

Hemispherectomy

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Hemispherectomy

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1. Core Definition

Hemispherectomy is a highly specialized and intricate neurosurgical procedure involving the partial or total surgical removal, disconnection, or disabling of one of the brain's cerebral hemispheres. This radical intervention is typically considered a last-resort treatment for severe, intractable neurological disorders, predominantly drug-resistant epilepsy originating from an entire cerebral hemisphere. The primary objective is to eliminate or significantly reduce disabling seizures by isolating or removing the dysfunctional half of the brain, thereby preventing the spread of epileptic activity to the healthy hemisphere and improving the patient's quality of life. The procedure is exceptionally challenging due to the brain's delicate nature and the profound functional implications of operating on such a large area.

The concept behind hemispherectomy capitalizes on the brain's remarkable capacity for plasticity, particularly in young children, where the remaining hemisphere can often compensate for many functions previously performed by the removed or disconnected one. This adaptability allows patients, especially those operated on at a young age, to regain significant functional abilities despite the extensive nature of the surgery. The decision to proceed with a hemispherectomy is made only after exhaustive diagnostic evaluations confirm that the pathology is confined to one hemisphere and that all other less invasive treatment options have been exhausted and proven ineffective.

While the procedure fundamentally involves addressing one half of the brain, the specific techniques have evolved considerably to minimize collateral damage and improve outcomes. The overarching goal remains consistent: to functionally separate the diseased hemisphere from the healthy one to stop the devastating impact of continuous or frequent seizures, which can severely impair cognitive, motor, and developmental trajectories. The efficacy of hemispherectomy is often profound, offering dramatic seizure reduction or freedom for carefully selected candidates, transforming the prognosis for many patients suffering from life-altering neurological conditions.

2. Etymology and Historical Development

The term "hemispherectomy" derives from "hemisphere," referring to half of the brain, and "-ectomy," meaning surgical removal. The historical roots of this profound neurosurgical intervention trace back to the pioneering work of **Dr. Walter Dandy**, a prominent American neurosurgeon. In 1928, Dr. Dandy performed the first documented hemispherectomy on a patient suffering from a malignant brain tumor. This initial application demonstrated the feasibility of removing an entire cerebral hemisphere, though the procedure carried significant risks and was primarily considered

for life-threatening conditions where palliative measures were insufficient.

Following Dandy's initial success, the procedure saw limited application due to its extreme invasiveness and associated high rates of morbidity and mortality. However, renewed interest emerged in the mid-20th century, particularly for the treatment of severe, intractable epilepsy. In the 1950s, surgeons like **Dr. K.J. Till** and others began to explore hemispherectomy as a treatment for chronic unilateral epilepsy, recognizing the potential for improved quality of life if seizures could be controlled. These early attempts, while often effective in achieving seizure freedom, were frequently complicated by issues such as delayed hydrocephalus, superficial cerebral hemosiderosis, and significant blood loss, leading to further refinements in surgical techniques.

The evolution of hemispherectomy has been marked by a continuous effort to achieve functional disconnection with minimal tissue removal, thereby mitigating the severe complications seen with earlier, more extensive resections. This led to the development of "functional" techniques in the latter half of the 20th century, which aimed to disconnect the entire hemisphere without completely removing large portions of brain tissue. Further innovations in the late 20th and early 21st centuries, particularly the development of various forms of "hemispherotomy," have revolutionized the procedure, making it safer and more effective for a broader range of patients, solidifying its place as a critical, albeit radical, option in epilepsy surgery.

3. Key Characteristics: Types of Hemispherectomy

The surgical approaches to hemispherectomy have evolved significantly over time, primarily driven by the need to reduce morbidity while maintaining seizure control efficacy. Today, the procedure is broadly categorized into several types, each with distinct surgical methodologies and associated risk profiles. Understanding these distinctions is crucial for appreciating the nuanced application of this complex surgery. The primary classifications include anatomic hemispherectomy, functional hemispherectomy, and various forms of hemispherotomy.

The original and most extensive form is **Anatomic Hemispherectomy**, also known as total hemispherectomy. This procedure involves the complete removal of the cerebral cortex, subcortical white matter, and deep gray matter structures (such as the basal ganglia and thalamus) from one entire hemisphere. While highly effective in eliminating seizure foci, anatomic hemispherectomy is associated with substantial risks due to the creation of a large cranial cavity. This empty space can lead to a phenomenon known as the "hemispherectomy syndrome," characterized by delayed hydrocephalus (requiring shunt placement), superficial cerebral hemosiderosis (iron deposition in the remaining brain tissue due to chronic bleeding from the cavity), and significant blood loss during surgery. Consequently, this highly resective approach is now rarely performed due to the availability of less invasive alternatives.

A significant evolution from the anatomic approach is **Functional Hemispherectomy**. This technique aims to achieve the functional isolation of an entire cerebral hemisphere without its complete removal. Instead, it involves a series of extensive disconnections of the hemisphere from the healthy brain, including the corpus callosum, internal capsule, and various cortical and subcortical pathways. Often, only a limited amount of brain tissue, such as the temporal lobe or parts of the frontal lobe, might be resected to facilitate the disconnections. The goal is to render the diseased hemisphere non-functional and electrically isolated, preventing seizure propagation while minimizing the risks associated with a large resection cavity. This approach significantly reduced complications like hydrocephalus and hemosiderosis compared to anatomic hemispherectomy.

Further refinement led to the development of various **Hemispherotomy** techniques, which are essentially minimally resective forms of functional hemispherectomy. These procedures are designed to achieve complete functional disconnection through a smaller craniotomy and minimal tissue removal, creating narrow corridors of disconnection rather than large resections. Examples include **Peri-insular Hemispherotomy**, **Vertical Hemispherotomy**, and **Lateral Hemispherotomy**. Peri-insular hemispherotomy, for instance, involves creating a disconnection around the insula, severing connections between the cerebral lobes and deep structures. These modern hemispherotomy techniques offer superior outcomes in terms of complication rates, particularly reducing the incidence of post-operative hydrocephalus and chronic bleeding, while maintaining comparable efficacy in seizure control. They represent the current gold standard for hemispherectomy procedures, offering a balance between effective seizure control and patient safety.

4. Indications and Patient Selection

Hemispherectomy is a procedure reserved for the most severe and intractable cases of epilepsy, specifically when seizures originate from and affect an entire cerebral hemisphere, and have proven resistant to all available pharmacological treatments. The decision to undertake such a radical surgery requires meticulous patient selection, involving a comprehensive multidisciplinary evaluation by a team of neurologists, neurosurgeons, neuropsychologists, and neuroradiologists. The primary candidates are typically infants and young children, whose developing brains exhibit greater neuroplasticity, enhancing the potential for functional recovery after surgery.

Several specific neurological conditions commonly lead to consideration for hemispherectomy. One prominent indication is **Rasmussen's Encephalitis**, a rare, progressive inflammatory disease characterized by intractable unilateral hemispheric epilepsy and progressive neurological deficits. Other critical indications include severe forms of **Sturge-Weber Syndrome**, a congenital disorder marked by a facial port-wine stain, glaucoma, and leptomeningeal angiomas, which often leads to intractable epilepsy and progressive neurological decline affecting one hemisphere. Furthermore, conditions such as **Hemimegalencephaly**, a congenital malformation where one

cerebral hemisphere is abnormally large and dysplastic, and extensive unilateral **Cortical Dysplasia**, which involves abnormal development of the cerebral cortex, are also strong indications when these pathologies lead to devastating, drug-resistant seizures.

The pre-operative evaluation process is extensive and crucial for confirming the unilateral nature of the pathology and assessing the potential for positive outcomes. This typically involves advanced neuroimaging techniques such as high-resolution **Magnetic Resonance Imaging (MRI)** to delineate the extent of the brain abnormality, **Electroencephalography (EEG)** and video-EEG monitoring to localize seizure onset and spread, **Positron Emission Tomography (PET)** to identify areas of hypometabolism, and **Functional MRI (fMRI)** to map critical eloquent areas. Neuropsychological assessments are also performed to establish a baseline of cognitive function and to predict post-operative changes. The ultimate goal of this rigorous evaluation is to ensure that the patient will benefit significantly from the surgery, with a high probability of achieving seizure freedom and improved developmental trajectory, outweighing the inherent risks of the procedure.

5. Surgical Procedure and Post-Operative Care

The surgical procedure for hemispherectomy, while varying in specifics depending on the chosen technique (e.g., functional hemispherectomy versus hemispherotomy), generally begins with a **craniotomy** - the surgical removal of a section of bone from the skull to access the brain. Under general anesthesia, the neurosurgeon carefully exposes the affected cerebral hemisphere. For functional hemispherectomy, the process involves a series of precise disconnections. Key white matter tracts, such as the **corpus callosum** (connecting the two hemispheres), the **internal capsule** (carrying motor and sensory fibers), and specific cortical-subcortical pathways, are meticulously severed. In some cases, a limited amount of tissue might be resected to facilitate these disconnections or remove particularly epileptogenic areas. Modern hemispherotomy techniques aim to create narrow disconnection corridors, minimizing tissue removal while achieving complete functional isolation of the diseased hemisphere.

Post-operatively, patients typically require intensive monitoring in a neurosurgical intensive care unit (ICU) for several days. Immediate concerns include managing pain, controlling post-operative seizures (which can occur as the brain adjusts), and monitoring for potential complications such as hemorrhage, infection, or cerebrospinal fluid (CSF) leaks. Due to the extensive nature of the surgery, blood transfusions may be necessary. The risk of delayed **hydrocephalus**, particularly with older anatomic techniques, necessitates careful monitoring for signs of increased intracranial pressure, and shunt placement may be required in some cases. The goal of immediate post-operative care is to stabilize the patient, manage acute symptoms, and prevent early complications.

Long-term recovery from hemispherectomy is a prolonged process that heavily relies on comprehensive **rehabilitation**. Patients typically experience significant neurological deficits immediately after surgery, most commonly contralateral **hemiparesis** (weakness or paralysis on the side of the body opposite the surgery) and a homonymous hemianopia (loss of vision in half of the visual field). A dedicated multidisciplinary rehabilitation team, including physical therapists, occupational therapists, and speech-language pathologists, plays a crucial role in helping the patient adapt and regain function. Intensive therapy is essential to maximize the brain's plasticity, especially in children, allowing the remaining hemisphere to reorganize and compensate for lost functions. Neurocognitive rehabilitation also addresses potential changes in attention, memory, and executive functions, aiming to optimize the patient's overall quality of life and functional independence.

6. Prognosis and Long-Term Outcomes

The prognosis following hemispherectomy, especially when performed in appropriately selected young patients, is often remarkably positive, particularly regarding seizure control. Studies consistently show high rates of seizure freedom or significant seizure reduction in individuals undergoing the procedure for intractable hemispheric epilepsy. For many children, this translates into a dramatic improvement in quality of life, allowing for better cognitive development, enhanced participation in daily activities, and a reduction in the need for multiple anti-epileptic medications, which often have their own debilitating side effects. The cessation of continuous seizure activity can alleviate the chronic encephalopathy that often accompanies severe epilepsy, potentially leading to improvements in attention, behavior, and even cognitive abilities.

While seizure control is a primary objective, long-term functional outcomes are also critical. Patients invariably experience permanent neurological deficits, most notably contralateral hemiparesis and homonymous hemianopia. However, due to the extraordinary plasticity of the developing brain, particularly in infants and very young children, the remaining hemisphere can often reorganize and assume many of the functions previously performed by the removed or disconnected hemisphere. This allows many children to achieve functional ambulation, fine motor skills, and communication abilities, albeit often with a degree of impairment. The extent of recovery is highly variable and depends on factors such as the patient's age at surgery, the underlying pathology, and the intensity of post-operative rehabilitation.

Long-term follow-up is essential to monitor for potential delayed complications, such as hydrocephalus (which can still occur even with modern techniques, though less frequently) or the emergence of new neurological issues. Neuropsychological assessments are regularly conducted to track cognitive development and identify areas where additional support or intervention may be beneficial. Despite the profound nature of the surgery, for many patients who suffer from devastating, drug-resistant hemispheric epilepsy, hemispherectomy offers the best, and often only,

chance at a life free from debilitating seizures, allowing for improved developmental trajectories and significantly enhanced overall well-being. The long-term impact on families is also significant, as the relief from constant seizure management can transform family dynamics and reduce caregiver burden.

7. Debates and Criticisms

Despite its life-changing potential for seizure control, hemispherectomy remains one of the most ethically complex and critically debated neurosurgical procedures due to its radical nature and irreversible impact. A primary area of debate revolves around the ethical implications of intentionally removing or functionally disabling half of a person's brain, particularly in young children who cannot provide informed consent. Critics often raise concerns about the profound neurological deficits that inevitably result from the surgery and the long-term quality of life for individuals living with only one cerebral hemisphere. These considerations necessitate an exceptionally rigorous pre-operative evaluation process to ensure that the anticipated benefits overwhelmingly outweigh the inherent risks and consequences.

Another point of discussion centers on the potential for complications, even with advanced surgical techniques. While modern hemispherectomy approaches have significantly reduced the incidence of severe post-operative issues like hydrocephalus and superficial cerebral hemosiderosis, these risks are not entirely eliminated. Other potential complications include infections, hemorrhage, CSF leaks, and the development of new neurological deficits. The extensive nature of the surgery also entails a prolonged recovery period and the necessity for intensive, often lifelong, rehabilitation, which can place considerable burden on patients and their families. The long-term psychological impact on the individual, particularly as they grow older and become more aware of their physical and cognitive differences, is also a significant area of concern and ongoing study.

Finally, ongoing research explores the ultimate limits of brain plasticity and potential for functional reorganization, especially as outcomes vary between pediatric and adult patients. While children often exhibit remarkable compensatory abilities, the long-term cognitive and social outcomes for these individuals are still being fully understood, with some studies suggesting subtle but persistent deficits in certain higher-order cognitive functions. There is continuous debate and innovation in surgical techniques, with a constant push to develop even less invasive yet equally effective methods to achieve hemispheric disconnection. These discussions underscore the commitment within the neurosurgical community to refine practices, improve patient selection, and continuously strive for the best possible outcomes for individuals facing severe, intractable neurological disorders that hemispherectomy aims to address.

Further Reading

[Hemispherectomy - Wikipedia](#)

[Hemispherectomy - Epilepsy Foundation](#)

[Hemispherectomy - Boston Children's Hospital](#)

[Hemispherectomy for Epilepsy: A Review - NCBI](#)

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