Detection of Acute Changes in Left Ventricular Function by Myocardial Deformation Analysis after Excessive Alcohol Ingestion

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Background: The effects of acute excessive alcohol ingestion on echocardiographic parameters of left ventricular (LV) function are unclear.

Methods: One hundred ninety-nine healthy subjects (44 ± 5 years, 71% male) were prospectively examined within 6 hours after excessive alcohol ingestion as well as after 4 weeks with strict alcohol abstinence. Echocardiography was performed at baseline and follow-up for conventional parameters (left ventricular ejection fraction [LVEF], transmitral E and A Doppler flow velocities, E/A ratio, tissue Doppler velocity lateral and septal (é), E/é ratio, deceleration time of E, and isovolumic relaxation time) and myocardial deformation data (such as global radial and global and layer-specific circumferential [endo and epi global CS] and longitudinal [endo and epi global LS] strain). Multivariate regression was used to assess the impact of independent variables on echocardiographic parameters.

Results: Alcohol levels were 1.2 ± 0.3 g/L at the time of drinking cessation. After alcohol ingestion endo CS (30% ± 2% vs 37% ± 3%, $P = .008$) and endo LS (27% ± 4% vs 33% ± 3%, $P = .002$) were significantly lower at baseline versus follow-up. Blood pressure, LVEF and heart rate, and other echocardiographic parameters did not differ between the two examinations. Alcohol levels were modestly, negatively associated with change in endo CS and endo LS ($r = -0.54$, 95% CI, −0.63 to −0.43, $P < .001$; and $r = -0.26$, 95% CI, −0.39 to −0.14; $P < .003$, respectively). Alcohol levels were the strongest predictor for endo CS ($\beta = -4.84$; 95% CI, −6.31 to −3.37) and endo LS ($\beta = -2.50$; 95% CI, −4.32 to −0.68).

Conclusions: Acute alcohol ingestion effects endocardial CS and LS, suggesting an acute and transient toxic effect on myocardial deformation, an effect that remains undetected by conventional echocardiographic parameters. The current findings may help clinicians to gain more understanding into the mechanism of developing an alcohol cardiomyopathy and to detect early persistent alcohol-induced myocardial disturbances for an effective therapy in time to prevent harm. (J Am Soc Echocardiogr 2017;30:235-43.)

Keywords: Alcohol consumption, Left ventricular function, Myocardial deformation analysis, Echocardiography

Left ventricular (LV) dysfunction depends on the progressive remodeling of the geometry and structure of the left ventricle that results in decreased myocardial contractility. A number of possible mechanisms have been implicated in the chronic loss of contractility, such as myocyte loss, intracellular organelle dysfunction, contractile proteins, calcium homeostasis, neurohormonal systems, and oxidative stress.[1,2] LV impairment is an early event in the development of heart disease. Indeed, patients with untreated asymptomatic LV dysfunction are at high risk for heart failure,[3] and, therefore, early detection of even marginal signs of cardiac abnormalities is of utmost clinical importance.

Chronic excess alcohol use is a well-established cause of dilated cardiomyopathy, and the existence of a U-shaped relationship between alcohol consumption and moderate LV systolic function (LV ejection fraction [LVEF] <40%) has been demonstrated.[4] Despite the fact that the mechanism of alcohol-induced cardiomyopathy remains unclear, abstinence from alcohol has been associated with improvement in LV function.[5,6]

In contrast, the acute effect of alcohol intoxication has been investigated only in small patient populations and the data are conflicting. A reduction of end-systolic wall stress (afterload) and contractility and a negative inotrope effect have been reported.[7]

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Abbreviations

E/A = Ratio of transmitral early (E) to late (A) Doppler flow velocities

CDT = Carbohydrate-deficient transferrin

CS = Systolic circumferential strain

DT = Deceleration time

EF = Ejection fraction

Endo = Endocardial

Epi = Epicardial

IVRT = Isovolumic relaxation time

LVEF = Left ventricular ejection fraction

LS = Systolic longitudinal strain

LV = Left ventricle/ventricular

RV = Right ventricular

A major problem in the assessment of LV function regards the use of standard echocardiographic measures of systolic and diastolic LV function, which, although widely used in clinical practice, do not allow the detection of small changes in LV myocardial contractility or relaxation.[8] This problem has been overcome by combining conventional echocardiography with imaging techniques such as tissue Doppler and tissue tracking.[9] A number of studies have recently shown that impairment in LV and right ventricular (RV) longitudinal function can be detected in several pathophysiologic conditions, despite normal conventional indices of systolic and diastolic ventricular function.[10,11] These studies used parameters as midwall fractional shortening, M-mode displacement, and tissue Doppler-derived peak systolic velocity, all limited by dependency from ultrasound angle, translation motion and tethering effects, and substantial noise artifacts. Thus, these echocardiographic methods are not widely employed in daily routine practice. Recent studies have also demonstrated that myocardial deformation analysis is considered a sensitive tool capable of detecting changes in viability or ischemia as well a decrease in alcohol-induced contractility.[12,13]

The aim of this study was to assess the effect of acute excessive alcohol ingestion on echocardiographic parameters of LV function by comparing the values obtained within 6 hours of excessive alcohol ingestion and after 4 weeks with strict alcohol abstinence.

METHODS

Subjects

We screened consecutive healthy subjects who presented for a checkup echocardiography in our department (Figure 1). After exclusion of subjects with any echocardiographic abnormality or any disease, we asked the remaining subjects to present again in case of an alcohol excess within the following weeks. One thousand one hundred ninety-five subjects agreed and signed informed consent; 210 healthy subjects presented with alcohol intoxication within 4 weeks after informed consent and were included in this prospective study. We limited the inclusion to a 4-week period to be sure that the informed consent was still valid. The time between presentation and cessation of alcohol consumption was recorded by statement of the subjects and the attendances. All subjects subsequently underwent an echocardiographic examination and blood sampling immediately after presentation and gave information about lifestyle. Alcohol intoxication was defined as behavioral and neurological disorder after consuming an individually unusual high amount of alcohol. After 4 weeks with strict alcohol abstinence, there was another presentation for echocardiography and blood samples in hospital. This time interval was chosen to obtain a high probability that potential alcohol-induced myocardial changes were healed. Each subject was asked to drink a volume of water that was equal to the volume of the alcoholic beverage they consumed 4 weeks previously at least 4 hours before the echocardiographic examination. This study was performed in accordance with local ethical guidelines (EK 242/14) and the Declaration of Helsinki.

Echocardiography

The echocardiographic imaging and analysis protocol have been described elsewhere in detail.[14] Blood pressure and heart rate were measured at the time of echocardiographic examinations. Echocardiograms were performed with a Vivid 7 and E9 System (GE Vingmed, Horton, Norway) equipped with a 2.5-MHz transducer. The frame rate for these studies was between 56 and 92 frames/sec using tissue harmonic imaging. Three LV parasternal short axis views at basal, midventricular, and apical levels and three views from an apical window (two- and four-chamber and long-axis view) were acquired. An 18-segment model was used to divide the LV. LVEF was assessed by the biplane Simpson's method using manual tracing of digital images. Transmitral flow recordings were obtained from the apical four-chamber view using the pulsed wave Doppler and placing the sample volume at the level of the mitral leaflet tips. Peak E and A flow velocities, the E/A ratio, and E wave deceleration time (DT) were measured. Additionally, the tissue Doppler-derived septal and lateral velocities were registered and the ratio E/é using the mean of the septal and lateral é values was calculated. The isovolumic relaxation time (IVRT) was determined using continuous-wave Doppler and placing the cursor between the LV outflow and the mitral valve. All measurements were performed in three consecutive heartbeats and were averaged.

Myocardial Deformation Analysis

Analyses of all echocardiographic loops from both scanners were performed offline with the aid of the commercially available software package (EchoPAC 113 1.0, GE Vingmed). This software was not changed or upgraded during the study and allowed for the rapid (few minutes) calculation of mean strain values for total wall thickness (global data) and additionally for the endocardial (endo) and epicardial (epi) layers as described elsewhere[15,16] (Figure 2). Circumferential (CS), longitudinal (LS), and radial myocardial deformation parameters were determined for each myocardial segment and averaged considering all 18 segments to obtain one value per patient. To avoid confusion, we expressed all strain data as absolute values. All echocardiographic data were analyzed by two blinded experienced cardiologists.

Measurement of Alcohol Levels

Alcohol levels were determined from blood samples and referred to as "real" baseline values. The time between echocardiographic examination and cessation of alcohol consumption was recorded. For each hour delay, 0.1 g/L of the total alcohol value was added to baseline values, to yield the "adjusted" baseline alcohol blood values. At follow-up, alcohol levels and carbohydrate-deficient transferrin (CDT) were also measured from blood samples. In addition, a drug usage screening was performed.

Statistical Analysis

Clinical characteristics of the study population are presented using frequencies or means ± SD. Continuous variables were compared