Virtual Computer Simulation Modeling for Prediction of Response to Cardiac Resynchronization Therapy

Jae-Sun Uhm
Min-Cheol Park
Min Kim
In-Soo Kim
Moo-Nyun Jin
Hee Tae Yu
Jaewon Oh
Chan-Joo Lee
Tae-Hoon Kim
Boyoung Joung
Hui-Nam Pak
Seok-Min Kang
Minki Hwang
Moon-Hyoung Lee
Eun Bo Shim

Introduction: Although cardiac resynchronization therapy (CRT) is an effective treatment strategy in patients with heart failure, it still has a problem in identifying non-responders to CRT. We recently developed the in-silico CRT modeling. The objective of this study was to validate the accuracy of the in-silico model.

Methods: We retrospectively included 14 patients (age, 66.1 ± 10.7 years, 4 men) with CRT who underwent cardiac computed tomography (CT) and magnetic resonance (MR) before CRT implantation. To construct the in-silico CRT model, we combined the 3D image using cardiac CT and MR images, based on electromechanical ventricular model with a lumped model of the circulatory system and electric pacing device (Figure). In-silico CRT response was defined as \( \Delta \text{left ventricular end-systolic volume (LVESV)} = \frac{\text{LVESV}_{\text{pre-CRT}} - \text{LVESV}_{\text{post-CRT}}}{\text{LVESV}_{\text{pre-CRT}}} \times 100 \geq 15\% \). We compared in-silico CRT response with clinical CRT response.

Result: In the in-silico model, 8 in 14 patients were CRT-responders. In clinical observation, 5 in 14 patients were CRT-responders. Positive and negative predictive value and accuracy rate of the in-silico model were 62.5%, 100%, and 78.6%, respectively. Agreement of CRT-responder between the in-silico model and clinical observation was moderate (Cohen’s \( \kappa \) coefficient = 0.588, \( p = 0.016 \)).

Conclusion: The present in-silico CRT modeling was feasible in identifying CRT-responders.