Journal of Cardiology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Cardiology

journal homepage: www.elsevier.com/locate/jjcc

Original article

Aortic annulus displacement assessed by contrast left ventriculography during invasive coronary angiography as a predictor of adverse events

Shingo Kuwata (MD, PhD), Kihei Yoneyama (MD, PhD), Kengo Suzuki (MD, PhD, FJCC), Masaki Izumo (MD, PhD), Kei Mizukoshi (MD, PhD), Kohei Koyama (MD, PhD), Yuki Ishibashi (MD, PhD), Takanobu Mitarai (MD), Ryo Kamijima (MD), Ken Kongoji (MD, PhD), Tomoo Harada (MD, PhD, FJCC), Yoshihiro J. Akashi (MD, PhD, FJCC)*

Division of Cardiology, Department of Internal Medicine, St. Marianna University School of Medicine, Kawasaki, Japan

A R T I C L E I N F O

Article history:
Received 15 August 2015
Received in revised form 30 November 2015
Accepted 1 December 2015
Available online xxx

Keywords:
Coronary angiography
Coronary artery disease
Echocardiography
Heart failure
Ventricular function

A B S T R A C T

Background: We propose the use of aortic annulus displacement (AAD) detected on contrast left ventriculography (LVG) during invasive coronary angiography as a marker of left ventricular (LV) long-axis shortening. In the present study, we aimed to investigate whether AAD is associated with adverse events in patients who underwent coronary angiography because of suspected coronary artery disease.
Methods: In this retrospective study, we evaluated the medical records of 998 consecutive patients who underwent invasive coronary angiography and LVG. LV lengths were measured from the apex to the aortic valve insertion by using LVG images. AAD (%) was calculated as [(LV end-diastolic length − LV end-systolic length)/LV end-diastolic length] × 100.
Results: The participants' median age was 67 years. Ninety-six adverse events (composite events; all-cause death, 39; congestive heart failure, 21; late revascularization, 34; and myocardial infarction, 2) were observed during a median follow-up period of 3.1 years. In multivariate Cox regression analysis, adverse events were associated with lower AAD (hazard ratio, 0.703; $p = 0.002$), after adjusting for traditional risk factors and coronary artery stenosis. The area under the curve of AAD for predicting adverse events was greater than that of LV ejection fraction (0.656 vs. 0.541, $p < 0.05$).
Conclusions: AAD was superior to LV ejection fraction as a predictor of adverse events in patients with and without coronary arterial stenosis. AAD may be the optimal method for assessing longitudinal LV systolic function in the catheter laboratory.

Introduction

Contrast left ventriculography (LVG) has been used to assess LV ejection fraction (LVEF) in clinical practice for almost 50 years [1]. Although LVEF plays an important role in clinical decision making, as many as 40–50% of patients with heart failure have preserved LVEF [2]. In recent years, advances in noninvasive imaging techniques such as echocardiography and magnetic resonance imaging have enabled their successful use in assessing regional and global systolic and diastolic function [3–7]. Myocardial strain, which becomes abnormal during the early stage of heart failure, may serve as an alternate indicator, and it appears to be a sensitive predictor of adverse outcome even in asymptomatic individuals [3–5]. By definition, strain (ε) is the percentage change in muscle length during myocardial contraction and relaxation. Thus, we believe that strain can be estimated from the long-axis displacement at systole and diastole using any imaging modality.

Based on data from the healthcare system, LVG is still reportedly performed during 60–80% of coronary angiographies (CAGs), and there is a wide variation in the views of invasive cardiologists regarding the utility of routine LVG [8,9]. To resolve a limitation of LVEF and a wide variety of views on using LVG, we propose the use of aortic annulus displacement (AAD), possibly representing LV long-axis shortening, as a marker of prognostic indicator in patients who undergo LVG.

* Corresponding author at: Division of Cardiology, Department of Internal Medicine, St. Marianna University School of Medicine, 2-16-1, Sugao, Miyamae-ku, Kawasaki-City, Kanagawa 216-8511, Japan. Tel.: +81 44 977 8111; fax: +81 44 976 7093.
E-mail address: yoakashi-circ@umin.ac.jp (Y.J. Akashi).

http://dx.doi.org/10.1016/j.jjcc.2015.12.012
0914-5087/

In the present study, we aimed to evaluate whether AAD can be prognostically assessed using contrast LVG; moreover, we sought to validate its use as a marker of LV long-axis shortening by evaluating its correlation with findings of longitudinal strain using two-dimensional speckle-tracking echocardiography (2D-STE).

Materials and methods

Patient population

In this retrospective study, we reviewed the records of 1095 patients who had undergone CAG and LVG along with diagnostic cardiac catheterization at St. Marianna University School of Medicine Hospital between May 2009 and August 2012. We did not exclude any degree of valvular disease, but we included all patients who underwent CAG and LVG for a clinical indication. Of these, 10 were excluded from the study because of poor image quality owing to factors such as catheter-induced premature ventricular contraction, whereas 87 were excluded because of atrial fibrillation; thus, 998 patients were included in the final retrospective analysis. All patients received optimal medical therapy, and the catheterization findings were assessed by at least three experienced cardiologists in each case. The St. Marianna University School of Medicine Human Subject Committee approved the study.

CAG and LVG

A description of the CAG method is provided in the online Supplementary 1. Obstructive coronary artery disease (CAD) was defined as stenosis of ≥75% of the diameter of a vessel, with a reference diameter of >1.5 mm, that required revascularization. Multi-vessel CAD was defined as the occurrence of ≥75% stenosis that required revascularization. All CAG findings were adjudicated by at least three experienced cardiologists.

Contrast LVG was performed using a 30° right anterior oblique projection with a 5F pigtail catheter placed in the LV, and 30 mL of contrast medium was injected at a flow rate of 10 mL/s by using the ACIST CVi power injector. Calibration was performed by using the tail-end diameter of the 5F pigtail catheter that was used to introduce the contrast agent. The frame rate of LVG was set at 15 frames/s. The LV end-systolic and end-diastolic volume, stroke volume, and LVEF were measured by using a semi-automated method with the XIDF-QCA801 software (Toshiba Medical Systems, Nasu, Japan), which was designed for quantitative coronary analysis and LV analysis. The LV lengths were measured at end-diastole (A and B in Fig. 1) and end-systole (C and D in Fig. 1). Two basal points were selected, each located in the interventricular anterior and inferior wall side of the aortic valve insertion. The apical endocardium at end-diastole was assessed at a site with the longest distance from the aortic valve annulus. The endocardial apex at systole was assessed at the same point as that during diastole. AAD was calculated as the percentage change in LV length from end-diastole to end-systole. The LV end-diastolic pressure (LVEDP) was defined as the pressure after atrial contraction, just before the increase in LV systolic pressure.

The investigators were blinded to the clinical details. Clinical risk factor measures are provided in online Supplementary 2.

Echocardiography

During LVG, 32 patients underwent 2D-STE (Vivid i portable echocardiography system; General Electric Medical Systems,

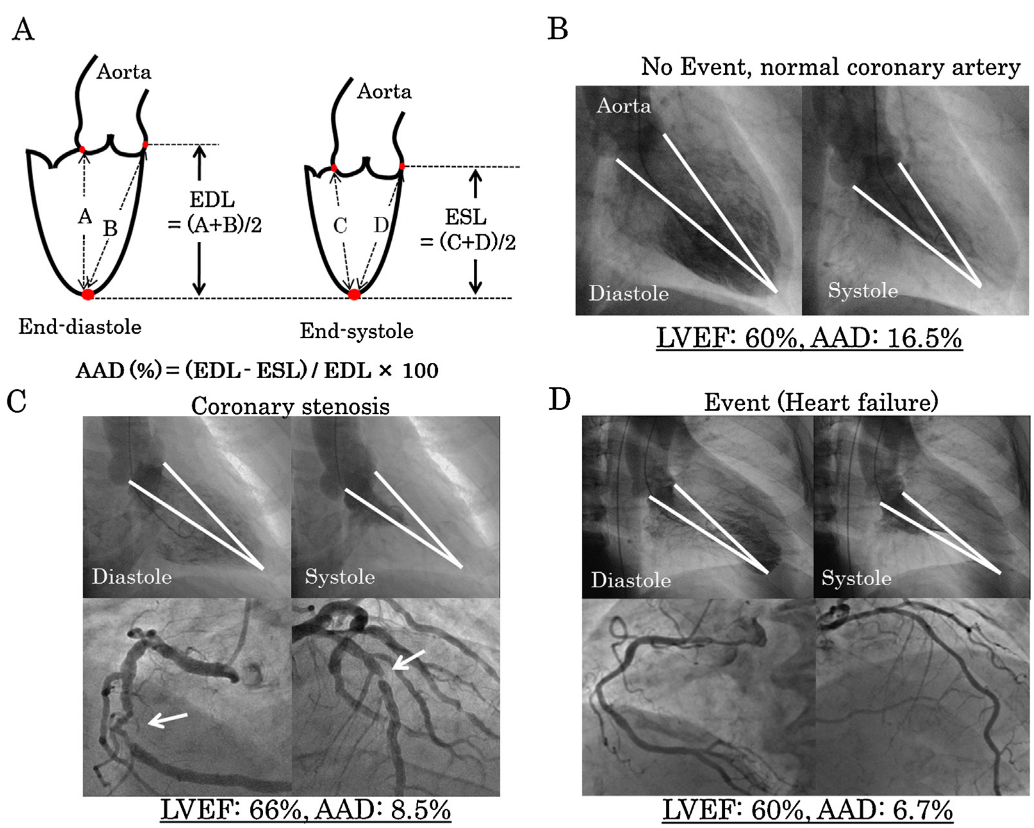

Fig. 1. Method for measuring aortic annulus displacement and representative samples. AAD (%) was calculated as the change in left ventricular length, normalized to EDL (A). AAD was relatively higher in a participant who was free of events (B), and was lower in a patient with coronary stenosis (C) and a patient who developed heart failure during follow-up, even though the three cases had similar LVEF (D). AAD, aortic annulus displacement; EDL, end-diastolic length; ESL, end-systolic length; LVEF, left ventricular ejection fraction.