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Echocardiographic diastolic function assessment is of modest utility in patients with persistent and longstanding persistent atrial fibrillation

Mária Kohári [a,b,1], David R. Okada [c], Larraitz Gaztanaga [a], Erica Zado [a], Francis E. Marchlinski [a], David J. Callans [a], Yuchi Han [a,*]

[a] Hospital of the University of Pennsylvania, Cardiovascular Division, Philadelphia, PA, United States
[b] Second Department of Internal Medicine and Cardiology Centre, University of Szeged, Szeged, Hungary
[c] Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, United States

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ABSTRACT

Background: Detection of concurrent diastolic dysfunction (DD) may be beneficial in patients with persistent and longstanding persistent atrial fibrillation (AF). The role of transthoracic echocardiography (TTE) in assessing DD in patients with AF has not been well characterized. We sought to determine the utility of TTE in detecting elevated left atrial pressure (LAP) in patients with persistent and longstanding persistent non-valvular AF using directly measured LAP as the reference standard.

Methods: We retrospectively studied 157 patients with persistent AF and preserved left ventricular ejection fraction who underwent pulmonary vein isolation (PVI). LAP was determined in conjunction with trans-septal puncture at the time of catheter ablation. TTE was performed 1 day after PVI and included two dimensional, pulse wave spectral Doppler and tissue Doppler assessments.

Results: The clinical parameter that strongly correlated with elevated LAP is longstanding persistent AF. Four strongest TTE parameters identified to moderately correlate with LAP include 1. left atrial minimum volume (LAVmin), 2. peak velocity of early mitral diastolic inflow velocity (E), 3. pulmonary vein systolic flow velocity (PVS), and 4. ratio of early diastolic transmitral inflow velocity to mitral annular velocity at the lateral site (E/E′ lateral).

Conclusion: Accurate assessment of diastolic dysfunction in patients with persistent and longstanding persistent AF is difficult using TTE. A combination of LAVmin, PVS, and E might be helpful to determine elevated LAP.

1. Introduction

Atrial fibrillation (AF) and heart failure (HF) are among the most common cardiac diseases encountered in clinical practice, and their incidence is rising as the population ages. Patients with concurrent AF and chronic HF, including those with preserved ejection fraction, have worse prognosis than patients with AF alone [1,2]. Accurate diagnosis of coexisting diseases is essential to the initiation of appropriate therapies. Recent studies have demonstrated the importance of early detection of diastolic dysfunction (DD) in patients with persistent and longstanding persistent AF [3–6]. Transthoracic echocardiography (TTE) is routinely used in the evaluation of diastolic function, but its utility in detecting DD in patients with persistent and longstanding persistent AF has not been well characterized. The ventricular filling index, or the ratio of early diastolic transmitral velocity E and early diastolic tissue Doppler velocity of the mitral annulus E/E′, is one of the commonly used TTE parameters that is sensitive for detection of elevated left atrial pressure (LAP) in patients with preserved ejection fraction [7,8]. There is work to suggest that E/E′ may also be sensitive for the detection of elevated LAP in a small cohort of 27 non-valvular AF patients; E/E′ septal ≥11 predicts elevated LV filling pressure (≥15 mm Hg) with sensitivity of 75% and specificity of 93% [9]. E/E′ also correlated with symptomatic HF in AF patients with preserved ejection fraction (EF) and E/E′ decreased with symptomatic improvement [10]. However, the potential role of other routinely used TTE parameters of diastolic function in detecting elevated LAP in patients with AF is not clear. Therefore, we sought to determine the utility of two dimensional (2D), pulsed wave spectral Doppler (PWD), and tissue Doppler imaging (TDI) echocardiographic parameters in detecting elevated LAP in a large cohort of

Abbreviations: AF, atrial fibrillation; HF, heart failure; LAP, left atrial pressure; RFA, radiofrequency catheter ablation; TTE, transthoracic echocardiography; LA, left atrium; LAA, left atrial area; LAV, left atrial volume; LAVi, indexed left atrial volume; E, early transmitral diastolic inflow; DT, deceleration time; PVS, pulmonary vein systolic flow velocity; PVD, pulmonary vein diastolic flow velocity; E/E′, ratio of early peak transmitral inflow to mitral annular motion velocity.

* Corresponding author at: Hospital of the University of Pennsylvania, 9 Gates Pavilion, Cardiovascular Division, 3400 Spruce Street, Philadelphia, PA 19104, United States.
E-mail address: Yuchi.han@uphs.upenn.edu (Y. Han).

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patients with persistent and longstanding persistent non-valvular AF using directly measured LAP as the reference standard.

2. Methods

2.1. Study population

The study protocol was approved by the Institutional Review Board at our institution with waiver of consent for retrospective review of existing clinical images. There were 493 patients with drug refractory persistent and longstanding persistent AF who underwent pulmonary vein isolation (PVI) by radiofrequency catheter ablation at our institution between April 2009 and April 2011. The patients were excluded from analysis if they had previous catheter ablation (251 patients), a history of open heart surgery (17 patients), moderate or severe mitral regurgitation (14 patients), reduced left ventricular (LV) ejection fraction (EF) (<50%, 30 patients), mitral annular calcification (5 patients), pacemaker dependency (4 patients), were in AF at time of TTE (7 patients), and no left atrial (LA) pressure registration (25 patients). Of the remaining 157 patients with chronic AF, 121 had persistent AF, defined as continuous AF for greater than 7 days or cardioversion after 48 h of continuous AF [11], and 36 had longstanding persistent AF, defined as continuous AF for greater than 12 months [11]. Clinical data were obtained by reviewing medical records.

2.2. Echocardiography

All patients underwent routine clinical TTE examinations including M-mode, 2D, PWD and TDI on the first post-procedural day following PVI using commercially available echocardiographic machines (Vivid 7; GE Healthcare Technologies, Waukesha, Wisconsin, USA or iE33, Philips Health Care, the Netherlands). All studies were analyzed in a blinded fashion on dedicated workstations (ProSolv CardioVascular Client version 4.0.4). LA diameter (LAD) was assessed in the parasternal long-axis view (PLAX). LA area (LAA) and LA length (LAL) were measured in the apical 4-chamber view (4C) and apical 2-chamber view (2C). LA volume (LAV) was derived using the biplane area–length method. Both LAA and LAV were measured at LV end-systole (LA maximum volume (LAVmax); LA maximum area (LAAmax)) and at LV end-diastole (LA minimum volume (LAVmin); LA minimum area (LAAmin)). LA volume index (LAVi) was calculated based on body surface area (BSA). Mitral inflow measurements using PWD included peak early flow velocity (E) and deceleration time of early mitral flow velocity (DT). Peak late mitral inflow velocity was not measured due to the diminutive atrial contraction post ablation. Pulmonary venous flow on PWD was characterized by peak systolic flow velocity (PVS), peak diastolic flow velocity (PVD) and systolic filling fraction or the ratio of PVS to PVD (PVSD). TDI using spectral Doppler including early velocities from the septal and lateral mitral annulus (E′ septal and E′ lat respectively) was obtained from the apical 4C view. E/E′ was calculated for both lateral and septal annular sites (E/E′ lateral and E/E′ septal respectively) and was also averaged between the two sites (E/E′ average).

2.3. Catheter ablation and left atrial pressure recordings

PVI was performed per routine at our institution as previously described [12,13]. Briefly, multipolar catheters were placed in the coronary sinus and posterior right atrium (RA) and a diagnostic intracardiac ultrasound catheter was advanced to the RA. Two trans-septal punctures were performed through which the ablation and circular mapping catheters were advanced into the LA. A bolus of unfractionated heparin was administered prior to the first trans-septal puncture and infusion was titrated to maintain activated clotting time between 350 and 400 s for the duration of the procedure. Immediately after the trans-septal access, the LA pressure was transduced through the trans-septal needle. LA x-wave pressure nadir, LA peak v-wave pressure, and mean LA pressure were recorded using an electrophysiologic recording system (Prucka-GE, Houston, TX, USA). Elevated LAP was defined as mean LAP equal to or greater than 15 mm Hg. All patients underwent antral PVI [13].

2.4. Statistical analysis

Statistical analyses were performed using STATA software (version 10, StataCorp, Texas, USA). Continuous variables were expressed as mean ± standard deviation and categorical variables were expressed as percentages. Relationship between mean LAP and TTE parameters were evaluated using univariate linear regression analysis followed by multiple linear regression. Potential determinants of elevated LAP were identified by univariate logistic regression analysis and all identified parameters were entered into multiple logistic regression. Comparison of data between the normal and elevated LAP groups was performed by use of a two-tailed, unpaired Student's t test. p values of <0.05 were considered statistically significant.

2.5. Reproducibility

Fifteen randomly selected studies were read by two independent blinded observers to assessing inter-observer variability. The same studies were re-interpreted by the first reader in a blinded fashion 3 months after the initial reading to assess intra-observer variability.

3. Results

3.1. Baseline clinical characteristics

Baseline patient characteristics are shown in Table 1. The patients' mean age was 60.6 ± 8.7 years (range 36 to 78 years). This group of patients is predominantly male and hypertensive. Seventy-seven percent of patients had persistent AF, whereas 23% had longstanding persistent AF. All patients had preserved LVEF (≥50%).

Table 1
Baseline characteristics of patients.

Characteristics	Total (n = 157)
Demographics and comorbidities	
Age (years)	60.6 ± 8.7
BSA (m^2)	2.2 ± 0.2
Gender (% male)	82
Hypertension (%)	67
Diabetes mellitus (%)	17
Stroke (%)	6
LVEF (%)	61.4 ± 6.6
Coronary artery disease (%)	13
History of heart failure (%)	3
Pacemaker or ICD (%)	3
Asthma, COPD (%)	8
Obstructive sleep apnea (%)	26
Thyroid disease (%)	7
Atrial fibrillation (%)	
Longstanding persistent	23
Persistent	77
Baseline medications (%)	
ACE Inhibitor	26
Angiotensin receptor blocker	12
Diuretic	26
Inhaled Beta agonist	3
Beta blocker	40
AAD Class I.	31
AAD Class III.	70
AAD Class IV.	22
Digoxin	16

Abbreviations: LVEF = left ventricular ejection fraction, ICD = implantable cardioverter-defibrillator, COPD = chronic obstructive pulmonary disease, ACE = angiotensin converting enzyme, ARB = angiotensin receptor blocker, AAD = anti-arrhythmic drug.