10.5005/jp-journals-10009-1543

REVIEW ARTICLE

Clinical Study of Fetal Neurobehavior by the Kurjak Antenatal Neurodevelopmental Test

[1]Raul Moreira Neto, [2]Asim Kurjak, [3]Selma Porovic, [4]Milan Stanojevic, [5]Ghalia Gaber

ABSTRACT

Fetal neurology is an evolving field in prenatal diagnosis and fetal medicine with great interest. The identification and diagnosis of brain damage prenatally has been a great challenge in obstetrics for many years. Investigations of the fetal behavior in comparison with morphological studies led to the conclusion that fetal behavioral patterns directly reflect developmental and maturational processes of fetal central nervous system (CNS). Four-dimensional ultrasound (4D US) has remarkably improved the assessment of the quality of fetal spontaneous movements, and enabled a better evaluation of fetal behavior. The assessment of normal neurobehavioral development by 4D US provided the opportunity to investigate functional characteristics of the fetus that could predict neurological developmental dysfunction. Some studies have already been carried out to evaluate this new methodology in the observation of the fetal behavior during different stages of gestation, in an attempt to better understand the relationships between the maturation of the CNS of the fetus and its implications on its behavior pattern. We present a review of literature on fetal behavior by 4D US.

Keywords: Fetal behavior, Fetal neurologic screening, Fetal neurology, Four-dimensional ultrasound, Prenatal brain impairment.

How to cite this article: Neto RM, Kurjak A, Porovic S, Stanojevic M, Gaber G. Clinical Study of Fetal Neurobehavior by the Kurjak Antenatal Neurodevelopmental Test. Donald School J Ultrasound Obstet Gynecol 2017;11(4):355-361.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Fetal behavior can be described as any fetal action or reaction seen by US.[1] This fetal activity has been observed by two-dimensional ultrasound (2D US) and many papers on fetal behavior assessed by 2D US have been published up to now.[2-4] This method of investigation of fetal behavior has limitations, mainly because only the number of movements can be visualized, while the quality of fetal movements could not be assessed. More than this, complex facial movements could not be depicted by using only 2D US, which has been considered as a great disadvantage of 2D US.[5,6] The development of 4D US has significantly increased the assessment of the quality of fetal movements and permitted better evaluation of fetal behavior compared with 2D US, especially in assessment of facial movements like sucking, yawning, blinking, smiling, and even crying.[7-10] As a result, spontaneous fetal movements, as an expression of neural activity, could be used as a marker for assessment of fetal neurological status.[11-13] The evaluation of fetal behavior could give the opportunity to recognize the difference between normal and abnormal neurological development, and even an early diagnosis of different structural or functional CNS abnormalities.[11] It has been proven by many studies that most of the neurological disorders like cerebral palsy (CP) develop prenatally, while postnatal and intrapartum factors are not that important.[14,15] Analysis of fetal behavior by 4D US should be standardized as any other clinical test.[13,16] Kurjak et al[17] in the field of perinatal neurology have proposed a prenatal screening test for assessment of motor activity called Kurjak antenatal neurodevelopmental test (KANET). This test is a continuation of 2D US assessment of fetal behavior using new 4D US technique and introduces some postnatal signs which have been part of postnatal neurological assessment developed by Amiel-Tison neurological assessment at term (ATNAT).[18-20] This was a new approach to the assessment of fetal neurological status enabling longitudinal follow-up of fetal behavior throughout gestation, making the clear distinction between neurologically normal, borderline, and abnormal fetuses.[19-23]

The aim of this review is to evaluate the contribution of 4D US in the assessment of fetal neurobehavior.

FOUR-DIMENSIONAL ULTRASOUND US EVALUATION OF FETAL BEHAVIOR

For a long time, the only approach for the follow-up of fetal well-being was the maternal sensation of fetal movements and obstetric auscultation of their heartbeats. After the appearance of real-time US, there was

[1,3]Specialist, [2]President and Professor, [4]Professor, [5]Consultant

[1]Department of Fetal Medicine, Ecomoinhos—School and Clinic of Ultrasound, Porto Alegre, Brazil

[2]International Academy of Perinatal Medicine, Zagreb, Croatia

[3]Department of Pediatric Dentistry, Public Health Center of the Sarajevo Canton, Sarajevo, Bosnia and Herzegovina

[4]Department of Obstetrics and Gynecology, Neonatal Unit Medical School, University of Zagreb, Sveti Duh Hospital Zagreb, Croatia

[5]Department of Obstetrics and Gynecology, Amrita Medical Center, Health Authority of Abu Dhabi, United Arab Emirates

Corresponding Author: Raul Moreira Neto, Specialist Department of Fetal Medicine, Ecomoinhos—School and Clinic of Ultrasound Porto Alegre, Brazil, e-mail: raul@ecomoinhos.com.br

Fig. 1: Three-dimensional image in frontal view

Fig. 2: Two-dimensional image in frontal view

Fig. 3: Three-dimensional image in profile view

Fig. 4: Two-dimensional image in profile view

a revolutionary change in the assessment of fetal well-being.[24] Undoubtedly, one of the most amazing advancements in ultrasonography was the 4D technology.[25,26] During the last decade, 4D sonography has encouraged studies on fetal behavior with more persuasive imaging data than those obtained by 2D conventional US and even other nonultrasonic methods.[9]

The first embryonic movements begin at the seventh to eighth week of gestation. Motor activity is clearly recognizable, consisting of several movement patterns between the 8th and 9th week and can be observable by 2D US.[23,25,27-29] Prechtl[11] stated that these are gross movements, involving the whole body. But 4D US has enhanced the investigation of the quality of spontaneous fetal movements and implementing a better evaluation of fetal behavior in comparison with 2D US.[7,9,10,28,30-34]

The majority of sequences of extension and flexion of the legs and arms are complex and may be better assessed with the 4D US (Figs 1 to 4). From 10 weeks onward, head anteflexion, retroflection, and rotation could easily be observed by this new method,[4,17] as well as facial movements, swallowing, mouth opening, and yawning (Figs 5 and 6). Moreover, 4D US seems to be the preferred approach for detecting sophisticated movements, such as overlapped rotations and changes in direction. These components make the movements fluent and elegant and

Fig. 5: Mouth opening

Fig. 6: Yawning

Fig. 7: Crying

Fig. 8: Tongue expulsion

Fig. 9: Smiling

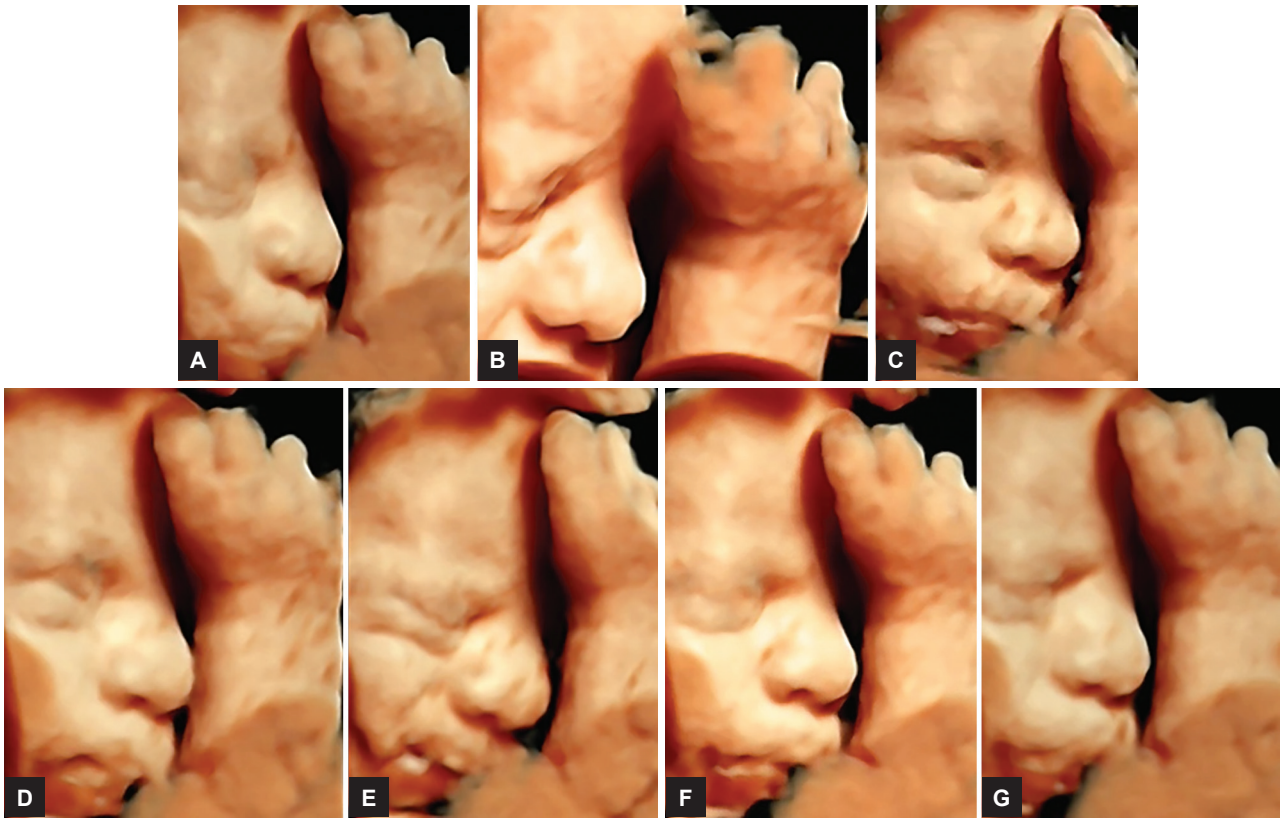
create the impression of complexity and variability, which can be depicted only by 4D US.[35]

The second half of pregnancy is characterized by the organization of fetal movement patterns and increase in complexity of movements.[13] Not only the movements but the periods of rest–activity cycles become recognizable.[36]

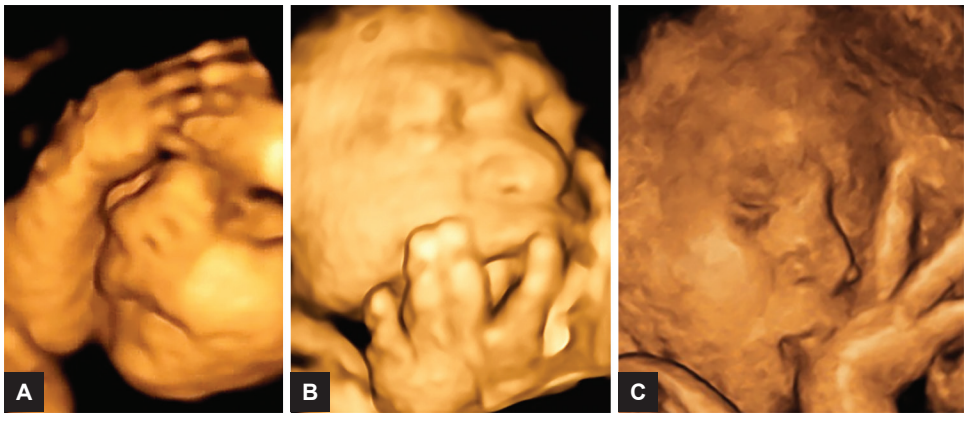
Besides, the surface rendering mode, seen only in 4D US, improves the visualization of fetal face and opens the possibility of assessment of a full range of facial expressions, including smiling, crying, scowling, and eyelid movements (Figs 7 to 9).[37-39] It is not possible to see these complex facial movements using real-time 2D US. Furthermore, 4D US combines the advantage of the spatial imaging of the fetal face with the addition of time, allowing detailed imaging of each fetal facial movement. Now we know that the observation of facial expression may be of scientific and diagnostic value (Fig. 10).[40]

For many years, obstetricians were concentrated mostly on the number of fetal movements which was considered as an indicator of fetal well-being. Later studies have shown that a count of movements is a unsatisfactory indicator of brain activity, mainly due to the great intra- and inter-individual variability and the large variations between normal and abnormal, which makes this method clinically useless.[41] Instead, changes of the elegance and fluency, as well as the variability and fluctuation of intensity and speed of general movements (GMs) were shown to be the best indicator of impaired brain activity, and they are considered to be the first sign of a supra-spinal control of the motor activity.[42] It became unmistakable that the qualitative changes in GMs of both the fetus and the neonate anticipate quantitative changes when the integrity of the nervous system is damaged (Fig. 11).[43]

Four-dimensional ultrasound emerged as a practical way for the evaluation of both brain function and structure. The analysis of fetal activity *in utero* by 4D US may allow early diagnosis of fetal neurological impairment.[9,44,45] A group of researchers from Zagreb, Croatia, led by Asim Kurjak, has had a great experience using 4D US in the assessment of fetal behavior.[17,29,46,47] Relying on their own



Figs 10A to G: Sequences of different facial expressions by 4D US



Figs 11A to C: Complex and sophisticated fetal movements

experiences in the field of fetal and neonatal neurology, they suggested a new scoring system for evaluation of fetal behavior based on the prenatal assessment of fetal motor activity and called it KANET.[17] This new test shows a relationship between fetal behavior and neurodevelopmental processes in different periods of pregnancy, making it possible to distinguish between normal and abnormal brain development.[18] The KANET has a great potential because is the first test that evaluates the functional development of the fetal CNS using 4D US in a structured and systematic way.[17] This test used a pioneering idea by using 4D US to assess fetal movements and facial expressions, similar to postnatal neonatal neurological tests, such as ATNAT and Prechtl's GMs.[17,21,48-52] The KANET has the capacity to detect and differentiate normal, borderline, and abnormal fetal behavior in high- and low-risk pregnancies and it can, consequently, become a relevant diagnostic tool for fetal neurological assessment. In order to make the test reproducible and easy to apply for fetal medicine specialists, its standardization was proposed in 2010 during the International Symposium on Fetal Neurology in Osaka, Japan, since then this has been widely accepted.[53] In 2014, a new consensus statement on the KANET was created in Bucharest during the 4th International Fetal Neurology Conference, with the conclusion that KANET is ready for use in everyday clinical practice for normal and high-risk fetuses.[54]

So far, KANET has proven its usefulness in standardization of neurobehavioral assessment, with the potential

for prenatal detection of fetuses with severe neurological dysfunction. Many studies using this method on fetal behavior have been conducted and published from different centers proving that conclusions about the use of KANET in everyday clinical practice have been accurately stated.[27,43,52-71] However, more research is needed in order to introduce the KANET as a screening test. Components of KANET and its resulting scores are shown elsewhere.[72]

CONCLUSION

As can be understood from this review, the development of US, especially the 4D technology, has enabled a unique insight into the neurological development of the fetus with the purpose of determining whether this tool could serve as a prenatal diagnostic method to detect prenatal neurological disorders which may result in development of CP. In addition, 4D US may become a method to assess fetal well-being.[9,17] In the last three decades, there were several attempts to create a diagnostic test for evaluation of fetal behavior. The tests were different, but none of them were implemented into daily clinical use.[2-4,73] With a multidisciplinary approach, a prenatal neurologic screening test based on neurological 4D technology was proposed. KANET is the first prenatal neurological test based on the 4D US technique, whose preliminary results are encouraging.[17,70,74-76] Results of numerous studies using KANET are promising and stimulating. However, all researchers involved in the estimation of fetal behavior using KANET agree that further studies in a large population with long-term follow-up are required and it is of utmost importance to continue the long-term follow-up of newborns who obtained borderline or abnormal scores after prenatal KANET assessment.

The development of 4D US has significantly improved the assessment of the quality of fetal movements and enabled a better evaluation of fetal behavior in comparison with 2D US. It is our belief that recent data obtained by 4D sonography are stimulating and might result in a more effective strategy to assess neurodevelopment before birth.

REFERENCES

1. Nijhuis, JG. Fetal behavior: developmental and perinatal aspects. Oxford: Oxford University Press; 1992.
2. Nijhuis JG, Prechtl HF, Martin CB Jr, Bots RS. Are there behavioral states in the human fetus? Early Hum Dev 1982 Apr;6(2):177-195.
3. Horimoto N, Koyanagi T, Maeda H, Satoh S, Takashima T, Minami T, Nakano H. Can brain impairment be detected by in utero behavioural patterns? Arch Dis Child 1993 Jul;69 (1 Spec No):3-8.
4. Prechtl HF, Einspieler C. Is neurological assessment of the fetus possible? Eur J Obstet Gynecol Reprod Biol 1997 Dec;75(1):81-84.
5. Arabin B. Two-dimensional real-time ultrasound in the assessment of fetal activity in single and multiple pregnancies. Ultrasound Rev Obstet Gynecol 2004;4:37.
6. Sepulveda W, Mangiamarchi M. Fetal yawning. Ultrasound Obstet Gynecol 1995 Jan;5(1):57-59.
7. Hata T, Dai SY, Marumo G. Ultrasound for evaluation of fetal neurobehavioral development: from 2-D to 4-D ultrasound. Infant Child Dev 2010;19:99-118.
8. Andonotopo W, Kurjak A. The assessment of fetal behavior of growth restricted fetuses by 4D sonography. J Perinat Med 2006;34(6): 471-478.
9. Kurjak A, Miskovic B, Andonotopo W, Stanojevic M, Azumendi G, Vrcic H. How useful is 3D and 4D ultrasound in perinatal medicine? J Perinat Med 2007;35(1):10-27.
10. Kurjak A, Predojevic M, Stanojevic M, Salihagic-Kadic A, Miskovic B, Badreldeen A, Talic A, Zaputovic S, Honemeyer U. Intrauterine growth restriction and cerebral palsy. Acta Inform Med 2012 Jan;18(2):64-82.
11. Prechtl HF. Qualitative changes of spontaneous movements in fetus and preterm infant are a marker of neurological dysfunction. Early Hum Dev 1990 Sep;23(3):151-158.
12. Einspieler C, Prechtl HF. Prechtl's assessment of general movements: a diagnostic tool for the functional assessment of the young nervous system. Ment Retard Dev Disabil Res Rev 2005;11(1):61-67.
13. Kurjak A, Carrera JM, Andonotopo W, Stanojevic M, Scazzocchio E. The role of 4D sonography in the neurological assessment of early human development. Ultrasound Rev Obstet Gynecol 2004;4:148-152.
14. Rees S, Harding R. Brain development during fetal life: influences of the intra-uterine environment. Neursci Lett 2004 May 6;361(1-3):111-114.
15. Harrison PJ. The neuropathology of schizophrenia. A critical review of the data and their interpretation. Brain 1999 Apr;122(Pt 4):593-624.
16. Kurjak A, Carrera JM, Medic M, Azumendi G, Andonotopo W, Stanojevic M. The antenatal development of fetal behavioral patterns assessed by four-dimensional sonography. J Matern Fetal Neonatal Med 2005 Jun;17(6):401-416.
17. Kurjak A, Miskovic B, Stanojevic M, Amiel-Tison C, Ahmed B, Azumendi G, Vasilj O, Andonotopo W, Turudic T, Salihagic-Kadic A. New scoring system for fetal neurobehavior assessed by three and four-dimensional sonography. J Perinat Med 2008;36(1):73-81.
18. Yigiter AB, Kavak ZN. Normal standards of fetal behavior assessed by four-dimensional sonography. J Matern Fetal Neonatal Med 2006 Nov;19(11):707-721.
19. Amiel-Tison C. Update of the Amiel-Tison neurological assessment for the term neonate or at 40 weeks corrected age. Pediatr Neurol 2002;27:196-212.
20. Kurjak A, Andonotopo W, Hafner T, Salihagic A, Standojevic M, Azumendi G, Ahmed B, Carrera JM, Troyano JM. Normal standards for fetal neuro-behavioral developments: longitudinal quantification by four-dimensional sonography. J Perinat Med 2006;34(1):56-65.
21. Stanojevic M, Kurjak A, Salihagic-Kadic A, Vasilj O, Miskovic B, Shaddad AN, Ahmed B, Tomasović S. Neurobehavioral continuity from fetus to neonate. J Perinat Med 2011 Mar;39(2):171-177.
22. Kuno A, Akiyama M, Yamashiro C, Tanaka H, Yanagihara T, Hata T. Three-dimensional sonographic assessment of fetal behavior in the early second trimester of pregnancy. J Ultrasound Med 2001 Dec;20(12):1271-1275.

23. Hopkins, B.; Prechtl, HF. A qualitative approach to the development of movements during early infancy. In: Prechtl HF, editor. Continuity of neural functions from perinatal to postnatal life. Vol. 94. Oxford: Blackwell Scientific Publications; 1984. pp. 179-197.
24. de Vries JI, Fong BF. Normal fetal motility: an overview. Ultrasound Obstet Gynecol 2006 Jun;27(6):701-711.
25. Andonotopo W, Medic M, Salihagic-Kadic A, Milenkovic D, Maiz N, Scazzocchio E. The assessment of embryonic and fetal neurodevelopment in early pregnancy: comparison between 2D and 4D scanning. J Perinat Med 2005;33(5):406-414.
26. Carrera JM. Fetal ultrasonography: the first 40 years. Ultrasound Rev Obstet Gynecol 2004;4:141-147.
27. De Vries JI, Visser GH, Prechtl HF. The emergence of fetal behavior I. Qualitative aspects. Early Hum Dev 1982;7: 301-322.
28. Kainer F, Prechtl HF, Fngele H, Einspieler C. Assessment of the quality of general movements in fetuses and infants of women with type-I diabetes mellitus. Early Hum Dev 1997 Nov 24;50(1):13-25.
29. Kurjak A, Vecek N, Hafner T, Bozek T, Funduk-Kurjak B, Ujevic B. Prenatal diagnosis: what does four-dimensional ultrasound add? J Perinat Med 2002;30(1):57-62.
30. Craig S, Permezel M, Doyle L, Mildenhall L, Garland S. Perinatal infection with Listeria monocytogenes. Aust N Z J Obstet Gynaecol 1996 Aug;36(3):286-290.
31. Goldstein I, Romero R, Merrill S, Wan M, O'Connor TZ, Mazor M, Hobbins JC. Fetal body and breathing movements as predictors of intra-amniotic infection in preterm premature rupture of membranes. Am J Obstet Gynecol 1988 Aug;159(2):363-368.
32. Hata T, Kanenishi K, Tanaka H, Marumo G, Sasaki M. Four-dimensional evaluation of fetal neurobehavioral development. Donald School J Ultrasound Obstet Gynecol 2010;4(3):233-248.
33. Sparling JW. Wilhelm IJ. Quantitative measurement of fetal movement: Fetal-Posture and Movement Assessment (F-PAM). Phys Occup Ther Pediatr 1993;12:97-114.
34. Andonotopo W, Stanojevic M, Kurjak A, Azumendi G, Carrera JM. Assessment of fetal behavior and general movements by four-dimensional sonography. Ultrasound Rev Obstet Gynecol 2004;4:103-114.
35. Horimoto N, Koyanagi T, Satoh S, Yoshizato T, Nakano H. Fetal eye movement assessed with real-time ultrasonography: are there rapid and slow eye movements? Am J Obstet Gynecol 1990 Nov;163(5 Pt 1):1480-1484.
36. Lee A. Four-dimensional ultrasound in prenatal diagnosis: leading edge in imaging technology. Ultrasound Rev Obstet Gynecol 2001;1:194-198.
37. Kozuma S, Baba K, Okai T, Taketani Y. Dynamic observation of the fetal face by three-dimensional ultrasound. Ultrasound Obstet Gynecol 1999 Apr;13(4):283-284.
38. Campbell S. 4D or not 4D: that is the question. Ultrasound Obstet Gynecol 2002;19:1-4.
39. Kurjak A, Azumendi G, Andonotopo W, Salihagic-Kadic A. Three- and four-dimensional ultrasonography for the structural and functional evaluation of the fetal face. Am J Obstet Gynecol 2007 Jan;196(1):16-28.
40. Prechtl H. Continuity of neural functions from prenatal to postnatal life. Cambridge University Press; 1991.
41. Hadders-Algra M. The neuronal group selection theory: a framework to explain variation in normal motor development. Dev Med Child Neurol 2000 Aug;42(8):566-572.
42. Kurjak A, Aantsaklis P, Stanojevic M. Fetal neurology: past, present and future. Donald School J Ultrasound Obstet Gynecol 2015;9(1):6-29.
43. Kurjak A, Pooh RK, Tikvica A, Stanojevic M, Miskovic B, Ahmed B, Azumendi G. Assessment of fetal neurobehavior by 3D/4D ultrasound. In: Pooh RK and Kurjak A, eds. Fetal Neurology. Jaypee Brothers Medical Publishers, New Delhi 2009, p 221-287.
44. Salihagic-Kadic A, Medic M, Kurjak A. 4D sonography in the assessment of fetal functional neurodevelopment and behavioural paterns. Ultrasound Rev Obstet Gynecol 2005;5(1):1-15.
45. Kurjak A, Pooh RK, Merce LT, Carrera JM, Salihagic-Kadic A, Andonotopo W. Structural and functional early human development assessed by three-dimensional (3D) and four-dimensional (4D) sonography. Fertil Steril 2005;84(5):1285-1299.
46. Kurjak A, Azumendi G, Vecek N, Kupesic S, Solak M, Varga D, Chervenak F. Fetal hand movements and facial expression in normal pregnancy studied by four-dimensional sonography. J Perinat Med 2003;31(6):496-508.
47. Gosselin J, Gahagan S, Amiel-Tison C. The Amiel-Tison neurological assessment at term: conceptual and methodological continuity in the course of follow-up. Ment Retard Dev Disabil Res Rev 2005;11(1):34-51.
48. Amiel-Tison C, Gosselin J, Kurjak A. Neurosonography in the second half of fetal life: a neonatologist's point of view. J Perinat Med 2006;34(6):437-446.
49. Stanojevic M, Kurjak A, Andonotopo W. Assessment of fetal to neonatal behavioral continuity by 4D ultrasonography. Ultrasound Obstet Gynecol 2006;28(3):360.
50. Stanojevic M, Kurjak A. Continuity between fetal and neonatal neurobehavior. Donald School J Ultrasound Obstet Gynecol 2008;2(3):64-75.
51. Filho GH, Júnior AE, Júnior MC, Nardozza LM, Moron AF. Assessment of fetal behavior using four-dimensional ultrasonography: current knowledge and perspectives. Rev Assoc Med Bras 2013;59(5):507-513.
52. Stanojevic M, Talic A, Miškoovic B, Vasilj O, Shaddad AN, Ahmed B, Salihagic-Kadic A, Predojevic M, Vladareanu R, Lebit D, et al. An Attempt to Standardize Kurjak's Antenatal Neurodevelopmental Test: Osaka Consensus Statement. Donald School J Ultrasound Obstet Gynecol 2011 Oct-Dec;5:317-329.
53. Stanojevic M, Antsaklis P, Kadic A, Predojevic M, Vladereau R, Vladenearu S, Neto RM. Is Kurjak antenatal neurodevelopmental test ready for routine clinical application? Bucharest consensus statement. Donald School J Ultrasound Obstet Gynecol 2015;9(3):260-265.
54. Lebit FB, Vladareanu R. The role of 4D ultrasound in the assessment of fetal behavior. Medica 2011 Apr;6(2):120-127.
55. Bellinger SA, Lucas D, Kleven GA. An ecologically relevant guinea pig model of fetal behavior. Behav Brain Res 2015 Apr 15;283:175-183.
56. Luetic AT. First experience in clinical application of KANET. Donald School J Ultrasound Obstet Gynecol 2015;9(1):96-99.
57. Vasilj O. Is in utero fetal neurological assessment comparible to postnatal neurological assessment? Donald School J Ultrasound Obstet Gynecol 2015;9(1):91-95.
58. Tomasovic S, Predojevic M. 4D ultrasound medical devices for recent advances on the etiology of cerebral palsy. Acta Inform Med 2011 Dec;19(4):228-234.
59. Vladareanu R, Lebit D, Constantinescu S. Ultrasound assessment of fetal neurobehavior in high-risk pregnancies. Donald School J Ultrasound Obstet Gynecol 2012 Apr-Jun;6(2):132-147.

60. Honemeyer U, Talic A, Therwat A, Paulose I, Patidar R. The clinical value of KANET test in studying fetal neurobehavior in normal and at-risk pregnancies. J Perinat Med 2013 Mar;41(2):187-197.
61. Kadic AS. Fetal neurology: the role of fetal stress. Donald School J Ultrasound Obstet Gynecol 2015;9(1):30-39.
62. Hata T, Kanenishi J, Hanoka U, Uematsu R, Marumo G, Tanaka H. HDlive study of fetal development and behavior. Donald School J Ultrasound Obstet Gynecol 2014;8(3): 250-265.
63. Reynoso C, Crespo-Eguílaz N, Alcázar JL, Narbona J. Motor behavior of human fetuses during the second trimester of gestation: a longitudinal ultrasound study. An Pediatr (Barc) 2015 Mar;82(3):183-191.
64. Predojević M, Talić A, Stanojević M, Kurjak A, Salihagić Kadić A. Assessment of motoric and hemodynamic parameters in growth restricted fetuses-case study. J Matern Fetal Neonatal Med 2014 Feb;27(3):247-251.
65. Kurjak A, Talic A, Stanojevic M, Honemeyer U, Serra B, Prats P, Di Renzo GC. The study of fetal neurobehavior in twins in all three trimesters of pregnancy. J Matern Fetal Neonatal Med 2013 Aug;26(12):1186-1195.
66. Athanasiadis AP, Mikos T, Tambakoudis GP, Theodoridis TD, Papastergiou M, Assimakopoulos E, Tarlatzis BC. Neurodevelopmental fetal assessment using Kanet scoring system in low and high-risk pregnancies. J Matern Fetal Neonatal Med 2013;26(4):363-368.
67. Kurjak A, Stanojević M, Predojević M, Laušin I, Salihagić-Kadić A. Neurobehavior in fetal life. Semin Fetal Neonatal Med 2012 Dec;17(6):319-323.
68. Hepper PG, Dornan JC, Lynch C, Maguire JF. Alcohol delays the emergence of the fetal elicited startle response, but only transiently. Physiol Behav 2012 Aug 20;107(1):76-81.
69. Talic A, Kurjak A, Stanojevic M, Honemeyer U, Badreldeen A, Direnzo GC. The assessment of fetal brain function in fetuses with ventriculomegaly: the role of the Kanet test. J Matern Fetal Neonatal Med 2012 Aug;25(8):1267-1272.
70. Kurjak A, Honemeyer U, Stanojevic M, Zalud I. Comparison between antenatal neurodevelopmental test and fetal Doppler in the assessment of fetal well-being. J Perinat Med 2013 Jan;41(1):107-114.
71. Neto MR. KANET in Brazil: first experience. Donald School J Ultrasound Obstet Gynecol 2015;9(1):1-5.
72. Morokuma S, Fukushima K, Yumoto Y, Uchimura M, Fujiwara A, Matsumoto M, Satoh S, Nakano H. Simplified ultrasound screening for fetal brain function based on behavioral pattern. Early Hum Dev 2007 Mar;83(3):177-181.
73. Kurjak A, Tikvica Luetic A, Stanojevic M, Talic A, Zalud I, Al-Noobi M, Perva S, Abushama M, Tomasovic S, Zaputovic S, et al. Further experience in the clinical assessment of fetal neurobehavior. Donald School J Ultrasound Obstet Gynecol 2010 Jan-Mar;4(1):59-71.
74. Kurjak A, Abo-Yaqoub S, Stanojevic M, Yigiter AB, Vasilj O, Lebit D, Shaddad AN, Ahmed B, Kavak ZN, Miskovic B, et al. The potential of 4D sonography in the assessment of fetal neurobehavior: multicentric study in high-risk pregnancies. J Perinat Med 2010;38(1):77-82.
75. Miskovic B, Vasilj O, Stanojevic M, Ivankovicc D, Kerner M, Tikvica A. The comparison of fetal behavior in high-risk and normal pregnancies assessed by four-dimensional ultrasound. J Matern Fetal Neonatal Med 2010 Dec;23(12):1461-1467.
76. Kurjak A, Ahmed B, Abo-Yaguab S, Younis M, Saleh H, Shaddad AN, Vasilj O, Al Bahar AJ, Miskovic B, Khenyab N. An attempt to introduce neurological test for fetus based on 3D and 4D sonography. Donald School J Ultrasound Obstet Gynecol 2008;2:29-44.