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Original article

How is the peri-patch myocardium in ventricular septal defect patch repair?

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ABSTRACT

Strain rate (SR) and strain (ε) in tissue Doppler imaging provide new noninvasive measurements of myocardial function, independent of heart motion.
This study assesses the extent of peri-patch regional myocardial function after patch repair of ventricular septal defect (VSD).
Myocardial SR and ε were recorded from the peri-patch myocardium and remote septum from patch area in 18 patients (1 month to 4 years of age, mean 2.3 years). Distance between the patch and the point of returning to remote normal strain (ε) profile was measured.
Compared to the remote myocardial region, peri-patch myocardium had decreased peak longitudinal SR ($-3.8 \pm 2.1\ s^{-1}$ vs. $-5.3 \pm 3.3\ s^{-1}$, $p < 0.05$), delayed time to peak longitudinal SR (144 ± 59 ms vs. 110 ± 46 ms, $p < 0.05$), decreased peak ε (longitudinal, $-20.8 \pm 8.1\%$ vs. $-28.7 \pm 11.1\%$; radial, $20.1 \pm 16.3\%$ vs. $34.3 \pm 22.4\%$, $p < 0.01$), and delayed time to peak ε (longitudinal, 314 ± 80 ms vs. 241 ± 63 ms; radial, 329 ± 99 ms vs. 265 ± 78 ms, $p < 0.0001$).
The mean distance from the patch to the remote patch ε curve was 2.55 ± 0.77 mm.
Conclusion: Peri-patch myocardium after repair of VSD has delayed and diminished contraction as compared to more remote normal myocardium.

Introduction

Non-invasive assessment of ventricular function in children could benefit from a technique that would characterize local myocardial deformation [1–6].

Myocardial wall velocities using tissue Doppler have been proposed as an advanced non-invasive modality of quantifying regional myocardial function in children [1–9]. However, tissue Doppler myocardial imaging detects regional velocity profiles with respect to the position of the transducer. Such velocities may be affected by cardiac movement and motion by contraction in adjacent myocardial segments [10].

In order to surmount this problem, techniques have become available to calculate local strain rate (SR) and strain (ε) from measured local spatial gradients in myocardial wall velocities [6,11]. These two parameters are able to characterize regional deformation of local myocardium. Peak SR represents the maximal velocity of deformation during systole, and regional systolic strain represents the magnitude of myocardial deformation from a reference point [11].

In adult patients, regional SR and ε calculation have been shown to quantify regional myocardial function in ischemic myocardium and after myocardial infarction [12–14]. In healthy children 4–16 years of age, normal systolic and diastolic longitudinal SR and ε values from all segments of the left and right ventricles have been defined [1,6,15,16].

SR and ε have been demonstrated to be homogenous along the extent of the ventricular septum. The effect of open heart surgery in congenital heart disease may have a detrimental effect on regional myocardial function, but this has not been systematically explored. Understanding the long- and short-term effects of myocardial injury by sewing or patch placement could potentially facilitate improved surgical techniques.

The purpose of this study was to quantify regional myocardial function near the ventricular septal patch in repaired ventricular septal defect (VSD) patients. Myocardial function of the peri-patch region was compared to the remote septal region which was assumed to provide a reference value.

Hypothesis

1. Normal SR and ε may be demonstrated at the remote septum far from the patch.
2. The systolic SR and ε values may be different at the peri-patch when compared to the remote myocardium.

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3. The time to peak ε may be different at the peri-patch from the remote myocardium.

Methods

Color tissue Doppler imaging (TDI) was recorded from parasternal long- and short-axis, and apical views in 18 patients (1 month to 4 years of age, mean 2.3 years of age), at the time of 1 month to 2 years after patch repair of VSD. Color TDI-derived spectral tracings of SR and ε were recorded from the peri-patch region, and from the remote septum of half distance between patch and apex. Peak values and time to peak values were compared between peri-patch and remote sites during systole and diastole. The mean distance between the patch and the point of returning to remote ε profile was measured.

Patient population

Eighteen patients with ages ranging from 1 month to 4 years (mean 2.3 years) were studied within 1 month to 2 years after patch repair of VSD. The perimembranous type and the muscular type of VSDs were included in this study. The sizes of the defect were 5–9 mm.

Definition

The two areas of myocardium immediately adjacent to each side of the patch were defined as the peri-patch area.

The segments of the septum far from the patch but adjacent to the peri-patch area were defined to be the remote-patch area.

Echocardiography

Echocardiographic studies were performed with the use of a Vingmed System V GE® (Horten, Norway) echocardiographic machine. Color TDI data were obtained in fundamental mode (2.5 MHz transducer) during three consecutive heart cycles. The digital data were recorded from the left ventricle and ventricular septum including patch, using standard and modified parasternal long-axis view, short-axis view, and apical four-chamber view.

Off-line analysis

Color tissue Doppler myocardial imaging was stored in digital format and transferred to a computer workstation for off-line analysis using EchoPac® software (GE Medical Systems, Milwaukee, WI, USA).

Longitudinal regional myocardial flow velocities were taken from color flow Doppler tissue loops from the apical views. Radial regional myocardial flow velocities were recorded from parasternal views. Color tissue Doppler myocardial imaging-derived spectral tracings of SR and ε were calculated and recorded from the peri-patch region, and from the remote septum half distance between patch and apex.

The distance between two points for measurements of myocardial deformation was set at 0.4–0.6 cm by EchoPac® software in this study. These distances were chosen in consideration of spatial sensitivity, although a distance between 0.5 cm and 1.0 cm has been frequently used in adults [7]. Peak values and time to peak values were compared between peri-patch and remote myocardium during systole and diastole. Finally, the distance between the patch and return to remote ε profile was measured by progressively moving the sample site toward apex away from the patch until ε profile became subjectively similar to the remote profile (Figs. 1–3).

Results

SR and ε of the remote myocardium

Because of lack of established normal values for SR and ε of the ventricular septum in this age group, the remote values were used as the patient's intrinsic reference values for comparison. The peak value of longitudinal systolic SR, magnitude of peak longitudinal ε were greater in magnitude and more variable than normal values for the mid septum in 4–16 year olds reported by Sutherland's group [16] (Table 1; Fig. 4). ε values are less variable and are closer to the published longitudinal normal values for 4–16 year old

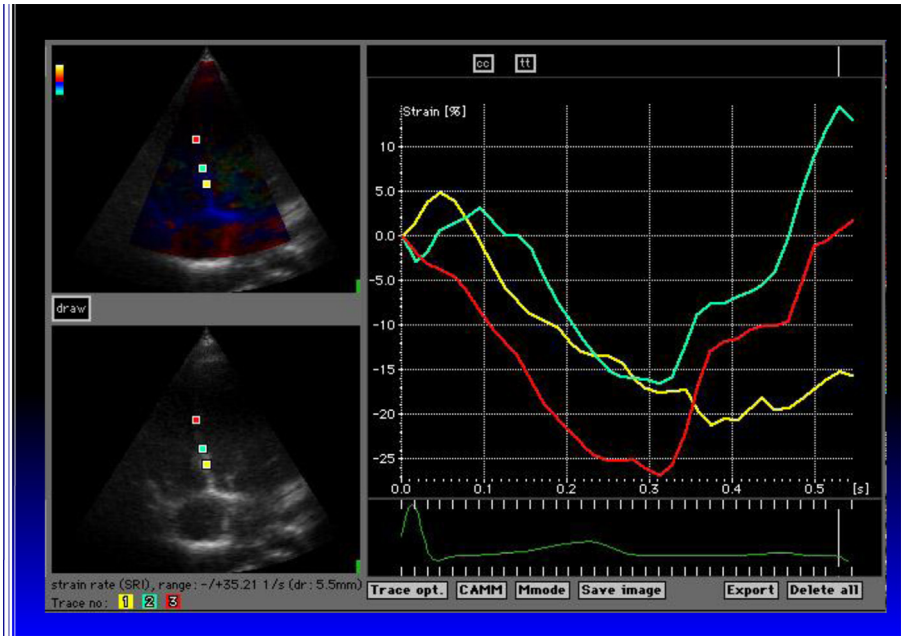

Fig. 1. Longitudinal strain at the middle of the patch, and at the point from peri-patch to remote myocardium. Yellow, patch; green, peri-patch; red, remote myocardium. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)