Introduction

Cardiac pacing may induce haemodynamic alterations. RV pacing may have deleterious effects including a decrease of LV function as well as an increase of heart failure hospitalizations and mortality. Biventricular pacing is established in patients with heart failure and left bundle branch block or chronic AV block to improve haemodynamics. In the future, device optimization employing quadripolar leads or multisite pacing may further increase the rate of responders. However, clinical evaluation represents the most important tool to recognize the necessity for device optimization. Device algorithms are not yet successfully established to replace clinical and echocardiographic evaluation.

Right Ventricular Pacing

Permanent cardiac pacing is the treatment of choice for patients with chronic high-degree atrio-ventricular (AV) block or symptomatic sick sinus syndrome (SSS). Most regularly the right ventricular (RV) pacing electrode is placed in the RV apex (RVA). However, various clinical studies have suggested that electrode placement in the RVA may induce a dyssynchronous contraction. This may further result in a reduction of left ventricular (LV) function, myocardial perfusion defects and severe heart failure. A negative effect of RV pacing was proven in a large cohort study of 11,426 patient who underwent pacemaker implantation. The authors reported a significant increase of heart failure events such as hospitalization or death due to heart failure. In a cohort of 304 patients permanent RV pacing was associated with heart failure in 26% of these patients. In a small group of 43 patients who were chronically paced due to complete AV block exercise myocardial scintigraphy was performed to assess myocardial perfusion in combination with radionuclide ventriculography to assess left ventricular function. This study revealed a relevant incidence of myocardial perfusion defects that were associated with apical wall motion abnormalities and a reduced global LV function. Apart from an increased risk of heart failure hospitalizations an increased occurrence of atrial fibrillation in the presence of ventricular desynchronization due to RV pacing has also been observed. In the DAVID-trial which included a total of 506 patients with implantable cardioverter-defibrillator (ICD) dual-chamber pacing was associated with an increased occurrence of the combined end point of death or hospitalization for heart failure as compared with patients who received a single-chamber ICD for backup pacing. The benefits of atrial pacing as compared with ventricular pacing in patients with SSS have already been confirmed in a study of 225 patients with a follow-up over 8 years. In this study, the authors described a significantly higher survival, less atrial fibrillation, fewer thromboembolic complications and less heart failure in patients who underwent atrial pacing as compared with patients who were paced in the RV.

The negative effects described in these studies are the result of several mechanisms. RVA pacing induces an abnormal electrical and mechanical activation of the ventricles.

Key Words:
Cardiac Pacing, Right Ventricular Pacing, Cardiac Resynchronization Therapy, Quadripolar Leads, Multisite Pacing.

Disclosures:
None.

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Biventricular Pacing

Biventricular pacing is generally recognized to improve clinical outcomes and to reduce heart failure hospitalizations and mortality in patients with chronic and symptomatic heart failure despite optimal medical therapy. In a large meta-analysis, cardiac resynchronization therapy (CRT) with biventricular pacing led to a decrease in hospitalizations by 37% and a decrease of mortality by 22% as compared with controls. The underlying mechanisms for the haemodynamic amelioration induced by CRT are attributed to the correction of electrical and mechanical dyssynchrony. Various clinical studies have underlined the beneficial effects of CRT in patients with severe heart failure and left bundle branch block. In addition, single left ventricular pacing has also been evaluated as a potential beneficial therapy in patients with heart failure. Auricchio et al. reported an increased aortic pulse pressure in patients with severe heart failure and wide left bundle branch block in the presence of left ventricular pacing employing an epicardial left ventricular lead. An enhanced contractile function by left ventricular pacing at the site of the greatest electrical delay was also described in other small cohorts of heart failure patients. In a recent meta-analysis of randomized controlled trials which compared biventricular to LV pacing a similar improvement of the clinical status was described. However, the authors reported a trend toward superiority of biventricular pacing over LV pacing for reverse remodeling and LV function. Another systematic review including 630 patients of randomized controlled trials biventricular and LV pacing appeared to achieve similar effects regarding all-cause mortality and hospitalizations. Of note, biventricular pacing was superior to conventional right ventricular pacing in patients with AV block and LV systolic dysfunction regarding death from any cause, urgent visit for heart failure or intravenous therapy. Furthermore, the LV end-systolic volume index was increased.

Potential Of Quadripolar Leads For Haemodynamic Device Optimization

Pacing the LV at the latest activated site is predictive of a most optimal increase in contractility. Standard haemodynamic device optimization involves optimization of the atroventricular delay as well as the interventricular delay. Some devices present algorithms for atrioventricular or interventricular delay optimization albeit echocardiographic optimization is commonly recognized to be superior for haemodynamic outcome. The development of multipolar pacing leads for placement in the coronary venous system can be regarded as one of the most important advancements of the last years. These leads have been evaluated in various clinical studies. An improved haemodynamic response associated with higher responder rates of biventricular pacing was reported for quadripolar leads as compared with unipolar or bipolar leads in a cohort of 27 patients. Tools for non-invasive haemodynamic analysis to assess haemodynamic response are measurement of cardiac output, blood pressure, total periphery resistance, LV diameters and volumes as well as stroke volume. A large multicenter study including 418 patients showed significantly lower rates of lead-related problems as well as reduced procedural and fluoroscopic times for system implantation.

In addition, a trend to a lower risk of surgical LV lead revision and a lower incidence of dislodgment was described. A lower rate of hospitalizations for heart failure and LV surgical lead revision for quadripolar leads as has also been reported in a cohort of 193 patients. Furthermore, the employment of quadripolar leads enables the clinician to perform haemodynamic vector personalization and thereby increase the rate of responders of cardiac resynchronization therapy. In single-center studies, echocardiographic optimization in the presence of quadripolar leads resulted in a significant improvement of functional NYHA class and LV ejection fraction over a period of 6 months.

Apart from quadripolar leads, multisite pacing also represents a promising perspective to increase the rate of responders. A significant reduction of echocardiographic dyssynchrony by multisite pacing has been described in a population of 52 patients. Multisite pacing can be achieved by placement of multiple pacing leads within the coronary sinus and its tributaries or by employing a quadripolar (or multipolar) lead to deliver pacing stimuli at different sites of the same vein.

Conclusions

Cardiac pacing regularly induces haemodynamic alterations. RV pacing is associated with deleterious effects including a decrease of LV function and an increase of hospitalizations and mortality. Biventricular pacing is an established therapy in patients with heart failure and left bundle branch block or chronic AV block to improve haemodynamics. In the future, device optimization employing quadripolar leads or multisite pacing may further increase the rate of responders. However, clinical evaluation represents the most important tool to recognize the necessity for device optimization. Device algorithms are not yet successfully established to replace...
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