Cerebral Palsy: Hope Through Research

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Introduction

In the 1860s, an English surgeon named William Little wrote the first medical descriptions of a puzzling disorder that struck children in the first years of life, causing stiff, spastic muscles in their legs and, to a lesser degree, their arms. These children had difficulty grasping objects, crawling, and walking. They did not get better as they grew up nor did they become worse. Their condition, which was called Little's disease for many years, is now known as spastic diplegia. It is just one of several disorders that affect control of movement and are grouped together under the term cerebral palsy.

Because it seemed that many of these children were born following premature or complicated deliveries, Little suggested their condition resulted from a lack of oxygen during birth. This oxygen shortage damaged sensitive brain tissues controlling movement, he proposed. But in 1897, the famous psychiatrist Sigmund Freud disagreed. Noting that children with cerebral palsy often had other problems such as mental retardation, visual disturbances, and seizures, Freud suggested that the disorder might sometimes have roots earlier in life, during the brain's development in the womb. "Difficult birth, in certain cases," he wrote, "is merely a symptom of deeper effects that influence the development of the fetus."

Despite Freud's observation, the belief that birth complications cause most cases of cerebral palsy was widespread among physicians, families, and even medical researchers until very recently. In the 1980s, however, scientists analyzed extensive data from a government study of more than 35,000 births and were surprised to discover that such complications account for only a fraction of cases -- probably less than 10 percent. In most cases of cerebral palsy, no cause of the factors explored could be found. These findings from the NINDS perinatal study have profoundly altered medical theories about cerebral palsy and have spurred today's researchers to explore alternative causes.

At the same time, biomedical research has also led to significant changes in understanding, diagnosing, and treating persons with cerebral palsy. Risk factors not previously recognized have been identified, notably intrauterine exposure to infection and disorders of coagulation, and others are under investigation. Identification of infants with cerebral palsy very early in life gives youngsters the best opportunity to receive treatment for sensory disabilities and for prevention of contractures. Biomedical research has led to improved diagnostic techniques such as advanced brain imaging and modern gait analysis. Certain conditions known to cause cerebral palsy, such as rubella (German measles) and jaundice, can now be prevented or treated. Physical, psychological, and behavioral therapy that assist with such skills as movement and speech and foster social and emotional development can help children who have cerebral palsy to achieve and succeed. Medications, surgery, and braces can often improve nerve and muscle coordination, help treat associated medical problems, and either prevent or correct deformities.

Much of the research to improve medical understanding of cerebral palsy has been supported by the National Institute of Neurological Disorders and Stroke (NINDS), one of the federal government's National Institutes of Health. The NINDS is America's leading supporter of biomedical research into cerebral palsy and other neurological disorders. Through this publication, the NINDS hopes to help the more than 4,500 American babies and infants diagnosed each year, their families, and others concerned about cerebral palsy benefit from these research results.

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What is Cerebral Palsy?

Cerebral palsy is an umbrella-like term used to describe a group of chronic disorders impairing control of movement that appear in the first few years of life and generally do not worsen over time. The term cerebral refers to the brain's two halves, or hemispheres, and palsy describes any disorder that impairs control of body movement. Thus, these disorders are not caused by problems in the muscles or nerves. Instead, faulty development or damage to motor areas in the brain disrupts the brain's ability to adequately control movement and posture.

Symptoms of cerebral palsy lie along a spectrum of varying severity. An individual with cerebral palsy may have difficulty with fine motor tasks, such as writing or cutting with scissors; experience trouble with maintaining balance and walking; or be affected by involuntary movements, such as uncontrollable writhing motion of the hands or drooling. The symptoms differ from one person to the next, and may even change over time in the individual. Some people with cerebral palsy are also affected by other medical disorders, including seizures or mental impairment. Contrary to common belief, however, cerebral palsy does not always cause profound handicap. While a child with severe cerebral palsy might be unable to walk and need extensive, lifelong care, a child with mild cerebral palsy might only be slightly awkward and require no special assistance. Cerebral palsy is not contagious nor is it usually inherited from one generation to the next. At this time, it cannot be cured, although scientific research continues to yield improved treatments and methods of prevention.

How Many People Have This Disorder?

The United Cerebral Palsy Associations estimate that more than 500,000 Americans have cerebral palsy. Despite advances in preventing and treating certain causes of cerebral palsy, the number of children and adults it affects has remained essentially unchanged or perhaps risen slightly over the past 30 years. This is partly because more critically premature and frail infants are surviving through improved intensive care. Unfortunately, many of these infants have developmental problems of the nervous system or suffer neurological damage. Research is under way to improve care for these infants, as in ongoing studies of technology to alleviate troubled breathing and trials of drugs to prevent bleeding in the brain before or soon after birth.

What Are the Different Forms?

Spastic diplegia, the disorder first described by Dr. Little in the 1860s, is only one of several disorders called cerebral palsy. Today doctors classify cerebral palsy into four broad categories -- spastic, athetoid, ataxic, and mixed forms -- according to the type of movement disturbance.

Spastic cerebral palsy. In this form of cerebral palsy, which affects 70 to 80 percent of patients, the muscles are stiffly and permanently contracted. Doctors will often describe which type of spastic

cerebral palsy a patient has based on which limbs are affected. The names given to these types combine a Latin description of affected limbs with the term plegia or paresis, meaning paralyzed or weak. The four commonly diagnosed types of spastic cerebral palsy are illustrated in the figure.

When both legs are affected by spasticity, they may turn in and cross at the knees. As these individuals walk, their legs move awkwardly and stiffly and nearly touch at the knees. This causes a characteristic walking rhythm, known as the scissors gait.

Individuals with spastic hemiparesis may also experience hemiparetic tremors, in which uncontrollable shaking affects the limbs on one side of the body. If these tremors are severe, they can seriously impair movement.

Athetoid, or dyskinetic, cerebral palsy. This form of cerebral palsy is characterized by uncontrolled, slow, writhing movements. These abnormal movements usually affect the hands, feet, arms, or legs and, in some cases, the muscles of the face and tongue, causing grimacing or drooling. The movements often increase during periods of emotional stress and disappear during sleep. Patients may also have problems coordinating the muscle movements needed for speech, a condition known as dysarthria. Athetoid cerebral palsy affects about 10 to 20 percent of patients.

Ataxic cerebral palsy. This rare form affects the sense of balance and depth perception. Affected persons often have poor coordination; walk unsteadily with a wide-based gait, placing their feet unusually far apart; and experience difficulty when attempting quick or precise movements, such as writing or buttoning a shirt. They may also have intention tremor. In this form of tremor, beginning a voluntary movement, such as reaching for a book, causes a trembling that affects the body part being used and that worsens as the individual gets nearer to the desired object. The ataxic form affects an estimated 5 to 10 percent of cerebral palsy patients.

Mixed forms. It is common for patients to have symptoms of more than one of the previous three forms. The most common mixed form includes spasticity and athetoid movements but other combinations are also possible.

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What Other Medical Disorders Are Associated With Cerebral Palsy?

Many individuals who have cerebral palsy have no associated medical disorders. However, disorders that involve the brain and impair its motor function can also cause seizures and impair an individual's intellectual development, attentiveness to the outside world, activity and behavior, and vision and hearing. Medical disorders associated with cerebral palsy include:

- Mental impairment. About one-third of children who have cerebral palsy are mildly intellectually impaired, one-third are moderately or severely impaired, and the remaining third are intellectually normal. Mental impairment is even more common among children with spastic quadriplegia.
- Seizures or epilepsy. As many as half of all children with cerebral palsy have seizures. During a seizure, the normal, orderly pattern of electrical activity in the brain is disrupted by uncontrolled bursts of electricity. When seizures recur without a direct trigger, such as fever, the condition is called epilepsy. In the person who has cerebral palsy and epilepsy, this disruption may be spread throughout the brain and cause varied symptoms all over the body -- as in tonic-clonic seizures -- or may be confined to just one part of the brain and cause more specific symptoms -- as in partial seizures.

Tonic-clonic seizures generally cause patients to cry out and are followed by loss of consciousness, twitching of both legs and arms, convulsive body movements, and loss of bladder control.

Partial seizures are classified as simple or complex. In simple partial seizures, the individual has localized symptoms, such as muscle twitches, chewing movements, and numbness or tingling. In complex partial seizures, the individual may hallucinate, stagger, perform automatic and purposeless movements, or experience impaired consciousness or confusion.

- Growth problems. A syndrome called failure to thrive is common in children with moderate-to-severe cerebral palsy, especially those with spastic quadriparesis. Failure to thrive is a

general term physicians use to describe children who seem to lag behind in growth and development despite having enough food. In babies, this lag usually takes the form of too little weight gain; in young children, it can appear as abnormal shortness; in teenagers, it may appear as a combination of shortness and lack of sexual development. Failure to thrive probably has several causes, including, in particular, poor nutrition and damage to the brain centers controlling growth and development. In addition, the muscles and limbs affected by cerebral palsy tend to be smaller than normal. This is especially noticeable in some patients with spastic hemiplegia, because limbs on the affected side of the body may not grow as quickly or as large as those on the more normal side. This condition usually affects the hand and foot most severely. Since the involved foot in hemiplegia is often smaller than the unaffected foot even among patients who walk, this size difference is probably not due to lack of use. Scientists believe the problem is more likely to result from disruption of the complex process responsible for normal body growth.

- Impaired vision or hearing. A large number of children with cerebral palsy have strabismus, a condition in which the eyes are not aligned because of differences in the left and right eye muscles. In an adult, this condition causes double vision. In children, however, the brain often adapts to the condition by ignoring signals from one of the misaligned eyes. Untreated, this can lead to very poor vision in one eye and can interfere with certain visual skills, such as judging distance. In some cases, physicians may recommend surgery to correct strabismus. Children with hemiparesis may have hemianopia, which is defective vision or blindness that impairs the normal field of vision of one eye. For example, when hemianopia affects the right eye, a child looking straight ahead might have perfect vision except on the far right. In homonymous hemianopia, the impairment affects the same part of the visual field of both eyes. Impaired hearing is also more frequent among those with cerebral palsy than in the general population.
- Abnormal sensation and perception. Some children with cerebral palsy have impaired ability to feel simple sensations like touch and pain. They may also have stereognosia, or difficulty perceiving and identifying objects using the sense of touch. A child with stereognosia, for example, would have trouble identifying a hard ball, sponge, or other object placed in his hand without looking at the object.

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What Causes Cerebral Palsy?

Cerebral palsy is not one disease with a single cause, like chicken pox or measles. It is a group of disorders with similar problems in control of movement, but probably with different causes. When physicians try to uncover the cause of cerebral palsy in an individual child, they look at the form of cerebral palsy, the mother's and child's medical history, and onset of the disorder.

In the United States, about 10 to 20 percent of children who have cerebral palsy acquire the disorder after birth. (The figures are higher in underdeveloped countries.) Acquired cerebral palsy results from brain damage in the first few months or years of life and can follow brain infections, such as bacterial meningitis or viral encephalitis, or results from head injury -- most often from a motor vehicle accident, a fall, or child abuse.

Congenital cerebral palsy, on the other hand, is present at birth, although it may not be detected for months. In most cases, the cause of congenital cerebral palsy is unknown. Thanks to research, however, scientists have pinpointed some specific events during pregnancy or around the time of birth that can damage motor centers in the developing brain. Some of these causes of congenital cerebral palsy include:

- Infections during pregnancy. German measles, or rubella, is caused by a virus that can infect pregnant women and, therefore, the fetus in the uterus, to cause damage to the developing nervous system. Other infections that can cause brain injury in the developing fetus include cytomegalovirus and toxoplasmosis. There is relatively recent evidence that placental and perhaps other maternal infection can be associated with cerebral palsy.
- Jaundice in the infant. Bile pigments, compounds that are normally found in small amounts in the bloodstream, are produced when blood cells are destroyed. When many blood cells are destroyed in a short time, as in the condition called Rh incompatibility (see below), the yellow-colored pigments can build up and cause jaundice. Severe, untreated jaundice can damage brain cells.
- Rh incompatibility. In this blood condition, the mother's body produces immune cells called antibodies that destroy the fetus's blood cells, leading to a form of jaundice in the newborn.
- Severe oxygen shortage in the brain or trauma to the head during labor and delivery. The

newborn infant's blood is specially equipped to compensate for low levels of oxygen, and asphyxia (lack of oxygen caused by interruption in breathing or poor oxygen supply) is common in babies during the stresses of labor and delivery. But if asphyxia severely lowers the supply of oxygen to the infant's brain for lengthy periods, the child may develop brain damage called hypoxic-ischemic encephalopathy. A significant proportion of babies with this type of brain damage die, and others may develop cerebral palsy, which is then often accompanied by mental impairment and seizures.

In the past, physicians and scientists attributed most cases of cerebral palsy to asphyxia or other complications during birth if they could not identify another cause. However, extensive research by NINDS scientists and others has shown that very few babies who experience asphyxia during birth develop encephalopathy soon after birth. Research also shows that a large proportion of babies who experience asphyxia do not grow up to have cerebral palsy or other neurological disorders. Birth complications including asphyxia are now estimated to account for about 6 percent of congenital cerebral palsy cases.

- Stroke. Coagulation disorders in mothers or infants can produce stroke in the fetus or newborn baby. Bleeding in the brain has several causes -- including broken blood vessels in the brain, clogged blood vessels, or abnormal blood cells -- and is one form of stroke. Although strokes are better known for their effects on older adults, they can also occur in the fetus during pregnancy or the newborn around the time of birth, damaging brain tissue and causing neurological problems. Ongoing research is testing potential treatments that may one day help prevent stroke in fetuses and newborns.

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What are the Risk Factors?

Research scientists have examined thousands of expectant mothers, followed them through childbirth, and monitored their children's early neurological development. As a result, they have uncovered certain characteristics, called risk factors, that increase the possibility that a child will later be diagnosed with cerebral palsy:

- Breech presentation. Babies with cerebral palsy are more likely to present feet first, instead of head first, at the beginning of labor.
- Complicated labor and delivery. Vascular or respiratory problems of the baby during labor and delivery may sometimes be the first sign that a baby has suffered brain damage or that a baby's brain has not developed normally. Such complications can cause permanent brain damage.
- Low Apgar score. The Apgar score (named for anesthesiologist Virginia Apgar) is a numbered rating that reflects a newborn's condition. To determine an Apgar score, doctors periodically check the baby's heart rate, breathing, muscle tone, reflexes, and skin color in the first minutes after birth. They then assign points; the higher the score, the more normal the baby's condition. A low score at 10-20 minutes after delivery is often considered an important sign of potential problems.
- Low birthweight and premature birth. The risk of cerebral palsy is higher among babies who weigh less than 2500 grams (5 lbs., 7 1/2 oz.) at birth and among babies who are born less than 37 weeks into pregnancy. This risk increases as birthweight falls.
- Multiple births. Twins, triplets, and other multiple births are linked to an increased risk of cerebral palsy.
- Nervous system malformations. Some babies born with cerebral palsy have visible signs of nervous system malformation, such as an abnormally small head (microcephaly). This suggests that problems occurred in the development of the nervous system while the baby was in the womb.
- Maternal bleeding or severe proteinuria late in pregnancy. Vaginal bleeding during the sixth to ninth months of pregnancy and severe proteinuria (the presence of excess proteins in the urine) are linked to a higher risk of having a baby with cerebral palsy.
- Maternal hyperthyroidism, mental retardation, or seizures. Mothers with any of these conditions are slightly more likely to have a child with cerebral palsy.
- Seizures in the newborn. An infant who has seizures faces a higher risk of being diagnosed, later in childhood, with cerebral palsy.

Knowing these warning signs helps doctors keep a close eye on children who face a higher risk for long-term problems in the nervous system. However, parents should not become too alarmed if

their child has one or more of these factors. Most such children do not have and do not develop cerebral palsy.

Can Cerebral Palsy Be Prevented?

Several of the causes of cerebral palsy that have been identified through research are preventable or treatable:

- Head injury can be prevented by regular use of child safety seats when driving in a car and helmets during bicycle rides, and elimination of child abuse. In addition, common sense measures around the household -- like close supervision during bathing and keeping poisons out of reach -- can reduce the risk of accidental injury.
- Jaundice of newborn infants can be treated with phototherapy. In phototherapy, babies are exposed to special blue lights that break down bile pigments, preventing them from building up and threatening the brain. In the few cases in which this treatment is not enough, physicians can correct the condition with a special form of blood transfusion.
- Rh incompatibility is easily identified by a simple blood test routinely performed on expectant mothers and, if indicated, expectant fathers. This incompatibility in blood types does not usually cause problems during a woman's first pregnancy, since the mother's body generally does not produce the unwanted antibodies until after delivery. In most cases, a special serum given after each childbirth can prevent the unwanted production of antibodies. In unusual cases, such as when a pregnant woman develops the antibodies during her first pregnancy or antibody production is not prevented, doctors can help minimize problems by closely watching the developing baby and, when needed, performing a transfusion to the baby while in the womb or an exchange transfusion (in which a large volume of the baby's blood is removed and replaced) after birth.
- Rubella, or German measles, can be prevented if women are vaccinated against this disease before becoming pregnant.

In addition, it is always good to work toward a healthy pregnancy through regular prenatal care and good nutrition and by eliminating smoking, alcohol consumption, and drug abuse. Despite the best efforts of parents and physicians, however, children will still be born with cerebral palsy. Since in most cases the cause of cerebral palsy is unknown, little can currently be done to prevent it. As investigators learn more about the causes of cerebral palsy through basic and clinical research, doctors and parents will be better equipped to help prevent this disorder.

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What Are the Early Signs?

Early signs of cerebral palsy usually appear before 3 years of age, and parents are often the first to suspect that their infant is not developing motor skills normally. Infants with cerebral palsy are frequently slow to reach developmental milestones, such as learning to roll over, sit, crawl, smile, or walk. This is sometimes called developmental delay.

Some affected children have abnormal muscle tone. Decreased muscle tone is called hypotonia; the baby may seem flaccid and relaxed, even floppy. Increased muscle tone is called hypertonia, and the baby may seem stiff or rigid. In some cases, the baby has an early period of hypotonia that progresses to hypertonia after the first 2 to 3 months of life. Affected children may also have unusual posture or favor one side of their body.

Parents who are concerned about their baby's development for any reason should contact their physician, who can help distinguish normal variation in development from a developmental disorder.

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How is Cerebral Palsy Diagnosed?

Doctors diagnose cerebral palsy by testing an infant's motor skills and looking carefully at the infant's medical history. In addition to checking for those symptoms described above -- slow development, abnormal muscle tone, and unusual posture -- a physician also tests the infant's

reflexes and looks for early development of hand preference.

Reflexes are movements that the body makes automatically in response to a specific cue. For example, if a newborn baby is held on its back and tilted so the legs are above its head, the baby will automatically extend its arms in a gesture, called the Moro reflex, that looks like an embrace. Babies normally lose this reflex after they reach 6 months, but those with cerebral palsy may retain it for abnormally long periods. This is just one of several reflexes that a physician can check.

Doctors can also look for hand preference -- a tendency to use either the right or left hand more often. When the doctor holds an object in front and to the side of the infant, an infant with hand preference will use the favored hand to reach for the object, even when it is held closer to the opposite hand. During the first 12 months of life, babies do not usually show hand preference. But infants with spastic hemiplegia, in particular, may develop a preference much earlier, since the hand on the unaffected side of their body is stronger and more useful.

The next step in diagnosing cerebral palsy is to rule out other disorders that can cause movement problems. Most important, doctors must determine that the child's condition is not getting worse. Although its symptoms may change over time, cerebral palsy by definition is not progressive. If a child is continuously losing motor skills, the problem more likely springs from elsewhere -- including genetic diseases, muscle diseases, disorders of metabolism, or tumors in the nervous system. The child's medical history, special diagnostic tests, and, in some cases, repeated check-ups can help confirm that other disorders are not at fault.

The doctor may also order specialized tests to learn more about the possible cause of cerebral palsy. One such test is computed tomography, or CT, a sophisticated imaging technique that uses X rays and a computer to create an anatomical picture of the brain's tissues and structures. A CT scan may reveal brain areas that are underdeveloped, abnormal cysts (sacs that are often filled with liquid) in the brain, or other physical problems. With the information from CT scans, doctors may be better equipped to judge the long-term outlook for an affected child.

Magnetic resonance imaging, or MRI, is a relatively new brain imaging technique that is rapidly gaining widespread use for identifying brain disorders. This technique uses a magnetic field and radio waves, rather than X rays. MRI gives better pictures of structures or abnormal areas located near bone than CT.

A third test that can expose problems in brain tissues is ultrasonography. This technique bounces sound waves off the brain and uses the pattern of echoes to form a picture, or sonogram, of its structures. Ultrasonography can be used in infants before the bones of the skull harden and close. Although it is less precise than CT and MRI scanning, this technique can detect cysts and structures in the brain, is less expensive, and does not require long periods of immobility.

Finally, physicians may want to look for other conditions that are linked to cerebral palsy, including seizure disorders, mental impairment, and vision or hearing problems.

When the doctor suspects a seizure disorder, an electroencephalogram, or EEG, may be ordered. An EEG uses special patches called electrodes placed on the scalp to record the natural electrical currents inside the brain. This recording can help the doctor see telltale patterns in the brain's electrical activity that suggest a seizure disorder.

Intelligence tests are often used to determine if a child with cerebral palsy is mentally impaired. Sometimes, however, a child's intelligence may be underestimated because problems with movement, sensation, or speech due to cerebral palsy make it difficult for him or her to perform well on these tests.

If problems with vision are suspected, the doctor may refer the patient to an ophthalmologist for examination; if hearing impairment seems likely, an otologist may be called in.

Identifying these accompanying conditions is important and is becoming more accurate as ongoing research yields advances that make diagnosis easier. Many of these conditions can then be addressed through specific treatments, improving the long-term outlook for those with cerebral palsy.

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How is Cerebral Palsy Managed?

Cerebral palsy can not be cured, but treatment can often improve a child's capabilities. In fact, progress due to medical research now means that many patients can enjoy near-normal lives if their neurological problems are properly managed. There is no standard therapy that works for all patients. Instead, the physician must work with a team of health care professionals first to identify a child's unique needs and impairments and then to create an individual treatment plan that addresses them.

Some approaches that can be included in this plan are drugs to control seizures and muscle spasms, special braces to compensate for muscle imbalance, surgery, mechanical aids to help overcome impairments, counseling for emotional and psychological needs, and physical, occupational, speech, and behavioral therapy. In general, the earlier treatment begins, the better chance a child has of overcoming developmental disabilities or learning new ways to accomplish difficult tasks.

The members of the treatment team for a child with cerebral palsy should be knowledgeable professionals with a wide range of specialties. A typical treatment team might include:

- a physician, such as a pediatrician, a pediatric neurologist, or a pediatric physiatrist, trained to help developmentally disabled children. This physician, often the leader of the treatment team, works to synthesize the professional advice of all team members into a comprehensive treatment plan, implements treatments, and follows the patient's progress over a number of years.
- an orthopedist, a surgeon who specializes in treating the bones, muscles, tendons, and other parts of the body's skeletal system. An orthopedist might be called on to predict, diagnose, or treat muscle problems associated with cerebral palsy.
- a physical therapist, who designs and implements special exercise programs to improve movement and strength.
- an occupational therapist, who can help patients learn skills for day-to-day living, school, and work.
- a speech and language pathologist, who specializes in diagnosing and treating communication problems.
- a social worker, who can help patients and their families locate community assistance and education programs.
- a psychologist, who helps patients and their families cope with the special stresses and demands of cerebral palsy. In some cases, psychologists may also oversee therapy to modify unhelpful or destructive behaviors or habits.
- an educator, who may play an especially important role when mental impairment or learning disabilities present a challenge to education.

Individuals who have cerebral palsy and their family or caregivers are also key members of the treatment team, and they should be intimately involved in all steps of planning, making decisions, and applying treatments. Studies have shown that family support and personal determination are two of the most important predictors of which individuals who have cerebral palsy will achieve long-term goals.

Too often, however, physicians and parents may focus primarily on an individual symptom -- especially the inability to walk. While mastering specific skills is an important focus of treatment on a day-to-day basis, the ultimate goal is to help individuals grow to adulthood and have maximum independence in society. In the words of one physician, "After all, the real point of walking is to get from point A to point B. Even if a child needs a wheelchair, what's important is that they're able to achieve this goal."

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What Specific Treatments Are Available?

Physical, Behavioral, and Other Therapies

Therapy -- whether for movement, speech, or practical tasks -- is a cornerstone of cerebral palsy treatment. The skills a 2-year-old needs to explore the world are very different from those that a child needs in the classroom or a young adult needs to become independent. Cerebral palsy

therapy should be tailored to reflect these changing demands.

Physical therapy usually begins in the first few years of life, soon after the diagnosis is made. Physical therapy programs use specific sets of exercises to work toward two important goals: preventing the weakening or deterioration of muscles that can follow lack of use (called disuse atrophy) and avoiding contracture, in which muscles become fixed in a rigid, abnormal position.

Contracture is one of the most common and serious complications of cerebral palsy. Normally, a child whose bones are growing stretches the body's muscles and tendons through running and walking and other daily activities. This ensures that muscles will grow at the same rate. But in children with cerebral palsy, spasticity prevents this stretching and, as a result, muscles do not grow fast enough to keep up with lengthening bones. The resulting contracture can disrupt balance and trigger loss of previous abilities. Physical therapy alone, or in combination with special braces (sometimes called orthotic devices), works to prevent this complication by stretching spastic muscles. For example, if a child has spastic hamstrings (tendons located behind the knee), the therapist and parents should encourage the child to sit with the legs extended to stretch them.

A third goal of some physical therapy programs is to improve the child's motor development. A widespread program of physical therapy that works toward this goal is the Bobath technique, named for a husband and wife team who pioneered this approach in England. This program is based on the idea that the primitive reflexes retained by many children with cerebral palsy present major roadblocks to learning voluntary control. A therapist using the Bobath technique tries to counteract these reflexes by positioning the child in an opposing movement. So, for example, if a child with cerebral palsy normally keeps his arm flexed, the therapist would repeatedly extend it.

A second such approach to physical therapy is "patterning," which is based on the principle that motor skills should be taught in more or less the same sequence that they develop normally. In this controversial approach, the therapist guides the child with movement problems along the path of normal motor development. For example, the child is first taught elementary movements like pulling himself to a standing position and crawling before he is taught to walk -- regardless of his age. Some experts and organizations, including the American Academy of Pediatrics, have expressed strong reservations about the patterning approach, because studies have not documented its value.

Physical therapy is usually just one element of an infant development program that also includes efforts to provide a varied and stimulating environment. Like all children, the child with cerebral palsy needs new experiences and interactions with the world around him in order to learn. Stimulation programs can bring this valuable experience to the child who is physically unable to explore.

As the child with cerebral palsy approaches school age, the emphasis of therapy shifts away from early motor development. Efforts now focus on preparing the child for the classroom, helping the child master activities of daily living, and maximizing the child's ability to communicate.

Physical therapy can now help the child with cerebral palsy prepare for the classroom by improving his or her ability to sit, move independently or in a wheelchair, or perform precise tasks, such as writing. In occupational therapy, the therapist works with the child to develop such skills as feeding, dressing, or using the bathroom. This can help reduce demands on caregivers and boost self-reliance and self-esteem. For the many children who have difficulty communicating, speech therapy works to identify specific difficulties and overcome them through a program of exercises. For example, if a child has difficulty saying words that begin with "b," the therapist may suggest daily practice with a list of "b" words, increasing their difficulty as each list is mastered. Speech therapy can also work to help the child learn to use special communication devices, such as a computer with voice synthesizers.

Behavioral therapy provides yet another avenue to increase a child's abilities. This therapy, which uses psychological theory and techniques, can complement physical, speech, or occupational therapy. For example, behavioral therapy might include hiding a toy inside a box to reward a child for learning to reach into the box with his weaker hand. Likewise, a child learning to say his "b" words might be given a balloon for mastering the word. In other cases, therapists may try to discourage unhelpful or destructive behaviors, such as hair-pulling or biting, by selectively presenting a child with rewards and praise during other, more positive activities.

As a child with cerebral palsy grows older, the need for and types of therapy and other support

services will continue to change. Continuing physical therapy addresses movement problems and is supplemented by vocational training, recreation and leisure programs, and special education when necessary. Counseling for emotional and psychological challenges may be needed at any age, but is often most critical during adolescence. Depending on their physical and intellectual abilities, adults may need attendant care, living accommodations, transportation, or employment opportunities.

Regardless of the patient's age and which forms of therapy are used, treatment does not end when the patient leaves the office or treatment center. In fact, most of the work is often done at home. The therapist functions as a coach, providing parents and patients with the strategy and drills that can help improve performance at home, at school, and in the world. As research continues, doctors and parents can expect new forms of therapy and better information about which forms of therapy are most effective for individuals with cerebral palsy.

Drug Therapy

Physicians usually prescribe drugs for those who have seizures associated with cerebral palsy, and these medications are very effective in preventing seizures in many patients. In general, the drugs given to individual patients are chosen based on the type of seizures, since no one drug controls all types. However, different people with the same type of seizure may do better on different drugs, and some individuals may need a combination of two or more drugs to achieve good seizure control.

Drugs are also sometimes used to control spasticity, particularly following surgery. The three medications that are used most often are diazepam, which acts as a general relaxant of the brain and body; baclofen, which blocks signals sent from the spinal cord to contract the muscles; and dantrolene, which interferes with the process of muscle contraction. Given by mouth, these drugs can reduce spasticity for short periods, but their value for long-term control of spasticity has not been clearly demonstrated. They may also trigger significant side effects, such as drowsiness, and their long-term effects on the developing nervous system are largely unknown. One possible solution to avoid such side effects may lie in current research to explore new routes for delivering these drugs.

Patients with athetoid cerebral palsy may sometimes be given drugs that help reduce abnormal movements. Most often, the prescribed drug belongs to a group of chemicals called anticholinergics that work by reducing the activity of acetylcholine. Acetylcholine is a chemical messenger that helps some brain cells communicate and that triggers muscle contraction. Anticholinergic drugs include trihexyphenidyl, benztropine, and procyclidine hydrochloride.

Occasionally, physicians may use alcohol "washes" -- or injections of alcohol into a muscle -- to reduce spasticity for a short period. This technique is most often used when physicians want to correct a developing contracture. Injecting alcohol into a muscle that is too short weakens the muscle for several weeks and gives physicians time to work on lengthening the muscle through bracing, therapy, or casts. In some cases, if the contracture is detected early enough, this technique may avert the need for surgery.

Surgery

Surgery is often recommended when contractures are severe enough to cause movement problems. In the operating room, surgeons can lengthen muscles and tendons that are proportionately too short. First, however, they must determine the exact muscles at fault, since lengthening the wrong muscle could make the problem worse.

Finding problem muscles that need correction can be a difficult task. To walk two strides with a normal gait, it takes more than 30 major muscles working at exactly the right time and exactly the right force. A problem in any one muscle can cause abnormal gait. Furthermore, the natural adjustments the body makes to compensate for muscle problems can be misleading. A new tool that enables doctors to spot gait abnormalities, pinpoint problem muscles, and separate real problems from compensation is called gait analysis. Gait analysis combines cameras that record the patient while walking, computers that analyze each portion of the patient's gait, force plates that detect when feet touch the ground, and a special recording technique that detects muscle activity (known as electromyography). Using these data, doctors are better equipped to intervene and correct significant problems. They can also use gait analysis to check surgical results.

Because lengthening a muscle makes it weaker, surgery for contractures is usually followed by months of recovery. For this reason, doctors try to fix all of the affected muscles at once when it is possible or, if more than one surgical procedure is unavoidable, they may try to schedule operations close together.

A second surgical technique, known as selective dorsal root rhizotomy, aims to reduce spasticity in the legs by reducing the amount of stimulation that reaches leg muscles via nerves. In the procedure, doctors try to locate and selectively sever overactivated nerves controlling leg muscles. Although there is scientific controversy over how selective this technique actually is, recent research results suggest it can reduce spasticity in some patients, particularly those who have spastic diplegia. Ongoing research is evaluating this surgery's effectiveness.

Experimental surgical techniques include chronic cerebellar stimulation and stereotaxic thalamotomy. In chronic cerebellar stimulation, electrodes are implanted on the surface of the cerebellum -- the part of the brain responsible for coordinating movement -- and are used to stimulate certain cerebellar nerves. While it was hoped that this technique would decrease spasticity and improve motor function, results of this invasive procedure have been mixed. Some studies have reported improvements in spasticity and function, others have not.

Stereotaxic thalamotomy involves precise cutting of parts of the thalamus, which serves as the brain's relay station for messages from the muscles and sensory organs. This has been shown effective only for reducing hemiparetic tremors (see glossary).

Mechanical aids

Whether they are as humble as velcro shoes or as advanced as computerized communication devices, special machines and gadgets in the home, school, and workplace can help the child or adult with cerebral palsy overcome limitations.

The computer is probably the most dramatic example of a new device that can make a difference in the lives of those with cerebral palsy. For example, a child who is unable to speak or write but can make head movements may be able to learn to control a computer using a special light pointer that attaches to a headband. Equipped with a computer and voice synthesizer, this child could communicate with others. In other cases, technology has led to new versions of old devices, such as the traditional wheelchair and its modern offspring that runs on electricity.

Many such devices are products of engineering research supported by private foundations and other groups.

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What Other Major Problems Are Associated with Cerebral Palsy?

Poor control of the muscles of the throat, mouth and tongue sometimes leads to drooling. Drooling can cause severe skin irritation and, because it is socially unacceptable, can lead to further isolation of affected children from their peers. Although numerous treatments for drooling have been tested over the years, there is no one treatment that always helps. Drugs called anticholinergics can reduce the flow of saliva but may cause significant side effects, such as mouth dryness and poor digestion. Surgery, while sometimes effective, carries the risk of complications, including worsening of swallowing problems. Some patients benefit from a technique called biofeedback that can tell them when they are drooling or having difficulty controlling muscles that close the mouth. This kind of therapy is most likely to work if the patient has a mental age of more than 2 or 3 years, is motivated to control drooling, and understands that drooling is not socially acceptable.

Difficulty with eating and swallowing -- also triggered by motor problems in the mouth -- can cause poor nutrition. Poor nutrition, in turn, may make the individual more vulnerable to infections and cause or aggravate "failure to thrive" -- a lag in growth and development that is common among those with cerebral palsy. To make swallowing easier, the caregiver may want to prepare semisolid food, such as strained vegetables and fruits. Proper position, such as sitting up while eating or drinking and extending the individual's neck away from the body to reduce the risk of choking, is also helpful. In severe cases of swallowing problems and malnutrition, physicians may recommend tube feeding, in which a tube delivers food and nutrients down the throat and into the stomach, or

gastrostomy, in which a surgical opening allows a tube to be placed directly into the stomach.

A common complication is incontinence, caused by faulty control over the muscles that keep the bladder closed. Incontinence can take the form of bed-wetting (also known as enuresis), uncontrolled urination during physical activities (or stress incontinence), or slow leaking of urine from the bladder. Possible medical treatments for incontinence include special exercises, biofeedback, prescription drugs, surgery, or surgically implanted devices to replace or aid muscles. Specially designed undergarments are also available.

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What Research Is Being Done?

Investigators from many arenas of medicine and health are using their expertise to help improve treatment and prevention of cerebral palsy. Much of their work is supported through the National Institute of Neurological Disorders and Stroke (NINDS), the National Institute of Child Health and Human Development, other agencies within the Federal Government, nonprofit groups such as the United Cerebral Palsy Research Foundation, and private institutions.

The ultimate hope for overcoming cerebral palsy lies with prevention. In order to prevent cerebral palsy, however, scientists must first understand the complex process of normal brain development and what can make this process go awry.

Between early pregnancy and the first months of life, one cell divides to form first a handful of cells, and then hundreds, millions, and, eventually, billions of cells. Some of these cells specialize to become brain cells. These brain cells specialize into different types and migrate to their appropriate site in the brain. They send out branches to form crucial connections with other brain cells. Ultimately, the most complex entity known to us is created: a human brain with its billions of interconnected neurons.

Mounting evidence is pointing investigators toward this intricate process in the womb for clues about cerebral palsy. For example, a group of researchers has recently observed that more than one-third of children who have cerebral palsy also have missing enamel on certain teeth. This tooth defect can be traced to problems in the early months of fetal development, suggesting that a disruption at this period in development might be linked both to this tooth defect and to cerebral palsy.

As a result of this and other research, many scientists now believe that a significant number of children develop cerebral palsy because of mishaps early in brain development. They are examining how brain cells specialize, how they know where to migrate, how they form the right connections -- and they are looking for preventable factors that can disrupt this process before or after birth.

Scientists are also scrutinizing other events -- such as bleeding in the brain, seizures, and breathing and circulation problems -- that threaten the brain of the newborn baby. Through this research, they hope to learn how these hazards can damage the newborn's brain and to develop new methods for prevention.

Some newborn infants, for example, have life-threatening problems with breathing and blood circulation. A recently introduced treatment to help these infants is extracorporeal membrane oxygenation, in which blood is routed from the patient to a special machine that takes over the lungs' task of removing carbon dioxide and adding oxygen. Although this technique can dramatically help many such infants, some scientists have observed that a substantial fraction of treated children later experience long-term neurological problems, including developmental delay and cerebral palsy. Investigators are studying infants through pregnancy, delivery, birth, and infancy, and are tracking those who undergo this treatment. By observing them at all stages of development, scientists can learn whether their problems developed before birth, result from the same breathing problems that made them candidates for the treatment, or spring from errors in the treatment itself. Once this is determined, they may be able to correct any existing problems or develop new treatment methods to prevent brain damage.

Other scientists are exploring how brain insults like hypoxic-ischemic encephalopathy (brain damage from a shortage of oxygen or blood flow), bleeding in the brain, and seizures can cause

the abnormal release of brain chemicals and trigger brain damage. For example, research has shown that bleeding in the brain unleashes dangerously high amounts of a brain chemical called glutamate. While glutamate is normally used in the brain for communication, too much glutamate overstimulates the brain's cells and causes a cycle of destruction. Scientists are now looking closely at glutamate to detect how its release harms brain tissue and spreads the damage from stroke. By learning how such brain chemicals that normally help us function can hurt the brain, scientists may be equipped to develop new drugs that block their harmful effects.

In related research, some investigators are already conducting studies to learn if certain drugs can help prevent neonatal stroke. Several of these drugs seem promising because they appear to reduce the excess production of potentially dangerous chemicals in the brain and may help control brain blood flow and volume. Earlier research has linked sudden changes in blood flow and volume to stroke in the newborn.

Low birthweight itself is also the subject of extensive research. In spite of improvements in health care for some pregnant women, the incidence of low birth-weight babies born each year in the United States remains at about 7 1/2 percent. Some scientists currently investigating this serious health problem are working to understand how infections, hormonal problems, and genetic factors may increase a woman's chances of giving birth prematurely. They are also conducting more applied research that could yield: 1) new drugs that can safely delay labor, 2) new devices to further improve medical care for premature infants, and 3) new insight into how smoking and alcohol consumption can disrupt fetal development.

While this research offers hope for preventing cerebral palsy in the future, ongoing research to improve treatment brightens the outlook for those who must face the challenges of cerebral palsy today. An important thrust of such research is the evaluation of treatments already in use so that physicians and parents have the information they need to choose the best therapy. A good example of this effort is an ongoing NINDS-supported study that promises to yield new information about which patients are most likely to benefit from selective dorsal root rhizotomy, a recently introduced surgery that is becoming increasingly in demand for reduction of spasticity.

Similarly, although physical therapy programs are a popular and widespread approach to managing cerebral palsy, little scientific evidence exists to help physicians, other health professionals, and parents determine how well physical therapy works or to choose the best approach among many. Current research on cerebral palsy aims to provide this information through careful studies that compare the abilities of children who have had physical and other therapy with those who have not.

As part of this effort, scientists are working to create new measures to judge the effectiveness of treatment, as in ongoing research to precisely identify the specific brain areas responsible for movement may yield one such approach. Using magnetic pulses, researchers can locate brain areas that control specific actions, such as raising an arm or lifting a leg, and construct detailed maps. By comparing charts made before and after therapy among children who have cerebral palsy, researchers may gain new insights into how therapy affects the brain's organization and new data about its effectiveness.

Investigators are also working to develop new drugs -- and new ways of using existing drugs -- to help relieve cerebral palsy's symptoms. In one such set of studies, early research results suggest that doctors may improve the effectiveness of the anti-spasticity drug called baclofen by giving the drug through spinal injections, rather than by mouth. In addition, scientists are also exploring the use of tiny implanted pumps that deliver a constant supply of anti-spasticity drugs into the fluid around the spinal cord, in the hope of improving these drugs' effectiveness and reducing side effects, such as drowsiness.

Other experimental drug development efforts are exploring the use of minute amounts of the familiar toxin called botulinum. Ingested in large amounts, this toxin is responsible for botulism poisoning, in which the body's muscles become paralyzed. Injected in tiny amounts, however, this toxin has shown early promise in reducing spasticity in specific muscles.

A large research effort is also directed at producing more effective, nontoxic drugs to control seizures. Through its Antiepileptic Drug Development Program, the NINDS screens new compounds developed by industrial and university laboratories around the world for toxicity and anticonvulsant activity and coordinates clinical studies of efficacy and safety. To date, this program has screened more than 13,000 compounds and, as a result, five new antiepileptic drugs --

carbamazepine, clonazepam, valproate, clorazepate, and felbamate -- have been approved for marketing. A new project within the program is exploring how the structure of a given antiseizure medication relates to its effectiveness. If successful, this project may enable scientists to design better antiseizure medications more quickly and cheaply.

As researchers continue to explore new treatments for cerebral palsy and to expand our knowledge of brain development, we can expect significant medical advances to prevent cerebral palsy and many other disorders that strike in early life.

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RESEARCH UPDATE: June 2000

Research conducted and supported by the National Institute of Neurological Disorders and Stroke (NINDS) continuously seeks to uncover new clues about cerebral palsy (CP). Investigators from the NINDS and the California Birth Defects Monitoring Program (CBDMP) presented data suggesting that very low birthweight babies have a decreased incidence of CP when their mothers are treated with magnesium sulfate soon before giving birth. The results of this study, which were based on observations of a group of children born in four Northern California counties, were published in the February 1995 issue of *Pediatrics.**

Low birthweight babies are 100 times more likely to develop CP than normal birthweight infants. If further research confirms the study's findings, use of magnesium sulfate may prevent 25 percent of the cases of CP in the approximately 52,000 low birthweight babies born each year in the United States.

Magnesium is a natural compound that is responsible for numerous chemical processes within the body and brain. Obstetricians in the United States often administer magnesium sulfate, an inexpensive form of the compound, to pregnant women to prevent preterm labor and high blood pressure brought on by pregnancy. The drug, administered intravenously in the hospital, is considered safe when given under medical supervision.

Scientists speculate that magnesium may play a role in brain development and possibly prevent bleeding inside the brains of preterm infants. Previous research has shown that magnesium may protect against brain bleeding in very premature infants. Animal studies have demonstrated that magnesium given after a traumatic brain injury can reduce the severity of brain damage.

Despite these encouraging research findings, pregnant women should not change their magnesium intake because the effects of high doses have not yet been studied and the possible risks and benefits are not known.

Researchers caution that more research will be required to establish a definitive relationship between the drug and prevention of the disorder. Clinical trials now underway, one of them a collaboration between the NINDS and the National Institute of Child Health and Human Development, are evaluating magnesium for the prevention of cerebral palsy in prematurely born babies.

*Nelson KB, and Grether JK. Can magnesium sulfate reduce the risk of cerebral palsy in very low birthweight infants? Pediatrics, February 1995, vol. 95, no. 2, page 263.

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More about the National Institute of Neurological Disorders and Stroke

The NINDS is the Federal Government's leading supporter of biomedical research on brain and nervous system disorders, including cerebral palsy. The NINDS conducts research in its own laboratories at the National Institutes of Health in Bethesda, MD, and supports research at institutions worldwide. The Institute also sponsors an active public information program. Other NINDS publications that may be of interest to those concerned about cerebral palsy include "Epilepsy: Hope Through Research"and "Dystonias Fact Sheet."

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Where can I get more information?

For more information on neurological disorders or research programs funded by the National Institute of Neurological Disorders and Stroke, contact the Institute's Brain Resources and Information Network (BRAIN) at:

BRAIN
P.O. Box 5801
Bethesda, MD 20824
(800) 352-9424
http://www.ninds.nih.gov

Information also is available from the following organizations:

Epilepsy Foundation
4351 Garden City Drive
Suite 500
Landover, MD 20785-7223
postmaster@efa.org
http://www.epilepsyfoundation.org
Tel: 301-459-3700 800-EFA-1000 (332-1000)
Fax: 301-577-2684
National charitable organization dedicated to the welfare of people with epilepsy. Works for children and adults affected by seizures through education, advocacy, services, and research towards a cure. Offers a Legal Defense Program through a fund.

March of Dimes Birth Defects Foundation
1275 Mamaroneck Avenue
White Plains, NY 10605
askus@marchofdimes.com
http://www.marchofdimes.com
Tel: 914-428-7100 888-MODIMES (663-4637)
Fax: 914-428-8203
Works to improve the health of babies by preventing birth defects and infant mortality through programs of research, community services, education, and advocacy.

Easter Seals
230 West Monroe Street
Suite 1800
Chicago, IL 60606-4802
info@easter-seals.org
http://www.easter-seals.org
Tel: 312-726-6200 800-221-6827
Fax: 312-726-1494
Provides services to help children and adults with disabilities and/or special needs as well as support to their families. Supports the National AgrAbility Project, a program for farmers, ranchers, and farmworkers with disabilities.

United Cerebral Palsy (UCP)
1600 L Street, NW
Suite 700
Washington, DC 20036
national@ucp.org
http://www.ucp.org
Tel: 202-776-0406 800-USA-5UCP (872-5827)
Fax: 202-776-0414
Works to advance the independence, productivity and full citizenship of people with cerebral palsy and other disabilities, through our commitment to the principles of independence, inclusion and self-determination.

National Disability Sports Alliance
25 West Independence Way
Kingston, RI 02881
info@ndsaonline.org
http://www.ndsaonline.org
Tel: 401-792-7130
Fax: 401-792-7132
Non-profit volunteer organization that offers a variety of services, publications, educational programs, fund-raising activities, sports medicine programs, video resources and general information about sports related activities.

Children's Neurobiological Solutions (CNS) Foundation
1726 Franceschi Road
Santa Barbara, CA 93103
fia@cnsfoundation.org
http://www.cnsfoundation.org
Tel: 866-CNS-5580 (267-5580) 805-965-8838
National, non-profit organization whose mission is to accelerate the development of brain repair therapies and cures by supporting cutting-edge collaborative research on brain damage due to childhood illness, injury, or any other cause. Provides information and resources for families and health care providers.

Children's Hemiplegia and Stroke Assocn. (CHASA)
4101 West Green Oaks Blvd., Ste. 305
PMB 149

Arlington, TX 76016
info437@chasa.org
http://www.chasa.org
Tel: 817-492-4325
Non-profit 501(c)(3) corporation that offers support and information for families of children who have hemiplegia due to stroke or other causes. Also provides information regarding research and causes of any type of pediatric stroke.

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Glossary

- Apgar score. A numbered score doctors use to assess a baby's physical state at the time of birth.
- apraxia. Impaired ability to carry out purposeful movements in an individual who does not have significant motor problems.
- asphyxia. Lack of oxygen due to trouble with breathing or poor oxygen supply in the air.
- bile pigments. Yellow-colored substances produced by the human body as a by-product of digestion.
- cerebral. Relating to the two hemispheres of the human brain.
- computed tomography (CT). An imaging technique that uses X rays and a computer to create a picture of the brain's tissues and structures.
- congenital. Present at birth.
- contracture. A condition in which muscles become fixed in a rigid, abnormal position causing distortion or deformity.
- dysarthria. Problems with speaking caused by difficulty moving or coordinating the muscles needed for speech.
- electroencephalogram (EEG). A technique for recording the pattern of electrical currents inside the brain.
- electromyography. A special recording technique that detects muscle activity.
- failure to thrive. A condition characterized by lag in physical growth and development.
- gait analysis. A technique that uses camera recording, force plates, electromyography, and computer analysis to objectively measure an individual's pattern of walking.
- gastrostomy. A surgical procedure to create an artificial opening in the stomach.
- hemianopia. Defective vision or blindness that impairs half of the normal field of vision.
- hemiparetic tremors. Uncontrollable shaking affecting the limbs on the spastic side of the body in those who have spastic hemiplegia.
- hypertonia. Increased tone.
- hypotonia. Decreased tone.
- hypoxic-ischemic encephalopathy. Brain damage caused by poor blood flow or insufficient oxygen supply to the brain.
- jaundice. A blood disorder caused by the abnormal buildup of bile pigments in the bloodstream.
- magnetic resonance imaging (MRI) -- an imaging technique which uses radio waves, magnetic fields, and computer analysis to create a picture of body tissues and structures.
- neonatal hemorrhage. Bleeding of brain blood vessels in the newborn.
- orthotic devices. Special devices, such as splints or braces, used to treat problems of the muscles, ligaments, or bones of the skeletal system.
- paresis or plegia. Weakness or paralysis. In cerebral palsy, these terms are typically combined with another phrase that describes the distribution of paralysis and weakness, e.g., paraparesis.
- palsy. Paralysis, or problems in the control of voluntary movement.
- reflexes. Movements that the body makes automatically in response to a specific cue.
- Rh incompatibility. A blood condition in which antibodies in a pregnant woman's blood can attack fetal blood cells, impairing the fetus's supply of oxygen and nutrients.
- rubella. Also known as German measles, rubella is a viral infection that can damage the nervous system in the developing fetus.
- selective dorsal root rhizotomy. A surgical procedure in which selected nerves are severed to reduce spasticity in the legs.
- spastic diplegia. A form of cerebral palsy in which both arms and both legs are affected, the legs being more severely affected.
- spastic hemiplegia (or hemiparesis). A form of cerebral palsy in which spasticity affects the

arm and leg on one side of the body.
- spastic paraplegia (or paraparesis). A form of cerebral palsy in which spasticity affects both legs but the arms are relatively or completely spared.
- spastic quadriplegia (or quadriparesis). A form of cerebral palsy in which all four limbs are affected equally.
- stereognosia. Difficulty perceiving and identifying objects using the sense of touch.
- strabismus. Misalignment of the eyes.
- ultrasonography. A technique that bounces sound waves off of tissues and structures and uses the pattern of echoes to form an image, called a sonogram.

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"Cerebral Palsy: Hope Through Research", NINDS. Publication date July 2001.

NIH Publication No. 93-159

Back to Cerebral Palsy Information Page

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