Is Impedance Cardiography-Derived Systolic Time Ratio a Useful Method to Determine Left Ventricular Systolic Dysfunction in Heart Failure?

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Introduction

Left ventricular ejection fraction (EF) is the most common measure of ventricular function in patients with heart failure (HF). However, serial measurements of EF utilizing echocardiography or radionuclide ventriculography are not practical or cost effective for guiding frequent management decisions.

Impedance cardiography (ICG) is a noninvasive method of obtaining hemodynamics. ICG utilizes the baseline and changes in electrical impedance to calculate hemodynamic parameters, and has been shown to be valid and reproducible in studies comparing ICG with the thermodilution method using a pulmonary artery catheter.

ICG also allows measurement of electromechanical timing intervals, such as the systolic time ratio (STR), defined as the ratio of the ventricular isovolumetric contraction time, measured as the pre-ejection period (PEP), divided by the left ventricular ejection time (LVET). Theoretically, a higher STR indicates poorer heart function since the isovolumetric contraction time of the ventricles takes longer in relation to the ejection time of the ventricles. As heart function deteriorates, the pre-ejection period increases and the left ventricular ejection time decreases, increasing the STR.

Objective

The purpose of the study was to compare the relationship between ejection fraction (EF) and the ICG parameter STR in patients with known heart failure (HF).

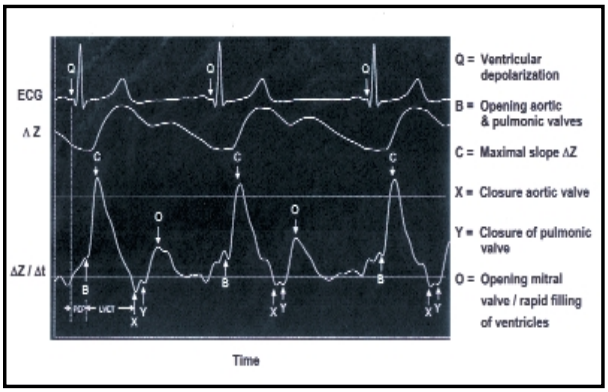
Methods

Patients
Retrospective chart review in consecutive patients enrolled in a comprehensive HF program. Patients with EF and STR measurements conducted within 14 days were included in the analysis.

Ejection Fraction
EF was derived from the multiple gated acquisition (MUGA) scan or echocardiogram (echo) method.

Systolic Time Ratio
Measurement of STR was determined by ICG (BioZ® ICG Monitor, CardioDynamics, CA). ICG requires four dual sensors placed on the neck and chest to transmit a low-amplitude, high-frequency, alternating electrical signal to the patient's thorax. Pulsatile changes in blood volume and velocity are measured as impedance changes, and then applied to electrocardiogram and blood pressure measurements to automatically calculate hemodynamic parameters such as cardiac output/index, systemic vascular resistance/index, and electro-mechanical timing intervals PEP, LVET, and STR (Figure 1).

Figure 1. ECG and ICG fiducial points



Statistical Methods

Paired values of EF and STR were compared. Correlation was calculated using Pearson's method. To evaluate STR as a diagnostic test for EF, a cut-off value of 0.50 was used. Values of EF and STR were compared to calculate sensitivity, specificity, and positive and negative predictive value of an STR $\geq$ 0.50 to an EF $\leq$ 50% or an STR < 0.50 to an EF > 50%.

Results

A total of 52 patients were evaluated. Baseline characteristics are shown in Table 1. MUGA EF was obtained on 23/52 (44.2%) and echo EF on 29/52 (55.8%). Mean EF was 37.6 ± 20.2%, range 10 to 80%. A total of 39/52 (75%) had EF $\leq$ 50%. The mean time between EF and STR measurements was 3.54 ± 4.67 days.

The overall correlation between EF and STR was 0.55 ($p < 0.001$). For identifying an EF $\leq$ 50%, STR $\geq$ 0.50 demonstrated a sensitivity of 92%, specificity of 85%, and positive and negative predictive values of 95% and 79%, respectively. Overall accuracy was 90.4%. Of the five patients in which STR did not agree with the EF category, two were from MUGA EF and three were from echo EF.

Table 1. Patient Characteristics

VARIABLE	N=52 value (%)
Gender	
Male	34 (65.4)
Female	18 (34.6)
Race	
White	34 (65.4)
Black	16 (30.8)
Hispanic	2 (3.8)
HF etiology	
Ischemic	13 (25)
Viral	6 (12)
Pulmonary hypertension	7(13)
Dilated cardiomyopathy	14 (27)
Diastolic dysfunction	3 (6)
Idiopathic	14 (27)
NYHA class	
Class I	2 (3.8)
Class II	17 (32.7)
Class III	2 (3.8)
Class IV	31 (59.6)

Table 2. Results

SYSTOLIC TIME RATIO (STR) VS. LEFT VENTRICULAR EJECTION FRACTION (EF)		
	STR $\geq$ 0.50	**STR < 0.50**
EF $\leq$ 0.50	36	3
EF > 0.50	2	11

Discussion

In this retrospective analysis, STR demonstrated a strong relationship with EF and was able to reasonably distinguish EF above 50% from EF 50% or below. The management of HF necessitates the frequent assessment of a patient's changing status.

Measurement of EF is considered an important diagnostic tool to quantify left ventricular function. However, serial measurements of EF are not considered to be cost effective to guide more frequent evaluation of disease progression or improvement based on treatments that target neurohormonal or hemodynamic dysfunction.

In contrast, the measurement of STR using ICG may offer such promise, as it is inexpensive and relatively simple to perform, taking only a few minutes in the outpatient or hospital setting. Decreases in STR could identify responses to therapy and increases in STR could signal potential decompensation.

Limitations

Because this study was retrospective in design, a prospective validation is suggested. EF and STR were not determined simultaneously, allowing for the possibility that changes in EF or STR may have occurred during the time between the two measurements.

Conclusions

The STR parameter has the potential to be a cost-effective and reliable method of determining the presence of left ventricular dysfunction in chronic HF, and may aid in decision making of evidence-based HF treatment strategies.