Dobutamine Stress Echocardiography: Impact of Abnormal Blood Potassium Levels on Cardiac Arrhythmias

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Background: Guidelines suggest that an abnormal blood potassium level is a relative contraindication to performing dobutamine stress echocardiography (DSE). However, this has not been previously studied.

Methods: We reviewed a consecutive series of patients who had potassium testing within 48 hours of undergoing DSE for the evaluation of myocardial ischemia over a 10-year period (N = 13,198). Normal potassium range in our laboratory is 3.6–5.2 mmol/L. Hemolyzed samples were not included. The association of potassium levels with the development of supraventricular and ventricular arrhythmias was assessed.

Results: The incidence of clinically significant arrhythmias was very low (supraventricular tachycardia/atrial fibrillation, 4.9%; nonsustained ventricular tachycardia, 2.9%; sustained ventricular tachycardia or ventricular fibrillation, 0.1%), confirming the overall safety of DSE. Most arrhythmias (88%) occurred in patients with normal potassium levels, and arrhythmia rates remained low in patients with potassium abnormalities. Patients with hyperkalemia had a lower risk of developing mild (odds ratio [OR], 0.39; 95% CI, 0.22–0.71) and severe (OR, 0.13; 95% CI, 0.01–0.68) supraventricular arrhythmias as well as mild ventricular arrhythmias (OR, 0.58; 95% CI, 0.40–0.83). Even though events were rare, patients with severe hypokalemia (potassium levels $\leq$ 3.1 mmol/L) had an increased risk of supraventricular arrhythmia and ventricular ectopy.

Conclusions: DSE is safe even in the setting of abnormalities in blood potassium concentrations, and hence cancellation of DSE in patients with potassium abnormalities does not appear warranted. Elevated potassium levels are associated with lower rates of clinically significant supraventricular and ventricular arrhythmias. While remaining at relatively low risk, patients with very low potassium levels ($\leq$3.1 mmol/L) at the time of DSE have a modestly increased risk of arrhythmia. Consideration could be given to correcting severe hypokalemia prior to DSE. (J Am Soc Echocardiogr 2017;■:■-■.)

Keywords: Stress testing, Arrhythmia, Fibrillation, Outcomes, Electrolytes, Echocardiography

Guidelines suggest that abnormal blood electrolyte levels are a relative contraindication to performing stress testing.[1] However, these recommendations have been based largely on consensus opinion rather than published data, with little published evidence regarding what degree of electrolyte derangement increases the risk of adverse events during stress testing. Outside of stress testing, it has been well described that abnormalities in blood potassium levels are associated with a greater incidence of arrhythmias.[2-4] A prior study described the safety of exercise echocardiography and found that serious ventricular tachyarrhythmias were rare and not associated with modest abnormalities in potassium levels.[5] This previous study focused on patients undergoing exercise echocardiography; to our knowledge, no prior studies have evaluated the arrhythmia risk in the setting of abnormal blood potassium levels in patients undergoing dobutamine stress echocardiography (DSE). Indeed, the significance of abnormalities of blood potassium at the time of DSE is of particular interest for a number of reasons. DSE is becoming an increasingly prevalent modality of stress testing, which is recognized to have a higher prevalence of arrhythmia compared with exercise echocardiography[6] due to the differences in patient populations and also to the proarrhythmic tendency of dobutamine itself.[7-10] Additionally, patients with advanced renal disease are commonly referred for DSE and frequently present with abnormalities of potassium.[11-14]

The aim of this study was to evaluate the relationship between blood potassium levels and arrhythmias at the time of DSE.

METHODS

Study Design

The study was performed with the approval of the Institutional Review Board of the Mayo Clinic. This retrospective analysis availed itself of

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This study received unrestricted support from the Department of Cardiovascular Diseases, Mayo Clinic.

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0894-7317/$36.00

http://dx.doi.org/10.1016/j.echo.2017.01.017

Abbreviations

AF = Atrial fibrillation

CKD = Chronic kidney disease

DSE = Dobutamine stress echocardiography

eGFR = Estimated glomerular filtration rate

LVEDD = Left ventricle end-diastolic dimension

LVEF = Left ventricular ejection fraction

OR = Odds ratio

PVC = Premature ventricular contraction

SVT = Supraventricular tachycardia

VF = Ventricular fibrillation

VT = Ventricular tachycardia

established clinical and stress echocardiographic databases. Subjects were selected from a consecutive series of patients in sinus rhythm ($n = 21,348$) who underwent clinically indicated DSE over a 10-year period (2003–13) for the assessment of myocardial ischemia. The subset of patients who had laboratory testing performed within 48 hours of their stress test formed the study population ($n = 13,198$; Figure 1). Pertinent medical history and stress test variables including arrhythmias were abstracted into a prospectively maintained database by specially trained nurses at the time of the DSE. Our echocardiography laboratory has not traditionally used specific potassium level abnormalities to routinely cancel stress tests. Whether to proceed with stress testing was at the discretion of the supervising echocardiologist.

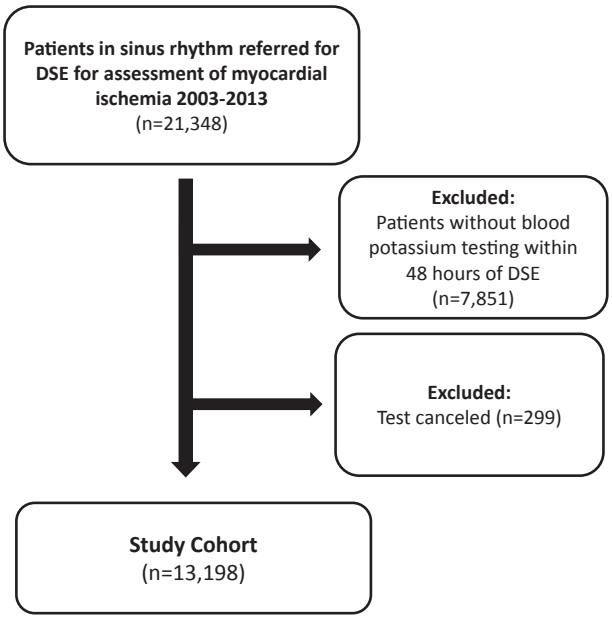

Figure 1 Study cohort.

Arrhythmias

Outcomes during DSE were assessed as either supraventricular or ventricular arrhythmias. Patients undergoing DSE at our institution have continuous cardiac monitoring throughout the dobutamine infusion, during recovery, and up until dismissal from the stress laboratory. Any arrhythmia occurring during the period of monitoring was included in this study. Groups included (1) transient atrial fibrillation (AF)/flutter or supraventricular tachycardia (SVT) which did not require treatment; (2) SVT or AF/flutter that required treatment (vagal maneuvers, intravenous pharmacotherapy, or urgent cardioversion); (3) frequent ventricular ectopic beats (>6 per minute); (4) nonsustained ventricular tachycardia (VT) not requiring treatment; and (5) VT that required treatment or ventricular fibrillation (VF). Treatment of VT was defined as the need for intravenous pharmacotherapy, cardioversion, or defibrillation. A study investigator reviewed electrocardiogram tracings on all clinically significant arrhythmia groups with the exception of the six or more premature ventricular contractions (PVCs) per minute group, which was tabulated from clinical study reports.

Potassium and Magnesium Testing

Blood potassium measurements were performed within 48 hours prior to stress testing. The normal potassium range was defined according to our laboratory standard as 3.6–5.2 mmol/L. The definition of mild hypokalemia was a potassium level of 3.2–3.5 mmol/L, and mild hyperkalemia was defined as a potassium level of 5.3–5.9 mmol/L. Severe hypokalemia was defined as a potassium level ≤3.1 mmol/L, and severe hyperkalemia was defined as a potassium level ≥6.0 mmol/L. Hemolyzed samples were not included in the analysis. Blood potassium concentration was measured in our laboratory by the indirect ion-selective electrode method.[15] For patients who also had a blood creatinine drawn within 48 hours prior to stress testing ($n = 12,795$ [96.9%]), the estimated glomerular filtration rate (eGFR) was calculated by the modification of diet in renal disease equation.[16] Creatinine levels were measured by the enzymatic colorimetric assay method in our laboratory. Patient events were assessed against defined chronic kidney disease (CKD) stages[17] as the following categorical groups: (1) no CKD, defined as eGFR > 60 mL/min/1.73 m^2; (2) stage IIIa, defined as eGFR 45–59; (3) stage IIIb, defined as eGFR 30–44; (4) stage IV, defined as eGFR 15–29; and (5) stage V, defined as eGFR < 15. Blood magnesium levels were measured by the enzymatic colorimetric assay method with a normal range of 1.7–2.3 mg/dL in our laboratory. Hypomagnesemia was defined as a blood magnesium level <1.7 mg/dL, and hypermagnesemia was defined as a blood magnesium level >2.3 mg/dL.

Potassium levels were assessed as a continuous variable and as a four-group categorical variable. Group differences (normokalemia vs mild hypokalemia, normokalemia vs severe hypokalemia, normokalemia vs mild hyperkalemia, and normokalemia vs severe hyperkalemia) were assessed by the χ^2 test. Other predictors of arrhythmia were assessed by univariate and multivariate logistic regression analysis. Variables considered in the univariate analysis included potassium level, eGFR, age per decade of life, gender, family history of coronary artery disease, angiotensin converting enzyme inhibitor or angiotensin receptor blocker use, beta blocker use, hypertension, hyperlipidemia, diabetes mellitus, prior coronary artery bypass graft surgery, prior myocardial infarction, prior percutaneous intervention, tobacco use, evidence of ischemia on stress testing, resting left ventricular ejection fraction (LVEF), and left ventricle end-diastolic dimension (LVEDD). Variables that demonstrated significant prediction of arrhythmias in univariate analysis were candidate variables for multivariate logistic regression analysis, which was done to identify independent predictors of arrhythmias. $P \leq .05$ was considered statistically significant.

RESULTS

Baseline characterisics of the study population are shown in Table 1. Population demographics were similar to those of prior published series of patients undergoing DSE.[6,10,18] Of the 13,198 patients, 7,106 were male (54%) and the mean age was 66 ± 13 years. In the