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REVIEW ARTICLE

Prenatal Beginnings of Temperament Formation—Myth or Reality? Case Study of a Twin Pregnancy

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ABSTRACT

Observation of the fetus *in vivo* by four-dimensional ultrasound provided abundant material for experimental studies of early neurobehavioral development. Consequently, a new scoring system for fetal neurobehavior, KANET, was created as a standardized, practical and reproducible method for qualitative and quantitative analysis of characteristics of fetal movement patterns. The eight parameters of KANET not only allow a differentiated comparison of fetal behavioral states but also enable prenatal diagnosis of abnormal neurological development. The knowledge that individual temperament is expressed by movement patterns is not new. To find answers to the question when temperament formation might begin, we applied KANET simultaneously at different gestational ages to both fetuses of a dichorionic twin pregnancy, and compared the results with temperament evaluation of both neonates 8 weeks postpartum.

Keywords: KANET, 4D ultrasound, Fetal behavior, Fetal temperament.

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INTRODUCTION

Is Fetal Temperament Measurable?

Since the era of ultrasound and, especially after clinical introduction of four-dimensional (4D) sonography, the veil covering fetal life has been pulled away. Obstetricians are now nearly in the same position as neonatologists in regards to analysis of movement patterns. The rapid sequence of novelties in computer technology has given us a noninvasive tool to study embryonic and fetal structural and functional development in detail. High end equipment can transmit three-dimensional images of the embryo/fetus in her/his environment in excellent quality with image frequencies of up to 25 Hz. Sonographic visualization of even nuances of facial expression alterations, literally highlighted by a recently introduced computer-generated virtual 'light-source', has earned the term 'fetoscopic view' due to its realism. The arrival of 4D was bound to inspire researchers to observe embryonal/fetal behavior by means of ultrasound. Given the evidence that prenatal behavior and its changes with advancing pregnancy reflect the maturational progress of the central nervous system (CNS) or in their absence potential neuromorbidity, it was a logical next step to conduct longitudinal studies of fetal movements in pregnancy, to describe and categorize different types of fetal behavior.[1] The Kurjak antenatal neurological evaluation test (KANET) for reproducible quantitative and qualitative assessment of *in utero* neurological function was created.[2]

Naturally, scoring fetuses with KANET raised the question whether scores might already express an individual's behavioral inclination, preference, disposition, reactivity or even temperament. Twin pregnancies offer an ideal biological model to observe first manifestations of individual behavior in two fetuses exposed to a nearly identical environment, except for differences in amniotic fluid volume or placenta territoriality occurring mainly in monochorionic (MC) twins.

Twin Pregnancy as Biological Model for Studies of Temperament Developments

Given the insight that infants come into this world well equipped with many sophisticated competencies, which have been prepared or acquired at some point in prenatal life, and accepting that twins are already born with distinct features and individual characteristics, we would like to examine the occurrence of interindividual behavioral differences of twin fetuses in an identical environment and the possibility of measuring these differences. To deserve the term 'temperament', individual fetal movement patterns, activity and reactivity should be persistent, their measurements reproducible during several assessments, and these features should be carried forward into postnatal life. As prenatal level rod KANET test lends itself to the obstetrician, for evaluation of postnatal behavioral characteristics, a questionnaire can be answered by the mother/father.

CASE REPORT

A 32-year-old European lady with polycystic ovary syndrome had conceived twins after 14 months unfulfilled pregnancy wish, using clomiphen citrate. After uncomplicated 12 weeks and 6 days of gestation, 1st trimester combined nuchal translucency (NT) screening revealed a

dichorionic diamniotic (DC/DA) twin pregnancy. NT was measured with 1.9 and 1.8 mm, screening results showed low risks of 1:6126, 1:6554 for trisomy 21 respectively. 2nd trimester screening at 23 weeks was normal for both fetuses. Fetus A (the leading fetus) was female, fetus B was male. The pregnancy was surveyed in regular intervals of 2 weeks, from 35 weeks onward weekly. In the course of pregnancy, KANET scores including Doppler of middle cerebral artery (MCA) and umbilical artery (UA) were evaluated three times for both twins during appointments at 29/+2, 31/+4 and 34/+6 weeks. Additional repeated ultrasound examinations including Doppler of MCA and UA showed normal wave forms, congruent biometry and similar amniotic fluid volumes.[2] Cardiotokographies with normal evaluation criteria were written at 36/+6 and 37/+5 weeks. Ward admission for elective LSCS followed at 38 weeks 5 days, and LSCS under spinal anesthesia was performed the same day. A female (A) and a male (B) child were delivered as cephalic position with 2 minutes time difference, umbilical artery (UA) pH 7.37 and Apgar 9(1́) 9(5́) minutes (twin A), UA pH 7.4 and Apgar 9(1́) 9(5́) minutes (twin B). Fetus A, the girl, weighed 2750 gm, fetus B, the boy, 2780 gm. Maternal postpartum hemorrhage was controlled with uterotonica and Bakri balloon insertion (Figs 1 and 2). Postnatal neurological examination of the twins by neonatologist was normal for both children. Both children had an uncomplicated neonatal period until a questionnaires about postnatal behavior was answered by the mother 8 weeks postpartum.

Fig. 1: Twin A, girl, 8 weeks postpartum

Fig. 2: Twin B, boy, 8 weeks postpartum

METHODOLOGY

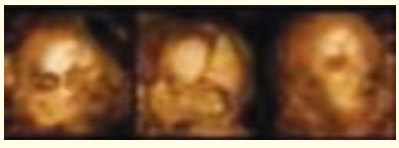
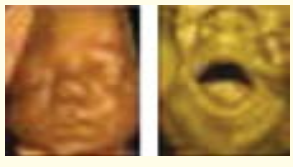
Methodology of Prenatal Assessment of Fetal Behavior: KANET Scoring System

Including the existing knowledge of structural criteria indicating neurological dysfunction, such as head circumference (HC) and overlapping cranial sutures (microcephaly), KANET uses a system of eight fetal structural and behavioral parameters to evaluate the status of fetal neurodevelopment. The score for abnormal fetuses is 0 to 5, borderline score is from 6 to 9, and normal score is 10 and above. The first part of the assessment consists of two-dimensional ultrasound examination (2D US) for the evaluation of fetal position, growth and anatomy followed by Doppler ultrasound of fetal circulation. Elevated umbilical artery Doppler pulsatility index (UA PI) >2 standard deviations above mean for GA and reduced middle cerebral artery pulsatility (MCA PI) index <2 standard deviations below the mean for GA, obtained in absence of the fetal movements are considered abnormal. The UA PI was measured in a free-floating loop of the umbilical cord. Measurements of the MCA PI were performed with color Doppler visualization of the circle of Willis in the fetal brain. Doppler studies were followed by the assessment of fetal behavior applying KANET test using 4D US. The examinations were performed by an experienced operator using the Voluson 730 pro with RAB 4 3D/4D probe. The duration of examinations was between 15 and 20 minutes per fetus. All parameters of the KANET scoring system were evaluated quantitatively and qualitatively, assigning to each parameter scores from 0 to 2. Scores from all parameters were summarized forming total KANET score (Table 1).

Methodology of Postnatal Assessment of Neonate Temperament: Maternal Questionnaire

For postnatal temperament assessment, we used a simplified toddler behavior assessment questionnaire (TBAQ).[3]

Table 1: The KANET scoring system assesses 8 fetal parameters

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

Contd...

Contd...

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

The concept of TBAQ is developed for toddlers at the age of two and had to be customized for the neonate of 8 weeks. On the basis of temperament assessment as described by Keuler et al 2011, we evaluated temperament dimensions, such as negative affect and effortful control, leaving away fear (of objects and social deprivation) as yet dormant temperament dimension.[4]

Positive emotionality (e.g. smiling) is also rarely expressed during the newborn period and therefore not included in the score but is observed more reliably between 2 and 3 months of age.[5]

The negative affect factor, which involves distress reactions, was defined by anger, activity level and soothability. Effortful control signifies the ability of the child to stay interested and allocate attention to relevant activities, such as rooting and sucking. Each of these temperament qualities were evaluated by the mother assigning scores between 0, 1 and 2 to the twins respective attitude. Other than for the KANET test, differentiation in normal, borderline and abnormal was not intended with the temperament score. In fact, the temperament score was meant solely to outline a certain profile of temperament dimensions in the neonate (Table 2).

Table 2: Modified temperament score*

Score	*0*	*1*	*2*
Anger	Never	Moderate	Explosive
Activity level	Low	Moderate	High
Soothability	Difficult	Moderate	Easy
Endurance rooting	Minimal	Moderate	High
Endurance sucking	Minimal	Moderate	High

*At postnatal age of 8 weeks

RESULTS

Prenatal KANET scores

Gestational age	*29 w2d*	*31w4d*	*34w6d*
Twin A KANET score	15	11	14
Twin B KANET score	11	9	9

During all three KANET assessment, twin B had lower scores than twin A (Figs 3 and 4).

Fig. 3: Twin A, girl, at 36 weeks

Fig. 4: Twin B, boy, at 35 weeks

Temperament Score*

Score	*0*	*1*	*2*	*Twin A (girl), 4.5 kg*	*Twin B (boy), 4.9 kg*
Anger	Never	Moderate	Explosive	0	2
Activity level	Low	Moderate	High	1	1
Soothability	Difficult	Moderate	Easy	2	0
Endurance					
Rooting	Minimal	Moderate	High	2	1
Sucking	Minimal	Moderate	High	2	1
Score result				7	5

*At postnatal age of 8 weeks

Negative affect factor, which involves distress reactions, and effortful control to stay interested and allocate attention (to rooting and sucking), was observed to be different in the twins during the first 8 weeks of postnatal life.

DISCUSSION

After fetal life and its visualization by 3D/4D ultrasound was evaluated and described in detail during the last decade, it has become generally accepted that neonatal capabilities and characteristics have their prenatal history in fetal pre-competencies. We now speak of the continuity of prenatal and postnatal development. Interest in the study of infant temperament has grown steadily during recent years, as early individual differences have been increasingly related to later personality and social development.[5] Temperament is defined as constitutionally based individual differences in reactivity and self-regulation, of an individual with relatively enduring biological make-up, influenced by heredity, maturation and experience. The term reactivity mentioned in this definition, refers to the arousability of emotional, motor and attentional responses. The term self-regulation refers to processes, such as attention, which can serve to modulate reactivity.[6]

The features of fetal neurobehavioral activity provide the basis for observational studies of individual differences in twins' activity *in utero*. But, when does temperament formation begin? According to Degani et al (2009), differences in activity in early pregnancy emerge even before distinct fetal behavioral patterns and are followed by temperamental differences postnatally.[7]

In twins, formation of temperament may be influenced by genetic factors, by shared environmental factors and by unique environmental factors. For instance, the unequally shared intrauterine environment in monozygotic twins might contribute to put each monozygotic twin on a progressively distinct behavioral path.[8,9] In the presented case of a dichorionic pregnancy, fetal environment provides equal conditions for both twins leaving aside the different gender of the fetuses. Prenatal repeated KANET scores are consistently lower for twin B, from as early as 29 weeks 1 day onward. The postnatal temperament score demonstrates equally differences between twin A and B, outlining a different temperamental profile for each twin. It is therefore likely that temperament formation is primarily initiated by constitutional factors, and modulation of these primary settings may be caused by superimposed environmental factors later on. Since fetal behavior seems to expresses not only neurological function, but as well fetal temperament, KANET test might be used as a tool to assess qualities of fetal temperament. Temperamental continuity from fetal to postnatal life could be assessed by modified TBAQ test.

CONCLUSION

The presented case of dichorionic twins illustrates the early endogenous origin of differences in temperament, since both fetuses were pre- and postnatally exposed to the same external factors. Intrauterine temperamental qualities were visible at 29 weeks and carried forward into the neonatal period, demonstrating ever again the basic principle of continuity of pre- and postnatal life. The authors consider the presented material as encouragement for further studies with representative case numbers to understand timelines and differentiation of fetal/postnatal temperament formation.

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