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# Left atrial strain as evaluated by two-dimensional speckle tracking predicts left atrial appendage dysfunction in patients with acute ischemic stroke

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ABSTRACT

*Background:* Left atrial appendage (LAA) dysfunction predisposes patients with atrial fibrillation (AF) to cardioembolic stroke. Two-dimensional (2D) speckle tracking was reported to be useful for evaluating left atrial (LA) regional function, as well as left ventricular function. However, it remains unclear whether 2D speckle tracking is useful for evaluating LAA dysfunction. Therefore, we investigated whether decreased LA strain may predict LAA dysfunction and thrombus formation in patients with acute ischemic stroke.

*Methods:* We performed transthoracic and transesophageal echocardiography in 120 patients (83 males, mean age 72 ± 11 years) within 7 days of onset of an acute ischemic stroke. Longitudinal LA strain was evaluated using 2D speckle tracking imaging at each LA segment, and peak systolic strain was calculated by averaging the results for each segment.

*Results:* Forty-eight patients had LAA dysfunction as defined by the presence of LAA thrombus and/or severe spontaneous echo contrast. LA peak systolic strain was significantly decreased in patients with LAA dysfunction compared to those without (32.3 ± 13.7% vs. 12.1 ± 7.2%, $p < 0.0001$). LA peak systolic strain was significantly correlated with LAA emptying flow velocity ($r = 0.693$, $p < 0.0001$). The optimum LA peak systolic strain cut-off value for predicting LAA dysfunction was 19%. Multivariate logistic regression analysis showed that LA peak systolic strain was an independent predictor of LAA dysfunction (odds ratio 0.059, 95% confidence interval 0.018–0.146; $p < 0.0001$).

*Conclusion:* Decreased LA peak systolic strain was independently associated with LAA dysfunction in patients with acute ischemic stroke.



## 1. Introduction

Cardioembolic stroke is an important clinical issue, because it is the most common cause of death in patients with acute ischemic stroke [1,2]. The left atrial appendage (LAA) was reported to be a major source of thromboembolism in stroke patients with atrial fibrillation (AF) [3–5]. Many clinical reports have indicated that left atrial (LA) mechanical remodeling is associated with thrombus formation in the LAA [6–8]. The presence of spontaneous echocardiographic contrast or reduced LAA peak flow velocity, as measured by transesophageal echocardiography (TEE), was reported to be useful for detecting LAA dysfunction, which causes thrombus formation in the LAA [9,10]. While transthoracic echocardiography (TTE) is widely used as a screening tool because it is a non-invasive procedure, it is thought to be difficult to detect LAA thrombus and evaluate LAA dysfunction by TTE. Recently, we reported that LAA wall velocity (LAWV) as measured by TTE was a useful parameter for measuring LAA function in patients with AF [11,12].

Two-dimensional (2D) speckle-tracking strain imaging is a novel method for quantitative real-time assessment of regional myocardial deformation that uses tracking of acoustic speckles or kernels rather than Doppler myocardial velocities [13]. It has been suggested that LA strain, as measured by 2D speckle tracking, can be used to evaluate dynamic LA function [14]. However, the association between LA strain and LAA function remains unclear. The aim of this study was to elucidate whether LA peak systolic strain is a novel non-invasive parameter for detecting LAA dysfunction in patients with acute ischemic stroke.

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## 2. Methods

### 2.1. Patients

We performed TTE and TEE in 127 patients referred to our hospital between April 2010 and November 2012 for treatment of acute cerebral infarction within seven days of onset. The median duration from stroke onset to time of TEE was 7 days (range 1–19). Patients with advanced malignant tumors, and/or infectious disease (n = 5), and those in whom TEE had failed (n = 2), were excluded. We enrolled 120 patients in the present study. We assessed the prevalence of risk factors for cerebral infarction at admission [15,16]. All patients underwent cerebral computed tomography and/or magnetic resonance imaging, and then neurosurgeons diagnosed clinical ischemic categories. Clinical ischemic stroke category was defined by the National Institute of Neurological Disorders and Stroke (NINDS) [17], and disease severity was assessed using the US National Institute of Health Stroke Scale (NIHSS) [18]. Patients with a history of AF prior to admission and/or documented AF on continuous electrocardiographic (ECG) monitoring during hospitalization were defined as patients with AF.

According to the NINDS clinical categorization, computed tomography findings, magnetic resonance imaging and TEE results, patients were categorized into two groups based on the incidence of cardioembolic stroke (n = 53, mean age 76 ± 9 years) or non-cardioembolic stroke (n = 67, mean age 69 ± 11 years).

### 2.2. Echocardiography

TTE was performed on a Vivid E9 ultrasound instrument (GE healthcare, Wauwatosa, WI, USA), equipped with a sector transducer (carrier frequency 2.5 or 3.75 MHz). A 5 MHz phased array multiplane probe was used for TEE. The following parameters were assessed using standard views and techniques [19]: left atrial dimension (LAD), left ventricular end-diastolic dimension (LVDd), left ventricular ejection fraction (LVEF), and the ratio of peak early mitral annular velocity to Ewave (E/E′), as measured by TTE. LA volume was assessed at LV end-systole by using the biplanar area-length method from 4- and 2-chamber views. Measurements of LA volume were indexed by body surface area (LA volume index; LAVI) [19]. Tissue Doppler velocities were measured at the septal and lateral annuli using spectral Doppler tissue imaging. LAWV, defined as LAA peak wall velocity, was measured using tissue Doppler imaging with the sample volume of pulsed-wave Doppler placed on the LAA tip [11,12].

LAA thrombus was diagnosed when a fixed or mobile echogenic mass could be clearly differentiated from the wall of the LA or LAA. Spontaneous echo contrast was considered to be present when dynamic, "smoke-like" echoes were seen within the atria and could not be eliminated by changes in the gain settings [20,21]. As previously reported by Fatkin D et al., spontaneous echo contrast was graded from 0 to 4+ by two independent echocardiologists and severe spontaneous echo contrast was judged to be 4+ [10]. LAA emptying flow velocity (eV) was measured using pulsed wave Doppler, with the sample volume placed 1 cm distal from the mouth of the appendage by TEE. LAA eV within each RR interval was determined by scanning the appendage at angles between 0° and 90° [22]. In patients with AF, echocardiographic parameters such as LAA eV and LA strain were calculated as the mean values from five cardiac cycles. We carefully measured parameters only in those cycles in which the preceding and measured cardiac cycles were nearly equivalent. All findings were evaluated by two independent experienced echocardiologists, who were blinded to the clinical and other details of the patients. LAA dysfunction was defined as the presence of LAA thrombus and/or severe spontaneous echo contrast [9,10].

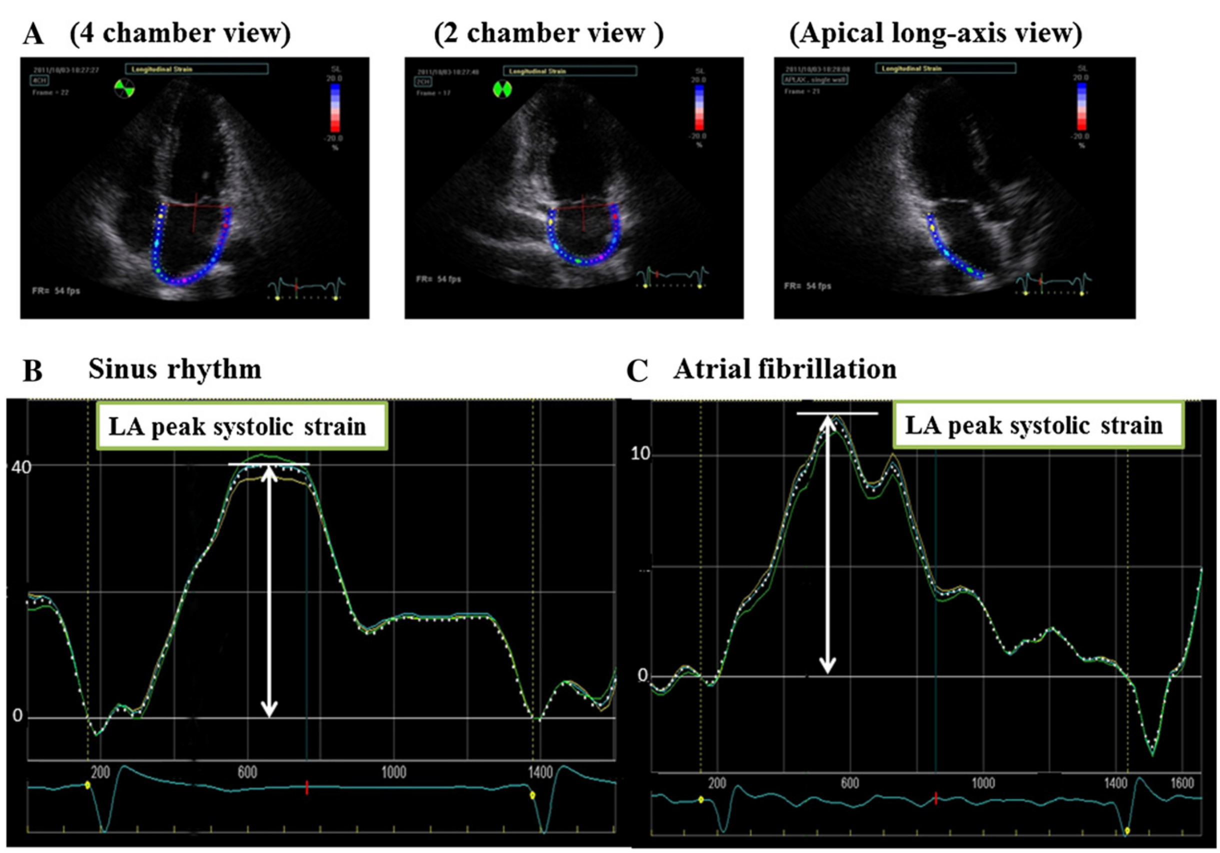


**Fig. 1.** Measurement of LA peak systolic strain. LA strain was estimated by averaging the longitudinal strain data obtained from the apical four-chamber, two-chamber and apical long-axis views. The LA myocardium was divided into five regions of equal area. Five segments were analyzed from the apical four- and two-chamber views, whereas only three segments were analyzed in the apical long axis view. LA, left atrium. We show good LA strain with sinus rhythm in Fig. 1B and bad LA strain with atrial fibrillation (Fig. 1C).