of 10. Seizures start as separate simple partial or complex partial seizures and may progress to epilepsia partialis continua (simple partial status epilepticus). Neuroimaging shows inflammatory encephalitis on one side of the brain that may spread if not treated. Dementia and hemiparesis are other problems. The cause is hypothesized to involve an immulogical attack against glutamate receptors, a common neurotransmitter in the brain.

- **Symptomatic localization-related epilepsies** are divided by the location in the brain of the epileptic lesion, since the symptoms of the seizures are more closely tied to the brain location rather than the cause of the lesion. Tumors, atriovenous malformations, cavernous malformations, trauma, and cerebral infarcts can all be causes of epileptic foci in different brain regions.

- **Temporal lobe epilepsy** (TLE), a symptomatic localization-related epilepsy, is the most common epilepsy of adults who experience seizures poorly controlled with anticonvulsant medications. In most cases, the epileptogenic region is found in the midline (mesial) temporal structures (e.g., the hippocampus, amygdala, and parahippocampal gyrus). Seizures begin in late childhood and adolescence. Most of these patients have complex partial seizures sometimes preceded by an aura, and some TLE patients also suffer from secondary generalized tonic-clonic seizures. If the patient does not respond sufficiently to medical treatment, epilepsy surgery may be considered.

- **Tuberous Sclerosis** (TSC) is a genetic disorder that causes tumors to form in many different organs, primarily in the brain, eyes, heart, kidney, skin and lungs. Several types of brain lesions can occur in individuals with TSC and 60% - 90% of people with TSC develop epilepsy.

- **West syndrome** is a triad of developmental delay, seizures termed infantile spasms, and EEG demonstrating a pattern termed hypsarrhythmia. Onset occurs between three months and two years, with peak onset between eight and 9 months. West syndrome may arise from idiopathic, symptomatic, or cryptogenic causes. The most common cause is tuberous sclerosis. The prognosis varies with the underlying cause. In general, most surviving patients remain with significant cognitive impairment and continuing seizures and may evolve to another eponymic syndrome, Lennox-Gastaut syndrome.

Causes

The diagnosis of epilepsy usually requires that the seizures occur spontaneously. Nevertheless, certain epilepsy syndromes require particular precipitants or triggers for seizures to occur. These are termed reflex epilepsy. For example, patients with primary reading epilepsy have seizures triggered by reading. Photosensitive epilepsy can be limited to seizures triggered by flashing lights. Other precipitants can trigger an epileptic seizure in patients who otherwise would be susceptible to spontaneous seizures. For example, children with childhood absence epilepsy may be susceptible to hyperventilation. In fact, flashing lights and hyperventilation are activating procedures used in clinical EEG to help trigger seizures to aid diagnosis. Finally, other precipitants can facilitate, rather than obligately trigger, seizures in susceptible individuals. Emotional stress, sleep deprivation, sleep itself, heat stress, alcohol and febrile illness are examples of precipitants cited by patients with epilepsy. Notably, the influence of various precipitants varies with the epilepsy syndrome. Likewise, the menstrual cycle in women with epilepsy can influence patterns of seizure recurrence. Catamenial epilepsy is the term denoting seizures linked to the menstrual cycle.

There are different causes of epilepsy that are common in certain age groups.

- During the neonatal period and early infancy the most common causes include hypoxic-ischemic encephalopathy, CNS infections, trauma, congenital CNS abnormalities, and metabolic disorders.
- During late infancy and early childhood, febrile seizures are fairly common. These may be caused by many different things, some thought to be things such as CNS infections and trauma.
- During childhood, well-defined epilepsy syndromes are generally seen.
- During adolescence and adulthood, the causes are more likely to be secondary to any CNS lesion. Further, idiopathic epilepsy is less common. Other causes associated with these age groups are stress, trauma, CNS infections, brain tumors, illicit drug use and alcohol withdrawal.
- In older adults, cerebrovascular disease is a very common cause. Other causes are CNS tumors, head trauma, and other degenerative diseases that are common in the older age group, such as dementia.

Pathophysiology

Mutations in several genes have been linked to some types of epilepsy. Several genes that code for protein subunits of voltage-gated and ligand-gated ion channels have been associated with forms of generalized epilepsy and infantile seizure syndromes. Several ligand-gated ion channels have been linked to some types of frontal and generalized epilepsies. One speculated mechanism for some forms of inherited epilepsy are mutations of the genes that code for sodium channel proteins; these defective sodium channels stay open for too long, thus making the neuron hyper-excitable. Glutamate, an excitatory neurotransmitter, may, therefore, be released from these neurons in large amounts, which — by binding with nearby glutamatergic neurons — triggers excessive calcium (Ca^{2+}) release in these post-synaptic cells. Such excessive calcium release can be neurotoxic to the affected cell. The hippocampus, which contains a large volume of just such glutamanergic neurons (and NMDA receptors, which are permeable to Ca^{2+} entry after binding of both sodium and glutamate), is especially vulnerable to epileptic seizure, subsequent spread of excitation, and possible neuronal death. Another possible mechanism involves mutations leading to ineffective GABA (the brain's most common inhibitory neurotransmitter) action. Epilepsy-related mutations in some non-ion channel genes have also been identified.

Epileptogenesis is the process by which a normal brain develops epilepsy after trauma, such as a lesion on the brain. One interesting finding in animals is that repeated low-level electrical stimulation to some brain sites can lead to permanent increases in seizure susceptibility: in other words, a permanent decrease in seizure "threshold." This phenomenon, known as kindling (by analogy with the use of burning twigs to start a larger fire) was discovered by Dr. Graham Goddard in 1967. It is important to note that these "kindled" animals do not experience spontaneous seizures. Chemical stimulation can also induce seizures; repeated exposures to some pesticides have been shown to induce seizures in both humans and animals. One mechanism proposed for this is called excitotoxicity. The roles of kindling and excitotoxicity, if any, in human epilepsy are currently hotly debated.

Other causes of epilepsy are brain lesions, where there is scar tissue or another abnormal mass of tissue in an area of the brain.

The complexity of understanding what seizures are have led to considerable efforts to use computational models of epilepsy to both interpret experimental and clinical data, as well as guide strategies for therapy.

Management

Epilepsy is usually treated with medication prescribed by a physician; primary caregivers, neurologists, and neurosurgeons all frequently care for people with epilepsy. However, it has been stressed that accurate differentiation between generalized and partial seizures is especially important in determining the appropriate treatment. In some cases the implantation of a stimulator of the vagus nerve, or a special diet can be helpful. Neurosurgical operations for epilepsy can be palliative, reducing the frequency or severity of seizures; or, in some patients, an operation can be curative.

The proper initial response to a generalized tonic-clonic epileptic seizure is to prevent the person from self-injury by moving them away from sharp edges, placing something soft beneath the head, and rolling the person into the recovery position. Should the person regurgitate, this should be allowed to drip out the side of the person's mouth. If a seizure lasts longer than 5 minutes, or if more than one seizure occurs without regaining consciousness emergency medical services should be contacted.

Medications

The mainstay of treatment of epilepsy is anticonvulsant medications. Often, anticonvulsant medication treatment will be lifelong and can have major effects on quality of life. The choice among anticonvulsants and their effectiveness differs by epilepsy syndrome. Mechanisms, effectiveness for particular epilepsy syndromes, and side-effects differ among the individual anticonvulsant medications. Some general findings about the use of anticonvulsants are outlined below.

Availability - Currently there are 20 medications approved by the Food and Drug Administration for the use of treatment of epileptic seizures in the US: carbamazepine (common US brand name Tegretol), clorazepate (Tranxene), clonazepam (Klonopin), ethosuximide (Zarontin), felbamate (Felbatol), fosphenytoin (Cerebyx), gabapentin (Neurontin), lacosamide (Vimpat), lamotrigine (Lamictal), levetiracetam (Keppra), oxcarbazepine (Trileptal), phenobarbital (Luminal), phenytoin (Dilantin), pregabalin (Lyrica), primidone (Mysoline), tiagabine (Gabitril), topiramate (Topamax), valproate semisodium (Depakote), valproic acid (Depakene), and zonisamide (Zonegran). Most of these appeared after 1990.

Medications commonly available outside the US but still labelled as "investigational" within the US are clobazam (Frisium) and vigabatrin (Sabril). Medications currently

under clinical trial under the supervision of the FDA include retigabine, brivaracetam, and seletracetam.

Other drugs are commonly used to abort an active seizure or interrupt a seizure flurry; these include diazepam (Valium, Diastat) and lorazepam (Ativan). Drugs used only in the treatment of refractory status epilepticus include paraldehyde (Paral), midazolam (Versed), and pentobarbital (Nembutal).

Some anticonvulsant medications do not have primary FDA-approved uses in epilepsy but are used in limited trials, remain in rare use in difficult cases, have limited "grandfather" status, are bound to particular severe epilepsies, or are under current investigation. These include acetazolamide (Diamox), progesterone, adrenocorticotropic hormone (ACTH, Acthar), various corticotropic steroid hormones (prednisone), or bromide.

Effectiveness - The definition of "effective" varies. FDA approval usually requires that 50% of the patient treatment group had at least a 50% improvement in the rate of epileptic seizures. About 20% of patients with epilepsy continue to have breakthrough epileptic seizures despite best anticonvulsant treatment.

Safety and Side Effects - 88% of patients with epilepsy, in a European survey, reported at least one anticonvulsant related side-effect. Most side effects are mild and "dose-related" and can often be avoided or minimized by the use of the smallest effective amount. Some examples include mood changes, sleepiness, or unsteadiness in gait. Some anticonvulsant medications have "idiosyncratic" side effects that can not be predicted by dose. Some examples include drug rashes, liver toxicity (hepatitis), or aplastic anemia. Safety includes the consideration of teratogenicity (the effects of medications on fetal development) when women with epilepsy become pregnant.

Principles of Anticonvulsant Use and Management - The goal for individual patients is no seizures and minimal side-effects, and the job of the physician is to aid the patient to find the best balance between the two during the prescribing of anticonvulsants. Most patients can achieve this balance best with *monotherapy*, the use of a single anticonvulsant medication. Some patients, however, require *polypharmacy*, the use of two or more anticonvulsants.

Serum levels of AEDs can be checked to determine medication compliance, to assess the effects of new drug-drug interactions upon previous stable medication levels, or to help establish if particular symptoms such as instability or sleepiness can be considered a drug side effect or are due to different causes. Children or impaired adults who may not be able to communicate side-effects may benefit from routine screening of drug levels. Beyond baseline screening, however, trials of recurrent, routine blood or urine monitoring show no proven benefits and may lead to unnecessary medication adjustments in most older children and adults using routine anticonvulsants.

If a person's epilepsy cannot be brought under control after adequate trials of two or three (experts vary here) different drugs, that person's epilepsy is generally said to be *medically refractory*. A study of patients with previously untreated epilepsy demonstrated that 47% achieved control of seizures with the use of their first single drug. 14% became seizure free during treatment with a second or third drug. An additional 3% became seizure-free with the use of two drugs simultaneously. Other treatments, in addition to or instead of, anticonvulsant medications may be considered by those people with continuing seizures.

Surgery

Epilepsy surgery is an option for patients whose seizures remain resistant to treatment with anticonvulsant medications who also have symptomatic localization-related epilepsy; a focal abnormality that can be located and therefore removed. The goal for these procedures is total control of epileptic seizures, although anticonvulsant medications may still be required.

The evaluation for epilepsy surgery is designed to locate the "epileptic focus" (the location of the epileptic abnormality) and to determine if resective surgery will affect normal brain function. Physicians will also confirm the diagnosis of epilepsy to make sure that spells arise from epilepsy (as opposed to non-epileptic seizures). The evaluation typically includes neurological examination, routine EEG, Long-term video-EEG monitoring, neuropsychological evaluation, and neuroimaging such as MRI, Single photon emission computed tomography (SPECT), positron emission tomography (PET). Some epilepsy centers use intracarotid sodium amobarbital test (Wada test), functional MRI or Magnetoencephalography (MEG) as supplementary tests.

Certain lesions require Long-term video-EEG monitoring with the use of intracranial electrodes if noninvasive testing was inadequate to identify the epileptic focus or distinguish the surgical target from normal brain tissue and function. Brain mapping by the technique of cortical electrical stimulation or Electrocorticography are other procedures used in the process of invasive testing in some patients.

The most common surgeries are the resection of lesions like tumors or arteriovenous malformations, which, in the process of treating the underlying lesion, often result in control of epileptic seizures caused by these lesions.

Other lesions are more subtle and feature epilepsy as the main or sole symptom. The most common form of intractable epilepsy in these disorders in adults is temporal lobe epilepsy with hippocampal sclerosis, and the most common type of epilepsy surgery is the anterior temporal lobectomy, or the removal of the front portion of the temporal lobe including the amygdala and hippocampus. Some neurosurgeons recommend selective amygdalahippocampectomy because of possible benefits in postoperative memory or language function. Surgery for temporal lobe epilepsy is effective, durable, and results in decreased health care costs. Despite the efficacy of epilepsy surgery, some patients decide not to undergo surgery owing to fear or the uncertainty of having a brain operation.

Palliative surgery for epilepsy is intended to reduce the frequency or severity of seizures. Examples are callosotomy or commissurotomy to prevent seizures from generalizing (spreading to involve the entire brain), which results in a loss of consciousness. This procedure can therefore prevent injury due to the person falling to the ground after losing consciousness. It is performed only when the seizures cannot be controlled by other means. Multiple subpial transection can also be used to decrease the spread of seizures across the cortex especially when the epileptic focus is located near important functional areas of the cortex. Resective surgery can be considered palliative if it is undertaken with the expectation that it will reduce but not eliminate seizures.

Hemispherectomy involves removal or a functional disconnection of most or all of one half of the cerebrum. It is reserved for people suffering from the most catastrophic epilepsies, such as those due to Rasmussen syndrome. If the surgery is performed on very young patients (2–5 years old), the remaining hemisphere may acquire some rudimentary motor control of the ipsilateral body; in older patients, paralysis results on the side of the body opposite to the part of the brain that was removed. Because of these and other side-effects, it is usually reserved for patients having exhausted other treatment options.

Other

A **ketogenic diet** (high-fat, low-carbohydrate) was developed in the 1920s, and was largely forgotten with the advent of effective anticonvulsants, but was resurrected in the 1990s. The mechanism of action is unknown. It is used mainly in the treatment of children with severe, medically intractable epilepsies, and the New York Times reported that use is supported by peer-reviewed research that found that the diet reduced seizures among drug-resistant epileptics by >50% in 38% of patients and by >90% in 7% of patients.

While far from a cure, operant-based **biofeedback** based on conditioning of EEG waves has some experimental support. Overall, the support is based on a handful of studies reviewed by Barry Sterman. These studies report a 30% reduction in weekly seizures.

Electrical stimulation methods of anticonvulsant treatment are both currently approved for treatment and investigational uses. A currently approved device is vagus nerve stimulation (VNS). Investigational devices include the responsive neurostimulation system (RNS) and deep brain stimulation (DBS).

- **Vagus nerve stimulation** (US manufacturer Cyberonics) consists of a computerized electrical device similar in size, shape and implant location to a heart pacemaker that connects to the vagus nerve in the neck. The device stimulates the vagus nerve at preset intervals and intensities of current. Efficacy has been tested in patients with localization-related epilepsies, demonstrating 50% of patients experience a 50% improvement in seizure rate. Case series have demonstrated similar efficacies in certain generalized epilepsies, such as Lennox-Gastaut syndrome. Although success rates are not usually equal to that of epilepsy surgery, it is a reasonable alternative when the patient is reluctant to proceed with

any required invasive monitoring, when appropriate presurgical evaluation fails to uncover the location of epileptic foci, or when there are multiple epileptic foci.

- **Responsive neurostimulator system** (US manufacturer Neuropace) consists of a computerized electrical device implanted in the skull, with electrodes implanted in presumed epileptic foci within the brain. The brain electrodes send EEG signals to the device which contains seizure-detection software. When certain EEG seizure criteria are met, the device delivers a small electrical charge to other electrodes near the epileptic focus, which disrupt the seizure. The efficacy of the RNS is under current investigation with the goal of FDA approval.

- **Deep brain stimulation** (US manufacturer Medtronic) consists of a computerized electrical device implanted in the chest in a manner similar to the VNS, but electrical stimulation is delivered to deep brain structures through depth electrodes implanted through the skull. In epilepsy, the electrode target is the anterior nucleus of the thalamus. The efficacy of the DBS in localization-related epilepsies is currently under investigation.

Noninvasive surgery using the gamma knife or other devices used in radiosurgery is currently being investigated as analternative to traditional open surgery in patients who would otherwise qualify for anterior temporal lobectomy.

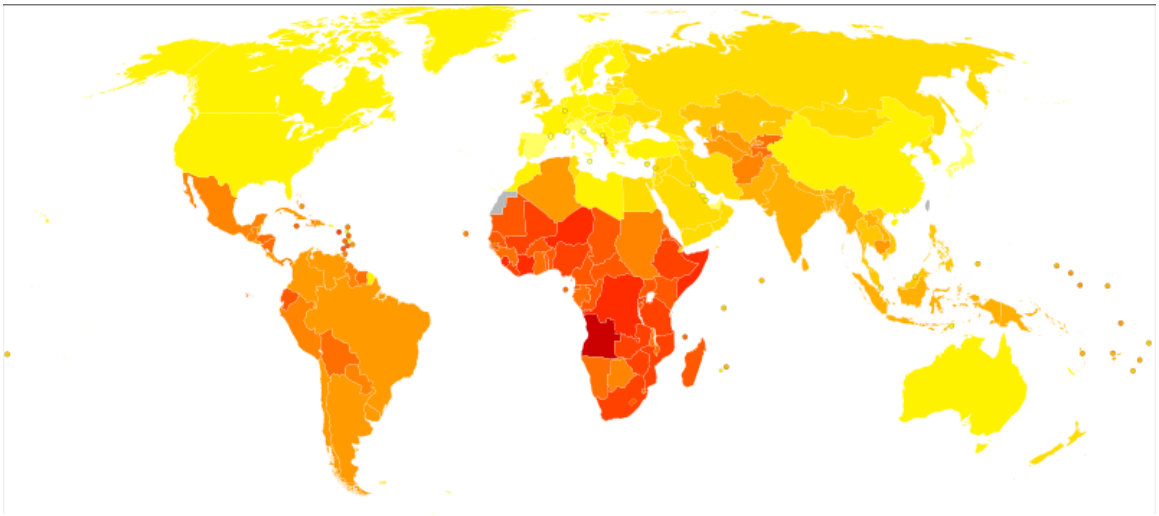
Avoidance therapy consists of minimizing or eliminating triggers in patients whose seizures are particularly susceptible to seizure precipitants (see above). For example, sunglasses that counter exposure to particular light wavelengths can improve seizure control in certain photosensitive epilepsies.

Canine warning system is where a seizure response dog, a form of service dog, is trained to summon help or ensure personal safety when a seizure occurs. These are not suitable for everybody, and not all dogs can be so trained. Rarely, a dog may develop the ability to sense a seizure before it occurs. Development of electronic forms of seizure detection systems are currently under investigation.

Seizure prediction-based devices using long-term EEG recordings is presently being evaluated as a new way to stop epileptic seizures before they appear clinically.

Alternative or complementary medicine, including acupuncture, psychological interventions, vitamins and yoga, was evaluated in a number of systematic reviews by the Cochrane Collaboration into treatments for epilepsy, and found there is no reliable evidence to support the use of these as treatments for epilepsy. Exercise or other physical activity have also been proposed as efficacious strategies for preventing or treating epilepsy. The Memorial Sloan-Kettering Cancer Center says dimethylglycine dietary supplement (DMG) will "enhance oxygen utilization during hypoxia, reduce lactic acid build-up in the blood during stressful events," and reduce the number of seizures experienced in epilepsy.

Epidemiology



Disability-adjusted life year for epilepsy per 100,000 inhabitants in 2002.
- no data
- less than 50
- 50-72.5
- 72.5-95
- 95-117.5
- 117.5-140
- 140-162.5
- 162.5-185
- 185-207.5
- 207.5-230
- 230-252.5
- 252.5-275
- more than 275

Epilepsy is one of the most common of the serious neurological disorders. Genetic, congenital, and developmental conditions are mostly associated with it among younger patients; tumors are more likely over age 40; head trauma and central nervous system infections may occur at any age. The prevalence of active epilepsy is roughly in the range 5–10 per 1000 people. Up to 5% of people experience non febrile seizures at some point in life; epilepsy's lifetime prevalence is relatively high because most patients either stop having seizures or (less commonly) die of it. Epilepsy's approximate annual incidence rate is 40–70 per 100,000 in industrialized countries and 100–190 per 100,000 in resource-poor countries; socioeconomically deprived people are at higher risk. In industrialized countries the incidence rate decreased in children but increased among the elderly during the three decades prior to 2003, for reasons not fully understood.

Beyond symptoms of the underlying diseases that can be a part of certain epilepsies, people with epilepsy are at risk for death from four main problems: status epilepticus (most often associated with anticonvulsant noncompliance), suicide associated with

depression, trauma from seizures, and sudden unexpected death in epilepsy (SUDEP) Those at highest risk for epilepsy-related deaths usually have underlying neurological impairment or poorly controlled seizures; those with more benign epilepsy syndromes have little risk for epilepsy-related death.

The NICE National Sentinel Audit of Epilepsy-Related Deaths, led by "Epilepsy Bereaved" drew attention to this important problem. The Audit revealed; "1,000 deaths occur every year in the UK as a result of epilepsy" and most of them are associated with seizures and 42% of deaths were potentially avoidable".

Certain diseases also seem to occur in higher than expected rates in people with epilepsy, and the risk of these "comorbidities" often varies with the epilepsy syndrome. These diseases include depression and anxiety disorders, migraine and other headaches, infertility and low sexual libido. Attention-deficit/hyperactivity disorder (ADHD) affects three to five times more children with epilepsy than children in the general population. Epilepsy is prevalent in autism.

History

The word *epilepsy* is derived from the Ancient Greek ἐπιληψία *epilēpsía*, which was from ἐπιλαμβάνειν *epilambánein* "to take hold of", which in turn was combined from ἐπί *epí* "upon" and λαμβάνειν *lambánein* "to take". In the past, epilepsy was associated with religious experiences and even demonic possession. In ancient times, epilepsy was known as the "Sacred Disease" because people thought that epileptic seizures were a form of attack by demons, or that the visions experienced by persons with epilepsy were sent by the gods. Among animist Hmong families, for example, epilepsy was understood as an attack by an evil spirit, but the affected person could become revered as a shaman through these otherworldly experiences.

However, in most cultures, persons with epilepsy have been stigmatized, shunned, or even imprisoned; in the Salpêtrière, the birthplace of modern neurology, Jean-Martin Charcot found people with epilepsy side-by-side with the mentally retarded, those with chronic syphilis, and the criminally insane. In Tanzania to this day, as with other parts of Africa, epilepsy is associated with possession by evil spirits, witchcraft, or poisoning and is believed by many to be contagious. In ancient Rome, epilepsy was known as the *Morbus Comitialis* ('disease of the assembly hall') and was seen as a curse from the gods.

Stigma continues to this day, in both the public and private spheres, but polls suggest it is generally decreasing with time, at least in the developed world; Hippocrates remarked that epilepsy would cease to be considered divine the day it was understood.

Society and culture

Legal implications

Many jurisdictions forbid certain activities to persons suffering from epilepsy. The most commonly prohibited activities involve operation of vehicles or machinery, or other activities in which continuous vigilance is required. However, there are usually exceptions for those who can prove that they have stabilized their condition. Those few whose seizures do not cause impairment of consciousness, have a lengthy aura preceding impairment of consciousness, or whose seizures only arise from sleep, may be exempt from such restrictions, depending on local laws. There is an ongoing debate in bioethics over *who* should bear the burden of ensuring that an epilepsy patient does not drive a car or fly an airplane.

Automobiles

In the U.S., people with epilepsy can drive if their seizures are controlled with treatment and they meet the licensing requirements in their state. The amount of time someone needs to be free of seizures varies in different states, but is most likely to be between three months and a year. The majority of the 50 states place the burden on patients to report their condition to appropriate licensing authorities so that their privileges can be revoked where appropriate. A minority of states place the burden of reporting on the patient's physician. After reporting is carried out, it is usually the driver's licensing agency that decides to revoke or restrict a driver's license.

In the UK, it is the responsibility of the patients to inform the Driver and Vehicle Licensing Agency (DVLA) if they have epilepsy. The DVLA rules are quite complex, but in summary, those that continue to have seizures or who are within 6 months of medication change may have their licence revoked. A person must be seizure free of an 'awake' seizure for 12 months (or had only 'sleep' seizures for 3 years or more) before they can apply for a license. A doctor who becomes aware that a patient with uncontrolled epilepsy is continuing to drive has, after reminding the patient of their responsibility, a duty to break confidentiality and inform the DVLA. The doctor should advise the patient of the disclosure and the reasons why their failure to notify the agency obliged the doctor to act.

Aircraft

In many countries, persons with any history of epilepsy are generally disqualified for the medical certifications required for all classes of pilot licenses. In the United States, FAA regulations disqualify applicants for medical certification with a history of epilepsy, although the final decision is made by FAA headquarters, and rare exceptions are sometimes made for persons who have had only an isolated seizure or two in childhood and have remained free of seizures in adulthood without medication.

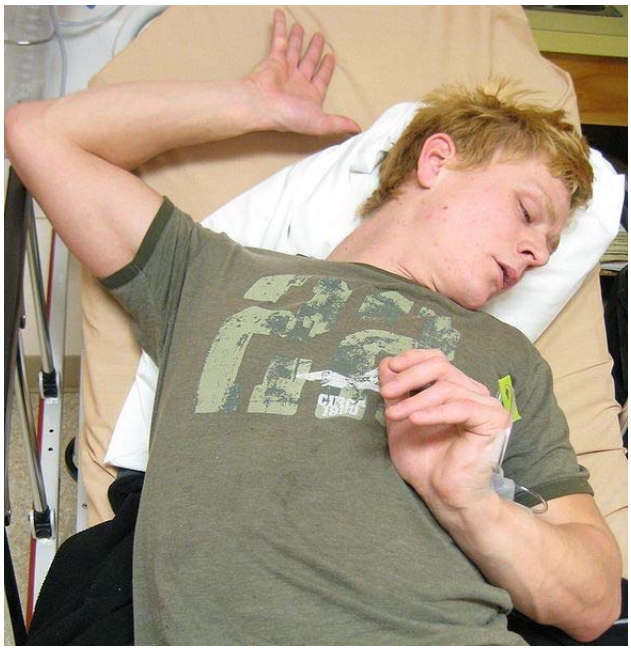
Notable cases

Many notable people, past and present, have carried the diagnosis of epilepsy. In many cases, their epilepsy is a footnote to their accomplishments; for some, it played an integral role in their fame. Historical diagnoses of epilepsy are not always certain; there is controversy about what is considered an acceptable amount of evidence in support of such a diagnosis.

Chapter 8

Dystonia

Dystonia



A person with medication induced dystonia.

ICD-10	G24.9
ICD-9	333
DiseasesDB	17912
MeSH	D004421

Dystonia is a neurological movement disorder, in which sustained muscle contractions cause twisting and repetitive movements or abnormal postures. The disorder may be hereditary or caused by other factors such as birth-related or other physical trauma, infection, poisoning (e.g., lead poisoning) or reaction to pharmaceutical drugs, particularly neuroleptics. Treatment is difficult and has been limited to minimizing the symptoms of the disorder, since there is no cure available.

Classification

Types of dystonia

- Generalized
- Focal
- Segmental
- Sexual
- Intermediate
- Acute Dystonic Reaction

Generalized dystonias

- Normal birth history and milestones
- Autosomal dominant
- Childhood onset
- Starts in lower limbs and spreads upwards
- Also known as "idiopathic torsion dystonia" (old terminology "dystonia musculrum deformans")

Focal dystonias

These are the most common dystonias and tend to be classified as follows:

Name	Location	Description
Anismus	muscles of the rectum	Causes painful defecation, constipation; may be complicated by encopresis.
Cervical dystonia (spasmodic torticollis)	muscles of the neck	Causes the head to rotate to one side, to pull down towards the chest, or back, or a combination of these postures.
Blepharospasm	muscles around the eyes	The sufferer experiences rapid blinking of the eyes or even their forced closure causing effective blindness.
Oculogyric crisis	muscles of eye and head	An extreme and sustained (usually) upward deviation of the eyes often with convergence causing diplopia. It is frequently associated with backwards and lateral flexion of the neck and either widely opened mouth or jaw clenching. Frequently a result of antiemetics such as the neuroleptics (e.g., prochlorperazine) or metoclopramide. Also can be caused by Chlorpromazine
Oromandibular dystonia	muscles of the jaw and muscles of	Causes distortions of the mouth and tongue.

	tongue	
Spasmodic dysphonia/Laryngeal dystonia	muscles of larynx	Causes the voice to sound broken or reducing it to a whisper.
Focal hand dystonia (also known as musician's or writer's cramp).	single muscle or small group of muscles in the hand	It interferes with activities such as writing or playing a musical instrument by causing involuntary muscular contractions. The condition is sometimes "task-specific," meaning that it is generally only apparent during certain activities. Focal hand dystonia is neurological in origin, and is not due to normal fatigue. The loss of precise muscle control and continuous unintentional movement results in painful cramping and abnormal positioning that makes continued use of the affected body parts impossible.

The combination of blepharospasmodic contractions and oromandibular dystonia is called cranial dystonia or Meige's syndrome.

Segmental dystonias

Segmental dystonias affect two adjoining parts of the body:

- Hemidystonia affects an arm and a leg on one side of the body.
- Multifocal dystonia affects many different parts of the body.
- Generalized dystonia affects most of the body, frequently involving the legs and back.

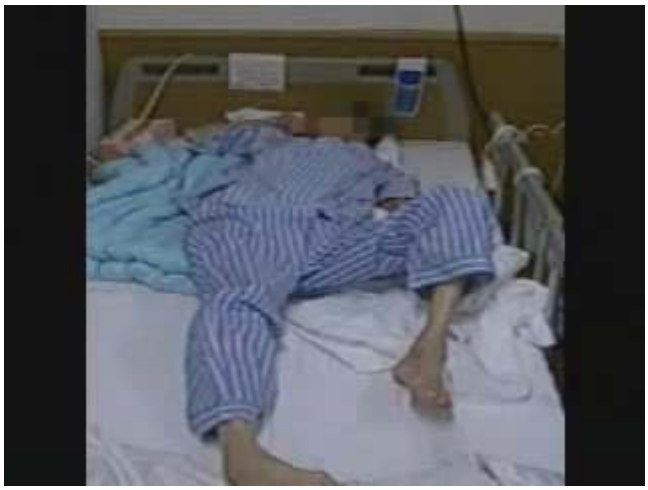
Genetic / primary

Name	OMIM	Gene	Locus	Alt Name
DYT1 (or EOTD)	128100	DYT1	9q34	early-onset torsion dystonia
DYT2	224500	unknown	unknown	autosomal recessive torsion dystonia
DYT3	314250	TAF1	Xq13	X-linked torsion dystonia
DYT4	128101	unknown	unknown	autosomal dominant torsion dystonia
DYT5 (or DRD)	128230	GCH1	14q22.1-q22.2	Dopamine-responsive dystonia
DYT6	602629	THAP1	8p11.21	
DYT7	602124	unknown	18p	Primary cervical dystonia
DYT8 (or	118800	MR1	2q35	paroxysmal nonkinesigenic

PNKD1)				dyskinesia 1
DYT9	601042	possibly KCNA3	1p	episodic choreoathetosis/spasticity
DYT10 (or EKD1)	128200	unknown	16p11.2-q12.1	episodic kinesigenic dyskinesia 1
DYT11	159900	SGCE	7q21	Myoclonic dystonia
DYT12	128235	ATP1A3	19q12-q13.2	
DYT13	607671	unknown, near D1S2667	1p36.32-p36.13	
DYT14	DYT5			
DYT15	607488	unknown	18p11	Myoclonic dystonia
DYT16	612067	PRKRA	2q31.3	
DYT17	612406	unknown, near D20S107	20p11.2-q13.12	
DYT18	612126	SLC2A1	1p35-p31.3	
DYT19 (or EKD2)	611031	unknown	16q13-q22.1	episodic kinesigenic dyskinesia 2
DYT20 (or PNKD2)	611147	unknown	2q31	paroxysmal nonkinesigenic dyskinesia 2

There is a group called myoclonus dystonia or myoclonic dystonia, where some cases are hereditary and have been associated with a missense mutation in the dopamine-D2 receptor. Some of these cases have responded remarkably to alcohol.

Signs and symptoms



Symptoms vary according to the kind of dystonia involved. In most cases, dystonia tends to lead to abnormal posturing, particularly on movement. Many sufferers have continuous pain, cramping and relentless muscle spasms due to involuntary muscle movements. Other motor symptoms are possible including lip smacking.

Early symptoms may include loss of precision muscle coordination (sometimes first manifested in declining penmanship, frequent small injuries to the hands, and dropped items), cramping pain with sustained use and trembling. Significant muscle pain and cramping may result from very minor exertions like holding a book and turning pages. It may become difficult to find a comfortable position for arms and legs with even the minor exertions associated with holding arms crossed causing significant pain similar to restless leg syndrome. Affected persons may notice trembling in the diaphragm while breathing, or the need to place hands in pockets, under legs while sitting or under pillows while sleeping to keep them still and to reduce pain. Trembling in the jaw may be felt and heard while lying down, and the constant movement to avoid pain may result in the grinding and wearing down of teeth, or symptoms similar to TMD. The voice may crack frequently or become harsh, triggering frequent throat clearing. Swallowing can become difficult and accompanied by painful cramping.

Electrical sensors (EMG) inserted into affected muscle groups, while painful, can provide a definitive diagnosis by showing pulsating nerve signals being transmitted to the muscles even when they are at rest. The brain appears to signal portions of fibers within the affected muscle groups at a firing speed of about 10 Hz causing them to pulsate, tremble and contort. When called upon to perform an intentional activity, the muscles fatigue very quickly and some portions of the muscle groups do not respond (causing weakness) while other portions over-respond or become rigid (causing micro-tears under load). The symptoms worsen significantly with use, especially in the case of focal dystonia, and a "mirror effect" is often observed in other body parts: use of the right hand may cause pain and cramping in that hand as well as in the other hand and legs that were not being used. Stress, anxiety, lack of sleep, sustained use and cold temperatures can worsen symptoms.

Direct symptoms may be accompanied by secondary effects of the continuous muscle and brain activity, including disturbed sleep patterns, exhaustion, mood swings, mental stress, difficulty concentrating, blurred vision, digestive problems and short temper. People with dystonia may also become depressed and find great difficulty adapting their activities and livelihood to a progressing disability. Side effects from treatment and medications can also present challenges in normal activities.

In some cases, symptoms may progress and then plateau for years, or stop progressing entirely. The progression may be delayed by treatment or adaptive lifestyle changes, while forced continued use may make symptoms progress more rapidly. In others, the symptoms may progress to total disability, making some of the more risky forms of treatment worth considering. In some cases with patients who already have dystonia, a subsequent tramatic injury or the effects of general anethesia during an unrelated surgery can cause the symptoms to progress rapidly.

An accurate diagnosis may be difficult because of the way the disorder manifests itself. Sufferers may be diagnosed as having similar and perhaps related disorders including Parkinson's disease, essential tremor, carpal tunnel syndrome, TMD, Tourette's syndrome, or other neuromuscular movement disorders.

Causes

The causes of dystonia are not yet known or understood; however, they are categorized as follows on a theoretical basis:

Primary dystonia is suspected to be caused by a pathology of the central nervous system, likely originating in those parts of the brain concerned with motor function, such as the basal ganglia, and the GABA (gamma-aminobutyric acid) producing Purkinje neurons. The precise cause of primary dystonia is unknown. In many cases it may involve some genetic predisposition towards the disorder combined with environmental conditions.

Secondary dystonia refers to dystonia brought on by some identified cause, usually involving brain damage, or by some unidentified cause such as chemical imbalance. Some cases of (particularly focal) dystonia are brought on after trauma, are induced by certain drugs (tardive dystonia), or may be the result of diseases of the nervous system such as Wilson's disease.

Environmental and task-related factors are suspected to trigger the development of focal dystonias because they appear disproportionately in individuals who perform high precision hand movements such as musicians, engineers, architects and artists. Chlorpromazine can also cause dystonia, which can be often misjudged as a seizure.

Treatment

Treatment has been limited to minimizing the symptoms of the disorder as there is yet no successful treatment for its cause. Reducing the types of movements that trigger or worsen dystonic symptoms provides some relief, as does reducing stress, getting plenty of rest, moderate exercise, and relaxation techniques. Various treatments focus on sedating brain functions or blocking nerve communications with the muscles via drugs, neuro-suppression or denervation. All current treatments have negative side effects and risks.

Physical intervention

Physical therapy can sometimes help with focal dystonia. A structured set of exercises is tailored to help the affected area.

Some focal dystonias have been proven treatable through movement retraining in the Taubman approach, particularly in the case of musicians. However other focal dystonias may not respond and may even be made worse by this treatment.

Medication

Different medications are tried in an effort to find a combination that is effective for a specific person. Not all people will respond well to the same medications. Medications

that have had positive results in some include: diphenhydramine, benzatropine, anti-Parkinsons agents (such as trihexyphenidyl), and muscle relaxers (such as diazepam).

Cannabidiol, one of the non-psychoactive cannabinoids found in cannabis sativa, was shown in a 6-week study to have reduced dystonic symptoms in all participants by up to 20-50%.

Anticholinergics

Medications such as anticholinergics (benzatropine), which act as inhibitors of the neurotransmitter acetylcholine, may provide some relief. In the case of a acute dystonic reaction, diphenhydramine is sometimes used (though this drug is well known as an antihistamine, in this context it is being used primarily for its anticholinergic role). In the case of Oculogyric crisis, diphenhydramine may be administered with excellent results with symptoms subsiding in a matter of minutes.

Muscle relaxants

Clonazepam, an anti-seizure medicine, is also sometimes prescribed. However, for most their effects are limited and side effects like mental confusion, sedation, mood swings and short-term memory loss occur.

Botulinum toxin injections into affected muscles have proved quite successful in providing some relief for around 3–6 months, depending on the kind of dystonia. Botox injections have the advantage of ready availability (the same form is used for cosmetic surgery) and the effects are not permanent. There is a risk of temporary paralysis of the muscles being injected or the leaking of the toxin into adjacent muscle groups causing weakness or paralysis in them. The injections have to be repeated as the effects wear off and around 15% of recipients will develop immunity to the toxin. There is a Type A and Type B toxin approved for treatment of dystonia; often those that develop resistance to Type A may be able to use Type B.

Noting that botulinum toxin has been shown to have an effect on inhibiting neurogenic inflammation, and evidence suggesting the role of neurogenic inflammation in the pathogenesis of psoriasis, the University of Minnesota has begun a clinical trial to follow up on the observation that patients treated with botulinum toxin for dystonia had dramatic improvement in psoriasis. See: Use of Botulinum Toxin to Treat Psoriasis.

Parkinsonian drugs

Dopamine agonists: One type of dystonia, dopamine-responsive dystonia, can be completely treated with regular doses of L-DOPA in a form such as Sinemet (carbidopa/levodopa). Although this doesn't remove the condition, it does alleviate the symptoms most of the time. (In contrast, dopamine antagonists can sometimes cause dystonia.)

Baclofen

A baclofen pump has been used to treat patients of all ages exhibiting muscle spasticity along with dystonia. The pump delivers baclofen via a catheter to the thecal space surrounding the spinal cord. The pump itself is placed in the abdomen. It can be refilled periodically by access through the skin.

Surgery

Surgery, such as the denervation of selected muscles, may also provide some relief; however, the destruction of nerves in the limbs or brain is not reversible and should only be considered in the most extreme cases. Recently, the procedure of deep brain stimulation (DBS) has proven successful in a number of cases of severe generalised dystonia. DBS as treatment for medication-refractory dystonia, on the other hand, may increase the risk of suicide in patients. Unfortunately, reference data of patients without DBS therapy are lacking.

Chapter 9

Neuropsychiatry

Neuropsychiatry is the branch of medicine dealing with mental disorders attributable to diseases of the nervous system. It preceded the current disciplines of psychiatry and neurology, inasmuch as psychiatrists and neurologists had a common training (Yudofsky and Hales, 2002). However, neurology and psychiatry subsequently split apart and are typically practiced separately. Nevertheless, neuropsychiatry has become a growing subspecialty of psychiatry and it is also closely related to the field of behavioral neurology, which is a subspecialty of neurology that addresses clinical problems of cognition and/or behavior caused by brain injury or brain disease. "Behavioral Neurology & Neuropsychiatry" fellowships are jointly accredited through the United Council for Neurologic Subspecialties (UCNS), in a manner similar to how the specialties of psychiatry and neurology in the United States have a joint board for accreditation, the American Board of Psychiatry and Neurology (ABPN).

The case for the rapprochement of neurology and psychiatry

Given the considerable overlap between these subspecialities, there has been a resurgence of interest and debate relating to neuropsychiatry in academia over the last decade. E.g.:

- Yudofsky S.C., & Hales E.H. (2002). Neuropsychiatry and the Future of Psychiatry and Neurology. *American Journal of Psychiatry*, 159(8), 1261–1264.
- Berrios G.E., Marková I.S. (2002) The concept of neuropsychiatry. A historical overview. *Journal of Psychosomatic Research* 53 : 629–638.
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Most of this work argues for a rapprochement of neurology and psychiatry, forming a specialty above and beyond a subspecialty of psychiatry. For example, Professor Joseph B. Martin, former Dean of Harvard Medical School and a neurologist by training, has summarized the argument for reunion: "the separation of the two categories is arbitrary, often influenced by beliefs rather than proven scientific observations. And the fact that

the brain and mind are one makes the separation artificial anyway." (Martin, 2002). These points and some of the other major arguments are detailed below.

Mind/brain monism

Neurologists have focused objectively on organic nervous system pathology, especially of the brain, whereas psychiatrists have laid claim to illnesses of the mind. This antipodal distinction between brain and mind as two different entities has characterized many of the differences between the two specialties. However, it is argued that this division is simply not veridical; a plethora of evidence from the last century of research has shown that our mental life has its roots in the brain. Brain and mind are argued not to be discrete entities but just different ways of looking at the same system (Marr, 1982). It has been argued that embracing this mind/brain monism is important for several reasons. First, rejecting dualism logically implies that all mentation is biological and so immediately there is a common research framework in which understanding—and thus treatment—of mental suffering can be advanced. Second, it removes the widespread confusion about the legitimacy of mental illness: all disorders should have a footprint in the brain-mind system.

In sum, one reason for the division between psychiatry and neurology was the difference between mind or first-person experience and brain. That this difference is artificial is taken as good support for a merge between these specialties.

Causal pluralism

Another broad reason for the divide is that neurology traditionally looks at the causes of disorders from an "inside-the-skin" perspective (neuropathology, genetics) whereas psychiatry looks at "outside-the-skin" causation (personal, interpersonal, cultural) (Kendler, 2005). This dichotomy is argued not to be instructive and authors have argued that it is better conceptualized as two ends of a causal continuum (e.g. Kendler, 2005). The benefits of this position are: firstly, understanding of etiology will be enriched, in particular between brain and environment. One example is eating disorders, which have been found to have some neuropathology (Uher and Treasure, 2005) but also show increased incidence in rural Fijian school girls after exposure to television (Becker, 2004). Another example is schizophrenia, the risk for which may be considerably reduced in a healthy family environment (Tienari et al., 2004).

Secondly, it is argued that this augmented understanding of etiology will lead to better remediation and rehabilitation strategies through an understanding of the different levels in the causal process where one can intervene. Indeed, it may be that non-organic interventions, like cognitive behavioral therapy (CBT), better attenuate disorders alone or in conjunction with drugs. Linden's (2006) demonstration of how psychotherapy has neurobiological commonalities with pharmacotherapy is a pertinent example of this and is encouraging from a patient perspective as the potentiality for pernicious side effects is decreased while self-efficacy is increased.

In sum, the argument is that an understanding of the mental disorders must not only have a specific knowledge of brain constituents and genetics (inside-the-skin) but also the context (outside-the-skin) in which these parts operate (Koch and Laurent, 1999). Only by joining neurology and psychiatry, it is argued, can this nexus be used to reduce human suffering.

Hitherto psychiatric disorders have organic basis

To further sketch psychiatry's history shows a departure from structural neuropathology, relying more upon ideology (Sabshin, 1990). A good example of this is Tourette syndrome, which Ferenczi (1921), although never having seen a patient with Tourette syndrome, suggested was the symbolic expression of masturbation caused by sexual repression. However, starting with the efficacy of neuroleptic drugs in attenuating symptoms (Shapiro, Shapiro and Wayne, 1973) the syndrome has gained pathophysiological support (e.g. Singer, 1997) and is hypothesized to have a genetic basis too, based on its high inheritability (Robertson, 2000). This trend can be seen for many hitherto traditionally psychiatric disorders (see table) and is argued to support reuniting neurology and psychiatry because both are dealing with disorders of the same system.

Linking traditionally psychiatric symptoms to brain structures and genetic abnormalities. (This table is in no way exhaustive but aims to show some of the neurological bases to hitherto psychiatric symptoms)

Psychiatric symptoms	E.g. Traditional psychiatric (psychoanalytic) explanation	E.g., Neural correlates
Depression	Narcissistic	Limbic-cortical dysregulation
Obsessive Compulsive Disorder	Poor maternal parenting	frontal-subcortical circuitry, right caudate activity
Schizophrenia	Narcissistic/escapism	NMDA receptor activation in the human prefrontal cortex
Visual hallucination	-	retinogeniculocalcarine tract, ascending brainstem modulatory structures
Auditory hallucination	-	frontotemporal functional connectivity
Eating disorder		Atypical serotonin system, right frontal and temporal lobe damage
Bipolar disorder	Narcissistic	Prefrontal cortex and hippocampus, anterior cingulate, amygdala

Improved patient care

Further, it is argued that this nexus will allow a more refined nosology of mental illness to emerge thus helping to improve remediation and rehabilitation strategies beyond current ones that lump together ranges of symptoms. However, it cuts both ways: traditionally neurological disorders, like Parkinson's disease, are being recognized for

their high incidence of traditionally psychiatric symptoms, like psychosis and depression (Lerner and Whitehouse, 2002). These symptoms, which are largely ignored in neurology (Yudofsky and Hales, 2002), can be addressed by neuropsychiatry and lead to improved patient care. In sum, it is argued that patients from both traditional psychiatry and neurology departments will see their care improved following a reuniting of the specialties.

Better management model

Schiffer et al. (2004) argue that there are good management and financial reasons for rapprochement.

The case for maintaining the separation of neurology and psychiatry

No psychiatric disorder has been completely "mapped"

The fact that no complete syndrome has been mapped in the brain or genome is used to suggest that psychiatric disorders are not bona fide and should thus be kept separate (e.g. Baughman and Hovey, 2006). On this issue, it is worth remembering that research into the neural correlates of psychiatric disorders is in its infancy: the answers may still be to come. One reason why they may not have been found so far is that complex mental disorders may result from minute and intricate brain-wide damage and complicated gene-environment interactions, which are only beginning to be understood. Disorders may not exist as tidy, localized neurodysfunction or genetic abnormalities but multi-factorial brain-wide disorders with complex interactions between environment and genetics (e.g. Green, 2001). Such distributed dysfunction may not be resolvable in the living brain with current technology. E.g. disparate behavioral disorders have been linked to identical neurodysfunction with imaging but show significant organic differences following neurohistological analysis (Rempel–Clower et al., 1996). Where physiopathology is extremely small and distributed or neural tissue is actually healthy it may be the disturbed information-processing that should be studied. E.g. Bell, Halligan and Ellis' (2006) work on cognitive deficits in delusions.

Pragmatic issues

The extent to which neuropsychiatry is practically possible has been questioned. As Sachdev (2005) has noted, psychiatrists and neurologists operate very different patient management strategies, which are skills honed by years of experience:

- Neurologist: Clinical examination skills; empiricism; objectivity; surgery
- Psychiatrist: Rich description of mental phenomena, well developed interviewing skills; understanding multiple causation; appreciation of individual differences; interpersonal context; psychological and behavioral therapies

Sachdev suggests to join them may be to dilute them both. Further, the ability to maintain a competent knowledge and skill base for both neurology and psychiatry with the advent of the inexorable increase in scientific knowledge may not be possible.

Summary of the arguments for neuropsychiatry

Diseases of the body have a physical manifestation that can often be caused by internal factors, external factors, or a combination of the two. Mental disorders should be no different and when together neurology and psychiatry's aim was to show that this was the case. Psychiatry departed the union preferring ideology over empiricism, including very environmentally-based etiology as well as espousing that the mind was something fundamentally different from the brain. Neurologists, however, finding no physiopathology for certain disorders left them to the psychiatrists, while themselves pursuing the diseases with clear physiopathology.

However, the cleavage between mind and brain and the causal dichotomies are argued not to be veridical. Psychiatric disorders are increasingly showing organic manifestation and demonstrate causation from something as distant as culture. Thus the reasons for the initial division are argued not to be useful or real ones. The two specialties are both dealing with disorders of the same system. Biological psychiatry and behavioral neurology show how the boundaries are being blurred. It is argued that there can be no objection to a reunion on philosophical or scientific grounds. However, there may be reasons to question whether neuropsychiatry would be practically possible. The differences in patient management, knowledge base and skill competency between neurology and psychiatry mean that being proficient in both may be impossible.

Chapter 10

Endoscopic Thoracic Sympathectomy and Neurosurgery

Endoscopic thoracic sympathectomy

Intervention:
Endoscopic thoracic sympathectomy

ICD-10 code:
ICD-9 code: 05.2
Other codes:

Endoscopic thoracic sympathectomy (ETS) is a surgical procedure where certain portions of the sympathetic nerve trunk are destroyed. ETS is used to treat hyperhidrosis, facial blushing, Raynaud's disease and reflex sympathetic dystrophy. By far the most common complaint treated with ETS is palmar hyperhidrosis, or "sweaty palms". In this disorder, the palms may constantly shed so much sweat that the affected person is unable to handle paper, sign documents, keep clothes dry, or shake hands. The result is often social phobia so severe as to be disabling.

Sympathectomy physically destroys some tissue anywhere in either of the two sympathetic trunks, which are long chains of nerve ganglia lying along either side of the spine. Each nerve trunk is broadly divided into three regions: cervical (neck), thoracic (chest), and lumbar (lower back). The most common area targeted in sympathectomy is the upper thoracic region, that part of the sympathetic chain lying between the first and fifth thoracic vertebrae.

In addition to the normal risks of surgery, such as bleeding and infection, sympathectomy has several specific risks, such as adverse changes in how nerves function.

Indications

ETS is most commonly used to treat severe hyperhidrosis of the upper body, Raynaud's phenomenon, and facial blushing.

There are reports of ETS being used to achieve cerebral revascularization for patients with moyamoya disease, and to treat headaches, hyperactive bronchial tubes, long QT syndrome and other conditions.

Thoracic sympathectomy can alter many bodily functions, including sweating, vascular responses, heart rate, heart stroke volume, thyroid, baroreflex,lung volume, pupil dilation, skin temperature, goose bumps and other aspects of the autonomic nervous system, like the fight-or-flight response. It may diminish the body's physical reaction to exercise.

Procedure

Sympathectomy involves division of adrenergic, cholinergic and sensory fibers which elaborate adrenergic substances during the process of regulating visceral function. It involves dissection of the main Sympathetic trunk in the upper thoracic region of the sympathetic nervous system, thus interrupting neural messages that ordinarily would travel to many different organs, glands and muscles. It is via these nerves of the autonomic nervous system that the brain is able to make adjustments in the body in response to changing conditions in the environment, changing emotional states, level of exercise, and other factors to maintain the body's homeostasis.

When performed endoscopically, the surgeon penetrates the chest cavity, making holes about the diameter of a straw between ribs. This allows the surgeon to insert the video camera in one hole and a surgical instrument in another.

Sympathectomy is accomplished by dissecting the nerve tissue of the main sympathetic chain. The clamping method, also referred to as **endoscopic sympathetic blockade** (ESB) employs titanium clamps around the nerve tissue, and was developed in an attempt to make the procedure reversible. However, reversal of the clamping procedure must be performed within a short time after clamping (a few days or weeks at most), and recovery may not be complete.

Results

The most common indication for ETS surgery is hyperhidrosis, or excessive sweating. However, one study on sweating before and one month after ETS demonstrated that the procedure increases total sweat production in a hot sauna.

Swedish National Board of Health and Welfare statement on treatment results says: "A large amount of international studies shows that an incision on the sympatikotomi nerve gives a very positive result when it comes to hand perspiration and also that the side effects are rare." Critics have raised serious questions about the methodology of such studies.

Sympathectomy works by disabling part of the autonomic nervous system, by surgically destroying it, and disrupting the signals to the brain. Many non-ETS doctors find this to be disturbing, as symptoms of the ANS dysfunction go further than the disabled

thermoregulation. Sympathectomy prevents the occurrence of a variety of bodily changes, and hence, prevents sensory feedback of those changes.

Exact results of ETS are impossible to predict, because of considerable anatomic variations in sympathetic nerve function from one patient to the next, and also because of variations in surgical technique. The autonomic nervous system is not anatomically exact and connections might exist with different parts of the body. This theory has been proven by the fact that a significant number of patients who have had sympathectomy for hand sweating might notice a reduction or elimination of feet sweating. No reliable operation exists for foot sweating per se except lumber sympathectomy.

Lumbar sympathectomy is largely of historical interest today, being reserved for cases of severe sympathetic dystrophy or selected cases of rest pain, where is it usually done by percutaneous ablation of the lumbar sympathetic chain by phenol injection under imaging guidance. Its original use as an operation for lower limb ischaemia has been superseded by direct revascularisation operations or endovascular revacularisation procedures such as angioplasty or angioplasty with stenting of occuded arteries with reasonable runoff i.e. endovascular surgery.

Studies by ETS surgeons have claimed an initial satisfaction rate around 85-95% with at least 2%-19% regretting the surgery and up to 51% of the patients complaining about decreased quality of life. One study shows a satisfaction rate as low as 28.6. Most patients report various adverse reactions as a result of the surgery. However, ETS surgeon Samuel S. Ahn of UCLA claims "100% success with no negative side effects".

A large study of psychiatric patients treated with this surgery showed significant reductions in fear, alertness and arousal. (Teleranta, Pohjavaara, et al. 2003, 2004). Arousal is essential to consciousness, in regulating attention and information processing, memory and emotion. This study also proves what many patients have claimed, that the surgery caused psychological changes. You cannot reduce 'bad' emotional responses, like fear or anxiety. If you reduce emotional responses, they will affect the whole range of emotions and their intensity. With the elimination of the heart rate variability, emotions are also 'capped'.

ETS patients are being studied using the autonomic failure protocol headed by David Goldstein, M.D. Ph.D., senior investigator at the U.S National Institute of Neurological Disorders and Stroke. He has documented loss of thermoregulatory function, cardiac denervation, and loss of vasoconstriction. Recurrence of the original symptoms due to nerve regeneration or nerve sprouting can occur within the first year post surgery, but regeneration can start years after sympathectomy. Nerve sprouting, or abnormal nerve growth after damage or injury to the nerves can cause other further damage. Sprouting sympathtetic nerves can form connections with sensory nerves, and lead to pain conditions that are mediated by the SNS. Every time the system is activated, it is translated into pain. This sprouting and its action can lead to Frey's syndrome, a well recognized after effect of sympathectomy, when the growing sympathetic nerves innervate salivary glands. This leads to excessive sweating when eating. For patients

different tastes can trigger this abnormal facial sweating (curiously this happens in the area where people who have undergone this procedure can not sweat any more normally). For some it only occurs with hot food, for others, with hot, sour - even by eating an apple, or sweet. Smelling can also cause abnormal reactions, as the signals get mixed up. Nerve regeneration and subsequent abnormal synapses is a well-documented phenomena.

Some patients have required an artificial pacemaker after developing bradycardia (slow heart beat) as a side effect of the surgery.

Risks and controversy

No surgery is risk-free, and ETS has both the normal risks of surgery, such as bleeding and infection, and several specific risks, such as changes in how nerves function. Bleeding during and following the operation may be significant in up to 5% of patients. Pneumothorax (collapsed lung) can occur (2% of patients).

Compensatory hyperhidrosis (sweating) is common over the long term, causing 1-2 percent of patients in one review to regret having had the surgery. The rates of severe compensatory sweating vary widely between studies, ranging from as low as 1.2% and as high as 30.9% of patients. Of those patients that develop this side effect, about a quarter said it was major and disabling.

ETS can cause corposcindosis, in which the patient feels like he or she is living in two separate bodies: one half of the body is numb or "dead," and the other half has hyperactive sympathetic nerve function.

The Finnish Office for Health Care Technology Assessment concluded in a 40 page systematic review that Endoscopic Thoracic Sympathectomy is associated with significant immediate and long-term adverse effects.

Quoting the aforementioned Swedish National Board of Health and Welfare statement: "The method can give permanent side effects that in some cases first will become obvious after some time. One of the side effects might be increased perspiration on different places on your body. Why and how this happens is still unknown. According to the research available about 25-75% of all patients can expect more or less serious perspiration on different places on their body, such as the trunk and groin area, this is *Compensatory sweating*.

However, it is also mentioned in the research that 0-10% regret having the surgery done for this reason. Other documented side effects are the inability to raise the heart rate when working out physically. This has in some cases led to decreased ability to perform your work and daily activities. Some patients also complained of not being able to control their body temperature and it is experienced from being very uncomfortable to disabling. However description of a changing sweating pattern does not give a comprehensive picture of the permanently disabled thermoregulation. Consequences of this go far

beyond some discomfort wearing damp, in some cases dripping clothes and showing up in public.

A reduced efficiency in maintaining normal body temperature in warm environments is consistent with the reduced ability or complete inability to sweat above the nipple line, a common ETS outcome first shown by Dr. Kotzareff. For a fully clothed person, only the hands, cranial region and neck are typically exposed. In a hot environment, a normal person's body is cooled primarily by evaporation of water vapor through the warmest areas of exposed skin. These areas are associated with the head and neck, which under very warm circumstances or vigorous exercise, visibly show moisture (sweat) accumulating as part of the cooling process. For an ETS patient that has lost ability to sweat from cranium, neck, and arms, an increased amount of body heat must be rejected via transpiration/sweating involving skin of the lower body. Unfortunately, this skin is generally at a lower temperature and usually covered by clothing - both factors that reduce the cooling efficiency and result in poor thermoregulation. An uncomfortably warm sensation and accumulation of sweat on large areas of skin underneath clothing can result. This is one theory on the aetiology of the increased sweating phenomenon after sympathectomy. However one of the pioneers of the procedure, Dr Lin, who performed over 7000 procedures, disputes the compensatory nature of the so called Compensatory Sweating. According to him this is a result of the dysregulated thermoregulation and hypothalamus. He objects to using the "Compensatory" term, he sees as misleading. Postoperative sweating phenomenon is a reflex response between sympathetic system and Hypothalamus. "It is absolutely not a compensatory mechanism. The term of “Reflex sweating” instead of compensatory sweating is used. Hypothalamus is the center of Autonomic Nervous System, which influences human mind, mentality and endocrine system. For this sake, Dr. Lin emphasized, “Endoscopic Sympathetic Surgery helps us open a gate to Autonomic Nervous System”.

There is much disagreement among ETS surgeons about the best surgical method, optimal location for nerve dissection, and as to the nature and extent of the consequent primary effects and side effects. The internet now features many websites run by surgeons extolling the benefits of ETS backed by patient testimonials. However, there are also many websites run by disabled ETS victims who complain of severe adverse reactions and lack of adequate informed consent. Several online discussion forums are dedicated to the subject of ETS surgery, where both positive and negative patient testimonials abound, but considering that this is an elective surgery for a benign condition, even a small number of badly affected number of patients is a high number.

In 2003, ETS was banned in its birthplace, Sweden, due to overwhelming complaints by disabled patients. In 2004, Taiwanese health authorities banned the procedure on patients under 20 years of age. In other countries it is highly unregulated procedure. Although it was never evaluated for safety and adverse effects, sympathectomy is listed on Medical Benefits Scheme, and is freely available to public patients.

In 2006, the FinOHTA group, the Finnish Office for Health Technology Assessment, showed in a review that there were strong indications of side effects as a result of this surgery.

• *No systematic reviews, meta-analyses, or clinical trials that evaluated the* effectiveness of endoscopic thoracic sympathectomy for treating facial blushing were identified. However, we have identified four case series related to the request (Drott et al. 1998, Rex et al. 1998, Telaranta 1998, Yilmaz et al. 1996). These studies were conducted in three countries (Sweden, Finland and the Netherlands).

• The four case series were not critically appraised because they are prone to bias and have significant methodological problems. These studies represent level IV evidence according to the NHMRC criteria and one should not draw firm conclusions from their findings.

• To date, the benefits or side effects associated with endoscopic thoracic sympathectomy for treating facial blushing have not been properly evaluated and reported. (Omar Ahmed PhD Centre for Clinical Effectiveness Monash Medical Centre Australia*)*

Other long term adverse effects: Ultrastructural Changes in the Cerebral Artery Wall Induced by Long-Term Sympathetic Denervation Sympathectomy eliminates the psychogalvanic reflex Cervical sympathectomy reduces the heterogeneity of oxygen saturation in small cerebrocortical veins Sympathetic denervation is one of the causes of Mönckeberg's sclerosis T2-3 sympathectomy suppressed baroreflex control of heart rate in the patients with palmar hyperhidrosis. We should note that baroreflex response for maintaining cardiovascular stability is suppressed in the patients who received the ETS. ETS patients should be warned that these mechanisms may play a role in the development of exertional heat stroke. Morphofunctional changes in the myocardium following sympathectomy.

In none of the limbs studied after sympathectomy could an increase in blood flow be produced reflexly by warming; in the majority of instances the opposite response, a decrease in blood flow was observed. One patient with documented transection of the spinal cord above T5 behaved like subjects after surgical sympathectomy. Retarded adaptation of hemodynamics to a sudden start of exercise after sympathectomy. The significant fall in left circumflex coronary flow was proportional to the decline in external heart work due to sympathectomy both at rest and under exercise. Chemical sympathectomy is associated with increased pulmonary metastases.

History

Sympathectomy developed in the mid-19th century, when it was learned that the autonomic nervous system runs to almost every organ, gland and muscle system in the body. It was surmised that these nerves play a role in how the body regulates many different body functions in response to changes in the environment, exercise and emotion.

The first sympathectomy was performed by Alexander in 1889. Since the sympathetic nervous system was well known to affect many body systems, the surgery was performed in attempts to treat many conditions, including idiocy, goitre, epilepsy, glaucoma, and angina pectoris. Thoracic sympathectomy has been indicated for hyperhidrosis (excessive sweating) since 1920, when Kotzareff showed it would cause anhidrosis (total inability to sweat) from the nipple line upwards.

A lumbar sympathectomy was also developed and used to treat excessive sweating of the feet and other ailments, and typically resulted in impotence in men. Lumbar sympathectomy is still being offered as a treatment for plantar hyperhidrosis, or as a treatment for patients who have a bad outcome (extreme 'compensatory sweating') after thoracic sympathectomy for palmar hyperhidrosis or blushing; extensive sympathectomy risks hypotension.

Sympathectomy itself is relatively easy to perform; however, accessing the nerve tissue in the chest cavity by conventional surgical methods was difficult, painful, and spawned several different approaches. The posterior approach was developed in 1908, and required resection (sawing off) of ribs. A supraclavical (above the collar-bone) approach was developed in 1935, which was less painful than the posterior, but was more prone to damaging important nerves and blood vessels.

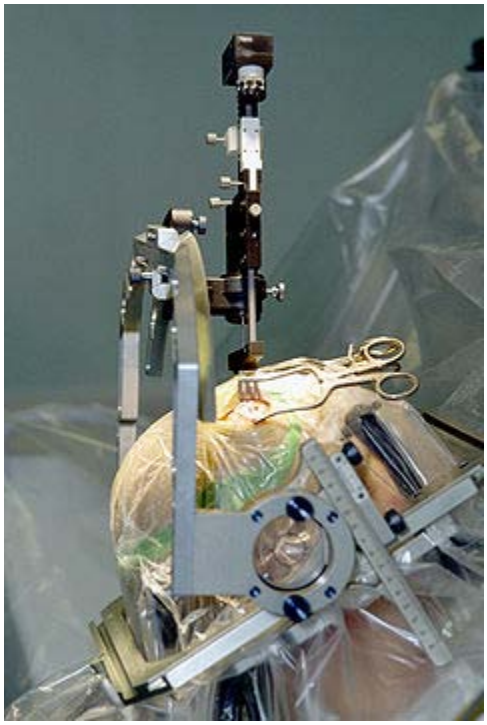
Because of these difficulties, and because of disabling sequelae associated with sympathetic denervation, conventional or "open" sympathectomy was never a very popular procedure, although it continued to be practiced for hyperhidrosis, Raynaud's disease, and various psychiatric disorders. With the popularization of lobotomy in the 1940s, sympathectomy fell out of favor as a form of psychosurgery.

The endoscopic version of thoracic sympathectomy was pioneered by Goren Claes and Christer Drott in Sweden in the late 1980s. The development of endoscopic "minimally invasive" surgical techniques have decreased the recovery time from the surgery and increased its popularity. Today, ETS surgery is practiced in many countries throughout the world.

In the mid-1990s a group of Swedish ETS patients complaining of disabling side effects formed the organization FFSO (people disabled by sympathectomy). The group grew to over 300 members and their work led to the procedure being banned in Sweden. The two surgeons who pioneered the technique, Drott and Claes, moved their practice from Sweden. They still perform the surgery.

Neurosurgery

Neurosurgery



Occupation	
Activity sectors	Surgery
Description	
Education required	Doctor of Medicine
Fields of employment	Hospitals, Clinics

Neurosurgery (or **neurological surgery**) is the medical specialty concerned with the prevention, diagnosis, treatment and rehabilitation of disorders that affect any portion of the nervous system including the brain, spinal column, spinal cord, peripheral nerves, and extra-cranial cerebrovascular system.

Education and training

In the United States, a neurosurgeon must generally complete four years of college, four years of medical school, a year-long internship (PGY-1) that is usually affiliated with their residency program, and five to six years of neurosurgery residency (PGY-2-6). Most, but not all, residency programs have some component of basic science or clinical research. Neurosurgeons may pursue an additional training in a fellowship, after residency or in some cases, as a senior resident. These fellowships include pediatric

neurosurgery, neurocritical care, functional and stereotactic surgery, surgical neuro-oncology, neurovascular surgery, Interventional neuroradiology, or skull base surgery. Neurosurgeons can also pursue fellowship training in neuropathology and neuro-ophthalmology.

In the UK students must earn A*- C Grades at GCSE (General Certificate of Secondary Education), then they must also achieve A*- C at A levels in Chemistry with at least one other Science or Maths. Also a UKCAT (UK Clinical Aptitude Test) or BMAT (BioMedical Admissions Test) can be used to gain access into some Medical Schools. Students have to study medicine for 5 years and achieve an MBBS qualification (Bachelor of Medicine and Bachelor of Surgery). Then the student must perform Foundation training lasting normally 2 years, this is a paid training job in a hospital or clinical situation setting covers a range of Medical specialties including Surgery. Core Surgical training is then taken which lasts for 2 years the difference in this is that the training would be themed towards a particular speciality.

Neurosurgical methods

Neuroradiology methods are used in modern neurosurgical diagnosis and treatment. computer assisted imaging computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), magnetoencephalography (MEG) and the development of stereotactic surgery. Some neurosurgical procedures involve the use of MRI and functional MRI intraoperatively.

Microsurgery is utilized in many aspects of neurological surgery. Microvascular anastomosis are required when EC-IC surgery is performed. The clipping of aneurysms is performed using a microscope. Minimally invasive spine surgery utilizes relies on these techniques. Procedures such as microdiscectomy, laminectomy, and artificial discs rely on microsurgery.

Minimally invasive endoscopic surgery is utilized by neurosurgeons. Techniques such as endoscopic endonasal surgery is used for pituitary tumors, craniopharyngiomas, chordomas, and the repair of cerebrospinal fluid leaks. Ventricular endoscopy is used for colloid cysts and neurocysticercosis. Endoscopic techniques can be used to assist in the evaculation of hematomas and trigeminal neuralgia. Repair of craniofacial disorders and disturbance of cerebrospinal fluid circulation is done by neurosurgeons, and depending on the situation, plastic surgeons. Conditions such as chiari malformation, craniosynostosis, and syringomyelia are treated. This is called cranioplasty.

Neurosurgeons are involved in Stereotactic Radiosurgery along with Radiation Oncologists for tumor and AVM treatment. Radiosurgical methods such as Gamma knife and Cyberknife are used.

Neurosurgeons have begun to utilize endovascular image guided procedures for the treatment of aneurysms, AVMs, carotid stenosis, strokes, and spinal malformations, and vasospasms. Also, nonvascular procedures such as Vertoplasty and Kyphoplasty are used

by neurosurgeons. Techniques such as angioplasty, stenting, clot retrieval, embolization, and diagnostic angiography are utilized.

Conditions

Other conditions treated by neurosurgeons include:

- Spinal disc herniation
- Cervical spinal stenosis and Lumbar spinal stenosis
- Hydrocephalus
- Head trauma (brain hemorrhages, skull fractures, etc.)
- Spinal cord trauma
- Traumatic injuries of peripheral nerves
- Infections
- Tumours of the spine, spinal cord and peripheral nerves
- Intracerebral hemorrhage, such as subarachnoid hemorrhage, intraparenchymal, and intraventricular hemorrhages
- Some forms of drug-resistant epilepsy
- Some forms of movement disorders (advanced Parkinson's disease, chorea) – this involves the use of specially developed minimally invasive stereotactic techniques (functional, stereotactic neurosurgery) such as ablative surgery and deep brain stimulation surgery
- Intractable pain of cancer or trauma patients and cranial/peripheral nerve pain
- Some forms of intractable psychiatric disorders
- Vascular malformations (i.e., arteriovenous malformations, venous angiomas, cavernous angiomas, capillary telangectasias) of the brain and spinal cord
- Peripheral neuropathies such as carpal tunnel syndrome and ulnar neuropathy
- Moyamoya disease

Chapter 11

Craniotomy and Decompressive Craniectomy

Craniotomy

	Intervention: Craniotomy
ICD-10 code:	
ICD-9 code:	01.2
Other codes:	

A **craniotomy** is a surgical operation in which a bone flap is (temporarily) removed from the skull, to access the brain. Craniotomies are often a critical operation performed on patients suffering from brain lesions or traumatic brain injury (TBI), and can also allow doctors to surgically implant deep brain stimulators for the treatment of Parkinson's disease, epilepsy and cerebellar tremor. The procedure is also widely used in neuroscience for extracellular recording, brain imaging, and for neurological manipulations such as electrical stimulation and chemical titration.

Human craniotomy is usually performed under general anesthesia but can be also done with the patient awake using a local anaesthetic; the procedure generally does not involve significant discomfort for the patient. In general, a craniotomy will be preceded by an MRI scan which provides a picture of the brain that the surgeon uses to plan the precise location for bone removal and the appropriate angle of access to the relevant brain areas. The amount of skull that needs to be removed depends to a large extent on the type of surgery being performed. The bone flap is then replaced using titanium plates and screws or another form of fixation (wire, suture, ...etc).

Craniotomy is distinguished from craniectomy (in which the skull flap is not immediately replaced, allowing the brain to swell, thus reducing intracranial pressure) and from trepanation, the creation of a burr hole through the cranium in to the dura mater.

Decompressive craniectomy

Intervention:
Decompressive craniectomy

ICD-10 code:
ICD-9 code: 01.2
Other codes:

Decompressive craniectomy is a neurosurgical procedure in which part of the skull is removed to allow a swelling brain room to expand without being squeezed. It is performed on victims of traumatic brain injury and stroke. Use of the surgery is controversial.

The procedure evolved from a primitive form of surgery known as trephining or trepanning. The older procedure, while common in prehistoric times, was deprecated in favor of other, less invasive treatments as they were developed; although it was still performed with some frequency prior to the twentieth century, its resurgence in modern form became possible only upon the development of precision cutting tools and sophisticated post-operative care such as antibiotics.

Results of clinical trials

Reduction of intracranial pressure

Though the procedure is considered a last resort, some evidence suggests that it does improve outcomes by lowering intracranial pressure (ICP), the pressure within the skull. Raised intracranial pressure is very often debilitating or fatal because it causes compression of the brain and restricts cerebral blood flow. The aim of decompressive craniectomy is to reduce this pressure. The part of the skull that is removed is called a bone flap. A study has shown that the larger the removed bone flap is, the more ICP is reduced.

Other effects

In addition to reducing ICP, studies have found decompressive craniectomy to improve cerebral perfusion pressure and cerebral blood flow in head injured patients.

Decompressive craniectomy is also used to manage major strokes, associated with "malignant" edema and intracranial hypertension. The pooled evidence from three randomised controlled trials in Europe supports the retrospective observations that early (within 48 hours) application of decompressive craniectomy after "malignant" stroke may result in improved survival and functional outcome in patients under the age of 55, compared to conservative management alone.

The procedure is recommended especially for young patients in whom ICP is not controllable by other methods. Age of greater than 50 years is associated with a poorer outcome after the surgery.

Complications

Infections such as meningitis or brain abscess can occur after decompressive craniectomy.

Children

In severely head injured children, a study has shown that decompressive craniectomy resulted in good recovery in all children in the study, suggesting the procedure has an advantage over non-surgical treatment in children. In one of the largest studies on pediatric patients, Jagannathan et al. found a net 65% favorable outcomes rate in pediatric patients for accidental trauma after craniectomy when followed for more than five years. Only three patients were dependent on caregivers. This is the only prospective randomised controlled study to date to support the potential benefit of decompressive craniectomy following traumatic brain injury.

Follow-up treatment

After a craniectomy, the risk of brain injury is increased, particularly after the patient heals and becomes mobile again. Therefore, special measures must be taken to protect the brain, such as a helmet or a temporary implant in the skull.

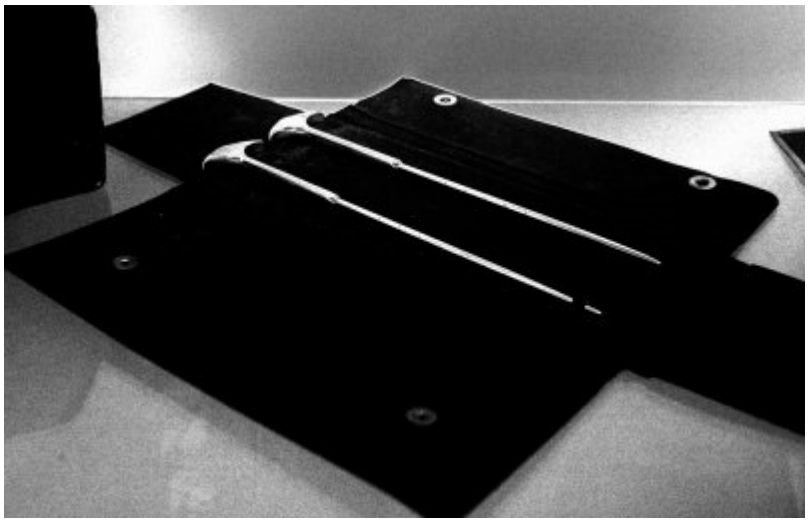
When the patient has healed sufficiently, the opening in the skull is usually closed with a cranioplasty. If possible, the original skull fragment is preserved after the craniectomy in anticipation of the cranioplasty.

Ongoing trials

Two prospective randomised controlled trials are currently being run in an attempt to provide Class I evidence on the role of surgical decompression in the treatment of raised intracranial pressure after severe head injury. The RESCUEicp study is an international multicentre trial, coordinated by the University of Cambridge Academic Neurosurgery Unit and the European Brain Injury Consortium (EBIC) and the DECRA trial is run and coordinated by the Australian centres.

Chapter 12

Lobotomy



Orbitoclast, used in transorbital lobotomy

Lobotomy (Greek: λοβός – *lobos*: "lobe (of brain)"; τομή – *tome*: "cut/slice") is a neurosurgical procedure, a form of psychosurgery, also known as a **leukotomy** or **leucotomy** (from the Greek λευκός – *leukos*: "clear/white" and *tome*). It consists of cutting the connections to and from the prefrontal cortex, the anterior part of the frontal lobes of the brain. While the procedure, initially termed a leukotomy, has been controversial since its inception in 1935, it was a mainstream procedure for more than two decades, prescribed for psychiatric (and occasionally other) conditions—this despite general recognition of frequent and serious side-effects. The Nobel Prize for Physiology or Medicine of 1949 was awarded to António Egas Moniz "for his discovery of the therapeutic value of leucotomy in certain psychoses". The heyday of its usage was from the early 1940s until the mid-1950s when modern neuroleptic (antipsychotic) medications were introduced. By 1951 almost 20,000 lobotomies had been performed in the United States. The decline of the procedure was gradual rather than precipitous. In Ottawa's psychiatric hospitals, for instance, the 153 lobotomies performed in 1953 were reduced to 58 by 1961, after the arrival in Canada of the antipsychotic drug chlorpromazine in 1954.

Context

The lobotomy was one of a series of radical and invasive physical therapies developed in Europe in the first half of the twentieth century. These psychiatric innovations signaled a break with a culture relegating psychiatric patients to asylums, which had prevailed because most serious forms of mental illness were treated only unsatisfactorily by extreme measure, or as unamenable to treatment. These new early twentieth century physical therapies, described as "heroic" in the sense of a desperate last-ditch act to save a life, included malarial therapy for general paresis of the insane (1917), barbiturate induced deep sleep therapy (1920), insulin shock therapy (1933), cardiazol shock therapy (1934), and electroconvulsive therapy (1938).

The development of the leukotomy procedure by Moniz in 1936, took place at a time when all of the above therapeutic interventions were extreme and experimental forms of therapy and most posed serious risks to the health of the patients who underwent them. Leukotomy was seen by many psychiatrists as no more severe than therapies such as insulin or cardiazol shock; these apparently successful procedures conceived for the treatment of patients suffering severe mental illnesses helped to create the intellectual climate and medical and social warrants that allowed a surgical procedure as radical and irreversible as leukotomy to appear as a viable and even necessary proposition. Moreover, Joel Braslow argues that from malarial therapy onward to lobotomy, physical psychiatric therapies "spiral closer and closer to the interior of the brain" with this organ increasingly taking "centre stage as a source of disease and site of cure." For Roy Porter, these often violent and invasive psychiatric interventions are indicative of both the well-intentioned desire of psychiatrists to find some medical means of alleviating the suffering of the thousands of patients in psychiatric hospitals in the twentieth century and also the relative lack of social power of those same patients to resist the increasingly radical and even reckless interventions of asylum doctors.

Pioneers

Gottlieb Burckhardt

In December 1888 Gottlieb Burckhardt, a psychiatrist with little experience of surgery, made one of the first forays into the field of psychosurgery when he operated on six patients, two women and four men aged between 26 and 51, in a private psychiatric hospital in Switzerland. Their diagnoses were, variously, one of chronic mania, one of primary dementia and four of original paranoia (*primäre Verrücktheit*, an obsolete diagnostic category sometimes anachronistically equated with schizophrenia) and, according to Burckhardt's case notes, they exhibited serious psychiatric symptoms such as auditory hallucinations, paranoid delusions, aggression, excitement and violence. He operated on the frontal, temporal, and tempoparietal lobes of these patients. The results were not overly encouraging as one patient died five days after the operation after experiencing epileptic convulsions, one improved but later committed suicide, another two showed no change, and the last two patients became "quieter". This equated to a success rate of 50%. Complications consequent to the procedure included epilepsy (in

two patients), motor weakness, "word deafness" and sensory aphasia. Only two patients are recorded as having no complications.

The theoretical basis of Burckhardt's action rested on three propositions. The first was that mental illness had a physical basis and that disordered minds were merely a reflection of disordered brains. Next, the associationist viewpoint of nerve functioning which conceived the nervous system as operating according to the following threefold division of labor: an input (or sensory or afferent) system, a connecting system which processed information and an output (or efferent or motor) system. The final assumption of Buckhardt's was that the brain was modular which meant that each mental module or mental faculty could be linked to a specific location in the brain. In accordance with such a viewpoint, Buckhardt postulated that lesions in specific areas of the brain might impact behavior in a specific manner. In other words, he thought that by cutting the connecting system, or second association state of brain's system of communication troubling symptoms might be alleviated without compromising either the nervous system's input or output systems. The procedure was aimed at relieving symptoms, not at curing a given mental disease. Thus, he wrote in 1891:

[I]f excitation and impulsive behaviour are due to the fact that from the sensory surfaces excitations abnormal in quality, quantity and intensity do arise, and do act on the motor surfaces, then an improvement could be obtained by creating an obstacle between the two surfaces. The extirpation of the motor or the sensory zone would expose us to the risk of grave functional disturbances and to technical difficulties. It would be more advantageous to practice the excision of a strip of cortex behind and on both sides of the motor zone creating thus a kind of ditch in the temporal lobe.

Burckhardt attended the Berlin Medical Conference of 1889, which was also attended by such heavyweight alienists as Victor Horsley, Valentin Magnan and Emil Kraepelin, and presented a paper on his brain operations. While his findings were subsequently widely reported in the psychiatric literature, the reviews were unremittingly negative and there was much ill ease generated by the surgical procedures he had performed. Kraepelin, writing in 1893, was scathing of Burckhardt's attempts, and stated that "he [Burckhardt] suggested that restless patients could be pacified by scratching away the cerebral cortex." Whilst Giuseppe Seppilli, the Italian professor of neuropsychiatry, remarked in 1891 that Burckhardt's view of the brain as modular did not "fit in well with the view held by most [experts] that the psychoses reflect a diffuse pathology of the cerebral cortex and [ran counter to] the conception of the psyche as a unitary entity".

Burckhardt wrote in 1891 that "Doctors are different by nature. One kind adheres to the old principle: first, do no harm (primum non nocere); the other one says: it is better to do something than do nothing (melius anceps remedium quam nullum). I certainly belong to the second category". The response to this statement was provided by the French alienist Armand Semelaigne when he wrote that "an absence of treatment was better than a bad treatment". After the publication of his impressive 81 page monograph on the subject in 1891, Burckhardt ended his research and practice of psychosurgery no doubt in part due to the ridicule he received from his colleagues over the methods he had employed.

Commenting on his monograph in 1891 the British psychiatrist William Ireland provided a succinct summation of his position:

Dr. Burckhardt has a firm faith in the view that the mind is made up of a number of faculties, holding their seats in distinct portions of the brain. Where excess or irregularity of function occurs he seeks to check it by ablation of a portion of the irritated centres. He defends himself from the criticisms which are sure to be directed against his bold treatment by showing the desperate character of the prognosis of the patients upon whom the operations were performed ...

Ireland, however, doubted that any English psychiatrist would have the "hardihood" to follow the path taken by Burckhardt.

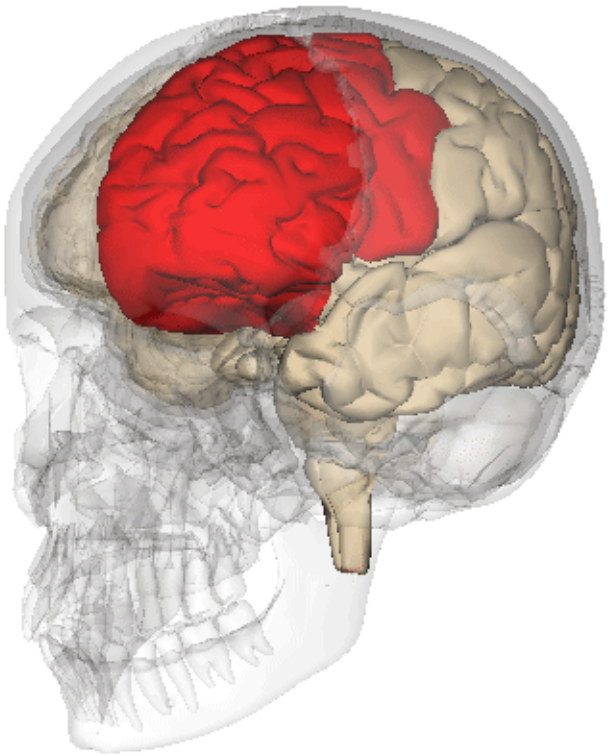
Egas Moniz

The next stage in the development of the procedure was provided by the Portuguese physician and neurologist António Egas Moniz, who was highly acclaimed for his work on cerebral angiography (radiographical visual of the blood vessels in the brain) in 1927. Despite having no clinical psychiatric experience and, indeed, little interest in psychiatry, in 1935 at the Hospital Santa Marta in Lisbon, he devised the surgery called prefrontal leukotomy which was carried out under his direction by the neurosurgeon Pedro Almeida Lima. He was also responsible for coining the term psychosurgery. The procedure involved drilling holes in the patient's head and destroying tissue in the frontal lobes by injecting alcohol. He later changed technique, using a surgical instrument called a leucotome that cut brain tissue by rotating a retractable wire loop (a quite different cutting instrument also used for lobotomies shares the same name). Between November 1935 and February 1936 Moniz and Lima operated on twenty patients, publishing their findings in the same year. Their own assessment was that 35% of the patients improved greatly, 35% improved moderately and that in the remaining 30% there was no change. The patients were aged between 27 and 62 years of age, twelve were female and eight were male. Nine of the patients were diagnosed as suffering from depression, six from schizophrenia, two from panic disorder, and one each from mania, catatonia and manic-depression with the most prominent symptoms being anxiety and agitation. The duration of the illness prior to the procedure varied from as little as four weeks to as much as 22 years, although all but four had been ill for at least one year. The post-operative follow-up assessment took place anywhere from one to ten weeks following surgery. The observed complications were less severe than in Burckhardt's sample as there were no deaths or epileptic convulsions and the most cited complication was fever.

The theoretical underpinnings of Moniz's *avant garde* psychosurgery were largely commensurate with the nineteenth century ones that formed the basis of Burckhardt's theories before him. Although in his later writings he referenced both the neuron theory of Ramón y Cajal and the conditioned reflex of Ivan Pavlov, in essence he simply interpreted this new neurological research in terms of the old psychological theory of associationism. He differed significantly from Burckhardt in that he did not think there

was any physical anatomical pathology in the brains of the mentally ill, but rather that their neural pathways were caught in fixed and destructive circuits As he wrote in 1936:

[The] mental troubles must have [...] a relation with the formation of cellulo-connective groupings, which become more or less fixed. The cellular bodies may remain altogether normal, their cylinders will not have any anatomical alterations; but their multiple liaisons, very variable in normal people, may have arrangements more or less fixed, which will have a relation with persistent ideas and deliria in certain morbid psychic states.



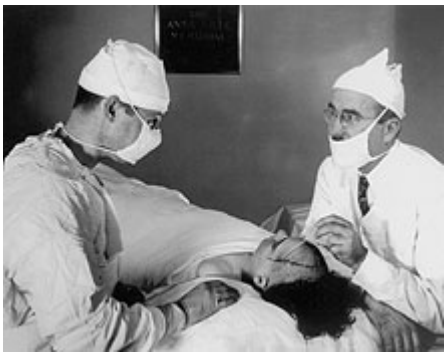
Left frontal lobe highlighted in red. Moniz targeted the frontal lobes in the leucotomy procedure which he first conceived in 1933.

The removal of these aberrant and fixed pathological brain circuits, therefore, might lead to some improvement in mental symptoms. Moniz believed that the brain would functionally adapt to such injury. A significant advantage of this approach was that, unlike the position adopted by Burckhardt, it was unfalsifiable according to the knowledge and technology of the time as the absence of a known correlation between physical brain pathology and mental illness could not disprove his thesis.

Traditionally, the question of why Moniz targeted the frontal lobes in particular has been answered by reference to a presentation by John Fulton and Carlyle Jacobsen at the Second International Congress of Neurology held in London in 1935. Fulton and Carlyle presented two chimpanzees who had undergone frontal lobectomies. The operation had had a pacifying effect on the two primates, who had previously suffered from behavioral disorders. It has been alleged that this provided the impetus and inspiration for Moniz to try the same technique on psychiatric patients. However, as Berrios points out, this conflicts with the fact that Moniz had told his colleague Lima in confidence as early as 1933 of his psychosurgical idea. Nor did he mention Fulton's and Carlyle's presentation as an influence when writing about the procedure in 1936. Indeed, as Kotowicz notes, his attention was drawn more to the case presented by Richard Brickner, at the same conference, of a patient who had had his frontal lobes ablated and, while experiencing a flattening of affect, had suffered no apparent decrease in intellect. Brickner had published on this case in 1932.

Moniz was given the Nobel Prize for medicine in 1949 for this work.

Walter Freeman



James Watts (left) and Walter Freeman performing a lobotomy

The American neurologist and psychiatrist Walter Freeman, who had also attended the London Congress of Neurology in 1935, was intrigued by Moniz's work, and with the help of his close friend, neurosurgeon James W. Watts, he performed the first prefrontal leukotomy in the United States in 1936 at the hospital of George Washington University in Washington. Freeman and Watts gradually refined the surgical technique and created the Freeman-Watts procedure (the "precision method", the standard prefrontal lobotomy).

The Freeman-Watts prefrontal lobotomy still required drilling holes in the scalp, so surgery had to be performed in an operating room by trained neurosurgeons. Walter

Freeman believed this surgery would be unavailable to those he saw as needing it most: patients in state mental hospitals that had no operating rooms, surgeons, or anesthesia and limited budgets. Freeman wanted to simplify the procedure so that it could be carried out by psychiatrists in mental asylums, which housed roughly 600,000 American inpatients at the time.

Inspired by the work of Italian psychiatrist Amarro Fiamberti, Freeman at some point conceived of approaching the frontal lobes through the eye sockets instead of through drilled holes in the skull. In 1945 he took an icepick from his own kitchen and began testing the idea on grapefruit and cadavers. This new "transorbital" lobotomy involved lifting the upper eyelid and placing the point of a thin surgical instrument (often called an orbitoclast or leucotome, although quite different from the wire loop leucotome described above) under the eyelid and against the top of the eyesocket. A mallet was used to drive the orbitoclast through the thin layer of bone and into the brain along the plane of the bridge of the nose, around fifteen degrees toward the interhemispherical fissure. The orbitoclast was mallated five centimetres into the frontal lobes, and then pivoted forty degrees at the orbit perforation so the tip cut toward the opposite side of the head (toward the nose). The instrument was returned to the neutral position and sent a further two centimetres into the brain, before being pivoted around twenty eight degrees each side, to cut outwards and again inwards (In a more radical variation at the end of the last cut described, the butt of the orbitoclast was forced upwards so the tool cut vertically down the side of the cortex of the interhemispherical fissure; the "Deep frontal cut".) All cuts were designed to transect the white fibrous matter connecting the cortical tissue of the prefrontal cortex to the thalamus. The leucotome was then withdrawn and the procedure repeated on the other side.

Freeman performed the first transorbital lobotomy on a live patient in 1946. Its simplicity suggested the possibility of carrying it out in mental hospitals lacking the surgical facilities required for the earlier, more complex procedure (Freeman suggesting that, where conventional anesthesia was unavailable, electroconvulsive therapy be used to render the patient unconscious). In 1947, the Freeman and Watts partnership ended as the latter was disgusted by Freeman's modification of the lobotomy from a surgical operation into a simple "office" procedure. Between 1940 and 1944, 684 lobotomies were performed in the United States. However, because of the fervent promotion of the technique by Freeman and Watts, those numbers increased sharply towards the end of the decade. In 1949, the peak year for lobotomies in the US, 5,074 procedures were undertaken, and by 1951 over 18,608 individuals had been lobotomised in the US.

Prevalence

Most lobotomy procedures were done in the United States, where approximately 40,000 people were lobotomized. In Great Britain, 17,000 lobotomies were performed, and the three Nordic countries of Finland, Norway and Sweden had a combined figure of approximately 9,300 lobotomies. Scandinavian hospitals lobotomized 2.5 times as many people per capita as hospitals in the US. Sweden lobotomized at least 4,500 people between 1944 and 1966, mainly women. This figure includes young children. In Norway

there were 2,500 known lobotomies. In Denmark there were 4,500 known lobotomies, mainly young women, as well as mentally retarded children.

Indications and outcomes: medical literature

According to the *Psychiatric Dictionary* published in 1970:

Prefrontal lobotomy is of value in the following disorders, listed in a descending scale of good results: affective disorders, obsessive-compulsive states, chronic anxiety states and other non-schizophrenic conditions, paranoid schizophrenia, undetermined or mixed type of schizophrenia, catatonic schizophrenia, and hebephrenic and simple schizophrenia. Good results are obtained in about 40 per cent of cases, fair results in some 35 per cent and poor results in 25 per cent are thereabouts. The mortality rate probably does not exceed 3 per cent. Greatest improvement is seen in patients whose premorbid personalities were 'normal', cyclothymic, or obsessive compulsive; in patients with superior intelligence and good education; in psychoses with sudden onset and a clinical picture of affective symptoms of depression or anxiety, and with behaviouristic changes such as refusal of food, overactivity, and delusional ideas of a paranoid nature.

Prefrontal lobotomy has also been used successfully to control pain secondary to organic lesions. In this case, the tendency has been to employ unilateral lobotomy, because of the evidence that a lobotomy extensive enough to reduce psychotic symptoms is not required to control pain.

According to the same source, prefrontal lobotomy reduces:

anxiety feelings and introspective activities; and feelings of inadequacy and self-consciousness are thereby lessened. Lobotomy reduces the emotional tension associated with hallucinations and does away with the catatonic state. Because nearly all psychosurgical procedures have undesirable side effects, they are ordinarily resorted to only after all other methods have failed. The less disorganized the personality of the patient, the more obvious are post-operative side effects. ...

Convulsive seizures are reported as sequelae of prefrontal lobotomy in 5 to 10 percent of all cases. Such seizures are ordinarily well controlled with the usual anti-convulsive drugs. Post-operative blunting of the personality, apathy, and irresponsibility are the rule rather than the exception. Other side effects include distractibility, childishness, facetiousness, lack of tact or discipline, and post-operative incontinence.

Criticism

As early as 1944 an author in the *Journal of Nervous and Mental Disease* remarked: "The history of prefrontal lobotomy has been brief and stormy. Its course has been dotted with both violent opposition and with slavish, unquestioning acceptance." Beginning in 1947 Swedish psychiatrist Snorre Wohlfahrt evaluated early trials, reporting that it is "distinctly hazardous to leucotomize schizophrenics" and lobotomy to be "still too

imperfect to enable us, with its aid, to venture on a general offensive against chronic cases of mental disorder" and stating that "Psychosurgery has as yet failed to discover its precise indications and contraindications and the methods must unfortunately still be regarded as rather crude and hazardous in many respects." In 1948 Norbert Wiener, the author of *Cybernetics*, said: "[P]refrontal lobotomy... has recently been having a certain vogue, probably not unconnected with the fact that it makes the custodial care of many patients easier. Let me remark in passing that killing them makes their custodial care still easier."

Concerns about lobotomy steadily grew. The USSR officially banned the procedure in 1950. Doctors in the Soviet Union concluded that the procedure was "contrary to the principles of humanity" and that it turned "an insane person into an idiot." By the 1970s, numerous countries had banned the procedure as had several US states. Other forms of psychosurgery continued to be legally practiced in controlled and regulated US centers and in Finland, Sweden, the UK, Spain, India, Belgium and the Netherlands.

In 1977 the US Congress created the National Committee for the Protection of Human Subjects of Biomedical and Behavioral Research to investigate allegations that psychosurgery—including lobotomy techniques—were used to control minorities and restrain individual rights. It also investigated the after-effects of surgery. The committee concluded that some extremely limited and properly performed psychosurgery could have positive effects.

By the early 1970s the practice of lobotomy had generally ceased, but some countries continued to use other forms of psychosurgery. In 2001 there were, for example, 70 operations in Belgium, about 15 in the UK and about 15 a year at Massachusetts General Hospital in Boston, while France had carried out operations on about 5 patients a year in the early 1980s.

Notable cases

- Rosemary Kennedy, sister of President John F. Kennedy, underwent a lobotomy at age 23 which left her permanently incapacitated.
- Howard Dully wrote a memoir of his late-life discovery that he had been lobotomized at age 12.
- New Zealand author and poet Janet Frame received a literary award the day before a scheduled lobotomy was to take place, and it was never performed.
- French Canadian singer Alys Robi underwent a lobotomy and later resumed singing professionally.
- Swedish modernist painter Sigrid Hjertén died following a lobotomy in 1948.
- Playwright Tennessee Williams's older sister Rose received a lobotomy which left her incapacitated for life; the episode is said to have inspired characters and motifs in certain of his works.

It is often said that when an iron rod was accidentally driven through the head of Phineas Gage in 1848, this constituted an "accidental lobotomy", or that this event somehow

inspired the development of surgical lobotomy a century later. According to the only book-length study of Gage, careful inquiry turns up no such link.

Literary and cinematic portrayals

Lobotomies have been featured in several literary and cinematic presentations that both reflected society's attitude towards the procedure and, at times, changed it. The 1946 novel *All the King's Men* by Robert Penn Warren described a lobotomy, saying it "would have made a Comanche brave look like a tyro [novice] with a scalping knife." The surgeon is portrayed as a repressed man who couldn't change others with love but instead resorted to "high-grade carpentry work." In Tennessee Williams's 1958 play, *Suddenly, Last Summer*, the protagonist is threatened with a lobotomy to stop her from telling the truth about her cousin Sebastian. The surgeon says, "I can't guarantee that a lobotomy would stop her *babbling*." Her aunt responds, "That may be, maybe not, but after the operation who would *believe* her, Doctor?"

A damning portrayal of the procedure is found in Ken Kesey's 1962 novel *One Flew Over the Cuckoo's Nest* and its 1975 movie adaptation. Several patients in the mental ward receive lobotomies in order to discipline or calm them. The operation is described as brutal and abusive, a "frontal-lobe castration". The book's narrator, Chief Bromden, is shocked: "There's nothin' in the face. Just like one of those store dummies." One patient's surgery changes him from an acute to a chronic mental condition. "You can see by his eyes how they burned him out over there; his eyes are all smoked up and gray and deserted inside."

Other sources include Sylvia Plath's 1963 novel *The Bell Jar*, in which the protagonist, Esther, reacts with horror to the "perpetual marble calm" of a lobotomized young woman named Valerie. Elliott Baker's 1964 novel and 1966 film version, *A Fine Madness,* portrays the dehumanizing lobotomy of a womanizing, quarrelsome poet who in the end is just as aggressive as ever. The surgeon is depicted as an inhumane crackpot. The 1982 biopic *Frances* includes a disturbing scene showing actress Frances Farmer undergoing transorbital lobotomy. The claim that a lobotomy was performed on Farmer (and that Freeman performed it) has been criticized as having little or no evidence supporting it.

In the 2010 Martin Scorsese psychological mystery-thriller film *Shutter Island* based on the novel of the same name set in the 1950s when lobotomy was considered an appropriate procedure by many in the psychiatric community, the main character, found to be criminally insane, is given the choice of facing up to the reality that he murdered his wife or be lobotomized. In the novel, it is clear he receives a lobotomy involuntarily after relapsing into insanity whereas the movie is ambiguous as to whether he faked his relapse in order to "die as a good man" by being lobotomized rather than "live as a monster" without the treatment. Dr. James Gilligan, a past director of Massachusetts' prison mental hospital and serving as a technical advisor stated:

“ We worked together to make sure the story reflected a true war that was going on in the mid-20th century within the psychiatric community: a war between those clinicians who wanted to treat these patients with new forms of psychotherapy, education and medicine, and those who regarded the violent mentally ill as incurable and advocated controlling their behavior by inflicting irreversible brain damage, including indiscriminate use of shock treatment and crude forms of brain surgery, such as lobotomies.

Chapter 13

Hemispherectomy and Bilateral Cingulotomy

Hemispherectomy

Intervention:
Hemispherectomy

ICD-10 code:
ICD-9 code: 01.52
Other codes:

Hemispherectomy is a surgical procedure where one cerebral hemisphere (half of the brain) is removed or disabled. This procedure is used to treat a variety of seizure disorders where the source of the epilepsy is localized to a broad area of a single hemisphere of the brain. It is solely reserved for extreme cases in which the seizures have not responded to medications and other less invasive surgeries.

History and changes

Hemispherectomy was first tried on a dog in 1888 by Friedrich Goltz. The first such operation on humans was done by Walter Dandy in 1923 for glioblastoma multiforme. In the 1960s and early 1970s, hemispherectomy involved removing half of the brain, but this resulted in unacceptable complications and side effects in many cases, predominantly filling of excessive body fluids in the skull with subsequent pressure to the remaining brain (known as hydrocephalus). The procedure was revitalized in children in the 1980s by Dr. Ben Carson at The Johns Hopkins Hospital. In many centers, the *functional hemispherectomy* has largely replaced this procedure, in which the temporal lobe is removed; a procedure known as corpus callosotomy is performed; and the frontal and occipital lobes are disconnected from the rest of the brain; however the traditional "anatomic" hemispherectomy has remained a viable procedure, due to its superiority in preventing future seizures compared with functional hemispherectomy.

Results

All hemispherectomy patients suffer at least partial hemiplegia on the side of the body opposite the removed or disabled portion, and may suffer problems with their vision as well.

This procedure is almost exclusively performed in children because their brains generally display more neuroplasticity, allowing neurons from the remaining hemisphere to take over the tasks from the lost hemisphere. This likely occurs by strengthening neural connections which already exist on the unaffected side but which would have otherwise remained small in a normally functioning, uninjured brain. One case, demonstrated by Smith & Sugar, 1975; A. Smith 1987, demonstrated that one patient with this procedure had completed college, attended graduate school and scored above average on intelligence tests. Studies have found no significant long-term effects on memory, personality, or humor after the procedure, and minimal changes in cognitive function overall. Generally, the greater the intellectual capacity of the patient prior to surgery, the greater the decline in function. Most patients end up with mild to severe mental retardation, which is usually already present before surgery. When resectioning the left hemisphere, evidence indicates that some advanced language functions (*e.g.,* higher order grammar) cannot be entirely assumed by the right side. The extent of advanced language loss is often dependent on the patient's age at the time of surgery.

Although initially thought to be limited solely to children, a recent study in 2007 by Dr. Shearwood McClelland III and Dr. Robert E. Maxwell indicated the long-term efficacy of anatomic hemispherectomy in carefully selected adults, with seizure control sustainable over multiple decades.

Foundations

The Hemispherectomy Foundation was formed in 2008 to assist families with children undergoing this procedure.

Bilateral cingulotomy

Intervention:
Bilateral cingulotomy

ICD-10 code:
ICD-9 code: 0.2
Other codes:

Bilateral cingulotomy is a form of psychosurgery, introduced in 1948 as an alternative to lobotomy. Today, it is mainly used in the treatment of obsessive-compulsive disorder, depression and addiction. It is also, rarely, used in the treatment of chronic pain. The objective of this surgical procedure is the severing of the supracallosal fibres of the cingulum bundle, which pass through the anterior cingulate gyrus.

Target

Bilateral Cingulotomy targets the anterior cingulate cortex, which is a part of the limbic system. This system is responsible for the integration of feelings and emotion in the human cortex. It consists of the cingulate gyrus, parahippocampal gyrus and the hippocampal formation.

Studies in patients that were a subject to bilateral cingulotomy, that involved fMRI analyses, showed that the anterior cingulate cortex has a key role in cognitive control and is highly likely to be involved in the control of attentional response, whereas the dorsal part of that region of the brain was not identified to be involved in such a process, although this is still under dispute. The function of the dorsal part of the cingulate cortex was connected to the sorting out and processing of conflicting information signals. In addition, neuroimaging studies also indicated that the anterior cingulate cortex participates in the modulation of cortical regions that are of higher order as well as sensory processing areas.

These findings have also been confirmed by stereotactic microelectrode analysis of single cortical neurons in a study, which involved nine patients undergoing bilateral cingulotomy. The study investigated the effect of performing attention demanding tasks on the activity of 36 neurons located in the anterior cingulate cortex. Upon analyzing of the results of the study it was concluded that the anterior cingulate cortex is indeed involved in the modification of cognitive tasks that require attention based on the fact that there was a change in the basal firing rate of neurons in that region during simulation of such tasks.

Neuroimaging also uncovered different sub-regions in the anterior cingulate cortex itself based on their function. It was proven that the caudal part of the anterior cingulate cortex plays a more important function in cognitive activities that involve attention, salience, interference and response competition. These results combined with electrophysiological investigation of the function of neurons in the anterior cingulate cortex have provided insights that can be used in the improvement of cingulotomy performed on patients treated for OCD. The basis behind this idea is the fact that a variation of certain tasks, Emotional Stroop tasks (ES), which have been particularly identified as exerting effects in OCD patients activate neurons in the more rostral part of the anterior cingulate cortex. Thus, theoretically if bilateral cingulotomy is performed in such patient in the rostral anterior cingulate cortex, better results should be obtained.

Moreover, OCD has been associated with a malformation of the basal ganglia . The function of this part of the human brain has been mapped to be composed of fiber tracks

associated with numerous parallel cortico-striato-thalamocortical circuits (CSTC), which are involved in sensorimotor, motor, oculomotor as well as the cognitive processes that are manifested by the limbic system. This pathway involves GABAergic inhibitory projections that serve as one of the means of communication between the different structures involved. It has been hypothesized that some forms of OCD are a result of disinhibition of a one or several of the circuits that operate in the CSTC. This is also indicated by a finding that showed a significant decrease in intracortical inhibition in OCD patients. Thus, lesions in the anterior cingulate cortex might contribute to the lessening of the disinhibition effect. This theory has been confirmed by another study which assessed the cortical inhibitory and excitatory mechanisms in OCD. The study measured the excitability of motor cortex, as well as intracortical inhibition in OCD patients and a control of healthy individuals. The results showed a significant decrease in intracortical inhibition, which resulted in a slowdown of interstimulus intervals by 3msec. In addition to its proximity to and association with the limbic system and the amygdala in particular, which plays a key role in emotional experience, the anterior cingulate cortex shares afferent and efferent pathways with a number of thalamic nuclei as well as the posterior cingulate and part of some parietal, frontal and supplementary motor cortex. All these underline the high likelihood that the anterior cingulate cortex must be linked to OCD.

Functional MRI analyses of the anterior cingulate cortex have also led to the introduction of bilateral cingulotomy for the treatment of chronic pain. Such application was introduced since the anterior cingulate cortex has been found to be related to the processing nociceptive information input. In particular the role of the anterior cingulate cortex is in the interpretation of how a stimulus affects a person rather than its actual physical intensity.

Procedure

In most cases the procedure starts with the medical team taking a number of CT scan X-ray images of the brain of the patient. This step ensures that the exact target, the cingulate cortex is mapped out, so that the surgeon can identify it. Then burr holes are created into the patient's skull using a drill. Lesions at the targeted tissue are made with the help of fine electrodes inserted very carefully at the right angle into the subject's brain based on plotting charts and making sure important arteries and blood vessels are intact. The electrode is placed in a probe , or a holder, with only its tip projecting. Upon the correct insertion of the holder into the brain tissue, air is injected and more scan images are taken. Then, after the medical team has made sure they are on the right track, the tip of the electrode is advanced to the plane of the cingulate where it is heated to 75-90 C. Once the first lesion is created it serves as a center around which several other lesions are created. In order to confirm whether lesions are made at the right place, scan images are taken postoperatively and analyzed.

Recent technological advances, however, have made bilateral cingulotomy a more precise operation. For example, nowadays a neurosurgical team that has to perform the procedure can use an MRI to identify the location of the anterior and posterior commissures. This

approach allows neurosurgeons to obtain a number of coronal images, which are then used to calculate the stereotactic coordinates of the place in the anterior cingulate cortex, where lesions need to be created. Moreover the MRI enables to differentiate more precisely the cell composition, and thus easily identify the gray matter in that region. This can then be further confirmed with the help of microelectrode recordings.

Side Effects

Patients usually recover from this operation over a period of 4 days. However, there are cases of subjects released from hospital after as few as 48 hours after the operation. The mild shorter postoperative complications that are most commonly related to bilateral cingulotomy are typical of head interventions and include but are not limited to nausea, vomiting, and headaches. However, in some cases patients exhibit seizures that sometimes appear up to two months after the surgical intervention. There is the discussion as to whether this is relevant and can be account to cingulotomy because such seizures were observed in patients that already had a history of this condition.

Case Studies

A recent study conducted at the Massachusetts General Hospital analyzed the outcome of bilateral cingulotomy in 44 patients for the treatment of OCD in the period between 1965 and 1986. Patients were followed up over a long term and evaluated based on several criteria: 1) how many of them were responders after a period of 6 months, 2) how many cingulotomies had a patient undergone before the examination of the effectiveness of the procedure, 3) did the patient show any significant change after the most recent procedure and 4) what were the side effects related to the procedure.

The follow up of the patients produced contradictory results, which indicated that bilateral cingulotomy is not the optimal treatment for OCD as of today. From the 44 patients only 32% could be classified as responders and showed significant improvement compared to the other subjects. Another 14% exhibited some signs of improvement. Multiple cingultomies lead to the increase in responders by 6% and to partial responders by 11%. However, the side effects associated with the procedure were numerous. Among the complaints that patients had after the surgery were deficits in memory and apathy although these were rarely observed. In addition, some of the subjects complained from some form of urinary disturbance ranging from urinary retention to incontinence. Hydrocephalus (2%) and seizures (2%) were also observed .

Another clinical study investigated the effect of bilateral cingulotomy for the treatment of refractory chronic pain. In this case 23 patients that were subject to 28 cingulotomies in total were followed up. The analyses aimed at determining how much the pain of each individual was affected after the procedure with the help of a questionnaire. In addition, the examiners tried to evaluate the social and family relations of the participants in the study. Based on the data obtained, cingulatomy for treatment of chronic pain showed promising results. 72% reported improvement in the level of pain experienced, and 50 % indicated that they no longer required painkillers after cingulotomy. More than half of the

patients also claimed that the surgical procedure was beneficial and contributed to the improvement of their social aspects.

Chapter 14

Hypophysectomy, Amygdalohippocampectomy and Intervertebral Disc Arthroplasty

Hypophysectomy

	Intervention: Hypophysectomy
ICD-10 code:	
ICD-9 code:	07.6
MeSH	D007016
Other codes:	

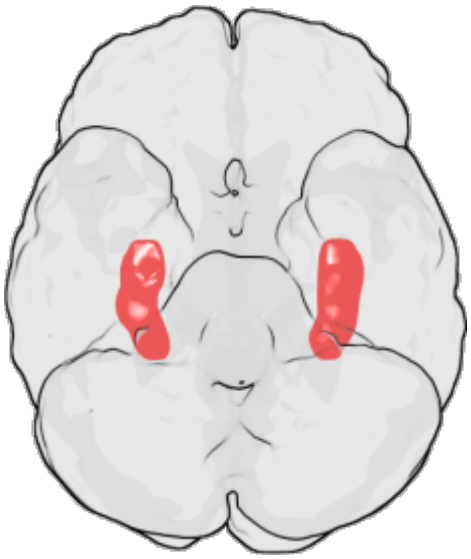
Hypophysectomy is the surgical removal of the hypophysis (pituitary gland). It is most commonly performed to treat tumors, especially craniopharyngioma tumors. Sometimes it is used to treat Cushing's syndrome due to pituitary adenoma. It is also applied in neurosciences (in experiments with lab animals) to understand the functioning of hypophysis.

Medications that are given as hormone replacement therapy following a complete hypophysectomy (removal of the pituitary gland) are Glucocorticoids and Thyroid Medications.

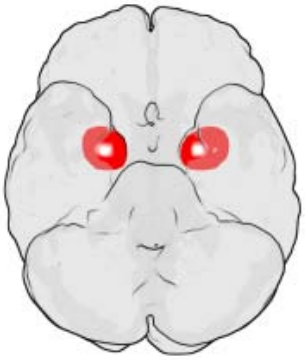
Complications

Hypophysectomy performed at any age causes atrophy of the thyroid and adrenal glands as well as asthenia and cachexia. When the procedure is performed before sexual maturity, the reproductive tract remains undeveloped and non-functional. There is also a general lack of growth. If performed after sexual maturity, there is loss of reproductive function along with atrophy of gonads and accessory reproductive structures.

Amygdalohippocampectomy



Hippocampus



Amygdalae

Amygdalohippocampectomy is a surgical procedure for the treatment of epilepsy. It consists of the removal of the hippocampus, which has a role in memory, spatial awareness, and navigation, and the amygdalae, which have a role in the processing and memory of emotional reactions, both structures forming part of the limbic system of the brain.

Amygdalohippocampectomy is used only when all other treatment options have failed to resolve the epilepsy. It is an effective treatment for most patients. However, possible adverse side effects include impaired memory and defects in visual perception.

Procedure

The amygalohippocampectomy is indicated when the focal point of the seizures can be anatomically localized to the hippocampus and amygdala. Normally, to be considered for this procedure, one must have failed all first-line treatments. The selective amygdalohippocampectomy will remove only the offending portions of the hippocampus and amygdala. When data from studies of the electrophysiology and neuropathy *vis-à-vis* temporal lobe epilepsy determines this area to be the origin of seizure activity, the removal of the hippocampus and amygdala is usually indicated. Computer imaging is sometimes used to guide this procedure. Patients continue normal activity after approximately six to eight weeks.

Statistics and side effects

Of 376 patients who had the amygdalohippocampectomy procedure performed, compared to other types of temporal lobe resections, two thirds of this population were reported free of disabling seizures. Some patients report defects in visual perception and impaired memory function.

Intervertebral disc arthroplasty

Artificial Disc Replacement (ADR), or **Total Disc Replacement (TDR)**, is a type of arthroplasty. It is a surgical procedure in which degenerated intervertebral discs in the spinal column are replaced with artificial devices in the lumbar (lower) or cervical (upper) spine. The procedure is used to treat chronic, severe low back pain and cervical pain resulting from degenerative disc disease.

Artificial disc replacement has been developed as an alternative to spinal fusion, with the goal of pain reduction or elimination, while still allowing motion throughout the spine. Another possible benefit is the prevention of premature breakdown in adjacent levels of the spine, a potential risk in fusion surgeries.

Regulation

United States

Two artificial discs have been approved by the FDA for use in the US: the Charite, manufactured by DePuy for use in the lumbar spine; and the ProDisc, manufactured by Synthes for use in the lumbar spine and cervical spine. They are FDA approved for one-level applications, after clinical trials were said to show patient improvement in motion and pain equivalent to spinal fusion. Two-level disc replacement surgery is considered experimental in the United States, but has been performed in Europe for many years.

While these two discs have received FDA approval, some insurance companies in the United States do not cover the surgery, still classifying it as experimental. Effective August 14, 2007, the Centers for Medicare & Medicaid Services (CMS) will not cover Lumbar Artificial Disc Replacement (LADR) for patients over the age of 60, on a national basis. Individual localities regulate the use of the procedure in patients 60 and under.

The Maverick, manufactured by Medtronic, has been prevented from entering the US market due to patent infringement litigation, ongoing as of September, 2010.

History

Artificial disc surgery is still relatively new in the United States, but has been used in Europe for more than 15 years.

The first device approved for use in the United States was the Charite artificial disc. Invented at Charite University Hospital in Berlin in the mid-1980s by the East German scientist, two-time Olympic champion in women's artistic gymnastics Karin Büttner-Janz and Kurt Schellnack, the disc received FDA approval in the United States in October 2004, following a four-year clinical trial.

The first surgeon to perform a Charite artificial disc surgery in the United States was Scott Blumenthal, M.D., a spine surgeon at Texas Back Institute in Plano, Texas. Blumenthal served as principal investigator for the Charite study in the US.

Dr. Rudolf Bertagnoli helped to develop Pro Disc and its surgical technique in Europe and has taught more than 2,500 surgeons how to perform the procedure.

Controversy

The New York Times, January 2008, raised concerns relating to the transparency of research being carried out by investors in Prodisc. Questions have been raised about the accuracy of that article.

A statement issued by The American Association of Orthopaedic Surgeons (AAOS) recommends caution in using the new devices, as the studies behind their approval were not designed to show their superiority, only that they produced results equivalent to existing treatments. The data shows that artificial disc replacement patients, when compared to spinal fusion patients, have a shorter recuperation period following surgery, but research also shows that spinal fusion patients show no better outcomes than patients undergoing physical therapy.

The AAOS also states that disc replacement requires a high level of technical skill for accurate placement, and has a significant level of risk if revision surgery is needed.

Members of AAOS and the American Association of Neurological Surgeons joined together as the Association for Ethics in Spine Surgery, formed to raise awareness of the ties between physicians and device manufactureres.

There are several class-action lawsuits pending against the Charite Artificial Disc, and reports of complications with the Pro Disc Artificial Disc implant when used in certain surgical situations.

Chapter 15

Rhizotomy

	Intervention: Rhizotomy
ICD-10 code:	
ICD-9 code:	03.1
MeSH	D019051
Other codes:	

A **rhizotomy** is a neurosurgical procedure that selectively severs problematic nerve roots in the spinal cord, most often to relieve the symptoms of neuromuscular conditions such as spastic diplegia and other forms of spastic cerebral palsy. In extreme cases, a rhizotomy may also be considered for a person suffering from severe back pain or a pinched nerve. The **selective dorsal rhizotomy** (SDR) for spastic cerebral palsy is the main use of rhizotomy for today's neurosurgeons. In this surgery, the spasticity-causing nerves are isolated and then targeted and destroyed. The sensory nerve roots, where spasticity is located, are first separated from the motor ones, and the nerve fibres to be cut are then identified via electromyographic stimulation. The one(s) producing spasticity are then selectively lesioned with tiny electrical pulses.

In spasticity, rhizotomy targets and destroys the damaged nerves that don’t receive gamma amino butyric acid, which is the core problem for people with spastic cerebral palsy. In this case, those nerves which, due to not receiving GABA, generate unusual electrical activity during the testing phase are considered to be the source of hypertonia, and are cut, while the remaining nerves and nerve routes carrying the correct messages remain fully intact.

Background

Dorsal rhizotomy or *selective dorsal rhizotomy* (SDR) is the most widely-used form of rhizotomy and is today a primary treatment for spastic diplegia, best done in the youngest years before bone/joint deformities from the pull of spasticity take place, but it can be performed safely and effectively on adults as well.

SDR is a permanent procedure that addresses the spasticity at its neuromuscular root: i.e., in the central nervous system that contains the misfiring nerves that cause the spasticity

of those certain muscles in the first place. After a rhizotomy, assuming no complications, the person's spasticity is usually completely eliminated, revealing the "real" strength (or lack thereof) of the muscles underneath.

Because the muscles may have been depending on the spasticity to function, there is almost always extreme weakness after a rhizotomy, and the patient will have to work very hard to strengthen the weak muscles with intensive physical therapy, and to learn habits of movement and daily tasks in a body without the spasticity. Rhizotomy's result is fundamentally unlike orthopedic surgical procedures, where any release in spasticity is essentially temporary.

Rhizotomy is usually performed on the pediatric spastic cerebral palsy population between the ages of 2 and 6, since this is the age range where orthopedic deformities from spasticity have not yet occurred, or are minimal. However, recent cases of successful SDR procedures among those with spastic diplegia across all major age ranges (years 3-40) has finally proven its universal effectiveness and safety regardless of the age of the spastic diplegic patient.

Although the concept of rhizotomy was conceived, tested and tried as early as, or possibly even earlier than, the 1930s, it was not in wide use for the treatment of spasticity until the last quarter of the 20th Century. Dr. Warwick Peacock of South Africa helped to begin the modern era of rhizotomy procedure in the early 1980s, and soon trained many other neurosurgeons in his technique; both Peacock and these other surgeons then went on to develop the procedure further using both their own intellectual refinements and refinements in medical equipment and technology that occurred from the 1980s through the 2000s.

Today, St. Louis Children's Hospital in St. Louis, Missouri has a "Center for Cerebral Palsy Spasticity" that is the only internationally-known clinic in the world to have conducted concentrated first-hand clinical research on SDR over an extended period. Its chief neurosurgeon in the field, Doctor T.S. Park (who was initially trained by Dr. Peacock), has performed thousands of SDR surgeries, some of them on adults, and is the originator of the L1-laminectomy modification to the SDR surgery in 1991, which sections the first dorsal root and enables the removal of significantly less spine-bone than in surgeries performed before 1991, as well as inherent release of the hip flexor muscles specifically as a result of that particular sectioning (prior to that, total hip flexor release was not necessarily possible). That L1-laminectomy modification has since become the standard, and SLCH has become internationally known as a major provider of the SDR surgery to those in need of it (for example, it is one of the first Google search results when inputting the word string "selective dorsal rhizotomy"). It is this clinic's opinion that patients with spastic diplegia or quadriplegia should have spasticity reduced first through SDR before undergoing muscle release or tendon release procedures, and other surgeons today share this view. A major qualifier in the cases taken on at SLCH, however, is that all of its adults have had only *mild* cases of spastic diplegia.

In September 2008, a ground-breaking SDR was performed that 'closed the gap' on concerns regarding age of the patient in SDR: Columbia-Presbyterian Children's Hospital's Richard C.E. Anderson performed an SDR surgery on a 28-year-old male with *moderate* spastic diplegia, which by the patient's own report has reduced his muscle tone nearly to the level of a "normal" person and enabled him to walk and exercise much more efficiently; also, Dr. Anderson in the past performed an SDR on a 16-year-old wheelchair-using female with *severe* spastic diplegia. Reportedly, that particular SDR enabled the young woman to ambulate, whereas before the surgery, she was too tight to do so.

Procedural outline

SDR begins with a 1- to 2-inch incision along the center of the lower back just above the waist. An L1 laminectomy is then performed: a section of the spine's bone, the spinous processes together with a portion of the lamina, are removed, like a drain-cap, to expose the spinal cord and spinal nerves underneath. Ultrasound and an x-ray locate the tip of the spinal cord, where there is a natural separation between sensory and motor nerves. A rubber pad is then placed to separate the motor from the sensory nerves. The sensory nerve roots, each of which will be tested and selectively eliminated, are placed on top of the pad, while the motor nerves are beneath the pad, away from the operative field.

After the sensory nerves are exposed, each sensory nerve root is divided into 3-5 rootlets. Each rootlet is tested with electromyography, which records electrical patterns in muscles. Rootlets are ranked from 1 (mild) to 4 (severe) for spasticity. The severely abnormal rootlets are cut. This technique is repeated for rootlets between spinal nerves L2 and S2. Half of the L1 dorsal root fibers are cut without EMG testing.

When testing and corresponding elimination are complete, the dura mater is closed, and fentanyl is given to bathe the sensory nerves directly. The other layers of tissue, muscle, fascia, and subcutaneous tissue are sewn. The skin is typically now closed with glue, but there are sometimes stitches to be removed from the back after 3 weeks. The surgery takes approximately 4 hours and typically involves one neurosurgeon, one anesthesiologist, and possibly an assortment of assisting physicians (as in the New York City September 2008 case). The patient then goes to the recovery room for 1–2 hours before being transferred to the intensive care unit overnight. Transfer from the ICU to a recovery room in the hospital is then done to enable direct post-surgical observation by the neurosurgeon and surgical team, but this usually lasts only about 3 days, during which the team performs range-of-motion tests that they record and compare to pre-surgery levels. After that short period, the patient, depending on circumstances and appropriateness, is either transferred to inpatient recovery or is linked to an intense outpatient exercise program and discharged from the hospital.

According to clinicians, it usually takes about one year from the date of surgery to achieve maximum results from SDR. However, videos from St. Louis Children's Hospital website have shown continued marked improvement as much as 5 years post-surgery, and presumably, if the person keeps exercising intensely, potential for continued

improvement and strengthening is, just as in a person born with normal muscle tone and range of motion, unlimited.

Complications

There is always abnormal sensitivity and tingling of the skin on the feet and legs after SDR because of the nature of the nerves that have been worked on, but this usually resolves within 6 weeks. There is no way to prevent the abnormal sensitivity in the feet. Transient change in bladder control may occur, but this also resolves within a few weeks.

If a certain degree of permanent numbness remains in certain leg-muscles, such as the quadriceps, ankles, and feet, this is usually not enough to prevent feeling and sensation, sensing of changes in temperature or pressure, etc. The affected muscle-areas simply feel less than before, and the trade-off in ease of movement is said to be immensely worth this change, should it occur.

In general, there is a *combined 5-10%* risk of any of the following more serious risks happening as a result of SDR. Because of technological advances in both the technology used in the surgery and also in the procedure itself, there have been no major cases of SDR that have had these side-effects.

- Permanent paralysis of the legs and bladder.
- Permanent impotence
- Sensory loss and/or numbness that is severe enough to not feel anything any more in the legs (not paralysis; movement is retained)
- Wound infection and meningitis - usually controlled with antibiotics
- Leakage of the spinal fluid through the wound, also repairable; the surgical team watches very closely post-surgery for this

A few patients in St. Louis experienced urinary tract infections and pneumonia, but these were successfully treated.

Those who walk independently before SDR

After the surgery all patients who were walking independently before surgery regained the independent walking within a few weeks after surgery. Patients maintain independent walking for the long term; when some have more difficulty walking independently they may eventually need an assistive device—however, in nearly all cases spasticity can be eliminated and the quality of independent walking improves; in many patients, physical therapy and braces become unnecessary after SDR. Orthopedic surgery is rarely required after SDR.

Those who walk with walkers or crutches before SDR

In children who are 2–7 years old and walk with a walker or crutches before SDR, independent walking after the procedure is possible. Once they have achieved independent walking, they can maintain it.

In children who are older than 7 years and walks with crutches, independent walking (inside or outside house) is possible. If they walk with walker at the age, they will most likely walk with a walker or crutches after the procedure, though it improves the quality of assisted walking and transition movements, and alleviates deformities of the legs. Many of these patients will need orthopedic surgeries after SDR.

Candidates for rhizotomy

Not all patients with spastic cerebral palsy benefit from SDR. For those under 18 years of age, rhizotomy requires that they be:

- At least 2 years of age
- Diagnosis of spastic diplegia, spastic quadriplegia or spastic hemiplegia
- Some form of independent mobility; for example, crawling or walking with or without an assistive device
- History of premature birth; if born at full term, child must have typical signs of spastic diplegia
- No severe damage to the basal ganglia on MRI examination
- Potential for improvement in functional skills

For adults between 19 and 40 years of age, rhizotomy requires:

- Diagnosis of spastic diplegia
- History of premature birth
- Currently ambulates independently *without* assistive device
- No fixed orthopedic deformities that either prevent current walking or would prevent walking after SDR; in these cases orthopedic releases are to be done first, after which SDR can be discussed.
- Potential for functional gains after SDR
- Intense motivation to attend intensive physical therapy and perform home exercise program

On the limited number of adult spastic diplegic people treated with rhizotomy, satisfactory functional gains in adult patients are similar to those in children.

Required circumstances

All candidates for rhizotomy must have good muscle strength in the legs and trunk. There must also be evidence of adequate motor control, or the ability to make reciprocal movements for crawling or walking, and to move reasonably quickly from one posture to

another. Chiefly, pediatric rhizotomy candidates are people with CP who have shown age-appropriate progression in motor development, but spasticity hampers the development of skills and/or causes gait patterns like the scissors gait. In adults, the primary requirements are that the person is able to ambulate independently, but spasticity limits energy, flexibility, walking speed and balance and sometimes causes pain/muscle spasms.

Conditions that preclude SDR

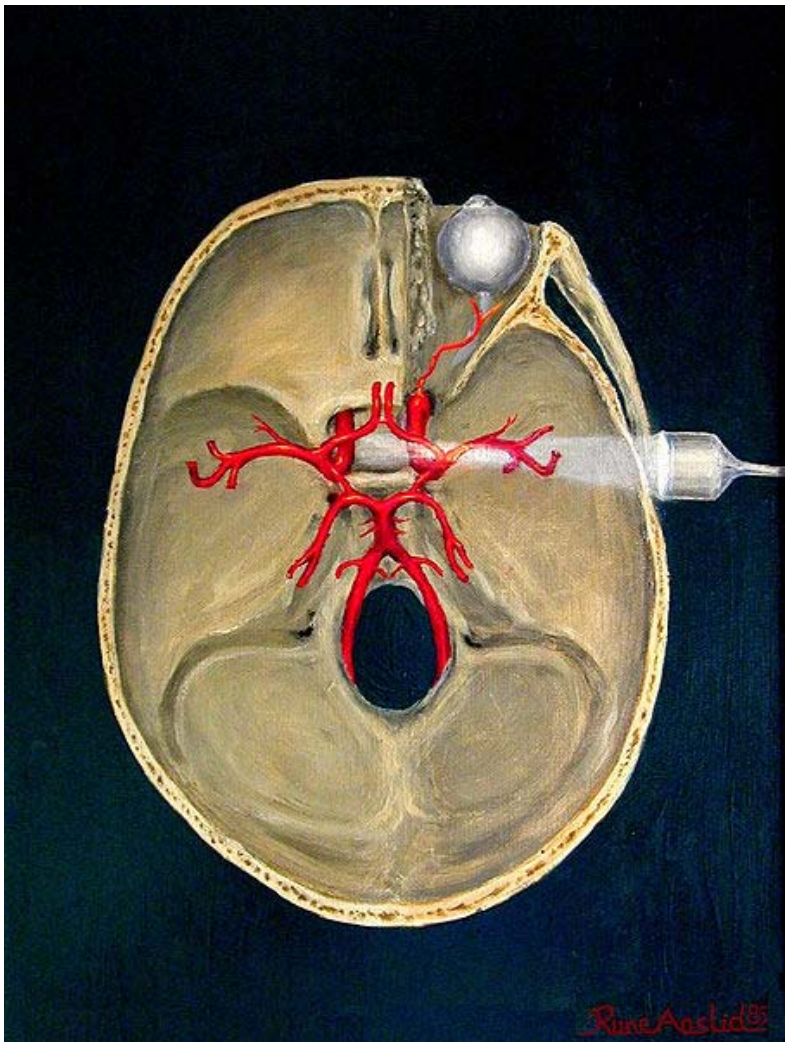
There are a few clinical situations in which it is likely that someone may not be a candidates for the surgery. These situations include those who have suffered meningitis, a congenital (birth-originating) brain infection, congenital hydrocephalus unrelated to the person's premature birth, a person who has suffered head trauma, or a person with some sort of familial disease (e.g., those with hereditary spastic paraplegia are said to not be SDR candidates). Also precluded are people who have a "mixed" CP with predominant rigidity or dystonia, significant athetosis, or ataxia; and those who have very severe scoliosis. However, as with any procedure, an individual evaluation is needed in all instances to determine eligibility.

Post-surgical restrengthening

Most rehabilitation from SDR is done on an outpatient basis, though it may also include an initial several-week inpatient component (but typically does not). Typical base restrengthening and restoration of full ambulatory function takes about twelve weeks (3 months) of intensive physical therapy 4-5 times per week, but subsequent buildup and maintenance beyond that initial several-week period is just as necessary, and may require continued 4-5 times per week therapy as much as 6 months postoperatively, for a total of about a year and four months after surgery in order to achieve *maximum basic* functionary movement from the surgery. Beyond that point, any continued strengthening is, as with any person's exercise regimen, undertaken strictly by the individual's own choice and direction.

Chapter 16

Transcranial Doppler



Transcranial doppler insonation of the cerebral circulation

Transcranial doppler ultrasound analyzer of blood velocity

Transcranial Doppler (TCD) is a test that measures the velocity of blood flow through the brain's blood vessels. Used to help in the diagnosis of emboli, stenosis, vasospasm from a subarachnoid hemorrhage (bleeding from a ruptured aneurysm), and other problems, this relatively quick and inexpensive test is growing in popularity in the United States. The equipment used for these tests is becoming increasingly portable, making it possible for a clinician to travel to a hospital, doctor's office or nursing home for both inpatient and outpatient studies. It is often used in conjunction with other tests such as MRI, MRA, carotid duplex ultrasound and CT scans.

Methods

Two methods of recording may be used for this procedure. The first uses "B-mode" imaging, which displays a 2-dimensional image as seen by the ultrasound probe. Once the desired blood vessel is found, blood flow velocities may be measured with a pulsed doppler probe, which graphs velocities over time. Together, these make a duplex test. The second method of recording uses only the second probe function, relying instead on the training and experience of the clinician in finding the correct vessels.

Applications of TCD

Clinical routine transcranial Doppler (TCD) ultrasound examination of the intracranial arteries was demonstrated to be possible in 1982 by Aaslid and colleagues. The value obtained for a particular artery is the velocity of blood flowing through the vessel, and unless the diameter of that vessel is established by some other means it is not possible to determine the actual blood flow. Thus TCD is primarily a technique for measuring relative changes in flow. The clinical utility of the technique is now well established for a number of different disease processes. The technology assessment report of the American Academy of Neurology published in 1990 stated that TCD has established value in the assessment of patients with intracranial stenosis, collaterals, subarachnoid hemorrhage, and brain death.

How it works

Blood flow velocity is recorded by emitting a high-pitched sound wave from the ultrasound probe, which then bounces off of various materials to be measured by the same probe. A specific frequency is used (usually a multiple of 2 MHz), and the speed of the blood in relation to the probe causes a phase shift, wherein the frequency is increased or decreased. This frequency change directly correlates with the speed of the blood, which is then recorded electronically for later analysis. Normally a range of depths and angles must be measured to ascertain the correct velocities, as recording from an angle to the blood vessel yields an artificially low velocity.

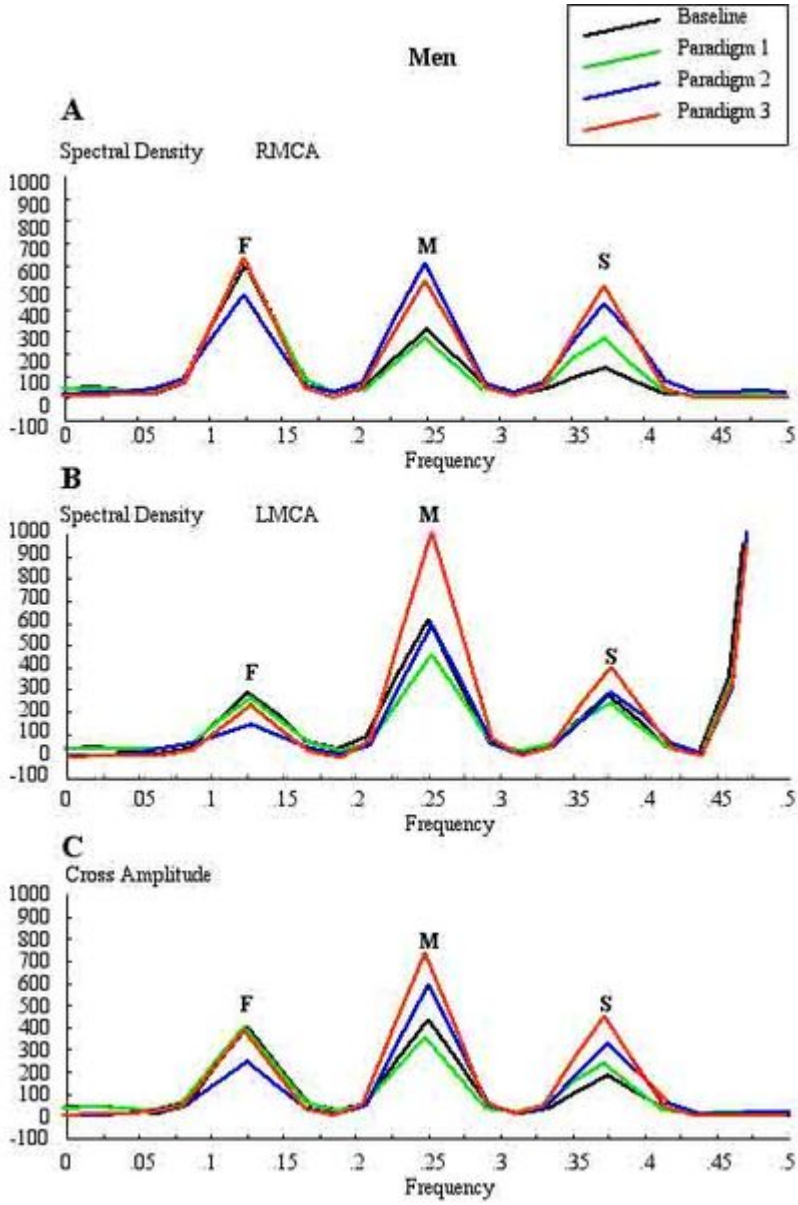
Because the bones of the skull block the transmission of ultrasound, regions with thinner walls - insonation windows - must be used for analyzing. For this reason, recording is performed in the temporal region above the cheekbone/zygomatic arch, through the eyes, below the jaw, and from the back of the head. Patient age, gender, race and other factors affect bone thickness, making some examinations more difficult or even impossible. Most can still be performed to obtain acceptable responses, sometimes requiring using alternate sites from which to view the vessels.

Functional Transcranial Doppler (fTCD)

Functional transcranial Doppler sonography (fTCD) is a neuroimaging tool for measuring cerebral blood flow velocity changes due to neural activation during cognitive tasks. Functional TCD utilizes pulse-wave Doppler technology to record blood flow velocities in the anterior, middle, and posterior cerebral arteries. Similar to other neuroimaging techniques such as functional magnetic resonance imaging or positron emission tomography, fTCD is based on a close coupling between regional cerebral blood flow changes and neural activation. Due to a continuous monitoring of blood flow velocity, TCD offers an excellent temporal resolution in comparison to other neuroimaging techniques. The technique is noninvasive and easy to apply. Blood flow velocity measurements are robust against movement artifacts. Since its introduction the technique has contributed substantially to the elucidation of the hemispheric organization of cognitive, motor, and sensory functions in adults and children. fTCD has been

particularly useful for the study of cerebral lateralization of major brain functions such as language, facial processing, color processing, intelligence processing and gender-related differences . Moreover, most established neuroanatomical substrates for brain function are perfused by the major cerebral arteries that could be directly insonated.

Functional Transcranial Doppler Spectroscopy (fTCDS)



Spectral Density Plots Right and Left Middle Cerebral Arteries Cross Amplitude Plots in Men.

Conventional fTCD has limitations for the study of cerebral lateralization. For example, it may not differentiate the lateralising effects due to stimulus characteristics from those due to light responsiveness, and does not distinguish between flow signals emanating from cortical and subcortical branches of the cerebral arteries of the circle of Willis. Each

basal cerebral artery of the circle of Willis gives origin to two different systems of secondary vessels. The shorter of these two is called the ganglionic system, and the vessels belonging to it supply the thalami and corpora striata; the longer is the cortical system, and its vessels ramify in the pia mater and supply the cortex and subjacent brain substance. Furthermore, the cortical branches are divisible into two classes: long and short. The long or medullary arteries pass through the grey substance and penetrate the subjacent white substance to the depth of three or four centimetres. The short vessels are confined to the cortex. Both cortical and ganglionic systems do not communicate at any point in their peripheral distribution, but are entirely independent of each other, having between the parts supplied by the two systems, a borderline of diminished nutritive activity. While, the vessels of the ganglionic system are terminal vessels, the vessels of the cortical arterial system are not so strictly ‘‘terminal’’. Blood flow in these two systems in the MCA territory supplies 80% of both hemispheres, including most neural substrates implicated in facial processing, language processing and intelligence processing at cortical and subcortical structures. The measurements of mean blood flow velocity (MFV) in the MCA main stem could potentially provide information about downstream changes at cortical and subcortical sites within the MCA territory. Each distal arm of the MCA vascular system could be separated into ‘‘near’’ and ‘‘far’’ distal reflection sites for the cortical and ganglionic (subcortical) systems, respectively. To accomplish this objective, one method is to apply Fourier analysis to the periodic time series of MFV acquired during cognitive stimulations. Fourier analysis would yield peaks representing pulsatile energy from reflection sites at various harmonics, which are multiples of the fundamental frequency;. McDonald in 1974 showed that the first five harmonics usually contain 90% of the entire pulsatile energy within the system of pressure/flow oscillations in the peripheral circulation. It could be presumed that each arm of the vascular system represents a single viscoelastic tube terminated by impedance, creating a single reflection site. Psychophysiologic stimulation induced vasomotor activity at each terminal site sets up a standing sinusoidal wave oscillation, comprising a summation of waves due to effects of incident, reflected, and re-reflected waves from distal to proximal point of measurement. fTCDS studies are performed with the participant placed in a supine posture with their head up at about 30 degrees. The probe holder headgear (e.g LAM-RAK (DWL, Sipplingen, Germany) are used with a base support on two earplugs and on the nasal ridge. Two 2-MHz probes are affixed in the probe holder and insonation performed to determine the optimal position for continuous monitoring of both MCA main stems at 50 mm depth from the surface of the probe. A serial recording of MFV for each stimulus is acquired and latter used for Fourier analysis. Fourier transform algorithm uses standard software (for example, Time series and forecasting module, Statistica for Macintosh, StatSoft, OK, USA). The most efficient standard Fourier algorithm requires that the length of the input series is equal to a power of 2. If this is not the case, additional computations have to be performed. To derive the required time series, the data were averaged in 10-second segments for 1-minute duration or each stimulus; yielding 6 data points for each participant and a total of 48 data points for all eight men and women, respectively. Smoothing the periodogram values was accomplished using a weighted moving average transformation. Hamming window was applied as a smoother;. The spectral density estimates, derived from single series Fourier analysis, were plotted, and the frequency regions with the highest estimates were marked

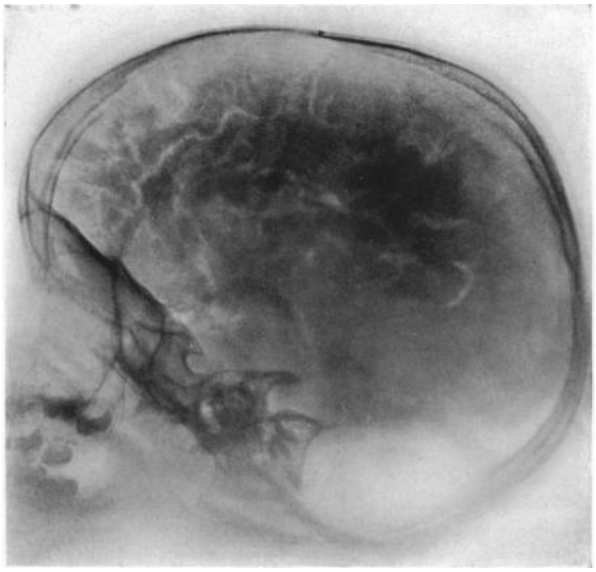
as peaks. The origins of the peaks are of interest in order to determine the reliability of the present technique. The fundamental (F), cortical (C) or memory (M), and subcortical (S) peaks occurred at regular frequency intervals of 0.125, 0.25, and 0.375, respectively. These frequencies could be converted to cycles per second (Hz), assuming that the fundamental frequency of cardiac oscillation was the mean heart rate. The fundamental frequency (F) of the first harmonic could be determined from the mean heart rate per second. For example, a heart rate of 74 bpm, suggests 74 cycles/60 or 1.23 Hz. In other words, the F-, C-, and S-peaks occurred at multiples of the first harmonic, at second and third harmonics, respectively. The distance of the reflection site for F-peak could be presumed to emanate from a site at $D1 = 1 / 4 * Wavelength$, or $D1 = c / 4f$, or $6.15(m / sec) / (4 * 1.23Hz) = 125cm$; where c is the assumed wave propagation velocity of the peripheral arterial tree according to McDonald, 1974. Given the vascular tortuosity, the estimated distance approximates that from the measurement site in the MCA main stem, to an imaginary site of summed reflections from the upper extremities, close to the finger tips when stretched sideways (Njemanze, 2007). The C-peak occurred at the second harmonic, such that the estimated arterial length (using common carotid $c = 5.5m / sec$) was given by $D2 = 1 / 8 * Wavelength$ or $c / 8 * 2f = 28cm$; and a frequency f2 of 2.46 Hz. The distance approximates the visible arterial length from the main stem of the MCA, through vascular tortuosity and around the cerebral convexity, to the end vessels at distal cortical sites such as the occipito-temporal junction on carotid angiograms of adults (Njemanze, 2007). The S-peak occurred at the third harmonic, and may have arisen from an estimated site at $D3 = 1 / 16 * Wavelength$ or $c / 16 * / 3f = 9.3cm$; and a frequency f3 of 3.69 Hz. The latter approximates the visible arterial length of the lenticulostriate vessels from the main stem of the MCA on carotid angiograms . Although not displayed, the fourth harmonic would be expected to arise from the MCA bifurcation in closest proximity to the measurement site in the main stem of the MCA. The pre-bifurcation length from the measurement point would be given by $D4 = 1 / 32 * Wavelength$ or $c / 32 * 4f = 3.5cm$; and a frequency f4 of 4.92 Hz. The calculated distance approximates that of the segment of MCA main stem just after the carotid bifurcation, where probably the ultrasound sample volume was placed, to the MCA bifurcation. Thus, these estimates approximate actual lengths. However, it has been suggested that the estimated distances may not correlate exactly with known morphometric dimensions of the arterial tree according to Campbell et al., 1989. The method was first described by Philip Njemanze in 2007, and was referred to as functional transcranial Doppler spectroscopy (fTCDS). fTCDS examines spectral density estimates of periodic processes induced during mental tasks, and hence offers a much more comprehensive picture of changes related to effects of a given mental stimulus. The spectral density estimates would be least affected by artefacts that lack periodicity, and filtering would reduce the effect of noise . The changes at the C-peak may show cortical longterm potential (CLTP) or cortical longterm depression (CLTD), which has been proposed to be suggest equivalents of cortical activity during learning (Njemanze, 2007) and cognitive processes>;. The flow velocity tracings are monitored during paradigm 1 comprising a checkerboard square as object perception are compared to whole face (paradigm 2) and facial element sorting task (paradigm 3). Fast Fourier transform calculations are used to obtain the spectral density and cross amplitude plots in the left and right middle cerebral arteries. The C-peak also called memory (M-peak) cortical peak could be seen arising during paradigm 3, a facial

element sorting task requiring iterative memory recall as a subject constantly spatially fits the puzzle by matching each facial element in paradigm 3 to that stored in memory (Paradigm 2) before proceeding to form the picture of the whole face.

Chapter 17

Pneumoencephalography and Pallidotomy

Pneumoencephalography



Pneumoencephalography

Pneumoencephalography (sometimes abbreviated PEG) is a medical procedure in which cerebrospinal fluid is drained to a small amount from around the brain and replaced with air, oxygen, or helium to allow the structure of the brain to show up more clearly on an X-ray picture. It is derived from ventriculography, an earlier and more primitive method where the air is injected through holes drilled in the skull.

The procedure was introduced in 1919 by the American neurosurgeon Walter Dandy.

Pneumoencephalography was performed extensively throughout the 20th century, but it was extremely painful and, as researchers would later discover, very dangerous. The test was generally not well tolerated by patients. Headaches and severe vomiting were common side effects. Replacement of the spinal fluid was by natural generation and

therefore required recovery for as long as 2-3 months before normal movement was restored. Modern imaging techniques such as MRI and Computed tomography have largely replaced Pneumoencephalography.

By the late 1980s the procedure was largely abandoned by the medical community, having been supplanted by the CT scan and metrizamide cisternography. Today, pneumoencephalography is limited to the research field and is used under rare circumstances. A related procedure is pneumomyelography, where gas is used similarly to investigate the spinal canal.

Pneumoencephalography appears in popular culture in the movie *The Exorcist* (1973), when Linda Blair's Regan MacNeil character undergoes the procedure. It is also referred to in Episode 7, Season 7 of House M.D.

Pallidotomy

Pallidotomy is a procedure where a tiny electrical probe is placed in the globus pallidus (one of the basal ganglia of the brain), which is then heated to 80 degrees celsius for 60 s, to destroy a small area of brain cells. Pallidotomy is used to treat dyskinesias in patients with Parkinson's disease.

Technique

In a pallidotomy, the surgeon destroys a tiny part of the globus pallidus by creating a scar. This reduces the brain activity in that area, which may help relieve movement symptoms such as tremor and rigidity.

Before surgery, detailed brain scans using MRI are done to identify the precise location for treatment.

The patient is awake during the surgery, but the scalp area where instruments are inserted is numbed with a local anesthetic. The surgeon inserts a hollow probe through a small hole drilled in the skull to the target location. Liquid nitrogen is then circulated inside the probe. The cold probe destroys the targeted brain tissue. The probe is then removed, and the wound is closed.

The surgery usually requires a 2-day hospital stay. Most people recover completely within about 6 weeks.

Indications

Parkinsonism

Pallidotomy may be considered when a patient with advanced Parkinson's disease has:

- Developed severe motor fluctuations, such as dyskinesias and on-off responses, as a result of long-term levodopa treatment.
- Severe or disabling tremor, stiffness (rigidity), or slow movement (bradykinesia) that medication can no longer control.
- Pallidotomy is not a good choice for treatment when a person has not responded to levodopa. Some studies suggest that people with parkinsonian symptoms who do not improve with levodopa therapy do not gain much benefit from pallidotomy.

The most striking effect of pallidotomy is a reduction in dyskinesias that are caused by long-term levodopa therapy. This improvement can be seen almost immediately. By reducing these side effects, pallidotomy enables some patients to adjust their levodopa dosage, allowing for better symptom control.

Pallidotomy may reduce tremor, muscle rigidity, bradykinesis, and other motor symptoms. Balance and speech may also be improved.

It is not known how long the effects of pallidotomy can be expected to last. Benefits may fade over time in some people.

Reduction in use

Doctors rarely perform pallidotomy anymore. Instead, doctors use deep brain stimulation, a procedure that does not destroy brain tissue and has fewer risks than pallidotomy.

This type of brain surgery has less risk today than in the past because technology allows the surgeon to identify with great precision the area of the brain that will be treated. Serious permanent complications are not common, although less serious side effects are.

Complications

Complications of pallidotomy can include a stroke caused by bleeding in the brain.

Many people who have a stroke recover fully and benefit from pallidotomy. Pallidotomy has caused problems with thought and memory (cognitive impairment) in some people.

Other risks include:

- Infection.
- Seizures.

History

Stereotactic pallidotomy was pioneered by Dr. Hirotaro Narabayashi.

Chapter 18

Nerve Conduction Study and Mini–Mental State Examination

Nerve conduction study

A **nerve conduction study** (NCS) is a test commonly used to evaluate the function, especially the ability of electrical conduction, of the motor and sensory nerves of the human body.

Nerve conduction velocity (NCV) is a common measurement made during this test. The term NCV often is used to mean the actual test, but this may be misleading since velocity is only one measurement in the test suite.

Purposes

Nerve conduction studies are used mainly for evaluation of paresthesias (numbness, tingling, burning) and/or weakness of the arms and legs. The type of study required is dependent in part by the symptoms presented. A physical exam and thorough history also help to direct the investigation. Some of the common disorders which can be diagnosed by nerve conduction studies are:

- Peripheral neuropathy
- Carpal tunnel syndrome
- Ulnar neuropathy
- Guillain-Barré syndrome
- Facioscapulohumeral muscular dystrophy
- Spinal disc herniation

Description

The nerve conduction study consists of the following components:

- Motor NCS
- Sensory NCS
- F-wave study

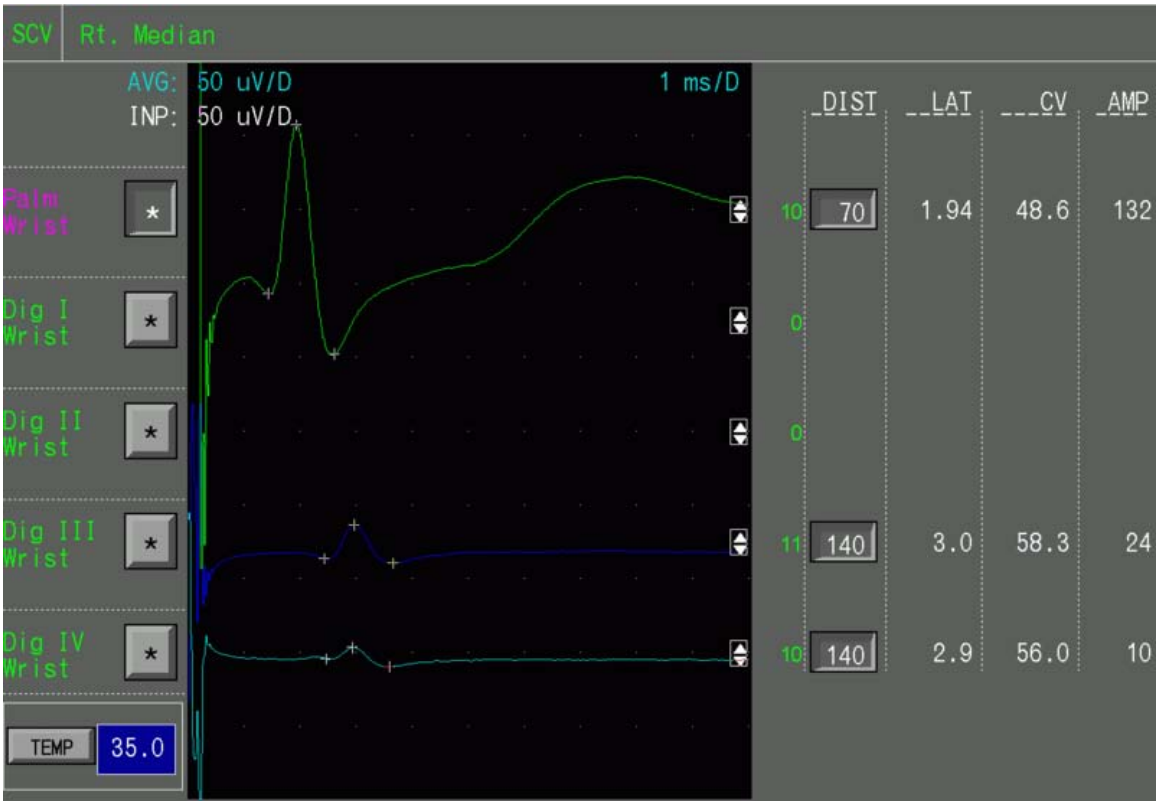
- H-reflex study

Motor NCS

Motor NCS are performed by electrical stimulation of a peripheral nerve and recording from a muscle supplied by this nerve. The time it takes for the electrical impulse to travel from the stimulation to the recording site is measured. This value is called the latency and is measured in milliseconds (ms). The size of the response - called the amplitude - is also measured. Motor amplitudes are measured in millivolts (mV). By stimulating in two or more different locations along the same nerve, the NCV across different segments can be determined. Calculations are performed using the distance between the different stimulating electrodes and the difference in latencies.

Sensory NCS

Sensory NCS are performed by electrical stimulation of a peripheral nerve and recording from a purely-sensory portion of the nerve, such as on a finger.The recording electrode is the more proximal of the two. Like the motor studies, sensory latencies are on the scale of milliseconds. Sensory amplitudes are much smaller than the motor amplitudes, usually in the microvolt (μV) range. The sensory NCV is calculated based upon the latency and the distance between the stimulating and recording electrode.



Sensory NCS: An example screenshot showing the results of a sensory nerve conduction velocity study of the right median nerve.

F-wave study

F-wave study uses supramaximal stimulation of a motor nerve and recording of action potentials from a muscle supplied by the nerve. This is not a reflex, per se, in that the action potential travels from the site of the stimulating electrode in the limb to the spinal cord's anterior horn cell and back to the limb in the same nerve that was stimulated. The F-wave latency can be used to derive the conduction velocity of nerve between the limb and spine, whereas the motor and sensory nerve conduction studies evaluate conduction in the segment of the limb. F waves vary in latency and an abnormal variance is called "chrono dispersion". Conduction velocity is derived by measuring the limb length in millimeters from the stimulation site to the corresponding spinal segment (C7 spinous process to wrist crease for median nerve). This is multiplied by 2 as it goes to the cord and returns to the muscle (2D). 2D is divided by the latency difference between mean F and M and 1 millisecond subtracted (F-M-1). The formula is 2D/(F-M-1).

H-reflex study

H-reflex study uses stimulation of a nerve and recording the reflex electrical discharge from a muscle in the limb. This also evaluates conduction between the limb and the spinal cord, but in this case, the afferent impulses (those going towards the spinal cord) are in sensory nerves while the efferent impulses (those coming from the spinal cord) are in motor nerves. This process cannot be changed.

Small-pain-fibers method

In 1998 a small-pain-fibers (spf-NCS) method was cleared by the FDA. This method uses an electrical stimulus with a neuroselective frequency to determine the minimum voltage causing conduction. Rather than comparing the data with population averages on a bell-shaped curve, which at best has about 65% sensitivity, the patient is his own control. In a three year LSU Pain Center study it was found that the nerve requiring the greatest voltage to cause conduction of the A-delta (Fast Pain) fibers identified nerve root pathology with 95% sensitivity. Besides being painless, the test is fast. A new version, uses a potentiometer to objectively measure the amplitude of the action potential at a distant site along the nerve being tested. The previous version relied on the patient reporting a sensation when the nerve fired. The spf-NCS does not require myelin loss to detect function change, so velocity is not measured.

Interpretation of nerve conductions

The interpretation of nerve conduction studies is complex, but in general, different pathological processes result in changes in latencies, motor and/or sensory amplitudes, or slowing of the conduction velocities to differing degrees. For example, slowing of the NCV usually indicates there is damage to the myelin. Another example, slowing across the wrist for the motor and sensory latencies of the median nerve indicates focal compression of the median nerve at the wrist, called carpal tunnel syndrome. On the other hand, slowing of all nerve conductions in more than one limb indicates generalized

diseased nerves, or generalized peripheral neuropathy. People with diabetes mellitus often develop generalized peripheral neuropathy.

Patient risk

Nerve conduction studies are very helpful to diagnose certain diseases of the nerves of the body. The test is not invasive, but can be a little painful due to the electrical shocks. The shocks are associated with a low amount of electrical current so they are not dangerous to anyone. Patients with a permanent pacemaker or other such implanted stimulators such as deep brain stimulators or spinal cord stimulators must tell the examiner prior to the study. This does not prevent the study, but special precautions are taken.

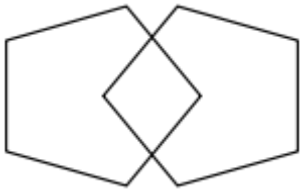
Mini–mental state examination

The **mini–mental state examination** (**MMSE**) or **Folstein test** is a brief 30-point questionnaire test that is used to screen for cognitive impairment. It is commonly used in medicine to screen for dementia. It is also used to estimate the severity of cognitive impairment at a given point in time and to follow the course of cognitive changes in an individual over time, thus making it an effective way to document an individual's response to treatment.

In the time span of about 10 minutes it samples various functions including arithmetic, memory and orientation. It was introduced by Folstein *et al.* in 1975,. This test is not the same thing as a mental status examination. The standard MMSE form which is currently published by Psychological Assessment Resources is based on its original 1975 conceptualization, with minor subsequent modifications by the authors.

Various other tests are also used, such as the Hodkinson abbreviated mental test score (1972, geriatrics) or the General Practitioner Assessment Of Cognition as well as longer formal tests for deeper analysis of specific deficits.

Test features



Interlocking pentagons used for the last question

The MMSE test includes simple questions and problems in a number of areas: the time and place of the test, repeating lists of words, arithmetic such as the serial sevens, language use and comprehension, and basic motor skills. For example, one question asks to copy a drawing of two pentagons (shown on the right).

Although consistent application of identical questions increases the reliability of comparisons made using the scale, the test is sometimes customized (for example, for use on patients that are intubated, blind, or partially immobilized. Also, some have questioned the use of the test on the deaf.) However, the number of points assigned per category is usually consistent:

Category	Possible points	Description
Orientation to time	5	From broadest to most narrow. Orientation to time has been correlated with future decline.
Orientation to place	5	From broadest to most narrow. This is sometimes narrowed down to streets, and sometimes to floor.
Registration	3	Repeating named prompts
Attention and calculation	5	Serial sevens, or spelling "world" backwards It has been suggested that serial sevens may be more appropriate in a population where English is not the first language.
Recall	3	Registration recall
Language	2	Name a pencil and a watch
Repetition	1	Speaking back a phrase
Complex commands	6	Varies. Can involve drawing figure shown.

Interpretation

Any score greater than or equal to 25 points (out of 30) is effectively normal (intact). Below this, scores can indicate severe (≤9 points), moderate (10-20 points) or mild (21-24 points). The raw score may also need to be corrected for educational attainment and age. Low to very low scores correlate closely with the presence of dementia, although other mental disorders can also lead to abnormal findings on MMSE testing. The presence of purely physical problems can also interfere with interpretation if not properly noted; for example, a patient may be physically unable to hear or read instructions properly, or may have a motor deficit that affects writing and drawing skills.

Copyright issues

The MMSE was first published in 1975 as an appendix to an article written by Dr. Marshal F. Folstein, Dr. Susan E. Folstein, and Dr. Paul R. McHugh. It was published in Volume 12 of the *Journal of Psychiatric Research*, a journal published by Pergamon Press, Ltd. at the time. While the MMSE was attached as an appendix to the article, the

copyright ownership of the MMSE remained with Dr. Folstein and his two coauthors. Pergamon Press was subsequently taken over by Elsevier Science, Ltd., and Elsevier took over Pergamon Press' copyright ownership of the Journal of Psychiatric Research.

The authors later transferred all their intellectual property rights, including the copyright of the MMSE, to MiniMental, LLC. A copyright registration form for the MMSE designating MiniMental, LLC as the owner of the MMSE copyright was registered with the U.S. Copyright Office on June 8, 2000 (Form TX 5-228-282). In March 2001, MiniMental, LLC entered into an exclusive agreement with Psychological Assessment Resources, Inc. (PAR), granting PAR the exclusive rights to publish, license, and manage all intellectual property rights to the MMSE in all media and languages in the world.

Despite the many free versions of the test that are available on the internet, the official version is copyrighted and must be ordered through PAR. The enforcement of the copyright on the MMSE has been compared to "stealth", or "submarine" patents, where a patent applicant would wait until an invention gains widespread popularity until allowing the patent to issue and only then commencing enforcement (such patent applications are no longer possible with changes made to the patent term). The enforcement of the copyright has led to researchers looking for alternative strategies in assessing cognition.

In February 2010, PAR released a second edition of the MMSE; 10 foreign language translations (French, German, Dutch, Spanish for the US, Spanish for Latin America, European Spanish, Hindi, Russian, Italian, and Simplified Chinese) were also created.

Chapter 19

Electromyography

Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an **electromyograph**, to produce a record called an **electromyogram**. An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analyzed to detect medical abnormalities, activation level, recruitment order or to analyze the biomechanics of human or animal movement.

Electrical characteristics

The electrical source is the muscle membrane potential of about -90 mV. Measured EMG potentials range between less than 50 μV and up to 20 to 30 mV, depending on the muscle under observation.

Typical repetition rate of muscle motor unit firing is about 7–20 Hz, depending on the size of the muscle (eye muscles versus seat (gluteal) muscles), previous axonal damage and other factors. Damage to motor units can be expected at ranges between 450 and 780 mV.

History

The first documented experiments dealing with EMG started with Francesco Redi's works in 1666. Redi discovered a highly specialized muscle of the electric ray fish (Electric Eel) generated electricity. By 1773, Walsh had been able to demonstrate that the Eel fish's muscle tissue could generate a spark of electricity. In 1792, a publication entitled *De Viribus Electricitatis in Motu Musculari Commentarius* appeared, written by Luigi Galvani, in which the author demonstrated that electricity could initiate muscle contractions. Six decades later, in 1849, Dubois-Raymond discovered that it was also possible to record electrical activity during a voluntary muscle contraction. The first actual recording of this activity was made by Marey in 1890, who also introduced the term electromyography. In 1922, Gasser and Erlanger used an oscilloscope to show the electrical signals from muscles. Because of the stochastic nature of the myoelectric signal, only rough information could be obtained from its observation. The capability of detecting electromyographic signals improved steadily from the 1930s through the 1950s, and researchers began to use improved electrodes more widely for the study of muscles.

Clinical use of surface EMG (sEMG) for the treatment of more specific disorders began in the 1960s. Hardyck and his researchers were the first (1966) practitioners to use sEMG. In the early 1980s, Cram and Steger introduced a clinical method for scanning a variety of muscles using an EMG sensing device.

It is not until the middle of the 1980s that integration techniques in electrodes had sufficiently advanced to allow batch production of the required small and lightweight instrumentation and amplifiers. At present, a number of suitable amplifiers are commercially available. In the early 1980s, cables that produced signals in the desired microvolt range became available. Recent research has resulted in a better understanding of the properties of surface EMG recording. Surface electromyography is increasingly used for recording from superficial muscles in clinical or kinesiological protocols, where intramuscular electrodes are used for investigating deep muscles or localized muscle activity.

There are many applications for the use of EMG. EMG is used clinically for the diagnosis of neurological and neuromuscular problems. It is used diagnostically by gait laboratories and by clinicians trained in the use of biofeedback or ergonomic assessment. EMG is also used in many types of research laboratories, including those involved in biomechanics, motor control, neuromuscular physiology, movement disorders, postural control, and physical therapy.

Procedure

There are two kinds of EMG in widespread use: surface EMG and intramuscular (needle and fine-wire) EMG. To perform intramuscular EMG, a needle electrode or a needle containing two fine-wire electrodes is inserted through the skin into the muscle tissue. A trained professional (such as a neurologist, physiatrist, or physical therapist) observes the electrical activity while inserting the electrode. The insertional activity provides valuable information about the state of the muscle and its innervating nerve. Normal muscles at rest make certain, normal electrical signals when the needle is inserted into them. Then the electrical activity when the muscle is at rest is studied. Abnormal spontaneous activity might indicate some nerve and/or muscle damage. Then the patient is asked to contract the muscle smoothly. The shape, size, and frequency of the resulting motor unit potentials are judged. Then the electrode is retracted a few millimeters, and again the activity is analyzed until at least 10–20 units have been collected. Each electrode track gives only a very local picture of the activity of the whole muscle. Because skeletal muscles differ in the inner structure, the electrode has to be placed at various locations to obtain an accurate study.

Intramuscular EMG may be considered too invasive or unnecessary in some cases. Instead, a surface electrode may be used to monitor the general picture of muscle activation, as opposed to the activity of only a few fibres as observed using an intramuscular EMG. This technique is used in a number of settings; for example, in the physiotherapy clinic, muscle activation is monitored using surface EMG and patients

have an auditory or visual stimulus to help them know when they are activating the muscle (biofeedback).

A motor unit is defined as one motor neuron and all of the muscle fibers it innervates. When a motor unit fires, the impulse (called an action potential) is carried down the motor neuron to the muscle. The area where the nerve contacts the muscle is called the neuromuscular junction, or the motor end plate. After the action potential is transmitted across the neuromuscular junction, an action potential is elicited in all of the innervated muscle fibers of that particular motor unit. The sum of all this electrical activity is known as a motor unit action potential (MUAP). This electrophysiologic activity from multiple motor units is the signal typically evaluated during an EMG. The composition of the motor unit, the number of muscle fibres per motor unit, the metabolic type of muscle fibres and many other factors affect the shape of the motor unit potentials in the myogram.

Nerve conduction testing is also often done at the same time as an EMG to diagnose neurological diseases.

Some patients can find the procedure somewhat painful, whereas others experience only a small amount of discomfort when the needle is inserted. The muscle or muscles being tested may be slightly sore for a day or two after the procedure.

Normal results

Muscle tissue at rest is normally electrically inactive. After the electrical activity caused by the irritation of needle insertion subsides, the electromyograph should detect no abnormal spontaneous activity (i.e., a muscle at rest should be electrically silent, with the exception of the area of the neuromuscular junction, which is, under normal circumstances, very spontaneously active). When the muscle is voluntarily contracted, action potentials begin to appear. As the strength of the muscle contraction is increased, more and more muscle fibers produce action potentials. When the muscle is fully contracted, there should appear a disorderly group of action potentials of varying rates and amplitudes (a complete recruitment and interference pattern).

Abnormal results

EMG is used to diagnose diseases that generally may be classified into one of the following categories: neuropathies, neuromuscular junction diseases and myopathies.

Neuropathic disease has the following defining EMG characteristics:

- An action potential amplitude that is twice normal due to the increased number of fibres per motor unit because of reinnervation of denervated fibres
- An increase in duration of the action potential
- A decrease in the number of motor units in the muscle (as found using motor unit number estimation techniques)

Myopathic disease has these defining EMG characteristics:

- A decrease in duration of the action potential
- A reduction in the area to amplitude ratio of the action potential
- A decrease in the number of motor units in the muscle (in extremely severe cases only)

Because of the individuality of each patient and disease, some of these characteristics may not appear in every case.

Abnormal results may be caused by the following medical conditions (please note this is nowhere near an exhaustive list of conditions that can result in abnormal EMG studies):

- Alcoholic neuropathy
- Amyotrophic lateral sclerosis
- Anterior compartment syndrome of the lower leg
- Axillary nerve dysfunction
- Becker's muscular dystrophy
- Brachial plexopathy
- Carpal tunnel syndrome
- Centronuclear myopathy
- Cervical spondylosis
- Charcot-Marie-Tooth disease
- Chronic Immune Demyelinating Poly[radiculo]neuropathy (CIDP)
- Common peroneal nerve dysfunction
- Denervation (reduced nervous stimulation)
- Dermatomyositis
- Distal median nerve dysfunction
- Duchenne muscular dystrophy
- Facioscapulohumeral muscular dystrophy (Landouzy-Dejerine)
- Familial periodic paralysis
- Femoral nerve dysfunction
- Fields condition
- Friedreich's ataxia
- Guillain-Barre
- Lambert-Eaton Syndrome
- Mononeuritis multiplex
- Mononeuropathy
- Motor neurone disease
- Multiple system atrophy
- Myasthenia gravis
- Myopathy (muscle degeneration, which may be caused by a number of disorders, including muscular dystrophy)
- Myotubular myopathy
- Neuromyotonia
- Peripheral neuropathy
- Poliomyelitis
- Polymyositis
- Radial nerve dysfunction
- Sciatic nerve dysfunction
- Sensorimotor polyneuropathy
- Sleep bruxism
- Spinal stenosis
- Thyrotoxic periodic paralysis
- Tibial nerve dysfunction
- Ulnar nerve dysfunction

EMG signal decomposition

EMG signals are essentially made up of superimposed motor unit action potentials (MUAPs) from several motor units. For a thorough analysis, the measured EMG signals can be decomposed into their constituent MUAPs. MUAPs from different motor units tend to have different characteristic shapes, while MUAPs recorded by the same electrode from the same motor unit are typically similar. Notably MUAP size and shape depend on where the electrode is located with respect to the fibers and so can appear to be different if the electrode moves position. EMG decomposition is non-trivial, although many methods have been proposed.

Applications of EMG

EMG signals are used in many clinical and biomedical applications. EMG is used as a diagnostics tool for identifying neuromuscular diseases, assessing low-back pain, kinesiology, and disorders of motor control. EMG signals are also used as a control signal for prosthetic devices such as prosthetic hands, arms, and lower limbs.

EMG can be used to sense isometric muscular activity where no movement is produced. This enables definition of a class of subtle motionless gestures to control interfaces without being noticed and without disrupting the surrounding environment. These signals can be used to control a prosthesis or as a control signal for an electronic device such as a mobile phone or PDA.

EMG signals have been targeted as control for flight systems. The Human Senses Group at the NASA Ames Research Center at Moffett Field, CA seeks to advance man-machine interfaces by directly connecting a person to a computer. In this project, an EMG signal is used to substitute for mechanical joysticks and keyboards. EMG has also been used in research towards a "wearable cockpit," which employs EMG-based gestures to manipulate switches and control sticks necessary for flight in conjunction with a goggle-based display.

Unvoiced speech recognition recognizes speech by observing the EMG activity of muscles associated with speech. It is targeted for use in noisy environments, and may be helpful for people without vocal cords and people with aphasia.

EMG has also been used as a control signal for computers and other devices. An interface device based on EMG could be used to control moving objects, such as mobile robots or an electric wheelchair. This may be helpful for individuals that cannot operate a joystick-controlled wheelchair. Surface EMG recordings may also be a suitable control signal for some interactive video games.

A joint project involving Microsoft, the University of Washington in Seattle, and the University of Toronto in Canada has explored using muscle signals from hand gestures as an interface device. A patent based on this research was submitted on June 26, 2008.