Table of Contents

1. Introduction **1**

1.1. Intrauterine Programming of Adult Disease 1

1.1.1. What is Intrauterine Programming? What are Its Mechanisms? 1

1.1.2. Fetal Programming and Its Potential Impact on Fetal Cardiac State 2

1.1.3. Myocardial Function of Fetuses in Disadvantageous Intrauterine Milieu and The Need for Establishing Standards for Future Studies 4

1.2. Current State of Ultrasonographic Evaluation of the Fetal Heart Function 6

1.2.1. Advances in Cardiac Function Assessment – Early Stages 6

1.2.2. Intracardiac Blood Flow Estimation with Pulsed Doppler as an Indicator of Diastolic Cardiac Function and Outflow Tract Doppler Examination as a Measure of Systolic Ventricular Function 7

1.2.3. Estimation of Myocardial Performance Index (MPI) as a Derivative of Doppler Studies 9

1.2.4. Newer Imaging Modalities – 3D Fetal Echocardiography, Tissue Doppler Imaging, Doppler-Independent Tissue Tracking Modalities (Speckle Tracking and Feature Tracking) 11

1.3. Purposes of the Study 14

2. Methods and Study Collective **15**

2.1. Definitions of Velocity, Displacement Strain and Strain Rate 15

2.1.1. Definitions related to Motion; Velocity and Displacement 16

2.1.2. Definitions related to Deformation 16

2.1.2.1. Strain 16

2.1.2.2. Strain Rate 18

2.2. Tissue Tracking Echocardiography 19

2.2.1. Feature Tracking Algorithm 19

2.2.1.1. Tracking of the Reference Points – Initial Steps 19

2.2.1.2. Tracking of Remaining Points 24

2.2.1.3. Application of a Sequence of Intermediate Passages

Fourier Transformation using the Periodicity of the Heart Motion 25

2.2.1.4. Border Strain, Strain Rate and Displacement 26

2.3. Study Collective 28

2.3.1. Recruitment of Participants, Inclusion / Exclusion Criteria 28

2.3.2. Maternal Characteristics 29

2.3.3. Fetal Characteristics 29

2.4. Evaluation Method 30

2.4.1. Ultrasound System and Transducers 30

2.4.2. Scan Settings 31

2.4.3. Data Acquisition 32

2.4.4. Software and Hardware 33

2.4.5. Data Processing with syngo VVI 33

2.4.6. Data Collection and Six-Segment Model to Asses Global Myocardial Function 36

2.5. Statistical Analysis 46

2.6. Ethics Committee Approval 46

3. Results 47

3.1. Global Cardiac Activity 47

3.1.1. Motion Parameters 48

3.1.1.1. Global Systolic Velocities 50

3.1.1.2. Global Diastolic Velocities 52

3.1.1.3. Global Displacement 54

3.1.2. Deformation Parameters 56

3.1.2.1. Global Strain 57

3.1.2.2. Global Systolic Strain Rate 59

3.1.2.3. Global Diastolic Strain Rate 61

3.2. Correlation between Ejection Fraction and Strain 66

3.3. Repeatability of VVI 69

3.3.1. Repeatability of Left Ventricular Parameters 69

3.3.2. Repeatability of Right Ventricular Parameters 73

3.4. Overview of the Results 76

4. Discussion **82**

4.1. Tissue Tracking in Fetal Echocardiography 82

4.1.1. A Comparison of Previous Studies, Their Results and Our Findings 82

4.1.2. Our Feature Tracking Algorithm Results 88

4.1.2.1. Motion Parameters 88

4.1.2.2. Deformation Parameters 88

4.1.2.3. Strain as a Sign of Pump Function 89

4.2. Critical Analysis of Our Study 90

4.2.1. Global Perspective Versus Regional Perspective 90

4.2.2. Is every heart the same? 90

4.2.3. No Comparison with Another Method 90

4.2.4. Other Limitations of Our Study 91

4.2.4.1. The Nature of Fetal Echocardiographic Examination 91

4.2.4.2. Issues Related to Software and Algorithm 91

4.3. Future Directions 95

5. Summary **97**

6. Zusammenfassung **100**

7. Literature **103**

8. Curriculum Vitae and Acknowledgement **110**

8.1. Curriculum Vitae 110

8.2. Acknowledgement 116