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Cardiac index in atrio- and interventricular delay optimized cardiac resynchronization therapy and cardiac contractility modulation

Abstract: Cardiac resynchronization therapy (CRT) is an established therapy for heart failure patients and improves quality of life in patients with sinus rhythm, reduced left ventricular ejection fraction (LVEF), left bundle branch block and wide QRS duration. Since approximately sixty percent of heart failure patients have a normal QRS duration they do not benefit or respond to the CRT. Cardiac contractility modulation (CCM) releases nonexcitatoy impulses during the absolute refractory period in order to enhance the strength of the left ventricular contraction. The aim of the investigation was to evaluate differences in cardiac index between optimized and nonoptimized CRT and CCM devices versus standard values. Impedance cardiography, a noninvasive method was used to measure cardiac index (CI), a useful parameter which describes the blood volume during one minutes heart pumps related to the body surface. CRT patients indicate an increase of 39.74 percent and CCM patients an improvement of 21.89 percent more cardiac index with an optimized device.

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1 Introduction

Cardiac resynchronization therapy (CRT) is an established therapy for heart failure patients and improves symptoms, quality of life in patients with sinus rhythm, reduced left ventricular ejection fraction (LVEF) lower or equal thirty five percent, left bundle branch block and QRS duration more than one hundred fifty millisecond [1, 2]. Since approximately sixty percent of heart failure patients have a normal QRS duration they do not benefit or respond to the CRT. Cardiac contractility modulation (CCM) releases nonexcitatoy impulses during the absolute refractory period in order to enhance the strength of the left ventricular contraction and improve exercise tolerance and quality of life [3]. The aim of the investigation was to evaluate differences in cardiac index between optimized and nonoptimized CRT and CCM to reference values with impedance cardiography, a noninvasive method. Cardiac index (CI) contains a relation of cardiac output (CO) and body surface area (BSA) from patients.

2 Methods

Cardiac index measurements of 36 patients with 10 CRT, 10 CCM and 16 reference patients (mean age 49.36±24.43 years, 6 females, 30 males) were mounted by noninvasive impedance cardiography and compared with an optimized and not optimized atrio- and interventricular delay.

Cardiac index consists of body surface area and cardiac output. The body surface area is calculated from the patient's height, weight and gender. Cardiac output is made up of stroke volume multiplied by heart rate.

Stroke volume in turn was measured with left ventricular ejection time (LVET) multiplied by the amplitude of the systolic wave in the ICG, divided by the base impedance (Z_0), overall the thorax and a part of the volume of the thorax which is electrically participated (V_{EPT}).

Patient data and values were mounted by Cardio Vascular Lab 2.5 software and CardioScreen 1000 hardware (Medis Medizinische Messtechnik GmbH, Ilmenau, Germany)

Statistical analysis was performed by Origin®9.1 software (OriginLab Corperation, Northampton, MA, USA).

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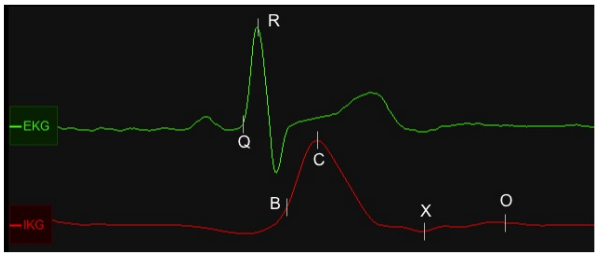

Figure 1: Electro- and impedance cardiography with markers set automatically. Aortic valves opening (B) and closure (X), maximum systolic flow (C) and opening of the mitral valve (O) are displayed in the ICG. The ECGs' markers are Q and R.

3 Results

3.1 Cardiac index comparison with CCM- and CRT-device before and after optimizing atrio- and interventricular delay

This investigation includes 36 patients (mean age 49.36±24.43 years, 6 females, 30 males) with 10 clinical measurements of CRT and CCM patients respectively and 16 reference values as measured by students. CRT patients (mean age 62.70±0.99 years, 10 males) improved cardiac index from 2.34±0.67 l/min/m^2 up to 3.27±0.99 l/min/m^2 with an increase of 39.74%. The cardiac index improvement of CCM Patients (mean age 75.60±0.51 years, 3 females, 7 males) is 21.89% from 2.33±0.65 l/min/m^2 to 2.84±0.51 l/min/m^2. Reference values from students (mean age 24.63±1.67 years, 3 females, 13 males) serve as standard values.

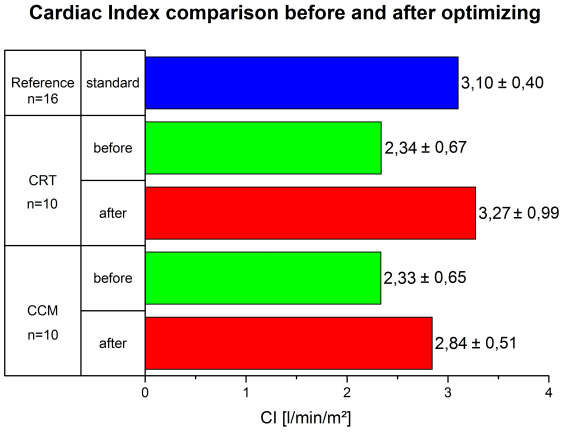

Figure 2: Cardiac index comparison of CCM and CRT patients towards reference values before and after optimizing atrio- and interventricular delay with standard deviation.

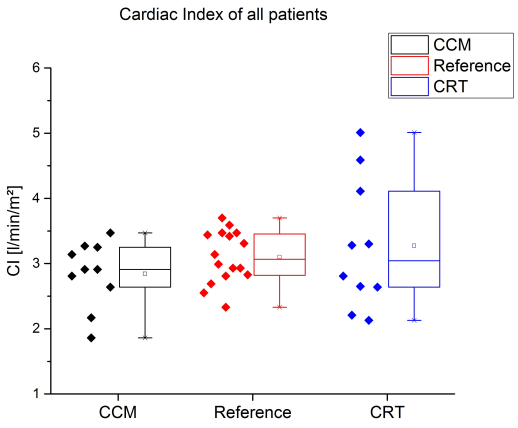

Figure 3: Cardiac index comparison of each patient with optimized atrio- and interventricular delay.

3.2 Additional parameters measured after optimizing atrio- and interventricular delay

Additional values like velocity index (VI), stroke volume (SV), stroke index (SI), cardiac output (CO) and acceleration index (ACI) were documented.

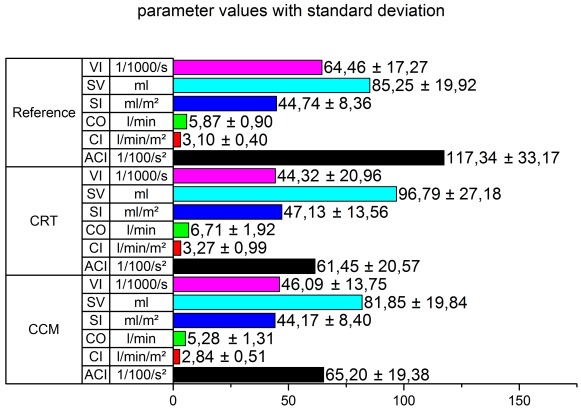

Figure 4: secondary parameter values of CRT and CCM patients versus reference with standard deviation after optimizing the devices.

4 Conclusion

Noninvasive impedance cardiography can be utilized to evaluate the improvement and increase of cardiac index in atrio- and interventricular delay optimized cardiac resynchronization therapy and cardiac contractility modulation.

Author's Statement

Conflict of interest: Authors state no conflict of interest. Material and Methods: Informed consent: Informed consent is not applicable. Ethical approval: The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee.

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