

*Donald School*  
Textbook of  
**Ultrasound in  
Obstetrics &  
Gynecology**

**5<sup>th</sup>**  
Edition

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## SECTION 1: General Aspects

|  |           |
|--|-----------|
| <b>1. Safety of Ultrasound in Obstetrics and Gynecology</b> .....                                  | <b>3</b>  |
| <i>Kazuo Maeda</i>   |           |
| • Diagnostic Ultrasound Devices and Ultrasound Intensity   | 3         |
| • Non-Hazardous Exposure Time of the Fetus to the Heat   | 4         |
| • Diagnostic Ultrasound Instruments and Ultrasound Intensity                                       | 4         |
| • Ultrasound Intensity of Doppler Ultrasound   | 4         |
| • The Effect of Direct Heating on Mammal Fetuses   | 5         |
| • The Ultrasound Intensity of No Bioeffect   | 5         |
| • "Alara" Principle  | 5         |
| • Absolute Temperature of the Tissue Exposed to Ultrasound   | 5         |
| • Thermal and Mechanical Safeties of Diagnostic Ultrasound by using Thermal and Mechanical Indices | 5         |
| • Thermal Safety of Ultrasound   | 6         |
| • Mechanical Index of Ultrasound   | 7         |
| • Safety of Diagnostic Ultrasound Devices  | 7         |
| • Nonmedical Use of Diagnostic Ultrasound  | 8         |
| • Safe Level of Ultrasound Intensity   | 8         |
| <b>2. Development of Three-dimensional Ultrasound</b> .....  | <b>10</b> |
| <i>Kazunori Baba</i>   |           |
| • What Can 3D Ultrasound Do?   | 10        |
| • Technical Aspects of 3D Ultrasound   | 11        |
| • Practical Tips   | 21        |
| <b>3. Artifacts, Pitfalls and Normal Variants</b> .....  | <b>26</b> |
| <i>Ivica Zalud, Frederico Rocha</i>  |           |
| • Definition   | 26        |
| • Mechanism  | 26        |
| • Classification   | 26        |
| • Reverberation  | 27        |
| • Shadowing  | 27        |
| • Enhancement  | 29        |
| • Mirror Artifacts   | 29        |
| • Refraction (Duplication) and Side Lobes  | 30        |
| • Other Artifacts  | 30        |
| • Doppler Ultrasound Artifacts   | 30        |
| • 3D Ultrasound Artifacts  | 33        |
| <b>4. Routine Use of Obstetric Ultrasound</b> .....  | <b>35</b> |
| <i>Geeta Sharma, Stephen T Chasen, Frank A Chervenak</i>   |           |
| • Basic Ultrasound   | 35        |
| • Safety   | 36        |
| • Guidelines for the Use of Obstetric Ultrasound   | 37        |
| • Randomized Controlled Trials of Routine Ultrasound   | 37        |
| • Critique of Radius Trial   | 44        |
| • Meta-Analyses of Randomized Controlled Trials  | 44        |
| • Diagnostic Ability of Routine Ultrasound   | 45        |
| • First Trimester Ultrasonography  | 49        |
| • Ethical Dimensions   | 50        |

## 5. **Medicolegal Issues in Obstetric and Gynecologic Ultrasound**..... 56

*Frank A Chervenak, Judith L Chervenak*

- Medical Negligence 56
- Guidelines 56
- Instrumentation and Safety 57
- Documentation 57
- Indications 57
- Examination Content 58
- Quality Control 58
- Litigation Related to Ultrasound 59
- Nonmedical Use of Ultrasonography 60

## SECTION 2: Obstetrics

## 6. **Fetal and Maternal Physiology and Ultrasound Diagnosis** ..... 63

*Aida Salihagic Kadic, Maja Predojevic, Asim Kurjak*

- Placenta 63
- Development of the Placenta 63
- Abnormal Placental Development and Ultrasound 65
- Functions of the Placenta 67

## 7. **HDlive Silhouette and HDlive Flow: New Application of 3D Ultrasound in Prenatal Diagnosis** ..... 93

*Ritsuko K Pooh*

- HDlive (High Definition Live) Technique 93
- HDlive Flow Imaging Technology 102

## 8. **Normal and Abnormal Early Pregnancy** ..... 112

*Tamara Illescas, Waldo Sepulveda*

- Intrauterine Pregnancy of Unknown Viability 113
- Normal Early Pregnancy 113
- Abnormal Early Pregnancy 120
- Diagnostic Ultrasound Criteria for Early Pregnancy Loss 122
- Ultrasound High-Risk Indicators for Early Pregnancy Loss 123

## 9. **Ectopic Pregnancy: Diagnosing and Treating the Challenge** ..... 127

*Sanja Kupesic Plavsic, Sonal Panchal, Ulrich Honemeyer*

- The Role of Biochemical Markers in Ectopic Pregnancy 128
- The Role of Ultrasound in the Diagnosis of an Ectopic Pregnancy 128
- Other Sites of Implantation 137
- Therapy 145

## 10. **Sonographic Determination of Gestational Age**..... 151

*Robin B Kalish, Frank A Chervenak*

- Assessment of Gestational Age by Last Menstrual Period 151
- Multifetal Pregnancies 155
- Choosing a Due Date 155
- Ultrasound Pitfalls 156

## 11. **Trophoblastic Diseases**..... 159

*Kazuo Maeda, Asim Kurjak*

- Classification, Development and Pathology 159
- Complete Hydatidiform Mole 159
- Partial Hydatidiform Mole 160

- Invasive Hydatidiform Mole 160
- Choriocarcinoma 160
- Placental Site Trophoblastic Tumor 162
- Epithelioid Trophoblastic Tumor 162
- Persistent Trophoblastic Disease 162
- Symptoms of Gestational Trophoblastic Disease 162
- Diagnosis of Gestational Trophoblastic Disease 163
- Therapy of Trophoblastic Diseases 170

## **12. First-trimester Ultrasound Screening for Fetal Anomalies and Adverse Pregnancy Outcomes .....176**

*Jon Hyett, Jiri Sonek*

- An Argument For Screening in the First Trimester 177
- Elements of First-Trimester Fetal Screening 178
- Quality Assurance in First-Trimester Ultrasound 188
- Screening Multiple Pregnancies for Down Syndrome 190
- First-Trimester Screening for Fetal Anomalies Other than Chromosomal Defects 191

## **13. Fetal Biometry.....203**

*Frederico Rocha, Ivica Zalud*

- First-Trimester Measurements 203
- Second-trimester Measurements 205

## **14. Doppler Ultrasound: State of the Art .....210**

*William Goh, Ivica Zalud*

- Pulsed Doppler Ultrasound in Maternal Fetal Medicine 210
- Color and Power Doppler Imaging 213
- Doppler Ultrasound in Three-dimensions 214

## **15. Guidelines for the Doppler Assessment of the Umbilical and Middle Cerebral Arteries in Obstetrics .....219**

*Autumn Broady, Ivica Zalud*

- Umbilical Artery 219

## **16. Ultrasound and Doppler Management of Intrauterine Growth Restriction .....223**

*José M Carrera, Francesc Figueras, Eva Meler Barrabés*

- Definitions 223
- Classification 223
- Incidence 224
- Screening 224
- Diagnosis 224
- Diagnosis of the Type of SGA 227
- Study of Fetal Deterioration 228
- Obstetric Management 231

## **17. Fetal Central Nervous System .....236**

*Ritsuko K Pooh*

- Transvaginal Neurosonography 236
- Basic Anatomical Knowledge of the Brain 236
- Transvaginal 3D Sonographic Assessment of Fetal CNS 237
- New Application of HDlive Silhouette and Flow in Fetal Neurology 244
- 3D/4D sonography and MRI: Alternatives or Complementaries 245
- Ventriculomegaly and Hydrocephalus 249
- Congenital CNS Anomalies 256
- Acquired Brain Abnormalities in Utero 277
- Future Aspects 283

|  |            |
|--|------------|
| <b>18. Corpus Callosum and Three-dimensional Ultrasound.....</b>   | <b>288</b> |
| <i>Sonila Pashaj, Eberhard Merz</i>  |            |
| <ul style="list-style-type: none"> <li>• Three-Dimensional over Two-dimensional Sonography in the Demonstration of the Corpus Callosum 288</li> <li>• Demonstration of the Normal Development of the Corpus Callosum using 3D Ultrasonography 291</li> <li>• Biometry of the Fetal Corpus Callosum by Three-dimensional Ultrasound 293</li> <li>• Detection of Fetal Corpus Callosum Abnormalities By Means of 3D Ultrasound 294</li> <li>• Discussion 296</li> </ul>  |            |
| <b>19. Detection of Limb Malformations: Role of 3D/4D Ultrasound.....</b>  | <b>302</b> |
| <i>Eberhard Merz</i>   |            |
| <ul style="list-style-type: none"> <li>• Incidence of Limb Anomalies 302</li> <li>• Etiology 302</li> <li>• 3D Ultrasound Appearance of the Limbs/Fetal Skeleton 302</li> <li>• 4D Ultrasound Appearance of the Limbs/Fetal Skeleton 304</li> <li>• Transvaginal/Transabdominal Ultrasound Examination of the Limbs/Fetal Skeleton 304</li> <li>• General Aspects of the Sonographic Detection of Limb Malformations 305</li> </ul>  |            |
| <b>20. The Fetal Thorax.....</b>   | <b>313</b> |
| <i>Aleksandar Ljubic, Tatjana Bozanovic</i>  |            |
| <ul style="list-style-type: none"> <li>• Developmental Anatomy and Ultrasonographic Correlations 313</li> <li>• Scanning Techniques 315</li> <li>• Pathology 315</li> <li>• Cystic Adenomatoid Malformation 319</li> <li>• Fetal Hydrothorax 321</li> <li>• Fetal Pleural Effusions 321</li> <li>• Lung Sequestration/Pulmonary Sequestration 324</li> <li>• Congenital Cystic Lung Lesions 326</li> </ul>   |            |
| <b>21. Three-dimensional and Four-dimensional Evaluation of the Fetal Heart .....</b>  | <b>329</b> |
| <i>Carmen Comas Gabriel</i>  |            |
| <ul style="list-style-type: none"> <li>• Impact of Congenital Heart Diseases: Epidemiology and Population at Risk 329</li> <li>• Prenatal Diagnosis of Congenital Heart Diseases: Current Situation 330</li> <li>• History of Fetal Echocardiography 331</li> <li>• New Perspectives in Three- and Four-dimensional Fetal Echocardiography 332</li> <li>• Clinical Application of 3D or 4D in Fetal Cardiovascular System 334</li> <li>• Spatiotemporal Imaging Correlation: A New Approach to Three- and Four-dimensional Evaluation of the Fetal Heart 335</li> <li>• Technical Bases 335</li> <li>• Advantages 338</li> <li>• Limitations 340</li> <li>• Current Applications and New Perspectives 341</li> <li>• First Spanish Study in Spatiotemporal Image Correlation Technology 346</li> </ul> |            |
| <b>22. Spatial and Temporal Image Correlation and Other Volume Ultrasound Techniques in the Fetal Heart Evaluation After 10 Years of Practice .....</b>  | <b>352</b> |
| <i>Marcin Wiechec, Agnieszka Nocun</i>   |            |
| <ul style="list-style-type: none"> <li>• Technical Aspects 352</li> <li>• The Process of STIC Acquisition 354</li> <li>• STIC in the First Trimester 370</li> <li>• Three-dimensional Printing 372</li> </ul>  |            |
| <b>23. Malformations of the Gastrointestinal System .....</b>  | <b>378</b> |
| <i>Vincenzo D'Addario, Grazia Volpe</i>  |            |
| <ul style="list-style-type: none"> <li>• Anterior Abdominal Wall Defects 380</li> <li>• Bowel Disorders 386</li> <li>• Nonbowel Cystic Masses 391</li> </ul>   |            |

|  |            |
|--|------------|
| <b>24. Fetal Neck Pathology</b> .....  | <b>394</b> |
| <i>Radu Vlădăreanu, Costin Berceanu</i>  |            |
| • Embryology   | 394        |
| • Neck Anomalies   | 395        |
| <b>25. Diagnostic Sonography of Fetal Urinary Tract Anomalies</b> .....                    | <b>419</b> |
| <i>Zoltán Tóth, Zoltán Papp</i>  |            |
| • Ultrasound Imaging of Normal Fetal Kidneys and Urinary Tract                             | 420        |
| • Renal Agenesis   | 422        |
| • Cystic Renal Dysplasia   | 423        |
| • Obstructive Uropathy   | 425        |
| • Renal Tumors   | 431        |
| • Determination of Fetal Renal Function  | 432        |
| • Treatment of Prenatally Diagnosed Renal and Urinary Tract Anomalies                      | 433        |
| <b>26. Fetal Musculoskeletal System</b> .....  | <b>436</b> |
| <i>Anna Maroto, Carlota Rodó, Elena Carreras</i>   |            |
| • Normal Ultrasound Appearance of Fetal Skeleton   | 436        |
| • Osteochondrodysplasias   | 438        |
| • Osteogenesis Imperfecta  | 445        |
| • Achondroplasia   | 446        |
| • Achondrogenesis  | 448        |
| • Campomelic Dysplasia   | 450        |
| • Spondylothoracic Dysplasia (Jarcho–Levin Syndrome)                                       | 450        |
| • Atelosteogenesis   | 451        |
| • Other Osteochondrodysplasias   | 451        |
| • Reductional Defects  | 451        |
| • Transverse Terminal Defects  | 452        |
| • Constriction Band Sequence   | 452        |
| • Phocomelia   | 453        |
| • Proximal Femoral Focal Deficiency  | 453        |
| • Split-Hand and Split-Foot Malformation (Ectrodactyly)                                    | 454        |
| • Hand and Foot Deformities  | 455        |
| • Polydactyly  | 458        |
| • Syndactyly   | 462        |
| • Hemivertebrae  | 466        |
| • Fetal Akinesia Deformation Sequence  | 466        |
| • Other Skeletal Defects   | 468        |
| <b>27. Sonographic Assessment of the Umbilical Cord</b> .....                              | <b>472</b> |
| <i>Edoardo Di Naro, Luigi Raio, Antonella Cromi, Alessandra Giocolano</i>                  |            |
| • Morphology   | 472        |
| • “Lean” Umbilical Cord  | 473        |
| • Large Umbilical Cord   | 473        |
| • Discordant Umbilical Artery  | 474        |
| • Single Umbilical Artery  | 476        |
| • Umbilical Cord Angioarchitecture   | 477        |
| • Umbilical Cord and Aneuploidies  | 480        |
| <b>28. Placenta: From Basic Facts to Highly Sophisticated Placenta Accreta Story</b> ..... | <b>483</b> |
| <i>Giuseppe Cali, Gabriella Minneci</i>  |            |
| • Anatomopathological Aspects of Placenta  | 483        |
| • Diagnosis of Placenta Accreta Spectrum   | 491        |
| <b>29. Measurement of Cervical Length</b> .....  | <b>505</b> |
| <i>Oliver Vasilj, Berivoj Miskovic</i>   |            |
| • General Facts About Uterine Cervix   | 505        |

|  |            |
|--|------------|
| <b>30. Monochorionicity: Unveiling the Black Box .....</b>   | <b>511</b> |
| <i>Alexandra Matias, Miguel Pereira-Macedo, Nuno Montenegro</i>  |            |
| <ul style="list-style-type: none"> <li>• The Monozygosity Phenomenon 511</li> <li>• Monochorionic Pregnancy as a High-risk Pregnancy: Twin-to-twin Transfusion Syndrome as a Paradigm to Treat 520</li> <li>• Discordance of Fetal Growth: What is Adaptation, Promotion, and Growth Restriction in Multiples? 525</li> <li>• Multiples and Cerebral Palsy: The Effect of Prematurity or More? 527</li> </ul>  |            |
| <b>31. Ultrasonography and Birth Defects .....</b>   | <b>533</b> |
| <i>Narendra Malhotra, Neharika Malhotra Bora, Jaideep Malhotra</i>   |            |
| <ul style="list-style-type: none"> <li>• Causes 535</li> <li>• Screening Methods and Tests 536</li> <li>• Ultrasound for Chromosomal Abnormalities and Congenital Defects 537</li> <li>• Trisomy 13 (Patau Syndrome) 541</li> <li>• Triploidy 541</li> <li>• Turner Syndrome 541</li> <li>• Trisomy 18 (Edwards Syndrome) 541</li> <li>• Neural Tube Defects 542</li> <li>• Role of Fetal Echocardiography in First and Second Trimester 545</li> <li>• Early Fetal Cardiac Screening 546</li> <li>• Ultrasonography for Extra Fetal Evaluation 546</li> <li>• Ultrasonography for Fetal Morphology Evaluation 550</li> <li>• Frequently Asked Questions about Ultrasound 552</li> </ul> |            |
| <b>32. Postpartum Ultrasound.....</b>  | <b>556</b> |
| <i>Ajlana Mulic-Lutvica</i>  |            |
| <ul style="list-style-type: none"> <li>• Normal Puerperium 556</li> <li>• Retained Placental Tissue 560</li> <li>• Postpartum Endometritis 566</li> <li>• Cesarean Section 567</li> <li>• Uncommon but Potentially Life-threatening Causes of Postpartum Bleeding 568</li> <li>• Placenta Accreta/Increta/Percreta 568</li> <li>• Pregnancy Luteomas 570</li> <li>• Congenital Uterine Malformations 570</li> <li>• Postpartum Urinary Retention 570</li> <li>• Puerperal Mastitis and Breast Abscess 571</li> </ul>   |            |
| <b>33. Three-dimensional Sonoembryology .....</b>  | <b>578</b> |
| <i>Ritsuko K Pooh, Kohei Shiota, Asim Kurjak</i>   |            |
| <ul style="list-style-type: none"> <li>• Modern Embryology by Magnetic Resonance Microscopy and Computer Graphics 578</li> <li>• Normal Embryo Visualization by Three-dimensional Sonoembryology 580</li> <li>• Fetal Abnormalities in Early Gestation 588</li> </ul>  |            |
| <b>34. Three-dimensional Ultrasound in the Visualization of Fetal Anatomy<br/>in the Three Trimesters of Pregnancy.....</b>  | <b>616</b> |
| <i>Giovanni Centini, Lucia Rosignoli</i>   |            |
| <ul style="list-style-type: none"> <li>• First Trimester of Pregnancy 618</li> <li>• Signs Predictive of Aneuploidy and Structural Embryo–fetal Alterations in the First Trimester 636</li> <li>• Second and Third Trimesters 643</li> </ul>   |            |
| <b>35. Three-dimensional Ultrasound in Detection of Fetal Anomalies .....</b>  | <b>675</b> |
| <i>Ritsuko K Pooh, Asim Kurjak</i>   |            |
| <ul style="list-style-type: none"> <li>• Prenatal Diagnosis of Anatomical Congenital Anomales 677</li> </ul>   |            |
| <b>36. Fetal Behavior Assessed by Four-dimensional Sonography .....</b>  | <b>708</b> |
| <i>Asim Kurjak, Panagiotis Antsaklis, Milan Stanojevic</i>   |            |
| <ul style="list-style-type: none"> <li>• The Evolution of Fetal Movements and Fetal Behavior Assessment with Ultrasound 708</li> <li>• Kurjak Antenatal Neurodevelopmental Test: The Assessment of Fetal Neurobehavior in the 21st Century 710</li> <li>• Neonatal Aspects of Fetal Behavior 726</li> </ul>  |            |

|   |            |
|---|------------|
| <b>37. Fetal Brain Function and Artificial Intelligence .....</b> | <b>732</b> |
| <i>Yasunari Miyagi, Toshiyuki Hata, Takahito Miyake</i>           |            |
| • Fetal Facial Expressions Recognized by Artificial Intelligence  | 732        |
| • Discrete Fourier Transform and Chaotic Dimension Analysis       | 734        |
| • The Free-energy Principle                                       | 735        |
| <b>38. Ultrasound-guided Fetal Invasive Procedures .....</b>      | <b>741</b> |
| <i>George A Partsinevelos, Aris J Antsaklis</i>                   |            |
| • Celocentesis  | 741        |
| • Embryoscopy and Fetoscopy                                       | 742        |
| • Multifetal Pregnancy Reduction and Selective Termination        | 745        |
| • Twin-to-twin Transfusion Syndrome                               | 747        |
| • Fetal Biopsy Procedures in Prenatal Diagnosis                   | 750        |
| • Congenital Diaphragmatic Hernia                                 | 751        |
| • Fetal Pleural Effusion  | 752        |
| • Fetal Lower Urinary Tract Obstruction                           | 753        |
| • Interventional Fetal Cardiology                                 | 754        |
| <b>39. Chorionic Villus Sampling .....</b>                        | <b>761</b> |
| <i>Ulla Marton, Asim Kurjak, Milan Stanojević</i>                 |            |
| • Contraindications for the Chorionic Villus Sampling             | 762        |
| • Technical Aspects of the Procedure                              | 762        |
| • Complications and Fetal Loss Risk                               | 764        |
| • Multiple Pregnancy  | 766        |
| <b>40. Amniocentesis and Fetal Blood Sampling .....</b>           | <b>769</b> |
| <i>Aris J Antsaklis, George A Partsinevelos</i>                   |            |
| • Amniocentesis   | 769        |
| • Indications   | 769        |
| • Fetal Blood Sampling  | 773        |
| <b>41. Invasive Genetic Studies in Multiple Pregnancy .....</b>   | <b>778</b> |
| <i>Aris J Antsaklis, George A Partsinevelos</i>                   |            |
| • Incidence of Structural Fetal Anomalies in Multiples            | 778        |
| • Risk of Aneuploidy in Multiples                                 | 779        |
| • Indications for Prenatal Diagnosis                              | 780        |
| • Invasive Procedures for Prenatal Diagnosis                      | 780        |
| • Fetal Blood Sampling  | 783        |
| <b>42. Overview of Fetal Therapy .....</b>                        | <b>786</b> |
| <i>Tuangsit Wataganara</i>  |            |
| • History of Fetal Therapy  | 786        |
| • Fetal Therapy Segment   | 789        |
| • Principles of Family Counseling for Fetal Therapy               | 789        |
| • Principles and Types of Fetal Therapy                           | 789        |
| • Ethics of Fetal Therapy   | 790        |
| <b>43. In-utero Pharmacologic Treatment .....</b>                 | <b>793</b> |
| <i>Tuangsit Wataganara</i>  |            |
| • Principles and Types of In-utero Pharmacologic Treatment        | 793        |
| • Fetal Congenital Pulmonary Airway Malformations                 | 795        |
| • Fetal Arrhythmias   | 795        |
| • Fetal Thyroid Diseases  | 797        |

|  |            |
|--|------------|
| <b>44. Ultrasound-guided Fetal Intervention.....</b>                                     | <b>801</b> |
| <i>Tuangsit Wataganara</i>   |            |
| • Rationale of Ultrasound-guided Fetal Intervention                                      | 801        |
| • Fetal Paracentesis   | 802        |
| • Fetal Shunting Procedures  | 804        |
| • Percutaneous Sclerotherapy (and Pleurodesis)   | 806        |
| <b>45. In-utero Stem Cell Transplantation and Gene Therapy.....</b>                      | <b>811</b> |
| <i>Tuangsit Wataganara</i>   |            |
| • History of In-utero Stem Cell Transplantation  | 811        |
| • Rationale For In-utero Stem Cell Transplantation                                       | 812        |
| • Human Experiences of In-utero Stem Cell Transplantation                                | 812        |
| • History of In-utero Gene Therapy   | 815        |
| • Rationale for In-utero Gene Therapy  | 816        |
| • Application of In-utero Gene Therapy   | 816        |
| • Risks of In-utero Gene Therapy   | 816        |
| <b>46. Fetoscopic Interventions.....</b>   | <b>820</b> |
| <i>Tuangsit Wataganara</i>   |            |
| • Principles of Fetoscopy  | 820        |
| • Equipments and Techniques  | 821        |
| • Complicated Monochorionic Twins  | 822        |
| • Severe Congenital Diaphragmatic Hernia   | 829        |
| • Lower Urinary Tract Obstruction  | 834        |
| <b>47. Open Fetal Surgery .....</b>  | <b>845</b> |
| <i>Tuangsit Wataganara</i>   |            |
| • Rationale of Open Fetal Surgery  | 845        |
| • Technical Aspects of Open Fetal Surgery  | 845        |
| • Fetal Meningocele  | 846        |
| • Fetal Tumor  | 851        |
| • Congenital Pulmonary Airway Malformation   | 861        |
| <b>48. Establishment of Fetal Therapy Center .....</b>                                   | <b>863</b> |
| <i>Tuangsit Wataganara</i>   |            |
| • Training Requirements  | 863        |
| • Definition of Fetal Therapy Center   | 866        |
| • Counseling Service at Fetal Therapy Centers  | 867        |
| • Personnel Requirements to Set up Fetal Therapy Center                                  | 867        |
| • Maintenance of the Expertise   | 868        |
| • Quality Assurance of Fetal Therapy Center  | 869        |
| • Importance of the Follow-up Data   | 870        |
| • Extrinsic Factors that can Affect the Performance of Fetal Therapy Program             | 870        |
| <b>49. Fetal Face and Four-dimensional Ultrasound .....</b>                              | <b>873</b> |
| <i>Mohamed Ahmed Mostafa AboEllail, Toshiyuki Hata</i>                                   |            |
| • Fetal Face Examination   | 873        |
| • Timing of Four-dimensional Ultrasound Visualization of Facial Movements                | 874        |
| • Different Patterns of Fetal Facial Movements Visualized by Four-dimensional Ultrasound | 874        |
| • Four-Dimensional Ultrasound and Fetal Emotion-Like Movements                           | 876        |
| • Four-Dimensional Ultrasound of Fetal Face and Kurjak's Antenatal Neurodevelopment Test | 877        |
| • Fetal Observable Movement System and Four-dimensional Ultrasound                       | 878        |
| • Hdlive of Fetal Face   | 879        |
| • Limitations of Four-Dimensional Ultrasound Use in Fetal Face Examination               | 879        |

**50. Three-dimensional Ultrasound for the Detection of Fetal Syndromes .....883***Sonila Pashaj, Eberhard Merz*

- Apert Syndrome 884
- Holt–Oram Syndrome 885
- Walker–Warburg Syndrome 886
- Van der Woude Syndrome 886
- Goldenhar Syndrome 887
- De Grouchy Syndrome 888
- Amniotic Band Syndrome 888
- Nager Syndrome 889
- Treacher-Collins Syndrome 890
- Trisomy 21 (Down Syndrome) 890
- Trisomy 13 (Patau Syndrome) 892
- Trisomy 18 (Edwards Syndrome) 893

**51. Ultrasound Role in Perinatal Infection.....901***Alaa Ebrashy*

- Ultrasound Features in Congenital Infection 901
- What is the Role of Invasive Procedures in the Diagnosis of Intrauterine Infection? 903
- Prenatal Management of Specific Congenital Infections using Ultrasound Markers and Invasive Procedures 904
- Toxoplasma 905

**SECTION 3: Gynecology****52. Normal Female Reproductive Anatomy.....913***Sanja Kupesic Plavsic, Ulrich Honemeyer, Asim Kurjak*

- Uterus 913
- Fallopian Tube 917
- Ovaries 917

**53. Uterine Lesions: Advances in Ultrasound Diagnosis .....925***Sanja Kupesic Plavsic, Ulrich Honemeyer, Asim Kurjak*

- Normal Uterus 926
- Endometrial Polyps 927
- Intrauterine Synechiae (Adhesions) 930
- Adenomyosis 931
- Endometrial Hyperplasia 932
- Endometrial Carcinoma 933
- Leiomyoma 938
- Leiomyosarcoma 942
- Advances In Ultrasound Imaging 945

**54. Uterine Fibroid .....948***Aleksandar Ljubic, Tatjana Bozanovic*

- Elastography 951
- Treatment 955
- Uterine Fibroid and Pregnancy 959
- Fibroids and Sterility 961
- Fibroid-like Conditions 961

**55. Three-dimensional Static Ultrasound and Three-dimensional Power Doppler in Gynecologic Pelvic Tumors .....965***Juan Luis Alcázar*

- Endometrial Cancer 965
- Uterine Leiomyomas and Sarcomas 970

- Cervical Cancer 971
- Adnexal Tumors 972
- Other Applications 976

|   |             |
|---|-------------|
| <b>56. Ultrasound in Human Reproduction .....</b>   | <b>981</b>  |
| <i>Veljko Vlasisavljevic, Jure Knez</i>   |             |
| <ul style="list-style-type: none"> <li>• Folliculogenesis 981</li> <li>• Ultrasound and Follicular Growth 982</li> <li>• Ultrasound and Ovulation 983</li> <li>• Ultrasound as the Tool for Prediction of Success and for Monitoring in Medically Assisted Reproduction 985</li> <li>• Ultrasound Monitoring in Unstimulated Cycles 987</li> <li>• The Role of Sonographic Evaluation of the Endometrium 987</li> </ul> |             |
| <b>57. New Insights into the Fallopian Tube Ultrasound .....</b>  | <b>993</b>  |
| <i>Sanja Kupesic Plavsic, Ulrich Honemeyer, Asim Kurjak</i>   |             |
| <ul style="list-style-type: none"> <li>• Pelvic Inflammatory Disease 993</li> <li>• Benign Tumors of the Fallopian Tube 1002</li> <li>• Malignant Tumors of the Fallopian Tube 1003</li> <li>• Fallopian Tube Torsion 1006</li> </ul>   |             |
| <b>58. Sonographic Imaging in Infertility .....</b>   | <b>1009</b> |
| <i>Sanja Kupesic Plavsic, Sonal Panchal</i>   |             |
| <ul style="list-style-type: none"> <li>• Uterine Causes of Infertility 1009</li> <li>• Ovarian Causes of Infertility 1024</li> <li>• Polycystic Ovarian Syndrome 1028</li> </ul>  |             |
| <b>59. Two-dimensional and Three-dimensional Saline Infusion Sonography and Hystero-contrast-salpingography .....</b>   | <b>1045</b> |
| <i>Sanja Kupesic Plavsic, Sonal Panchal</i>   |             |
| <ul style="list-style-type: none"> <li>• Ultrasound Assessment of the Uterus and the Fallopian Tubes 1046</li> <li>• 3D and 4D Hy-Co-Sy with Automated Coded Contrast Imaging and Sonovue 1058</li> </ul>   |             |
| <b>60. Guided Procedures using Transvaginal Sonography .....</b>  | <b>1063</b> |
| <i>Sanja Kupesic Plavsic, Sonal Panchal</i>   |             |
| <ul style="list-style-type: none"> <li>• Transvaginal Puncture Procedures 1063</li> <li>• Conservative Management of an Ectopic Pregnancy 1070</li> <li>• Other Applications 1072</li> </ul>  |             |
| <b>61. Ultrasound in the Postmenopause .....</b>  | <b>1075</b> |
| <i>Sonal Panchal, Biserka Funduk Kurjak</i>   |             |
| <ul style="list-style-type: none"> <li>• Challenges of the Postmenopause 1075</li> <li>• Instrumentation 1076</li> <li>• Scanning in the Postmenopause 1076</li> <li>• Postmenopausal Ovary 1078</li> <li>• The Postmenopausal Uterus 1084</li> <li>• Postmenopausal Endometrium 1089</li> </ul>  |             |
| <b>62. The Use of Ultrasound as an Adjunct to the Physical Examination for the Evaluation of Gynecologic and Obstetric Causes of Acute Pelvic Pain .....</b>  | <b>1098</b> |
| <i>Sanja Kupesic Plavsic, Ulrich Honemeyer</i>  |             |
| <ul style="list-style-type: none"> <li>• Gynecologic Etiologies of Acute Pelvic Pain 1098</li> </ul>  |             |
| <b>63. Ultrasound in Urogynecology .....</b>  | <b>1116</b> |
| <i>Ashok Khurana</i>  |             |
| <ul style="list-style-type: none"> <li>• Clinical Considerations 1116</li> <li>• Investigations 1116</li> <li>• Technical Concepts, Protocols, Norms and Ultrasound Findings 1117</li> </ul>  |             |

|   |             |
|---|-------------|
| <b>64. Three/Four-dimensional, Vocal, HDlive and Silhouette Ultrasound in Obstetrics, Reproduction and Gynecology .....</b> | <b>1129</b> |
| <i>Juan Carlos Castillo, Francisco Raga, Oscar Caballero, Francisco Bonilla Jr, Fernando Bonilla-Musoles</i>                |             |
| <b>Obstetrics: First and Second Trimester Normal Fetal Scan</b>   | 1129        |
| • Normal HDlive Image   | 1129        |
| • Pathological Images Using 3D/4D Ultrasound And HDlive   | 1129        |
| • Radiance System Architecture (RAS) or Silhouette HDlive   | 1135        |
| • Comments to These New US Modes  | 1136        |
| • Day-by-day Ultrasonographic Characteristics Between The 28 Days and 35 Days of Pregnancy (4th to 5th Week)                | 1137        |
| • Ultrasonographic Characteristics Between the 5th and 6th Week   | 1138        |
| • Ultrasonographic Characteristics Between the 6th and 7th Week   | 1140        |
| • Ultrasonographic Characteristics in the 7th Week  | 1141        |
| • Ultrasonographic Characteristics in the 8th Week  | 1141        |
| • Ultrasonographic Characteristics in the 9th Week  | 1142        |
| • Ultrasonographic Characteristics in the 10th Week   | 1143        |
| • Ultrasonographic Characteristics in the 11th Week   | 1143        |
| • Ultrasonographic Characteristics in the 12th Week   | 1144        |
| • Ultrasonographic Appearance from the 13th Week Onwards  | 1144        |
| • Findings in the 15th Week   | 1145        |
| • Miscellaneous   | 1145        |
| • Comments  | 1146        |
| <b>Reproduction</b>   | 1157        |
| • Normal Cycle  | 1157        |
| • IVF Stimulation Cycles  | 1157        |
| • Evaluation of Gynecological Pathologies Related with Infertility  | 1157        |
| • Polycystic Ovaries and the Ultrasonographic Evaluation  | 1160        |
| • State of the Art: New Criteria and US Modes   | 1160        |
| • Polycystic Ovarian Morphology   | 1160        |
| • Ovarian Medulla   | 1163        |
| • Medulla Vascularization   | 1164        |
| • Intrauterine Devices  | 1165        |
| • Identification of the IUD Type  | 1167        |
| <b>Gynecology</b>   | 1169        |
| • Normal Uterus and Benign Uterine Tumors   | 1169        |
| • Uterus  | 1169        |
| • Endometrial and Myometrial Pathologies  | 1169        |
| • Müllerian Malformations   | 1169        |
| • Gynecology  | 1169        |
| • Endometrial Hyperplasia and Cancer, Fallopian Tube Pathology  | 1175        |
| • Cancer  | 1176        |
| • Differentiation of Benign and Malignant Ovarian Masses  | 1178        |
| • Criteria For Categorizing Benign vs. Malignant Ovarian Masses   | 1184        |
| <b>65. Music and Ultrasound: Origins of Our Emotional Connection to Music.....</b>  | <b>1201</b> |
| <i>Helena Dukić Satinović</i>   |             |
| • Development of Fetal Hearing  | 1201        |
| • Fetal Music Perception  | 1202        |
| • Fetal Music Memory  | 1206        |
| • Prenatal Origin of Music  | 1207        |
| <b>Index .....</b>  | <b>1213</b> |

# Fetal Behavior Assessed by Four-dimensional Sonography

Asim Kurjak, Panagiotis Antsaklis, Milan Stanojevic

## ■ INTRODUCTION

### Recent Advances of 3D Ultrasonography

In utero behavior of the fetus is assessed with the assistance of ultrasound technology, through direct observation in utero of real-time movements and activities of the fetus.<sup>1-3</sup> Ultrasound technology that is now used in everyday clinical practice allows us to study not only the anatomy but also the movements and behavior of the fetus in real time. It has been shown fetal behavior has a specific pattern that corresponds to brain maturation of the fetus at each week or trimester.<sup>4</sup> Both anatomic and functional development of the human brain is a complex and long-lasting procedure that goes through strictly structured developmental stages, which start from the second month of gestational age and continue after birth up to adult life.<sup>4</sup> The cornerstones of human brain development are demonstrated in **Table 1**. This process cannot be always

predetermined as it is affected by a variety of genetic and epigenetic factors and can be influenced by incidents that may occur any time during pregnancy. In cases of prematurity, no matter how much intensive neonatal units have progressed, we still have not reached a point where the conditions of ex life are similar to in utero ones, making extremely premature neonates more susceptible to neurological problems.<sup>5,6</sup> The degree at which the brain development will be affected by external factors (genetic factors, external stimuli, pathological conditions, or even environmental changes) is uncertain and cannot be predicted. So, neurological impairment is a great challenge, as its diagnosis in utero is very difficult, and even when we suspect it, again we are often unable to detect the degree at which the fetus will be affected. What is more we cannot be certain of the exact time that the damage occurs: Antepartum, intrapartum, or postpartum, as the diagnosis is most often done after birth.<sup>4</sup> The diagnosis of neurological impairment is one of the greatest challenges in obstetrics and the cause and effect relationship of neurological disabilities most of the times is uncertain. A method that could assess fetal behavior and as a result assess the neurological integrity of the fetus would be a method that would provide many useful information.<sup>6,7</sup> Kurjak's antenatal neurodevelopmental test (KANET) with the use of 4D ultrasound assesses fetal behavior in a similar way that a neonate is assessed postnatally and we now have robust evidence from multicentric studies that it can be used in everyday clinical practice.

**TABLE 1:** Major events in neural development.<sup>4</sup>

| Developmental event   | Peak time of occurrence                                 |
|---|---|
| Primary neurulation (dorsal-induction)  | 3–4 weeks antenatally                                   |
| Prosencephalic cleavage (ventral induction)   | 5–6 weeks antenatally                                   |
| Neuronal proliferation:<br>• Cerebral<br>• Cerebellar                                     | 2–4 months antenatally<br>2–10 months postnatally       |
| Neuronal migration:<br>• Cerebral<br>• Cerebellar   | 3–5 months antenatally<br>4–10 months antenatally       |
| Neuronal differentiation:<br>• Axon outgrowth<br>• Dendritic growth and synapse formation | • 3 months to birth<br>• 6 months to 1 year postnatally |
| Synaptic rearrangement  | Birth to years postnatally                              |
| Myelination   | Birth to years postnatally                              |

## THE EVOLUTION OF FETAL MOVEMENTS AND FETAL BEHAVIOR ASSESSMENT WITH ULTRASOUND

The cerebral growth and maturation of a fetus appear to be represented by its behavior in utero,<sup>8,9</sup> while studies

have shown that their movements are very good indicators of neurobehavioral organization and of the future neurological integrity of the fetus.<sup>10-17</sup> Two-dimensional (2D) ultrasound allowed up to a point the complete evaluation of the fetal anatomy and gave the opportunity to view fetal movements. One of the pioneering studies about the importance of fetal movements was published more than three decades ago offering the first knowledge in this new field of fetal medicine and at the same time the inspiration to study the fetal behavior as a whole in utero.<sup>18</sup> de Vries et al. followed and analyzed the qualitative and quantitative aspects of giving more details on the movements and a more methodological way of studying them.<sup>19-21</sup>

Based on the first analysis of fetal movements by 2D ultrasonography, de Vries classified movements into different patterns as follows:

- *Sideways bending*: Started between seventh and eighth gestational weeks, slow and small displacements at one or two poles of the fetus occur, lasting from half a second to two seconds, which usually occur as a single event and disappear through gestation.
- *Startle*: A startle consists of a rapid phase contraction of all limb muscles. It often spreads to the trunk and neck. It occurs frequently in the first trimester from 8 weeks on.
- *General movements (GMs)*: These movements are complex movements including neck, trunk, and limbs that are applicable if the whole body is moved but no distinctive patterning or sequencing of the body parts can be recognized. They wax and wane in intensity, force, and speed, and they have gradual beginning and end. These movements are performed from 8 weeks and on.
- *Hiccups*: These consist of a jerky contraction of the diaphragm. Hiccups appear from 9 weeks and on, often in series, for up to several minutes, and isolated arm and leg movements can be observed.
- *Breathing-like*: Fetal breathing-like movements are usually paradoxical in a way that every contraction of the diaphragm (which after birth leads to an inspiration) causes an inward movement of the thorax. The onset of fetal breathing-like is around the 10th week of gestation. Early in pregnancy, they are present continually and are associated with activity in the postural muscles of the neck and limbs.
- *Isolated arm or leg movement*: These movements appear around the 10th week of gestation and they vary in speed and amplitude. They involve extension, flexion, external and internal rotation, or abduction and adduction of an extremity, without movements in other body parts.
- *Twitches*: Twitches are quick extensions or flexions of a limb, or the neck. They are not generalized or repetitive.
- *Clonic movements*: These are repetitive movements of one or more limbs at a rate of about three per second.
- *Isolated retroflexion of the head*: Retroflexions of the head are usually carried out slowly, but they can also be fast and jerky. These movements can be seen around the 10th week of gestation and on.
- *Isolated rotation of the head*: Rotation of the head is carried out at a slow velocity and only exceptionally at a higher speed. The head may turn from a midline position to one side and back.
- *Isolated anteflexion of the head*: Anteflexion of the head is carried out only at a slow velocity. The displacement of the head is small. The duration is about 1 second.
- *Jaw movements*: The onset of irregular jaw opening is at 11th week. The opening may be either slow or quick. The duration of opening varies from <1 to 5 seconds.
- *Sucking and swallowing*: At 13 weeks, rhythmical sucking movements, often followed by swallowing, occur in bursts indicating that the fetus is drinking amniotic fluid.
- *Hand-head contact*: In this pattern of movement, the hand slowly touches the face, and the fingers frequently extend and flex. These movements appear from 10th week onward and at first they usually represent an accidental contact of a hand with the face or mouth. Subgroups of these movements are:
  - *Hand-to-head*: When hand movement ends at contact of fingers with the parieto-occipitotemporal region of the head
  - *Hand-to-mouth*: When hand movement ends at contact of thumb or finger with the mouth, lips, or the immediate oral region
  - *Hand-near-mouth*: When movement ends with fingers in fluid between nose and shoulders/nipples or between both shoulders. Hands must be below eyes and within the area defined by the ears, less than a hand away from the mouth
  - *Hand-to-face*: When movement ends with hand in contact with the face (cheeks, chin, and forehead)
  - *Hand-near-face*: When movement ends with finger in fluid in front of the face but not in mouth region

- *Hand-to-eye*: When movement ends with hand or palm or fingers in the eye region
- *Hand-to-ear*: When movement ends at hand contact with the ear
- *Stretching*: This movement is a complex motor pattern, which is always carried out at a slow speed and consists of the following components: Forceful extension of the back, retroflexion of head, and external rotation and elevation of the arms. It retains an identical movement form into adult life.
- *Yawning*: This motor activity is similar to the yawning observed after birth: Prolonged wide opening of the jaws followed by quick closure, often with retroflexion of the head and sometimes elevation of the arms. This movement pattern is nonrepetitive and it appears around 11th week. The anatomical criterion for fetal yawning is retraction of the tongue, whereas yawning in adults is characterized by an extended tongue.
- *Rotation of the fetus*: Rotation of the fetus occurs around the sagittal or transverse axis. A complete change in position around the transverse axis, usually with a backwards somersault, is achieved by a complex GM, including alternating leg movements, which resemble neonatal stepping.

It has been suggested that distinguishing between types of fetal movements and behavior according to each trimester could help to disperse routine-normal fetal behavioral patterns, from possible pathological patterns.<sup>21-24</sup> The method that brought a revolution to fetal real-time imaging was 4D ultrasonography which offered a more objective and accurate way than 2D ultrasound.<sup>24-27</sup> 3D/4D ultrasound has now become routine in clinical practice and fetal assessment offering better pictures than 2D ultrasound and allowing observation of fetal movements, even detailed ones such as fingers and facial movements.<sup>28,29</sup> Especially for the face, it represents the most visible part of the human being. All major senses are facilitated in this region and expressed through facial expressions. The long-term study of fetuses with 4D ultrasound allowed the production of measurable units that could be finally applied systematically for the assessment of fetal behavior.<sup>30</sup> One of the greatest advantages of 4D ultrasound compared to 2D is the detailed pictures of the fetal face (e.g., smiling, crying, mouthing, and blinking), something that cannot be achieved with 2D ultrasound. When comparing assessment of fetal behavior by 2D and 4D ultrasound, the advantage of 4D is better depiction of fetal facial expressions in three dimensions (3D) with the possibility to assess them in almost real time

with the new sophisticated ultrasound machines having fast frame rates.

There are now studies that prove that with the use of 4D differences in fetal behavior can indeed be identified and with these findings eventually abnormal characteristics can be identified.<sup>31-33</sup> The commencement of fetal movements has been shown by ultrasound studies that occurs very early in fetal life and much earlier than pregnant women can start feeling them.<sup>26</sup> Until a mother can start feeling them and until delivery these movements go through a process that they become more organized and with details such as facial expressions.<sup>34</sup> Studies regarding neonatal neurology have shown that the neonatal behavioral examination can give more information about a possible impairment than a typical neurological examination. That initiated a series of studies that aimed to find the exact structure of the development of fetal behavior for each month or each trimester, in order to first of all to define what is a possible normal behavior and then to identify and diagnose abnormal patterns.<sup>1-4,18-23,35</sup> About 5 years ago, the Zagreb group developed a methodical system for assessing the integrity of the nervous system of fetuses, by applying 4D ultrasound.<sup>36</sup> This test was named KANET, standing for Kurjak's antenatal neurodevelopmental test. Its innovation is that it assesses the fetus in the same way that neonates are assessed neurologically after birth, using similar parameters, with the use of 4D ultrasound.<sup>37-39</sup> While 2D ultrasound is used only for the assessment of fetal startles and GMs, introduction of KANET test enabled assessment of not only movements but also some signs used in postnatal neurological assessment like cranial sutures, head circumference, and finger movements of the hand for the detection of neurological thumb (adducted thumb in the clenched fist).

### **KURJAK ANTENATAL NEURODEVELOPMENTAL TEST: THE ASSESSMENT OF FETAL NEUROBEHAVIOR IN THE 21ST CENTURY**

Timely diagnosis of brain impairment is the main reason why so many studies have been conducted regarding the anatomical and functional integrity of the fetal nervous system as well as the understanding of their reactions. The results that these studies showed gave the motivation for the development of a structured way of assessing fetal behavior in a similar way that neonatal assessment is done.<sup>1</sup> KANET is a new pioneering method of fetal evaluation

mainly by 4D ultrasound that 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.<sup>36,37</sup> It consists of general parameters such as GMs of the fetus and some parameters that are used postnatally for neonatal assessment incorporated by the Amiel-Tison Neurological Assessment at Term (ATNAT) signs.<sup>37,40</sup> The following parameters are included 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, and gestalt perception of GMs (overall perception of the body and limb movements with their qualitative assessment).

Studies show a continuity of the behavioral pattern that follows a fetus from its in utero life to its postpartum attitude 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.<sup>41</sup> The absence of Moro's reflex can be attributed to the differences of the environment in which a fetus develops compared to the postnatal environment, and these differences concern mainly the differences of gravity in the two environments.<sup>6</sup> The parameters finally decided to be used for the KANET test were the result of long-term multicentric studies regarding neurological assessment and the GMs emergence of the fetuses.<sup>40,42</sup>

Kurjak's antenatal neurodevelopmental test is an integrated test consisting of parameters that concern in utero behavior and movements, but also signs which are used postnatally for detection of neurodevelopmental impairment (neurological thumb, overlapping sutures, and small head circumference).<sup>43</sup> KANET is a test that has been standardized, and studies show that it is a method with good reproducibility and the learning curve is very reasonable for physicians and medical staff with good ultrasound background.<sup>43</sup> Regarding the gestational age at which KANET should be performed it has been decided that the best period is the third trimester of pregnancy, and particularly after 28 weeks. The test is proposed to last about 15–20 minutes, and it has been decided that it is best to be performed at periods that the fetus is awake. If this is not achievable because the fetus goes through its sleeping period, the test should be repeated in 30 minutes or the following day, at a minimum period of 14–16 hours.

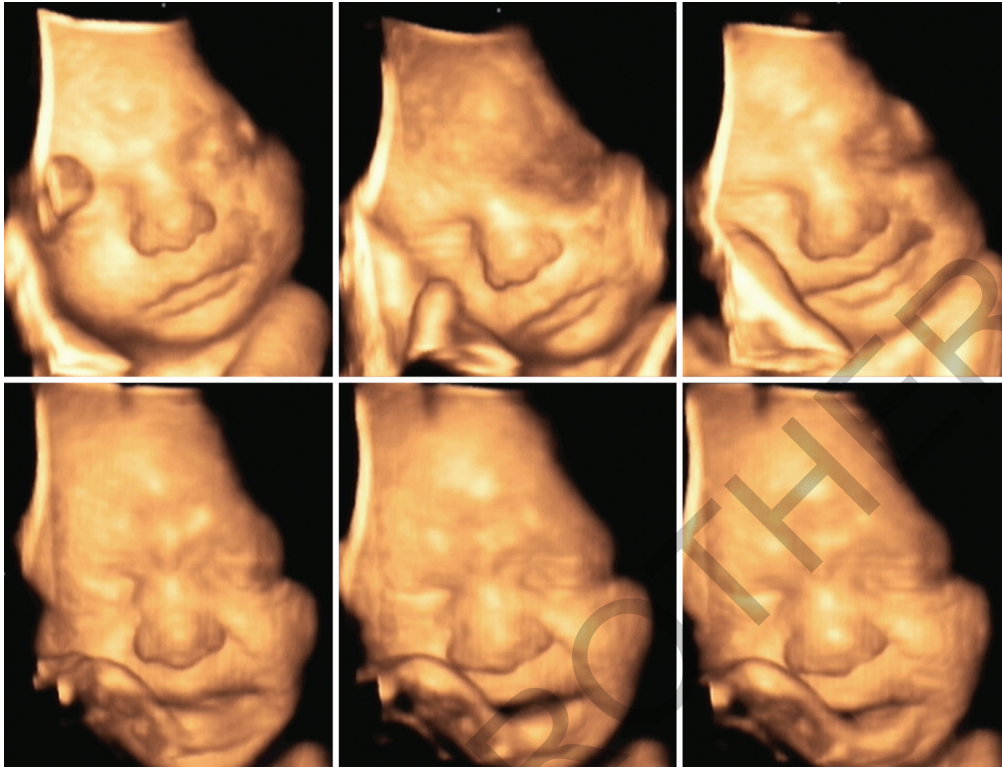
When the test is abnormal or the score is borderline, it is proposed that test is repeated every 2 weeks until

delivery. Very important features are facial movements and eye blinking—"the face is the mirror of the brain". The overall number of movements must be documented in all cases and compared with normal values as presented in previous studies and reviews<sup>40,42</sup> (**Figs. 1 to 6**).

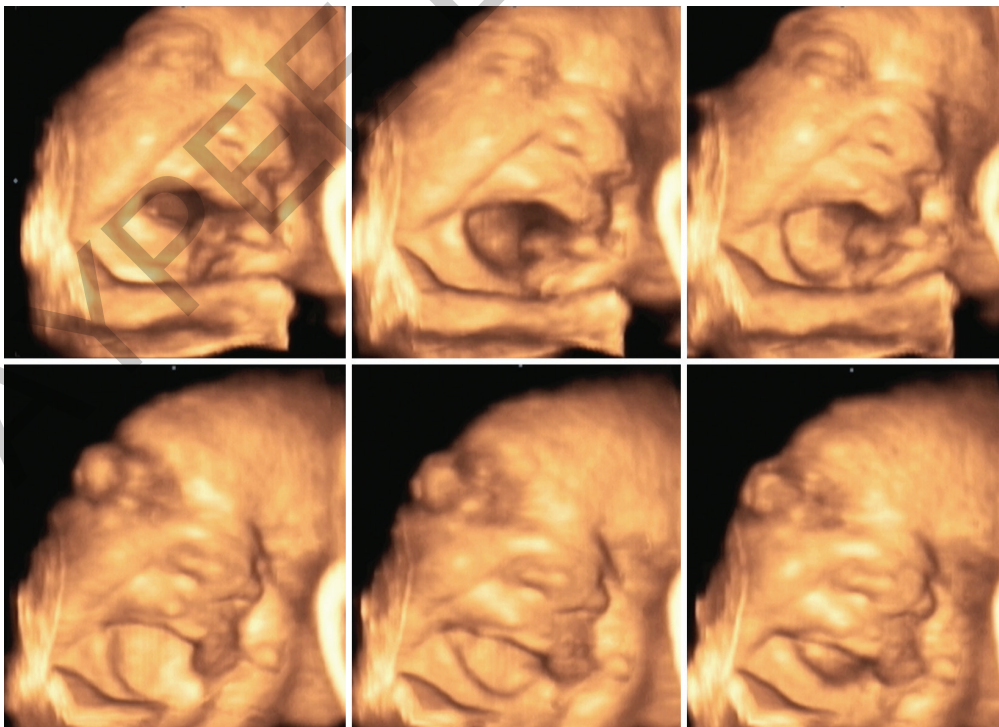
Examiners who apply KANET should have proper training and adequate experience in low- and high-risk pregnancies. Interobserver and intraobserver variability has to be documented. The suggestion regarding the ultrasonographic machines used is to have a frame rate of at least 24 volumes/sec. KANET consists of eight parameters (**Table 2**). The results of KANET are divided in three groups: (1) Abnormal, when the score is 0–5, (2) borderline for a score from 6 to 13, and finally (3) normal for a score 14–20 (**Table 3**). A 2-year follow-up should be available and documented for all fetuses that KANET has been applied, in order to draw safe conclusions.

The aim of the KANET test is to evaluate fetal motoric activity and through that the development of the nervous activity. KANET depends on realistic images compared to the traditional 2D ultrasound and maternal perception of fetal movements, as it can demonstrate fetal movements in real time. As mentioned above, parameters used by KANET are a mixture of GMs, some parameters from ATNAT which means that there is a continuity from fetal to neonatal life after delivery, plus the fact that the integrity of fetal nervous system is up to a point represented by the quality and quantity of the movements that a fetus has in utero and its overall behavior.<sup>22,44–49</sup>

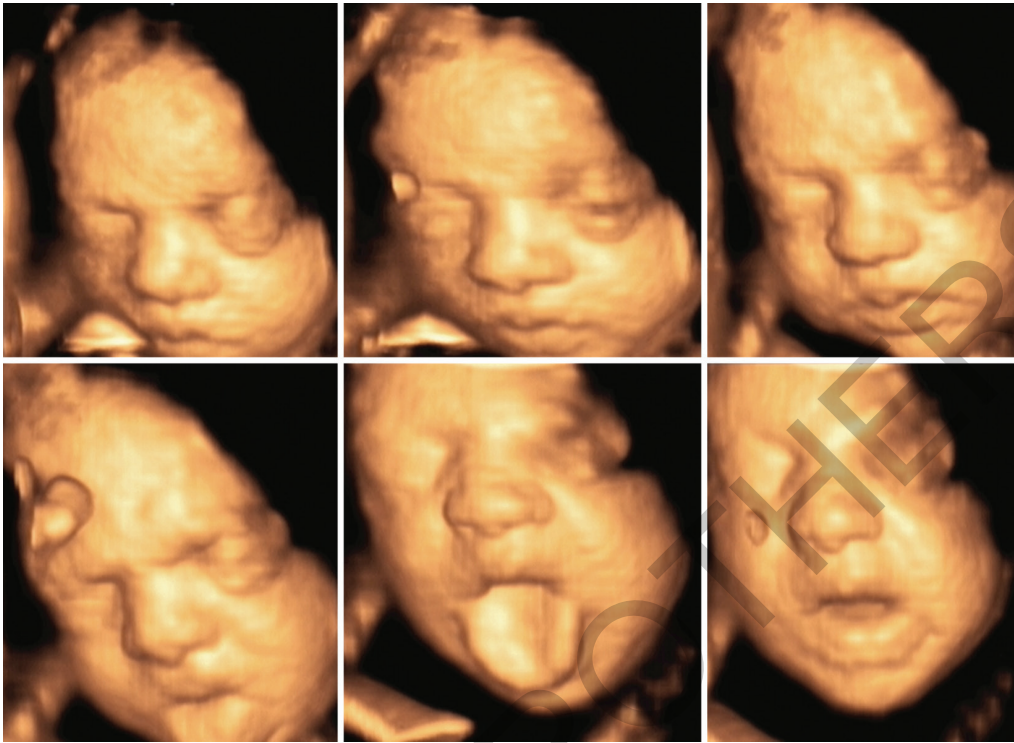
Studies show<sup>50–55</sup> that KANET can identify severe motoric impairment in fetuses with already diagnosed anatomical central nervous system (CNS) abnormalities or chromosomal abnormalities. Also it has been proven that the results of KANET in both low- and high-risk populations correspond to a very high extent with the final outcome and particularly in high-risk populations, KANET can be a very useful tool providing information regarding the prognosis and the grade of impairment of these cases.<sup>56</sup> KANET constitutes the first test applying 4D ultrasound, which has been standardized attempting to simplify things and offers a scoring system, with an aim to be introduced in clinical practice.<sup>57–59</sup> Regarding the applicability of KANET, studies show that it is relatively easy to learn and well accepted by pregnant women; it has a reasonable learning curve of about 80 cases and the duration of the KANET appears reasonable, as it should last about 15–20 minutes.<sup>54</sup>



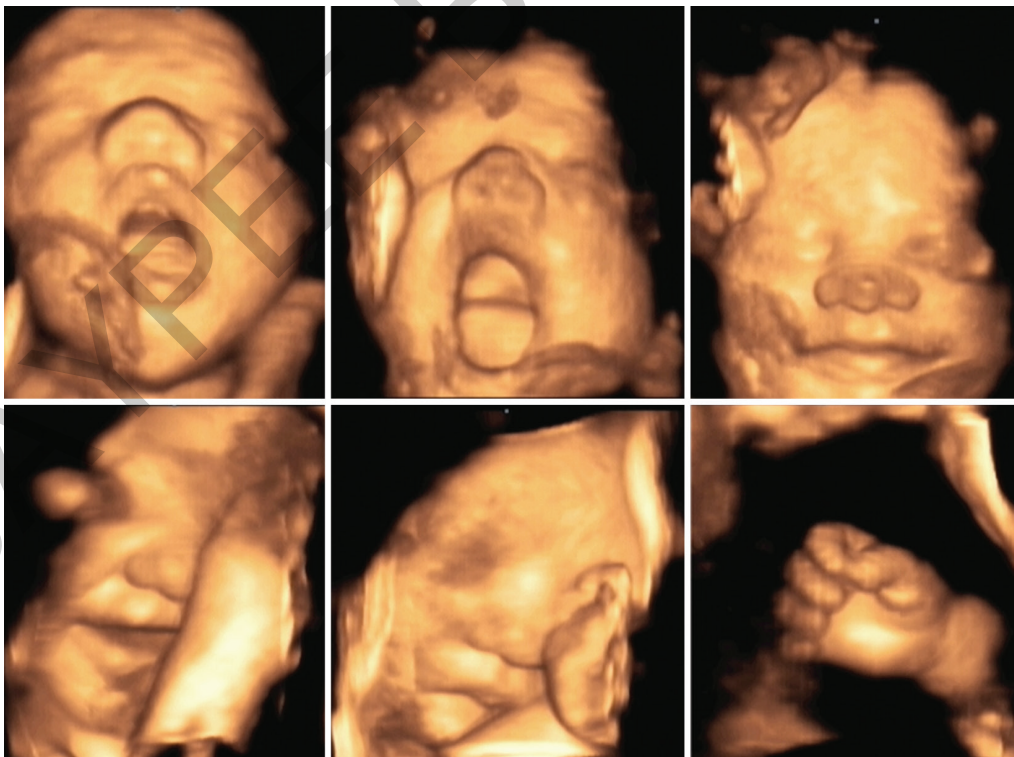
**Fig. 1:** Typical fetal facial expressions as seen during the performance of Kurjak's antenatal neurodevelopmental test (KANET) and recorded.



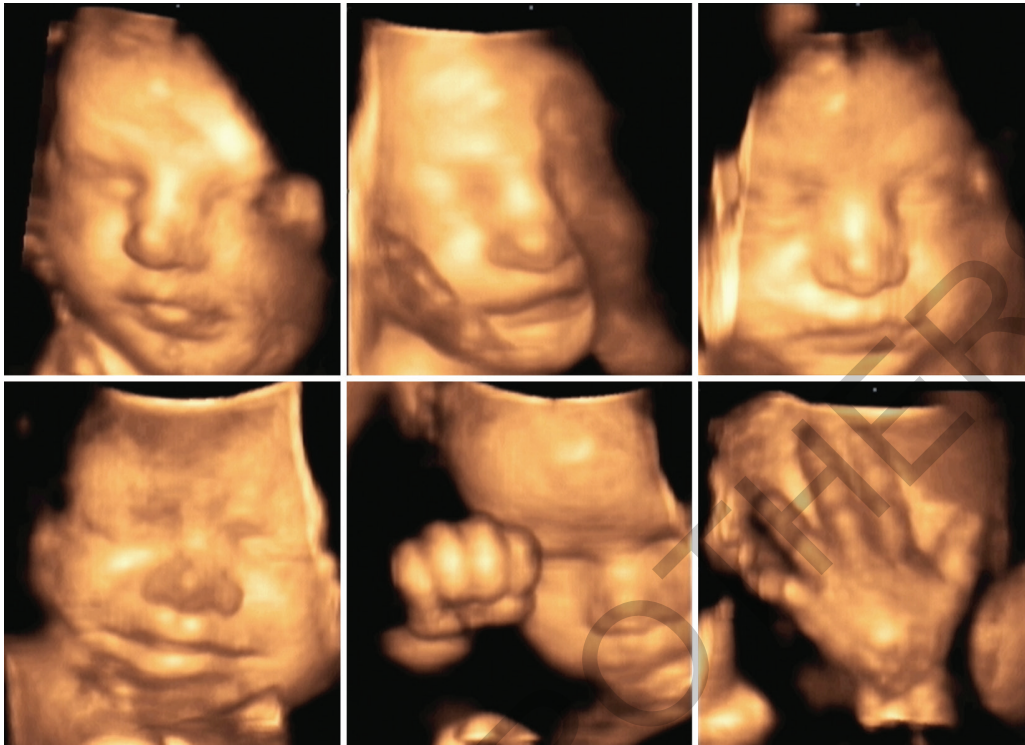
**Fig. 2:** Mouthing and yawning is an important parameter of Kurjak's antenatal neurodevelopmental test (KANET) and a good sign of neurological development.



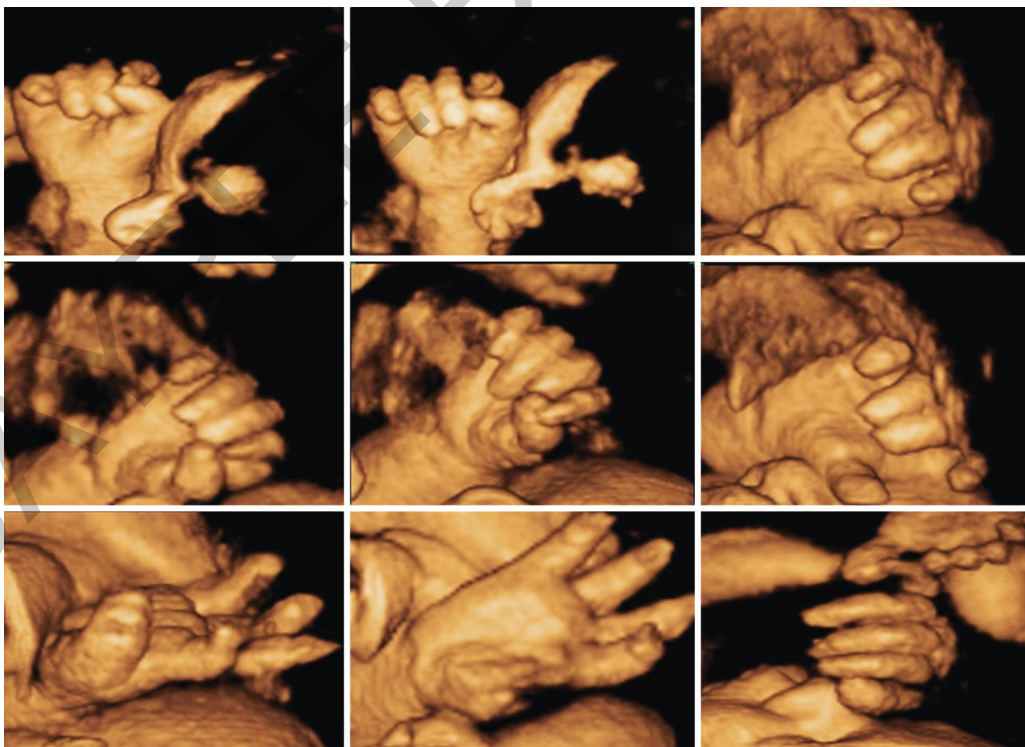
**Fig. 3:** Typical tongue expulsion while fetus is at an awake state.



**Fig. 4:** Mouth opening, yawning, smiling, and finger movements during the performance of Kurjak's antenatal neurodevelopmental test (KANET).






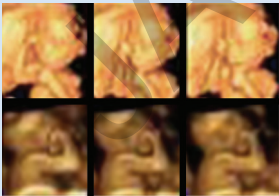


**Fig. 5:** Facial expressions, eye blinking, and finger movements as part of neurological assessment of the fetus with 4D ultrasound [Kurjak's antenatal neurodevelopmental test (KANET)].




**Fig. 6:** Fetal hand and finger movements. Detailed movements are very indicative of the neurological maturation and very important parameter of Kurjak's antenatal neurodevelopmental test (KANET).

**TABLE 2:** The parameters of standardized KANET.<sup>43</sup>

| <i>Sign</i>   | <i>Score</i>                   |   |  | <i>Sign score</i> |
|---|--------------------------------|---|--|-------------------|
|   | <b>0</b>                       | <b>1</b>  | <b>2</b>   |                   |
| Isolated head anteflexion<br>                        | Abrupt                         | Small range (0–3 times of movements)  | Variable in full range, many alternation (>3 times of movements)     |                   |
| Cranial sutures and HC<br>                           | 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 |                   |
| Isolated eye blinking<br>                            | Not present                    | Not fluent (1–5 times of blinking)  | Fluency (>5 times of blinking)                                       |                   |
| Facial alteration (grimace or tongue expulsion)<br> | Not present                    | Not fluent (1–5 times of alteration)  | Fluency (>5 times of blinking)                                       |                   |
| or Mouth opening (yawning or mouthing)<br>         |                                |   |  |                   |
| Isolated leg movement<br>                          | Cramped                        | Poor repertoire or small in range (0–5 times of movement)   | Variable in full range many alternation (>5 times of movements)      |                   |
| Isolated hand movement<br>                         | Cramped or abrupt              | Poor repertoire or small in range (0–5 times of movement)   | Variable in full range many alternation (>5 times of movements)      |                   |
| or Hand to face movements<br>                      |                                |   |  |                   |

Contd...

Contd...

| Sign   | Score   |                                     |   | Sign score |
|--|---|-------------------------------------|---|------------|
|  | 0   | 1                                   | 2   |            |
| Fingers movements<br> | Unilateral or bilateral clenched first (neurological thumb) | Cramped invariable finger movements | Smooth and complex, variable finger movements |            |
| Gestalt perception of GMs  | Definitely abnormal   | Borderline                          | Normal  |            |
|  |   |                                     | Total score                                   |            |

(GA: gestational age; GMs: general movements; HC: head circumference; KANET: Kurjak's antenatal neurodevelopmental test; SD: standard deviation)

**TABLE 3:** Kurjak's antenatal neurodevelopmental test scoring system.<sup>43</sup>

| Total score | Interpretation |
|-------------|----------------|
| 0–5         | Abnormal       |
| 6–9         | Borderline     |
| 10–16       | Normal         |

Kurjak's antenatal neurodevelopmental test is a new test that takes advantage of the potential offered by the evolution of ultrasound technology, and especially 4D ultrasound for the better assessment of fetal structural and behavioral integrity and especially in order to study details of facial and finger movements. It has been proven that KANET is the method that is well accepted by both examiners and pregnant women, and it has been appropriately standardized. KANET appears to offer useful information about fetal neurobehavior and has the potential to detect and discriminate normal, borderline and abnormal fetal behavior mainly in high-risk pregnancies, so that it can be a valuable diagnostic tool for fetal neurological assessment.<sup>43,60</sup> So far KANET has proven its usefulness in standardization of neurobehavioral assessment, with the potential of prenatal detection of fetuses with severe neuronal dysfunction (Figs. 7 to 9).<sup>60</sup>

According to the Bucharest consensus statement on KANET, it is needed to perform 80 KANET tests by experienced ultrasound specialist in order to be familiar to assess a fetus with 4D ultrasound in 20 minutes. It was calculated that one needs 10–15 cases in 7 days in order to learn the basics of the technique which can be reproducible. The number of tests was comparable with other ultrasound tests like nuchal translucency screening (40 tests by experienced ultrasound specialist) and anomaly scan (100–200 tests by experienced specialist).

In a study that 1,712 KANET tests were performed on 655 patients, the success rate of the test ranged between 91 and 95%. Success rate for the assessment of particular signs of the KANET was between 88% for isolated eye blinking and 100% for mouth opening and isolated leg movement. KANET had almost 100% negative predictive value. Interobserver agreement between two examiners for different components of the KANET test were assessed by calculation of Kappa values, which were lowest for the facial expression ( $K = 0.68$ ) and highest for the finger movements ( $K = 0.84$ ), proving that KANET test is a reliable method to be used with confidence in everyday clinical practice after appropriate education of experienced examiner. What are the more appropriate educational courses with certificate of completion on the performance of KANET are organized by the Ian Donald School of Ultrasound (Figs. 10 to 12).

### Evidence of Prenatal Detection by the Application of KANET According to Multicentric Studies

First form of KANET scoring system was applied by Andonotopo et al.<sup>55</sup> Their aim was to assess whether facial expression and body movements could be of any diagnostic value regarding cerebral palsy (CP) in growth restricted fetuses. They studied 50 pregnancies with intrauterine growth restriction (IUGR) after 28 weeks of pregnancy. They noted decreased behavioral activity in the IUGR fetuses compared to the non-IUGR. This preliminary study motivated further studies about the usefulness of 4D ultrasound for the assessment of fetal behavior. Introduction of KANET as a method could identify characteristics in fetal behavior or movement that manifested some degree of brain impairment. For the development of this test several neonates with variable



Fig. 7: Normal Kurjak's antenatal neurodevelopmental test (KANET) at 34 weeks of gestation.

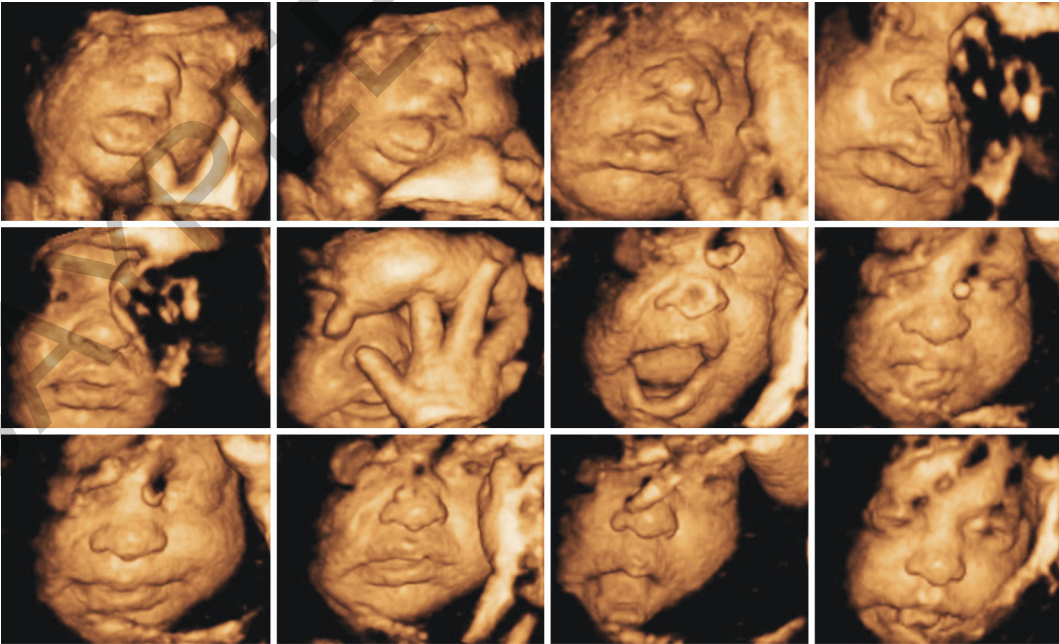
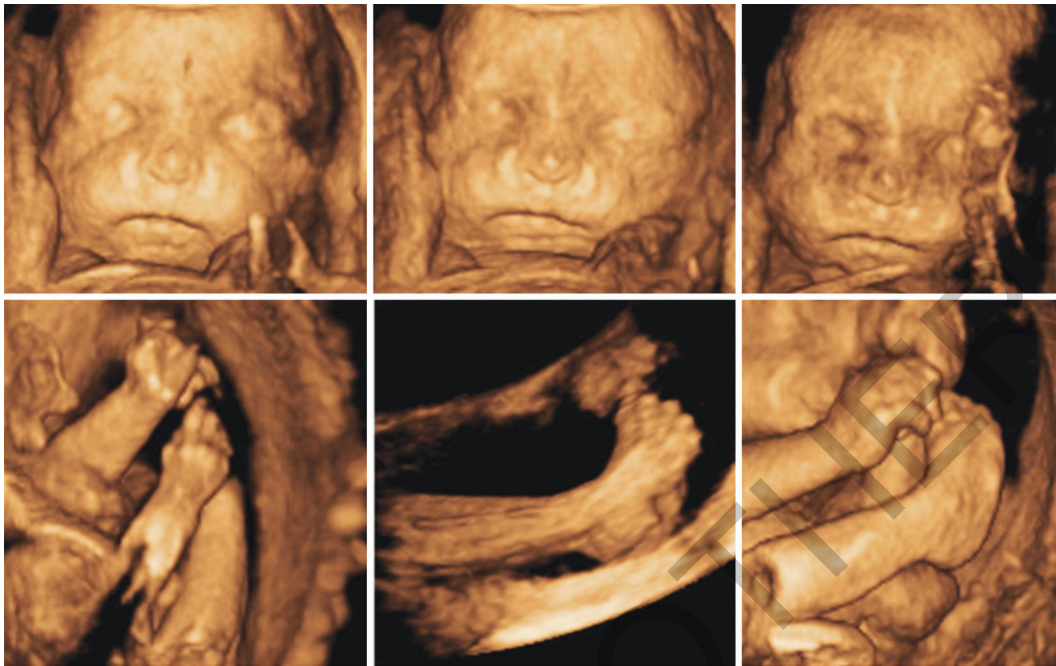
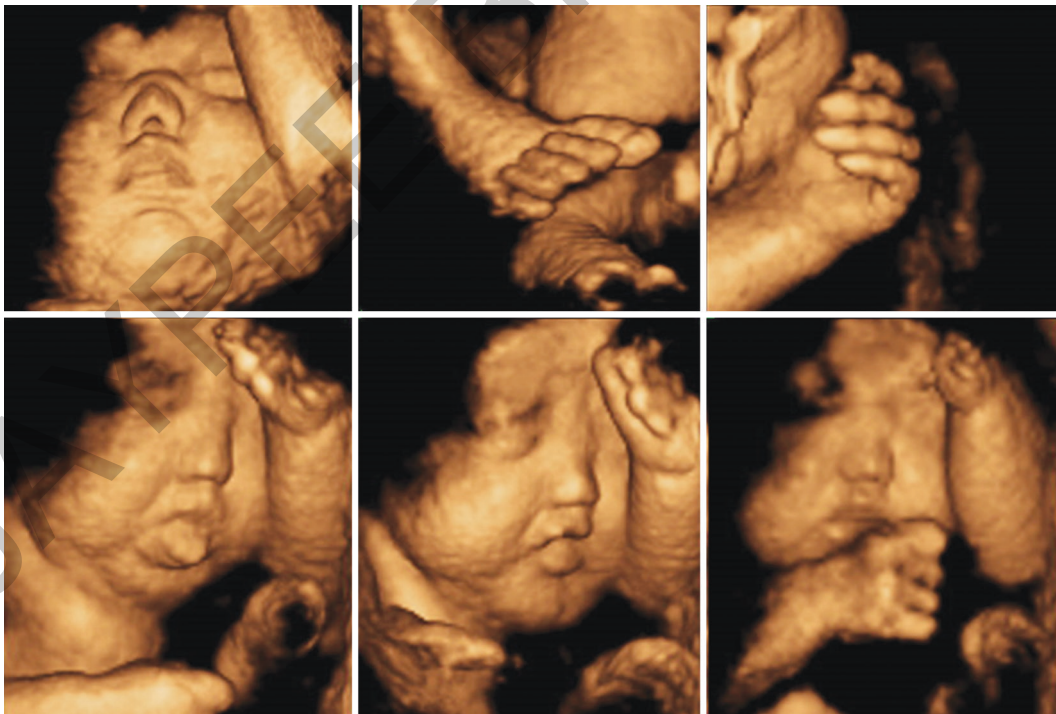


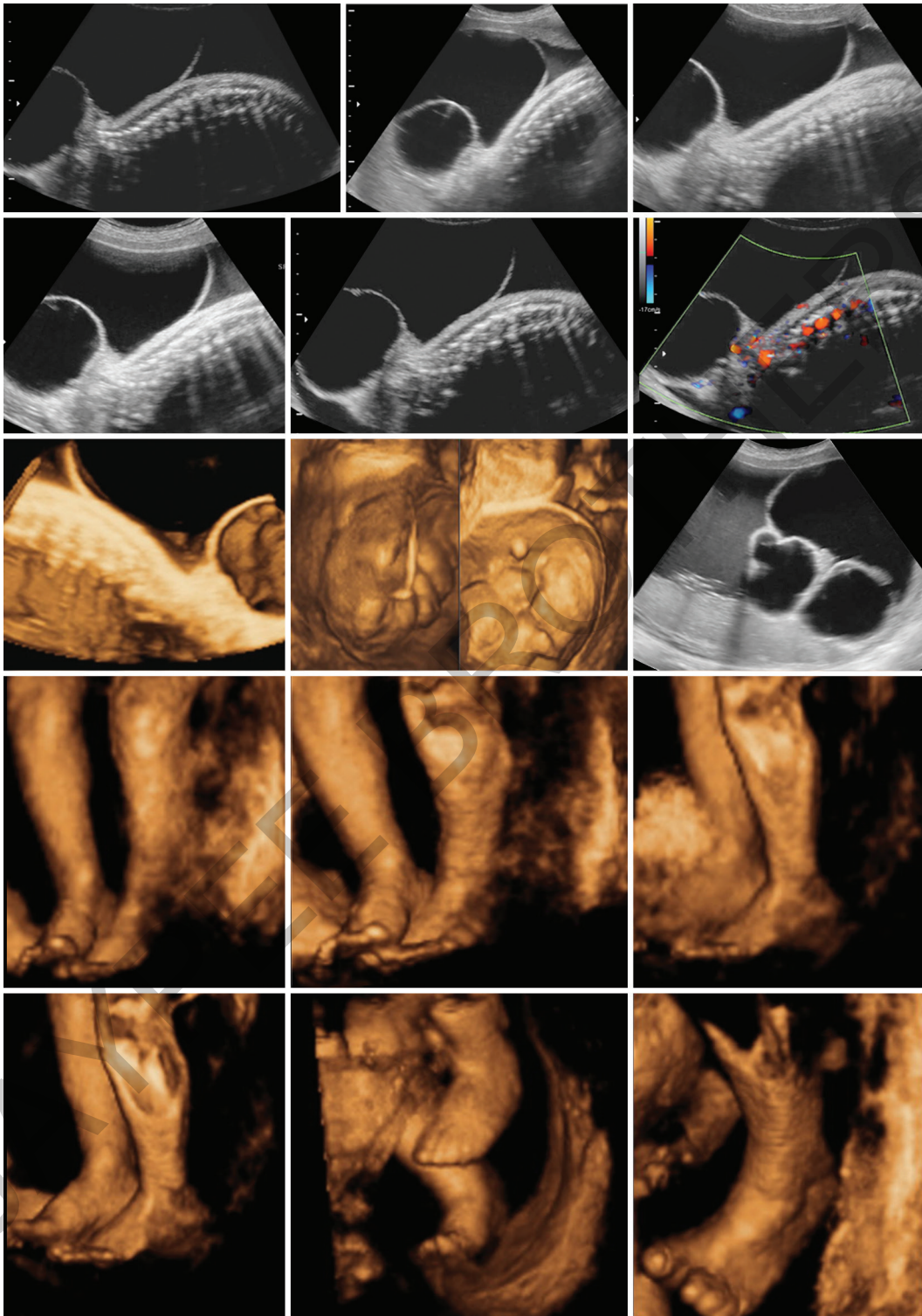
Fig. 8: A complete Kurjak's antenatal neurodevelopmental test (KANET)—facial alterations mouthing, eye blinking, and hand movement.



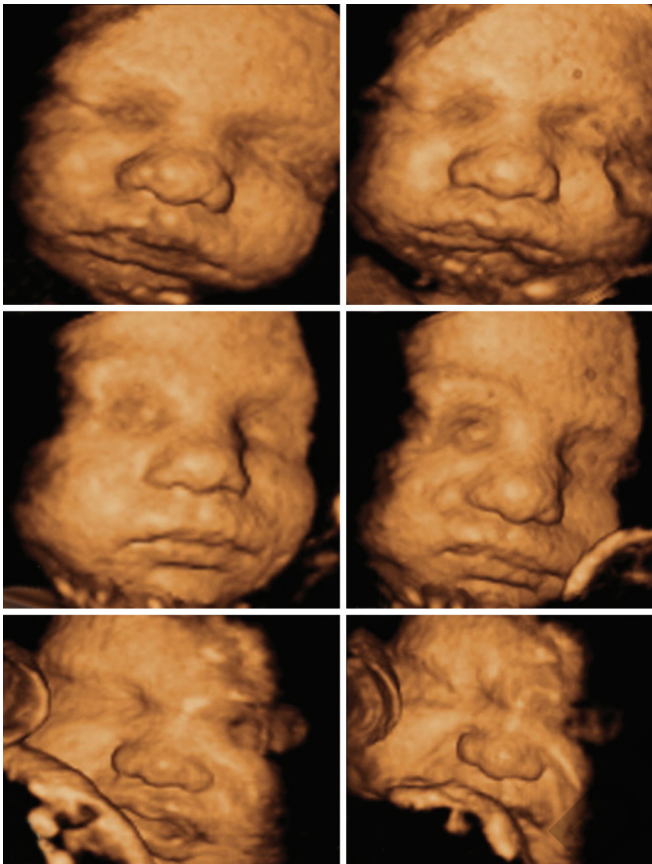
**Fig. 9:** Abnormal Kurjak's antenatal neurodevelopmental test (KANET) score at 28 weeks of a fetus with severe hydranencephaly after cytomegalovirus (CMV) infection. No facial alterations or mouth movements were identified ("frozen face or face like mask"), fists remained clenched and no leg movements were seen (right foot deviated inward—club foot).



**Fig. 10:** Abnormal Kurjak's antenatal neurodevelopmental test (KANET) score at 31 weeks of gestation, of a fetus with semilobar holoprosencephaly. Mouth movements were identified (tongue expulsion), but otherwise facial alterations were minimal and the KANET score was abnormal (KANET score = 4). No leg movements were seen and neurological thumb was identified. Neonate died 3 days after delivery.



**Fig. 11:** Special application of Kurjak's antenatal neurodevelopmental test (KANET). This is a patient with sacrococcygeal teratoma. An ultrasound specialist experienced in KANET was asked to assess the integrity of the mobility of the lower extremities of the fetus. The experience acquired as KANET is applied in more and more cases which can offer a wide knowledge of the in utero behavior and motoric activity of the fetus and give answers to special problems.



**Fig. 12:** Kurjak's antenatal neurodevelopmental test (KANET) test—facial alterations and grimacing.

forms of neurological impairment were examined and compared with “normal” neonates. The idea was to try and identify similar differences during in utero life in order to diagnose brain impairment prenatally. KANET was applied retrospectively in 100 low-risk pregnancies and all fetuses were assessed and after delivery, with the score 14–20 characterized as normal. Then the test was applied to 120 high-risk pregnancies according to the postnatal assessment, and neonates were divided into three groups: Normal, mildly or moderately abnormal, and abnormal. According to the results, the scoring system was divided to prenatal score 14–20 (normal), 5–13 (mildly or moderately abnormal), and 0–5 (abnormal). From the abnormal cases, four were diagnosed with alobar holoprosencephaly, one with severe hydrocephaly, one with thanatotropic dysplasia, and four cases with multiple severe structural abnormalities. Following this preliminary study (**Table 4**), many studies applied KANET and assessed its usefulness

for the detection of neurological impairment during in utero life.<sup>25,32</sup>

In one of the studies out of 288 high-risk pregnancies, seven abnormal cases were included and also 25 cases with borderline KANET score, yielding 32 fetuses at neurological risk. There were also 11 cases with abnormal KANET, of which six fetuses died in utero and five were terminated. The seven remaining neonates with abnormal KANET were followed up postnatally at 10 weeks and from these neonates, three had confirmed pathological ATNAT score postpartum. These three cases included a neonate with arthrogryposis, a neonate with cerebellar vermian complete aplasia and one case with a history of CP in a previous pregnancy.

The main characteristic of these three cases was the facial expressions, which appeared significantly diminished—these faces are characterized as masks due to lack of expressions noted at the time of ultrasound examination. The remaining four cases with pathological KANET did not show abnormal ATNAT postnatally and the examiners characterized the neurological assessment as normal. These four cases included a case of ventriculomegaly, a case complicated by preeclampsia, one case with maternal thrombophilia and one case complicated by oligohydramnios. From the 25 cases diagnosed with borderline KANET result, 22 neonates showed a borderline ATNAT score and were followed up, while the three remaining cases showed normal ATNAT result. These three cases were complicated by ventriculomegaly, chorioamnionitis, and maternal thrombocytopenia, respectively. The cases with pathological prenatal score and normal postnatal ATNAT were characterized by the following risk factors: Ventriculomegaly, Dandy-Walker malformation, skeletal dysplasia, increased amniotic fluid, gestational diabetes, hydrocephaly, thrombophilia, preeclampsia, achondroplasia, oligohydramnios, nonimmune hydrops, chorioamnionitis, growth restriction, Down's syndrome, and thrombocytopenia.

From the three cases with pathological KANET, at neonatal assessment with ATNAT-2 showed confirmed abnormal Prechtl's GMs (these were the cases with arthrogryposis and with cerebellar vermian aplasia) while there were six more cases which were characterized as pathological (history of previous neonate with CP, Dandy-Walker syndrome, hydrocephaly, Down's syndrome, ventriculomegaly, and nonimmune hydrops). From the

## Donald School Textbook of Ultrasound in Obstetrics & Gynecology

Professors Asim Kurjak and Frank A Chervenak are international educational leaders in the field of obstetric and gynecologic ultrasound. They are strong believers in globalization and the free transmission of knowledge which will benefit all female, pregnant, and fetal patients. They direct the Ian Donald Inter-University School of Ultrasound which now has 129 branches throughout the world—a model of successful international friendship and collaboration that the world at large can learn from.

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Academician **Asim Kurjak** MD PhD, currently serves as a Professor of Obstetrics and Gynecology at Medical School Universities of Zagreb and Sarajevo. He is also a Professor Emeritus at International University Sarajevo School of Science and Technology, Sarajevo, Bosnia and Herzegovina.



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From 1985 to 2002, Dr Kurjak served as Head, Department of Obstetrics and Gynecology, Medical School University of Zagreb, Sveti Duh Hospital.

He has published over 1,200 papers. His papers have been cited more than 17,000 times with h-index 70 (from: Google Scholar). He has authored, co-authored, or co-edited 126 books, and two books are in preparation.

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He is the President of the International Academy of Perinatal Medicine and the President of the International Academy of Sciences and Arts in Bosnia and Herzegovina. He is also the Director of Ian Donald Inter-University School of Medical Ultrasound and an Editor-in-Chief of Donald School Journal of Ultrasound in Obstetrics and Gynecology.

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