21

CHARGE Syndrome or Association

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Overview

First identified by Hall (1979), CHARGE is an acronym describing a constellation of defects: coloma of the eye, heart defects, atresia of the choanae, retardation of growth or development, genital hypoplasia, and ear malformations (Pagon, Graham, & Sybert, 1980). It is a congenital disorder developing in the first 30–60 days of conception and is estimated to have an occurrence rate of between 1 in 8,000 and 1 in 15,000 births (Hall, 1995). The etiology of CHARGE is unknown, with neither genetic factors nor environmental teratogens (e.g., virus, drugs, radiation) having been ruled out. The patterns of defects in CHARGE can be difficult to diagnose, even by specialists, because of the variability found in the degree of impairment. A diagnosis of CHARGE is generally based on having at least four of six primary features.

1. *Coloboma of the eye.* This term is used to describe a missing piece, notch, or fissure of any part of the eye. Approximately 80% of children with CHARGE have one or more colobomas, with the degree of visual impairment depending on the location. The most common are colobomas of the iris (the colored membrane) or retina, which receives images formed by the lens. A coloboma of the iris is characterized by an iris that is keyhole shaped and usually does not affect visual functioning. Retinal colobomas can cause blind spots in the visual field in one or both eyes, with the extent of visual impairment depending on placement. Colobomas of the optic nerve, which transmits visual signals to the brain, result in the greatest impairment of vision. Colobomas involving the macula, which is part of the retina, will affect detailed vision. Some children with CHARGE have microphthalmia (one small eye). This is usually a sign of a retinal coloboma, and vision is generally poor. It also is possible to have the absence of an eye, or anophthalmia. Children with CHARGE vary a great deal in the extent to which their vision is affected depending on the location of colobomas in one or both eyes. Corrective lenses generally provide some benefit.
2. *Heart defects.* Between 55% and 80% of children with CHARGE experience some type of congenital heart defect. The most common

involve conotruncal anomalies, affecting the outflow tracks and great vessels leaving the heart. One form is tetralogy of Fallot, which involves (a) a ventricular septal defect, or a hole between the ventricles; (b) obstructed outflow of blood from the right ventricle to the lungs; (c) a displaced aorta so that it receives blood from both ventricles; and (d) enlargement of the right ventricle. Children with CHARGE also may have other various septal defects (openings between heart chambers). These conditions may require surgery or may be managed through medication. Some septal defects may close on their own. Because severe heart defects account for some deaths among children with CHARGE, it is essential that a cardiologist be involved as early as possible.

3. *Atresia of the choanae.* Also termed *choanal atresia*, this is a blockage of the nasal passages at birth. The blockage may involve bone or cartilage (or both) or membranes. Sometimes this manifests itself as choanal stenosis, meaning merely a narrowing of the passages. Choanal atresia occurs in between 1 in 5,000 and 1 in 8,000 births. About two thirds of these involve only one side of the nasal passage, and 90% are bony or cartilaginous. At least half of the time it is associated with other anomalies. It occurs in about 50% of children with CHARGE. Because infants are nasal breathers, those born with bilateral choanal atresia (in both nostrils) have breathing difficulties at birth. Surgery is performed to correct this defect as early as the surgeon believes acceptable, which may be within 24 hr of birth. The surgery involves perforating the blockage and placing plastic tubes, or stents, from the inside out through the nostrils. The holes may need to be enlarged and the stents replaced several times until the nasal passages stay open. A major long-term complication associated with choanal atresia is recurrent middle-ear infections.
4. *Retardation of growth or development or both.* Except for those born prematurely, most children with CHARGE are of normal height and weight at birth. However, gains in height and weight are often slow after birth, with ultimate height at or below the third percentile. Because this shortness is proportional, it is not indicative of dwarfism. The growth delay may be caused by growth hormone deficiency, pituitary abnormalities, or nutritional difficulties. Growth hormone shots may be necessary for some. Growth delay should be monitored by an endocrinologist.
5. *Genital hypoplasia.* Underdevelopment of the genitals is found in about 75% of the boys with CHARGE. Boys may have a small penis or undescended testicles (or both). In some cases the testicles may be missing. Some boys have epispadius or hypospadias, in which the urethral opening is not at the end of the penis and must be surgically corrected. External hypoplasia is less common in girls, but the labia, or external skin folds, may be small or absent. Urinary tract problems may occur because of malformations in the ureters connecting the kidneys and the bladder or

because of malposition of the kidneys, which needs surgical correction. In both sexes, puberty may be delayed or absent. Pituitary or hypothalamic deficiency is generally present. Boys have been successfully treated with testosterone. Growth hormones used to treat retarded physical development also should assist with the development of secondary sex characteristics.

6. *Ear malformations.* Children with CHARGE may have external or internal ear malformations. The former are so distinctive that a presumptive diagnosis of CHARGE could be made on the basis of them. Typical are short, wide, asymmetrical ears that look as if they have been stretched or bent. Sometimes ears are low hung and rotated. If treated early, the outer ear may be successfully reshaped.

About 85% of children with CHARGE have hearing loss, generally in the moderate-to-severe range. The type is typically mixed loss, a combination of conductive loss, usually because of middle-ear infections, and sensorineural, often because of underdevelopment of or damage to the cochlea. Middle-ear infections may be caused by (a) small ear canals, (b) malformation of the three tiny bones or ossicles, or (c) fluid as a result of poorly working eustachian tubes. Although other children generally grow out of middle-ear infections fairly early, children with CHARGE may have problems into adolescence. Although the hearing loss may be progressive, this is not characteristic of CHARGE and may in fact be related to severe middle-ear infections. The children often show what is described as a wedge-shaped audiogram: a large, low-frequency conductive loss and a high-frequency sensorineural loss. The use of hearing aids is complicated by the shape of the outer ear, drainage from the middle ear, and a small ear canal. Children with CHARGE also have vestibular problems, generally attributed to malformations in the semicircular canals of the inner ear. Independent walking is attained on average by the age of 5 years, but the children typically maintain an awkward, off-balance gait.

Mental retardation is difficult to assess in CHARGE because of the confounding factors of health status, vision impairments, and hearing impairments. Measured IQ scores in the range of 30–80 typically have been reported. However, one third of the children in one study had normal intelligence, and others had not been tested by an expert in deaf–blindness (Blake & Brown, 1993). Nevertheless, most children with CHARGE are functionally delayed and receive special education services. Those children with bilateral choanal atresia may have experienced incidents of asphyxia before repair, which could account for some cases of retardation.

Brain abnormalities occur in approximately 50% of the children with CHARGE. Holoprosencephaly is the failure of a portion of the forebrain to develop normally and can result in closely set eyes, missing front teeth, and microcephaly (abnormal smallness of the head or cranial area). Arhinencephaly is the absence of the olfactory bulbs and tracts. Other central nervous system problems include facial palsy, congenital vocal cord paralysis, and cranial nerve abnormalities.

Other features commonly observed in people with CHARGE include significant feeding or swallowing difficulties (the majority of children experience some form of this), cleft lip or palate, tracheoesophageal fistula (the trachea, or wind pipe, and esophagus are abnormally connected), gross motor delays, esophageal atresia (the esophagus ends in a pouch instead of connecting to the stomach), DiGeorge syndrome (absence of the thymus and parathyroid glands), gastroesophageal reflux (the regurgitation of food into the esophagus, similar to constant heartburn), renal anomalies, premature birth, tactile and oral defensiveness, polyhydramnios (excess amniotic fluid in mother during pregnancy), and CHARGE facial features. CHARGE facial features include a square-shaped head, flat cheekbones, facial asymmetry, a wide nose with a high bridge, and unusual ears. Ptosis, or droopy eyelids, also may be present.

Outcomes

At birth, the heart defects and choanal atresia are the most serious complications. However, mortality seems largely related to the aspiration of secretions due to swallowing difficulties and reflux. Survival rate in one study was 78% at 1 year and 60% at 10 years (Wyse, Al-Mahdawi, Burn, & Blake, 1993).

Multiple surgeries may be necessary. In addition to those identified earlier (i.e., heart, choanal atresia, genital), other common surgeries performed include tracheostomy for breathing problems and gastrostomy for feeding due to swallowing problems. Many children outgrow their swallowing difficulties by around the age of 10 years. If they have not eaten orally for some time, intensive training is needed for them to begin to accept food orally.

Many children with CHARGE have dual sensory impairments. Because the educational prognosis for those with congenital deaf–blindness is poor, it is essential that these children be monitored by an audiologist and ophthamologist or optometrist. These are not easy children to examine because of vestibular difficulties, tactile defensiveness (they do not like to be touched), and lack of communication. The audiologist should use a variety of physiological (auditory brain stem and tympanic) and behavioral tests (i.e., careful observation of responses; J. W. Thelin, personal communication, December 16, 1995). Hearing aids and glasses should be encouraged.

Because there are so many different problems, children with CHARGE see numerous medical and educational specialists. Hartshorne (1993) found that parents contacted an average of 17 different professional types. During approximately the first 3 years of life, management of acute medical and health problems seems to dominate the care of children with CHARGE. Most of the time, the more severe health problems subside around the age of 3 years and educational issues come into focus. Because of the varying degrees of disabling conditions seen in CHARGE, educational diagnosis and intervention also vary widely. The degree of sensory

impairment present (deafness, blindness, or both) is likely the most defining factor in the child's educational outcome. Because of the availability of appropriate early intervention, some of these children do very well, and we have met some who are attending college, driving cars, and supporting themselves through employment.

Psychoeducational Implications

It must be clearly understood that children with CHARGE do not manifest the same degree of educational need. We have had experience with children diagnosed with CHARGE who were visually impaired, hearing impaired, deaf–blind, physically impaired, health impaired, or severely multiply impaired, as well as children with CHARGE who manifest only visible facial features of CHARGE and function at an average or above level. Those without significant disabilities may have experienced many of the medical problems early in life, but, because they have intact hearing and vision, they are not as at risk educationally. With children for whom health problems are mostly resolved, the defining factor for educational outcomes seems to be the level of hearing and vision present. An informal survey of parents with children with CHARGE and deaf–blindness indicated that many of these parents believed their children would function at an average cognitive level if they had intact vision and hearing. Much of the medical research on CHARGE indicates a high incidence of mental retardation in these children, but sensory impairments are not always taken into account by the medical researchers when making these diagnoses. Clearly, psychoeducational research is needed to supplement the medical research in this area.

Thus, it is important to consider keeping high expectations when working with children with CHARGE. Many educators and parents have found much potential in these children as they grow. The learning curve seems to increase with time, especially as medical, balance, and feeding issues are resolved.

There is a wide variation in sensory and other impairments in children with CHARGE. Therefore, it is necessary to plan interventions for these children on the basis of individual disabilities and needs (i.e., deaf–blind vs. hearing impaired) rather than generating interventions from the diagnosis of CHARGE by itself.

During infancy and early childhood, early intervention is crucial. Many children benefit from physical, occupational, and speech and language therapies as well as from consultation from experts in the fields of hearing and vision. If a child is deaf–blind (i.e., there is some degree of vision and hearing impairment, but not necessarily complete losses), expertise also should be sought out in that area. Educational interventions for those who are deaf–blind are drastically different from interventions for children who are either deaf or blind. Blake and Brown (1993) found a large discrepancy between the level of sensory impairment in their participants (N = 39) and the amount of educational and therapeutic support

provided for them. This was attributed partly to a shortage of skilled and qualified staff and to a lack of local educational provision for children with multisensory impairments. Because deaf–blindness is such a low-incidence disability, this is not surprising. Accessing the expertise needed to educate these children can be a dilemma for some multidisciplinary teams.

At the infancy and preschool stage, parents need much support in coordinating their child's medical and educational care. Ideally, a case coordinator is used to help organize the massive amounts of information, scheduling, and caretaking the parent must deal with at this age. An interdisciplinary approach is necessary to facilitate this process, and the development of an individualized family service plan is essential. Families also should be put in contact with the CHARGE Syndrome Foundation (referenced on p. 160).

Children with CHARGE use a full continuum of available placement options. Some children attend schools or classrooms for the deaf, and some attend residential programs for children with deaf–blindness. Others attend resource rooms or receive inclusion services (receiving needed support in general education classrooms). Still others are in need of only vision consultant services or no services at all.

Perhaps the most important factor in a successful educational program for a child with CHARGE is the use of a transdisciplinary team approach that encourages parental involvement and provides frequent follow-up. Using this approach ensures that the diversity of educational needs of children with CHARGE can be appropriately met.

Annotated Bibliography

Blake, K. D., & Brown, D. (1993). CHARGE association looking at the future: The voice of a family support group. *Child: Care, Health, and Development, 19*, 395–409.

Although done in England, this is a useful survey of parents, presenting the variability in CHARGE as well as educational status and types of support and services received.

CHARGE Syndrome Foundation, Inc. *CHARGE Accounts* [Quarterly Newsletter]. Available from Marion A. Norbury, CHARGE Syndrome Foundation, 2004 Parkade Blvd., Columbia, MO 65202-3121.

The newsletter contains many accounts of children written by parents as well as articles for parents written by professionals.

Edwards, B. M., Van Riper, L. A., & Kileny, P. R. (1995). Clinical manifestations of CHARGE association. *International Journal of Pediatric Otorhinolaryngology, 33*, 23–42.

A study of 24 cases of CHARGE that illustrates the variability in outcomes. It contains an excellent overview of audiological findings.

Resources

CHARGE Syndrome Foundation, Inc., Marion A. Norbury, Contact, 2004 Parkade Blvd., Columbia, MO 65202-3131; 800-442-7604
http://www.kumc.edu/gec/support/charge.html/

The foundation publishes a quarterly newsletter, sponsors biennial conferences, and publishes informational material.

Minnow's Place CHARGE Syndrome Homepage
http://www.geocities.com/Heartland/1220/

The homepage is a wealth of information about CHARGE, including updated diagnostic criteria from the last biennial conference, photographs of children, and many links. It also sponsors a CHARGE listserv and chat room.

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