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Original article

Longitudinal left ventricular strain impairment in type 1 diabetes children and adolescents: A 2D speckle strain imaging study

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Abstract

Aim. – Type 1 diabetes (T1D) involves complex metabolic disturbances in cardiomyocytes leading to morphological and functional abnormalities of the myocardium. The relationship between T1D and cardiac structure and function in children is not well established. Our study investigated whether T1D is associated with early subclinical myocardial disturbances in children and adolescents, and whether the state of metabolic control and diabetes duration are influential factors.

Methods. – Standard echocardiography, tissue Doppler imaging (TDI) and two-dimensional (2D) strain imaging were prospectively performed in 100 T1D children (age: 11.3 ± 3.6 years, 52 boys) and compared with 79 controls.

Results. – The diabetic and control children were comparable with respect to age, gender, heart rate and blood pressure. There were no significant differences between the two groups in left ventricular (LV) ejection fraction, LV remodelling and TDI parameters. Conventional mitral Doppler demonstrated significantly fewer diastolic filling abnormalities with an early filling wave in the diabetes group. Global longitudinal strain (GLS) was also significantly lower in the T1D children, while circumferential strain and radial strain did not differ. GLS correlated with HbA_{1c} ($r = 0.52$; $P < 0.01$), but there was no correlation with diabetes duration.

Conclusion. – Our results suggest that LV longitudinal myocardial deformation is decreased in young patients with T1D, and glycaemic control may be the main risk factor for these changes. Further follow-up is now necessary to precisely determine the clinical significance of these myocardial changes detected by 2D strain imaging in T1D children.

Keywords: Type 1 diabetes; Children; 2D strain; Echocardiography

1. Introduction

Type 1 diabetes (T1D) is a major cardiovascular risk factor associated with excess mortality in young adults due to premature cardiovascular events [1], including heart failure [2]. T1D involves complex metabolic disturbances in cardiomyocytes leading to morphological and functional abnormalities of the myocardium [3]. The relationship between T1D and cardiac structure and function in children and adolescents is not well established. Most of the previous studies focused on diastolic function using standard two-dimensional (2D) and Doppler echocardiography, while the study of systolic function

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was restricted to measurement of left ventricular ejection fraction (LVEF) [4,5]. 2D strain imaging is a recent echocardiographic method for the assessment of myocardial function.

The left ventricular myocardium is a complex three-dimensional structure consisting of myocardial fibres orientated in different directions and responsible for three principal types of deformation, or 'strain': global longitudinal strain (GLS); radial strain; and circumferential strain. 2D strain imaging is a robust echocardiographic technique that enables evaluation of the three components of myocardial deformation from a standard 2D view. 2D strain imaging has been shown to be the most sensitive echocardiographic tool for the detection of the subclinical impairment of myocardial function observed in many conditions predisposing to heart failure [6].

The present study used 2D strain imaging to investigate whether T1D children and adolescents show early abnormalities in myocardial function. In addition, the relationship between these myocardial features and glycaemic control and diabetes duration were investigated.

2. Methods

2.1. Population

The study prospectively recruited diabetic patients aged 5 to 18 years followed-up at the paediatric department of the Caen teaching hospital. T1D was diagnosed according to World Health Organization criteria [7] together with the permanent need for insulin therapy. Exclusion criteria were the presence of cardiopathy, significant concomitant disease, medication known to modify cardiac function, high blood pressure, smoking, dyslipidaemia and obesity [defined as a body mass index (BMI), adjusted for gender and age, exceeding the 97th percentile according to French reference values] [8]. Not included were recently diagnosed (< 1 year) diabetic children. Diabetic patients were compared with healthy control children from our outpatients department of paediatric cardiology selected from children being investigated for physiological cardiac murmur whose echocardiography was normal. To be included in the control group, children had to have no personal antecedents or family history of either high blood pressure or hypercholesterolaemia. The study protocol was approved by the hospital ethics review board. Patients provided their informed consent through legal representatives.

2.2. Clinical evaluation

Demographic details of age, gender, weight, height and heart rate were recorded. Their body surface area (BSA) was calculated according to the Dubois formula and expressed in m^2. BMI was calculated according to the formula of weight (kg) divided by height squared (m^2). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured after 10 minutes at rest with a calibrated automatic blood pressure monitor (Datascope® DUO). For diabetic patients, diabetes duration (expressed in years) was considered for each individual based on the full-attained age on the first day of insulin therapy.

2.3. Biochemistry

Fasting blood samples were taken from the diabetic children to analyze lipid balance [total cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides and low-density lipoprotein (LDL) cholesterol, calculated according to the Friedewald formula; Beckman Coulter DxC 800 system, cholesterol oxidase and cholesterol esterase method] and HbA_{1c}. HbA_{1c} was measured by high-performance liquid chromatography (Tosoh Corporation, Tokyo, Japan). This study used the mean quarterly HbA_{1c} (mmol/mol, %) for the year prior to the study.

2.4. Echocardiography

Every subject underwent a 2D echocardiography examination (iE33 system, S5 probe, Philips Healthcare, Best, The Netherlands), including the standard echocardiographic views, tissue Doppler imaging (TDI) and 2D strain analysis.

2.4.1. Conventional echocardiography and tissue Doppler imaging

LVEF was assessed using the biplane Simpson's method in apical view. Left ventricular end-diastolic dimension (LV-EDD), interventricular septal end-diastolic dimension (IVS-EDD) and left ventricular posterior wall end-diastolic dimension (LVPW-EDD) were measured in time motion (TM) mode in parasternal long-axis view. Left ventricular mass (LVM) was calculated by the Devereux formula and indexed by height raised to the power of 2.7. The mitral Doppler signal was recorded in the apical four-chamber view, with the Doppler sample volume placed at the tip of the mitral valve. Peak velocities of early (E) and late (A) filling waves, early/late filling ratio of peak velocities (E/A) and mitral deceleration time (MDT) were measured on the basis of transmitral flow velocities. Left atrial volume (LAV) was measured from standard apical two- and four-chamber views at end-systole, using the biplane method, and indexed to BSA. Acquisitions in pulsed-wave TDI mode were made in apical four-chamber view. The sample volume was placed at the basal level of the right ventricular and left ventricular free walls to measure tricuspid peak systolic velocity (St) and early mitral peak diastolic velocity (Ea).

2.4.2. 2D strain analysis

For this analysis, standard 2D grey-scale acquisitions were made in the short-axis parasternal view at the mitral papillary muscles and in the three standard apical chamber views. All images were recorded at a high image rate at > 50 Hz and stored for post-processing analysis with QLAB advanced quantification software (Philips). Using apical views, fast semi-automatic contouring of the endocardium was carried out by placing three points on the image (basal septum, basal lateral wall and apex) at the endocardium and epicardium. The software then suggested a region of interest of adjustable thickness that could be repositioned by the operator, but which had to correspond to the thickness of the wall to be analyzed. The operator ensured contouring and optimal tracking of the movements of each wall segment by the software. When myocardial tracking was considered optimal by the operator, the software analyzed the