**REVIEW ARTICLE**

# Cerebral Palsy: State of Art

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**Abstract**

Cerebral palsy (CP) is the most common motor disability in childhood. It affects 2 to 2.5 children in 1000 live-births, with 20 to 30 fold increased prevalence in preterm infants. Despite of progress in perinatal care, the prevalence of cerebral palsy did not change in the last 50 years. New knowledge about etiological factors, such as inflammation, elevated level of cytokines, vascular strokes and genetic factors shift the origin of cerebral palsy mostly into antenatal period, making intrapartal damage responsible for less than 10% of cases. CP is becoming increasingly the subject of interdisciplinary research. Fetal neurosonography with a growing number of studies promises better understanding of the normal functional maturation of the human brain which may lead to effective prevention and treatment of cerebral palsy. Advances in 4D ultrasound resulted in development of KANET as tool for detection of abnormal fetal behavior.

**Keywords:** Cerebral palsy, etiology of cerebral palsy, ATNAT, KANET, 4D ultrasound, fetal neurosonography.

## INTRODUCTION

Understanding the structure and function of the fetal nervous system has been the dream of physicians for centuries. The pioneering efforts of Ian Donald in obstetric ultrasound in the latter part of the twentieth century have permitted this dream to become a reality. The initial contribution of obstetric ultrasound focused on the normal and abnormal structure. As first neurosonographic diagnose, anencephaly was described, followed later by increasingly subtle central nervous system abnormalities such as agenesis of the corpus callosum. Now, 4D sonography in the functional evaluation of the fetal brain has become the challenge for investigators in obstetric ultrasound. There are many functional neurological abnormalities, with cerebral palsy (CP) as one of the most important, whose causes are still poorly understood. This etiological uncertainty makes CP a rewarding medicolegal field. Attorneys throughout the world want to relate neurological abnormalities exclusively to intrapartum events associated with suspected hypoxemia, such as usage of oxytocin, forceps or vacuum delivery, and failure to perform a timely cesarean delivery. As shown by growing scientific evidence this is justified only in 10% of cerebral palsy.

The obstetricians quest, however, is to better define normal and abnormal fetal neurological function *in utero* so that fetuses at risk for adverse neurological outcome can be recognized already antenatally, irrespective of the intrapartum management. The Kurjak Antenatal Neurological Test (KANET), a new prenatal scoring test, has been introduced and evaluated in four centers in high-risk pregnancies. Here might be a tool at hand for *in utero*, fetal diagnose of neurological impairment.[1]

## DEFINITION

Cerebral palsy (CP) is the most common chronic motor disability during childhood. It is not a single disease but an "umbrella" term for disorders of movements and posture, resulting in limitations of activity due to nonprogressive disturbances that occurred in the developing brain.[2] It was described first by the English orthopedic surgeon William Little in 1861. Over the time, it became the subject of interest of many eminent medical minds, as proven by an abundance of literature. A large number of definitions used in different situations and for different purposes, demonstrate the difficulties to define this clinical entity. The heterogeneity of disorders covered by the term CP, together with advances in understanding its development, led to a new definition, proposed by the Executive Committee for the Definition of Cerebral Palsy 2004:

"Cerebral palsy (CP) describes a group of disorders of development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behavior, and/or a seizure disorder" (Fig. 1).

## PREVALENCE OF CP

Cerebral palsy affects 2 to 2.5 in 1000 live-born children.[3] It occurs 20 to 30 times more often in infants weighing less

**Fig. 1:** Definition of cerebral palsy: chronic nonprogressive motoric disability including disorders of development, movement and posture



**Fig. 2:** Rate of cerebral palsy in different categories of preterm infants (Adapted from Jarvis SN, Glinianaia SV, Torrioli M-G, et al.Cerebral palsy and intrauterine growth in single births: A European collaborative study. Lancet 2003;362:1107; with permission)

than 1500 gm at birth. Very preterm infants, less than 32 weeks of gestation, represent 2% of all births. They also represent 25% of children later diagnosed with cerebral palsy. Term and near- term infants have been shown to account for at least half of all diagnosed cases of CP. Despite improvements in obstetric care in the last 50 years, the number of CP cases have not gone down.[4] Fetal heart monitoring was introduced with the expectation that CP rates would decline as a result of its use. In summary, the incidence of CP did not decrease with all the progress in modern neonatal care. The contrary happened during the seventies and eighties of the last century, when CP became more frequent as a result of increased survival rates of extremely premature infants after *in vitro* fertilization (IVF), followed by preterm delivery (Fig. 2).

There are several prenatal factors, including preterm delivery, low birth weight, infection/inflammation in the close fetal environment, multiple gestation, and other pregnancy complications, that have been associated with the occurrence of cerebral palsy in both the preterm and term infants. Intrapartal asphyxia played only a minor role. Despite optimized treatment in neonatal intensive care units (NICU) of systemic inflammations like necrotising enterocolitis, and preventive ventilation strategies against severe hypocarbia in extreme preterm infants, there is no evidence of decreasing rates of CP.

Replacement of surfactant as respiratory distress syndrome (RDS) prophylaxis had the largest impact on the survival rate but again did not influence the rate of cerebral palsy. There is an evident affiliation of maternal prenatal treatment with glucocorticoids and risk of CP.[5] Active
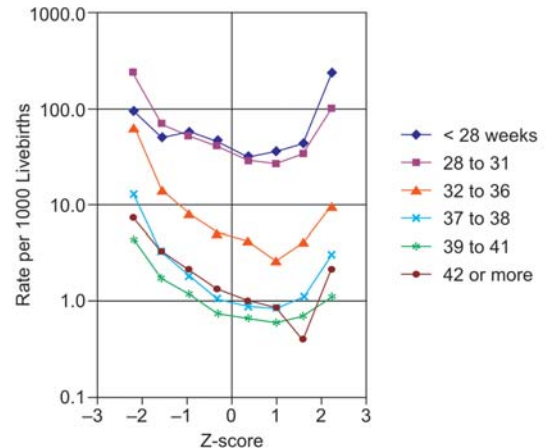
research is still going on about magnesium sulfate treatment of the mother for fetal brain protection, since there may be gross motor function improvement with magnesium in children born before the 30th week of gestation.[6]

The major categories of cerebral palsy and their reported frequencies are: spastic diplegia (44%), most common type in preterm infants; spastic hemiplegia (33%), ataxic/ dyskinetic CP (12%), and spastic quadriplegia (6%), the only type associated with intrapartum asphyxia in term infants.

## CLASSIFICATION

Cerebral palsy is a term for a wide heterogeneous group of nonprogressive neurological impairment which have in common a disturbance in the appropriate developmental sequence of acquisition of basic motor skills. Taking into account the variety in etiology, clinical symptomatology, and timing of development of the disorder, it remains a challenge to classify CP. There are different classification systems for CP, according to the nature of movement disorder (spasticity, ataxia, dystonia and athetosis), anatomic and topographical distribution of the motor abnormalities (hemiplegia, diplegia, and quadriplegia), and functional severity. The tool most commonly used for classification of CP according to the functional severity is GMFCS.[7] GMFCS classifies children with CP by their age-specific gross motor activity, describing five levels in the following age groups: up to 2 years, 2 to 4 years, 4 to 6 years and 6 to 12 years. The advantage of this system is that the classification of the

| Anatomical site of brain lesion | Cerebral cortex, pyramidal tract, extrapyramidal tract or cerebellum and its connections |
|---|---|
| Clinical symptoms and signs | Spasticity, dyskinesia or ataxia |
| Topographical involvement of extremities | Quadriplegia, diplegia, hemiplegia |
| Degree of muscle tone | Isotonic, hypotonic or hypertonic |
| Timing of the presumed insult | Prenatal, intrapartal, postnatal |

**Fig. 3:** Classification of cerebral palsy (Perlstein MA, 1952)



**Fig. 4:** Quality of life (Michael O'Shea, Semin Perinatol 2008;32:35-41)

child is more consistent, objective, and reproducible, due to less bias of the examiner.[7,8] The classification systems being used for the assessment of fine motor function are the ABILHAND-kids[9] system, the Fine Motor Function (BFMF) Classification and the Manual Ability Classification System. Surveillance for Cerebral Palsy in Europe (SCPE) developed a classification system of four groups, looking at presence or absence of hypotonia and hypertonia: ataxic CP, spastic CP bilateral or unilateral, and dyskinetic CP (dystonic and choreatoid).[2] The Australian Cerebral Palsy Register uses a limb-by-limb description.[10] The 2004 International Workshop on the Definition and Classification recommended a limb-by-limb topographic description and classification according to timing, etiology and neuro-imaging findings, as well as associated morbidity[2] (Fig. 3).

### ASSOCIATED MORBIDITY

Associated problems are an important determinant of the outcome of cerebral palsy, having a significant impact on quality of life and degree of handicap. The SCPE Collaboration has reported that 31% of the children with cerebral palsy have a severe intellectual disability.[11] Mental retardation is most common. 60% of children with spastic quadriplegia suffer from a great degree of cognitive impairment. Visual impairment and disorders in ocular motility were reported in 28% of children with cerebral palsy: strabismus, amblyopia, nystagmus, optic atrophy, and refractive errors. Children with periventricular leukomalacia are more likely to have a perceptual visual problem. Hearing impairment occurs in 12% children with cerebral palsy.

35 to 62% of children with CP develop epilepsy. Those with spastic quadriplegia or hemiplegia have a higher incidence of epilepsy than children with diplegia and ataxic CP.

Speech and language disorders are caused by cortico-bulbar and oromotor dysfunctions and seem to be strongly associated with mental retardation.

Abnormalities in tactile sensations and psychiatric disorders are well-documented (Fig. 4).

### ETIOLOGY

Since Little first described the entity, until the present day, a lot of ideas about the etiology of cerebral palsy have been spread. Little regarded intrapartal asphyxia as the prime etiological factor. McNutt in 1885 described intrapartal trauma as the cause of neurological damage.[12]

Freud suggested 1897 that the conditions root was during the intrauterine development of the brain, and difficult birth was merely a symptom of deeper issues that influenced fetal development. Approximately 40 years later the importance of intrauterine anoxia and other prenatal factors were realized and assessed.[13]

Nowadays it is a widely accepted view that CP has a complex and multifactorial etiology, with perinatal ischemic hypoxia responsible for only approximately 10% of all cases.

Preconceptional, prenatal, intrapartal and postnatal influences can interact to result in permanent damage of the developing central nervous system. White matter damage, described as periventricular leucomalacia (PVL), the most important identifiable risk factor for the development of cerebral palsy, occurs usually between the 28th and 34th week of gestation.

It is most likely induced by a variety of ethological factors:

Infection and cytokine activity have an important role in the destruction of the oligodendroglia, resulting in periventricular leukomalacia (PVL).[14]

Intrauterine exposure to inflammation is connected with higher incidence of CP: an elevated level of proinflammatory cytokines interleukin 6,8, a high concentration of white blood cells in the amniotic fluid, and  presence of funisitis as a sign of fetal systemic inflammatory response, were all significantly associated with the development of cerebral palsy at the age of three years.[15]

Furthermore, elevated umbilical cord plasma concentration of interleukin 6 was an independent significant predictor of developing PVL.[16]

Some studies suggest the role of chorioamnionitis as a risk factor for cystic PVL and development of cerebral palsy in term and near term infants.[17] Considering the mechanisms of brain injury, it is still unclear, if infections/cytokines cause the damage, or if cytokines only mediate the damage. Cytokines are able to mediate intravascular cell adhesion, coagulation, thrombosis, and vasoconstriction.

Fetal inflammatory response to intrauterine infection seems to be more important than maternal response. The preterm birth with preterm rupture of membranes is processed by a cytokine response in the fetus. Gestational age at the time of infection plays an important role in the development of fetal infection and fetal inflammatory response.[18] The outcome seems to be depending on the inflammatory agent and the gestational age, and whether the infection is primary or recurrent.

A growing body of evidence indicates a strong genetic influence on the occurrence of cerebral palsy.[19]

It seems that genetic polymorphism of interleukin 6 CC increases the risk of cerebral palsy.[20]

3 : 1000 newborns  survive intrapartal hypoxic ischemic encephalopathy, but only 0.3 of these develop significant neurological consequences associated with cerebral palsy. Recent studies suggest an association of apolipoprotein å and occurrence of CP, as well as association with severity of cerebral palsy and likelihood for microcephaly.[21,22] Furthermore, high incidence of cerebral palsy (86 per 1000) in extreme premature infants and recently suggested genetic linkage to premature birth[23,24] led to the inclusion of prematurity in the group of genetic factors for cerebral palsy.

Genetically caused cerebral dysgenesis, and metabolic disorders which affect those brain areas involed in motor control, are well-documented causes of cerebral palsy.[25]

A specific "cerebral palsy" gene has been identified.[26]

Perinatal intracranial hemorrhage and stroke are well known risks for the development of cerebral palsy.[27] Factors contributing to the increased risk for stroke include chorioamnionitis, coagulation disorders, and placental vascular pathology.

The placenta is suspected to be a source for embolic material causing perinatal stroke, but in 50% of all cases of fetal stroke no riskfactors could be identified.[28]

Inherited and acquired thrombophilic disorders have been connected with cerebral palsy.[29,30] There is a strong association between perinatal stroke and thrombophilia factors. Factor V abnormalities are associated with porencephaly and hemiplegic CP.

Minor thrombophilias have most likely an independent role in the occurrence of cerebral palsy, even in the absence of stroke and related imaging findings[31] (Table 1).

*Multiple gestation* increases the risk for the development of cerebral palsy. The prevalence of cerebral palsy in monozygotic twins is 106 per 1000 live births, while for dizygotic twins 29 per 1000 live births.[33,34] The increase of CP with the number of fetuses is exponential. The main reason for that seems to be preterm birth and death of a co-twin or co-triplet,[35] although multiple gestation is also related to IUGR, pre-eclampsia/ eclampsia, dysgenesis, and intrapartal complications. The survivor twin has a 20% overall risk of neurological impairment. The embolic and ischemic theory of CP[36] is based on the fact that brain impairment of the survivor twin has been seen almost exclusively in monochorionic twins with interplacental vascular connections. The normal birth weight of survivor twins does not decrease the risk of cerebral palsy. This fact led to the hypothesis that cerebral palsy of unknown etiology

**Table 1:** The multifactorial etiology of CP

- Prematurity (78 percent)
- Intrauterine growth restriction (34 percent)
- Intrauterine infection (28 percent)
- Antepartum hemorrhage (27 percent)
- Severe placental pathology (21 percent)
- Multiple pregnancy (20 percent)

In a series of 213 children diagnosed with **CP:** other etiopathology than acute intrapartum hypoxia was identified in 98 percent of cases[32]

in singleton pregnancies may be attributed to an early loss of an unrecognized monochorionic twin.[35]

IVF procedures were mentioned by many authors as a significant factor for the increase of cerebral palsy due to high multiple gestation rate and prematurity.[37]

However, with all these facts and theories, the etiology of cerebral palsy still remains unclear in the majority of children.

## A Neurological Examination of the Newborn

A neurological examination of the newborn should be performed in any newborn suspected to have a neurological

abnormality, in case of ominous history with episodes of perinatal vaginal bleeding or perinatal asphyxia , or if the fetus belongs to a high-risk group: multiple pregnancy especially high order like triplets, monochorionic twins especially with TTTS, survivor twin after fetal demise, perinatal infections. A prenatal history should include information on pregnancy, such as prenatal exposure to drugs, toxin, or infections, maternal diabetes, acute maternal illness, trauma, radiation exposure, prenatal care, and reduced fetal movements. The neurological examination should include the following components:

*General assessment* of the vital signs, determination of the gestational age (GA), whether the baby is small, normal, or large for GA, then examination of head and spine. Any abnormality needs critical analysis in regards to underlying congenital disorder with neuropathology.

*Motor function assessment*, based upon evaluation of passive tone and posture, and active motor activity. Hypotonia is the most commonly identified motor abnormality, and is due to a variety of neurologic and muscular disorders .

*Cranial nerve (CN) evaluation* CN-development is GA-dependant. CNs III, IV, VI are responsible for extraocular movements and can be assessed by observing the spontaneous eye movements or the response of the newborn to the Doll's eyes test. The functional status of CNs V, VII, IX, X, and XII is demonstrated by the infant's sucking and swallowing. CNs I and XI are not tested in newborns.

*Reflex examination* to test the integrity of the central and peripheral nervous system: the focus is on examination of deep tendon, superficial, and so called primitive reflexes. These primitive or developmental reflexes like Moro, stepping, grasp, and asymmetrical tonic neck reflex need coordinated action of multiple muscles and nerves.

*Sensory assessment* The newborn's response to sensory stimuli is difficult to evaluate and therefore mostly not part of the neurological assessment.

*Behavioral testing* It looks at the consolability of the newborn and the habituation phenomenon and can assess higher cortical functions.

Careful assessment of abnormal neurologic findings helps in defining the site and extent of injury, which then guides the choice of further management decisions. Persistent neurologic dysfunction is associated with an increased risk of permanent disability. Preterm infants with abnormal neurologic examination at the time of discharge compared to those with a normal examination have an increased risk of long-term motor impairment like cerebral

palsy.[38,39] The risk of cerebral palsy increases in infants with persistent marked hypotonia, weak cry, poor sucking, and decreased level of activity.

## How to Identify Neurological Abnormalities in the Newborn?

In most normal term infants, small amplitude, choreoathetoid movements of the hands are seen. Common normal findings during active sleep include fragmentary myoclonus that migrates from one limb to another, facial twitches, and irregular respiratory rate. Although jitteriness or tremulousness can occur in normal awake infants, sustained tremulousness beyond the fourth day of life may be a marker of cortical dysfunction.[40]

*Active muscle function* By 32 to 34 weeks gestation, infants should exhibit symmetric, smooth, and spontaneous movements in all extremities.

*Abnormal motor exam* Hypotonia (decreased muscle tone) is the most common motor abnormality. When associated with weakness and absent tendon reflexes, it indicates a disorder of the anterior horn cells of the spinal cord or the peripheral nerves or muscle (the motor unit). When hypotonia is associated with relative preservation of mobility, and if tendon reflexes are brisk or exaggerated, CNS pathology may be the reason like in trisomia 21. In premature infants with gestational ages below 28 to 30 weeks, it may be difficult to identify a motor abnormality because of their premature tone, posture, and motility.

The hypotonic term infant lies supine in a frog-like position with the hips abducted and the limbs abnormally extended,[40] and spontaneous activity is decreased.

*Hypertonia* is less common than hypotonia and indicates a dysfunction of the pyramidal or extrapyramidal systems. *Spasticity* is a form of hypertonia that accompanies pyramidal tract dysfunction: typical is a "clasp knife" type of resistance on bending the extremity, due to an abnormal lengthening-shortening reaction of the muscle, mainly in the distal portion of the extremity. *Rigidity* is an increased resistance to bending of the joint throughout the motion which feels like bending a "lead pipe", and may have proximal or distal accentuation. Spasticity or rigidity may sometimes be difficult to differentiate. Most common etiologies of hypertonia are congenital brain anomalies and hypoxic-ischemic lesions.

*Opisthotonus*, a persistent arching of the neck and trunk, indicates lack of cerebral cortical inhibition of the labyrinthine-brainstem-spinal cord motor projections being the pathway for extension of the trunk and proximal

extremities. It is often seen with moderate to severe acute bilirubin encephalopathy, or as a sign of severe generalized disturbance of cortical function.

The Prechtl test, which is based upon classifying neurologic abnormalities into five neurologic syndromes, was reported to be a good predictor of neurological outcome at two years of age,[41,42] though in general the newborn neurologic examination has some limitations in its specificity and its ability to predict long-term outcome.

There are two profiles of brain damage: the *dynamic* profile, typical for the recent insults, and the *static* (i.e. post-dynamic) profile typical for the insults that occurred *in utero*, at least several weeks earlier. The dynamic profile is characterized by variable signs for CNS depression increasing within the first three days and decreasing gradually after that period. To determine the exact timing of occurrence of the brain damage, neurologists therefore use repeated neurological assessment over the first three days of life. The identification of a high arched palate (due to insufficient molding force of a hypoactive tongue), non-reducible adduction of thumb (due to the absence of a spontaneous activity) (Fig. 5) and ridges over cranial sutures (due to impairment of hemispheric growth) (Fig. 6) complete the stabile type of profile, thus shifting the occurrence of brain injury into the earlier intrauterine life. The Amiel-Tison Neurologic Assessment Test (ATNAT) to evaluate the CNS function in the neonate, intended a simplification of the clinical instrument of neurological screening of newborns. The complete procedure takes approximately 5 minutes, using a simple 0, 1, and 2 scoring system with a good interrater reliability. ATNAT is based on the response to specific maneuvers and focuses on the exploration of passive and active tonus according to neurological maturation. The facts on different maturation of lower (the brainstem and cerebellum) and upper (cerebral hemispheres and basal ganglia) motor system explain the principles of the test. The maturation of the lower motor system begins at 24 weeks, its essential role is to maintain posture and flexor tone. The maturation of the upper motor system begins at 32 GW and extends to the first two years in a descending wave. Its role is to control the lower motor system, the relaxation of the limbs, to control antigravity forces, and thus to allow erect posture, walking, and fine motor functions. Based on these facts, the signs depending on the integrity of the upper motor system have been emphasized, while the signs depending on the lower motor system function were de-emphasized. The CNS optimality is

diagnosed according to normal results in four subgroups of the parameters: adequate hemispheric growth, absence of the CNS depression, integrity of the upper motor control, and stability of the autonomic nervous system.[43]

## The Next Step: Prenatal Diagnoses of Neurological Impairment

A fact which still represents a serious obstacle to effective research strategies for diagnose, therapy and prevention of cerebral palsy, is that the diagnosis of CP is retrospective, and rarely made before the age of six months for severe, twelve months for moderate, and 24 months for minor forms. Even though it is a fact that an effective treatment for cerebral palsy is not available, the early diagnosis of cerebral palsy could be critical from the point of view of the child, the mother, the family, and the obstetrician. Taking into account that etiological factors of cerebral palsy are mostly located in the prenatal period, attempts were made to diagnose neurological impairment during the intrauterine life. After the fetal brain anatomy and its morphological development could be visualized by using 2D ultrasound, the functional development of the fetal CNS still remains largely unknown.[44] Prechtl found spontaneous motility as the expression of spontaneous neural activity to be an efficient marker for normal or disturbed development of the central nervous system.[45, 46] Therefore, it was suggested that the assessment of fetal behavior in different periods of gestation might make it possible to distinguish between normal and abnormal development.[47] 2D real time ultrasound was used for the quantitative study of fetal activity. Qualitative 2D studies were estimated low due to subjectivity of the examiner, and abnormal quantitative 2D assessment was considered an unspecific sign of neural dysfunction. The introduction of 4D ultrasound enabled researchers to conduct objective quantitative as well as qualitative studies of fetal behavior.[48]

A Kurjak and coworkers produced the first study using 4D ultrasound techniques, to obtain longitudinal standard parameters of normal fetal neurological development in all trimesters of a normal pregnancy.[49,50]

The next step was the identification of *abnormal* patterns of fetal behavior, based on quality of general movements, primary reflexes and precompetences (Figs 7 to 10). In order to achieve an objective analysis, Kurjak and coworkers standardized the assessment of fetal behavior and its interpretation by producing and using a neurological scoring test for the fetus.[1] The preliminary study suggested that the scoring system could be a predictive marker for fetal neuro-developmental outcome in both low-and high-risk

**Fig. 5:** Clenched fist, neurological thumb



**Fig. 6:** Cranial ridges



**Fig. 7:** Hand, fingers



**Fig. 8:** Hand to mouth



**Fig. 9:** Eye blinking



**Fig. 10:** Tongue expulsion

populations.[51] Though intrauterine conditions for fetal motor activity are different from postnatal life not only in regards to gravity, there are similarities between the neonatal optimality test of Amiel –Tison (ATNAT),[52,53] and the scoring system for the assessment of neurological status in fetuses (Table 2).

Further paper showed the continuity of the behavioral pattern from the fetal to the neonatal life.[54] This fact could encourage the attempts to diagnose potential risk for neurological injury prenatally.

## CONCLUSION

While during the last two decades obstetricians have become a risk group in regards to medicolegal complications, there have been substantial advances in understanding the etiology of cerebral palsy: only 10% of later diagnosed CP are caused by intrapartum asphyxia. But many questions still remain open. The final goal of prevention may be more achievable after scientific comprehension of many collaborative factors involved in the origination of CP, this still mysterious entity. The new field of fetal neurology with the latest diagnostic tool KANET offers a great professional challenge. With 4D sonography it is now possible to define reproducible parameters for the assessment of normal neurobehavioral development. There is urgent need for further multicentric studies until a sufficient degree of normative data is available
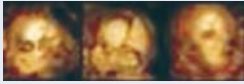


**Fig. 11:** Cerebral palsy still remains a mysterious entity

and the predictive validity of specific aspects of fetal neurobehavior to child developmental outcome is better established.

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| Sign | Score | | | Sign Score |
|------|-------|---|---|------------|
| | **0** | **1** | **2** | |
| Isolated head anteflexion  | Abrupt | Small range (0-3 times of movements) | Variable in full range, many alteration (> 3 times of movements) | |
| Cranial sutures and head circumference  | Overlapping of cranial sutures head circumference below or above the normal limit (–2 SD) according to GA | Normal cranial sutures normal head circumference | | |
| Isolated eye blinking  | Not present | Not fluent (1-5 times of blinking) | Fluency (> 5 times of blinking) | |
| Facial alteration (grimace or tongue expulsion)  | Not present | Not fluent (1-5 times of alteration) | Fluency (> 5 times of alteration) | |
| Mouth opening (yawning or mouthing)  | Not present | Not fluent (1-3 times of alteration) | Fluency (> 3 times of alteration) | |
| Isolated hand movement  | Cramped | Poor repertoire | Variable and complex | |
| Isolated leg movement  | Cramped | Poor repertoire | Variable and complex | |

*Table 2:* KANET test

*Contd...*

*Contd...*

| Sign | Score | | | Sign Score |
|------|-------|---|---|------------|
| | 0 | 1 | 2 | |
| Hand to face movements  | Abrupt | Small range (0-5 times of movement) | Variable in full range, many alternation (< 6 times of movements) | |
| Fingers movements  | Unilateral or bilateral clenched fist, (neurological thumb) | Cramped invariable finger movements | Smooth and complex, variable finger movements | |
| Gestalt perception of GMs | Definitely abnormal | Borderline | Normal | |
| | | | **Total score** | |

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