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THE NORMAL AND ABNORMAL FETAL NEURODEVELOPMENT ASSESSED BY NEW TEST – KANET

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Abstract

One of the greatest challenges of obstetrical ultrasonography is the better understanding of fetal neurological function. Neurological problems such as cerebral palsy are poorly understood and often falsely attributed to intrapartum events, while for the majority of cerebral palsy cases it has been proven that the causative pathway starts long before delivery. Several attempts have been made in order to define normal and abnormal fetal neurological function and to develop a method of assessment of the integrity of the fetal nervous system, but still without satisfactory sensitivity.

Fetal behavioral patterns are directly reflecting developmental and maturational processes of fetal central nervous system. It has been suggested that the assessment of fetal behavior during different periods of gestation may provide valuable information about normal and abnormal brain development, and contribute to the early diagnosis of various structural or functional neurological abnormalities. The introduction of three and four dimensional ultrasound (3D & 4D) allowed real time assessment of fetal behavior. Details of the fetal face, and especially movements of mouth, eyes (facial expressions) and fingers have been made possible with the introduction of 4D ultrasound. KANET is the first method that attempted to use 4D ultrasound in order to assess and combine parameters of fetal behavior and form a scoring system that would assess the fetus in a comprehensive and systematic approach, in the same way that neonatologists perform a neurological assessment in newborns during the first days of their life, in order to determine their neurological status. KANET appears to be able to identify functional characteristics of the fetus that predict normal and abnormal neurological development and hopefully future results of the prospective multicentric studies that are taking place at the moment in the next few years it will provide more information on fetal neurology. Such information will be of great value in counseling mothers of high risk pregnancies, like for

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example in cases with previous child with cerebral palsy and also provide valuable evidence for cases of litigation.

Key words: Fetal behavior, fetal brain function, KANET test, 4D sonography

Introduction

Recent advances of technology and especially of three dimensional (3D) and four dimensional (4D) ultrasound, have given us the opportunity to study in real time and with explicit detail parts of fetal anatomy and fetal activity, that we could not imagine it would be possible even a few years ago. We now know that there is a specific fetal behavioral pattern that corresponds to each week or trimester of fetal life and this pattern reflects the steps of human brain development and maturation (1-4). The development of the human brain is a long lasting procedure that with specific developmental stages, starting from the first few weeks of in utero life and continues long after birth, in such a way that it remains incomplete at the end of in utero life and continues to evolve for decades after birth (4). Human brain development is also very sensitive and affected by wide variety of factors and defects at any of stage of fetal or neonatal life. For example in neonates born very prematurely the brain development ex utero as much as we try to resemble the intrauterine environment cannot follow the genetically programmed growth pattern that the brain should have in utero (5-6). Genetic factors, external stimuli, pathological conditions or even environmental changes, can affect the fetal human brain up to a degree that may be difficult to assess, especially prenatally. Many times we cannot detect fetal brain impairment, and even in cases when we suspect that fetal brain impairment may exist, in most cases we are unable to clarify how will the fetus be affected. Neurological compromises may occur prenatally, perinatally and/or even postnatally or neonatally, and their clinical picture, varies ranging from mild behavioral and learning disabilities to severe cerebral palsy (CP) (4). Neurological disability is one of the most feared complications in obstetrics and its diagnosis antenatally is one of the greatest challenges. The assessment fetal neurobehavior both in normal and abnormal cases is a major project, since first of all we need to study and understand the normal cases before we can compare them with the pathological ones in order to draws safe conclusions (6-7).

Can we assess fetal behavior with ultrasound?

We know that fetal behavioral patterns reflect the degree of development and maturation of the fetal nervous system, and it has also been proved that the

quality and quantity of fetal movements reflect the neurological integrity of the fetus (8-17). The introduction of two dimensional ultrasound allowed the assessment of fetal anatomy, but also the direct monitoring of fetal activity (18). Fetal movements were studied and analyzed with 2D even 30 years ago (18-21), and further studies suggested that the assessment of fetal behavior in the specific periods of in utero life could make it possible to distinguish between normal and abnormal brain developmental patterns (21-24). Advances in ultrasound technology introduced 3D & 4D ultrasound, offering exceptional images of the fetus in utero and in real time, allowing to evaluate even the movements and the behavior of the fetus in utero, overcoming the problem of subjective poorer quality images obtained with 2D ultrasound (24-28). 4D ultrasound allows imaging of details of fetal face and fetal expressions (e.g. smiling, crying, mouthing and blinking), something that cannot be achieved with 2D ultrasound. Studies have shown that with 4D ultrasound it is feasible to distinguish between normal and abnormal behavioral patterns of the fetus, which could eventually lead to early diagnosis of brain impairment, enabling us to produce measurable parameters for the assessment of normal neurobehavioral development (29-32).

Fetal movements occur much earlier than when pregnant women can feel them, even during the embryonic period starting with gross, asynchronized movements of the whole embryo and finally leading to organized and detailed movements, as well as facial expressions towards the end of the pregnancy (33-34). Regarding neonates the assessment of neonatal behavior is a better predictor of neurodevelopmental disability than neurological examination. So the question would be whether by studying fetal behavior we could identify cases of normal and abnormal brain development, and also whether we could achieve earlier diagnosis of various structural or functional abnormalities of the fetal nervous system (1-4,18-23,58). The first structured and systematic way for assessing the integrity of the fetal central nervous system, by using 4D ultrasound, was called Kurjak's antenatal neurodevelopment test (KANET), and its innovation is that it assesses the fetus in utero in the same way that neonates are examined postnatally for brain damage, incorporating parameters from neonatal neurological tests (Amiel-Tison), with the use of 4D ultrasound (35-38).

What is Kurjak's Antenatal NEurodevelopmental Test (KANET)?

Kurjak's antenatal neurobehavioral test (KANET) is a new scoring system for the assessment of fetal neurobehavior based on prenatal evaluation of the fetus by 3D/4D ultrasound (35). It is a combination of some parameters consisting

of fetal general movements (GM) and of postnatal Amiel-Tison Neurological Assessment at Term (ATNAT) signs, which can be easily visualized prenatally by using 4D ultrasound (36,40). The following parameters have been incorporated in the KANET test: isolated head anteflexion, overlapping cranial sutures, head circumference, isolated eye blinking, facial alterations, mouth opening (yawning or mouthing), isolated hand and leg movements and thumb position, Gestalt perception of general movements (overall perception of the body and limb movements with their qualitative assessment).

Several papers have shown that there is a continuity of behavior from pre- to postnatal life and it has been observed that all movements which are present in neonates are also present in fetal life, with the exception of Moro's reflex, which cannot be demonstrated in fetuses (41). This is probably due to a different environment to which fetus and neonate are exposed. The fetus lives in an environment of microgravity, while the newborn is exposed to full gravity, which creates certain obstacles for neurodevelopment in the first months of life (6). The parameters were chosen based on developmental approach to the neurological assessment and on the theory of central pattern generators of general movements emergence, and were the product of multicentric studies conducted for several years (39-40). KANET is a combination of assessments of fetal behavior, general movements and three out of four signs which have been postnatally considered as symptoms of possible neurodevelopmental impairment (neurological thumb, overlapping sutures and small head circumference) (42).

KANET test has been standardized, it is reproducible and easily applied by fetal medicine specialists (42). KANET should be performed in the 3rd trimester of pregnancy, between 28 and 38 weeks. The duration of the examination should last between 15-20 minutes, and fetuses should be examined while they are awake. If the fetus is in the sleeping period, the assessment should be postponed for 30 minutes or for the following day, at a minimum period of 14-16 hours. In cases of grossly abnormal or of borderline score, the test should be repeated every two weeks until delivery. Special attention should be paid to the facial movements and to eye blinking, which are prenatally very informative and important ("the face is the mirror of the brain"). Overall number of movements should be defined in very active or inactive fetuses and compared with normal values of previous studies (39-40). All the examiners should have extensive hands-on education for the application of KANET test, both in low and in high-risk pregnancies. Interobserver and intraobservere variability should be available. It is advisable to use 4D ultrasound machines, with frame rate of minimum 24 volumes/second. KANET consists of eight

parameters. A score range of 0-5 is characterized as abnormal, a score calculated from 6-13 is considered borderline and a score range of 14-20 is normal. After that neonates should be followed up postnatally for neurological development for a two years period.

The test evaluates quantitative as well as qualitative aspects of fetal motor behavioral patterns. The parameters examined by this test are a combination of general movements (GMs) and parameters adopted from Amiel Tison Neurological assessment at term (ATNAT) (43-44). The criterion of quality and quantity of spontaneous GMs is believed to have excellent reliability in evaluating the integrity of fetal CNS (22,45). Furthermore a continuity of behavioral patterns from prenatal to the postnatal period has been proven (46-48). Both those facts justify the choice of the parameters used in this test, making KANET theoretically appropriate for the assessment of fetal behavior. According to previous reports (49-54) KANET easily recognizes serious functional impairment associated with structural abnormalities. Studies have shown that application of KANET in both low and high risk populations has given good results and especially in high risk populations, KANET may provide useful information regarding the neurological outcome of these fetuses (55). KANET is the first test which is based on 4D ultrasound, with an original scoring system and has been standardized, so it can be implemented in everyday practice, overcoming the practical difficulties and covering the gaps of methods that were used in the past for the evaluation of fetal behavior (57-60). Studies show that KANET is easily applicable to most pregnancies, the learning curve is reasonable for physicians who already have training in obstetrical ultrasound and the actual duration of KANET ranges from 15-20 minutes, showing strong evidence that it can be widely implemented in everyday clinical practice (53).

What have studies about KANET shown so far?

One of the first studies to use a preliminary form of the KANET scoring system was that by Andonotopo et al in 2006. They aimed to assess fetal facial expression and quality of body movements and examine if they are of diagnostic value for brain impairment in fetuses with growth restriction. In that prospective study of 50 pregnancies with IUGR fetuses in the 3rd trimester of pregnancy, a tendency of less behavioural activity in IUGR than normal fetuses has been noted. The results of the study encouraged future investigation of the use of 4D ultrasound for quantitative and qualitative assessment of fetal behaviour as possible indicators of the neurological condition in IUGR fetuses (54).

The Zagreb group in 2008, were the first to introduce the KANET for the assessment of neurological status of the fetus, aiming to the detection of fetal brain and neurodevelopmental alterations due to in utero brain impairment. In order to develop the new scoring system they identified severely brain damaged neonates and neonates with good neurological condition and then compared the neonatal findings, with corresponding findings in utero. In the group of 100 low-risk pregnancies they retrospectively applied KANET. After delivery, postnatal neurological assessment (ATNAT) was performed and all neonates assessed as normal reached a score between 14-20, which was assumed to be the score of optimal neurological development. New scoring system was applied in the group of 120 high-risk pregnancies in which, based on postnatal neurological findings, three subgroups of newborns were identified: normal, mildly or moderately abnormal and abnormal. Based on this, a neurological scoring system has been proposed. All normal fetuses reached a score from 14-20. Ten fetuses who were postnatally described as mildly or moderately abnormal achieved a prenatal score of 5-13, while another ten fetuses postnatally assigned as neurologically abnormal had a prenatal score 0-5. Among this group four had alobar holoprosencephally, one had severe hypertensive hydrocephaly, one had thanatotrophic dysplasia and four fetuses had multiple malformations. This study inspired a large series of multicenter studies that used the KANET in order to assess the usefulness of this promising new scoring system for the assessment of neurological status in fetuses and the recognition of signs of early brain impairment in utero (25,32).

The results of the first multicenter study, which included 288 high risk pregnancies, from four different centers, were published in 2010. They identified seven cases with abnormal KANET and twenty five cases with borderline KANET score, yielding 32 fetuses at neurological risk. There were also 11 cases with abnormal KANET, of which 6 fetuses died in utero and 5 were terminated. The seven remaining neonates with abnormal KANET were followed up postnatally at 10 weeks and out of these seven cases, three were found to have abnormal ATNAT scoring postnatally. These were a case of arthrogryposis, a case of vermis aplasia and a fetus whose previous sibling had verified cerebral palsy. The fetuses in these three cases had especially reduced facial movements – the faces were like masks during the ultrasounds. The remaining four cases were considered normal (ventriculomegaly, pre-eclampsia, thrombophilia, oligohydramnios). Out of 25 borderline KANET there were 22 borderline newborns by ATNAT, whereas three were normal (ventriculomegaly, syndrome of intra-amniotic infection, maternal thrombocytopenia). Those who were abnormal prenatally and normal postnatally had the following

prenatal risk-factors: ventriculomegaly, Dandy-Walker malformation, skeletal dysplasia, polyhydramnios, gestational diabetes, hydrocephaly, thrombophilia, pre-eclampsia, achondroplasia, oligohydramnios, non-immune hydrops, intra-amniotic infection, IUGR, trisomy 21, thrombocytopenia. Out of three abnormal neonates neonates after ATNAT assessment two had definitely abnormal Prechtl's premature GMs (arthrogryposis and vermis aplasia) and an additional six were considered abnormal (neonate of the mother with the previous cild with CP, Dandy-Walker syndrome, hydrocephaly, trisomy 21, ventriculomegaly, non-immune hydrops). The remaining 21 children had normal optimal or normal suboptimal GMs. During their study they also followed the pregnancy of a fetus with acrania, which the mother had refused to terminate due to religious reasons, documenting the evolution of the fetal behavior from 20 weeks and as the motor control was shifting from the lower to the upper control center the fetus ended up with a very low KANET score. The authors reached the conclusion that there is a potential for antenatal detection of serious neurological conditions, especially in identifying the fetuses from high-risk pregnancies at neurological risk (49).

Miskovic et al applied KANET in 226 cases, both high and low risk pregnancies and compared the results. They found three cases of abnormal KANET, that had chromosomal abnormalities and all three had abnormal ATNAT, as well. The KANET scores from both groups were compared to the results of the ATNAT tests, and found statistically significant difference among the low and the high risk groups, for eight out of the ten KANET parameters (isolated anteflexion of the head, eye blinking, facial expressions – grimacing, tongue expulsion, mouth movement such as yawning, jawing, swallowing – isolated hand movements, hand to face movements, fist and finger movements and general movements). Comparison of KANET and ATNAT showed statistically significant, moderate correlation between the two tests, which means that the neuropaediatric exam (ATNAT) confirmed the prenatal findings of 4D ultrasound examination (KANET). The authors concluded that these preliminary results were promising and stated that further studies are needed before the test could be recommended for wider clinical practice (53).

Talic et al around the same period, in a multicenter study, published the largest series of KANET so far, with 620 singleton pregnancies, both low and high risk cases (100 low risk and 520 high risk cases), excluding however fetuses with structural abnormalities, that were studied between 26 and 38 weeks of gestation. Fetuses with congenital anomalies multiple pregnancies were excluded from the study. The high risk group of patients consisted of the following subgroups: threatened preterm delivery with or

without preterm rupture of membranes (PPROM), previous child diagnosed with CP, hypertension in pregnancy with or without pre-eclampsia, diabetes before pregnancy or gestational diabetes, intrauterine growth restriction, polyhydramnios, Rhesus isoimmunisation, placental bleeding and maternal fever >39^{o}C. Analysis of the data confirmed statistically significant difference in the distribution of fetal KANET scores between the two populations. Impressively the largest incidence of fetuses with abnormal KANET was noticed in the subgroup of participants with a previous child diagnosed with cerebral palsy (23.8%) and the largest incidence of fetuses with borderline KANET was observed in the subgroup of mothers with fever (56.4%). The following parameters of KANET test significantly differed between the fetuses from low and high-risk pregnancies: overlapping cranial sutures, head circumference, isolated eye blinking, facial expressions, mouth movements, isolated hand movements, isolated leg movements, hand to face movements, finger movements and general movements. The authors observed that a low KANET score is predictive of both intrauterine or neonatal death – they had two intrauterine deaths in fetuses with low KANET (scores of 3 and 4 respectively) and one neonatal death (with a KANET score of 2). In 10 out of 36 fetuses with abnormal KANET after 2 and 6 months, postnatal neurological examination indicated severely abnormal finding: four of them had severe generalized spasticity. The study demonstrated the potential of KANET to detect and discriminate normal from borderline and abnormal fetal behavior in normal and in high-risk pregnancies. Other neonates are still followed up in this study, in order to reach safe conclusions (52).

Honemeyer et al studied 100 fetuses, who underwent, between 28-38 weeks of gestation, up to 3 times during their pregnancy assessment by KANET. The fetuses were followed-up postnatally, immediately after delivery and again at 12 weeks of life, with systematic neurological assessment by the neonatologist. The results from the scoring systems of pre-and postnatal evaluation were compared. Results showed that a normal prenatal KANET score is significantly predictive of normal postnatal neurological assessment of the newborn immediately after delivery and at 12 weeks of life. The authors concluded that that normal antenatal KANET scores is a very good predictor of a normal postnatal neurological outcome (61).

Lebit et al used part of the KANET to assess fetal movements throughout pregnancy in 144 low risk pregnancies, between 7-38 weeks of gestation, concluding to a specific pattern of fetal behavior for each trimester of pregnancy (34). The authors noticed that in the first trimester fetal movements grow rapidly in frequency and complexity, while in the second half of

pregnancy the motor behavior significantly increases in frequency and variability. Facial expressions and eye movements also appear in second trimester, with the first eye movements starting at about 18 weeks. In late pregnancy fetal movements show a decline and the periods of rest start to grow. This decrease is rather a consequence of the brain maturation process rather than reduced amount of amniotic fluid (25,33). They concluded that dynamic evaluation of fetal behavior reflects directly the processes of maturation and development of the central nervous system and that KANET test has much to offer in the assessment of fetal behavior (34).

A very important study was that by Talic et al which aimed to assess the differences in fetal behavior in both normal fetuses and fetuses with cerebral ventriculomegaly, by using KANET. They studied 240 fetuses between 32-36 weeks of gestation, 140 fetuses with venticulomegaly and 100 normal fetuses. 6% of the fetuses from the low risk-control group had pathological KANET scores, while 34.9% of the fetuses with ventriculomegaly had pathological KANET. The largest number of abnormal KANET scores was found in 22 fetuses with severe ventriculomegaly, accompanied by other structural abnormalities (Dandy-Walker, Arnold-Chiari, agenesis of the corpus callosum, holoprosencephaly, encephalocele, spina bifida, choroid plexus cyst, osteogenesis imperfect type II, thanatophoric dysplasia type I and Meckel Gruber syndrome). There were no fetuses with abnormal KANET in the group of isolated mild and moderate ventriculomegaly. The authors concluded that prenatal neurological findings of the fetuses by application of KANET test is in concordance with their postnatal outcome and that evaluation of fetal behavior by KANET in fetuses with cerebral ventriculomegaly had the potential to detect fetuses with abnormal behavior, adding a functional dimension of the central nervous system evaluation to the brain morphology. Also the degree of ventriculomegaly and the presence of coexisting congenital malformations, appeared to be important factors determining the final KANET score. The results of this study were very positive and showed that KANET could provide useful information for the correct assessment and counseling of patients with a common finding, such as ventriculomegaly, the significance of which is not well defined (55).

More recently, Abo-Yaqoub *et al* studied 40 pregnant women with high risk pregnancies for neurological abnormalities, between 20 and 38 weeks of gestation using KANET scoring system and compared the results with 40 low risk cases, in order to determine the role of 4D ultrasound in prenatal assessment of fetal neurobehavior and in the prediction of adverse neurological outcome. The difference in the range of KANET score was significant

between the 2 groups and all cases with abnormal KANET proved to be abnormal postnatally, whereas those with normal or borderline KANET scores were neurologically normal at least in the early neonatal period that they were assessed. The parameters that were significantly different between the two groups were: isolated head anteflexion, isolated eye blinking, facial expressions, mouth movements, isolated hand movements, hand-to-face movements, finger movements and general movements. For isolated leg movements and cranial sutures, the difference was not significant (51).

Vladareanu et al. applied KANET in 196 singleton pregnancies (61 low risk and 135 high risk patients) between 24 and 38 weeks of gestation in a period of 3 years. Most fetuses in the study who obtained normal KANET score belonged to the low risk pregnancies, those who obtained borderline score were fetuses with intrauterine growth restriction (IUGR) and with increased resistance index (RI) of middle cerebral artery (MCA) and most fetuses with abnormal KANET score derived from pregnancies complicated by threatened preterm delivery with PPROM. There was statistical significant difference in fetal movements in the two groups. In normal pregnancies, most foetuses (93.4%) achieved a normal KANET score compared to 78.5% of the foetuses from high risk pregnancies. Borderline and abnormal scores were dominant in high risk pregnancies. In the high risk pregnancy group, most abnormal KANET scores were in pregnancies complicated by threatened preterm delivery with PPROM (25%). Most foetuses with pregnancies complicated by IUGR with MCA RI index changes and with hypertension above 160/100 mm Hg achieved borderline score (50%). The highest percentage of normal fetal movements was found in pregnancies complicated by Rh isoimmunisation without hydrops fetalis (96%). The characteristics of reduced speed and amplitude were found in the threatened preterm delivery group. There was a reduction of both number and duration of general movements in the IUGR group. The IUGR foetuses moved less and their general movements were poorly organised. Alterations in the quality of fetal movements were accompanied by considerable decrease in the quantity of fetal movements. The authors concluded that KANET can be useful for early diagnosis of neurological disorders that become manifest in perinatal and postnatal period (62).

Honemeyer et al. studied 56 singleton pregnancies (24 low-risk and 32 high-risk cases) between 28-38 weeks of gestation and applied serial KANETs on them, performing a total of 117 tests in total. They did not identify any abnormal KANET scores, but two thirds of the borderline scores occurred in the high-risk pregnancies. Because they performed more than one KANET in each pregnancy they introduced the average KANET score,

which derived from the scores of each fetus during pregnancy. Only one fetus had a borderline average KANET score, and this fetus who belonged to the high-risk group, was the only one out of 56 pregnancies who had an abnormal early neurological outcome. When the authors compared all the 18 borderline KANET scores with fetal diurnal rhythm based on maternal observation, they noticed that 89% of the borderline scores of the at-risk group were recorded at times that the mothers characterised them as active periods, compared with 33.3% in the low-risk pregnancies. The authors concluded that KANET is suggestive of expressing the risk for neurodevelopmental fetal disorders, but the connection of fetal diurnal rhythm and pregnancy risk status should be investigated further (63).

Kurjak *et al*. studied 869 high and low risk singleton pregnancies taking under consideration the results of the Doppler studies of umbilical and middle cerebral arteries, and noticed that fetal behavior was significantly different between the normal group and the following subgroups of fetuses: fetal growth restriction (FGR), gestational diabetes mellitus, threatened preterm birth, antepartum haemorrhage, maternal fever, sibling with cerebral palsy, and polyhydramnios (74). The authors concluded that their study showed a new clinical application of the KANET test in early identification of fetuses at risk for adverse neurological outcome.

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Conclusion

One of the greatest challenges of obstetrical ultrasonography is the better understanding of fetal neurological function [38,64]. Neurological problems such as cerebral palsy are poorly understood and often falsely attributed to intrapartum events, while for the majority of cerebral palsy cases it has been proven that the causative pathway starts long before delivery (65-67). Several attempts have been made in order to define normal and abnormal fetal neurological function and to develop a method of assessment of the integrity of the fetal nervous system, but still without satisfactory sensitivity (49, 66-68).

Fetal behavioral patterns are directly reflecting developmental and maturational processes of fetal central nervous system (66-68). It has been suggested that the assessment of fetal behavior during different periods of gestation may provide valuable information about normal and abnormal brain development, and contribute to the early diagnosis of various structural or functional neurological abnormalities (19). The introduction of three and four dimensional ultrasound (3D & 4D) allowed real time assessment of fetal behavior. Details of the fetal face, and especially movements of mouth, eyes (facial expressions) and fingers have been made possible with the introduction

of 4D ultrasound (69-73). KANET is the first method that attempted to use 4D ultrasound in order to assess and combine parameters of fetal behavior and form a scoring system that would assess the fetus in a comprehensive and systematic approach, in the same way that neonatologists perform a neurological assessment in newborns during the first days of their life, in order to determine their neurological status (34). KANET appears to be able to identify functional characteristics of the fetus that predict normal and abnormal neurological development and hopefully future results of the prospective multicentric studies that are taking place at the moment in the next few years it will provide more information on fetal neurology. Such information will be of great value in counseling mothers of high risk pregnancies, like for example in cases with previous child with cerebral palsy and also provide valuable evidence for cases of litigation.

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Funkcija fetalnog mozga ispitana KANET testom

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Sažetak

Jedan od najvećih izazova u suvremenoj perinatalnoj medicini je upoznavanje funkcije fetalnog mozga. Ultrazvučna dijagnostika napravila je snažan prodor u gotovo potpuno razumijevanje strukturalnih normalnih i abnormalnih promjena fetalnog CNS-a. To nije tako s funkcionalnim ispitivanjima i tu se nalazimo tek na početku.

2008. godine veliki multinacionalni znanstveni projekt proizveo je novi test koji omogućava prenatalno ispitivanje funkcije fetalnog mozga. U čast

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voditelja projekta A. Kurjaka test je međunarodni koncensus u Osaki nazvao po njemu KANET, Kurjak Antenatal Neurodevelopmental Test. Istraživanja u 10 sveučilišnih središta u svijetu zaključuju da je test vrlo korisna novina jer se po prvi put u kliničku praksu uvodi novi test temeljen na praćenju pokreta fetusa, izrazima lica i kontinuitetu između fetalnog i neonatalnog ponašanja. Multicentrične studije pokazale su iznenađujuće visoku podudarnost pa je test preporučen za rutinsku upotrebu u svih trudnica, niskorizičnih i visokorizičnih. Preliminarni rezultati pokazuju da se upotrebom KANET-a mogu još u maternici prepoznati fetusi s neurološkim oštećenjima od kojih je najteži oblik moždana paraliza. Utvrđeno je da kvalitet i kvantitet fetalnih pokreta pokazuje različite i uočljive parametre u neurološki zdravih fetusa u odnosu na one s neurološkim poremećajima. Skora rutinska upotreba omogućit će prenatalno otkrivanje moždane paralize. Kako bez dijagnoze nema terapije, jednom utvrđena međunarodna prihvatljivost testa stimulirat će na traganje za metodama liječenja ove do sada neizlječive bolesti. Znanost zna desetine neuroprotektivnih supstanci koje bi se mogle uvoditi izravno u fetalni krvotok metodom kordocenteze i tako još u maternici liječiti neurološke poremećaje fetusa. To otvara jednu posve novu stranicu u povijesti fetalne terapije gdje je i mrvica novog znanja dragocjena. Autori prikazuju povijest KANET testa, detaljnu analizu međunarodnih rezultata i daju praktične upute kako test racionalno i pouzdano primijeniti u trudnice.

Ključne riječi: fetalno ponašanje, funkcija fetalnog mozga, KANET test, 4D ultrazvuk

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