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Immediate mechanical effects of acute left bundle branch block by speckle tracked strain

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Abstract

Introduction: Left bundle branch block (LBBB) is a known complication of transcatheter aortic valve replacement (TAVR) and has been shown to predict worsened outcomes in TAVR patients. A regional longitudinal strain pattern, termed the "classic" pattern of left ventricular (LV) dyssynchrony, which is thought to be due to LBBB, is highly predictive of response to cardiac resynchronization therapy. Whether LBBB causes this "classic" pattern is not known.

Methods: We retrospectively studied patients undergoing TAVR who also underwent pre- and post-TAVR strain analysis to determine if the "classic" pattern arose in those who developed TAVR-induced true LBBB. After removing patients with baseline conduction abnormalities or insufficient studies 9 patients had sufficient data for analysis. Six patients developed LBBB after TAVR and 3 patients did not develop LBBB after TAVR. ECGs were analyzed for the new onset of LBBB after TAVR. Global longitudinal strain (GLS) and regional longitudinal strain patterns were analyzed for changes between pre- and immediately post-TAVR examinations.

Results: Patients who did not develop LBBB showed no significant changes in their regional longitudinal strain pattern. Those patients who did develop LBBB showed significant increase in their difference of time-to-onset of contraction between the septal and lateral walls post-TAVR (22 ± 14 ms vs 111 ± 49 ms; $p = 0.003$) and in their difference of time-to-peak contraction between the septal and lateral walls post-TAVR (63 ± 56 ms vs 133 ± 46 ms; $p = 0.002$). Early lateral wall pre-stretch and delayed lateral wall peak contraction emerged in all patients with LBBB but early septal peak contraction meeting the established criteria was present in only one patient.

Discussion: The onset of LBBB led to acute, measurable changes in the regional longitudinal strain pattern consisting of early lateral wall pre-stretch and delayed lateral wall peak contraction. These represent 2 of the 3 findings in the "classic" pattern of LV dyssynchrony. Early termination of septal wall contraction meeting established criteria was not routinely found. Time and/or other factors may be required to develop the full "classic" pattern.

Keywords: Left bundle branch block; Cardiac resynchronization therapy; Regional longitudinal strain; Congestive heart failure; Dyssynchrony

Introduction

The relationship between left bundle branch block (LBBB) and congestive heart failure (CHF) is complex and the mechanism by which LBBB may lead to worsening of CHF is not yet fully elucidated. Early work by Prinzen and colleagues demonstrated that dyssynchronous mechanical

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contraction of the left ventricle (LV), induced by RV apical pacing in canines, could be directly visualized using strain analysis [1–3]. Typical findings included early stretching and late contraction of segments that experience delayed electrical activation as well as variable early termination of contraction in segments that experienced no delay in electrical activation.

Advancing from this data, a set of echocardiographic regional strain analysis criteria which were hypothesized to reflect mechanical patterns resulting from underlying LBBB was recently developed and termed the "classic" pattern of regional longitudinal strain. These criteria were used to predict responsiveness to cardiac resynchronization therapy (CRT) in patients with CHF and were found to be highly predictive (95% sensitive and 91% specific) of response to CRT [4] and correlated with new, strict criteria for true LBBB by 12-lead ECG [5]. This characteristic strain pattern involves early stretching of the lateral wall, delayed lateral wall peak contraction and early peak contraction of the septal wall. These findings in patients are correlates to the progression of physiologic changes contemporaneously published by Leenders and Prinzen et al. which have been studied using computer modeling [6]. Taken together, these data suggest that those patients who exhibit true LBBB physiology, as opposed to nonspecific intraventricular conduction delay (IVCD) with which it is often confused based on EKG, are likely responders to CRT. However, whether or not the development of LBBB actually leads to the "classic" pattern is unknown.

LBBB is a known complication of aortic valve replacement and has been demonstrated to develop in approximately 30%–50% of patients undergoing certain types of transcatheter aortic valve replacement (TAVR) procedures. Recent data from Houthuizen and Prinzen et al. have shown that patients who develop LBBB after TAVR are at increased risk for death [7]. The cause of this phenomenon is unclear at this time.

While some patients with LBBB progress to (LV) dilatation and CHF, many do not. The relationship between LBBB and mechanical response and the progressive impairment of LV function are not well proven in patients. The TAVR population represents an excellent human population to study the mechanical effects of LBBB because of the ability to precisely identify the time of onset of LBBB and because new EKG findings consistent with LBBB found immediately after TAVR can be safely assumed to represent true LBBB and not IVCD, which develops progressively over time [8]. The aim of this present study was to use the combined observations of these previous studies to explore the hypothesis that the acute onset of LBBB would result in acute mechanical changes in regional longitudinal strain compatible with the "classic" strain pattern which is thought to be caused by true LBBB. To our knowledge, this association has not been previously demonstrated.

Methods

Study population

All patients receiving TAVR at Duke University Medical Center in the 26 months between January 1, 2011 and February 28, 2013 were retrospectively screened for enrollment. All patients who underwent TAVR had 12-lead ECG and echocardiographic studies pre- and post-TAVR. Echo examinations at our center for TAVR patients were performed with multiple vendor ultrasound platforms. For our study we utilized only those studies performed using GE Vivid 7 (GE Vingmed Ultrasound, Horten Norway) imaging systems. Regional strain analyses on available GE studies were performed as in previous studies investigating the "classic" pattern of mechanical delays [4] using GE EchoPAC software BT12 (GE Vingmed Ultrasound, Horten, Norway). Strain analysis could not be performed with this software using other vendor platforms. For this software echocardiographic data must be obtained on GE ultrasound machines. Therefore patients who did not have both pre-TAVR and post-TAVR studies performed on a GE system were not able to be included in our study. Available strain data in patients who developed LBBB after TAVR were compared to patients who did not develop LBBB.

All patients had pre- and post-TAVR ECGs for determination of the presence of procedure-induced LBBB. The average number of days the ECGs were obtained prior to and after the TAVR procedure were 8.6 days (range 0–85 days) and 1.1 days (range 0–4 days), respectively.

Of the 110 patients screened for enrollment, 31 patients had available studies performed on GE Vivid 7 or E9 equipment both pre- and post-TAVR (Fig. 1). All remaining patients had studies conducted using other vendor equipment.

Of the 31 patients with sufficient echocardiograms, 9 had baseline abnormal conduction and were excluded (1 with LBBB, 4 with RBBB, 1 with LAFB, 3 were paced). All remaining patients were in normal sinus rhythm at baseline without the presence of any bundle branch or fascicular block. Of the 22 remaining patients with sufficient echocardiographic data and normal conduction at baseline, 2 patients had pacemaker implantation early post-TAVR and

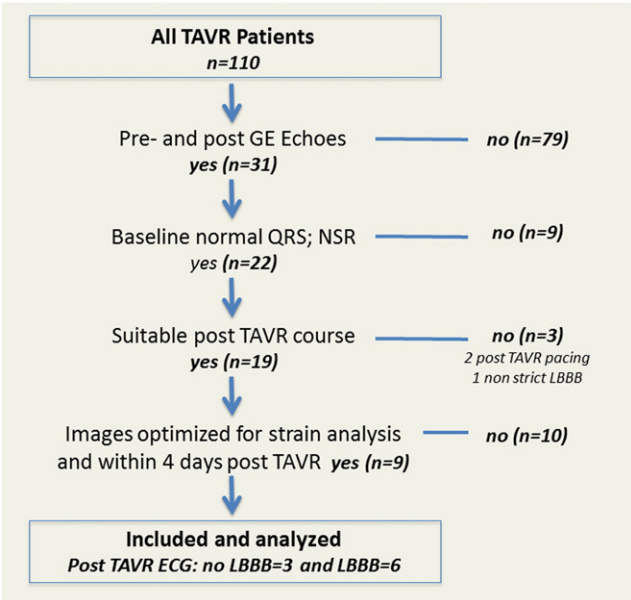

Fig. 1. Flow chart for inclusion/exclusion of patients in this study.