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Congestive Heart Failure

For Clinicians Treating Congestive Heart Failure and its Co-Morbid Conditions Including Hypertension and Coronary Artery Disease

MODALITIES • CONCEPTS • MANAGEMENT

Difficult Cases in Heart Failure

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Editors

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Atrioventricular Interval Optimization Utilizing Thoracic Electrical Bioimpedance

The authors describe the use of thoracic electrical bioimpedance, a noninvasive, simple, low risk technique to optimize atrioventricular delay in a patient with a dual chamber pacemaker, right ventricular infarct, and symptoms NYHA Functional Class III–IV. Optimization of the atrioventricular interval was associated with improvement of hemodynamic parameters and resolution of the symptoms of heart failure. The application of noninvasive hemodynamic parameters might have a great deal of impact in the management of patients with several cardiovascular diseases. Multicenter studies are underway.
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Thoracic electric bioimpedance (BioZ® Systems) is a new, low cost, low risk noninvasive tool, which allows the continuous recording of hemodynamic parameters, including cardiac output, stroke volume, and cardiac contractility.[1] Although its use is not widespread, it can be utilized to tailor medical therapy to hemodynamic parameters in patients with heart failure. We report herein, a case of a patient with a low cardiac output state secondary to a right ventricular infarct in whom, atrioventricular conduction and heart rate in a dual chamber pacemaker were optimized to achieve an adequate cardiac output utilizing thoracic electric bioimpedance.

Case Report

A 46 year old white female with a history of an aortic valve replacement and a right ventricular infarct requiring the insertion of a dual chamber pacemaker and heart failure symptoms, NYHA Functional Class III–IV, was transferred to our institution for a heart transplant evaluation. Upon examination she complained of chronic dyspnea on exertion, orthopnea, and fatigue with a decrease in exercise capacity limited to 50 feet. These symptoms started after the aortic valve replacement and became progressively worse in the last 2 years. Reviewing her medical records it was found that she had a right ventricular infarction secondary to a surgical sacrifice of the right coronary artery. The latter required the insertion of a dual chamber pacemaker. In addition, she once had ventricular arrhythmias treated with amiodarone. She was admitted to the telemetry unit for evaluation. Her past medical history was also significant for hypothyroidism. Her physical examination revealed a blood pressure of 100/80 mm Hg in both arms, a heart rate of 60 bpm, a right ventricular lift, tricuspid regurgitation, jugular venous pressure of 10 cm H_2O, and bilateral lower extremity edema. Medication at the time of admission were: warfarin 5 mg a day, levothyroxine 0.1 mg a day, torsemide 20 mg tid, spironolactone 100 tid, and amiodarone 200 mg once a day. The ECG revealed sinus rhythm with a rate of 58 and a right bundle branch block. An echocardiogram revealed a dilated right ventricle and right atrium, a normal functioning prosthetic valve in the aortic position, and a normal left ventricular function. A noninvasive assessment of hemodynamic parameters, utilizing thoracic electric bioimpedance, was performed and revealed a cardiac output of 4.2 L/min and a cardiac index of 2.1 L/min/m^2. In addition, the thoracic fluid content, a parameter of fluid load, was 50 KOhm^{-1} (normal values: 21–37 KOhm^{-1}). Her laboratory tests were normal and her TSH was within normal limits. The decision was made to apply thoracic bioimpedance continuously and interrogate the pacemaker, to change the settings, in order to achieve a better cardiac output. Upon interrogation of the pacemaker, several modifications in its settings were performed and hemodynamic parameters were measured at the same time. When the rate was modified to 85 bpm and the atrioventricular interval was modified to 180 msec, the cardiac output increased to 6.0 L/min and the cardiac index to 3.2 L/min/m^2. These changes represented a 30% increase in these hemodynamic parameters; the patient had a brief episode of flushing that abated quickly. She was discharged the next day and at the time she was walking 250–300 feet without dyspnea or fatigue. Two months later the patient continued to do well and hemodynamic parameters remained normal (cardiac index 3.0 L/min/m^2 and thoracic fluid content 26 KOhm^{-1}).

Discussion

The patient reported herein demonstrates the use of thoracic electric bioimpedance to adjust the settings of a dual chamber pacemaker in order to achieve a better hemodynamic profile. In addition, these changes were associated not only with an improvement of hemodynamic parameters, but also with a resolution of symptoms.

Thoracic electrical bioimpedance (BioZ® Systems) is a technology which converts the measurement of electrical resistance of the thorax to a high frequency, low and constant magnitude electrical current into a host of parameters related to different physiological functions. This tool is a noninvasive, low cost, low risk technique in which, the thorax acts as a transducer and the surface electrodes placed at both ends (on the neck and at diaphragm level) provide the connection. This equipment (Figure) utilizes a tetrapolar system of electrodes, separating the measurement current pathway from the thoracic electrical bioimpedance sensing pathway. One set of external surface pregelled electrodes (usually two pairs) placed on the upper abdomen and upper neck is the source and sink of a constant magnitude, high frequency measurement current, which provides homogenous coverage of the thorax with a high frequency electrical field. The high frequency current develops and high frequency voltage across the thorax, proportional to the thoracic electrical bioimpedance, is sensed by a second set of electrodes. This set of electrodes (usually also two pairs) is located at the landmarks delineating the thorax (i.e., the root of the neck and the diaphragm [xiphoid process]) level. The ECG is also detected by this set of electrodes. The ECG QRS complex is utilized as a clock (timing signal) of the thoracic electrical bioimpedance and its Q time is used as the starting point of measurement of the systolic time interval. Since the blood through the thoracic aorta has the highest conductivity, the detection of changes in the pulsatile flow as a function of time allows the calculation of cardiac out stroke volume, thoracic fluid conductivity, and other hemodynamic indices, such as indices of contractility. It is important to emphasize that these measurements are reproducible and carry fewer costs and risk than right heart catheterization.[2,3]

Interestingly, this technology can also be used with a great deal of accuracy, if patients have different types of pacemakers,[4] as it was done in our patient. Changes in the dual chamber pacemaker settings, more importantly the atrial ventricular interval, allowed improvement in this patient not only in cardiac output but also in resolution of the symptoms. In patients with right ventricular failure as

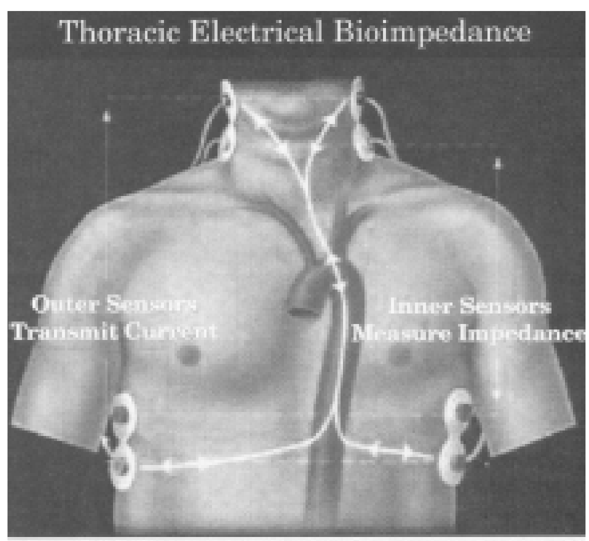

Figure. Thoracic electrical bioimpedance technology.

well as in patients with heart failure, it is very important to maintain normal atrioventricular conduction and having a noninvasive technique that is useful in measuring accurate hemodynamic parameters becomes of paramount importance. In addition, the application of this technique in the outpatient setting during the follow up period allows the physician to correlate the clinical improvement with changes in the hemodynamic parameter, longitudinally.

Conclusion

Thoracic electrical bioimpedance is a noninvasive tool that can be used in many settings, including in critical care. We have also shown that this technique is useful to maximize pacemaker function in order to achieve an optimal cardiac output in a patient with right ventricular failure secondary to a right ventricular infarction.

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