Cerebral palsy

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Key points

- Cerebral palsy (CP) refers to a nonprogressive disease of the brain originating during the prenatal, neonatal, or early postnatal period
- Spasticity of motor movement is by far the most common presentation of CP
- More subtle manifestations of CP include difficulties with speech, perceptive impairment, urinary incontinence, sensory loss, and difficulties with balance
- Treatment may require multiple specialty consultation and a combined approach to therapy across several providers including oral medications, injections, and even orthopedic surgery

Background

Description

- Cerebral palsy (CP) is a nonprogressive (static) disorder of motor function and movement that usually manifests early in life as a result of central nervous system damage to the developing brain
- CP remains a clinical diagnosis. Evidence of motor dysfunction must be present, and clinical findings and symptoms may evolve over time. Most patients exhibit symptoms as infants or toddlers; diagnosis is often made before 2 years of age
- Delayed motor milestones are one of the most common complaints
- Patients with dystonia or movement disorders present later in childhood (aged older than 2 years)
- Often associated with abnormalities of speech, vision, intellect, and (frequently) seizures
- CP encompasses a wide spectrum of clinical presentations ranging from normal intelligence with mild motor deficits to severe retardation and inability to walk. Although there is delay in developmental motor milestones, mental retardation is seen in only 30% to 50% of patients with cerebral palsy
- Therapy, whether for movement, speech, or activities of daily living, is the cornerstone of cerebral palsy management
- Patients with cerebral palsy and comorbid seizure disorders should receive anti-epileptic agents suitable for the type of seizures that they experience
- Cardinal features:
  - Hypotonia with spasticities
  - Delay in developmental milestones
  - Extrapyramidal symptoms
- Diplegia
- Hemiplegia
- Seizures (30%)
- Mental retardation (30%)

**Epidemiology**

**Incidence and prevalence**

- 1.5 to 2.5 per 1,000 live births
- Time trends in CP are due to advances in perinatal care in the last 40 years: there was a sharp increase in prevalence of CP in very low birth weight (VLBW) infants during the 1980s, which has been attributed to the increased survival in VLBW infants due to advances in newborn intensive care. This recent increase seems to have leveled off and may be on the decline.
- Patients with mild forms of CP that do not result in severe functional impairment may remain undiagnosed, leading to underestimation of the true prevalence of CP

**Demographics**

**Age:**

- CP is more common in children who are born very prematurely or at term
- Swedish data indicate that 36% of patients were born at less than 28 weeks' gestation, 25% between 28 and 32 weeks' gestation, 2.5% between 32 and 38 weeks' gestation, and 37% at full term
- Most patients are identified by 2 years of age due to delayed motor milestones

**Gender:**

- There is a slightly higher prevalence in the male population, with a male:female ratio of 1.5:1.

**Race:**

- There is a higher prevalence among black non-Hispanic children compared with white non-Hispanic children

**Socioeconomic status:**

- Poor prenatal care may increase the incidence of cerebral palsy
- Living in substandard housing with lead paint may increase the incidence of cerebral palsy

**Causes and risk factors**
Birth asphyxia used to be considered the principal etiology for CP. However, it is now believed that 70% to 80% of cases of CP are due to antenatal factors, while only 10% to 28% of cases are due to birth asphyxia in term and near-term infants.

More than 1 etiologic factor is often identified. For example, intrauterine infection may result in growth restriction, maternal fever, and prematurity, all of which have been associated with CP.

Prenatal causes:

- Abnormal intrauterine growth may be the result of multiple factors such as placental insufficiency, intrauterine infection, and chromosomal abnormalities, among others.
- Maternal infections and fever: evidence of maternal fever around the time of delivery and chorioamnionitis have been associated with low Apgar scores, neonatal encephalopathy, seizures, and increased risk of CP.
  - TORCH infections (toxoplasmosis, syphilis, rubella, cytomegalovirus, varicella zoster, HIV, herpes viruses) are thought to be responsible for 5% of CP cases.
- Multiple births: twins carry a higher risk of CP when compared to single births; risk of having a child with CP is 0.2% for single births, 1.3% for twins, and 7.6% for triplets.
  - Weight discordance greater than 30% is associated with a 5-fold increased risk of CP.
  - Death of a co-twin or co-triplet is associated with a 10% and 29% risk of CP for the surviving twin or triplets, respectively.
- Placental pathology:
  - Thrombotic lesions and placental ischemia have been associated with spastic diplegia.
  - Chronic villitis (focal areas of inflammation) has been associated with growth restriction, preterm birth and pre-eclampsia.
- Genetic factors
- Maternal metabolic disturbances (diabetes mellitus type 1 or type 2 or thyroid abnormalities)
- Intrauterine exposure to toxins
- Malformations of cortical development

Perinatal causes:

- Hypoxia-ischemia: 6% of children with CP have an identifiable birth complication that could result in hypoxia. Neonatal encephalopathy is usually present.
- Periventricular leukomalacia (PVL) increases the risk of CP, independent of gestational age. Approximately 75% of infants with cystic PVL develop CP.
- Fetal/neonatal stroke: most often resulting in hemiplegic CP.
- Hyperbilirubinemia
  - Hemolytic disease in the newborn, especially due to Rh incompatibility, was previously a common cause of kernicterus and CP prior to the use of Rho(D) immune globulin. It is still being reported in North America, Western Europe and the developing world.
Kernicterus is the preferred term to describe the chronic permanent sequelae of bilirubin toxicity. Affected children often develop severe athetoid CP.

Postnatal causes:

- Stroke
- Trauma
- Infection

**Associated disorders**

- Seizures
- Scoliosis
- Deafness
- Mental retardation
- Visual impairments: strabismus, nystagmus, optic atrophy
- Speech deficits
- Feeding difficulties
- Urinary incontinence
- Attention deficit hyperactivity disorder
- Learning disabilities
- Depression
- Autism

**Screening**

Not applicable.

**Primary prevention**

**Summary approach**

- Since the cause of cerebral palsy is not always known, it is difficult to prevent; however, some prenatal causes can be prevented with appropriate prenatal care
  - The risks associated with preterm delivery may be minimized with early and regular prenatal physician visits
  - The use of antenatal corticosteroids (i.e., betamethasone) in patients at risk for pre-term delivery seems to reduce the risk of CP by protecting against neonatal intraventricular hemorrhage (IVH)
  - Prophylactic magnesium sulfate was administered to women for whom preterm delivery was imminent in the Beneficial Effect of Antenatal Magnesium (BEAM) trial to assess reduction in the risk of death or moderate to severe cerebral palsy in their children. The results suggested that although the risk of death or moderate to severe CP did not seem to decrease, the overall rate of CP was reduced among child survivors
• Head injuries can be prevented by proper positioning in car seats
• Routine vaccinations in infants can prevent many cases of meningitis that leads to brain injury

Preventive measures

• Administering prophylactic magnesium sulfate to women for whom preterm delivery is imminent may reduce the incidence of CP
• Pregnant women should be advised not to smoke because it increases the risk of prematurity. Smoking also damages the placenta and can contribute to neonatal hypoxia and brain damage, which increases the risk of cerebral palsy
• Pregnant women should be advised not to drink alcohol or take unprescribed drugs because of risk of neural tube damage to the baby. Early brain damage during development in utero can lead to cerebral palsy
• Pregnant women should avoid eating raw shellfish and soft cheeses
• Pregnant women should avoid all unnecessary X-ray radiation because it may damage developing neural tissue, which can increase the risk of developing cerebral palsy
• Exposure to toxins should be avoided, such as ingestion or inhalation of lead paint
• Ensure that any high-risk delivery occurs in a center where any complications can be managed (e.g., cesarean section for prolonged labor, fetal distress, or dystocia)
• If a preterm delivery is imminent, ensure that the adequate staff and facilities are available to manage the neonate and prevent hypoxia and acidosis after delivery. Low birth weight infants are at increased risk of developing cerebral palsy from intracerebral hemorrhage and periventricular leukomalacia. Prematurity is the most common natal cause of cerebral palsy
• Infants should receive Haemophilus influenzae type b and pneumococcal vaccines to protect against meningitis
• Rh-negative women should receive Rho(D) immune globulin to prevent destruction of fetal blood cells
• Pregnant women should be assessed for immunity to rubella. Rubella infections during pregnancy can damage the developing brain
• Ensure that any diabetic woman has good glycemic control when pregnant to decrease the risk of developmental problems in the fetus
• Minimize intrauterine exposure to maternal infection

Evidence

• A systematic review assessed the effects of magnesium sulfate as a neuroprotective agent when given to women considered at risk of preterm birth in 5 RCTs inclusive of 6,145 neonates. Women presenting from 24.0 to 31.6 weeks' gestation with advanced preterm labor or premature rupture of the membranes and no recent exposure to magnesium sulfate were randomized to receive either intravenous magnesium sulfate or masked study drug placebo. If after 12 hours delivery had not occurred and was not anticipated, the infusion was stopped. Patients were assessed for signs of intolerance to the study medications and maternal data were collected up to hospital discharge. Up to 3 follow-up visits were scheduled over 2 years where certified examiners, masked to study group
assignment, collected physical and neurological data, including a modified Gross Motor Function Classification Scale. The Bayley Scale of Infant Development was also administered. Antenatal magnesium sulfate reduced the risk of cerebral palsy. There was also a significant reduction in the rate of substantial gross motor dysfunction. Overall there were no significant effects of antenatal magnesium therapy on combined rates of mortality with cerebral palsy. There were higher rates of minor maternal side effects in the magnesium groups, but no significant effects on major maternal complications. [1]

Level of evidence: 1

References

**Diagnosis**

**Summary approach**

- Diagnosis is made primarily by taking a careful history and thorough physical examination; it is very important to establish that the child is not progressively losing function. When in doubt, serial neurological examinations may be required to ensure that the disorder is static.
- Most children come to medical attention during the first 2 years of life when they fail to achieve normal developmental milestones. Rarely, when movement disorders are the primary manifestation, clinical symptoms may appear later in childhood.
- Laboratory tests or electromyography with nerve conduction studies may be useful to rule out metabolic diseases or nerve and muscle disorders. Imaging studies may reveal abnormalities that are suggestive of cerebral palsy.

CP may be classified according to the extremities involved, and/or characteristics of neurologic dysfunction.

- According to the extremity involved:
  - Monoplegia
  - Hemiplegia: frequently due to focal ischemia, malformations of cortical development and grade IV intraventricular hemorrhage
  - Diplegia: although the lower extremities are primarily affected, some degree of upper extremity involvement is often present. Spastic diplegia is more frequently encountered in premature children (below 32 weeks of gestational age or less than 1,500 g in birth weight)
  - Quadriplegia: all 4 extremities involved. The term 'double hemiplegia' has been used in some instances when there is some degree of asymmetry between the two sides. Spastic quadriplegia is more frequently seen in full-term newborns with global hypoxic ischemic injury (global hypoxia and watershed infarction)
  - A Scandinavian study reported that 44% of patients are affected by the diplegic form, followed by hemiplegic (33%) and quadriplegic (6%) forms

- According to neurological dysfunction:
  - Spastic
  - Hypotonic: due to cerebellar involvement
o Ataxic: with cerebellar involvement
o Dyskinetic (extrapyramidal, choreoathetoid): due to predominant basal ganglia involvement in patients with acute severe hypoxia and kernicterus. Symptoms consistent with a movement disorder may appear later in life
o Mixed

Clinical presentation

Symptoms:

- Delay in meeting gross motor developmental milestones; this is the primary concern observed by parents
- Weakness

Signs:

- During infancy, the child may be hypotonic, and physically and developmentally delayed
- Early hand preference (before 3 years of age) may be the earliest manifestation of hemiplegic CP
- Past 1 year of age, the child may continue to have primitive reflexes
- Spasticity is the most common clinical type of cerebral palsy; it is caused by injury to pyramidal tracts in the developing brain
- Abnormal posture

Examination:

- Evaluate the child's muscle tone. Hypotonicity, hypertonicity, or variable tone may be present
- Determine whether there is a right or left hand preference. Most babies do not develop a hand preference before 3 years of age; babies with cerebral palsy often do so prior to 6 months. Early handedness often indicates weakness of the unused hand or arm
- Check the child's primitive reflexes. In normal infants, these reflexes disappear by 6 to 12 months of age
- Look for spasticity. Spasticity is defined as velocity-dependent resistance to passive movement of the affected muscle(s) or body part. This is the most common clinical type of cerebral palsy
- Evaluate the patient's motion or ability to remain still. Athetosis, dystonia, and ballismus may occur
- Look for ataxia. Unsteady gait may lead to delayed walking
- Check for tremor. A small, pendular, repetitive tremor may occur following encephalitis
- Look for associated abnormalities. These may include ophthalmological impairments (strabismus, amblyopia, nystagmus, optic atrophy, refractory errors), hearing impairments, or speech/language disorders

Questions to ask:
• **Were there any complications during pregnancy or delivery?** Maternal infection or exposure to noxious substances, as well as lack of oxygen or a difficult and delayed delivery are important prenatal and perinatal causes of cerebral palsy. An abnormal perinatal period is the biggest predictor of cerebral palsy

• **Was the child hypotonic as an infant?** Hypotonia often precedes spasticity

• **Has the child met developmental milestones?** Delay in achieving milestones is often the parent’s foremost concern

• **When did symptoms become noticeable?** Abnormalities may not be evident initially after the birth. Often, they become noticeable over time because maturation of neurons in the basal ganglia is required for expression of spasticity, dystonia, and athetosis. The average age of diagnosis is 13 months

• **Did the mother use illicit drugs while pregnant?** Exposure to toxins is associated with cerebral palsy

• **Did the mother have any infections while pregnant or during delivery?** Toxoplasmosis, rubella, cytomegalovirus, herpes simplex virus, chorioamnionitis, umbilical cord inflammation, foul-smelling amniotic fluid, maternal sepsis, fever during labor, and urinary tract infections have been associated with cerebral palsy

**Diagnostic testing**

• [Laboratory studies](#) can be used to rule out hereditary or neurodegenerative disorders

• Imaging studies using [magnetic resonance imaging](#) (preferable), [computed tomography](#), or [ultrasound](#) will show structural abnormalities

• [Electromyography and nerve conduction studies](#) can be used to rule out muscle and nerve diseases

**Laboratory studies**

**Description**

• Laboratory studies may be ordered to rule out metabolic and neurodegenerative disorders, but they play no role in the diagnosis of cerebral palsy per se

**Normal result**

Lactate and pyruvate levels:

• Lactate: 6.3 to 19.8 mg/dL (0.7 to 2.2 mmol/L)

• Pyruvate: 0.44 to 1.23 mg/dL (50 to 140 μmol/L)

**Thyroid function studies:**

• Thyroid stimulating hormone: 2 to 11 μU/mL

• Thyroxine, total (T4): 4.5 to 12.0 μg/dL (58 to 155 nmol/L)

• Thyroxine, free: 0.8 to 2.7 ng/dL (10.3 to 34.8 pmol/L)

• Tri-iodothyronine: 59 to 174 ng/dL (0.91 to 2.70 nmol/L)
- T4 index: 0.35 to 6.2 μU/mL

Other:
- Ammonia: 9 to 33 μmol/L
- Serum quantitative amino acids
- Chromosomal analysis

Comments
- May rule out or diagnose other potentially treatable diseases
- Not diagnostic for cerebral palsy
- Expensive
- Not standardized

Magnetic resonance imaging of the brain or spinal cord

Description
- Magnetic resonance imaging of the brain or spinal cord
- Results in the best definition of cortical and white matter abnormalities
- Readily shows ischemic changes
- Imaging method of choice for older children. For some children the experience is claustrophobic; sedation may be required

Normal result
- No evidence of cystic or congenital malformation

Comments
- Brain MRI abnormalities may be present in up to 89% of patients; abnormalities are seen more frequently in patients with a history of prematurity due to the detection of PVL
- Diagnostic yield depends on the specific type of CP
- May be helpful in determining timing of injury (prenatal, perinatal, postnatal)
- May determine if the appropriate level of myelination is present for a given age
- In children with spasticity of legs and worsening incontinence, spinal cord imaging may be useful to identify a tethered spinal cord
- May diagnose and allow monitoring of hydrocephalus
- Gadolinium contrast is safe
- MRI is expensive and entails a long scanning time and stillness, as it is motion sensitive

Computed tomography of the brain

Description
- A high-resolution scan of the brain
- Yield from CT scans varies depending on the specific type of CP with the lowest yield seen in patients with dyskinetic CP. Abnormalities are detected in 77% of patients with CP

**Normal result**

- No evidence of cystic or congenital malformation

**Comments**

- May identify congenital abnormalities, intracranial hemorrhage
- May identify periventricular leukomalacia, which is suggestive of cerebral palsy, more clearly than ultrasound in infants
- May diagnose and allow monitoring of hydrocephalus
- An abnormal CT may also suggest associated conditions (epilepsy, mental retardation)
- Scanning is rapid, widely available
- Minor abnormalities may be missed
- Radiation exposure via iodinated contrast may be necessary

**Ultrasound of the head**

**Description**

- Not as sensitive as MRI in detecting brain abnormalities, but may be helpful in diagnosis and prognosis

**Normal result**

- No evidence of cystic or congenital malformation

**Comments**

- May be used in early neonatal period; useful in medically unstable infants who cannot tolerate transport for more detailed neuroimaging
- May identify structural abnormalities
- May show evidence of hemorrhage or hypoxic injury
- May diagnose and allow monitoring of hydrocephalus
- Entails no radiation exposure
- This test is operator-dependent in that it relies heavily on the skill of the radiographer
- Acoustic window is needed

**Electromyography and nerve conduction studies**

**Description**
Tiny needle transducers are inserted into the belly of a muscle and serial motor unit potentials are measured and recorded. Performed to rule out other muscle and neurodegenerative diseases.

**Normal result**

- Normal nerve firing electrical activity and expected muscle discharge in response to stimulation.

**Comments**

- Evaluates patients for other muscle and neurodegenerative diseases.
- Causes discomfort.
- Acetylcholinesterase inhibitors and low temperatures may alter result and lead to abnormal electromyographic results.

**Differential diagnosis**

**Dopa-responsive dystonia**

- A broad category of dystonias that respond to treatment with levodopa.
- Features:
  - Dopa responsive dystonia (Segawa disease) is due to guanosine triphosphate cyclohydrolase deficiency.
  - Autosomal dominant with incomplete penetrance; symptoms may vary between affected family members.
  - Patients classically present with exercise-induced dystonia, or symptoms that worsen toward the end of the day (diurnal variation).
  - The disorder should be suspected in patients with spastic diplegia with fluctuations in tone and gait, particularly worsening toward the end of the day.
  - Less frequent manifestations include writer’s cramp and restless leg syndrome.
  - Genetic studies may be used to confirm the disease.
  - Cerebrospinal fluid (CSF) examination show abnormal levels of neurotransmitter metabolites (low homovanillic acid level, normal or low normal 5-hydroxyindoleacetic level and reduced BH4) and pterin.
  - Treatment with L-dopa/carbidopa results in significant improvement in the majority of patients.

**Muscular dystrophy**

- A group of inherited myopathies characterized by progressive muscle weakness and muscle degeneration. Clinical expression of muscular dystrophies varies widely with respect to severity, age of onset, muscles first and most affected, rate of disease progression, and inheritance patterns.
- Features:
Progressive muscle weakness; muscles first affected vary with each type of muscular dystrophy
- Calves often enlarged (Duchenne muscular dystrophy)
- Cardiac involvement possible
- Shoulder girdle weakness predominates in some types of muscular dystrophy
- Joint deformities may occur
- Facial muscle weakness with wasting of shoulders and upper arms, is characteristic of facioscapulohumeral dystrophy
- Myotonia
- Hypotonia at birth may be severe, leading to respiratory and feeding difficulties. A congenital myopathy should be suspected in these patients, especially in the absence of risk factors for hypoxic injury. These infants characteristically appear weak with normal mental status (although certain types of congenital muscular dystrophy may also be associated with central nervous system abnormalities)
- Elevated levels of serum creatine kinase, electromyography findings, and histopathologic features on muscle biopsy can aid diagnosis

Benign congenital hypotonia
- Marked by floppiness in infants
- Diagnosis of exclusion

Hydrocephalus
- **Hydrocephalus** is a condition involving excessive accumulation of cerebrospinal fluid (CSF) in the brain. Symptoms of hydrocephalus vary with age, disease progression, and individual tolerance to CSF
- Features:
  - In infancy, hydrocephalus is often associated with an unusually large head size
  - Problems with balance, poor coordination, and muscle spasticity
  - Classicallly found in older patients with a triad of clinical signs: ataxia (gait disturbance), dementia, and urinary incontinence
  - May occur after a history of head trauma, subarachnoid hemorrhage, or meningitis
  - Diagnosed through neurologic evaluation
  - Other symptoms may include weakness, speech disturbance, ataxia, apraxia, seizures, and sensory loss

Familial spastic paraparesis (hereditary spastic paraplegia)
- A group of inherited disorders that are characterized by progressive weakness and stiffness of the legs
- Features:
  - Severe, progressive, lower extremity spasticity is the primary feature
  - Delayed walking may be the initial manifestation in childhood
Associated symptoms include optic neuropathy, retinopathy, dementia, ataxia, ichthyosis, mental retardation, peripheral neuropathy, and deafness.

**Tethered spinal cord syndrome**

- A neurological disorder caused by the abnormal stretching of the spinal cord
- **Features:**
  - In children, symptoms can include lower extremity weakness, bowel and/or bladder abnormalities, scoliosis, back pain
  - Hair tufts, dimples, and lipomas may be found on inspection of the lower back
  - In adults, symptoms can include sensory and motor problems, and loss of bowel and bladder control

**Spinal tumors**

- Primary tumors of the spinal cord are rare. They constitute between 10% and 19% of all primary CNS neoplasia, with approximately 5,000 cases diagnosed annually
- **Features:**
  - 50% of tumors occur in the thoracic region, 30% in the lumbosacral region, and 20% in the cervical region
  - Sensory/motor clinical presentation is usually related to spinal cord compression with asymmetric motor complaints predominating, progressing over a period of weeks to months
  - Motor defects result from lower motor neuron involvement and are characterized by loss of reflexes and muscle weakness/wasting
  - Spinal root involvement can cause atrophy, pain (e.g., sharp, stabbing, burning), numbness, weakness, sensory loss (e.g., pain, temperature)
  - Magnetic resonance imaging of the spinal axis/cord is the usual initial test of choice to demonstrate a spinal lesion

**Dandy-Walker syndrome**

- A congenital brain malformation characterized by hypoplasia of the cerebellar vermis and cystic dilatation of the fourth ventricle, often associated with other CNS abnormalities
- **Features:**
  - Macrocephaly
  - Hydrocephalus
  - Delayed milestones

**Neuronal migration disorders (NMDs)**

- A group of birth defects caused by the abnormal migration of neurons in the developing brain and nervous system, including schizencephaly, porencephaly, lissencephaly, agyria, macrogyria, pachygyria, microgyria, micropolygyria, and neuronal heterotopias
- **Features:**
  - Impaired motor function
- Seizures
- Mental retardation
- Abnormal head size (macro or microcephaly)

Congenital cytomegalovirus infection (CMV)

- **Congenital CMV infection** is characterized by cytomegalic cells with viral inclusions. Primary acquired infection in childhood may result in a mild febrile illness or may be entirely asymptomatic in immunocompetent hosts. The disease can have severe, possibly fatal, consequences in congenitally infected infants or in severely immunocompromised individuals.
- **Features**
  - Most infected babies appear normal at birth, but 5% to 25% develop significant psychomotor, ocular, or dental abnormalities within the following several years.
  - Congenital CMV is one of the most common causes of hearing loss in children.
  - Microcephaly is common.

Mitochondrial myopathies

- Mitochondrial disorders frequently manifest with myopathy. Central and peripheral nervous system involvement may occur.
- **Features**
  - Signs and symptoms generally occur before the age of 20, initially with muscle weakness and extreme fatigue.
  - Neuroimaging with magnetic resonance imaging is useful in confirming the disorder; basal ganglia abnormalities are often seen.
  - Heart disease may occur, resulting in arrhythmias and cardiomyopathy.
  - Poor coordination.
  - Limited eye mobility and droopy eyelids.
  - Deafness.
  - Blindness.
  - Seizures.

Inherited metabolic disorders

- Also called inborn errors of metabolism, these are heritable genetic disorders of biochemistry. Examples include albinism, cystinuria, phenylketonuria, and some forms of gout, sun sensitivity, and thyroid disease.
- **Features:**
  - Often present with progressive clinical course and acute exacerbations and regression or loss of skills during intercurrent illness.
  - Abnormal lactate and pyruvate—may indicate abnormality in energy metabolism.
  - In patients with predominant basal ganglia involvement a mitochondrial disorder should be excluded.
  - Abnormal thyroid function may cause deficit in muscle tone, deep tendon reflexes, mental retardation, or movement disorders.
Elevated ammonia may indicate liver dysfunction
Urine amino acids may suggest metabolic disorders
Chromosomal abnormalities may affect various organs

Juvenile Huntington disease (Westphal variant)
- **Juvenile Huntington disease** is an inherited autosomal dominant disorder with complete penetrance caused by a trinucleotide expansion within the IT-15 gene on chromosome 4
  - Features:
    - Psychiatric manifestations may occur before onset of the movement disorder
    - Common manifestations include dystonia, choreoathetosis, myoclonus and tremor
    - MRI reveals atrophy of the head of the caudate nucleus; with advanced disease, cerebral and cerebellar atrophy may occur
    - Diagnosis is based on history and genetic testing

Wilson disease
- Wilson disease is an inherited disorder in which large amounts of copper accumulate throughout the body
  - Features:
    - Although accumulation begins at birth, the disease may be asymptomatic in the early years of childhood. Signs and symptoms may become evident between the ages of 6 and 40 years, depending on severity of the disease
    - The primary symptom (affecting approximately 40% of patients) is liver disease
    - Neurologic problems, including tremor, rigidity, speech impediments, behavioral changes

Rett syndrome
- Rett syndrome is a neurodegenerative disorder resulting from mutations in the MECP2 (most common) and CDKL5 genes
  - Features:
    - Most common in girls
    - Apparent normal early development is followed by loss of acquired hand skills and speech
    - Head circumference is normal at birth but deceleration of head growth results in acquired microcephaly
    - Stereotypic hand movements such as hand wringing and washing
    - Progressive ataxia
    - Seizures
    - Social withdrawal occurs early in childhood
    - Intellectual development is often impaired

Consultation
- Refer to a neurologist
• Refer for genetic testing
• Refer to a pediatric neuropsychologist for neuropsychological testing

Treatment

Summary approach

Goals:

• Prevent contractures
• Minimize muscle spasticity
• Improve patient's ability to ambulate, perform everyday activities, and have meaningful social interactions. Cerebral palsy is a lifelong condition that neither improves substantially nor, if correctly diagnosed, worsens in severity

Summary of therapies:

• Therapy, whether for movement, speech, or activities of daily living, is the cornerstone of cerebral palsy management
  o Physical therapy is used to enhance motor skills, improve muscle strength, and prevent contractures
  o Occupational therapy is used to enhance skills required for daily living
  o Speech therapy assists communication in children with speech problems
  o Behavioral therapy complements other therapies by using psychological theories and techniques
  o Psychologic counseling assists patients in dealing with emotional and psychologic challenges
  o Special education may assist children with special learning needs
  o Mechanical devices may assist patients in sitting, walking, or communicating and are used as adjuncts to various therapies
• Seizures may be treated with various anti-epileptic medications
• Drugs are used primarily to manage spasticity:
  o OnabotulinumtoxinA injection is the treatment of choice for focal spasticity
  o Baclofen is a muscle relaxant that may decrease reflexes at the level of the spinal cord
  o Dantrolene may be used to treat spasticities
  o Diazepam may be useful for myoclonus, chorea, or athetosis
  o Anticholinergic agents may reduce tremor, akinesia, rigidity, and drooling
• Orthopedic surgery may be necessary for tendon-lengthening procedures, rhizotomy, or management of scoliosis

Medications

OnabotulinumtoxinA (botulinum toxin, type A)
Baclofen
Dantrolene
Diazepam
Anticholinergic agents

Non-drug treatments

Physical therapy for cerebral palsy

Description

- A program of exercises tailored by a physiotherapist to the individual patient's requirements

Indication

- May improve motor performance, contracture development, and prevent weakening and deterioration of muscles

Comments

- The therapist provides parents and patients with a strategy and drills that can help improve performance so that therapy continues at home
- Regular activities are crucial to maximizing the use of limbs, for ambulation, and for reducing the risk of contractures

Evidence

- A systematic review examined 22 RCTs and the experience of over 800 pediatric-age patients for effectiveness of physical therapy in children with cerebral palsy. The review found evidence of improvement in forearm and hand movement and in overall limb functionality with physical therapy directed to the upper extremities. The reviewers found little evidence of improvement in walking speed or gait length from physical therapy of the lower extremities; nor was strength-training unequivocally beneficial. [5] Level of evidence: 1
- A systematic review of 8 studies inclusive of 11 patients found constraint-induced movement therapy was effective at improving upper extremity use in patients with CP. However, the reviewers could not pinpoint a specific level of intensity of treatment that would uniformly produce improved body function and outcomes. The reviewers also demonstrated an increased frequency of use of the upper extremity following constraint-induced movement therapy for children with hemiplegic CP. [6] Level of evidence: 3
- An RCT of 21 patients compared the effects of a home-based, 6-week strength-training program versus no strength-training in spastic diplegic cerebral palsy (with independent ambulation, with or without gait aids). Those participating in the strength-training program increased lower limb strength at 6 weeks, an improvement which was still apparent at follow-up in the 12th week. There was also a trend toward improvement in scores for standing, running and jumping, and faster stair climbing at 6 weeks. [7] Level of evidence: 2
References
Occupational therapy for cerebral palsy

Description

- Teaches the patient skills such as feeding, dressing, or using the bathroom; may include vocational training

Indication

- Used in patients who need assistance in performing activities of daily living

Comments

- May provide recreation and leisure activities
- The therapist provides parents and patients with a strategy and drills that can help improve performance and enable the therapy to be continued in the home

Speech therapy

Description

- A speech therapist determines the cause of the patients' difficulty in expressing themselves and implements techniques and aids to address the difficulty

Indication

- May help children overcome speech difficulties

Comments

- May assist in use of special communication devices
- Therapy may continue as long as speech problems persist
- Parents should continue drills that help to improve performance at home

Evidence

- A systematic review of 12 RCTs of varying size (8 patients to 20 patients) examined the effects of speech and language therapy for children with cerebral palsy. The reviewers found positive trends in communication skills such as use of speech and gesture to articulate thought, but durable improvement could not be substantiated. [8] Level of evidence: 2
- A systematic review sought contemporary RCTs to examine the impact of speech and language therapy administered to young children with dysarthria. The reviewers sought specifically to identify practices that improve the intelligibility of speech and enhance communication in the dysarthric. The reviewers found no suitable studies on which to
acknowledge or challenge current practice (which often includes voice supplementation devices) and made no recommendations for or against current practice. [9] Level of evidence: 3

References
Behavioral therapy

Description
- Uses psychologic theory and techniques to complement other therapies

Indication
- Discourages behaviors that are destructive; may provide positive reinforcement rewards for improvements in skills

Comments
- Parents should reinforce behaviors that are encouraged by the therapist

Psychologic counseling

Description
- Counseling for emotional and psychologic challenges

Indication
- Neuropsychologic adjunct to pharmacologic and surgical therapy

Comments
- Provides emotional outlet and support, offers encouragement
- Provides psychologic insight into perceptions and feelings
- Parents should offer emotional support to children
- Parents may benefit from therapy as well
- May be needed at any age, but particularly necessary during adolescence

Special education

Description
- One-on-one educational assistance for children with special learning needs

Indication
• Children with learning disabilities

Comments

• Parents can use the skills and drills used by the special education coordinator to facilitate learning at home

Mechanical devices

Description

• Mechanical devices used in the treatment of cerebral palsy include shoes with hook-and-loop closure, computerized communication devices, special typewriters, special feeding devices, wheelchairs, walkers, standing frames, poles, and customized seating arrangements

Indication

• Physical limitations at home, at school, or in the workplace

Comments

• Assist with sitting and standing postures, in ambulation, and in communication
• Parents need to provide support, encouragement, and drills to improve performance and continue therapy in the home

Orthopedic surgery

Description

• Tendon lengthening procedures, rhizotomy and spinal fusion may be offered in selected cases

Indication

• Used for preventing progressive deformity and removing mechanical or anatomic barriers to mobility and function

Complications

• Risks include infection, pain, and adjustment of the wrong muscle, which may worsen movement disorders

Comments

• May reduce contractures to improve movement, reduce spasticities, and improve posture
Encourage ambulation as soon as possible following surgery; the more mobile the patient, the more likely tendons will be transferred and lengthened rather than released.

Neurosurgical treatment is generally indicated only after less-invasive options have been exhausted.

Evidence

- An RCT of 25 patients evaluated selective dorsal rhizotomy (SDR) against orthopedic lengthening and release surgery in patients with cerebral palsy spasticity-related gait impairment. The SDR group improved significantly in quality of movement attributes at 6 months after surgery and gross motor skills (standing, walking, running, and jumping) gains were seen 2 years after surgery. The orthopedic group improved significantly in certain quality of movement attributes 6 months after surgery and in standing skills within the first postsurgical year. Self-care skills, mobility, and social function gains were seen earlier and with greater frequency in the SDR group. Both surgical interventions demonstrated multidimensional benefits for ambulatory children with spastic diplegia. [10] Level of evidence: 2

- An RCT compared the effects of combined dorsal rhizotomy and physical therapy versus physical therapy alone in children with spastic cerebral palsy. Changes in ankle dorsiflexion, foot progression angle, and hip and knee extension in stance were significantly better in the selective dorsal rhizotomy group compared with the physical therapy group at 1 year. Differences were not associated with significant improvements compared to baseline in functional gait as determined by changes in time/distance parameters or ambulatory status. [11] Level of evidence: 2

References

Special circumstances

Comorbidities

Patients with cerebral palsy and comorbid seizure disorders should receive anti-epileptic agents suitable for the type of seizures that they experience. These patients should be under the supervision of a neurologist.

Patient satisfaction/lifestyle priorities

Comprehensive therapy is initiated early to improve motor and language skills.

Consultation

- Refer to an audiologist for evaluation of hearing deficits
- Refer to an orthopedic surgeon for evaluation and surgery
- Refer to a neurologist for management of hyperactivity
- Refer to gastroenterologist or a nutrition/feeding team for nutritional assessment and treatment
- Refer to a learning disability team to identify specific learning disabilities, assess motor and cognitive progression, and guide schooling
- Refer to ophthalmologist to treat nystagmus, strabismus, and optic atrophy

**Follow-up**

- Management requires close neurologic follow-up and interventions from multiple specialties

**Prognosis:**

- Morbidity and mortality are generally associated with concomitant medical complications
- Although there is delay in developmental motor milestones, mental retardation is seen in only 30% to 50% of patients with cerebral palsy
- Approximately 25% of patients with cerebral palsy are unable to walk. The ability to sit up by the age of 2 years is a good predictive sign of eventual ambulation
- In patients with spastic quadriplegia, a less favorable prognosis correlates with a longer delay in resolution of extensor tone
- Epilepsy occurs in one third of children with cerebral palsy
- With appropriate therapeutic interventions, many patients with cerebral palsy may integrate academically and socially

**Therapeutic failure:**

- Incapacitating athetosis may occasionally respond to levodopa, a dopamine precursor
- Children with dystonia may benefit from anticholinergic agents, such as trihexyphenidyl

**Clinical complications:**

- Obesity (adults or children) caused by ambulation difficulties
- Constipation
- Gastroesophageal reflux with aspiration pneumonia
- Dental caries
- Aspiration pneumonia
- Bronchial dysplasia
- Asthma
- Decubitus ulcers and skin sores
- Orthopedic contractures, hip dislocations, or scoliosis
- Seizures
- Increased incidence of attention deficit hyperactivity disorder, mental retardation, and learning disabilities
- Increased incidence of depression
- Hearing loss, especially in patients with a history of bilirubin encephalopathy and congenital CMV infection
- Decreased visual acuity, visual field abnormalities, strabismus
Patient education

- Parents should employ the skills and drills utilized by therapists to assist patients in performing exercises, reviewing behavioral, speech, and occupational approaches so that therapy is continued in the home.

Questions patients ask:

- **What is cerebral palsy?** Cerebral palsy is a broad term used to describe chronic disorders that impair control of movements.
- **What are the symptoms of cerebral palsy?** Symptoms vary widely. Patients may experience difficulties with fine motor tasks, experience trouble walking or maintaining balance, or have involuntary movements.
- **What other disorders may be associated with cerebral palsy?** Mental retardation and seizures may be present, but cerebral palsy does not always cause profound handicaps.
- **Is cerebral palsy contagious or a genetic disease?** No.
- **What are the different forms of cerebral palsy?** Cerebral palsy may be classified either by evidence of primary symptoms (spasticity, ataxia) or by the areas of the body that are affected (monoplegia, diplegia, hemiplegia, or quadriplegia).
- **What causes cerebral palsy?** It is believed that cerebral palsy occurs as a result of brain injury during gestation or delivery or during the first few months of life. Known causes include infections during pregnancy, placental damage, prematurity, asphyxia during delivery, and brain infection or injury during the first 2 years of life.
- **How is cerebral palsy diagnosed?** Cerebral palsy is diagnosed mainly by evaluating a child's muscle tone and reflexes and by assessment of movement. Imaging studies may also show changes that commonly occur with cerebral palsy.
- **How is cerebral palsy treated?** A team of healthcare professionals, including orthopedic surgeons, physical and occupational therapists, and neurologists, work together to manage cerebral palsy. Drugs and surgery may decrease muscle spasticities and associated complications.
- **Can cerebral palsy be prevented?** Since the cause of cerebral palsy is not always known, it is difficult to prevent. However, some prenatal causes, including Rh incompatibility, congenital rubella syndrome, and kernicterus can be prevented with appropriate prenatal and postnatal care. Additionally, head injuries can be prevented by proper positioning in car seats. Routine vaccinations in infants can prevent many cases of meningitis. The risk of preterm delivery may be minimized with early and regular prenatal physician visits.

Online information for patients:

- KidsHealth from Nemours: [Cerebral palsy](#)
- TeensHealth from Nemours: [Cerebral palsy](#)
- Centers for Disease Control and Prevention: [Cerebral palsy: signs and causes](#)
- American Academy of Family Physicians: [Cerebral palsy in children](#)
- United Cerebral Palsy: [Exercise principles and guidelines for persons with cerebral palsy and neuromuscular disorders](#)
- March of Dimes: [Birth defects: Cerebral palsy](#)
Resources

Summary of evidence

Evidence

Prenatal magnesium sulfate:

- A systematic review assessed the effects of magnesium sulfate as a neuroprotective agent when given to women considered at risk of preterm birth in 5 RCTs inclusive of 6,145 neonates. Women presenting from 24.0 to 31.6 weeks' gestation with advanced preterm labor or premature rupture of the membranes and no recent exposure to magnesium sulfate were randomized to receive either intravenous magnesium sulfate or masked study drug placebo. If after 12 hours delivery had not occurred and was not anticipated, the infusion was stopped. Patients were assessed for signs of intolerance to the study medications and maternal data were collected up to hospital discharge. Up to 3 follow-up visits were scheduled over 2 years where certified examiners, masked to study group assignment, collected physical and neurological data, including a modified Gross Motor Function Classification Scale. The Bayley Scale of Infant Development was also administered. Antenatal magnesium sulfate reduced the risk of cerebral palsy. There was also a significant reduction in the rate of substantial gross motor dysfunction. Overall there were no significant effects of antenatal magnesium therapy on combined rates of mortality with cerebral palsy. There were higher rates of minor maternal side effects in the magnesium groups, but no significant effects on major maternal complications. [1] 

Level of evidence: 1

OnabotulinumtoxinA:

- A systematic review of 3 small randomized, controlled trials (RCTs) including a total of 52 patients examined the efficacy of botulinum toxin for the treatment of leg spasticity in children with cerebral palsy. One of these trials found nonsignificant gait improvement in children treated with botulinum toxin when compared with placebo. Two other studies compared botulinum toxin with the use of casts. There were improvements in gait, range of ankle movement, muscle tone, and motor function in both groups. However, there were no significant differences between the groups for either trial. A 3-dimensional gait analysis found that maximal plantar flexion and maximal dorsiflexion during walking was significantly greater in those patients treated with botulinum toxin compared to casting. The reviewers concluded that there is no strong evidence to support or refute the use of botulinum toxin. [2] Level of evidence: 1

- A systematic review of 10 RCTs inclusive of 300 patients compared intramuscular onabotulinumtoxinA administered alongside occupational therapy and onabotulinumtoxinA alone as an adjunct to managing the upper limb in children with spastic CP. A combination of onabotulinumtoxinA and occupational therapy was more effective than occupational therapy alone in reducing impairment, improving activity level outcomes, and goal achievement, but not for improving quality of life or perceived self-competence. The evidence suggests that onabotulinumtoxinA should not be used in
isolation in children with spastic CP but should be accompanied by planned occupational therapy. [3] Level of evidence: 1

Baclofen:

- A placebo-controlled prospective study of 11 patients compared the effect of intrathecal baclofen (bolus and continuous infusion) versus placebo on functional parameters in 11 patients with spasticity of cerebral origin (mainly cerebral palsy). Significant functional improvements were observed in 8 of the 11 patients following bolus administration of baclofen, with beneficial effects recorded out to 2 years' duration in 6 patients. The data suggest that bolus administration of intrathecal baclofen is superior to continuous infusion in durable treatment of cerebral spasticity from CP. [4] Level of evidence: 2

Physical therapy:

- A systematic review examined 22 RCTs and the experience of over 800 pediatric-age patients for effectiveness of physical therapy in children with cerebral palsy. The review found evidence of improvement in forearm and hand movement and in overall limb functionality with physical therapy directed to the upper extremities. The reviewers found little evidence of improvement in walking speed or gait length from physical therapy of the lower extremities; nor was strength-training unequivocally beneficial. [5] Level of evidence: 1
- A systematic review of 8 studies inclusive of 11 patients found constraint-induced movement therapy was effective at improving upper extremity use in patients with CP. However, the reviewers could not pinpoint a specific level of intensity of treatment that would uniformly produce improved body function and outcomes. The reviewers also demonstrated an increased frequency of use of the upper extremity following constraint-induced movement therapy for children with hemiplegic CP. [6]
- An RCT of 21 patients compared the effects of a home-based, 6-week strength-training program versus no strength-training in spastic diplegic cerebral palsy (with independent ambulation, with or without gait aids). Those participating in the strength-training program increased lower limb strength at 6 weeks, an improvement which was still apparent at follow-up in the 12th week. There was also a trend toward improvement in scores for standing, running and jumping, and faster stair climbing at 6 weeks. [7] Level of evidence: 2

Speech therapy:

- A systematic review of 12 RCTs of varying size (8 patients to 20 patients) examined the effects of speech and language therapy for children with cerebral palsy. The reviewers found positive trends in communication skills such as use of speech and gesture to articulate thought, but durable improvement could not be substantiated. [8] Level of evidence: 2
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References

Evidence references


Guidelines

The Quality Standards Subcommittee of the American Academy of Neurology and the Practice Committee of the Child Neurology Society have jointly produced the following:


The American Academy of Pediatrics Committee on Children with Disabilities has produced the following:

Further reading


Codes

ICD-9 code

- 343.0 Infantile cerebral palsy; diplegic
- 343.1 Infantile cerebral palsy; hemiplegic
- 343.2 Infantile cerebral palsy; quadriplegic
- 343.3 Infantile cerebral palsy; monoplegic
- 343.4 Infantile hemiplegia
- 343.8 Other specified infantile cerebral palsy
- 343.9 Infantile cerebral palsy, unspecified

FAQ

- **Does cerebral palsy imply mental retardation?** No. Although there is delay in developmental motor milestones, mental retardation is seen in only 30% to 50% of patients with cerebral palsy
• **Is there a diagnostic test for cerebral palsy?** No, there is no single diagnostic test for the condition. Diagnosis is based on history and examination in addition to confirmatory tests.

• **Do children with cerebral palsy have a 'typical' deficit?** No. The deficit depends on the area of the brain affected. Most commonly, patients have spasticity and/or rigidity.

• **Are there genetic implications from the diagnosis of cerebral palsy?** Generally, no. However, if cerebral palsy is due to a genetic disorder such as an enzyme deficiency, then there is a higher likelihood of inheritance.

• **Is a pediatric neurology referral warranted in all suspected cases of cerebral palsy?** A pediatric neurology consultation is recommended to assist in diagnosis of a specific underlying disorder. This could have important implications for the patient and assist in future family planning decisions.

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