Three-dimensional echocardiography with left ventricular strain analyses helps earlier prediction of right ventricular pacing-induced cardiomyopathy

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Background and objectives: Right ventricular (RV) pacing can lead to progressive ventricular dysfunction over a certain period. This pacemaker-induced cardiomyopathy (PiCMP) may be more common than previously reported. Speckle tracking imaging is a recent development in echocardiography that can identify left ventricular (LV) dysfunction even before the LV ejection fraction (LVEF) value decreases. Three-dimensional (3D) echocardiography has made more accurate assessment of LVEF possible. The objectives of this study are to study the incidence of RV PiCMP using 3D echocardiography and LV strain analysis over a follow-up of 6 months, and to identify its predictors.

Methods: This is an observational study of consecutive patients without structural heart disease and with a baseline EF of more than 45% who received a permanent pacemaker. They were observed over a 6-month period. PiCMP was defined as a decrease in LVEF by 10 percentage points or a decrease in LV strain by 15% from baseline in the absence of other known causes of cardiomyopathy. PiCMP incidence and its associations were analyzed over a 6-month period.

Results: The incidence of PiCMP was not only significant over a period of 6 months but also at 24 hours. Significant drops in 3D EF were noted in one (2.8%) patient at 24 hours and in another four (11.1%) patients at 6 months. A significant decrease in LV global longitudinal strain was noted in 23 (63.9%) patients by 6 months. In seven of these patients, there was significant decrease in global longitudinal strain 24 hours after implantation. In analyzing longitudinal strain, the parameter significantly influencing a decrease was a pacing percentage of $\geq$20% ($p = 0.023$).

Conclusions: PiCMP is not uncommon in patients undergoing pacemaker implantation and is associated with RV pacing. PiCMP was associated with a ventricular pacing percentage of $\geq$20%. 3D echocardiography with LV strain analysis plays a vital role in identifying LV dysfunction at an earlier stage compared to EF. PiCMP, if picked up and intervened upon early, can help impede its progression.

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Introduction

Implantable cardiac pacing devices are the only effective treatment for symptomatic bradyarrhythmias, and right ventricular (RV) apex has been the traditional site of pacing because of ease of implantation and lead stability. However, RV pacing can lead to progressive ventricular dysfunction by causing electrical and mechanical dyssynchrony. This pacemaker-induced cardiomyopathy (PiCMP) may be more common than previously reported. PiCMP has been variably defined based on decrease in left ventricular ejection fraction (LVEF) as assessed by two-dimensional echocardiography. One accepted definition is a decrease in LVEF by 10 percentage points. The recent development of speckle tracking echocardiography (STE) to measure LV strain has facilitated detection of LV systolic dysfunction before a perceptible change in EF occurs. Three-dimensional (3D) echocardiography has also made assessment of LVEF more accurate. In this observational study, our intent was to estimate the incidence of PiCMP as assessed both by LV strain and LV 3D ejection fraction (3D EF) and identify the factors predicting its incidence.

Abbreviations

3D	three-dimensional
EF	ejection fraction
GLS	global longitudinal strain
LV	left ventricular
PiCMP	pacemaker induced cardiomyopathy
RVOT	right ventricular outflow tract
RVHS	right ventricular high-septum
RVMS	right ventricular mid-septum
RVA	right ventricular apex
RVFW	right ventricular free wall
STE	speckle tracking echocardiography

Methods

After institutional review board approval was obtained, consecutive patients undergoing permanent pacemaker implantation in our institution were recruited over a 6-month period, and each patient was followed up for a minimum of 6 months. Informed written consent was taken from all patients included in our study. The inclusion criteria were adult patients with permanent pacemaker implantation [VVI (R)/DDD (R)/VDD (R)] and normal EF (more than 45% by two-dimensional Simpson's method) at the time of implantation. The exclusion criteria were patients undergoing implantable cardioverter defibrillator implantation or cardiac resynchromization therapy, structural heart disease defined as the presence of congenital cardiac disease (shunt lesions and complex cyanotic and acyanotic heart diseases), valvular heart disease, or cardiomyopathies, and patients with arrhythmias such as atrial fibrillation, frequent ventricular ectopics, or any incessant tachycardia that can produce LV dysfunction. A total of 36 patients were recruited during the study period.

All patients underwent echocardiography at baseline prior to pacemaker implantation, and at 24 hours and 6 months after implantation. Echocardiography was performed by the primary investigator using Vivid E9 (GE Healthcare System, Horten, Norway) ultrasound system with 4V-D transducer (volume phased matrix array with a frequency range of 1.5–4.0 MHz). LV strain was calculated using 4D Auto LVQ software (GE Healthcare system, GE Vingmed Ultrasound A/S, Horten, Norway) offline. A standard 12-lead surface electrocardiogram at 25 mm/s was done immediately after implantation, and paced QRS width and axis were determined using standard criteria. The site of RV pacing was determined by chest X-ray in both posteroanterior and lateral views. In lateral view, lead position was divided as apical and nonapical. RV lead-tip position in the posteroanterior view was classified as RV outflow tract (RVOT), RV high-septum (RVHS), RV mid-septum (RVMS), RV apex (RVA), and RV free wall (RVFW) as described previously by Thebault et al. [1]. For analysis RVOT, RVHS, and RVMS were grouped together, and RVFW and RVA were considered together. Pacemaker interrogation was done immediately after implantation and at 6 months. PiCMP was defined as decrease in LVEF by 10 percentage points or a decrease LV global longitudinal strain (GLS) by 15% from baseline (not the absolute decrease in GLS value) in the absence of other known causes of LV dysfunction. This is assessed at 24 hours and at 6 months.

Statistical methods

All the categorical variables such as sex, type of pacemaker, ventricular lead position, paced QRS axis quadrant, and ventricular pacing percentage were summarized as frequency and percentage (%). All continuous variables such as age, QRS duration EF, and longitudinal strain were examined for normality and summarized as

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